resilient hills & coasts

Climate Change Adaptation Plan

for the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island Region

Resilient Hills & Coasts

Climate Change Adaptation Plan for the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island Region.

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Disclaimer

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Content

Acknowledgement of Country

Project partners acknowledge the traditional owners of the lands and waters of the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island. We acknowledge the deep feelings of attachment and the relationship of Aboriginal people to country, and respect their ongoing custodianship.

Photo: Courtesy of Alexandrina Council

Acronyms

AR5 – Fifth Assessment Report (released by the IPCC)

BOM – Bureau of Meteorology

CCIA – Climate Change in Australia

CSIRO – Commonwealth Scientific and Industrial Research Organisation

DEWNR – Department of Environment, Water and Natural Resources

ENSO – El Niño Southern Oscillation

GCM – Global Climate Model or Global Circulation Model

IOD – Indian Ocean Dipole

IPCC – Intergovernmental Panel on Climate Change

IVA – Integrated Vulnerability Assessment

LGA SA – Local Government Association of South Australia

NRM – Natural Resources Management

RCP – Representative Concentration Pathway

RDA – Regional Development Australia

RH&C – Resilient Hills and Coasts

SACR – SA Climate-ready

SAMDB – South Australian Murray-Darling Basin

Mayors' Foreword

Photo: Courtesy of Mount Barker District Council

Our changing climate presents significant challenges for our communities, economies and natural environment. We have a shared responsibility to act and to apply individual and collective effort and ingenuity to build the resilience of all within our region to respond and adapt to climate change.

The Adelaide Hills, Fleurieu Peninsula and Kangaroo Island region will be warmer and drier with rising sea levels. We know that there is great diversity across our communities, our economies and our natural environments, and there is strength in this diversity. But there are still risks to manage and opportunities to pursue, and we support a proactive approach to working with our communities to explore and address both.

The regional journey toward climate change mitigation and adaptation has just begun, and this Plan and the research and reports upon which it is built, represent significant steps in guiding regional action. We are committed to working together to implement regional priorities and, to complement this, each of our councils will initiate local action. We are also committed to collaborating with state government agencies to ensure the best outcome for the region.

In particular, as a regional collective, we will further explore the two key strategic themes of:

- ***where we build*** - improving planning for, and management of, development in high risk areas
- ***what we build*** - providing leadership in climate-ready development.

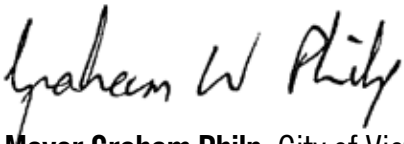
We are pleased to present this Adaptation Plan to guide future regional-scale action. This plan represents input and expertise gathered from across community, government, business and academia and we extend our thanks to everyone who has contributed to its development over the last two years. As a group we commit to transitioning this plan into tangible action, and to embedding climate change considerations into our everyday decision-making. As we move forward into the implementation stage, we invite and encourage you to join us in taking positive action to build the climate resilience of our region.

Mayor Bill Spragg, Adelaide Hills Council

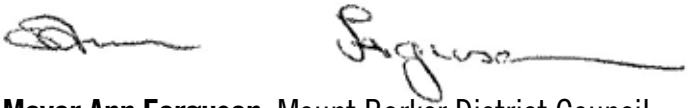
Mayor Glen Rowlands, District Council of Yankalilla

Mayor Keith Parkes, Alexandrina Council

Mayor Peter Clements, Kangaroo Island Council



Mayor Graham Philp, City of Victor Harbor



Mayor Ann Ferguson, Mount Barker District Council

Executive Summary

Photo: Courtesy of District Council of Yankalilla

Global climate change is underway with impacts being experienced world-wide. The magnitude and rate of change to the climate (and associated impacts) depend on the action taken both locally and globally to mitigate greenhouse gas emissions.

Global mitigation is critical, but at the same time, changes to our climate are already locked in, which means that adaptation is just as important. Proactive planning and action will help us to cope with the ongoing impacts of climate change. Adaptation is required at all levels and involves each one of us. This plan seeks to drive and support action at the local and regional level, while actively interfacing with higher level planning and policy development.

About the RH&C Project

Resilient Hills & Coasts (RH&C) is a partner project between local government, NRM Boards and state and federal governments to develop a Regional Climate Change Adaptation Plan for the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island region. The focus of the RH&C project is to make sure that the region remains a strong and vibrant place to live, work and visit; and that businesses, communities and environments can respond positively to the challenges and opportunities presented by a changing climate.

Despite some global action being taken to manage and reduce greenhouse gas emissions, substantial adaptation will be required because of changes to our climate that are already occurring. By being proactive and responding to existing climate change impacts at the same time as planning for those that are likely to occur in the future,the RH&C region can position itself to successfully manage adverse impacts and take advantage of any opportunities.

This Regional Climate Change Adaptation Plan (Adaptation Plan) provides the foundation for a coordinated and collaborative response to climate change impacts and identifies priorities for adaptation across the RH&C region.

Climate change in the region

While there is natural variability in the climate of the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island region, climate change is creating a different climate with warmer and drier conditions, increasing heatwaves and bushfire risk, higher sea levels and increased storm surge. The oceans are also acidifying as carbon dioxide dissolves into sea water, posing a significant threat to marine ecosystems. Further impacts due to warming oceans include a change in ocean circulation patterns and currents, with implications for biodiversity, fishing and climate.

Projections of future climate consider the impact of different emissions scenarios, that is, different quantities of greenhouse gasses being released into the Earth's atmosphere.

Whilst the outcomes for an intermediate emissions scenario are described below, the high emissions scenario that we are currently tracking on would see a greater rate and magnitude of change in land and sea surface temperature,rainfall and sea level rise over the coming decades. If a high emissions trajectory is continued, implementation of many of the adaptation options identified in this Plan will need to be accelerated, impacts will be more severe and adaptation action will be far more difficult and costly*.

Intermediate, stabilisation scenario – an emissions pathway where the impact of climate change on the atmosphere is stabilised before 2100 by using a range of technologies and strategies for reducing greenhouse gas emissions (referred to as RCP4.5).

High emissions scenario – an emissions pathway characterized by increasing greenhouse gas emissions over time leading to high greenhouse gas concentration levels (referred to as RCP8.5).

Under intermediate emissions by 2070 for the Adelaide Hills and Fleurieu Peninsula:

- rainfall is projected to decline by about 6%
- rainfall intensity could increase by 11%
- maximum temperatures are projected to increase by 1.5ºC
- minimum temperatures could increase by 1.2ºC
- extreme heat in Victor Harbor could increase by 30% to 11 days per year over 35ºC.

* https://www.whitehouse.gov/sites/default/files/docs/the_cost_of_delaying_action_to_stem_climate_change.pdf

The increase in fire weather for the Adelaide Hills and Fleurieu Peninsula, based on projections for Adelaide, is an increase from 1.7 severe fire danger days per year under current conditions to 2.6 per year by 2090 under an intermediate emissions pathway.

Under intermediate emissions by 2070 for Kangaroo Island:

- rainfall is projected to decline by about 7.9%
- rainfall intensity could increase by 8%
- maximum temperatures are projected to increase by 1.2ºC
- minimum temperatures could increase by 1.0ºC.

For ocean and gulf waters, projections under intermediate emissions suggest a:

- rise in sea levels of 33cm by 2070
- rise in sea surface temperatures of 1.2ºC by 2090
- decline of 0.15 pH units by 2090.

Process

The Adaptation Plan has been developed via a three step process:

Step 1: Mapping vision, values and key decisions (completed in 2014).

Step 2: Integrated Vulnerability Assessment (Kangaroo Island IVA completed 2014, Adelaide Hills and Fleurieu Peninsula IVA completed 2016).

Step 3: Identifying and prioritising adaptation options (Adaptation Action Plan completed 2016).

Step 1 involved the completion of values and issues mapping exercises. **Step 2** involved using these results to develop indicators for two integrated vulnerability assessments. Together, the integrated vulnerability assessments examined a total of 108 indicators (54 for Kangaroo Island and 53 for the Adelaide Hills and Fleurieu Peninsula).

Based on the results of the integrated vulnerability assessments, together with consideration of emerging opportunities, key areas of decision making were developed as the basis for further adaptation planning. The themes for key areas of decision making were as follows:

Adelaide Hills and Fleurieu Peninsula:

- agriculture
- climate-ready homes and buildings
- coastal ecosystems
- community facilities and open space
- emergency management services
- infrastructure assets
- landscape conservations
- built coastal assets
- vulnerable members of the community
- water-dependent ecosystems.

Kangaroo Island:

- agricultural productivity
- built coastal assets
- condition of sealed and unsealed roads
- essential services and infrastructure
- health and well-being of vulnerable members of the community
- protecting against bushfire threat (emergency services management)
- wild-catch fisheries productivity
- biosecurity
- terrestrial ecosystems
- aquatic ecosystems.

Note that the four NRM-related themes for Kangaroo Island (final four dots points in above list) are not considered in this Plan as these are being addressed through the implementation of the *'Climate Change Ready' Kangaroo Island NRM Plan 2017-2027*.

Photo: Courtesy of Adelaide Hills Council

Step 3 involved identifying priority adaptation options based on the key areas of decision making for each of these themes. In addition, regional priority adaptation options were identified through the use of an action prioritisation framework, which combined:

- the results of a qualitative cost-benefit analysis of all options
- consideration of their regional relevance
- practicality of implementation.

The regional adaptation priorities for RH&C, which present actions that have implementation responsibilities for all project partners, are (in alphabetical order)*:

Adaptive management of protected areas on public lands - Adaptive management of protected areas on public lands will focus on managing fuel loads in close proximity to towns and private land. The emphasis on fuel loads will become increasingly important as fire risk increases and the community seeks to balance maintenance of environmental values and ecosystem services with public health and safety concerns.

Climate-ready guidelines for public realm and green infrastructure management - Preparing and commencing implementation of 'climate-ready' guidelines for public realm and green infrastructure management will include appropriate material and tree species selection, shade coverings, inclusion of water sensitive urban design features, and opportunities for misting infrastructure.

Diversification of agricultural activities - Diversification of agricultural activities will focus on investigating and encouraging the use of different varieties and types of crops and pasture, and livestock management practices, from warmer and drier parts of the State, and nationally. This will build adaptive capacity to future warmer and drier conditions and more intense rainfall which will reduce soil moisture and increase erosion risk respectively.

Build more energy efficient housing - Focussing on building more energy efficient housing will require installation (and potentially development) of energy efficient building materials and fixtures. This will be supported through

* Noting that some issues, such as water availability, apply across multiple key areas of decision making and so are not considered independently.

government incentives and local government advocating development of such materials, working with the development industry (e.g. builders, developers, manufacturers) and research institutes.

Incorporate design allowances for increases in extreme events - Governments, local government in particular, will ensure that new and renewed infrastructure is designed to allow for increases in extreme events, such as greater fire risk and flooding induced by more intense rainfall events.

Improved management of native vegetation on private properties - Landholders managing native vegetation on private properties will be supported, where possible, through the use of well-funded incentives.

Restricting development in hazard prone areas - Development in hazard prone areas will be prevented or restricted, such as areas at risk from sea level rise along the coast, bushfires inland and infrastructure and dwellings at risk from flooding following intense rainfall events. While this response may take some time to gain community support, in the long term it will avoid impacts on people and reduce the costs (e.g. insurance) associated with protecting or relocating assets and people, and recovering post-disaster.

Increase stormwater harvesting to improve water quantity and quality management - With rainfall seasonality, quantity and intensity projected to change, greater emphasis is required on water quality management, especially in relation to stormwater. Water quality improvement will require continued investment in water sensitive urban design, stormwater retention areas and water recycling.

In addition to these regional priorities, continued ***education and awareness raising*** about the impacts and response options to climate change is essential to underpin broad scale adaptation. Equally, ***anticipatory monitoring and evaluation*** is needed across all sectors to detect climatic change impacts and develop triggers for implementing different strategies.

Whilst the region faces significant challenges in adapting to climate change, it is better placed than many others in the State due to its naturally cooler climate, and diversity of industries across the region. The preferable climate combined with increasing population could stimulate business activity and lead to opportunities such as:

- encouraging the development of low carbon communities with housing that is energy and water efficient and resilient to climate change
- incorporating "climate-ready" design principles into new buildings and essential services infrastructure
- increasing interest in green infrastructure for residential developments.

Successfully implementing this Plan will require:

- maintaining momentum as the project transitions from planning to implementation
- localising action, to take up implementation with individual project partners
- responsive project management and governance reflecting on the learnings from the project to date and on the experience of similar projects
- strengthening engagement and partnerships between project partners but also with community, industry, business, education and government sectors
- a flexible and responsive approach to new information that emerges about the rate and magnitude of climate change.

Consultation

Over 120 people from across from community, business, government, industry, academia and project partners attended project workshops and focus groups that informed the development of the vulnerability assessment and adaptation plan.

Additionally, over 270 people involved in the project since its inception in 2014, were emailed a direct link to the draft adaptation plan and invited to provide feedback.

A public consultation process was also conducted inviting feedback from community on the draft plan. Through these processes, the project received thirteen written submissions ranging in views, but the majority supported the adaptation options contained in the plan.

Photo: Courtesy of Alexandrina Council

PART A | Context

Photo: Courtesy of Mount Barker District Council

INTRODUCTION

Global climate change impacts are already being experienced world-wide. The planet is now committed to warming and associated climate changes over the coming decades, though the magnitude and rate at which this change occurs will depend on what mitigation actions are taken at the global level to reduce greenhouse gas emissions. Despite global action being taken to manage and reduce greenhouse gas emissions, climate change continues to occur, meaning that adaptation is, and will be, required now and into the future. By being proactive and planning now for the impacts that are already occurring and those likely to occur in the future as the climate continues to change, regions can position themselves to manage adverse impacts and take advantage of any opportunities that arise.

Resilient Hills and Coasts (RH&C) is a climate change adaptation planning project covering the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island region (Figure 1).

The project partners are the:

- Adelaide Hills Council
- Alexandrina Council
- City of Victor Harbor
- Mount Barker District Council
- District Council of Yankalilla
- Kangaroo Island Council
- Department of Environment, Water & Natural Resources
- Natural Resources Adelaide and Mount Lofty Ranges
- Natural Resources Kangaroo Island
- Regional Development Australia Adelaide Hills, Fleurieu and Kangaroo Island
- Southern and Hills Local Government Association.

By collaborating, the RH&C region can deliver a coordinated response to climate change. By sharing information, resources, responsibilities and actions, resilience can be built to benefit the community, businesses and the environment. This Climate Change Adaptation Plan (henceforth Adaptation Plan) provides the foundation for a coordinated and collaborative response to climate change and identifies priorities for adaptation across the region. It also addresses the requirements of the South Australian Climate Change Adaptation Framework for regions in the State to develop regional climate change adaptation plans.

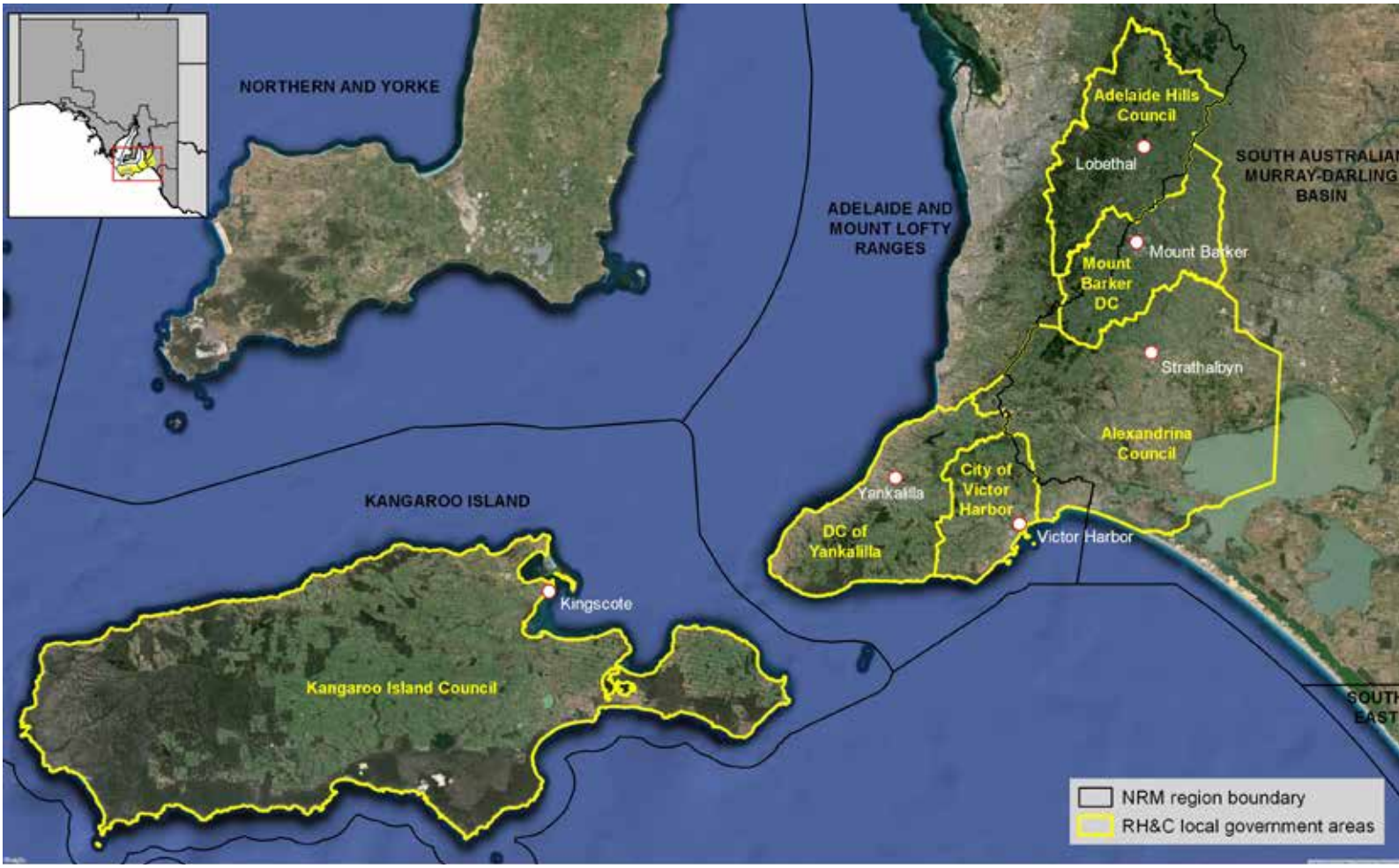
The objective of this Adaptation Plan are to:

- provide an overview of how climate change is likely to impact the RH&C region
- summarise the process involved in preparing the Plan, covering outcomes from previous stages
- describe the key areas for adaptation planning, referred to as "key areas of decision making"
- identify priority adaptation options for each key area of decision making
- outline the regional priority adaptation options.

Because of the unique geography of the RH&C region, together with how the first phase of the project was delivered, this Adaptation Plan is presented in four main parts:

1. **Part A - Context**: provides an overall introduction to the project and the region, projected climate changes for two sub-regions (i.e. Kangaroo Island, Adelaide Hills/Fleurieu Peninsula), and a summary of how this Plan has been developed
2. **Part B - Adelaide Hills and Fleurieu Peninsula**: presents the priority adaptation options and adaptation pathways for the mainland sub-region
3. **Part C - Kangaroo Island**: presents the priority adaptation options and adaptation pathways for the Kangaroo Island sub-region
4. **Part D – The Region**: focusses on the Region as a whole and implementing the plan. It presents a set of regional adaptation priorities, highlights opportunities for the Region, discusses the plan review, and also identifies alignment between this Plan and that for the South Australian Murray-Darling Basin region which partially overlaps with the RH&C region.

This Adaptation Plan is a plan for the region and its implementation resides with individuals and organisations across the region including service providers, State and local government agencies, not-for-profit organisations, business and industry, infrastructure owners and managers, community, and community groups.



Important notes: (i) This map is not guaranteed to be free from error or omissions, and has been produced for the exclusive use of the Client and Seed Consulting Services (ii) Any contours are suitable only for the purpose of this plan; their accuracy has not been verified and no reliance should be placed upon them for any purpose other than the original purpose of this map (iii) Aerial photos and imagery have been overlaid as best fit on the boundaries shown and precision is approximate only (iv) Scale shown is correct for original plan and any copies of this plan should be verified by checking against the scale bar (v)This figure may not be copied unless this note is included.

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Figure 1. Resilient Hills and Coasts area in relation to LGA and NRM boundaries

Photo: Courtesy of DEWNR

THE RESILIENT HILLS AND COASTS REGION

The RH&C region, covers a land area of approximately 8,752km2 characterised by a highly variable topography and geology, from coastal dunes and rocky escarpments to inland fertile hills and pasturelands. It includes the entire Kangaroo Island natural resources management (NRM) region and parts of the Adelaide and Mount Lofty Ranges and South Australian Murray-Darling Basin NRM regions (Figure 1).

The population is approximately 120,000 people and is currently growing and aging, which is changing the region's demographics, though not consistently across all council areas (Resilient Hills and Coasts, 2014a). For example, population growth rates tend to be highest in the Victor Harbor local government area and lowest in the Adelaide Hills, and the aging population is prevalent in coastal townships on the Fleurieu Peninsula, which present particularly attractive retirement destinations.

Comparatively, more inland local government areas within the region are experiencing growing younger populations, due largely to population growth from inland migration by working-aged people and young families (Resilient Hills and Coasts, 2014a). Mount Barker, for example, is the largest town in the Adelaide Hills, but is also one of the fastest growing regional centres in Australia and is on track to become the State's second biggest regional city (Mt Barker District Council 2015).

The region's communities tend to be well educated and qualified, and on average are physically healthier and have lower unemployment rates, compared to the State though the health and affluence of communities in the region also varies geographically (Resilient Hills and Coasts, 2014a). For example, compared to the rest of the region, the Adelaide Hills local government area has the lowest unemployment rates as well as the highest proportion of education graduates. In the Adelaide Hills and Fleurieu Peninsula region, almost half of the region's workforce commutes to areas outside of the region for work, which is facilitated through good connections to the Adelaide metropolitan area.

Due to its geographic isolation by sea, Kangaroo Island's workforce is largely contained on the island. This physical isolation also places the Island at increased risk of social disconnectedness with limited access options to the mainland and the larger metropolitan areas. However, the residents of Kangaroo Island maintain a community with a high level of social connectedness, as is evident from their rate of volunteering which is the highest in the region, and nearly double the average rate for the whole State (URPS 2014).

A major challenge on the Island, and also in the mainland's coastal townships, will be ensuring energy, water and communications infrastructure, as well as emergency services, are able to withstand climate change impacts, particularly sea level rise and storm surges. Predicted increasing tourism to the region's mainland coastal townships and Kangaroo Island will likely facilitate this challenge by acting as a catalyst for the creation and upgrading of essential services, facilities and infrastructure. The predicted tourism influx also presents one of the best opportunities for future job creation in the region, which is likely to help decrease unemployment rates and also decrease the need for some workers to commute outside of the region for work.

The region supports a successful economy, with a strong and diverse primary production sector, including dryland cropping, irrigated cropping, horticulture, aquaculture, viticulture and livestock grazing. Forestry and commercial precincts, together with an increasingly growing tourism industry add to the region's overall economic prosperity (Resilient Hills and Coasts, 2014a).

The heterogeneous landscape of the region further underpins the region's numerous natural environmental assets and services including terrestrial, coastal, aquatic and marine systems which support a diverse assemblage of flora and fauna species (including threatened species), a number of threatened plant communities, and nationally and internationally significant wetlands (Resilient Hills and Coasts, 2014a).

The RH&C region has a Mediterranean climate and as such experiences natural variability in weather during the year, characterised by hot dry summers and cold wet winters. Compared to other parts of South Australia, the region is characterised by moderate to high rainfall and cooler summers. Interaction between the land and sea along the coast shapes much of the landscape. Climate patterns vary year to year as well as with major climate influences (Bureau of Meteorology, 2016) including the:

- **Indian Ocean Dipole (IOD)**, which affects the climate of Australia and other countries that surround the Indian Ocean Basin, and is a significant contributor to rainfall variability.
- **El Niño Southern Oscillation (ENSO)**, the oscillation between El Niño and La Niña conditions which affects rainfall and temperature in eastern Australia.

The result of these and other climate influences are natural and major variations in rainfall and temperature, especially drought cycles. In addition to this natural variability in climate, there are longer term changes in rainfall, temperature and other variables occurring as a result of climate change.

HOW WILL CLIMATE CHANGE AFFECT THE REGION?

The following section provides an overview of climate change, climate projections modelling, and climate projections relevant to the RH&C region. Further detailed information and references can be found in the Climate Projections Report developed for the RH&C project (Resilient Hills and Coasts, 2015).

Overview

Climate is the average weather over long periods of time (IPCC, 2013a). The World Meteorological Organization defines the climate as the average weather over a 30 year period. Climate change refers to altered climate trends (e.g. increasing temperatures, decreasing rainfall) as averaged over decades or longer. It differs from climate variability which refers to short-term weather fluctuations (1-10 years) (e.g. drought and non-drought cycles) which may occur despite the underlying climate trend.

Climate change is a consequence of the release of greenhouse gases like carbon dioxide, methane and nitrous oxide into the Earth's atmosphere (CSIRO and Bureau of Meteorology, 2015). These gases are produced from a range of natural sources as well as from human activities like energy production, transport, industrial processing, waste management, agriculture, and land management. Greenhouse gases trap the sun's energy in the Earth's atmosphere leading to changes in the global climate. These changes include: increasing air temperatures, changes to rainfall patterns, rising sea levels, and increasing sea surface temperatures.

The most authoritative source of information on climate change is provided by the Intergovernmental Panel on Climate Change (IPCC). Every five to six years the IPCC produces an Assessment Report which presents the most up-to-date scientific knowledge regarding climate change. The most recent of these reports is the Fifth Assessment Report (AR5), released in 2013 (IPCC, 2016). Climate change modelling results contained in these reports are used globally to underpin climate change action, including adaptation planning.

It is not possible to 'pxredict' or 'forecast' what the future climate might be. Instead, climate models use emissions and land-use scenarios to develop a range of "projections/scenarios" that can be used to explore what future climate conditions may occur. These projections contain inherent variability, which are important to understand when determining how best to use climate data in adaptation planning (Resilient Hills and Coasts, 2015). Two of the main sources of variability in climate projections derive from the choice of global climate model/s (GCMs) and representative concentration pathway (RCP).

Global Climate Models are numerical models that explore how processes in the atmosphere, ocean, cryosphere and land surface respond to increasing greenhouse gas concentrations. GCMs are used to generate projections for climate variables like temperature and rainfall. Given the variability that exists across the projections outputs of climate modelling, communication of the outputs often use the median or 50th percentile model output (sometimes described as the "best estimate"), or the 10th and 90th percentile outputs.

Representative Concentration Pathways refer to four main scenarios presented in IPCC AR5 which consider time series of alternative emissions together with concentrations of the full suite of greenhouse gases, aerosols and chemically active gases, as well as varying land-use/land cover to produce alternative future climate conditions (IPCC, 2013b).

Photo: Courtesy of Adelaide Hills Council

The four main RCPs outlined in AR5 as the basis for the climate projections (IIASA, 2009) are:

- **RCP2.5 "Peak and decline scenario"** – an emissions pathway leading to very low greenhouse gas concentration levels a so-called "peak" scenario (radiative forcing peaks at approximately 3 W m–2 before 2100 and then declines)
- **RCP4.5 "Intermediate, stabilisation scenario"** – an emissions pathway where the impact of climate change on the atmosphere is stabilised before 2100 by using a range of technologies and strategies for reducing greenhouse gas emissions (radiative forcing stabilises at approximately 4.5 W m–2 after 2100)
- **RCP6.0 "Intermediate, stabilisation scenario"** – an emissions pathway where the impact of climate change on the atmosphere is stabilised after 2100 by using a range of technologies and strategies for reducing greenhouse gas emissions (radiative forcing is stabilised at approximately 6.0 W m–2 after 2100)
- **RCP8.5 "High emissions scenario"** – an emissions pathway characterized by increasing greenhouse gas emissions over time leading to high greenhouse gas concentration levels.

For South Australia, there are two main sources of information on climate projections, which both use RCPs and GCMs presented in the IPCC's AR5 (Resilient Hills and Coasts, 2015):

- **SA Climate-ready (SACR)***: released in February 2015, this is the Goyder Institute's "Agreed downscaled climate projections for South Australia" project. The project provides regional-scale projected climate trends for the State for four future timeframes (2030, 2050, 2070 and 2090), under two RCPs (RCP4.5 and RCP8.5), and for five climate variables: areal evapotranspiration; temperature; rainfall; vapour pressure deficit; and solar radiation
- **Climate Change in Australia (CCIA)****: released in February 2015, this is a nationally-focused CSIRO and Bureau of Meteorology project that provides future "application ready" climate data for eight GCMs. Information for the following climate variables is available: fire weather days; sea surface temperature; mean and extreme sea-level rise; sea surface salinity; ocean acidification; solar radiation; point potential evapotranspiration; temperature; rainfall; wet areal evapotranspiration; relative humidity; and wind speed.

Separate projections data are available for the Adelaide Hills and Fleurieu Peninsula and Kangaroo Island.

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* Further information and regional scale summaries generated from SACR can be found at: www.goyderinstitute.org or https://data.environment.sa.gov.au for access to the detailed datasets.

** Additional information on the project and access to projection data can be found at www.climatechangeinaustralia.gov.au.

Regional projections

Since the 1950's, South Australia has experienced nearly 1°C of warming and a reduction in average rainfall (CSIRO and Bureau of Meteorology, 2015). This warming and drying is projected to continue into the future and will lead to changes in the environment, economy and community. By 2050, Victor Harbor's climate is predicted to be similar to the current climate of Nuriootpa and Port Lincoln (under an intermediate emissions scenario), whereas Kingscote will be more similar to Yorketown's current conditions. By 2090, Victor Harbor's climate will be more similar to Adelaide's and Keith's current climate, and Kingscote will be more similar to current climate conditions in Nhill in the Wimmera region of Victoria (Resilient Hills and Coasts, 2015).

Specific projections for climate variables used in the RH&C project are shown in Table 1 and briefly described below, with further details available in the Climate Projections Report (Resilient Hills and Coasts, 2015). Unless indicated otherwise, projections data is from SA Climate-ready. Note that extreme heat and fire projections have not been specifically calculated for Kangaroo Island. Instead, projections used for the Adelaide Hills and Fleurieu Peninsula region are also applied to Kangaroo Island.

Table 1

Climate variable projections for the Adelaide Hills and Fleurieu Peninsula (AHFP) and Kangaroo Island (KI) sub-regions under an intermediate emissions pathway (RCP4.5) to 2070 (for further details see Resilient Hills and Coasts (2015)).

Climate Variable	Projected Change by 2070	
	AHFP	KI
Rainfall - annual median - declining	5.7%	7.9%
Rainfall - summer median - declining	9.6%	9.9%
Rainfall - autumn median - declining	3.2%	7.5%
Rainfall - winter median - declining	6%	6%
Rainfall - spring median - declining	16.4%	17.3%
Rainfall - intensity - increasing	11%	8%
Temperature - annual median maximum - increasing	1.5ºC	1.2ºC
Temperature - summer median maximum - increasing	1.5ºC	1.3ºC
Temperature - autumn median maximum - increasing	1.5ºC	1.2ºC
Temperature - winter median maximum - increasing	1.3ºC	1.1ºC
Temperature - spring median maximum - increasing	1.9ºC	1.4ºC
Temperature - annual median minimum - increasing	1.2ºC	1ºC
Temperature - summer median minimum - increasing	1.1ºC	1ºC
Temperature - autumn median minimum - increasing	1.2ºC	1.1ºC
Temperature - winter median minimum - increasing	1ºC	0.9ºC
Temperature - spring median minimum - increasing	1.2ºC	1.1ºC
Temperature - annual number of days above 35ºC - increasing	57% increase	
Temperature - annual number of days above 40ºC - increasing	150% increase	
Fire - annual number of severe fire risk days - increasing	65% increase	
Sea level - increasing	33 cm	
Temperature - sea surface - increasing	1.2ºC by 2090	
Ocean acidity - increasing	0.15 decline in pH units to 2090 (41%)	

Adelaide Hills and Fleurieu Peninsula

Rainfall
By 2050, the annual median rainfall is projected to decline by 6.8% and 7.4% compared with the baseline (1986-2005) under the intermediate and high emissions pathways, respectively. By 2070, projected rainfall decline under the intermediate emissions pathway is 6%, compared to 11% under the high emissions pathway.

Under 2070 projections, for example, Mt Barker's current annual average rainfall of 733mm would decline to 689mm under the intermediate emissions pathway and 652mm under the high emissions pathway. Under the same timeframe and pathways, Port Elliot's current 485mm annual average rainfall would decline to 456mm and 432mm.

Seasonal differences in average rainfall are also projected for the region. By 2050, median spring average rainfalls are projected to decline by 11.9% under the intermediate emissions pathway compared to 4.3% and 4.4% in autumn and winter, respectively. Under the high emissions pathway, the spring decline is 21% compared to 3.5% and 4.9% in autumn and winter.

By 2070, the projected decline in median spring rainfall under an intermediate emissions pathway is 16.4%, compared with 3.2-9.6% for other seasons. For the high emissions pathway, the spring decline is 20.6% compared to 7.5-11.6% for other seasons.

Rainfall intensity
According to the CCIA project, there is high confidence that the intensity of heavy rainfall events (maximum 1-day rainfall) will increase in the RH&C region, despite projected decreases in mean rainfall. The CCIA does not provide quantitative modelling for rainfall intensity. However, for the purposes of obtaining regional projections, other recent analyses outside of SACR and CCIA has been drawn upon to project increases in rainfall intensity in the Adelaide Hills and Fleurieu Peninsula region by 9% and 11% by 2050 under an intermediate and high emissions pathway, respectively, and at least 11% and 16% by 2070.

On Kangaroo Island, rainfall intensity could increase by 2050 by nearly 8% and 9%, respectively, under an intermediate and high emissions pathway. By 2070, this could increase to 8% and 13%.

Maximum temperature
Compared to baseline temperatures, annual median maximum temperatures will increase under an intermediate emissions pathway by 1.3ºC and 1.5ºC by 2050 and 2070, respectively. Comparatively, under a high emissions pathway, temperature increases are projected to be 1.6ºC and 2.3ºC by 2050 and 2070, respectively.

To give a regional example, this means that the annual median maximum temperatures at Mt Barker by 2070 could increase from the current 20.3ºC to 21.8ºC or 22.6ºC under an intermediate or high emissions pathway, respectively. Under the same future timeframe and emissions pathways, Parawa annual median maximum temperatures could increase from 17.8ºC to 19.3ºC or 20.1ºC.

Maximum temperatures vary across seasons, particularly for spring. For example, by 2050 under an intermediate emissions pathway, the increase in spring median maximum temperatures is 1.6ºC compared to 1.2ºC for all other seasons; and 2.0ºC compared to 1.5-1.6ºC for all other seasons under a high emissions pathway.

A similar trend continues in 2070, where summer, autumn, and winter median maximum temperatures are projected to increase by 1.3-1.5ºC under an intermediate emissions pathway compared with 1.9ºC in spring. Under a high emissions pathway summer, autumn, and winter increase by 2.1-2.3ºC, and spring by 2.9ºC.

Minimum temperature
Annual median minimum temperatures show a similar trend to maximums, suggesting an increase by 2050 of 1.0ºC and 1.3ºC under the intermediate and high emissions pathways, respectively. By 2070, the projected increase in minimum temperatures under an intermediate emissions pathway is 1.2ºC compared with 2.0ºC under a high emissions pathway.

The difference in projected median minimum temperatures across seasons is generally minimal. By 2050, the SACR projected increases under the intermediate emissions pathway are between 0.8-1.1ºC across seasons, and for the high emissions pathway, 1.2-1.5ºC. By 2070, the range of change increases slightly under


Photographer: Pip Masters

the intermediate emissions pathway to 1.0-1.2ºC. It is only under the high emissions pathway for 2070 that the seasonal difference is more pronounced, with summer and winter increases of 1.8-1.9ºC compared with 2.2-2.3ºC for autumn and spring.

Heat extremes

The Adelaide Hills and Fleurieu Peninsula is likely to experience an increase in extreme heat (i.e. number of days over 35ºC or 40ºC) in the future . However, specific projections of changes in extreme heat using CCIA results are available only for Adelaide and Victor Harbor.

In Adelaide, by 2050 the number of days over 35ºC is projected to increase from 17 per year to 23 or 27 per year under intermediate or high emissions pathways, respectively. By 2070, under the same emissions pathways, the number of days over 35ºC is projected to increase to 25.5 or 31 per year. A greater increase occurs for the number of days over 40ºC, with at least a doubling by 2050 under intermediate and high emissions, and an increase from 2 days per year to 5.5 or 8.5 by 2070.

In Victor Harbor, by 2050 the number of days over 35ºC will increase from 7 to 10 or 10.5 under the intermediate or high emissions pathways, and by 2070 will increase to 11 or 14.

Under baseline conditions (1986 – 2005), Victor Harbor had not recorded any days over 40ºC. However, by 2050, it is projected to experience 1 or 1.5 days per year above 40ºC under the intermediate or high emissions pathways, and 1.5 or 2 days by 2070.

Fire weather

Fire weather projections were estimated in the CCIA project using the McArthur Forest Fire Danger Index (FFDI), which is a widely used measure to forecast the influence of weather on fire behaviour (Hope, *et al.*, 2015).

Fire weather is considered 'severe' when FFDI exceeds 50 and 'extreme' when FFDI exceeds 75. The CCIA project generated FFDI projections for four weather stations in South Australia, of which Adelaide is the most relevant to the RH&C region. The other locations in the State are Ceduna, Woomera, and Mt Gambier. FFDI was calculated at Adelaide by Hope *et al.* (2015) for only two future timeframes (2030 and 2090).

The FFDI projections indicate increased fire weather in the future for Adelaide. General fire weather danger is projected to increase by 2030 by 6% or 13% under intermediate or high emissions pathways, and by 12% or 29% by 2090.

The number of days per year with a 'severe' fire danger rating is projected to increase by 2030 from 1.7 days under baseline conditions to an average of 2.6 or 2.1 under the intermediate and high emissions pathways, respectively. By 2090, this will increase to 2.6 and 4 days per year (Hope, *et al.*, 2015).

Note that the weather metrics differ and fuel loads (linked to wild fire risk) are substantially lower in Adelaide, compared to the RH&C region. As such, although the Adelaide-based projections are the most RH&C relevant projections available at the time of this project, they likely underestimate the number of fire risk days within much of the RH&C region.

Annual rainfall in the Adelaide Hills and Fleurieu Peninsula is projected to decline by 2070, and annual maximum and minimum temperatures will increase.

Photographer: Colin Wilson

Kangaroo Island

Rainfall
By 2050, annual median rainfall is projected to decline by 7.5% or 8.9% under intermediate or high emissions pathways, respectively. By 2070, rainfall is projected to decline by 7.9% under an intermediate emissions pathway, compared with 12.5% under a high emissions pathway. For Kingscote by 2070, this would result in a decline in rainfall from the current annual average of 489mm to 450mm or 428mm under an intermediate or high emissions pathway, respectively.

Seasonal differences are apparent by 2050, with spring projected to experience a 13.9% decline in median rainfall under an intermediate emissions pathway, compared to 5.2% and 4.7% decline in autumn and winter, respectively. Under the high emissions pathway the spring decline is 23.8% compared to 5.1% and 8.3% during winter and autumn.

By 2070, the spring decline in median rainfall under the intermediate emissions pathway is projected to be 17.3%, compared to 6.0-9.9% for summer, autumn, and winter. For the high emissions pathway, the decline in spring rainfall is 23.7% compared to 10.1-17.3% for the other seasons.

Maximum temperature
Compared to baseline temperatures, SACR projects that under an intermediate emissions pathway, annual median maximum temperatures will increase by 1.1ºC and 1.2ºC by 2050 and 2070, respectively. Comparatively, under a high emissions pathway, temperatures are projected to increase by 1.3ºC and 1.9ºC by 2050 and 2070, respectively.

An increase in annual median maximum temperatures of this magnitude would see the average maximum temperature at Kingscote increase from the current 19.6ºC to 20.8ºC or 21.5ºC under an intermediate or high emissions pathway, respectively.

Seasonal differences by 2050 are minimal, ranging from 0.9-1.2ºC under the intermediate emissions pathway and 1.2-1.5ºC for the high emissions pathway. The difference between seasons for median maximum temperatures by 2070 under an intermediate emissions pathway is minor, with winter temperatures projected to increase by 1.1ºC and spring only slightly higher at 1.4ºC. Under a high emissions pathway summer, autumn and winter are projected to increase by 1.8-1.9ºC and spring by 2.3ºC.

Minimum temperature
Annual median minimum temperatures show a similar trend to maximums, suggesting an increase by 2050 of 0.8ºC and 1.1ºC under the intermediate and high emissions pathways, respectively. By 2070, the SACR projected increase in minimum temperatures under an intermediate emissions pathway is 1.0ºC compared with 1.6ºC under a high emissions pathway.

The difference in projected median minimum temperatures across seasons by 2050 is minimal for the intermediate emissions pathway (0.7-0.9ºC). In contrast, the difference between seasons is greater for the high emissions pathway with the spring increase of 1.5ºC greater than for other seasons (1.0-1.2ºC).

By 2070, projected median minimum temperatures across seasons are 0.9-1.1ºC under an intermediate emissions pathway. In contrast, the difference between seasons is greater for the high emissions pathway with the spring increase of 2.2ºC greater than for other seasons (1.5-1.8ºC).

Annual rainfall on Kangaroo Island is projected to decline by 2070 and annual maximum and minimum temperatures will increase.

Ocean and Gulf waters

For Ocean and Gulf waters, projections suggest a:

- rise in sea levels of 33cm by 2070 under an intermediate emissions pathway
- rise in sea surface temperatures of 1.2ºC by 2090 under an intermediate emissions pathway
- decline of 0.15 pH units by 2090 under an intermediate emissions pathway.

Under a high emissions pathway these changes could be much greater, for example, with sea levels reaching 0.6 m by the end of the century.

Ocean and gulf waters will increase in temperature, pH will decline and sea levels will rise.

Ocean and gulf waters will increase in temperature, pH will decline and sea levels will rise.

Photo: Courtesy of DEWNR

HOW HAS THIS PLAN BEEN DEVELOPED?

Approach

This Adaptation Plan was developed in two main phases and has involved the active participation of the region's project partners as well as key stakeholders and subject matter experts in order to provide a strong foundation for adaptation (Figure 2).

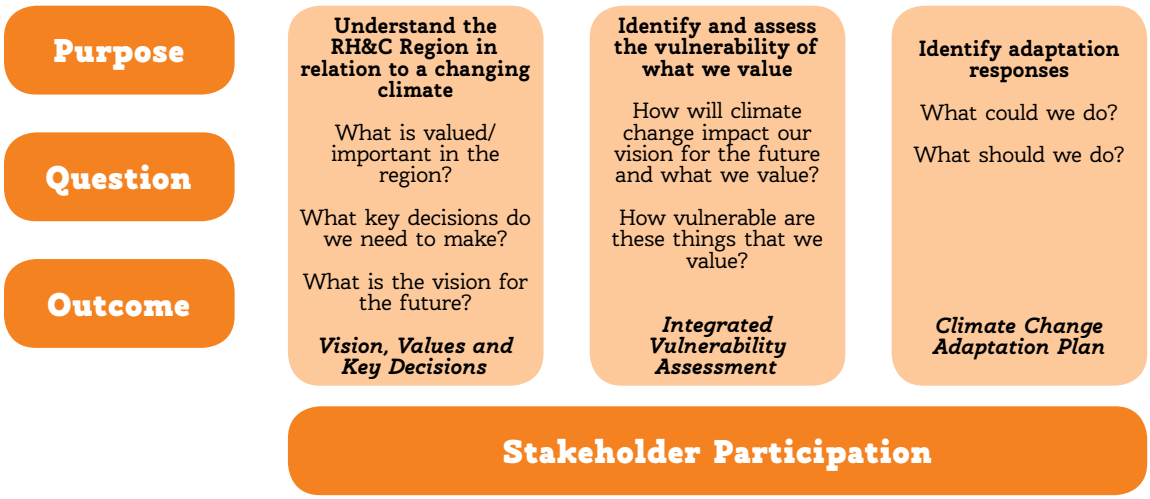


Figure 2. Overview of key steps undertaken to develop the RH&C Adaptation Plan.

As a collective, project partners, with input from community, business, government, industry and academia, completed the initial phase of the RH&C project in 2014, which included three main steps:

- a "Knowledge Audit" describing the profile of the whole region (Resilient Hills and Coasts, 2014a)
- values mapping workshops for the Adelaide Hills and Fleurieu Peninsula sub-region to assess stakeholder issues and values in relation to climate change adaptation (note that the Kangaroo Island sub-region conducted independent values mapping, the results of which were considered in the following phase of the project)
- an integrated vulnerability assessment for Kangaroo Island sub-region (Resilient Hills and Coasts, 2014b).

The second phase involved:

- preparation of an up-to-date climate change projections report for the whole region (Resilient Hills and Coasts, 2015)
- an integrated vulnerability assessment for the Adelaide Hills and Fleurieu Peninsula (Resilient Hills and Coasts, 2016)
- a process to identify and prioritise adaptation options for each sub-region and the region as a whole.

Because of the geographic spread of the region and different project partner planning processes, the initial values mapping and integrated vulnerability assessment phases were conducted at separate times. In contrast, the process to identify and prioritise adaptation options was delivered at the same time, through a series of workshops conducted in Victor Harbor, Stirling and Kingscote in February 2016.

For the purposes of this Regional Adaptation Plan, specific elements relating to barrages located at the mouth of the River Murray are not considered as they are covered in the Regional Adaptation Plan for the South Australian Murray-Darling Basin (Siebentritt, *et al.*, 2014).

The project has incorporated a series of workshops involving representatives of organisations that play a role in the region's:

- assets and infrastructure
- emergency management
- local economic development and sustainability
- natural environment, open space and water
- social and community resilience and health.

Attachment A lists stakeholders who attended either workshops or focus groups during the preparation of the Adaptation Plan.

Photo: Courtesy of District Council of Yankalilla

Identifying priorities for adaptation planning

Values mapping and visioning exercises conducted separately in the Adelaide Hills and Fleurieu Peninsula and on Kangaroo Island identified those values that were important to stakeholders in the region in the context of projected climate change impacts. The focus of values and key issues for the Adelaide Hills and Fleurieu Peninsula were:

- agriculture and food security
- population growth
- water availability and quality
- community health, connectedness and emergency services
- coastal habitats and infrastructure
- ecosystem services, urban biodiversity and green infrastructure.

Key values to emerge for Kangaroo Island were:

- resilient environment
- healthy happy community
- innovative sustainable local community
- collective local leadership and use of local knowledge
- prosperity
- education and learning
- distinctiveness.

Using the values and key issues identified for each sub-region to select indicators, two integrated vulnerability assessments were undertaken consistent with the approach described in the Local Government Association of South Australia's *Guidelines for Developing a Climate Change Adaptation Plan and Integrated Climate Change Vulnerability Assessment*. Together, the integrated vulnerability assessments assessed a total of 108 indicators (54 for Kangaroo Island and 53 for the Adelaide Hills and Fleurieu Peninsula). A subset of indicators was identified as having a higher vulnerability to climate change than others. These high vulnerability indicators and their relevant themes are described in Attachment B. Note that some indicators, such

Photo: Courtesy of Natural Resources Adelaide & Mt Lofty Ranges

as water availability, were important across multiple sectors in the region and so were considered as part of all assessments, rather than considered independently. Based on the results of the integrated vulnerability assessment together with consideration of emerging opportunities, key areas of decision making were developed as the basis for further adaptation planning.

Key areas of decision making describe:

- important priorities for a region, making a connection between something of value or importance to stakeholders such as an asset or service
- potential climate change impacts on the important priorities
- possible responses.

The key areas of decision making that are the focus of this Adaptation Plan are presented in Table 2. Note that while ten key areas of decision-making are presented for Kangaroo Island in Table 2, the four NRM-related key areas of decision making are not considered further in this Adaptation Plan but will rather be addressed through the implementation of the 'climate change ready' Kangaroo Island NRM Plan 2017-2027. In addition, the remaining six key areas of decision making for Kangaroo Island are consolidated in to four for the purposes of further discussion in this Adaptation Plan, reflecting consolidation that occurred at the stakeholder workshop.

Adaptation options for each key area of decision making were identified by the project team and then reviewed and refined by key stakeholders and subject matter experts at a series of project workshops. The full list of adaptation options identified during the project is presented in Attachment C.

To assist with prioritisation, workshop participants were asked to conduct a qualitative cost-benefit analysis on proposed adaptation options. Further prioritisation was then conducted by the project steering committee using an action prioritisation framework to assist with identifying regional adaptation priorities. The framework applied a three-step filtering process based on the results of the costs-benefit analysis, assessment of the regional relevance of an option (relevance to multiple key areas of decision making and multiple project partners), and practicality (availability of funding and project partner role in delivery).

In addition to option prioritisation, this project used an applied adaptation pathways approach to determine the potential implementation sequencing of adaptation options. Further information about the adaptation pathways approach and a legend for interpreting the pathways maps is provided in Attachment D.

Table 2.
Key areas of decision making for the Resilient Hills and Coasts region. Pairs of Kangaroo Island themes and key areas of decision making boxed in bold indicate those that are considered together for the remainder of the report.

Theme	Projected Change by 2070
Adelaide Hills and Fleurieu Peninsula	
Agriculture	How do we maintain agricultural productivity and water security, especially for horticulture, viticulture and dryland grazing, given projected declining rainfall and increasing temperature?
Climate-ready homes and buildings	How do we improve the quality and efficiency of homes and buildings as the risk of extreme events such as fire, extreme heat and flooding as a consequence of rainfall intensity and sea level rise increases?
Coastal ecosystems	How do we maintain the condition and extent of sedimentary coastal ecosystems given projected increases in sea levels?
Community facilities and open space	How do we maintain and expand community facilities and open space areas for sport and recreation to meet a growing community's demands given projected declines in rainfall and increasing temperature and fire risk coupled with increasing population and development?
Emergency management	How do we respond to the growing demand for emergency management services across multiple sectors as the risk of extreme events such as fire, extreme heat and flooding (as a consequence of rainfall intensity and sea level rise) increases?
Infrastructure assets	How do we maintain and expand infrastructure assets, such as roads and energy networks, given projected declines in rainfall and increasing temperature and fire risk?
Landscape conservation	How do we maintain and improve the condition of natural landscapes (plains, flanks, uplands) given projected declines in rainfall and increasing temperature and fire risk?
Built coastal assets	How do we maintain the condition of public coastal assets given projected increases in sea levels?
Vulnerable members of the community	How do we enhance the health, safety and well-being of vulnerable members of the community as the risk of extreme events such as fire, extreme heat and flooding (as a consequence of rainfall intensity and sea level rise) increases?
Water-dependent ecosystems	How do we protect water-dependent ecosystems given projected declining rainfall and increasing temperature and fire risk?
Kangaroo Island	
Agricultural productivity	How do we maintain levels of crop, horticulture, and wool production, given projections of declining rainfall and higher average temperatures?
Built coastal assets	How can built assets along the coast be managed in the face of sea level rise and coastal inundation?
Condition of sealed and unsealed roads	How can the condition of sealed and unsealed roads be managed in the face of altered climate conditions such as increasing rainfall intensity and sea level rise, as well as increasing use?
Essential services and infrastructure	How can the condition and performance of energy and telecommunications networks be improved given the expected increasing frequency and intensity of extreme climatic events such as heatwaves and bushfires?
Health and well-being of vulnerable members of the community	How can we maintain the well-being of vulnerable members of the community given the increasing risk of extreme conditions such as heatwaves and bushfires?
Protecting against bushfire threat (emergency management)	How can we better protect natural environments, farming assets and built infrastructure against more frequent and intense bushfires, particularly given the limited residential volunteer pool coupled with geographic isolation from the mainland?
Wild-catch fisheries production	How can levels of production in wild-catch fisheries be maintained given changing oceanic conditions?
Biosecurity	How can the Island manage the impacts of pest and plant animal threats?
Terrestrial ecosystems	How can the current diversity of vegetation communities be maintained, particularly those providing important habitats and resources for threatened species (e.g. forest communities)?
Aquatic ecosystems	How can suitable habitats be maintained for aquatic dependent species (e.g. frogs and freshwater fishes) given future predicted drier and hotter conditions that will influence the availability of high quality fresh surface water?

Photo: Courtesy of Alexandrina Council

PART B | Adelaide Hills and Fleurieu Peninsula

PRIORITY ADAPTATION OPTIONS

Agriculture

Key area of decision-making

How do we maintain agricultural productivity and water security, especially for horticulture, viticulture and dryland grazing, given declining rainfall and increasing temperature?

The Adelaide Hills and Fleurieu Peninsula supports a strong and diverse agriculture sector. Major produce from the region includes (Resilient Hills and Coasts, 2014a):

- livestock farming to produce meat and fibre
- fresh food such as fruit (e.g. apples, pears, cherries, berries), vegetables (e.g. brassicas) and broad-acre crops (e.g. wheat, barley)
- wine, such as cool climate wines from the Adelaide Hills.

Climate change impacts

The Integrated Vulnerability Assessment (Resilient Hills and Coasts, 2016) and the assessment for key agricultural industries in the Adelaide and Mount Lofty Ranges Natural Resource Management Region (Thomas *et al.* 2016), found that the productivity of agriculture was found to be highly susceptible

Photo: Courtesy of Alexandrina Council

to projected declines in winter and spring rainfall together with increases in extreme heat and evaporation. Declining rainfall will impact the availability and quality of ground- and surface-water as well as productivity of pastures and the need to irrigate permanent crops (e.g. apples and vineyards). Extreme heat will influence the ripening time of crops and could cause negative physiological responses in stock, such as reduced growth and increased trauma.

The response to climate change in the Adelaide Hills and Fleurieu Peninsula is also occurring at a time when the population in the region continues to grow and the proportion of small acreage or hobby farmers continues to rise.

Priority adaptation options

The Adelaide Hills and Fleurieu Peninsula have built significant adaptive capacity in its agricultural industries in response to periodic drought, with growers adopting land management practices that enable them to farm during extended periods of reduced rainfall.

An immediate priority option is to continue to **improve seasonal forecasting** relating to rainfall and temperature which will provide growers with the ability to make better decisions on farms, such as when to trade stock or determining how to manage projected water demand over a coming irrigation season. This option should be led by the Bureau of Meteorology and can build on an existing suite of forecasting tools that have been developed, such as three-month rainfall and temperature forecasts, and soil moisture and evaporation models. The improvement of seasonal forecasting should continue to occur into the foreseeable future in order to ensure the most up-to-date scientific information is being captured (Figure 3).

Another immediate priority option is to **disseminate information to build the capacity of primary producers** so that they have the skills and understanding needed to implement adaptive land and water management techniques. This can be achieved by working with existing farming groups, economic development organisations and industry associations such as the Apple and Pear Growers Association of South Australia, South Australian Dairy Farmers Association, Livestock SA, Adelaide Hills Wine and rural land management groups. Communications exercises will need to be conscious of the change in farm types, with the trend towards an increasing number of smaller acreages being managed by people with less extensive farming experience. The dissemination of information and capacity building should be ongoing into the foreseeable future in order to ensure the most up-to-date knowledge and scientific information is communicated and applied at the local scale of action and management (Figure 3).

It is expected that within ten years, farming in the region will need to further **diversify agricultural activities** and adopt "adaptive processes". This will involve looking to other regions locally and globally, that already have a similar climate to that predicted for the Adelaide Hills and Fleurieu Peninsula and identify useful management practices, or different crop varieties or animal breeds that may be appropriate, noting the need to more closely manage greenhouse gas emissions from livestock. In this regard, the region is at an advantage compared with other parts of South Australia because it is likely to experience conditions that already occur elsewhere. Once implemented, investigating diversification options and learning from other locations should continue into the foreseeable future (Figure 3).

Triggers

The speed at which new adaptation practices are adopted will be influenced by a range of triggers. From a climate perspective, an increase in the frequency and intensity of droughts, fires and other extreme events will be important which in turn will influence the cost of farming (e.g. by driving up input costs such as insurance) and the viability of some production systems in the region. The introduction of new technologies will also drive changing farm management practices although it is likely this will be as a response to opportunities to better manage farm costs or increase productivity, with adaptation being an indirect benefit. Additional triggers could include marketing opportunities, generational change and insurance related risks.

Enablers and barriers to adaptation

Agricultural adaptation options need to demonstrate alignment with stakeholder values relating to lifestyle and agricultural productivity, without which the uptake of options is likely to be low. Broad-scale uptake of options is likely to be facilitated through existing networks, with a subset of stakeholders acting as leaders and champions of new approaches and actions.

As is often the case in long-standing businesses involving social and generational gaps, there is likely to be a degree of resistance to change, even if champions are able to demonstrate promotion of lifestyle and agricultural productivity. Addressing a number of key barriers will be critical in facilitating the uptake of options across the Adelaide Hills and Fleurieu Peninsula. Key barriers include:

- the need to demonstrate the cost-benefit of options (e.g. sustainability versus profit)
- overcoming previous bad experiences with new knowledge and clearly communicating and interpreting complex information for relevance at the scale of on-ground application
- addressing low levels of understanding in some government agencies of on-ground issues
- addressing conflicting or inappropriate financial and budgeting strategies and legislation.

Key points

Adaptation for agriculture requires greater sharing of information with farmers on adaptive land and water management techniques, improved seasonal forecasting, and diversification of agricultural activities.

Adaptation Pathway

Adaptation options

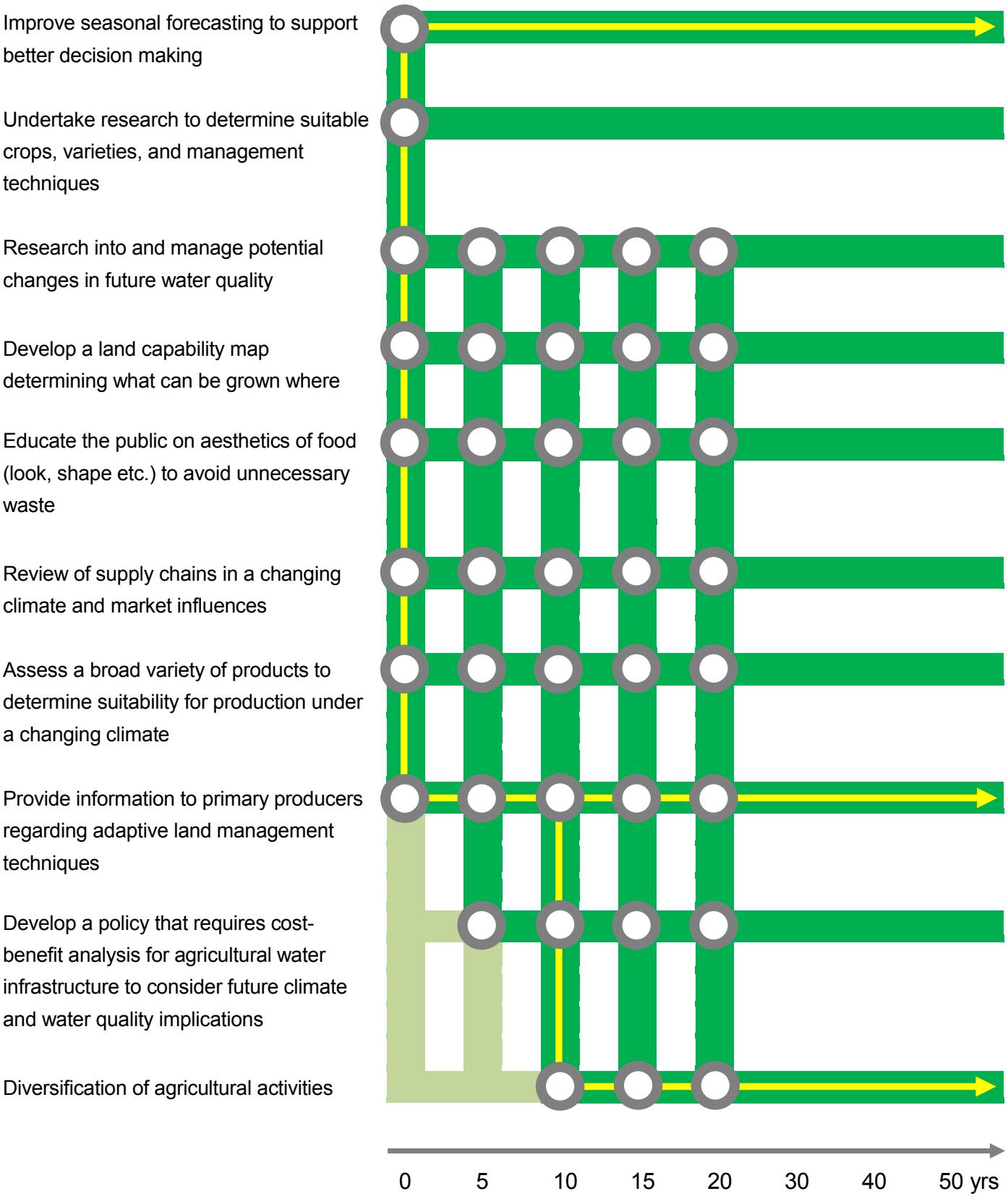


Figure 3. Adaptation pathway for agriculture in the Adelaide Hills and Fleurieu Peninsula.
Refer Attachment D for legend and explanation of adaptation pathways.

Photo: Courtesy of City of Victor Harbor

Climate-ready homes and buildings

The Adelaide Hills and Fleurieu Peninsula is highly valued as a place to live and work. Residential housing within the region's urban areas varies in age and condition, however, significant numbers of new homes are being constructed in response to growing populations in towns such as Goolwa, Mt Barker and Victor Harbor. The region contains a broad array of non-residential private and public buildings including four public hospitals, one private hospital, two TAFE SA campuses (Victor Harbor, Mount Barker), as well as a large number of childcare centres, preschools and schools.

State and local heritage buildings also occur in the region and are particularly valued by both locals and tourists (e.g. Steam Ranger Heritage Railway).

Potential impacts of climate change

Based on the Integrated Vulnerability Assessment (Resilient Hills and Coasts, 2016), homes and buildings will be susceptible to increasing extreme events such as extreme heat, bushfires, and flooding, all of which can result in direct physical damage to infrastructure.

The addition of new housing in the region presents an opportunity to build climate-ready housing, more suited to a future climate that is warmer and drier. Not only can these buildings be better designed to cope with changing climatic conditions and frequency of extreme events, but they can also provide improved living conditions for residents, and decrease energy use. The region already has examples of sustainable developments e.g. "Beyond" at Hayborough.

Priority adaptation options

A raft of options has been identified that collectively will increase the number of climate resilient homes and buildings in the region, either as a consequence of improved design of new buildings or retrofitting of existing buildings. An **agreed minimum standard and definition for climate-ready buildings** is required (Figure 4). If commenced now, it is anticipated that this task should be completed within ten to fifteen years. Once established, these standards can form the basis of **encouraging cultural change in the development industry** (Figure 4), which will require engagement with builders, insurers and the finance sector (among others). This can be led by local government but will require support from State government agencies and industry associations.

Preparation and implementation of guidelines on how to encourage greater use of climate-ready building techniques, can be used to raise awareness about the benefits of climate-resilient buildings, especially to the community and building industry. The preparation of guidelines is anticipated to occur over the next five years with implementation ongoing (Figure 4).

A past barrier to greater adoption of climate resilient housing has been concerns about additional short-term costs when compared to traditional building practices, despite the reduced long-term operational costs of more energy efficient buildings. In response to this barrier, within five to ten years, adaptation will require **development of more affordable energy-efficient building materials and fixtures and incentives for increased construction of climate-ready buildings.** Local government can provide an advocacy role implementing these options, working with State government agencies and industry associations. Both of these options should be continued into the foreseeable future in order to ensure new technologies are captured and construction of suitable buildings continue (Figure 4).

Additional options identified for the region but that are considered to have too high a cost at present include housing replacement (for buildings that are not "climate-ready") and mandating building requirements in some new residential developments (minimum requirements). The latter requires further support by the development industry and so in the interim the focus needs to be on educating new house builders about lifetime versus up-front costs. While not high priorities at present, both options may require further consideration in the future as the impacts of climate change are experienced in the region.

Triggers

A wide range of triggers exist that could lead to greater implementation of options to create more climate resilient housing and buildings. The most important triggers are considered to be:

- lack of continuity of electricity supply (meaning that household appliances such as air-conditioning are not able to be used)

Photo: Courtesy of City of Victor Harbor

- increasing electricity and insurance costs
- increased State government leadership for climate-ready housing.

Other triggers could include:

- increasing frequency and intensity of heatwaves
- experiencing drought or heavy rain events
- changes in the cost benefit analysis between retrofitting and rebuilding homes
- property sales and land divisions
- insurance company policies or a major bushfire increasing the demand for "bushfire ready" housing.

Enablers and barriers to adaptation

Taking actions to maintain the condition and enhance the operation of existing homes and buildings under extreme events will be enabled by increasing community demand for climate-ready buildings. Community buy-in will be further facilitated by greater sharing of existing knowledge about how to create climate-ready buildings.

Key barriers to creating climate-ready buildings centre on budget and governance constraints. Specifically, there is a need to demonstrate the cost-benefit of adaptation, without which the costs can be viewed as being too high. In addition, motivation and willingness at the community level needs to be reflected or promoted at local and State government levels.

Key points

Priority adaptation options for climate-ready homes and buildings are: agree to a minimum standard and definition for climate-ready buildings; encourage cultural change in the development industry; amend development plans to include minimum building requirements; prepare guidelines on how to encourage greater use of climate-ready building techniques; and raise awareness about the benefits of climate-resilient buildings. Within five to ten years adaptation will require incentives for increased construction of "climate-ready" buildings and development of more affordable energy-efficient building materials.

Adaptation Pathway

Adaptation options

Agree to a minimum standard that defines climate-ready buildings

Encourage cultural change in building, development and finance industries

Prepare and implement guidelines on climate-ready building techniques

Amend the development plan to require region-wide climate-ready housing initiatives

Raise awareness about the benefits of climate-resilient buildings (especially to building industry and community)

Better integrate building standards and planning regulations

Mandate building requirements in some new residential developments

Encourage affordable energy efficient building materials and fixtures through Government incentives

Provide incentives for increased construction of “climate-ready” buildings (community uptake)

Consider replacement of old houses that are not climate-ready

Relocate existing infrastructure and housing

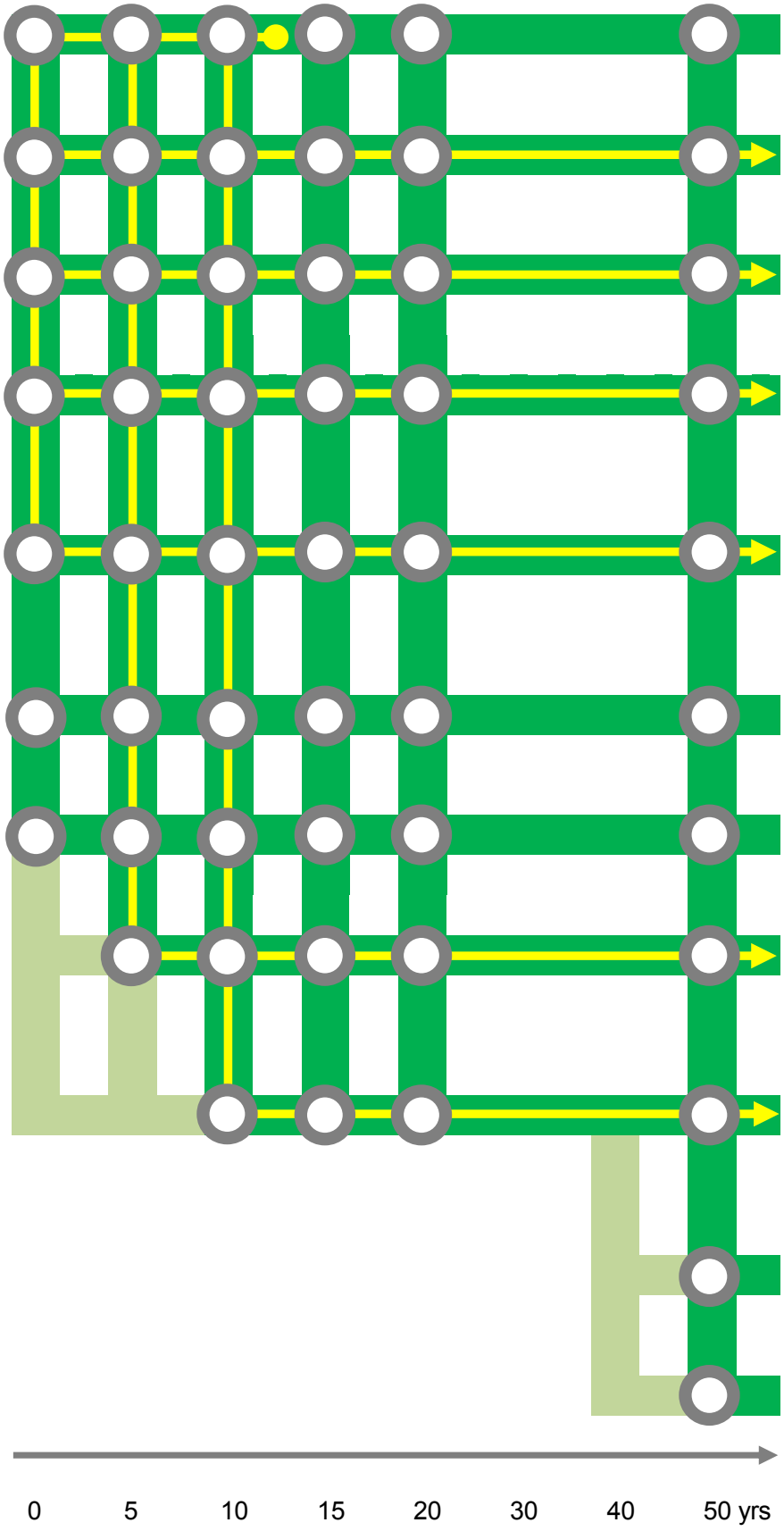


Figure 4. Adaptation pathway for climate-ready homes in the Adelaide Hills and Fleurieu Peninsula. Refer Attachment D for legend and explanation of adaptation pathways.

Coastal ecosystems

Key area of decision-making

How do we maintain the condition and extent of sedimentary coastal ecosystems given projected increases in sea levels?

The region's extensive coastline is characterised by a mix of low and high energy coastal ecosystems (i.e. samphire and estuaries), beach-dune ecosystems, and coastal cliff ecosystems (including softer calcareous and harder lithology cliffs) (West, 2016). The coastline's near-shore marine environment supports both seagrass and reef ecosystems and a range of substrates. Such coastal systems are valued in the region for supporting a diversity of flora and fauna species, as well as a range of recreational and commercial activities.

Climate change impacts

Based on the Integrated Vulnerability Assessment (Resilient Hills and Coasts, 2016), coastal ecosystems will be most influenced by increasing sea levels, increasing rainfall intensity (causing localised run-off), and increasing ocean acidity.

Soft coastal ecosystems like beaches have high exposure to climate change due to low topographic variability, high realised sensitivity and little or no adaptive capacity because of barriers that impede coastal (landward) migration, especially in close proximity to townships.

Priority adaptation options

Soft coastal ecosystems like beaches require transformational adaptation to pre-empt their likely loss under sea level rise. Enacting such transformational adaptation can be aided by: **(a) amending planning regulations and the *Coast Protection Act 1972*** to ensure that development approval processes adequately reflect projected sea level increases climate change impacts; and **(b) revising development plans to establish improved zoning for sensitive coastal features and to allow for future inland migration** of ecosystems, saltmarshes, dunes and coastal wetlands.

Both options require some initial lead time preparation and planning before implementation can commence, after which they should be continued into the foreseeable future (Figure 5).

While options are being pursued that will allow for future migration of coastal ecosystems, **restoring and enhancing coastal dunes** is an immediate adaptation priority (Figure 5). This involves continuing the work of existing organisations and community groups, including Natural Resources Adelaide and Mount Lofty Ranges, and the Goolwa to Wellington Local Action Planning group. This action should also be continued into the foreseeable future (Figure 5).

Restoration and enhancement of dunes can be aided in some locations by improving the quality and reducing the quantity of stormwater discharges from urban areas which cause localised erosion at discharge points to the ocean and cause sedimentation and deliver nutrients to near-shore marine ecosystems. This can be achieved through water sensitive urban design and increasing stormwater retention areas.

Triggers

Triggers for greater implementation of adaptation options in the coastal zone are likely to include:

- major storm surge-induced flooding events resulting in damage to dune systems, cliff erosion, major infrastructure damage and sewer backups
- court decisions resulting from damage by storm or sea level rise events
- threats to private property
- changing composition of marine species
- reduced accessibility to beaches because of high sea levels or damaged beach infrastructure.

To determine the timing of such events, monitoring and modelling of the retreat of sand dunes in response to sea level rise needs to be improved.

Enablers and barriers to adaptation

Adaptation of coastal ecosystems will be greatly facilitated by the high value that people place on the coastal zone – even if these human values are not directly related to the ecosystem values they will still have beneficial implications. For example, people value being able to readily access clean, sandy beaches.

Photo: Courtesy of Alexandrina Council

It is also true that community values over time may change in response to evolving climate change impacts.

Although such community-held human values may directly or indirectly facilitate adaptation of coastal ecosystems, they may also present a barrier if there is considered to be little recognition of the role that ecosystems play.

For example, without a clear understanding of the importance of coastal ecosystems, people may operate under a strong entitlement mindset, and advocate access and use of coastal areas unimpeded by environmental rules and regulations. Additional barriers to protecting coastal ecosystems are likely to be the cost of enabling inland migration, especially where this would require relocation of existing infrastructure , and uncoordinated hard coastal defences installed by individuals to protect private property.

Key points

Transformational adaptation is required to pre-empt the likely loss of soft coastal ecosystems. This can be aided by revising development plans to improve zoning for sensitive coastal features and allow for future inland migration of these ecosystems. Whilst options are being pursued that allow for migration of coastal ecosystems, restoring and enhancing coastal dunes is a high adaptation priority.

Adaptation Pathway

Adaptation options

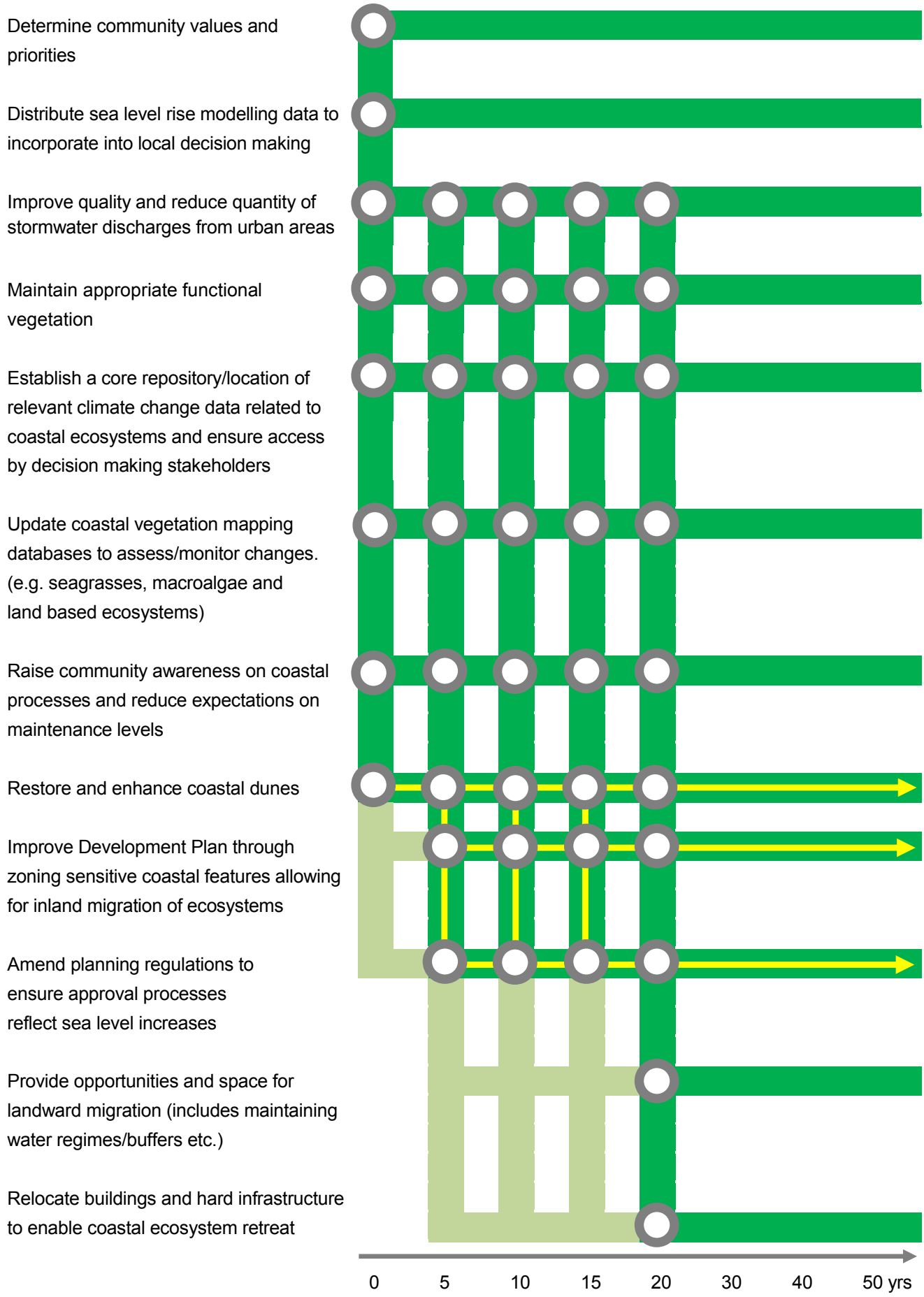


Figure 5. Adaptation pathway for coastal ecosystems on the Fleurieu Peninsula.
Refer Attachment D for legend and explanation of adaptation pathways.

Community facilities and open space areas

Key area of decision-making

How do we maintain and expand community facilities and open space areas for sport and recreation to meet a growing community's demands given projected declines in rainfall and increasing temperature and fire risk coupled with increasing population and development?

Community facilities and open space areas are valued for their role in supporting community health, wellbeing and connectedness by providing opportunities for formal and informal recreation, health and fitness, social interaction, relaxation, and children's play and development. A large number of open space areas and community facilities occur within the region including: formal parks, playgrounds and reserves sporting clubs and infrastructure (e.g. tennis and netball courts, soccer and hockey fields, equestrian facilities, lawn bowls greens and cricket ovals) recreation tracks and trails libraries, child care centres, and emergency services buildings community centres and meeting halls (for community programs such as scouts, guides, and Returned Service League) (URPS, 2014).

Climate change impacts

Based on the Integrated Vulnerability Assessment (Resilient Hills and Coasts, 2016), community facilities and open space areas will be influenced most by projected changes in:

- altered rainfall patterns (i.e. amount and intensity), which will influence turf maintenance (e.g. water availability for irrigation of ovals)
- increasing extreme heat, which will influence participation rates in outdoor sporting and recreation activities
- bushfire risk, which could lead to cancellation of events but also direct damage to buildings and other infrastructure
- rising sea levels which could damage low lying areas of vegetated open space and community facilities (e.g. life-saving clubs, bowling clubs, foreshores).

Priority adaptation options

Adapting community facilities and open space in the Adelaide Hills and Fleurieu Peninsula requires a combination of policy, awareness raising and on-ground activities (Figure 6).

Underpinning all adaptation is the immediate need for **education and awareness** raising about the impacts of climate change and potential response options, with such education and awareness being an ongoing requirement (Figure 6). A particular focus in the Adelaide Hills and Fleurieu Peninsula will be initiatives to support activity centres, small to medium sized enterprises and business groups to better understand risks and how to prepare, respond and recover from extreme event related emergencies.

Another immediate priority will be **preparing 'climate-ready' guidelines regarding public realm and streetscape management**. These will outline appropriate material and tree species selection, shade cover, methods for inclusion of water sensitive urban design features in community facilities and open space, and opportunities for misting infrastructure. While this can be addressed at an individual local council scale, it also lends itself to a regionally collaborative approach. The preparation of such guidelines, if commenced now, is anticipated to occur over the next five years, after which ongoing revision and updating of the guidelines should be undertaken as necessary (Figure 6).

A direct and tangible outcome of preparing 'climate-ready' guidelines will be measures to **enhance the 'greenness' of retail and commercial centres**, which should be implemented on ground wherever possible. This will be especially pertinent along main streets and in car parking areas in order to help reduce the urban heat island effect which will be exacerbated by climate change-driven temperature increases. Being able to minimise temperatures in urban centres will have substantial public health benefits and provide for more desirable shopping precincts, leading to enhanced local economic prosperity.

The implementation of actions that enhance urban greenness should be ongoing (Figure 6).

Within ten years, a major policy response will be to implement **development plan amendments** that: (a) restrict development in areas at high risk from climate hazards such as sea level rise and bushfire (b) require climate sensitive building design (Figure 6). This will reduce the future risk of infrastructure damage in hazard prone areas and ensure that community members are not at high risk when using community facilities and open space.

Triggers

Triggers for implementing additional adaptation options for recreational and sporting clubs are likely to include changing financial viability of clubs (e.g. lack of volunteers causing increased operational costs) and when maintenance costs become unviable. Community, economic triggers could include decline in commercial activity in towns and population shifts leading to lower participation rates.

Enablers and barriers to adaptation

The importance of community facilities and open spaces for providing desirable lifestyle attributes, particularly for young and active people, is well understood. This means that a high social value is often placed on such facilities and spaces, which will greatly facilitate a proactive approach to implementation of adaptation options.

Despite this, it is anticipated that community engagement around adaptation options will still be important, especially amongst aging and retirement populations who may place a lower value on open space areas.

Photo: Courtesy of Alexandrina Council

Key points

Adaptation of community facilities and open space areas requires development plan amendments that restrict development in hazard prone areas and require climate sensitive building design. Climate-ready guidelines will provide broad direction regarding public realm and streetscape management, which in-turn will guide enhancing the 'greenness' of retail and commercial centres. Underpinning adaptation of community facilities will be education and awareness raising.

Adaptation Pathway

Adaptation options

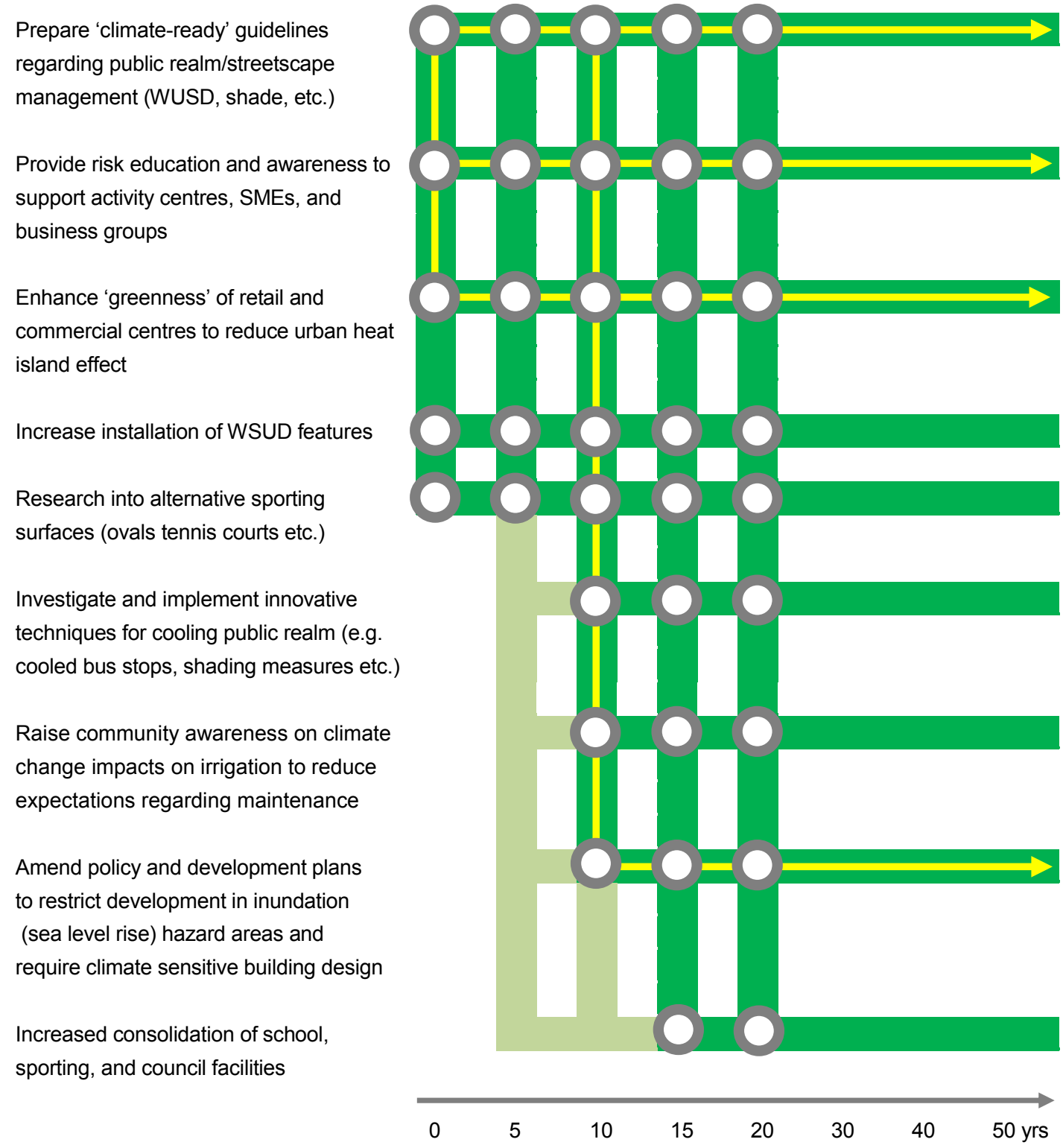


Figure 6. Adaptation pathway for community facilities and open space areas in the Adelaide Hills and Fleurieu Peninsula. Refer Attachment D for legend and explanation of adaptation pathways.

Emergency management

Key area of decision-making

How do we respond to the growing demand for emergency management services across multiple sectors as the risk of extreme events such as fire, extreme heat and flooding (as a consequence of rainfall intensity and sea level rise) increases?

Emergency management services are highly valued across the region for their role in emergency prevention, preparation, response and recovery. Emergencies can threaten the health and safety of residents, affect the condition of buildings and infrastructure, as well as farm plantings and stock. Emergency services are provided by SA Police, the Metropolitan Fire Service, Country Fire Service, SA Ambulance Service, State Emergency Service, and Surf Lifesaving Clubs. Volunteers also play a vital role in helping to deliver emergency management services in the region.

Potential impacts of climate change

Based on the Integrated Vulnerability Assessment (Resilient Hills and Coasts, 2016), changes to the region's climate will affect the frequency and severity of emergencies. Bushfires, extreme heat events and storms in particular will increase the demand for emergency management services. As well as their direct impact on property and infrastructure, they can also impact the ability for critical emergency services to function adequately, for example, through delayed response times due to communication network damage or access routes being limited (e.g. damaged or blocked). Bushfire is likely to be particularly important in the Adelaide Hills and Fleurieu Peninsula.

Priority adaptation options

An immediate adaptation focus for emergency services management is to **improve early warning systems for flood and fire**. This will require work with the Bureau of Meteorology and potentially the development of mobile phone apps that advise of emerging high risk conditions. This option has already been initiated by emergency services providers, and it is expected that work on early warning systems should be complete within ten years (Figure 7).

Adaptation also requires work to assist the community and businesses to better prepare for extreme events, especially fire. The first part of this strategy will involve **community education (prior to an event)** involving the CFS and local government. This should use an "all hazards" approach and include welcome packs for new residents. The action should continue into the foreseeable future (Figure 7). Community education can also be improved through working with organisations such as the Insurance Council of Australia regarding **community messaging around risk and insurance**. As insurance policies and communities change, this option should be continued into the foreseeable future (Figure 7).

A second key element of preparation is **greater enforcement of Section 105F notices** under the *Fire & Emergency Services Act 2005*, which requires landowners to take action to protect property on their land from fire, or to prevent or inhibit the outbreak of fire on their land, or the spread of fire through their land. Although requiring implementation now, this action should also be continued into the foreseeable future (Figure 7). Future adaptation options could include advocating for legislative change to the *Fire and Emergency Services Act* to reduce timeframes for 'action in default' of Section 105F, although this is expected to not be required for at least several decades to come.

Triggers

Key triggers for implementation of emergency management adaptation options will be improved knowledge of risk to vulnerable persons as well as major emergencies that result in fatalities, serious injury or asset damage. Other triggers could include

- an increase in demand for emergency services because of more frequent and intense climate hazards
- lack of access to emergency management services volunteers
- negative media to the response to extreme events
- failure to reduce risks through existing fire prevention measures (e.g. Section 105F notices)
- increasing insurance costs and declining visitor numbers due to safety concerns.

Photo: Courtesy of City of Victor Harbor

Enablers and barriers to adaptation

Adaptation in the emergency services sector will be informed by drawing on the experience of other regions and their solutions (e.g. use of plantings and infrastructure to reduce flood risk), education about the value of emergency management services, continued collaborative work between emergency management services and councils, and improved and evolving communications and modelling technologies.

A key barrier to adaptation is the "she'll be right", "it won't happen to me", and "I can handle it" attitude of some people who tend to focus on what are perceived as more imminent priorities unless extreme events are occurring frequently or recently. Effective education and information dissemination (including extreme event warnings) that elicit community action and response is essential.

Limited legislative obligations together with ambiguity in council roles in emergency management may also inhibit the implementation of adaptation options. In addition, implementation will also be hindered by an inability of short-term planning and institutional processes to prioritise funding and resourcing and to consider long-term issues like climate change.

Key points

Adaptation for emergency services management requires a focus on better fire preparation through community education involving the CFS and local government, community messaging around risk and insurance, and greater enforcement of Section 105F notices. To assist with responding during emergencies, greater emphasis is required on improving early warning systems for flood and fire.

Adaptation Pathway

Adaptation options

Figure 7. Adaptation pathway for emergency management in the Adelaide Hills and Fleurieu Peninsula. Refer Attachment D for legend and explanation of adaptation pathways.

Photo: Courtesy of District Council of Yankalilla

Infrastructure assets

Key area of decision-making

How do we maintain and expand infrastructure assets, such as roads, water management and energy networks, given projected declines in rainfall and increasing temperature and fire risk?

The Adelaide Hills and Fleurieu Peninsula supports a wide diversity of infrastructure assets that service major towns and growing urban centres as well as the large areas of farming and public conservation lands. Key infrastructure assets include (URPS, 2014):

- arterial roads managed by State government (e.g. South Eastern Freeway) and local roads managed by local councils
- footpaths, shared paths, street lighting, and traffic safety and control assets
- a railway line between Mount Barker and Victor Harbor (traverses the Mount Barker, Alexandrina and Victor Harbor LGAs), and the Adelaide-Melbourne rail line (traverses Adelaide Hills and Mount Barker LGAs).

The importance of transport networks in growing parts of the region is highlighted by the Adelaide Hills, where approximately 60% of residents work outside the region mainly in metropolitan Adelaide because of proximity to the Adelaide Hills and accessibility via the South Eastern Freeway.

Significant water resource management and treatment infrastructure also occurs in the Adelaide Hills and Fleurieu Peninsula such as (SA Water, 2014 URPS, 2014):

- stormwater pipes, culverts, pits and channels
- a number of council operated waste-water treatment plants/systems

SA Water operated country waste-water treatment plants (Bird-in-Hand, Gumeracha, Hahndorf, Heathfield, Myponga, Victor Harbor)

surface water pipes primarily used for urban and irrigation uses, including two of the State's five major pipelines which bisect the region (Murray Bridge-Onkaparinga and Mannum-Adelaide pipelines)

six reservoirs – four contained entirely within the region (including one on Kangaroo Island) and two partially coinciding with the region.

Climate change impacts

Based on the Integrated Vulnerability Assessment (Resilient Hills and Coasts, 2016), altered rainfall patterns (i.e. amount and intensity), and increasing extreme heat and bushfires are having the greatest influence on the condition and functioning of the region's infrastructure assets. For example, rainfall amount will influence soil heavage and cracking, and rainfall intensity will impact on flooding. Extreme heat will influence how infrastructure is used by the community and fire could cause direct physical damage to major infrastructure.

While the adaptive capacity of some existing infrastructure may be low, local population growth will increase demand for new facilities which presents an opportunity to design them in a way that is better suited to the region's future climate.

Priority adaptation options

Adaptation for infrastructure in the Adelaide Hills and Fleurieu Peninsula requires immediate changes to planning and building requirements for constructing new infrastructure to ensure that they meet agreed energy efficiency and water reuse standards (relates also to Section 1.1 – Climate-ready homes and buildings). Such planning and building requirements will need to be assessed and potentially changed again in the future based on learnings and the availability of new technologies/materials, and so this option should be actively continued into the foreseeable future (Figure 8).

Documented climate risk assessments are required on a project-by-project basis for local government. While initially this may be viewed as an additional activity to existing practices, the aim should be for this to become a business-as-usual practice (Figure 8). A specific extension of this is the need to **identify points of vulnerability in the road network**, such as through

the development of a roads database. This will need to consider future potential climate impacts and potential risks for sealed (expected to be detrimental because of hotter drier conditions causing cracking and deterioration of the road seal) and unsealed (expected to be beneficial because of less rainfall) roads (Figure 8).

Within five years, adaptation should focus on incorporating **greater allowances for increases in extreme events** in infrastructure design **(Figure 8)**. This will be particularly relevant to stormwater management infrastructure, which may need to be larger in size to continue to operate effectively if the frequency and intensity of rainfall increases. An alternative to modifying infrastructure design will be to relocate it in order to reduce exposure to extreme events altogether, which in some towns will lead to the **undergrounding of power lines in high risk areas** (Figure 8). This will not only reduce the risk of fire resulting from high winds causing power lines to contact and spark on vegetation, but will also improve general landscape aesthetics and make it easier to plant trees in urban areas to provide cooling and other benefits (which supports priority options identified in Section 5.4). However, implementation of this option will need to consider the impact of decentralisation of electricity generation, such as through rooftop solar PV, which may influence the extent to which major power lines are required.

While not identified as immediate priorities, potential major future changes for water management infrastructure are also noteworthy. In response to declining rainfall and increasing local population, the Adelaide Hills and Fleurieu Peninsula may need to consider greater use of recycled water, potentially even for mixing with potable supplies. Related to this will be the need to ensure that community wastewater management systems and sewer pump stations close to the coast are not impacted by rising sea levels, which could require their re-location, although this is not expected to be a concern for several decades.

Triggers

Key triggers that will inform decision making for adaptation of infrastructure are likely to include: increasing frequency of intense storm events leading to annual flooding of homes and the public realm, increasing frequency of fires impacting the community and requiring the relocation of infrastructure, and declining rainfall (acting as a trigger to identify new water sources). Other triggers could also include changing costs for water and electricity, and reduced transport access leading to road upgrades or new roads.

Enablers and barriers to adaptation

Despite the community valuing the services provided by infrastructure in the region, it is expected that there will be substantial values-based barriers to adaptation. For example, water is a critical resource, yet negative community perceptions associated with recycled water may greatly inhibit the uptake of water reuse schemes as an adaptation option (noting that these are not likely to be required for at least another decade).

Support for climate adapted infrastructure will be facilitated through engaging the community and providing education on climate change impacts. It will also be important that decision-makers and administrators provide unified support for options. This will be aided by ensuring that climate change impacts and adaptation options are clearly recognised and prioritised in current standard practices, regulations, and policies. Ultimately though, major climatic events may prove to be the key catalyst for changing community perceptions and opinions.

Key points

Adaptation for infrastructure requires changes to planning and building requirements to include energy efficiency and water reuse measures, greater allowance for projected increases in extreme events in infrastructure design and undergrounding of power lines in high risk areas. Documented climate risk assessments will start to become an increasing feature of adaptation for infrastructure (such as identifying points of vulnerability in the road network).

Adaptation Pathway

Adaptation options

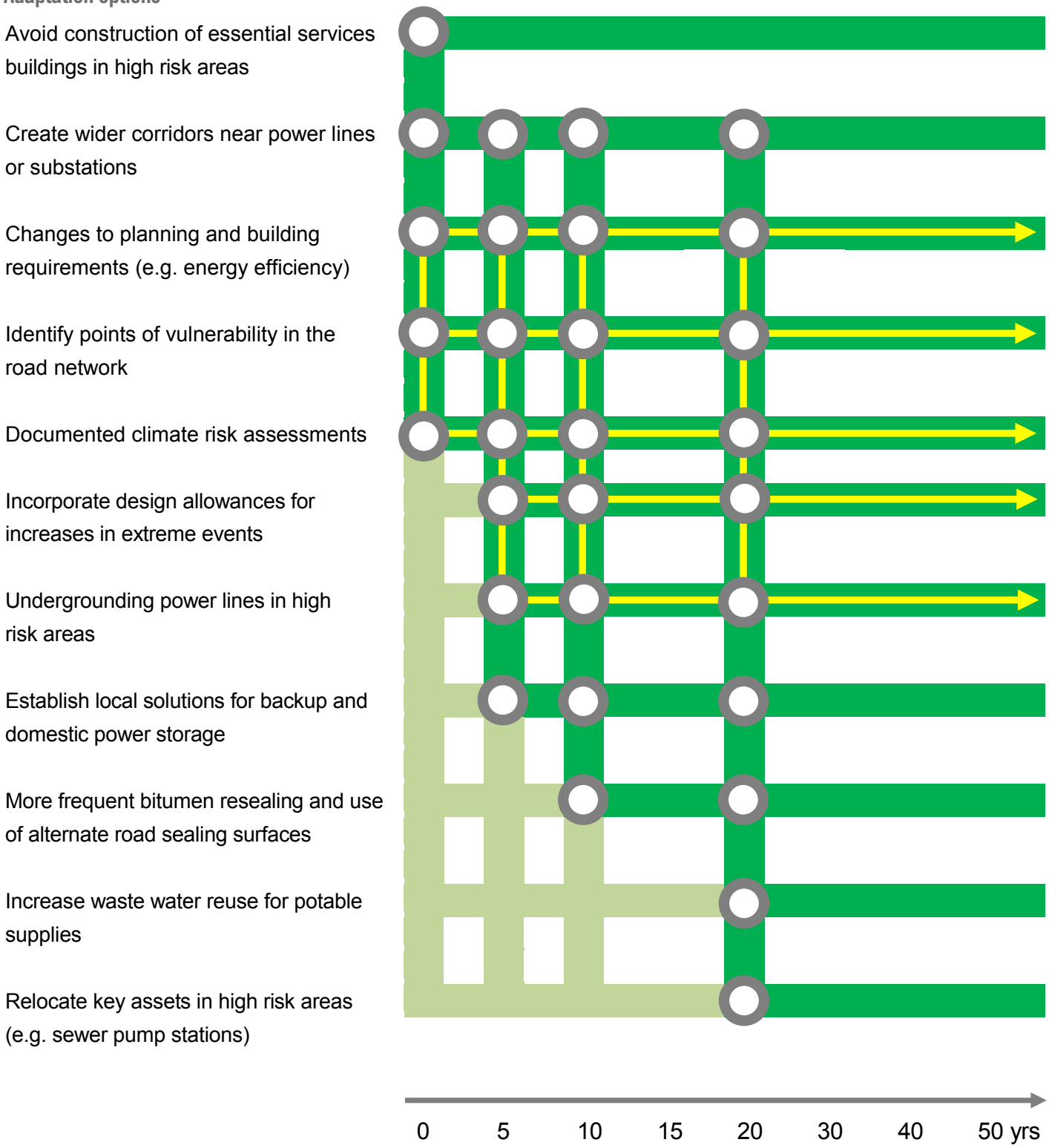


Figure 8. Adaptation pathway for infrastructure assets in the Adelaide Hills and Fleurieu Peninsula.

Photo: Courtesy of Mount Barker District Council

Landscape conservation

Key area of decision-making

How do we maintain the condition of natural landscapes given projected declines in rainfall and increasing temperature and fire risk?

The Adelaide Hills and Fleurieu Peninsula is comprised of highly valued and variable natural landscapes.

In the region these include some of the State's most frequented and well known parks, such as: Cleland Wildlife Park and Morialta Conservation Park in the Adelaide Hills area, Granite Island Recreation Park in the Victor Harbor area, and Deep Creek Conservation Park in the Yankalilla area (Government of South Australia 2014).

Remnant vegetation, together with the range of other natural assets, play a critical role in supporting numerous environmental features of significance at local, State, Federal, and international levels. These include endangered species and ecological communities listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), internationally important migratory bird species; Commonwealth heritage places; natural, indigenous and historic places on the register of the national estate; and numerous state and territory reserves (Resilient Hills and Coasts, 2014a).

Photo: Courtesy of Natural Resources Adelaide & My Lofty Ranges

Climate change impacts
Based on the Integrated Vulnerability Assessment (Resilient Hills and Coasts, 2016), altered rainfall patterns (i.e. amount and intensity), and increasing extreme heat and bushfires are having the greatest influence on the condition of native flora and fauna in the region and therefore landscape conservation.

The impact of climate change will vary between vegetation communities (e.g. grassland, woodland and forest communities) and landscape types (e.g. plains versus higher elevation areas) depending on the extent of past clearance and landscape modification and local topography, which will influence the availability of climate refuges. Potential interactions between climate change impacts and existing threatening processes (e.g. agriculture and urbanisation) will also become increasingly important.

Priority adaptation options
Primary producers in the region will play important roles in enhancing landscape resilience through conservation actions undertaken on private land which will complement similar actions elsewhere in the landscape. For example, the increasing number of smaller acreages being managed by people with less extensive farming experience provides an opportunity, if properly managed, to contribute to resilience through increased diversity and more intensive management.

No regret adaptation options for immediate implementation (see Figure 9) include:

- **protecting existing natural features** by stopping further losses of native vegetation
- **better managing threats** such as pests and diseases
- **managing, restoring and increasing functional landscape connectivity** to support reassembly of flora and fauna
- **identifying, protecting and managing climate refugia** to provide locations in the landscape for native flora and fauna to retreat to as the climate changes
- **restoring natural landscapes by reinstating impaired ecological functions and processes** such as grazing and fire disturbance dynamics
- **encouraging land use changes with positive rather than negative biodiversity outcomes**. This can be supported through recognition of landscape values and adaptation requirements in the development planning system.

All priority actions listed above are recognised as being important for ecosystem health regardless of climate change impacts, but will become especially important for facilitating ecological resilience and long-term persistence of species populations, communities, processes and functions. Accordingly, these options should continue to occur into the foreseeable future, with the exception of the "restoring natural landscapes" option, which is considered to be a useful focal option for implementation over the next 30 years, after which it is anticipated that other options will become more pertinent (Figure 9). Within ten years it is anticipated that there may also be a need to support **transitions in ecological communities**. The planning work for this option needs to commence now.

It should be noted that many of the options identified for landscape conservation are only relevant in some landscapes and under certain projections scenarios and hence further work is required to develop targeted implementation plans. This will be aided by a categorisation of landscapes linked to adaptation options.

Triggers
The main trigger for implementation of adaptation options in the future will be observed declines in existing flora and fauna species or communities or when unexpected changes in populations are observed. The main tool currently used by councils for monitoring such changes is the Bushland Rapid Assessment Technique (Bush RAT).

It is essential that partners in natural landscape management in the region invest in anticipatory monitoring and evaluation to detect climatic change impacts and develop conceptual models of likely change and triggers for different strategies.


Photographer: Nicail Nicol

Enablers and barriers to adaptation

Maintaining natural landscapes, ecological processes and functional native vegetation communities requires more community support and appreciation for the ecosystem services that they provide. This requires a shift from a utilitarian, human use view of the landscape to a greater focus on inherent environmental values. This transition can be assisted by working with environmental champions in the community.

Barriers to maintaining natural landscapes, ecological processes and functional vegetation communities include a lack of understanding of ecosystem services and the seemingly overwhelming magnitude of the management challenge. In addition, misinformation and negative bias against native vegetation in the media generates confusion and scepticism in the community, which in turn creates aversion to change.

Key points

Adaptation of natural landscapes requires protection of existing natural features by stopping further losses of native vegetation; better management of threats such as pests and diseases; managing, restoring and increasing connectivity to support reassembly of flora and fauna; identifying, protecting and managing climate refugia; restoring natural landscapes by reinstating impaired ecological functions and processes; and encouraging land use changes with positive rather than negative biodiversity outcomes.

Adaptation Pathway

Adaptation options

Protect existing natural features

Better manage threats (e.g. fire, pests and diseases)

Manage, restore, and increase connectivity to support migration and range shifts of flora and fauna

Identify, protect and manage climate refugia

Encourage land use changes with positive rather than negative biodiversity outcomes

Restore natural landscapes by reinstating impaired ecological functions and processes

Continue to include 'local species' in plantings as some may adapt

Identify, measure and monitor ecosystem services and value natural capital

Investigate the use of non-local native species which may be more resilient to changing climatic conditions

Consider and prepare for potential transitions in ecological communities

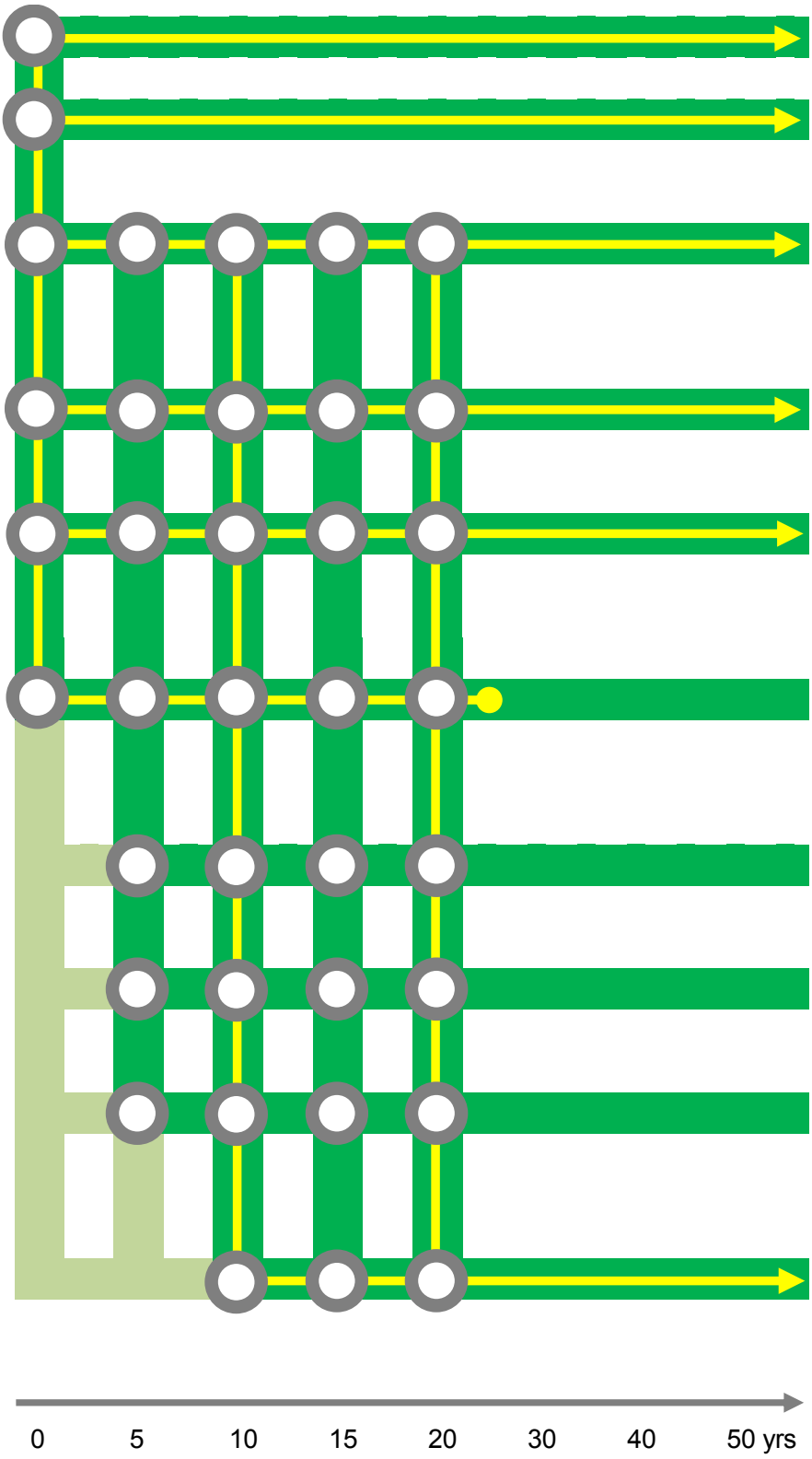


Figure 9. Adaptation pathway for natural landscapes in the Adelaide Hills and Fleurieu Peninsula. Refer Attachment D for legend and explanation of adaptation pathways.

Built coastal assets

Key area of decision-making

How do we maintain the condition of built coastal assets given projected increases in sea levels?

The Adelaide Hills and Fleurieu Peninsula contains a number of built coastal assets, which are highly valued for supporting recreational, residential, and commercial activities. For example, there are ten coastal jetties, twenty eight coastal boat ramps and three marinas (Goolwa, Hindmarsh Island and St Vincent/ Wirrina Cove). There are also buildings (e.g. surf lifesaving clubs), and transport infrastructure (e.g. roads, pathways) located in the coastal zone. Collectively these assets provide key infrastructure for accessing and using an iconic part of the State's coastline.

Climate change impacts

Based on the Integrated Vulnerability Assessment conducted for the region (Resilient Hills and Coasts, 2016) the greatest impact from climate change on built coastal assets will be sea level rise, though increasing rainfall intensity is also important in some locations susceptible to erosion, such as sandy beaches as opposed to rocky shores. Sea level rise will impact assets through permanently inundating low lying areas along the coast, but also exposing assets at higher elevations to greater risk of flooding and wave damage during extreme high sea levels, such as during storms. The effectiveness of assets may also be compromised, for example, requiring boat ramps to have new or additional protection works to provide safe harbour and to prevent over-topping during storm events.

The barrages that separate Lake Alexandrina and the Coorong are a major built coastal asset in the region that have social, economic, environmental and cultural significance. However, they have not been considered in this assessment because climate impacts on this asset were addressed in the development of the climate change adaptation plan for the South Australian Murray-Darling Basin (see **Section 7.4**).

Priority adaptation options

Responding to sea level rise in the coastal zone typically involves a combination of options that aim to defend, retreat or abandon natural or built assets. The initial focus of adaptation for built coastal assets in the Adelaide Hills and Fleurieu Peninsula is on defence (Figure 10).

An immediate priority is to prevent built coastal assets from being constructed in high risk areas. This will be facilitated through **development and implementation of guidelines for coastal management design** (Figure 10). These will outline planning controls for inclusion in development plans, propose areas for restricted development and outline setback distances from the coast for construction, building on information already available in Coast Protection District plans. This option, which will primarily involve local councils and the Coast Protection Board, provides an opportunity for collaboration across the region and with other regions given that similar challenges around development planning in the coastal zone are being confronted elsewhere in the State.

The option to **increase sand replenishment** aims to maintain beaches which act as soft structural barriers to sea level rise and extreme sea levels during storms. This option will require local and State Government agreeing to the frequency of replenishment relative to available budgets. Consideration will need to be given to how long this option will be effective into the future given that it may no longer be viable in some locations once thresholds of sea level rise are reached. Furthermore, it will only be viable if suitable sand size and volumes are readily available. For the purpose of this Plan, it is estimated that sand replenishment will be viable for a further two decades, although this will require additional verification and ongoing monitoring (Figure 10).

Linked to sand replenishment is **protecting and enhancing dunes**, which includes planting appropriate vegetation in some locations to reduce sand erosion. This will provide protection for built coastal assets through maintaining existing soft structural barriers, which may be especially effective during storm surge events. Not only will this option support adaptation for coastal assets, it will also support coastal ecosystems and maintain the beach environment for recreational use. Both sand replenishment of beaches and dune protection and enhancement will require collaboration amongst a number of organisations

including between local councils, Natural Resources Adelaide and Mont Lofty Ranges, the Coast Protection Board and local environment groups such as the Goolwa to Wellington Local Action Planning Group. Unlike sand replenishment, the protection and enhancement of coastal dunes should be ongoing wherever such dunes continue to occur (Figure 10).

At this stage, more transformational options such as relocating or abandoning assets (e.g. beach access, boat ramps, beach cafes, surf lifesaving clubs), or establishing major new hard protection infrastructure such as sea walls are not considered immediate priorities for the region, though they may be considered as priorities for certain local councils. These options were assessed as having both high economic cost and high benefits but considered to be not required for at least another one to two decades. However, if sea level rise is to occur more rapidly than projected, such options will need to be implemented sooner.

Triggers

Triggers for decision making regarding public coastal assets will be linked to sea level rise and the extent to which:

- there is sustained damage to built assets such as paths, walls, boat ramps and stormwater infrastructure due to storms and erosion
- key regional assets such as coastal bowling clubs and Granite Island are regularly flooded
- tourism numbers decline because of impacts on natural features such as the Lower Lakes
- foreshore vegetation in public parks dies back due to salt leaching into the soil.

Enablers and barriers to adaptation

Maintaining built coastal assets requires a united community vision. The availability of existing local to global knowledge, publications, and practical examples will help to facilitate a united front, though only if such knowledge can be readily accessed and understood. Without the ability to learn from others' knowledge and experiences, unifying competing priorities in the community may only occur following extreme events (e.g. flooding from major storm surge, or asset loss due to coastal slump). This would cause triggers for decision making to be refined.

Other barriers to maintaining built coastal assets on the mainland include: a lack of ongoing research and knowledge-building; substantial processes and "red tape" required at the State level for most proposed activities impacting the coastal zone; the lack of a single department/authority with governance and responsibilities over public coastal assets and Council development approval panels ignoring Coast Protection Board advice.

Key points

Adaptation for built coastal assets will involve sand replenishment to maintain beaches, protecting and enhancing dunes to reduce sand erosion, preventing built coastal assets from being constructed in high risk areas and developing guidelines for coastal management and design.

Photo: Courtesy of City of Victor Harbor

Adaptation Pathway

Adaptation options

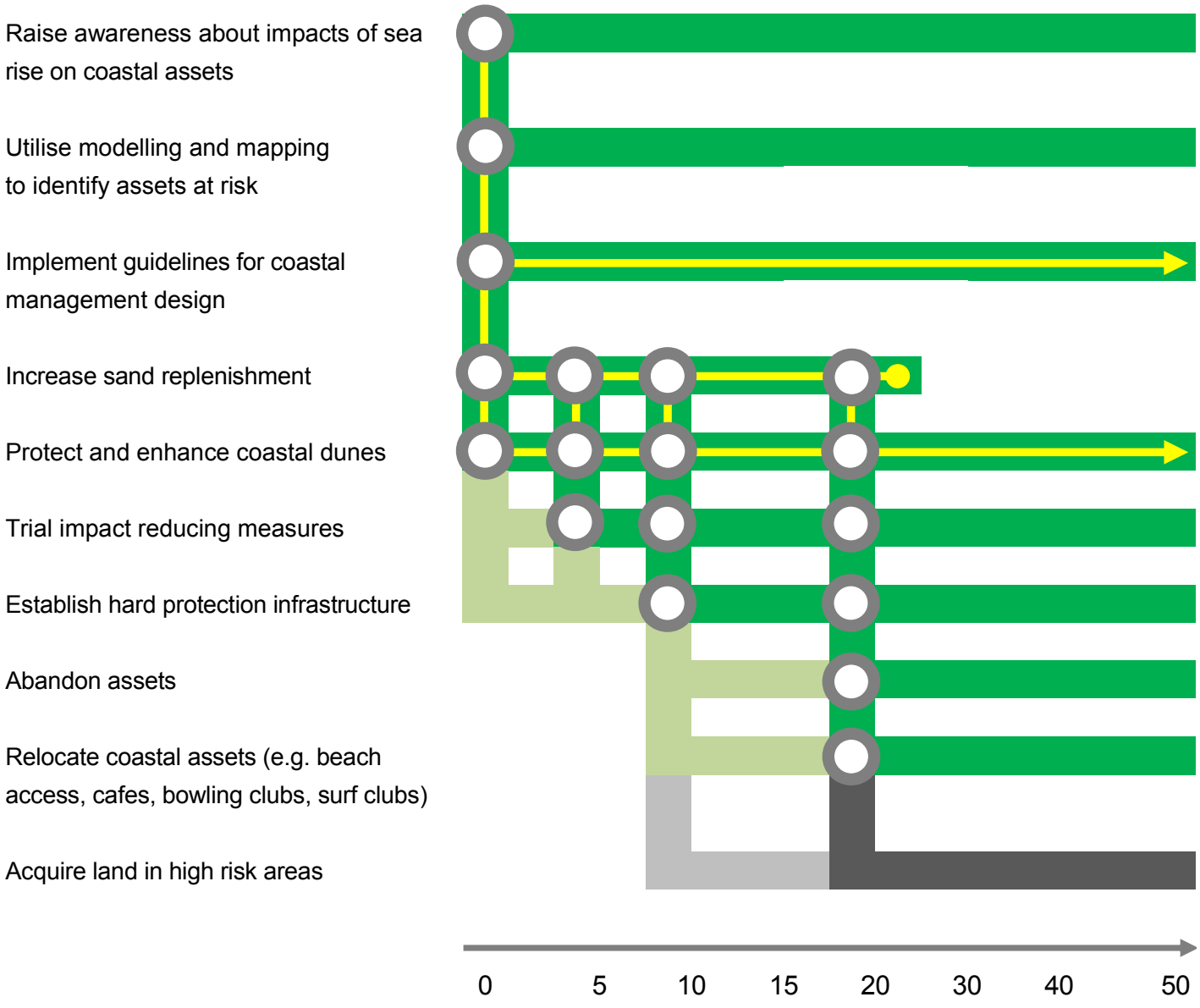


Figure 10. Adaptation pathway for built coastal assets on the Fleurieu Peninsula.

Vulnerable members of the community

Key area of decision-making

How do we enhance the health, safety and well-being of vulnerable members of the community as the risk of extreme events such as fire, extreme heat and flooding (as a consequence of rainfall intensity and sea level rise) increases?

Vulnerable members of the community live across the Adelaide Hills and Fleurieu Peninsula, though higher populations tend to occur in the coastal and hills areas, particularly given the attractiveness of such areas for retirees. The region as a whole compares well with other parts of the State with respect to vulnerable members of the community (Resilient Hills and Coasts, 2014a), for example:

- community connectedness is relatively strong with personal mobility and volunteering rates well above the State average. Internet access and the number of people requiring assistance with core activities is on par with the State average
- unemployment rates have been historically low compared with the remainder of the State over the past decade
- income support levels are below the State average, although the percentage of people receiving an aged pension is above the State average in Victor Harbor (25%) and Alexandrina and Yankalilla (18% each) reflecting the high number of retirees.

Climate change impacts

Based on the Integrated Vulnerability Assessment (Resilient Hills and Coasts, 2016), the health, safety and well-being of low income households followed by people aged over 75 were considered most vulnerable to the impacts of climate change. For low income households, this was due to their sensitivity and low adaptive capacity to extreme events, driven by limited funds to prepare, respond, and recover from extreme events such as extreme heat and fire.

The health of older, frail people is expected to be directly impacted by an increasing number of extreme events, especially associated with extreme heat and bushfire. While extreme weather will negatively affect the community, the Adelaide Hills and Fleurieu Peninsula is likely to be impacted less than some other parts of the State.

Priority adaptation options

Heat waves are likely to have a large impact on vulnerable members of the community. **Scoping potential government responses relating to provision of heat refuges** is an immediate priority for the region and should aim to identify which local or State government buildings are suitable as refuges for the community during periods of extreme heat. This option is considered to be able to be completed within the next ten years (Figure 11). There is also a need to continue to **implement and enhance heatwave response services** such as the Australian Red Cross' Telecross REDi service, with this option identified as being of use in to the foreseeable future (Figure 11).

Education and awareness raising was highlighted as an important strategy to: (a) improve understanding of the health impacts of climate hazards; and (b) assist people to understand how to prepare, respond and recover from extreme events. Such education and awareness raising activities should be focussed on frail-aged people, people with a disability and members of the community from non-English speaking backgrounds. Providing similar information to tourists in the region will also be beneficial. Accordingly, this option will be of relevance into the foreseeable future (Figure 11).

A particular focus of education and awareness raising needs to be on **educating people about what to do on catastrophic fire days**. The CFS can provide important support in this regard such as through its Bushfire Safer Places advice*. This outlines a hierarchy of places that can offer relative safety from bushfire. They are broken into three categories called Bushfire Safer Settlements (suitable for use during forecast bad fire weather or

* See: http://www.cfs.sa.gov.au/site/prepare_for_bushfire/know_your_area/bushfire_safer_places.jsp

Photo: Courtesy of Adelaide Hills Council

during bushfire), Bushfire Safer Precincts (suitable for use during forecast bad fire weather or during bushfire) and Last Resort Refuges (not suitable for extended use and may provide only limited protection during bushfire). Education of the community will be important to continue into the foreseeable future (Figure 11).

Within five years, a priority adaptation option for vulnerable members of the community is to **prevent development of facilities such as aged care residences, hospices and hospitals in hazard prone areas**. This includes those areas that may be at heightened risk in the future from sea level rise or bushfire. Preventing development in high risk areas reduces the risk of harm to people in these facilities, the need to relocate people during extreme events, and potential damage to assets. Planning work will need to commence immediately if this approach is to be implemented within five years, though the implementation of this option should be ongoing (Figure 11).

While adopting more climate sensitive building designs is also a favoured option, it is recognised as having high costs and high benefits if it is adopted at a whole-of-community scale and therefore needs to be considered as part of a region-wide initiative (see Section 5.2).

Triggers

Implementing options that build adaptive capacity for vulnerable members of the community will likely be reactive and triggered by extreme heat, fire or flooding events that result in additional mortality or hospital admissions. Another driver of change will be an increase in the cost of health service provision as a consequence of climate change impacts.

Enablers and barriers to adaptation

Many communities in the region are already highly resilient and connected. Implementing adaptation options to help vulnerable members of the community respond to a changing climate can draw on existing community champions, programs and community warning systems.

Barriers to implementing adaptation options will include the time taken to generate change in policy and encourage the community to adopt new practices, especially where they are geographically dispersed and have varying levels of capacity (e.g. funding, volunteer resources).

Key points

Adaptation for vulnerable members of the community requires preventing development of facilities such as aged care residences, hospices and hospitals in hazard prone areas, education and awareness raising to explain how to prepare for extreme events and respond, enhancing heatwave response services, and scoping potential government responses regarding the provision of heat refuges.

Adaptation Pathway

Adaptation options

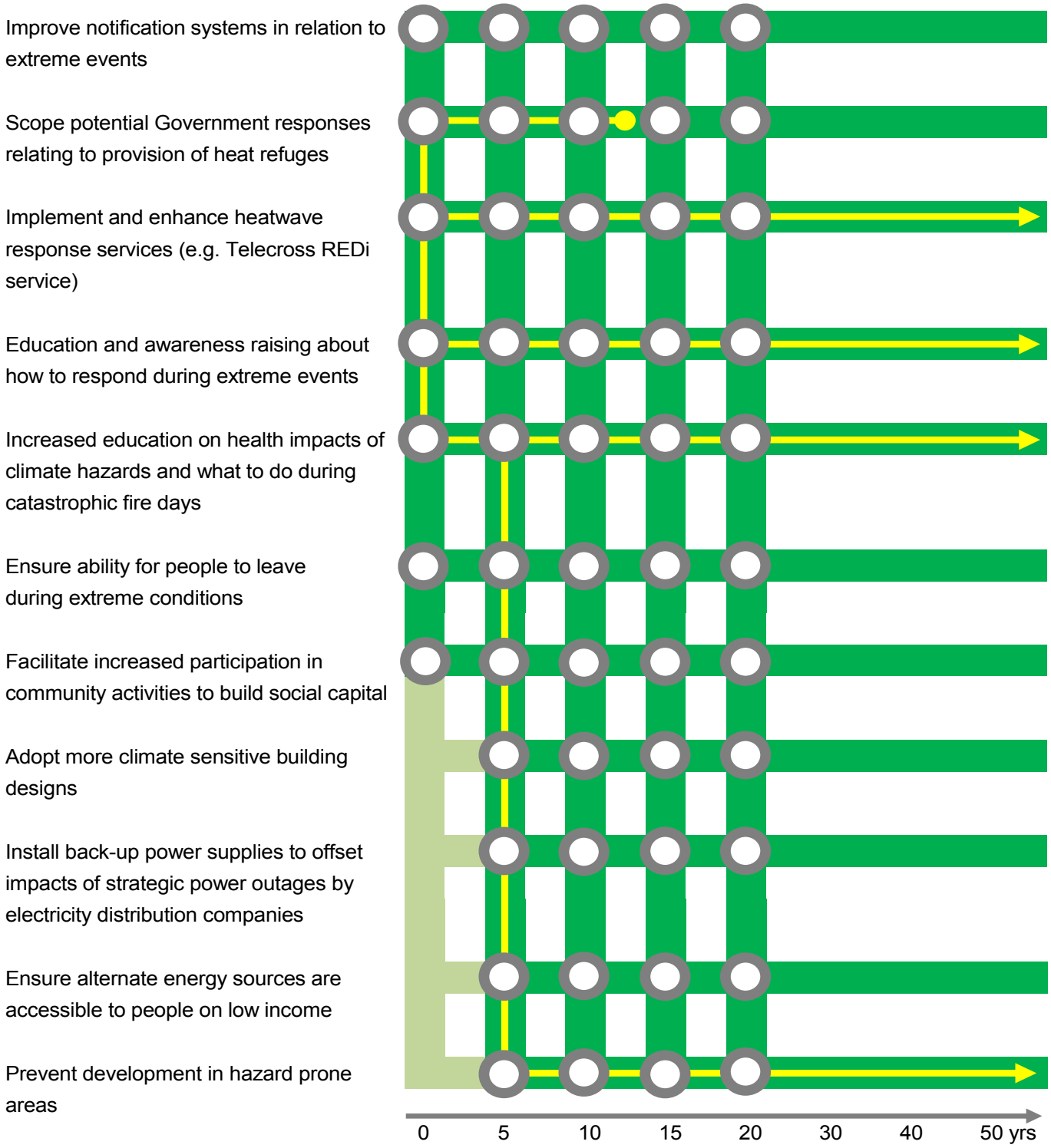


Figure 11. Adaptation pathway for vulnerable members of the community in the Adelaide Hills and Fleurieu Peninsula. Refer Attachment D for legend and explanation of adaptation pathways.

Photo: Courtesy of Adelaide Hills Council

Water-dependent ecosystems

Key area of decision-making

How do we protect water-dependent ecosystems given projected declining rainfall and increasing temperature and fire risk?

Water-dependent ecosystems, such as wetlands and riparian zone communities, are valued in the Adelaide Hills and Fleurieu Peninsula for the multiple roles they play in supporting biodiversity, improving water quality and as recreational assets.

Surface water in the region includes numerous minor natural watercourses (e.g. streams and rivers), constructed watercourses as well as natural and constructed water bodies (e.g. lakes, wetlands, reservoirs). The region includes either partially or completely five main river basins: Torrens River, Onkaparinga River, Myponga River, Fleurieu Peninsula, Lower Murray River, and Kangaroo Island (Bureau of Meteorology, 2016). These are divided into ten smaller river catchment areas. Groundwater resources also supply creeks, rivers and wetlands in the region.

Of particular note in the region are the:

- internationally important (RAMSAR listed) Coorong and Lakes Alexandrina and Albert
- Federally listed threatened ecological communities:
  - Sub-tropical and Temperate Coastal Saltmarsh (listed as occurring in Alexandrina, Kangaroo Island, and Victor Harbor local council areas)
  - Swamps of the Fleurieu Peninsula (listed as occurring within Alexandrina, Victor Harbor, and Yankalilla local council areas).

Climate change impacts

Based on the Integrated Vulnerability Assessment (Resilient Hills and Coasts, 2016), when and how often flows occur and the quality and quantity of water available will have significant impacts on water-dependent ecosystems. Increasing fire risks, changing seasonal and annual rainfall amounts, and increasing

average temperature as a consequence of climate change will therefore be particularly important.

Priority adaptation options

At a broad landscape scale, water dependent ecosystems will require re-assembling of these systems to maintain stability and ecological function. Within this broad requirement, immediate priority adaptation options for the region include (see Figure 12):

- **supporting landholders to manage native vegetation in water dependent ecosystems on private properties**. This can be achieved through providing incentives. The Fleurieu Swamps vegetation management guidelines for landholders (Conservation Council SA, 2011) is an example of the support that can be provided to landholders needing to manage native vegetation associated with water dependent ecosystems occurring on private properties
- **adaptive management of protected areas**, such as through management of fuel loads which will be particularly


Photo: Courtesy of Mount Barker District Council

important given the negative impact fire can have on wetlands but the need to manage loads to protect human life and assets

- **identifying and developing functional landscape connections** to enable the movement of aquatic species
- **identifying, managing and protecting** priority ecological assets (e.g. Fleurieu Swamps, Deep Creek Conservation Park)
- **protecting populations of threatened species** (e.g. through seed banking, translocation, captive population breeding programs).

Within five years, adaptation will also need to focus on:

- **increasing stormwater harvesting** to improve water quality and quantity
- **establishing natural flow patterns**, which may require securing low flows or the use of landscape engineering solutions.

The five year lead time for these options is required to prepare and plan for implementation, especially re-establishing natural flow patterns, which requires further work and stakeholder engagement to determine how best to achieve this outcome.

Triggers

The major trigger for greater implementation of adaptation options will be when flow patterns or water regimes at critical sites drop below thresholds to sustain water dependent ecosystems. This could also manifest as a shift in vegetation composition in swamps or wetlands to more terrestrial species. Other triggers could include events such as fire which lead to the total loss of habitat.

As for other natural landscapes in the region, it is essential that partners in water dependent ecosystem management in the region invest in anticipatory monitoring and evaluation to detect climatic change impacts and develop conceptual models of likely change and triggers for different strategies.

Enablers and barriers to adaptation

While the knowledge to facilitate adaptation of water-dependent ecosystems to climate change exists, the environment is often not adequately prioritised and so adaptation tends to be inhibited by a lack of funding.

Adequately prioritising the environment requires: clear objectives and targets, strong legislative support and advocacy, and a cohesive cross-agency approach. On-ground uptake of adaptation options also requires buy-in from land owners which will be influenced by the opinions, values, and actions of their family, peers and broader community.

Photo: Courtesy of Alexandrina Council

Key points

Water dependent ecosystems require active and transformational adaptation, which may require reassembly to maintain stability and ecological function. As part of this, priority adaptation options include supporting landholders to manage native vegetation on private properties; adaptive management of protected areas with a focus on fire; identifying and developing corridors to enable the movement of aquatic species; identifying, managing and protecting priority ecological assets; protecting populations of threatened species. Within five years, adaptation will also need to consider how to re-establish and manage natural flow patterns, with adequate lead time to determine how best to achieve this outcome.

Adaptation Pathway

Adaptation options

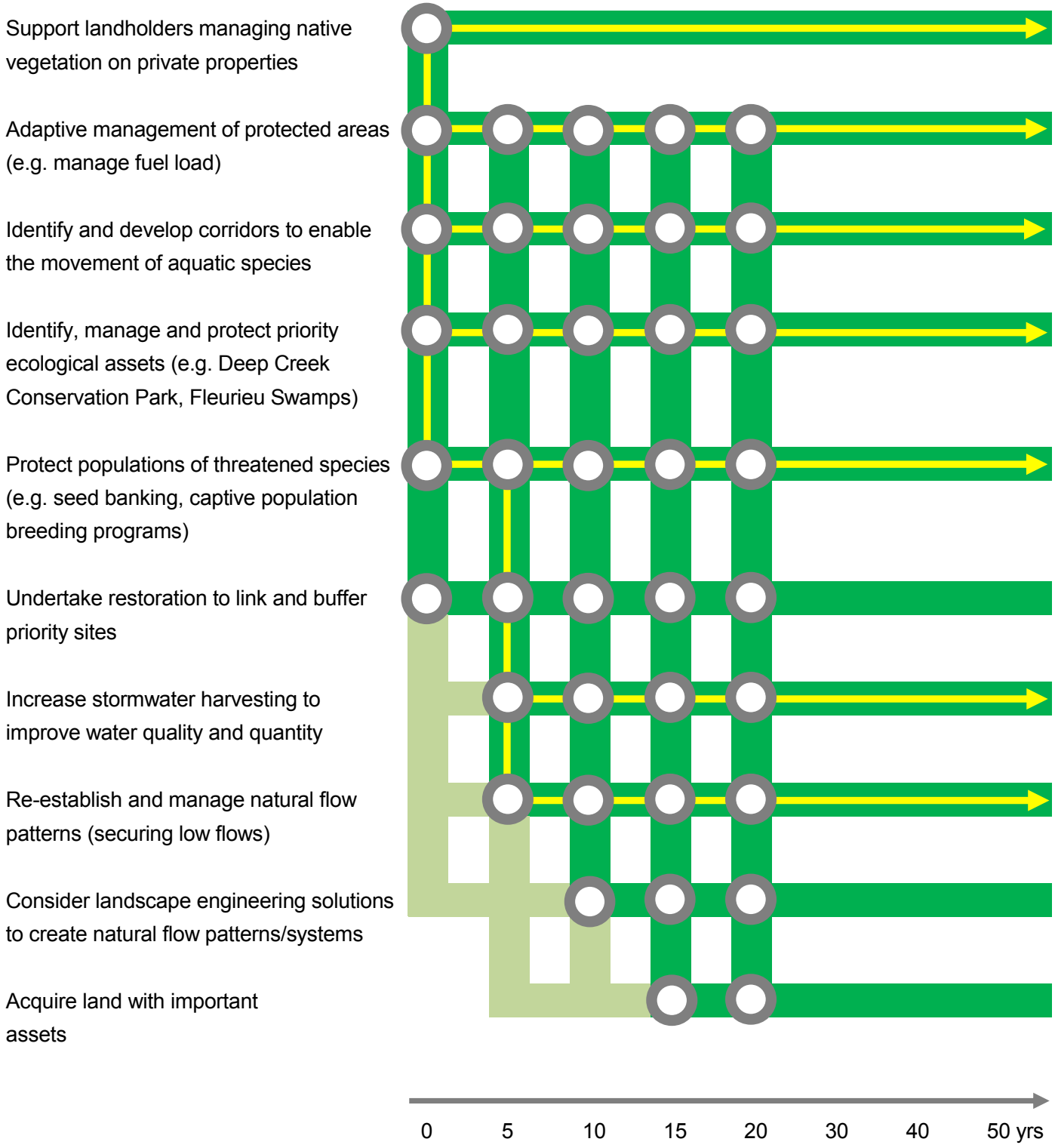


Figure 12. Adaptation pathway for water dependent ecosystems in the Adelaide Hills and Fleurieu Peninsula. Refer Attachment D for legend and explanation of adaptation pathways.

PART C | Kangaroo Island

Photo: Courtesy of Natural Resources Kangaroo Island

This section of the Plan focuses on key areas of decision making that relate to Kangaroo Island's agricultural productivity, built coastal assets, emergency services management including vulnerable members of the community, and essential services and transport infrastructure. The NRM-related key areas of decision making are addressed by the regional NRM plan.

PRIORITY ADAPTATION OPTIONS

Agriculture

Key areas of decision-making

How do we maintain levels of crop, horticulture, and wool production, given projections of declining rainfall and higher average temperatures?

A number of agricultural industries occur on Kangaroo Island that are highly valued for their importance to the local economy, including cereal cropping, viticulture, livestock production, wool industries and honey production. Being separated from the mainland, agriculture on Kangaroo Island has some unique features that have supported the development of a strong premium food and wine brand. For example, honey is produced from a near pure Ligurian strain of bee and the Island is free from many pests and diseases making it an ideal location to produce seed potatoes.

Climate change impacts

Based on the Integrated Vulnerability Assessment (Resilient Hills and Coasts, 2014b), declining rainfall is particularly important for cropping industries (though there may be potential benefits due to decreased waterlogging), while horticulture, livestock (especially on the eastern end of the Island) and wool industries are most influenced by increasing bushfire risk and temperature. Rainfall impacts directly on pasture production though the lack of spring rainfall is especially problematic for finishing off.

Comparatively, fire directly impacts farm assets (e.g. buildings, plant and equipment), stock and permanent plantings. Being isolated from the mainland, the Island is likely to be less susceptible to terrestrial dispersed pest and disease threats that may be enhanced by a changing climate on the mainland. However, given the extensive coastal boundary of the Island, consideration needs to be given to potential pests and diseases that may arrive by sea.

Priority adaptation options

An immediate priority for adaptation is to **improve seasonal forecasting**, which will require support from the Bureau of Meteorology and will be an ongoing action into the foreseeable future (Figure 13). The use of **spring and summer seasonal forecasts for planning farm operations** will help growers to plan and better manage operations ahead of time and should be integrated as part of standard practice (Figure 13). The focus of improved seasonal weather forecasting for Kangaroo Island needs to include greater emphasis on the accuracy of both long- and short-term forecasts.

Within five years, a priority for adaptation (and mitigation) will be to start **incorporating carbon sequestration into food based agriculture** to a greater degree (Figure 13). On Kangaroo Island this will primarily focus on increasing soil carbon levels, such as through addition of biochar or increasing levels of organic matter. Such practices when used as standard practice over the long-term can assist in retaining moisture and nutrients in the soil which may assist during drier conditions, but subject to the availability of approved methodologies, carbon credits might also be generated for sale through emissions reduction schemes.

Another high priority for primary production on Kangaroo Island is to diversify agricultural production systems. This will require local **evaluation of alternative production systems** such as new varieties of crops or pasture, the selection of livestock suited to new seasonal conditions (e.g. shorter turn over of lighter lambs),


Photographer: Quentin Chester

and other food/fruit and medicinal plants that are suited to a warmer, drier climate. Emphasis will need to be on learning from what is already occurring on the drier parts of the Island and similar locations elsewhere. Diversification can be aided through involvement of formal and informal farming groups and support organisations such as Agriculture Kangaroo Island, Rural Solutions, and the KI NRM Board, as well as off-island industry and research organisations and individual farmers willing to share their knowledge and experience.

In addition to new learnings and altered practices, traditional measures such as shelter belts and windbreaks will assist with reducing the impact of strong winds on stock and crops, reducing evaporation, erosion and flooding. Building long-term resilience into agricultural productions systems will be further aided by reducing existing system stresses (e.g. by enclosure-feeding at key times) and supporting the natural functioning of surrounding ecosystems (e.g. through strategic revegetation).

Triggers

There are multiple triggers that could influence when famers on Kangaroo Island start to increase their adoption of new practices. These could include:

- declining rainfall that, for example, may lead to lack of run-off into farm dams for individual growers or a continued run of dry seasons
- declining returns (farm profit) per enterprise and the ability for farmers to access finance
- observed declines in natural resources as evidenced by bare, drifting paddocks and increasing salinity.

Barriers and enablers

Broad-scale uptake of adaptation options on Kangaroos Island will be largely facilitated through community support (i.e. friends, family, and neighbours) of the options, though such support may equally inhibit uptake if directed away from the proposed changes. Further facilitation of options uptake will occur through:

- physically demonstrating the benefits of change (e.g. changing farm practices, carbon trading opportunities) through localised and Island-specific research trials
- hosting field days
- working with farmers to ensure they have confidence in the reliability of information underpinning the adaptation options
- understanding and allaying any risk concerns associated with enacting the options.

It will be important that adaptation options are shown to have clearly considered the complexities associated with farming on the Island, particularly the interconnectedness of practices meaning that a single change requires changing many component farming elements. Consideration must also be given to the often exacting market requirements, industry standards and community expectations, which can be challenging to meet on the Island, compared to the mainland. Another key barrier to agricultural adaptation will occur if adaptation values and drivers do not align with farming values and drivers for change.

Key points

Adapting agriculture to climate change will require diversifying agricultural production systems; improved seasonal forecasting; incorporating carbon sequestration into food-based agriculture primarily through increasing soil carbon; and building the resilience of supporting ecosystems.

Adaptation Pathway

Adaptation options

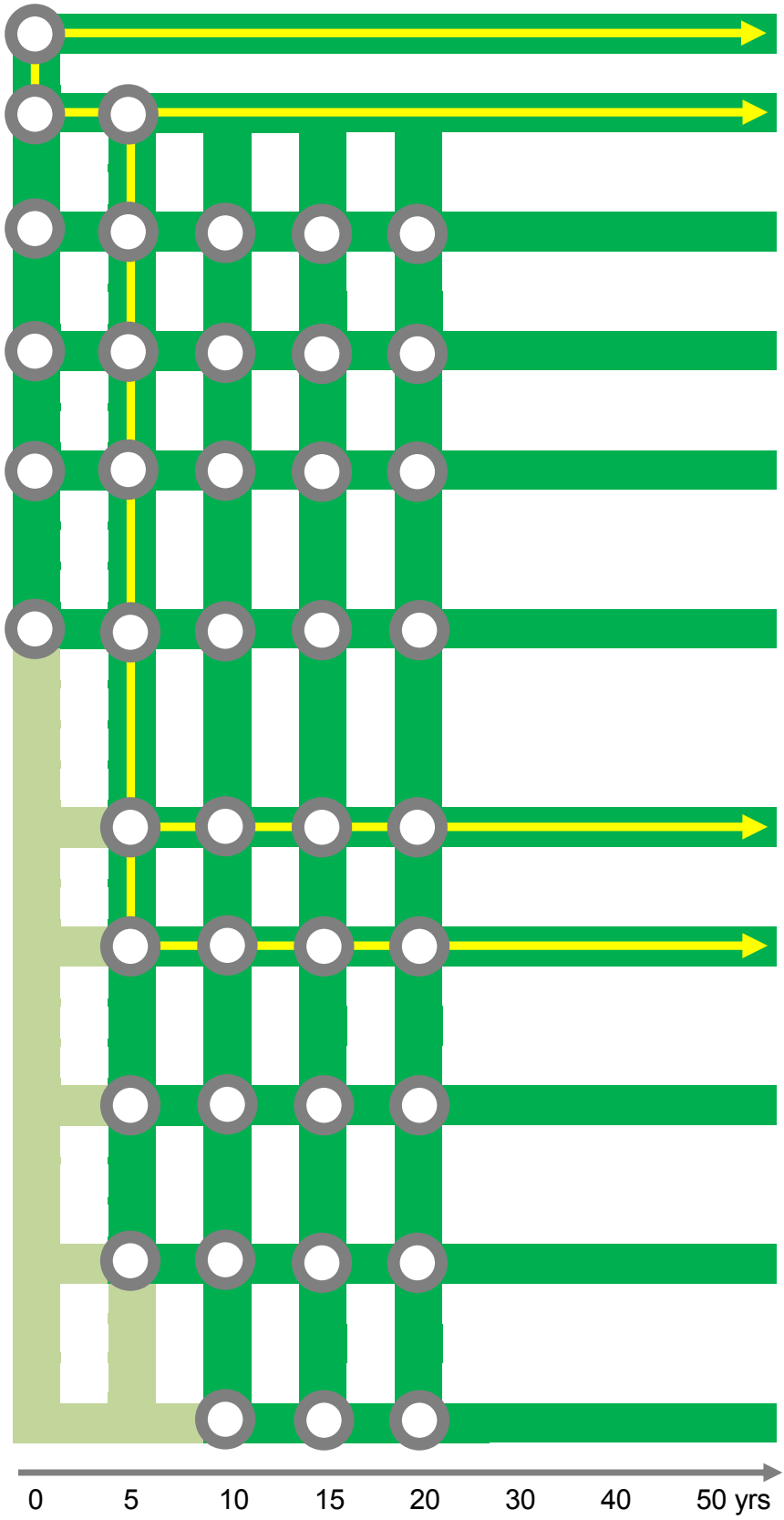


Figure 13. Adaptation pathway for agriculture on Kangaroo Island.
Refer Attachment D for legend and explanation of adaptation pathways.

Built coastal assets

Key areas of decision-making

How can built assets along the coast be managed in the face of sea level rise and coastal inundation?

Much of the Kangaroo Island population lives within a short distance of the coastline, making regular use of built coastal assets. These assets are highly valued by residents and visitors for recreational and commercial purposes and include roads, buildings, jetties and wharves (e.g. Penneshaw, Kingscote, and Vivonne Bay). Notably, most of the Island's major settlements are also located on the coast (e.g. Kingscote, Penneshaw).

Climate change impacts

Based on the Integrated Vulnerability Assessment conducted for Kangaroo Island (Resilient Hills and Coasts, 2014b), sea level rise, increased storm surge and subsequent flooding from ocean inundation present the greatest climate change threats to the Island's built coastal assets. This risk will increase as sea levels rise over the coming century.

Priority adaptation options

Adaptation for built assets in the coastal zone on Kangaroo Island will require the **development and implementation of policy options for existing and future assets in high risk area**s (Figure 14). This policy should consider a portfolio of options, including the protection of assets, the potential for and appropriateness of compensation, and planning for potential future relocation. Whilst the development of policies will likely be achieved in the next five to ten years, implementation will be ongoing (Figure 14).

Related to the development of policy options is the implementation of **guidelines for coastal management design**. These guidelines will become an enabler for action and will be described in further detail in policy responses for assets in high risk areas. For example, a guideline may provide information on whether set back distances or floor heights for new construction works are required.

Possible future adaptation options include: abandoning, removing, relocating or re-purposing built coastal assets, all of which involve potentially high economic and/or social costs and benefits. Of these future options, establishing major hard protection infrastructure (e.g. sea walls) was considered a last resort by workshop participants. However, if sea level rise occurs more quickly than has been projected, these options will need to be considered sooner rather than later. As such, a clear direction on the preferred response strategy should be scoped in the short term (Figure 14).

Triggers

A wide range of triggers was identified that could influence when adaptation options are implemented in coastal areas, including:

- projected rate and extent of sea level rise indicating when adaptation options should be implemented
- loss of assets or restricted access because of inundation (e.g. Hog Bay Road being cut off at Pelican Lagoon, damage to the ferry terminal at Penneshaw)
- reduced investment due to the risk of the Island being "cut off' because of inundation damage to transport and infrastructure

Photo: Courtesy of Natural Resources Kangaroo Island

- reduced revenue to local businesses due to decreased tourist visitation because of transport risks
- major increases in insurance premiums, a refusal to insure and/or difficulty in securing finance
- inability to sell real estate because of declining property values or lengthening timeframes to sell.

Enablers and barriers to adaptation

Although much of Kangaroo Island's residential, retail, and recreational infrastructure is located along its coastlines, much of it is not located at or close to sea level due to the Island's topography, though coastal erosion and retreat may still impact it.

Where sea level rise does pose an immediate and direct risk to infrastructure, there are likely to be a number of barriers to protecting built coastal assets. Barriers to adaptation include a degree of scepticism in the community regarding the projected impacts of climate change. This will need to be countered by continued education and awareness raising about the observed and projected impacts of climate change.

Facilitating the uptake of adaptation options on the Island will require the identification of local community members who will champion the options and "lead the way". There will also need to be clear policies on liability (i.e. public versus private – who bears the cost and who benefits), resources and funding, and development planning and zoning regulations. In addition, a positive cost-benefit will need to be demonstrated in order to facilitate a proactive rather than reactive approach.

Key points

Adaptation for built assets in the coastal zone on Kangaroo Island will require the development of policy responses for existing and future assets in high risk areas and guidelines for coastal management design.

Adaptation Pathway

Adaptation options

Figure 14. Adaptation pathway for built coastal assets on Kangaroo Island.
Refer Attachment D for legend and explanation of adaptation pathways.

Emergency management

Key areas of decision-making

How can we better protect natural environments, farming assets and built infrastructure against more frequent and intense bushfires, particularly given the limited residential volunteer pool coupled with geographic isolation from the mainland?

How can we maintain the well-being of vulnerable members of the community given the increasing risk of extreme conditions such as heatwaves and bushfires?

Kangaroo Island supports extensive natural vegetation highly valued for its biodiversity, aesthetic and economic benefits. The region is recognised as one of South Australia's biodiversity hotspots. However, without appropriate management this vegetation also presents a bushfire risk to the community and key industries on Kangaroo Island. Emergency services are provided by SA Police, the Country Fire Service, State Emergency Services and the SA Ambulance Service.

Additional fire-fighting resources external to the Island are at times required when responding to major bushfire threats. A key focus of emergency management services on Kangaroo Island is the protection of vulnerable members of the community, especially those living in major towns or in isolated areas, while at the same time protecting the Island's unique biodiversity.

Climate change impacts

Based on the Integrated Vulnerability Assessment (Resilient Hills and Coasts, 2014b), increasing bushfire risk is a key threat to the Island's community, infrastructure, economy and environment. Of particular concern is the risk to vulnerable members of the community living in high risk locations such as people from low-income households, people with a disability, and/or people aged over 75 years.

Priority adaptation options

An immediate priority for adaptation is to help prepare for fire events through additional education and awareness-raising activities. Of particular importance will be **improved early warning systems** prior to fire events. This can be facilitated through greater use of mobile phone apps and increased **community awareness on risk and insurance**, working in partnership with the Insurance Council of Australia. Such systems should be developed (if not already available), promoted and adopted within ten years (Figure 15).

A key aspect of adaptation for emergency management on Kangaroo Island will be **whole-of-island vegetation management planning**, with a particular focus on fire being managed to meet biodiversity conservation objectives in general and to achieve fuel load reduction outcomes in identified areas. While increasing functional connectivity for plant and animal species across the landscape will serve to build the resilience of ecosystems, this will require identification of "pinch points" that stop the spread of fire. Proactive planning of this type will also help to indicate what level of resourcing is needed to conduct prescribed burns.

Further adaptation options that were identified and considered to have high benefit compared to costs include:

- amending development planning to ensure that no community facilities are constructed in significantly fire prone areas or areas that are difficult to access during a fire. This can be complemented by educating members of the community about the consequences of where they choose to live and the type of home they construct or live in
- facilitating increased volunteerism through targeted and innovative campaigns.

Photo: Courtesy of Natural Resources Kangaroo Island

Triggers
It is anticipated that a 50% increase in severe fire risk on Kangaroo Island will likely lead to an accelerated implementation of new adaptation measures including amendments to planning and policy. Other triggers will be the consequences of low volunteer numbers being available to assist in fire management (e.g. west end of the Island) and a lack of compliance with legislation and regulations leading to greater fire risk and impacts (which will drive policy change).

Enablers and barriers to adaptation
The Kangaroo Island community is intimately aware of the bushfire threat on the Island and the need to implement adaptation options to protect against bushfires. Despite this awareness, there is a lack of understanding regarding the management of prescription burns, which will continue to be a key adaptation option. Continued awareness raising about how these are designed and managed is paramount.

Despite a regulatory framework being in place and legislative responsibilities assigned, a barrier to effective fire management is that the landholder carries the risk of prescribed burns on private land, which is a disincentive to action, together with the cost of preparing a fire management plan and having resources on hand to control the fire. A whole-of-island approach to managing native vegetation may go some way to addressing these issues.

Key points

Adaptation options for emergency management that will assist in protecting vulnerable members of the community and aid with biodiversity conservation involve whole-of-island vegetation management planning to reduce fire risk, community messaging around risk; and insurance developed in partnership with the Insurance Council of Australia; and improved early warning systems leading into fire events.

Adaptation Pathway

Adaptation options

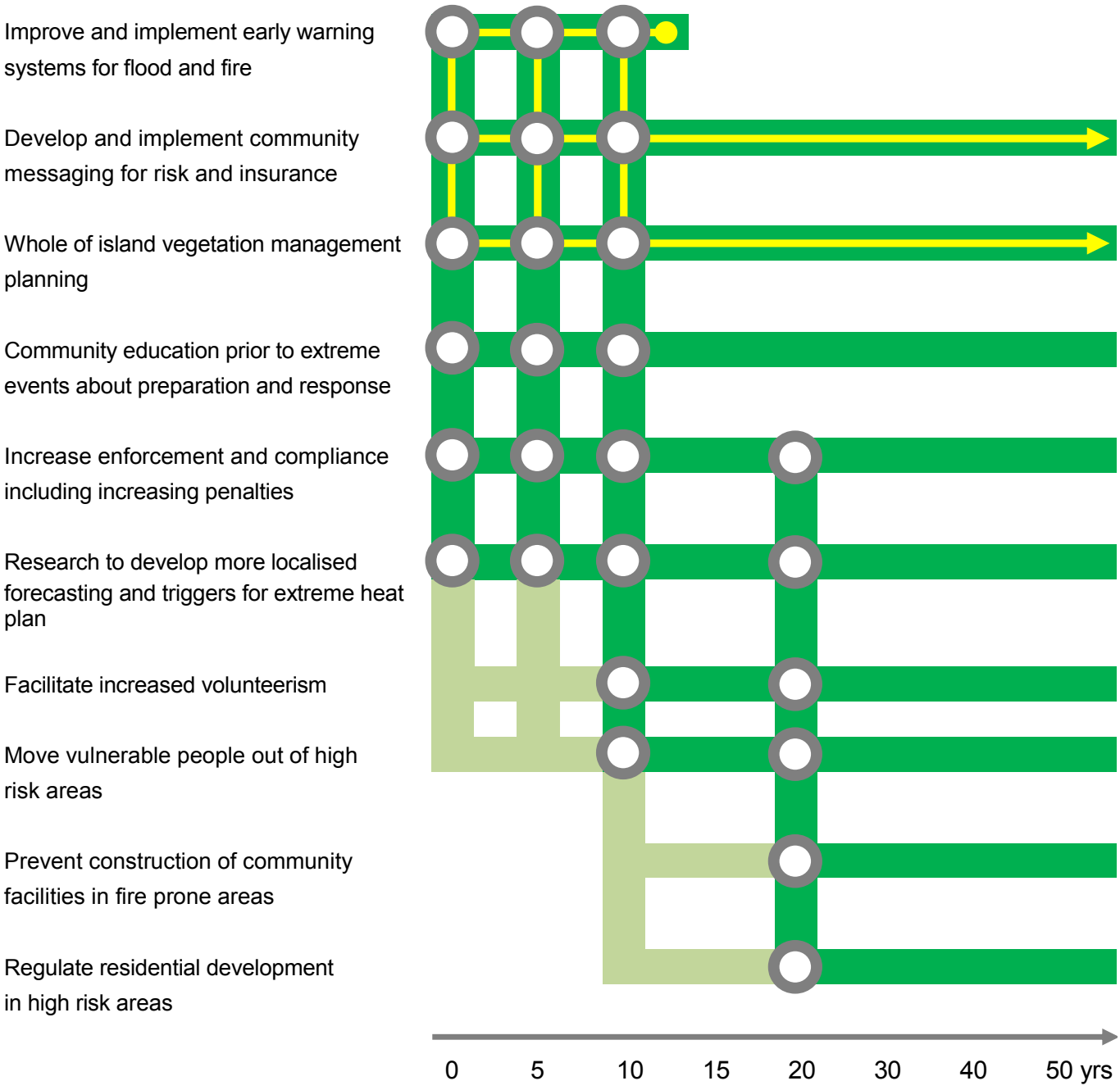


Figure 15. Adaptation pathway for emergency management on Kangaroo Island. Refer Attachment D for legend and explanation of adaptation pathways.

Essential services and transport infrastructure

Key areas of decision-making

How can the condition and performance of energy and telecommunications networks be improved given the expected increasing frequency and intensity of extreme climatic events such as heatwaves and bushfires?

How can the condition of sealed and unsealed roads be managed in the face of altered climate conditions such as increasing rainfall intensity and sea level rise, as well as increasing use?

The condition and performance of energy and telecommunications services is highly valued on Kangaroo Island. However, there are existing concerns about the effectiveness of this infrastructure. Access to both is essential for people to maintain contact within the community and with the mainland, for the operation of businesses and for coordinating resources during emergencies. Energy on Kangaroo Island is predominantly from conventional sources delivered by an undersea cable from the mainland. However, some renewables do exist, such as a dual-axis solar array system installed at the Kangaroo Island Airport plus a 14 kW solar system installed at the Kingscote Town Hall, as part of the Island's Visible Solar Project (Kangaroo Island Council, 2014). There is also widespread community support for much greater use of renewables to power Kangaroo Island in the future.

Roads on Kangaroo Island provide critical access to remote locations and services, facilitate delivery of supplies, and are a key asset in supporting the agriculture and tourism industries. The majority of roads on the Island are unsealed and maintained by Kangaroo Island Council.

Climate change impacts

Climate change-induced increases in temperatures, heatwaves, and bushfires are increasing the demand for essential services, causing a higher number of black-out periods, and increasing the risk of physical damage to associated infrastructure (Resilient Hills and Coasts, 2014b). This in turn has a negative impact on the community and business on the Island.

Sea level rise, and increasing rainfall intensity, heatwaves and temperatures also negatively impacts the condition of roads. Potential increased tourism, resulting from warmer and longer fine weather conditions may also increase the wear and tear on roads. Future flood damage is of major concern for unsealed roads in the wake of flooding in the MacGillivray/Haines area of Kangaroo Island since June 2013, where the estimated damage bill is more than Kangaroo Island Council's total rates revenue.

Priority adaptation options

An immediate priority for adaptation of transport infrastructure on Kangaroo Island is to **identify points of vulnerability in the sealed and unsealed road network** through development of a roads database. This will identify points in the network vulnerable to flooding (e.g. MacGillivray/Haines) and/or fire. To do this, further flood modelling will need to be undertaken for inland areas of the Island and the current understanding of coastal evacuation requirements for small towns, such as Vivonne Bay, will need to be improved. Identifying such points is not considered to be an ongoing requirement, rather it is likely to be able to be completed within five years of commencement (Figure 16).

Another adaptation option that applies to all essential services and transport infrastructure on Kangaroo Island will be to **make design allowances for increases in extreme events**, such as fire and flood and extended periods of warmer and drier conditions (Figure 11). This option, which is considered important to implement within the next five years, will primarily be the responsibility of Kangaroo Island Council and needs to include allowances for strategic road upgrades requiring vegetation clearance, raised road levels or re-routing (where necessary) to

allow for storm surge in some coastal locations, improved road drainage, and stormwater management infrastructure upgrades. However, consideration must be given regarding potential maladaptive actions, such as the removal of roadside vegetation which may lead to increased erosion and loss of important native flora and habitat.

Additional analysis is required to clarify priorities amongst the following adaptation options: a strategic transport plan considering future transport modes and demands; more frequent bitumen resealing in response to temperature induced oxidation; provision of additional resources for alternative exit/entry points on farms; strategic freight depots in regions for livestock and grain that link with collector freight roads; and, strategic water storage points across the Island for road works and maintenance.

While energy infrastructure upgrades can make design allowances for future climate risks, further work is also required to determine whether the majority of Kangaroo Island's energy will continue to come from the mainland via the undersea cable or whether alternative power supplies can be generated, such as from solar, wind, tidal or biomass energy generation (EconSearch, 2013).

Although not identified as priorities during the development of this Plan, further consideration should also be given to ecosystem-based adaptation options such as maintaining and restoring seagrass beds to reduce coastal wave energy and storm surge impacts, and protecting and revegetating coastal dune and beach areas to reduce on-shore coastal erosion. These responses provide a mixture of social, economic and environmental benefits.

Triggers

A key trigger for implementing adaptation options for transport infrastructure will be the community pressure resulting from damage to roads caused by extended dry conditions, major floods, access issues during bushfires and storm surge. For energy, a trigger will be the point at which demand growth exceeds the supply capacity of the existing undersea cable or when local distributed power solutions (e.g. solar PV) are at cost parity with traditional sources.

Enablers and barriers to adaptation

Although improved design standards are available, and their benefits known, implementing such options on Kangaroo Island could be impeded by a lack of clarity with regard to cost-benefits, water resources management policy implications, and nuances of the Island compared to the mainland (i.e. approaches implemented on the mainland may not be the best for Kangaroo Island). This will need to be addressed through continued education and awareness raising, especially in relation to cost-benefit analysis results.

In addition, adaptation options involving new technologies will require dedicated community education and engagement strategies to gain support for on-ground implementation. The impacts of short-term political cycles on long-term planning, delivery and monitoring of adaptation requirements will also need to be overcome in order to successfully implement options.

Key points

A priority adaptation option for transport infrastructure on Kangaroo Island is to identify points of vulnerability in the sealed and unsealed road network. A further option that applies to all essential services and transport infrastructure will be to make design allowances for increases in extreme climatic events. This is also important in underpinning provision of emergency services on the Island.

Adaptation Pathway

Adaptation options

Identify points of vulnerability in the road network

Create wider corridors near powerlines or substations

Investigate internal capacity building regarding the impacts of climate change on assets and procurement

Develop alternative energy solutions on the Island

Incorporate design allowances for increases in extreme events

Seal currently unsealed roads to protect against stormwater damage

More frequent bitumen resealing and use of alternate road sealing surfaces

Develop strategic water and freight points across the Island

Develop alternate entry and exit points on farms

Renew the undersea power cable

Investigate alternate road sealing surfaces

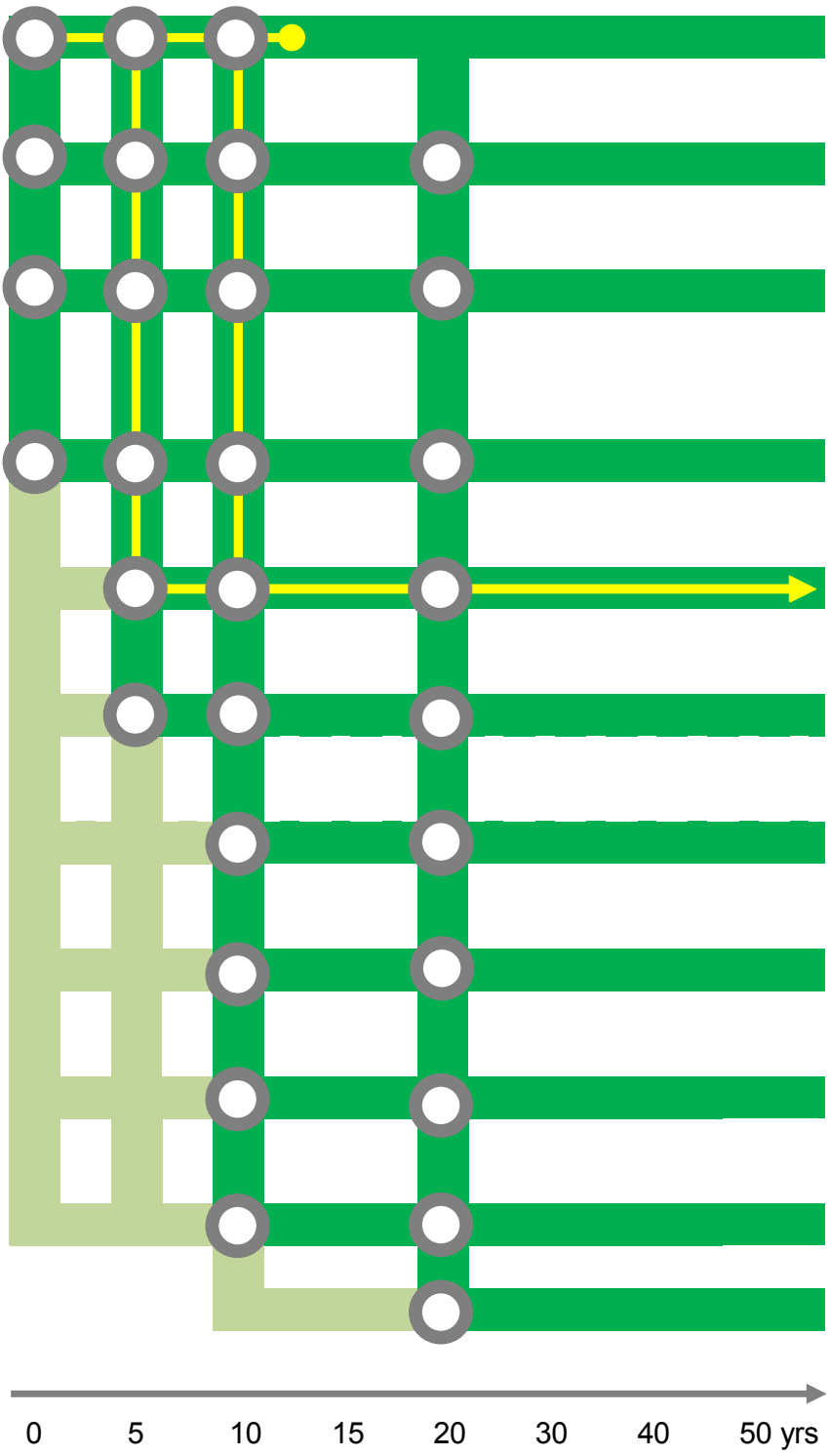


Figure 16. Adaptation pathway for essential services and transport infrastructure on Kangaroo Island. Refer Attachment D for legend and explanation of adaptation pathways.

Photo: Courtesy of Natural Resources Kangaroo Island

PART D | The Region

IMPLEMENTING THE PLAN

Regional priority adaptation options

Parts B and C of this Plan presented priority adaptation options for key sectors in the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island. These adaptation options were identified and prioritised with input from subject matter experts, key stakeholder representatives and additional analysis. A further aim of this Plan is to identify regional priority adaptation options that are relevant to multiple sectors and partner organisations, as outlined in this section.

Regional priorities were identified using a three step prioritisation process, involving qualitative cost-benefit analysis, assessment of regional relevance, and consideration of the practicality of implementation (see Section 4.2 for further details). A summary of the relevance of regional priority options to the different key areas of decision-making is provided in Table 3.

The adaptation priorities for the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island region are as follows:

Adaptive management of protected areas on public lands

This option will need to be led by the Department of Environment, Water and Natural Resources, working closely with local government to manage community concerns where public lands are in close proximity to towns and private land. As the climate

Photo: Courtesy of Mount Barker District Council

changes there will be a need to continually learn from how the environment in the region responds. This will require adaptive management of protected areas on public lands, with a focus on managing fuel loads. The emphasis on fuel loads will become increasingly important as fire risk increases and the community seeks to balance maintenance of environmental values and ecosystem services with public health and safety concerns.

This option was assessed as having high social benefits because of improved fire management, but also moderate economic (avoided losses and impacts) and moderate environmental benefits. Social and environmental costs were assessed as low, but economic costs moderate because of the costs of implementing such a strategy.

Responsibility: Department of Environment, Water and Natural Resources, local government (six regional councils)

Climate-ready guidelines for the public realm and green infrastructure

To continue to thrive in the region, the public realm and streets need to adapt to changing conditions, especially increased periods of extreme heat, greater fire risk and greater flood risk from intense rainfall. Preparing and commencing implementation of 'climate-ready' guidelines for public realm and streetscape management will include appropriate material and tree species selection, shade coverings, inclusion of water sensitive urban design features, and opportunities for misting infrastructure.

This option was assessed as having high social benefits because of improved public spaces that are better adapted to a changing climate (e.g. increasing extreme heat), but also moderate economic (enhanced attractiveness of retail and business precincts) and moderate environmental benefits. Social and

environmental costs were assessed as low, but economic costs moderate because of the costs of developing and starting to implement the guidelines.

Responsibility: Local government (six regional councils)

Diversification of agricultural activities

Climate change will lead to warmer and drier conditions in the RH&C region, and without adaptation will lead to declines in agricultural productivity and viability. Projected increasing fire incidence is also likely to damage stock and farm plant and equipment. However, the milder existing conditions in the region mean that other parts of South Australia already experience similar climatic conditions to those projected for the RH&C region. By learning from warmer and drier parts of the state, diversification of agricultural activities can be facilitated, including: planting different varieties and types of crops and pasture, identifying better adapted livestock types, and implementing alternative livestock management practices.

This option was assessed as having high social and economic benefits because of the importance to people's livelihoods and the region's economy of maintaining agricultural production in the region. Social, economic and environmental costs were assessed as being relatively low.

Responsibility: Farming systems groups, industry associations, Primary Industries and Regions South Australia, Regional Development Australia Adelaide Hills, Fleurieu and Kangaroo Island

Develop more energy efficient housing

While the RH&C region is already at an advantage compared to other parts of South Australia because of its comparatively cooler climate, climate resilient buildings will be more suited to the warmer and drier conditions that will emerge in the future. A major element of climate resilient buildings will be energy efficient building materials and fixtures. These can be supported through government incentives, but will also benefit from local government advocating development of such materials, working with the development industry (e.g. builders, developers, manufacturers) and research institutes.

This option was assessed as having high social benefits because of reduced cost of living pressures and the creation of more climate-ready housing that will improve health and well-being and reduce energy consumption. The economic benefit was assessed as moderate because of the opportunity to stimulate economic activity while the economic cost was low because the primary role of local government is as an advocate and facilitator of change.

Responsibility: Local government (six regional councils), Regional Development Australia Adelaide Hills, Fleurieu and Kangaroo Island

Incorporate infrastructure design allowances for increases in extreme events

Infrastructure in the region provides essential services including electricity, potable water supply, water management and transport services. Current infrastructure has been designed for existing climate conditions, however, these will change in the future as periods of extreme heat increase, fire risk becomes higher, and the risk of flooding and sea inundation in low lying areas increases. A regional adaptation priority is for local government in particular to ensure that new and renewed infrastructure is designed to cope with increases in extreme events. The goal is for this to become a business-as-usual activity. This is important given that the operational lifetime of many assets will be in excess of 50 years, meaning that the climate in 2070 and beyond needs to be considered. The rapid growth of the region's population means that new infrastructure in particular can include design allowances for extreme events.

This option was assessed as having high economic costs and benefits. The cost of constructing infrastructure to new specifications would be high, however, the benefits from avoiding additional costs due to infrastructure failure in the long term would also be high. Improved continuity of service provision in the future results in a high assessed social benefit.

Responsibility: Local government (six regional councils), Department of Planning, Transport and Infrastructure, Regional Development Australia Adelaide Hills, Fleurieu and Kangaroo Island

Improved management of native vegetation on private properties

While vast areas of remnant vegetation exist on protected public lands, important vegetation and habitats also exist on private property. A future adaptation priority across a range of landscape types in the region is to support landholders managing native vegetation on private properties, where possible through the use of well-funded incentives. This will require leadership from private landholders and support from Natural Resources Management Boards and the Department of Environment, Water and Natural Resources, with the latter providing incentives for improved management.

This option was assessed as having high environmental and moderate social benefits, because of improvements in ecosystem conditions and health and well-being of the community, respectively. In contrast, the economic costs and benefits were both assessed as moderate.

Responsibility: Natural Resources Adelaide and Mount Lofty Ranges and the Department of Environment, Water and Natural Resources

Restricting development in hazard prone areas

In order to reduce impacts on people and infrastructure, a key adaptation strategy in the region will be to prevent or restrict development in hazard prone areas. This includes areas at risk from sea level rise along the coast, bushfires inland and infrastructure and dwellings at risk from flooding following intense rainfall events. Local government will work together on modelling and mapping projects to identify areas at high risk and implement policy and development plan amendments. This response may take some time to gain community support, however, in the long term it will avoid impacts on people and reduce the costs associated with protecting or relocating assets and people.

Because restricting development in hazard prone areas will require a range of actions in order to meet its objectives (e.g. mapping, modelling, policy review), consideration should be given to how implementation is sequenced, specifically determining what actions are required immediately and what can be delayed for delivery in five or more years time.

This option was assessed as having high social and economic benefit because of avoided impacts on community health and well-being and reduced damage and costs of repair for residential and commercial buildings, infrastructure (e.g. transport, water management) and essential services.

Responsibility: Local government (six regional councils), Department of Planning, Transport and Infrastructure, Coast Protection Board

Increase stormwater harvesting to improve water quantity and quality management

Water will continue to be essential for the health and well-being of the community, economic prosperity and environmental condition in the RH&C region. With rainfall seasonality, quantity and intensity projected to change, greater emphasis is required on water quality management, especially in relation to stormwater. Managed well, stormwater can be a resource to support different sectors in the region, but if managed poorly, it could have a significant negative impact on receiving waterways such as rivers, streams, wetlands and coastal ecosystems. Water quality improvement will require continued investment in water sensitive urban design, stormwater retention areas and water recycling.

This option was assessed as having high environmental and high social benefits but low respective costs because of the improved management of flood risk and water quality. The economic costs and benefits were both assessed as high because of high construction costs on the one hand and avoided costs from flood damage on the other.

Responsibility: Local government (six regional councils), Natural Resources Adelaide and Mount Lofty Ranges, Water Sensitive SA

In addition to the regional priority adaptation options described above, consideration of the triggers, enabling conditions and barriers for decision making suggest that the following two actions are also regional priorities:

Anticipatory monitoring and evaluation – This Plan identifies a range of triggers that will either inform or drive decision making for climate change adaptation in the region. While many of the triggers are reactive, a proactive approach to informing decision making is also required. As such, it is essential that partners in the region invest in anticipatory monitoring and evaluation to detect climatic change impacts and develop conceptual models of likely change and triggers for different strategies. This links strongly with the adaptation pathways approach whereby the results of such monitoring can better inform when adaptation options should be commenced.

Responsibility: Local and state government, RDA Adelaide Hills, Fleurieu Peninsula and Kangaroo Island, industry groups.

Education and awareness raising – The need to better inform the community and businesses about the broad range of potential impacts of climate change was considered for almost all of the key areas of decision making. While it was assessed as an adaptation option in its own right, it is also an essential enabler of many of the high priority options identified in this Plan. Education and a wareness raising should be progressed through the development of a Resilient Hills and Coasts education and awareness raising program that works across the community and businesses.

Responsibility: Local and state government, RDA Adelaide Hills, Fleurieu Peninsula and Kangaroo Island, industry groups.

Photo: Courtesy of Natural Resources Kangaroo Island

Table 3. Alignment of regional priority adaptation options for key areas of decision making.

Regional priority adaptation options	Key area of decision making themes									
	Infrastructure and assets	Agriculture	Built coastal assets	Climate-ready buildings	Emergency management	Community facilities and open space	Vulnerable members of community	Water dependent ecosystems	Coastal ecosystems	Landscape Conservation
Adaptive management of protected areas on public lands					✖	✖		✖	✖	✖
Climate-ready guidelines for public realm and streetscape management	✖		✖	✖	✖	✖	✖			
Diversification of agricultural activities		✖								✖
Energy efficient housing	✖			✖						
Incorporate infrastructure design allowances for increases in extreme events	✖		✖	✖	✖	✖	✖			
Managing native vegetation on private properties		✖			✖			✖	✖	✖
Restricting development in hazard prone areas	✖		✖	✖	✖	✖	✖		✖	✖
Water quality improvement measures through improved stormwater management and harvesting	✖	✖		✖	✖	✖		✖	✖	✖

Opportunities

Whilst the region faces significant challenges in adapting to climate change, it is better placed than many other regions in the State due to its naturally cooler climate and diversity of industries, tourism attractions and amenities across the region. Another important factor for the region is that the population is expected to grow further, especially in locations such as Mount Barker, Victor Harbor and Goolwa (Resilient Hills and Coasts, 2014a).

These drivers present opportunities in responding to a changing climate. For example, the preferable climate and increasing population could stimulate business activity such as in the construction and service sectors. This could lead to opportunities such as:

- encouraging the development of low carbon communities with housing that is energy and water efficient and resilient to climate change
- incorporating climate-ready design principles into new buildings and essential services infrastructure
- increasing interest in green infrastructure for residential developments.

In addition, the region offers a diversity of tourism experiences, which present greater resilience to a changing climate. For example, summer tourism based on coastal attractions is still likely to be popular because of the comparatively lower temperatures experienced on the Fleurieu Peninsula compared with metropolitan Adelaide. However, even if tourism was to decline during the summer period as a consequence of greater periods of extreme heat and more frequent fire risk days, the region still offers tourism experiences during other seasons e.g. autumn leaves/gardens festivals, winter bed and breakfast getaways. With climate change responses in South Australia now focusing on both adaptation and low carbon economic growth, the Resilient Hills and Coasts region is well positioned to build resilience to a changing climate by implementing the adaptation options identified in this Plan, as well as benefit from climate change mitigation opportunities that will be associated with greater adoption of climate-ready housing, installation of new energy infrastructure (e.g. solar PV), diversifying agricultural activities to include soil carbon sequestration and investing in natural landscape restoration (e.g. through revegetation).

Periodic review

As the climate changes over time, more information will become available on the impacts on key sectors in the region and possible opportunities. This will mean that adaptation options will require periodic review, resulting in some options ceasing to be implemented, while others not currently considered a priority will commence. New options will also emerge. Reviews can be designed to coincide with regional partner planning review timeframes, the emergence of significant new understanding or innovation, or the availability of new climate projection data from the IPCC, which occurs about every five to six years.

Periodic review can be aided through the development of indicators to determine the extent to which priority adaptation options are being implemented, and whether triggers for decision-making are being met. Developing such indicators can build on the triggers identified for each of the individual key areas of decision-making themes. This will likely involve a combination of climate (e.g. average temperature, annual rainfall, extreme heat, sea level, number of severe or worse fire danger days) and system related indicators (e.g. condition of infrastructure and property damage, condition of ecosystems, hospital admissions).

Future reviews should also consider when adaptation will need to move beyond continuing with existing best practice and moving toward greater transformational responses, such as may be the case where people or infrastructure will need to be relocated in high risk areas.

Acknowledging that both information and impacts will change, the response to the changing climate will need to be adaptive. It is recommended that climate change indicators, impacts and progress toward implementation of actions be reviewed at least every two years. The governance of this arrangement will need to be resolved, and the potential for a Regional Sector Agreement may be one way to ensure ongoing monitoring and evaluation.

Photo: Courtesy of Alexandrina Council

Alignment with adaptation in the South Australian Murray-Darling Basin

Alexandrina Council and the District Council of Mount Barker Council overlap with parts of the South Australian Murray-Darling Basin Natural Resources Management Region, meaning that comparison of adaptation priorities in this neighbouring region are warranted.

The climate change adaptation plan for the South Australian Murray-Darling Basin (SAMDB) called "Building Resilience to a Changing Climate" (Siebentritt, *et al.*, 2014) was released in 2014 and was informed by past studies and reports relevant to climate change in the region as well as the experience and local knowledge of stakeholders, with over 150 people participating in interviews, workshops and information and feedback sessions.

The project followed a similar process to the development of the RH&C Adaptation Plan, involving values mapping, an integrated vulnerability assessment and identification and prioritisation of adaptation actions within and between sectors.

There is strong alignment between the SAMDB Plan and this Plan, with the former's key area of decision making themes being:

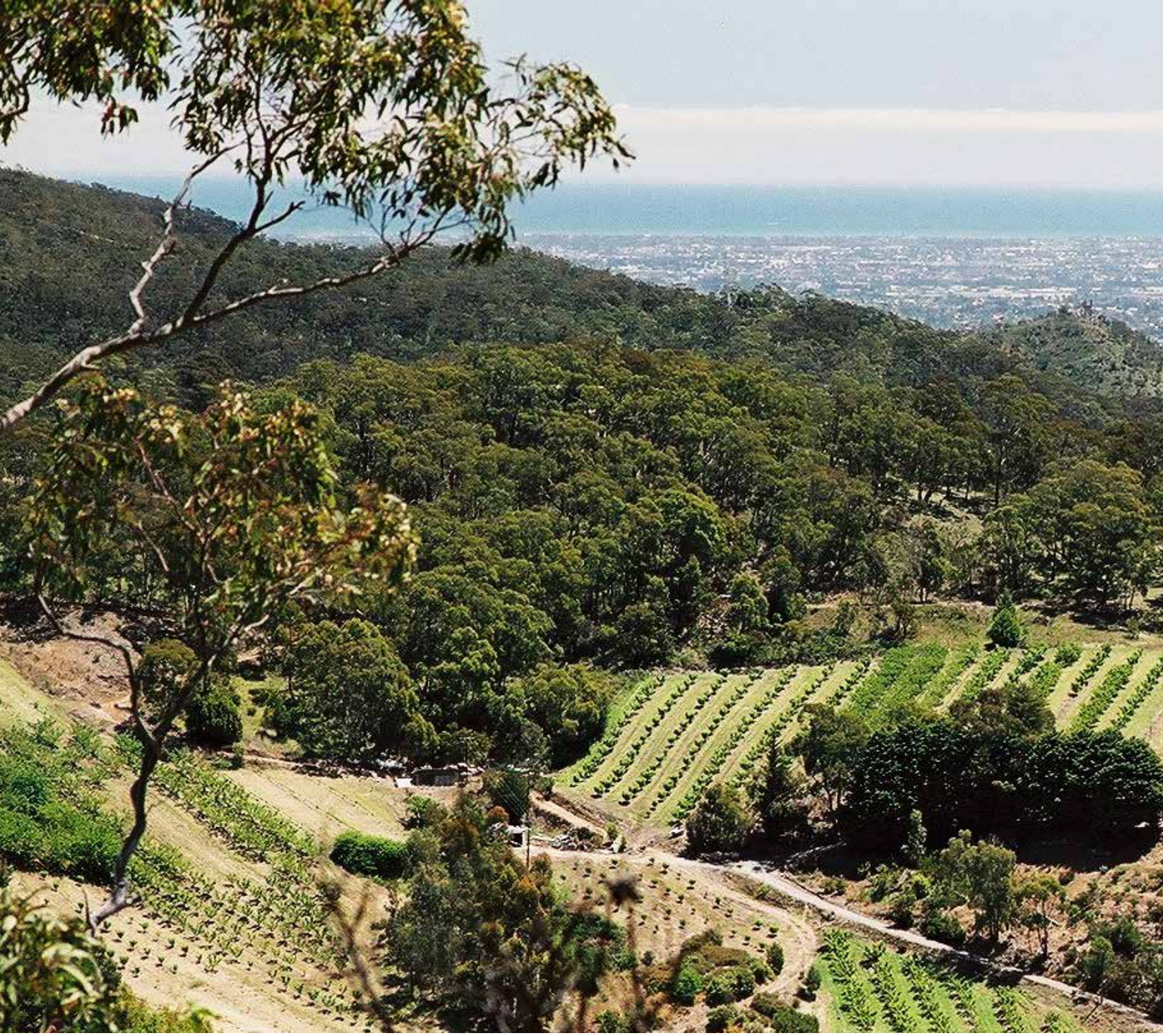
- native vegetation
- pest plants and animals
- Coorong and Lower Lakes
- vulnerable members of the community
- emergency services
- essential services
- irrigation
- dryland farming:

The primary difference between the plans is the focus on water management for irrigation and the environment as it relates to the River Murray in the Murraylands and Riverland areas.

The priority adaptation options from the SAMDB Adaptation Plan that most directly align with the RH&C region, and where opportunities may exist to collaborate for relevant RH&C partners, include:

- **Native vegetation** - support and promote landholders managing high value native vegetation on private properties
- **Coorong and Lower Lakes** - commence social engagement to increase community awareness and to promote informed debate about the future adequacy, operation and location of the Barrages
- **Vulnerable members of the community** - help vulnerable members of the community be better prepared for extreme events by building social capital (connectivity and resilience) and encouraging the construction of more climate resilient buildings
- **Emergency services management** - facilitate increased rates of volunteerism
- **Essential services** - develop adaptive infrastructure for local solutions to backup and power storage for water, sewer and telecommunications infrastructure, as well as domestic storage to support distributed power systems like solar photovoltaic (PV)
- **Dryland (rain dependant) farming** - no till or reduced till practice, crop breeding and soil improvement where applicable and cost effective should continue to be encouraged.

None of the adaptation priorities identified in the SAMDB Adaptation Plan are considered to be maladaptive in relation to RH&C priorities.



Open consultation

Over 120 people from across from community, business, government, industry, academia and project partners attended project workshops and focus groups that informed the development of the vulnerability assessment and adaptation plan. Additionally, over 270 people involved in the project since its inception in 2014, were emailed a direct link to the draft adaptation plan and invited to provide feedback.

A public consultation process was also conducted inviting feedback from community on the draft plan. Through this process, the project received thirteen written submissions ranging in views, but the majority supported the adaptation options contained in the Plan. Feedback received will inform implementation, and among constructive criticisms and ideas received, project partners noted:

- the ongoing acknowledgement that mitigation and adaptation are both critical in responding to our changing climate
- responsive planning and action is required, noting that the Plan is based on a medium emissions scenario (RCP4.5) and future planning will need to track and respond to changes and impacts as they evolve (especially if climate change continues to track at the higher emissions scenario)
- the need to further involve and empower community and community groups in both awareness raising across multiple platforms (open forums, media articles, social media) and action (incentives, provision of research, real-world examples)

Photo: Courtesy of Natural Resources Adelaide & Mt Lofty Ranges

- the importance of the next generation in climate change adaptation – programs and projects with schools should be considered
- the necessity to facilitate cooperative and collaborative arrangements between multiple layers of government around key themes such as research and dissemination of information, hazards mapping, and development planning and regulation
- vegetation is an important climate change adaptation consideration and requires collaborative initiatives and support to manage and conserve remnant vegetation and to facilitate revegetation
- government has a critical role to play in fostering behavioural change and leading by example
- innovation is a critical factor in adapting to climate change – from crop diversity to biosequestration, from incentive schemes to establishing new industries (such as native foods), from alternative housing design to planning regulations - more research and support is required to support adaptation
- there is an ongoing need to provide clear and accessible information for multiple audiences, and tangible and specific examples of adaptation action is crucial in promoting awareness and empowering future action.

Project partners thank everyone who has been involved in the project, including those who have taken time to share their knowledge and ideas through recent consultation.

Next steps

As climate change continues to increase in its magnitude and impact across the globe there is a need for rapid decarbonisation and significantly increased carbon sequestration. At the same time, local and regional communities and businesses need to start adapting to a changing climate that will be very different to what is currently being experienced.

This Plan has outlined sector-specific adaptation priorities as well as regional scale adaptation priorities that deliver a combination of social, economic and environmental benefits and that are relevant to all project partners. Successful implementation of the Plan requires:

- Momentum
  - Project partners recognise that maintaining momentum as the project transitions from planning to implementation is a critical factor in ensuring its success in building resilience and enabling adaptation.
  - Partners have committed to a 12-month implementation phase to transition from planning into action.
- Localising action
  - The Plan adopts a regional perspective. In the next stage, the RH&C steering committee will collaborate with a range of partners to implement regional priorities identified in the Plan.
  - Utilising the knowledge and data accumulated during the regional planning process it is intended that each of the local council areas will produce a local action plan to guide tailored, sub-regional action.

Photo: Courtesy of Natural Resources Kangaroo Island

- Each of the local government partners is committed to working with their communities to localise climate change adaptation planning and action in alignment with relevant regional priorities identified herein.

- Responsive project management
  - Ongoing evaluation and lessons learnt will inform decision-making.
  - Governance arrangements will be reviewed and improved to ensure that project governance is adaptive and fit for purpose.
  - A framework for monitoring, and evaluating progress against priorities will be designed and implemented.
- Guarding against maladaptation
  - Maladaptation occurs when an adaptation action taken to help one sector or system has a negative consequence on another.
  - While the Plan has a clear list of priority adaptation options, climate change adaptation must also consider the decisions that are being made in general across the region and whether these are maladaptive, that is, reducing adaptive capacity of the community or businesses.
- Strengthening engagement and partnerships
  - Project partners are committed to expanding and strengthening engagement and collaboration across the region, not only with each other, but with community, industry, business, education and government sectors.
- Flexibility and revision
  - Local and regional communities and businesses need to start adapting to a changing climate that will be very different to what is currently being experienced. While change is occurring and will continue, the exact rate and extent is not known with precision. This means that a flexible adaptation approach with regular revision based on how sectors and systems are changing in response to a changing climate.
  - Climate change projections will continue to be reviewed and refined as the climate continues to change and actions are taken locally and globally to mitigate emissions and slow the rate and magnitude of change. This information should be used to inform reviews of progress against this plan and additional actions that may be required.
  - At the same time, new technologies and experiences from around the globe will influence how we respond to climate change impacts, including how climate change impacts interact with other global challenges such as food security.
  - The project partners recognise that the current Plan is based on the best available scientific knowledge and practical stakeholder knowledge at the time of the workshops and writing, and that adaptation actions and priorities may need to change in the future as scientific and technological advances occur, and we continue to learn from our own and others' experiences.

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Glossary

Unless stated otherwise, all definitions are from IPCC (2013a, 2014).

Adaptation - the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.

- *Incremental adaptation* - *Adaptation* actions where the central aim is to maintain the essence and integrity of a system or process at a given scale.
- *Transformational adaptation* - *Adaptation* that changes the fundamental attributes of a system in response to climate and its effects.

Aerosol - a suspension of airborne solid or liquid particles, with a typical size between a few nanometres and 10 µm that reside in the atmosphere for at least several hours. Aerosols may influence climate in several ways: directly through scattering and absorbing radiationand indirectly by acting as cloud condensation nuclei or ice nuclei, modifying the opticalproperties and lifetime of clouds.

Atmosphere - the gaseous envelope surrounding the Earth.

Baseline/reference - the baseline (or reference) is the state against which change is measured.

Climate - usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years.

Climate change - climate change refers to a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.

Climate change in Australia (CCIA) – a national-focused climate change project released in February 2015 and led by the CSIRO and Bureau of Meteorology (CSIRO and Bureau of Meteorology 2015).

Climate model (spectrum or hierarchy) - a numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for some of its known properties.

Climate variability - climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes etc.) of the climate on all spatial and temporal scales beyond that of individual weather events.

Emission scenario - a plausible representation of the future development of emissions of substances that are potentially radiatively active (e.g. greenhouse gases, aerosols) based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socioeconomic development, technological change) and their key relationships.

Greenhouse gas - greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and by clouds.

Global climate model (GCM) – also called general circulation models are mathematical representations of the climate system which explicitly represent large-scale synoptic features of the atmosphere (CSIRO and Bureau of Meteorology 2015).

Integrated vulnerability assessment (IVA) – a process used to assess the likelihood (or exposure) and consequence (or sensitivity) of climate change impacts on key issues, as well as assessing the adaptive capacity of issues in order to ensure a full understanding of vulnerabilities (Local Government Association of South Australia 2015).

Key Area of Decision Making - an area of decision-making in an organisation, sector or region within which adaptation options may be needed to manage the impacts of climate change on an asset, value or service (Siebentritt and Stafford-Smith *in review*).

McArthur Forest Fire Danger Index (FFDI) - The McArthur Forest Fire Danger Index (FFDI) is widely used to forecast the influence of weather on fire behavior. FFDI is based on the temperature (°C), T, wind speed (km h-1), v, relative humidity (%), RH, and a component representing fuel availability called the Drought Factor (Dowdy *et al.* 2009).

Mitigation - a human intervention to reduce the sources or enhance the sinks of greenhouse gases.

Projection - a projection is a potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Unlike predictions, projections are conditional on assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realised.

Radiative forcing - radiative forcing is the change in the net, downward minus upward, radiative flux (expressed in W m–2) at the tropopause or top of atmosphere due to a change in an external driver of climate change.

Regional climate model (RCM) - a climate model at higher resolution over a limited area. Such models are used in downscaling global climate results over specific regional domains.

Representative concentration pathways (RCP) - scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases and aerosols and chemically active gases, as well as land use/land cover.

South Australia Climate-ready (SACR) – a Goyder Institute research project to develop an agreed set of downscaled climate change projections for South Australia to support proactive responses to climate change in water resource planning and management at a State and regional scale (Goyder Institute 2015).

Trigger - when a monitored system driver (e.g. sea level rise or temperature rise) changes to a point where existing response options should be reviewed and new options implemented, i.e. a decision point is triggered. A trigger may occur without a threshold yet being reached (e.g. a degree of sea level rise not yet expressed in terms of a bad flood because a storm tide has not yet happened), but the conditions are set for a system threshold to be crossed before decision-makers can do anything about it. Note that a trigger should be easily monitored, for quick action.

ATTACHMENT A - WORKSHOP AND FOCUS GROUP PARTICIPANTS

Stakeholders involved in developing the Resilient Hills and Coasts Climate Change Adaptation Plan who attended either a project workshop or focus group. People shown in bold text are members of the RH&C project's steering committee.

Name	Organisation
Mark Agnew	Natural Resources Kangaroo Island
Glyn Ashman	SA Water
Pat Austin	Kangaroo Island Council
Zafi Bachar	**Natural Resources Adelaide and Mount Lofty Ranges**
Carol Bailey	District Council of Mount Barker
Sherie Bain	Goolwa - Wellington LAP
Jenny Bell	Community member
Jeremy Bell	Be Active Field Officer
Sharon Bremmer	Strathalbyn District Commerce Association
Piers Brissenden	Natural Resources Adelaide and Mount Lofty Ranges
Lauren Burton	**Department of Environment, Water and Natural Resources**
Sarah Carlson	Adelaide Hills Wine
Glen Carter	DC Mount Barker
Alan Collett	SA Water
Ben Coventry	City of Victor Harbor
John Crompton	City of Victor Harbor
Michael Cutting	Natural Resources South Australian Murray-Darling Basin
Peter Dinning	Alexandrina Council
Lyn Dohle	PIRSA
Brian Doman	**City of Victor Harbor**
Alex Donald	SA Water
Caroline Dorr	Department of Environment, Water and Natural Resources
Peter Doumouras	Department of Environment, Water and Natural Resources
Rebecca Duffield	Conservation Council SA
Alison Eaton	Department of Environment, Water and Natural Resources
Ranae Eden	Adelaide Hills Council
Jeff Edwards	Department of Environment, Water and Natural Resources
Anne Ellis	Adelaide Hills Council
Rob Ellis	Natural Resources Kangaroo Island
Gene Evans	Livestock SA
David Farrelly	**Alexandrina Council**
John Fernandez	Kangaroo Island Council
Julie Fiedler	Horse SA
Grant Flanagan	Natural Resources Kangaroo Island
Nicole Fox	District Council of Mount Barker
Tony Fox	Department of Environment, Water and Natural Resources
Peter Francis	Port Elliot Surf Life Saving Club
Margaret Gardener	Alexandrina Council
Grant Gartrell	Alexandrina Council
Carol Gaston	Goolwa and District Community Bank
Joan Gibbs	University of South Australia
Linda Green	Adelaide Hills Council

Name	Organisation
Steve Gregor	Kangaroo Island Natural Resources Management Board
Debra Gregory	Alexandrina Council
Tom Gregory	Alexandrina Council
Simon Grenfell	Alexandrina Council
Jeff Grinnell	Adelaide Hills Council
Peter Hammond	Viticulture
Alan Harvey	Alexandrina Council
Peter Hayman	South Australian Research and Development Institute
Kathy Hayter	**Alexandrina Council (RH&C Project Co-ordinator)**
Peter Heylen	Country Fire Service
Phillipa Holden	**Natural Resources Kangaroo Island**
Vivienne Holloway	City of Victor Harbor
Andrew Houlihan	Alexandrina Council
Sara Hourez	Kangaroo Island Natural Resources Management Board
Amelia Hurren	Trees for Life
Corey Jackson	District Council of Yankalilla
Kate Jessep	City of Victor Harbor
Martine Kinloch	Natural Resources Kangaroo Island
Lisa Kirwan	Alexandrina Council
Olga Kostic	RDA Adelaide Hills, Fleurieu and Kangaroo Island
Miranda Lang	Fleurieu Peninsula Tourism
Patrick Langlands	Yankalilla Council
Terry Lee	**RDA Adelaide Hills, Fleurieu and Kangaroo Island**
Sharon Leith	**Adelaide Hills Council**
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David Lloyd	University of SA
Jan Loveday	RDA Adelaide Hills, Fleurieu and Kangaroo Island
David Lynch	Kangaroo Island Council
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Ian MacFarland	Sheep Connect SA
Karl Manarangi	District Council Mount Barker
Shen Mann	**Alexandrina Council**
Ross Manthorpe	Rural Skills Australia
Peter Manuel	Flag Australia
Graeme Martin	**Southern Hills Local Government Association**
Bev Maxwell	Viticulturalist
John McArthur	Adelaide Hills Council
Priti Meda	SA Fire & Emergency Services
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Lachlan Miller	Adelaide Hills Council
Damian Moroney	Natural Resources Adelaide and Mount Lofty Ranges
Kerri Muller	Kerri Muller NRM
David Mullins	Alexandrina Council

Name	Organisation
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Graham Philp	City of Victor Harbor
Sheryn Pitman	DEWNR
Luke Price	Natural Resources Adelaide and Mount Lofty Rages
Terri Purvis	SA State Emergency Service
Dennis Rainsford	Adelaide Hills Council
Peggy Rismiller	Kangaroo Island Natural Resources Management Board
Sally Roberts	Alexandrina Council
Matt Robertson	**District Council of Yankalilla**
Dan Rogers	Department of Environment, Water and Natural Resources
Karen Rokicinski	Alexandrina Council
Greg Sarre	**District Council of Mount Barker**
Anna Schmidt	Alexandrina Council
Liz Schofield	Goolwa to Wellington Local Action Planning Association
John Sharp	Livestock SA
Rebecca Shepherd	Adelaide Hills Council
Ben Simon	Goolwa to Wellington Local Action Planning Association
Sally Smith	Adelaide Hills Tourism
Bill Spragg	Adelaide Hills Council
Cameron Stafford	Rural Land Management, Adelaide Hills Council
Martin Stokes	Natural Resources Adelaide and Mount Lofty Ranges
Kathie Stove	Kangaroo Island Natural Resources Management Board
Neville Styan	Alexandrina Council
Susan Sweeney	Department of Environment, Water and Natural Resources
Bronson Symmonds	Alexandrina Council
Caroline Taylor	Natural Resources Adelaide and Mount Lofty Ranges
Richard Trethewey	Kangaroo Island Natural Resources Management Board
Tim Vale	Conservation Council SA
Jason van Weenan	Natural Resources Adelaide and Mount Lofty Ranges
Marta Vergara-Godoy	SA Water
Lynton Vonow	Adelaide Hills Council
Peter Watton	Trees for Life
Martin Weidenbach	Natural Resources Adelaide and Mount Lofty Ranges
Susan Wiliams	University of Adelaide
Aaron Wilksch	**Kangaroo Island Council**
Amy Williams	Primary Producers SA
Colin Wilson	Viticulturalist
Matt Wittwer	Adelaide Hills Council
Graeme Wynwood	SA State Emergency Service

ATTACHMENT B - HIGH VULNERABILITY INDICATOR SUMMARY

High vulnerability indicators identified in the integrated vulnerability assessment. Indicators were relatively ranked as high, medium, or low based on their vulnerability score, where: Vulnerability = ((Exposure + Sensitivity) – Adaptive Capacity) + 10

Theme	High Priority Indicators
Adelaide Hills and Fleurieu Peninsula	
Agriculture	Agricultural productivity, mostly in relation to horticulture, viticulture and dryland grazing
Biodiversity (marine, aquatic, terrestrial)	Condition of wetlands and riparian zone ecological communities Condition of native vegetation (woodlands, forests, grasslands, scattered trees) Condition of reefs and sea grass in marine habitats Condition and extent of coastal zone ecological communities
Coastal management	Condition of public coastal assets
Community health & well-being	Health safety and well-being of vulnerable members of the community, defined as people aged over 75 years and under 15 years, people with a disability, and people from low income households Community participation in clubs, organisations and groups Community services and facilities meet the needs of all community members
Emergency management	Demand for emergency management services
Infrastructure & urban areas	Condition and effective operation of public and privately owned buildings, including State and local built heritage items and retail and commercial centres in towns Effective operation of road network
Kangaroo Island	
Community connectedness	Participation in industry associations Participation in organised sport, church or community group in local area
Social inclusion/exclusion	Impact on people geographically isolated from transport services
Essential services	Condition and performance of energy and telecommunications network infrastructure
Transport services	Condition of roads
Health	Impact on people aged over 65 years
Primary production	Level of production (wild catch fisheries)
Local government services	Property values
Biodiversity	Number of native flora species/communities that are threatened (regional, state) Area of native vegetation cover outside of DEWNR reserves Seabirds Abundance and diversity of frogs Area of native vegetation cover by vegetation type (Forest)
Pest plants and animals	Impact of pest plant and animal threats to the terrestrial environment
Water	Quality of surface water

ATTACHMENT C - ADAPTATION OPTIONS

The following table provides the full list of adaptation options identified for each of the key areas of decision-making. Shown for each adaptation option is an assessment by workshop participants of whether the option is: currently occurring in the region and will be suitable in its current form for adaptation (current); currently occurring but will require some alteration to be suitable for adaptation (altered); or is not currently occurring in the region but should be implemented to facilitate adaptation (new).
NB. Not all options were assessed as to whether they were current, altered or new.

Theme	Adaptation options	Current	Altered	New
Adelaide Hills and Fleurieu Peninsula				
Climate-ready buildings	1. Relocate existing infrastructure and housing.			✓
	2. Provide incentives for increased construction of "climate-ready" buildings.		✓	
	3. Raise awareness about the benefits of climate-resilient buildings particularly within the building industry and community.	✓		
	4. Identify barriers to implementing existing provisions of the building code for climate-ready housing.	✓		
	5. Mandate minimum sustainable building requirements in some new residential developments.	✓		
	6. Prepare guidelines on how to encourage greater use of climate-ready building techniques.			✓
	7. Propose amendments to the development plan regarding minimum requirements.	✓		
	8. Better integrate building standards and planning regulations.		✓	
	9. Consider replacing buildings less suited to the projected changing climate.			✓
	10. Encourage cultural change promoting climate-ready building in the building and development industry including insurance and finance industries.	✓		
	11. Region-wide development plan initiatives for climate-ready housing.	✓		
	12. Cultivate a reputation as a region for climate-ready buildings.	✓		
	13. Increase affordable energy-efficient building materials and fixtures through government incentives including an advocacy role for local governments.		✓	
	14. Ensure quality control of products going into buildings based on minimum requirements and enforcing this through certification.		✓	
	15. Advocacy partnerships for building industry regarding climate-ready approaches including not creating limiting deals.	✓		
	16. Agree to a minimum standard for what constitutes a climate-ready building (eg. Local government defines characteristics).		✓	
Community facilities and open space areas	1. Increase installation of Water Sensitive Urban Design features.	✓	✓	
	2. Enhance 'greenness' of retail and commercial centres, especially main streets and car parking areas to reduce urban heat island effect.	✓	✓	
	3. Prepare 'climate-ready' guidelines regarding public realm/streetscape management including: appropriate material and species selection, shade cover, inclusion of Water Sensitive Urban Design features, opportunities for misting infrastructure, and water features.			✓
	4. Implement Policy and Development Plan amendments that restrict development in inundation (sea level rise) hazard areas and require climate sensitive building design.			✓
	5. Provide education and awareness to support activity centres, small-medium enterprises, and business groups (e.g. to plan for emergency preparation, response and recovery).			✓
	6. Provide additional bushfire management techniques around buildings, for example installation of mounds or sprinklers connected to back-up water.	✓	✓	
	7. Raise community awareness regarding climate change and its impact on irrigation in order to reduce expectations regarding maintenance levels and what constitutes best practice.			✓
	8. Investigate and implement innovative techniques for cooling public realm (e.g. solar fans, cooled bus stops, shading techniques and wall gardens).			✓
	9. Modify timing and location of sporting events including evening and twilight events and/or use of indoor facilities.			✓
	10. Amalgamation/co-location of facilities including schools and local council and regional facilities.	✓	✓	✓

Theme	Adaptation options	Current	Altered	New
	11. Undertake further research into and implement more appropriate surface materials for sporting ovals and tennis courts.		✓	✓
	12. Increase shared use/consolidation of sporting facilities.			✓
	13. Modify current governance models from small local clubs focus to a broader management structures model.			✓
Emergency management	1. Facilitate increased volunteerism.			✓
	2. Improve early warning systems for extreme events.	✓	✓	
	3. Enforce section 105 notices regarding clean-up of land and fuel load.	✓		
	4. Reduce red-tape and OH&S barriers to volunteering for SES, CFS.			
	5. Establish and implement early warning systems for storms, floods, fires and other hazards.		✓	
	6. Work with the Insurance Council of Australia regarding community messaging around risk and insurance.			✓
	7. Regulate development in high risk areas (measures to protect rather than prevent).		✓	
	8. Undertake modelling to identify future areas at high risk from bushfire, heatwaves, and flooding from sea level rise.		✓	
	9. Community education on potential emergency hazards (prior to an event) through CFS, and local government (e.g. welcome packs for new residents) using an 'All hazards' and regional education approach.		✓	
	10. Establish informal networks (social connectivity) through community groups. (eg. through local sporting clubs.		✓	
	11. Advocate for legislative change to Fire and Emergency Services Act to reduce timeframes for 'action in default' of section 105F.			✓
	12. Increase engagement by local government, CFS and other emergency management agencies. Increase support of these agencies.		✓	
	13. Educate/engage with persons from non-English speaking backgrounds within our communities. Assist emergency services to get information to pickers/employers of visitors. Tap into these sites for educating.			✓
Landscape conservations	1. Manage, restore, and increase connectivity to support migration and range shifts of flora and fauna.		✓	
	2. Identify, manage, protect, and increase refugia.		✓	
	3. Inspire positive ecosystem/human interactions.			✓
	4. Identify, measure and monitor ecosystem services and integrate ecosystem services with sustainable living practices.			✓
	5. Continue to include 'local species' in plantings, as some may adapt.	✓		
	6. Investigate the use of non-local native species which may be more resilient to changing climatic conditions.			✓
	7. Favour land use changes with positive rather than negative biodiversity outcomes.		✓	
	8. Manage landscapes for desired and manageable fire regimes.		✓	
	9. Consider and prepare for potential transitions in vegetation communities.			✓
	10. Explore the potential benefits of underground houses including reduced bushfire risk and less energy consumption for in-door climate regulation.			✓
	11. Value natural capital against other types of capital.			✓
Vulnerable members of the community	1. Implement and enhance heatwave response services (e.g. Telecross REDi service).	✓	✓	
	2. Scope potential government responses relating to provision of heat refuges.	✓	✓	
	3. Facilitate increased participation in community activities to build social capital (connectivity and resilience).	✓	✓	
	4. Raise education and awareness regarding health impacts of climate hazards.	✓	✓	
	5. Review and refine State arrangements for emergency warnings and communications for tourists and visitors to the region.	✓	✓	✓
	6. Amend development plan policy to prevent construction of community facilities in high risk areas.	✓	✓	
	7. Adopt more climate sensitive building designs.	✓	✓	
	8. Install back-up power supplies to offset the impacts of strategic power outages by electricity distribution companies.			✓
	9. Plant more appropriate trees in urban areas, with a focus on vulnerable community hotspots.	✓	✓	

Theme	Adaptation options	Current	Altered	New
	10. Assess and plan for population growth impacts on infrastructure.			✓
	11. Implement energy rebates for low income earners.	✓	✓	
	12. Implement affordable alternative sources of energy accessible to people low income.	✓	✓	✓
	13. Increase education and awareness regarding what to do before and during extreme hazard events.	✓	✓	
	14. Improve emergency hazard notification systems in relation to fire/flood/storm– including clearer information on where and when events are occurring.	✓	✓	✓
	15. Improve the ability of vulnerable people to evacuate safely during extreme conditions.			✓
Agriculture	**1.** Undertake research and development for chill units including adapting varieties and researching sprays.		✓	
	2. Identify, trial and establish new crop varieties.		✓	
	3. Research and implement alternative vine canopy management to benefit viticulture.			
	4. Modifying stocking rates, water availability (drinking) and feed (import).			
	5. Manage canopies and provide shading (e.g. shade cloth for cherries and apples).	✓		
	6. Use spring and summer seasonal forecasts to prepare ahead of time - research on how historical rainfalls may influence.			
	7. Increase frost mitigation efforts due to potential increase from drying climate.			
	8. Implement research into viability of crops in a changing climate to inform adaptation to suitable varieties.			
	9. Diversify agricultural production.			
	10. Improved dissemination of research to primary producers.			
	11. Increase local government's advocacy role in encouraging research opportunities.			
	12. Implement more water reuse into current projects while projecting impacts of water quality on soils.			
	13. Advocacy role and buy in by community to invest in research and adaptation elements to ensure a readiness for future changes.			
	14. Reverse engineering - what will the climate be in 50 years and what should we be producing at that time. Can then plan and modify practices.			
	15. Facilitate cultural change - evolves over generations.			
	16. Increase current practices of netting.			
	17. Review of supply chains - who are we growing for and where are the markets.			
	18. Assess water quality impacts under future climate change scenarios.			
Coastal ecosystems	**1.** Continue and maintain modelling and mapping to assist with risk management.			
	2. Support sand replenishment programs.		✓	
	3. Abandon selected mudflat and samphire areas that are unable to persist due to coastal squeeze and identify which areas are able to adapt.		✓	
	4. Investigate and implement engineering solutions (e.g. seawalls, artificial seagrass/coral beds).		✓	✓
	5. Relocate buildings and hard infrastructure to enable coastal ecosystem retreat.			✓
	6. Investigate and implement land-use change solutions to minimise sediment load.			
	7. Raise community awareness on coastal processes and reduce expectations on maintenance levels.		✓	
	8. Enhance coastal dunes to provide protection and allow migration.			
	9. Monitor beaches and near shore sand reserves.		✓	
	10. Maintain appropriate functional vegetation.			
	11. Acquire land in high risk areas.			✓
	12. Update coastal vegetation mapping database(s) to assess/monitor changes. e.g. seagrasses, macroalgae and land based ecosystems.			✓
	13. Distribute modelling data on projected sea level rise to incorporate into local decision making.			✓
	14. Amend/add to Planning Regulations and Coast Protection Act to ensure approval processes reflect projected sea level increases.			✓

Theme	Adaptation options	Current	Altered	New
	15. Improve Development Plan zoning of sensitive coastal features including saltmarshes, dunes, coastal wetlands and allow for future inland migration.			
	16. Ensure coastal systems are correctly zoned within Development Plans to ensure protection of systems and assist in infrastructure planning.		✓	
	17. Increase coastal ecosystem resilience through minimising impacts from recreational activities and introduced pest species.		✓	
	18. Improve stormwater quality and reduce stormwater discharge from urban areas through, Water Sensitive Urban Design, recycling, and retention areas.			✓
	19. Maintain and protect existing geographic linkages and establish additional linkages for the migration/translocation of species.		✓	✓
	20. Establish a core repository/location of relevant climate change data related to coastal ecosystems and ensure access by decision making stakeholders.			✓
	21. Continue to promote and update Coastal Action Plans and Costal Conservation studies prepared by Coastal Management DEWNR and rolled out by NRM groups so that data is current.			
Infrastructure assets	**1.** Establish local solutions for backup and domestic power storage.			✓
	2. Integrate decentralised distributed power supply systems.			✓
	3. Avoid construction of essential services buildings in high risk areas.		✓	
	4. Create wider corridors near power lines or substations.	✓		
	5. Consider strategic transport plans considering future transport modes and demands.			
	6. Identify points of vulnerability in the network (e.g. roads database).		✓	
	7. Incorporate design allowances for increases in extreme events.		✓	
	8. Undertake research and development on improved techniques/materials.		✓	
	9. Implement more reuse of waste water through dual use systems for new developments, agricultural use, increased utilisation of ASR, and construction implementation of more Community Wastewater Management Schemes.		✓	
	10. Increase the utilisation of undergrounding power lines in high fire risk areas.	✓		
	11. Increased development in the region due to 'climate refugees' leaving hotter drier Adelaide to Hills or Fleurieu.		✓	
	12. Implement changes to planning and building requirements to promote increased energy efficiency and water use.		✓	
	13. Reduce run-off in urban areas through local detention.		✓	
	14. Documented Risk assessments for climate change on project by project basis for major developments.			
Built coastal assets	**1.** Prepare guidelines for coastal management design.	✓		
	2. Increase support of sand replenishment.		✓	
	3. Develop modelling and mapping for risk management and planning to identify assets at risk.		✓	
	4. Raise awareness regarding coastal processes to reduce expectations.			✓
	5. Protect and enhance coastal dunes.	✓		
	6. Establish hard protection infrastructure.	✓	✓	
	7. Acquire land in high risk areas.			✓
	8. Relocate assets.			✓
	9. Abandon assets.			✓
	10. Trial of impact reducing measures (e.g. Storm surge barriers, sea grass).		✓	
Water-dependent ecosystems	**1.** Implement pest plant and animal control.		✓	
	2. Identify and develop corridors to enable species movement.			
	3. Protect isolated patches of native vegetation and provide additional buffers.		✓	
	4. Support landholders managing native vegetation on private properties.		✓	
	5. Identify, manage and protect refugia.		✓	
	6. Consider landscape engineering solutions.			✓

Theme	Adaptation options	Current	Altered	New
	7. Create reserves with hard boundaries and intensively manage within them.			
	8. Undertake revegetation and/or rehabilitation in cleared/degraded areas.			✓
	9. Improve water-use efficiency for irrigators.		✓	
	10. Restricting urban sprawl - improving high density development approach (e.g. rainwater tanks).		✓	
	11. Implement stormwater harvesting improvements (water quantity and quality improvements).		✓	
	12. Re-establish/retain natural flow patterns (securing low flows).			✓
	13. Buyback/acquisition of land with important assets.			✓
	14. Adaptive management of protected areas (include fuel load).		✓	
	15. Backup populations of threatened species (seed bank, translocation captive populations).		✓	
Kangaroo Island				
Agricultural productivity	1. Investigate and start farming new varieties of existing crops or pasture suited to Kangaroo Island's seasonal conditions through local evaluation of farming systems.	✓	✓	
	2. Improve prices through market development.	✓		
	3. Improve short and long term weather forecasting.			
	4. Incorporate carbon sequestration into food based agriculture.			✓
	5. Improve soil structure and soil health through changes in farming systems e.g. cover crops, subsoil amelioration etc.		✓	
	6. Adapting stocking rates to seasonal conditions, increase water harvest (graded catchments) and decrease water loss (evaporation).			
	7. Change sowing/planting schedules to avoid risky periods (seasonal response).	✓		
	8. Use spring and summer seasonal forecasts allowing greater preparation.			
	9. Develop and implement long term water plan to utilise water for golf course, potential farming and community use.			✓
	10. Develop mechanism to decrease financial risk of changing farming systems through strong, independent research and regionally focussed extension program.			
Built coastal assets	1. Prepare guidelines for coastal management design.	✓	✓	
	2. Develop modelling and mapping for risk management and planning to identify assets at risk.	✓	✓	
	3. Increase education regarding risks to coastal processes.	✓	✓	✓
	4. Establish hard protection infrastructure.	✓	✓	✓
	5. Relocate assets.			✓
	6. Abandon assets.			✓
	7. Develop policy options for existing and future assets in high risk areas eg. protection, compensation, planning relocation (policy portfolio).			✓
	8. Remove assets.			✓
	9. Re-purpose assets/areas.			✓
Condition of sealed and unsealed roads	1. Consider strategic transport plan considering future transport modes and demands.	✓	✓	
	2. Identify points of vulnerability in network (e.g. roads database).	✓	✓	✓
	3. Undertake research and development on improved techniques/materials.	✓	✓	
	4. Implement more frequent bitumen resealing due to temperature induced oxidation.	✓		
	5. Seal currently unsealed strategic roads to protect against stormwater damage and ensure community can get in and out of their homes and farms.		✓	
	6. Investigate alternate road sealing surfaces such as polymer binders and concrete/fly ash.	✓		
	7. Consider longer term approaches to road maintenance and changes in materials that could have longer lifespan.		✓	
	8. Investigate internal capacity building regarding the implications of projected climate change on assets, procurement etc.			

Theme	Adaptation options	Current	Altered	New
	9. Make design allowances for increases in extreme events including fire, flood, heat/dry.		✓	
	10. Make resources available for alternative exit/entry points on farms - grade farm roads.			✓
	11. Install strategic water storage points across Island for road works and maintenance.			✓
	12. Install strategic freight depots in regions for livestock/grain that link with freight roads.			✓
Essential services infrastructure	**1.** Establish local solutions for backup and domestic power storage.	✓		
	2. Integrate distributed power supply systems through under-sea cable.			
	3. Create wider corridors near power lines or substations.			
	4. Make design allowances for increases in extreme events.			
	5. Reduce reliance on power from the grid through greater localised power production from solar, wind, and biomass energy.			
	6. Improve water policy and management.	✓		
	7. Establish local solutions for backup and domestic power storage.	✓		
Health and well-being of vulnerable members of the community	**1.** Implement and enhance heatwave and bushfire response services (e.g. Telecross REDi service).			
	2. Scope potential government responses relating to provision of heat refuges.			✓
	3. Facilitate increased participation in community activities to build social capital (connectivity and resilience).			
	4. Raise education and awareness regarding health impacts of climate hazards.			
	5. Review and refine State arrangements for emergency warnings and communications for tourists and visitors to the region.			
	6. Amend development plan policy that prevents construction of community facilities in high risk areas.			
	7. Adopt more climate sensitive building designs.			✓
	8. Establish more trees in urban areas, with a focus on vulnerable community hotspots.			✓
	9. Install back-up power supplies to offset the impacts of strategic power outages by electricity distribution companies.			
Protecting against bushfire threat (Emergency Management Services)	**1.** Facilitate increased volunteerism through targeted and innovative campaigns.	✓	✓	
	2. Reduce red-tape and OH&S barriers to volunteering for SES, CFS.			✓
	3. Improve early warning systems for flood and fire.	✓	✓	
	4. Identify areas where housing should not be located due to high risk, difficulty to access etc.	✓	✓	
	5. Increase enforcement and compliance efforts including increasing penalties (anecdotal evidence suggest that some landholders think it is easier to pay a fine than undertake clean up).	✓	✓	
	6. Work with the Insurance Council of Australia regarding community messaging around risk and insurance.			✓
	7. Continue research to develop more localised forecasting and triggers for extreme heat plan, allowing extreme heat in regional areas to be better mitigated.			✓
	8. Amend development plan to ensure no community facilities in fire prone areas.			✓
	9. Remove vulnerable people from hazard prone areas.			✓
	10. Increase education on dangers of living in hazard prone region and how to be aware, build, react through a local plan.	✓	✓	
	11. Implement whole of island vegetation plan focusing on biodiversity benefits and fuel load reductions.			✓
	12. Reduce impact of rate of change - allowing nature to adapt. Need to differentiate between large natural areas and areas closer to infrastructure and housing.			

Photo: Courtesy of Alexandrina Council

ATTACHMENT D - ADAPTATION PATHWAYS ANALYSIS

Adaptation pathways provides a way of considering and visualising adaptation options. 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 and communities to consider a range of possible actions, how they will be impacted by climate change through time, and whether any options have a 'use-by-date' (i.e. a point in time at which they are no longer viable or useful for addressing the impact being experienced).

Pathways maps enable the exploration of what combination of options are most suitable for adapting to future climate change and how these could be sequenced over time (i.e. what should be done now, versus what can be delayed). This type of analysis can break down the disempowering sense that 'everything' will be affected by climate change, or that everything needs to be done at once. (Siebentritt & Stafford-Smtih, In review)

The horizontal axis of the pathway shows both a timescale, and expected changes to the climate that are relevant to the key area of decision making. The range of adaptation options identified for the key area of decision making are listed on the vertical axis of the pathways map.

Figure 17 describes the symbology used on each pathways map. A vertical line through 'decision point' circles identifies a point in time at which a decision needs to be made between different options. The timing of the decision is indicative relative to the x-axis. This is based on the premise that as climate changes some options will become less suitable as adaptation measures and so new ones may be required. The length of the horizontal lines shows how long the option can be expected to effectively address the key area of decision making.

The preferred pathway (yellow line/s, see Figure 17) identifies which options should be progressed now and into the future based on currently available information and preferences for implementation, including information provided by stakeholders at adaptation workshops. The preferred pathway does not preclude current actions that contribute to future adaptation from continuing but rather indicates actions over and above current practice that are required to enable adaptation to climate change impacts.

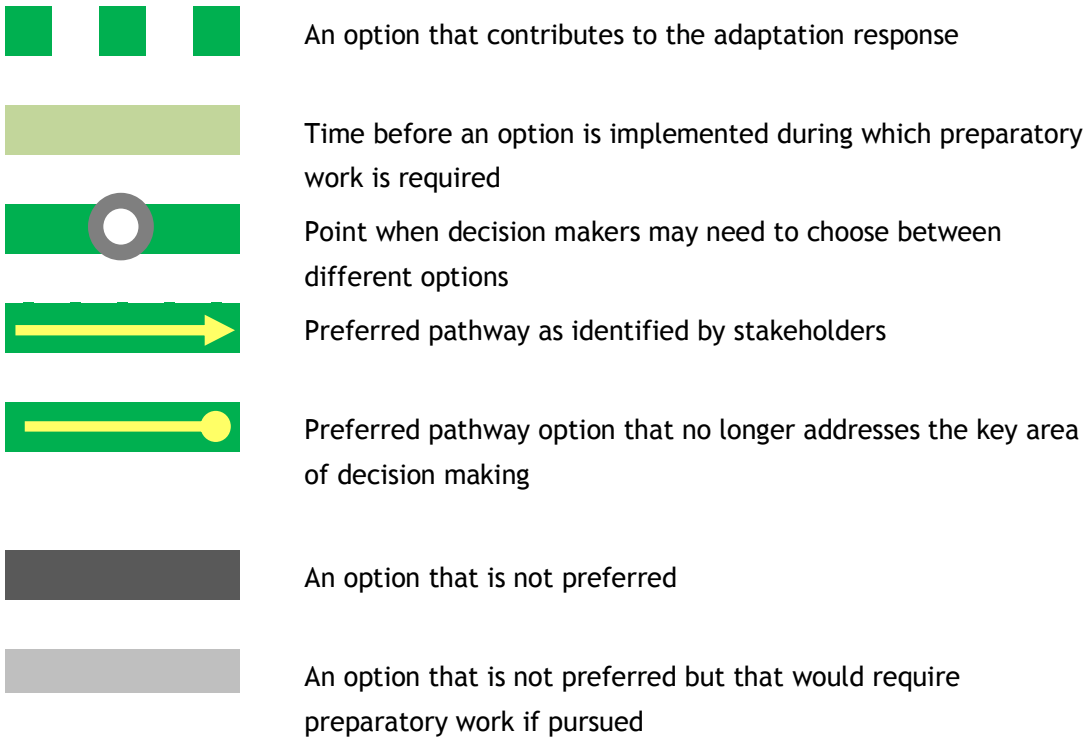

Figure 17. Adaptation pathways map legend.


Photo: Courtesy of Alexandrina Council

Further Information

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Resilient Hills & Coasts...

is a collaborative project formed to develop a regional climate change Adaptation Plan for the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island region of South Australia.

Resilient Hills & Coasts aims to strengthen the resilience of our communities, economies and the natural environment to respond and adapt to the changing climate.

Our people

Population 118,700+

18% young people 0-14 years old

64% 15-64 years old

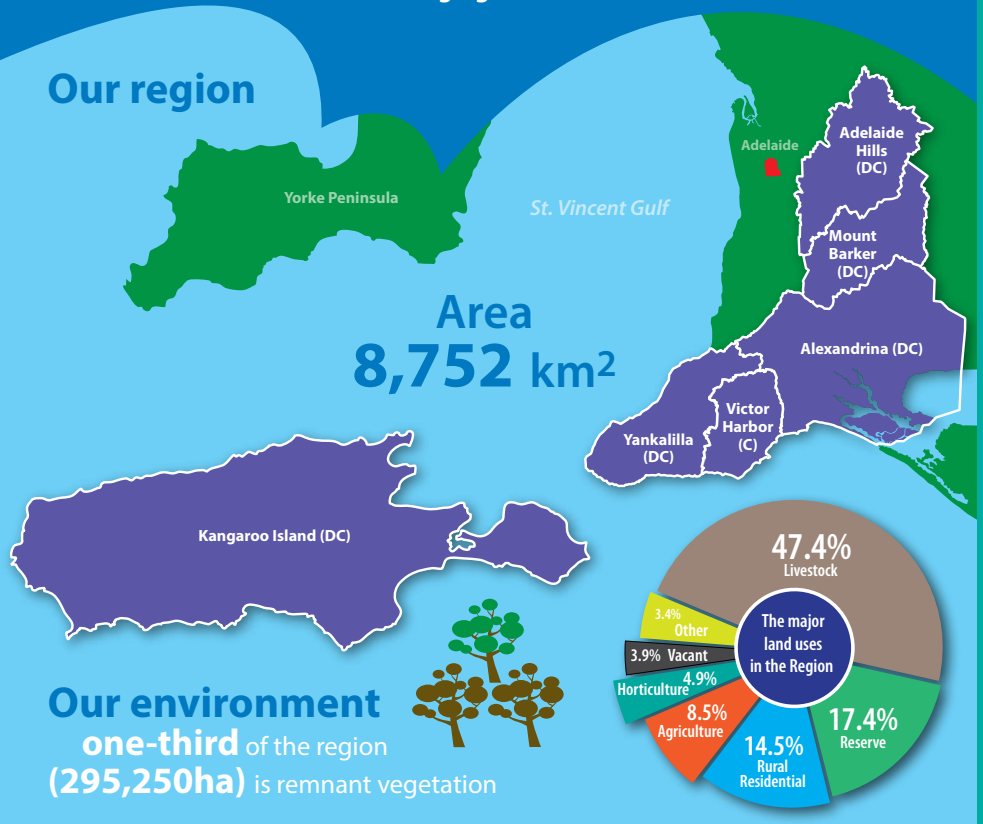
18% retirees >65 years old

27% approximate increase projected over the next **12 years to 2026**

1 in 3 people volunteer

Project partners acknowledge the traditional owners of the land and waters of the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island region.
We acknowledge the deep feelings of attachment and relationship of Aboriginal people to country, and respect their ongoing custodianship.

Our region



Area 8,752 km²

Our environment

one-third of the region **(295,250ha)** is remnant vegetation

Our changing climate ...by 2070

- **6%** DRIER
- **1.5°C** WARMER
- **33cm** SEA LEVEL RISE
- Number of days over 35°C in Victor Harbor will increase from **7 to 11 days**, and in Adelaide from **17 to 25 days**

Highly **variable natural** and **built environment**

Our economy

Top five sectors in terms of people employed

- retail trade **14.6%**
- health & community services **12.6%**
- agriculture, forestry & fishing **10.8%**
- property & business services **9.1%**
- education & training **9.0%**

Our visitors

$397 million in annual spending by tourists

The main tourist experiences reported for 2012/13 were food and wine, nature based, Indigenous, culture and heritage.

Unless otherwise indicated, climate change modelling is based on intermediate RCP4.5 emissions pathway for 2070. Median figures are shown from Climate Change in Australia modelling, using a 1986 – 2005 baseline. It is acknowledged that variances will occur across the geographic spread of the region. The full range of projections for RH&C region can be found in the report 'Climate Change Projections for the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island Region' available at **http://www.alexandrina.sa.gov.au/resilienthillscoasts**

More information: http://www.alexandrina.sa.gov.au/resilienthillscoasts

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