









Natural Resources SA Arid Lands

Far North and Outback SA Climate Change Adaptation Plan

Prepared by

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Acknowledgement of Country

Today we stand in footsteps millennia old. May we acknowledge the traditional owners whose cultures and customs have nurtured, and continue to nurture this land, since men and women awoke from the great dream. We honour the presence of these ancestors who reside in the imagination of this land and whose irrepressible spirituality flows through all creation. (Jonathon Hill)

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Acronyms

- APY Anangu Pitjantjatjara Yankunytjatjara
- **AR5** Fifth Assessment Report
- AW Alinytjara Wilu<u>r</u>ara
- **BoM** Bureau of Meteorology
- CCIA Climate Change in Australia
- CFS Country Fire Service
- CSIRO Commonwealth Scientific and Industrial Research Organisation
- **DAFF** Department of Agriculture, Fishers and Forestry
- **DEH** The Department for Environment and Heritage
- DEWNR Department of Environment, Water and Natural Resources
- DPLG Department of Planning and Local Government
- ENSO El Niño Southern Oscillation
- FFDI Forest Fire Danger Index
- **GAB** Great Artesian Basin
- GCM Global Climate Models
- GHG Greenhouse gas
- **GL** Gigalitre
- IPCC Intergovernmental Panel on Climate Change
- **ML** Megalitre
- **NRM** Natural Resource Management
- **OCA** Outback Communities Authority
- RCP Representative Concentration Pathways
- RDA Regional Development Australia
- SAAL South Australian Arid Lands
- **SACES** South Australian Centre for Economic Studies
- SACR SA Climate Ready
- **SAFECOM** South Australian Fire and Emergency Services Commission
- SES State Emergency Service

Preface

Regional Australia experiences constant change: across social, economic and environmental domains. We have a history of resilience and strength in the face of adversities. And a capacity to make the most of our opportunities. For us, sustainable development means being prepared and ready to respond to the challenges – whether in our communities, our economies or in our landscapes.

Regional Development Australia Far North, the Outback Communities Authority and the South Australian Arid Lands Natural Resource Management Board present this Far North and Outback SA Climate Change Adaptation Plan.

This Plan was developed with input from key decision-makers in the many complex and diverse sectors that make up our Region. While it provides the basis for more targeted work by key sectors, it also signals that there are actions we can begin working on together, whether in relation to infrastructure, labour and skills, business development, communication, or environment and land management.

The Plan offers a strategic guide to a range of options and pathways that may be taken regionally. Information is the key: as we seek out more knowledge and share what we learn, together we can develop specific, targeted and appropriate strategies and actions to lead us forward.

The regional cross-sectoral approach at the heart of this Plan is a powerful tool. It can help us shape the economic prosperity and sustainability of our communities into the future. Our unique region - the place where we choose to live, work and visit – deserves our positive commitment now.

Led and facilitated by community leaders, the Far North and Outback SA Climate Change Adaptation Plan is a call to action: only a collaborative effort will ensure we seize the opportunities while tackling the risks of continuing climate change.

Executive Summary

Executive summary

The Far North and Outback SA region has a rich history shaped by an at times harsh and extreme climate. The community and economy has a strong connection to country, for both Aboriginal and non-Aboriginal cultures. The economy of the region is diverse and is underpinned by pastoral, mining and extractive industries and tourism. The region's natural terrestrial and aquatic ecosystems are unique, with many iconic plants and animals.

While climate variability is a feature of the region, new drivers are at play with major social and economic changes occurring. Underlying these drivers is a trend of international significance, climate change, which will impact how the community, economy and environment functions in the region in the coming century.

The region has already started exploring the impacts of climate change and potential response options. This Plan consolidates this work to identify regional, cross sectoral adaptation priorities. It builds on past research and analysis into climate change impacts and draws heavily on the expertise of stakeholders and their knowledge of the impacts and potential responses to a variable climate. Its primary purpose is to identify regional, cross sectoral adaptation priorities.

Implementation of the regional priorities in this Plan will contribute to meeting the goals and actions of the Outback Communities Authority Region Economic Growth and Investment Strategy, the South Australian Arid Lands Natural Resource Management Plan and the Alinytjara Wilu<u>r</u>ara Regional Natural Resources Management Plan.

While the underlying variability of the region's climate will continue, the broad trend will be for warmer conditions, declining average rainfall, and continued variability in the timing and quantity of intense rainfall events. In Spencer Gulf, sea levels and water temperatures will rise.

Following review of key literature and informed by an extensive stakeholder engagement process, eight key sectors were identified to focus adaptation planning. Adaptation options were identified that address key areas of decision making. Given that the primary purpose of this Plan is to identify regional, cross sectoral adaptation priorities these options are a starting point for further more detailed analysis by each sector. Options identified for key areas of decision making are as follows:

Coastal development - How do we maintain the condition of coastal developments in Port Augusta and the surrounding region given the increasing flood risk caused by rising sea levels?

In the next five years, adaptation for coastal developments in Port Augusta and the surrounding region should focus on the development and revision of policies and coastal management guidelines, mapping of high risk areas and maintaining living shorelines. In 5-10 years, on-ground work will be required to improve natural and built defences. In the coming two to three decades, the effectiveness and appropriateness of coastal defences will determine the extent to which built and natural assets need to be relocated or abandoned.

Essential services - How do we maintain effective operation of essential services (water and electricity) given increasing average temperature, extreme heat, and continued variability in the timing and intensity of rainfall?

Adaptation for essential services requires further planning, capacity building, risk mapping and standards development in the next five years. However, within 5 to 10 years the emphasis will need to shift toward implementing on-ground actions that build adaptive capacity, such as solar powered desalination and solar PV-battery back-up installations. As the long-term effects of climate change are experienced over the next two to three decades, the region will need to consider moving some essential services infrastructure and possibly determine how best to manage periodic shutdowns of communities and towns.

Health, safety and wellbeing of the community - How do we maintain and enhance the health, safety and wellbeing of the community, workers and visitors to the region as the risk of extreme events such as heat waves increase?

In the next five years, work is required to build on existing programs and actions to improve the health and wellbeing of the community, such as building capacity and awareness about weather extremes, developing early warning systems, enhancing virtual health care delivery, and upgrading infrastructure. Further adaptation in 5 to 10 years will need to focus on the built environment and construction of more climate sensitive buildings. In two to three decades' greater consideration will need to be given to how the region's health and emergency management services will operate with the potential for greater movements of people during the summer period.

Mining and extractive industries - How do we maintain the productivity of mining and extractive industries in the region given projected impacts of extreme heat and changing rainfall patterns on mine workers and infrastructure?

The mining and extractive industries will continue to build on existing initiatives to prepare for climate change, such as helping people and infrastructure prepare, respond and recover from extreme events. Over the next 5 to 10 years, the focus on automating mine site operations will likely increase leading to a reduction in the presence of mine site workers in the region. In two to three decades' time, there is likely to be greater self-reliance of mines operating in remote regions.

Pastoralism - How do we maintain the economic contribution of agriculture in the region given increasing average temperatures and extreme heat, reduced average rainfall and continued variability in the timing and intensity of rainfall?

Pastoralism will need to continue expanding on practices for managing livestock and the land in extreme conditions. In the next five years this will require further investigation into alternate breeds and fodder production systems and consideration of whether polices regarding pastoral land management need changing. The adaptive capacity of pastoralism will also be influenced by underpinning business support infrastructure, such as energy, water, transport and telecommunications. In one to two decades, a transition to alternative land use may be required in areas where the viability of pastoralism is declining.

Aquatic ecosystems - How do we maintain and build the resilience of riparian zones and wetland systems as the climate becomes warmer and rainfall patterns change?

In the next five years, adaptation should focus on maintaining the connectivity, persistence and water quality of priority aquatic refugia'. Over the next two to three decades adaptation measures will need to protect species at risk through seed banking, captive breeding and acquiring land with important ecological assets.

Terrestrial ecosystems - How do we maintain the condition of terrestrial ecosystems given the increasing average temperature, extreme heat, and continued variability in the timing and intensity of rainfall along with threats posed by pest plants and animals?

Terrestrial ecosystems in the region are highly vulnerable to climate change, especially plants, reptiles and snails. In the short term actions will be required that build resilience such as reducing threatening processes (e.g. pest plants and animals, total grazing pressure) and improved monitoring to make more informed management decisions. In the longer term greater emphasis will need to be placed on acquiring land with important ecological assets or protect populations of species at risk from climate change through more intensive measures such as seed banking and captive population breeding.

Transport services and infrastructure - How do we maintain and enhance transport services and infrastructure given increasing average temperature, extreme heat, and continued variability in the timing and intensity of rainfall?

Maintaining and improving upon transport services and infrastructure is vital for supporting the resilience of the community and economy in the region. In the next five years adaptation planning will need to review and update design standards for road and rail infrastructure to allow for climate change impacts and upgrade airstrips to minimise isolation in the region. In 5 to 10 years, adaptation measures will need to reduce demand for transport services and infrastructure and implement actions that build the resilience of the network. In two to three decades, transport services and infrastructure will need to accommodate for potentially large movements of people across the region on a seasonal basis.

To identify priorities for regional implementation, the sector options were reviewed to determine those that are of regional scale or relevance, common to more than one key decision area, will deliver multiple benefits, and would benefit from a coordinated, regional response across key regional stakeholders. The resulting regional, cross sectoral adaptation priorities are:

- establish a regional governance model;
- establish a forum for engaging Aboriginal communities;
- build the capacity of people in the region to adapt;
- use risk assessment approaches to prioritise adaptation responses;
- embed climate considerations into design standards and asset management plans;
- prepare a 'Climate Ready Roads' Strategy;
- increase installation of small scale renewable energy and battery storage;
- increase provision of communications to support the delivery of financial, education and health services; and
- facilitate transformation of land use across the rangelands.

Using an adaptation pathways approach, the potential sequencing of region scale options was considered. This showed that many of the cross sectoral priorities that will build resilience and adaptive capacity are for implementation in the short term, but that longer term more strategic and transformational options should also be considered. This will include the need to determine how the community and economy will function with an increase in extreme events, especially extreme heat and will need to balance the potential for greater seasonal movements of people out of the region (especially the northern areas) with the inherent value of people living and working as custodians of the land, which will lead to greater investment in construction of more climate resilient houses and community facilities.

The implementation of adaptation options will need to consider existing barriers and enablers to decision making. This will mean that future work on climate change will need to:

- develop a greater understanding of how community aspirations to remain living in the area and the strong connection to country for both Aboriginal and intergeneration families can be supported;
- create policies that present financial incentives and grants to stimulate action; and
- invest further in capacity building with decision makers and visitors to the region to improve their understanding about what conditions are like in the Far North and Outback.

In addition to making progress with implementing cross sectoral priorities, the next steps for adaptation in the region is to (1) encourage key sectors to further elaborate on their own adaptation priorities, and (2) identify indicators, triggers and thresholds to inform the timing of future adaptation based decision making.

1 Introduction

1 Introduction

The Far North and Outback region of South Australia has a resilient and productive community and economy. It is characterised by a unique semi-arid and arid environment, being home to iconic native plants and animals of national and international significance.

While climate variability is a feature of the region, new drivers are now at play with major social and economic changes occurring: the Port Augusta power station has closed which in turn has led to the closure of the Leigh Creek coal mine; mining activity and investment has fluctuated off the back of changing commodity prices; new technology has entered the region which uses solar thermal energy to desalinate water and produce food; management of nuclear waste is being presented as a potential economic opportunity. Added to this is climate change, which will impact how the community, economy and environment functions in the region in the coming century.

The Far North and Outback SA already has significant experience in living with a variable climate. Work has also commenced within several sectors to explore climate change impacts and response options. This Climate Change Adaptation Plan is the next stage in developing the climate change response for the region, consolidating the impacts and response options at a regional scale for multiple sectors. It aligns strongly with the goals and actions of the Outback Communities Authority Region Economic Growth and Investment Strategy, the South Australian Arid Lands Natural Resource Management Plan and the Alinytjara Wilurara Regional Natural Resources Management Plan.

1.1 Background

The Far North and Outback SA covers the majority of South Australia, extending from just south of Port Augusta to the northern, western and eastern borders of the State. It includes the Far North Regional Development Australia (RDA) region, the Outback Communities Authority (OCA) (including the towns of Woomera, Marree, Innamincka, Oodnadatta and Marla), four Local Government areas (District Council of Coober Pedy, Flinders Ranges Council, Corporation of the City of Port Augusta, and the Municipal Council of Roxby Downs), and the South Australian Arid Lands (SAAL) and Alinytjara Wilurara (AW) natural resources management (NRM) regions.

The SAAL and AW NRM regions comprise the north eastern half and north western half of South Australia, covering approximately 770,000 square kilometres (RDA Far North, 2016).

The Far North and Outback SA covers a diverse range of landscapes from the coast extending north and transitioning from semi-arid to arid conditions. Key sectors within the region are mining, agriculture, tourism and defence (RDA Far North, 2014).

This region has particular importance to South Australia as it:

- is home to the majority of South Australia's extractive resources and industries;
- consists of large areas of food production, predominantly stock grazing;
- is a significant region for national security through the growing defence sector;
- is one of the State's most visited tourist regions;
- is home to a wide array of unique flora and fauna; and
- has highly valued Indigenous cultural heritage.

As with the rest of the State, seasonal variability in temperature and rainfall is common, as is the quantity of rainfall that occurs between seasons. The landscape, community and key industries can be exposed to extended periods of hot dry conditions followed by short periods of intense rainfall (DEWNR, 2013a). Despite this natural variability, climate change is modifying the underlying climatic conditions. For example, the majority of the Far North has already experienced nearly 1.0°C of warming since the 1950s with some parts experiencing 1.0 to 1.5°C of warming (CSIRO and BoM, 2015).

A warming and drying trend is projected in the future and will lead to changes in the environment, economy and community. The region is particularly vulnerable to changes in climate due to the naturally dry and hot conditions. Of great concern to much of the region is the potential for an increase in water scarcity and associate costs which is already a significant issue faced by communities and industries.

1.2 About this Plan

This Climate Change Adaptation Plan is the culmination of work from a climate change adaptation planning project covering the Far North and Outback SA. The focus of the Plan is to determine how to build the resilience and productivity of the region as the climate changes. As such, the intent is to identify risks and to respond to these, but to also explore opportunities that may exist.

The primary stakeholders for the project include:

- Regional Development Australia Far North;
- Outback Communities Authority; and
- Natural Resources South Australian Arid Lands.

Other key stakeholders for this plan include Natural Resources Alinytjara Wilu<u>r</u>ara, The Flinders Ranges Council, Port Augusta City Council, District Council of Coober Pedy, Municipal Council of Roxby Downs, Upper Spencer Gulf Common Purpose Group, Traditional Owners of the region, and the Zone Emergency Management Committee. The primary purpose of this Plan is to identify regional, cross sectoral adaptation priorities. In addition, the Plan identifies:

- how the region's climate will change in the future;
- potential impacts of climate change on key sectors;
- areas of decision making that need to consider climate change the most;
- adaptation options for key sectors.

The regional, cross sectoral adaptation priorities are not the only adaptation options for implementation in the Region, but rather, they provide a starting point to focus initial regional, cross-sectoral action. The Plan is focussed on adaptation options to respond to a different future climate. It does not specifically address climate change mitigation (which reduces emission of greenhouse gases), although many of the options will address both challenges. The focus on adaptation is important because many adaptation initiatives are best developed and implemented at a local and regional scale by people who understand how their community and economy functions and interacts with the environment.

2 The Region

2 The Region

The Far North and Outback SA region covers the Far North RDA region, the Outback Communities Authority (OCA) (including the towns of Woomera, Marree, Innamincka, Oodnadatta and Marla), four Local Government areas (District Council of Coober Pedy, The Flinders Ranges Council, Corporation of the City of Port Augusta, and the Municipal Council of Roxby Downs), and the SAAL and AW NRM regions (Figure 1).

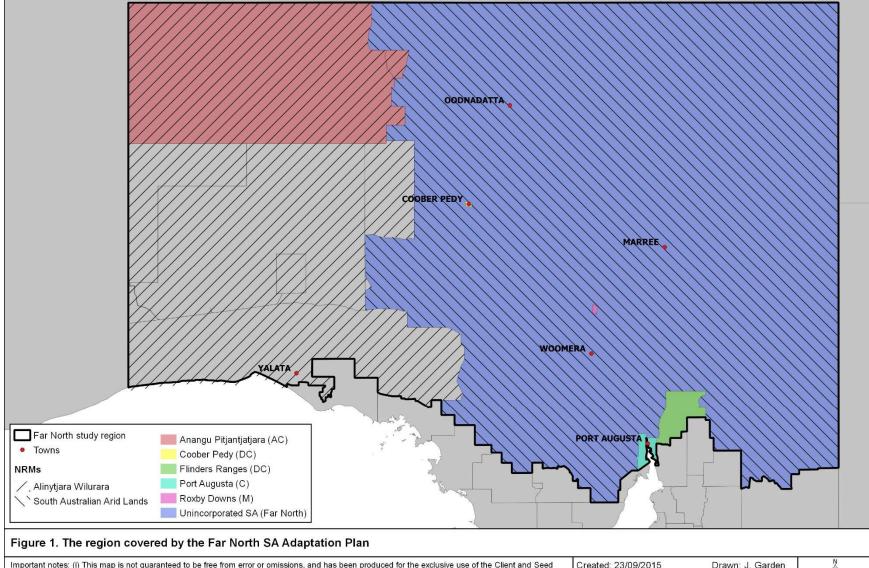
Anangu Pitjantjatjara Yankunytjatjata and Maralinga Tjarutja are also within the region, established under the *Pitjantjatjara Land Rights Act 1981* and the *Maralinga Land Rights Act 1984* respectively. Nepabunna and Yalata are Aboriginal Community Councils operating on Aboriginal Lands Trust land (Local Government Association of South Australia, 2016).

The average temperature in the Far North and Outback is greater than for the more southern regions of the State with Port Augusta, Marree, and Oodnadatta recording average annual maximum temperatures of 24.7, 28.8, and 29.1°C respectively (Bureau of Meteorology, 2015). Rainfall varies across the region with Port Augusta, Marree, and Oodnadatta recording average annual rainfall of 255, 162 and 174 mm, respectively (Bureau of Meteorology, 2015). Rainfall for 255, 162 and 174 mm, respectively (Bureau of Meteorology, 2015). Rainfall from outside of the Far North is also important to the region, with the northwest (Finke) and northeast (Cooper) floodplains relying heavily on rainfall-fed flood pulses from upstream in the Northern Territory and Queensland.

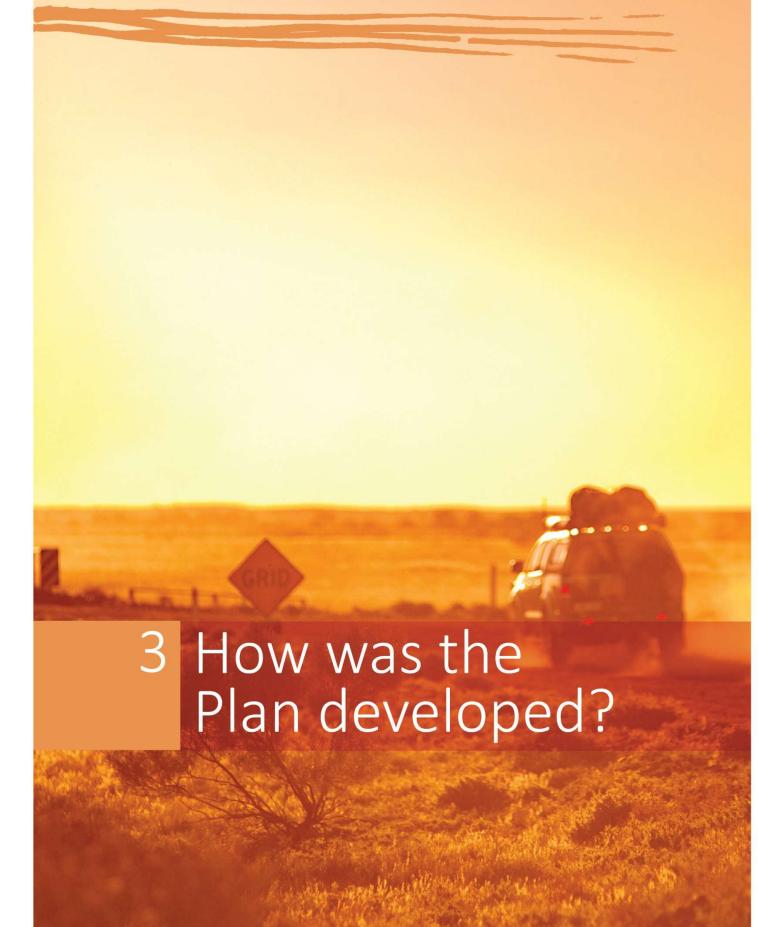
Much of the region is used for agriculture, which covers 411,000 square kilometres including 212 pastoral properties within the Unincorporated Areas of the Far North and around 50 primary production leases within the Council regions. As of 2013, more than 50,000 square kilometres of the RDA Far North outback areas were under mining exploration leases. Defence also covers a large area, with the Woomera Test Range consisting of 127,000 square kilometres and Cultana Training Area expansion from 503 to 2,093 square kilometres. The Woomera Prohibited area is designated for military test activities under Commonwealth Government legislation (RDA Far North, 2014). Land is also managed for conservation purposes by the State Government and private non-profit organisations.

Within the AW NRM region, no privately owned land exists and most of it is held as dedicated Aboriginal lands either in the trust of, or owned by, the Yalata, Anangu Pitjantjatjara Yankunytjatjara Lands, and Maralinga Tjarutja Lands land holding authorities (Natural Resources Alinytjara Wilu<u>r</u>ara, 2014). The remainder of the region is restricted for traditional Aboriginal uses and conservation purposes and is managed by the Department of Environment, Water and Natural Resources (AW NRM Management Board, 2011).





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3 How was the Plan developed?

3.1 Approach

Development of the Plan occurred through three main stages (Figure 2) that integrated an understanding of the science of climate change and the values of people in the region with an exploration of impacts and potential responses to climate change.

The first stage of the project delivered a Knowledge Audit. This provided a summary of climate change projection information based on data from the Goyder Institute's SA Climate Ready project, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology's (BoM) Climate Change in Australia. The projections summary forms the basis of Section 4 in this Plan.

The Knowledge Audit also summarised the key findings of past work into climate change impacts and response options for the region, providing the information required to underpin the project's integrated vulnerability assessment and identification of adaptation options.

The key sectors assessed in the Knowledge Audit were, biodiversity, defence, emergency management, health and well-being, infrastructure, minerals and energy, pastoralism, tourism and water resources management. These sectors align strongly with the goals and objectives of the RDA Far North SA, OCA and the two NRM Boards, especially to improve the well-being of people living, working and visiting the Far North and Outback.

The second stage of the project delivered an integrated vulnerability assessment, consistent with the requirements of the South Australian Adaptation Framework. The aim of this assessment was to determine which sectors and systems in the region are most vulnerable to the impacts of climate change and therefore should be considered when identifying adaptation options.

The third stage of the project focussed on identifying adaptation options for key sectors in the region. There was a strong emphasis on adaptation priorities that are cross sectoral and regional in scale. As described in Section 5 and 6, many adaptation options were identified that are of benefit beyond climate change adaptation.

The project has been underpinned by an extensive stakeholder engagement process. A list of people involved with the development of this plan is presented in Attachment A. Two face to face workshops were conducted in Port Augusta during the project (20 June 2016, 24 August 2016) to seek input on potential adaptation options, sequencing of adaptation, decision point triggers and cross regional priorities.

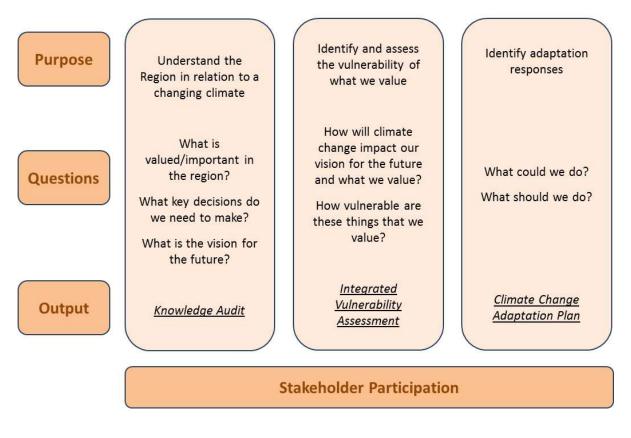


Figure 2. Summary of the process used for this project.

Given the geographical spread of the region and difficulty some stakeholders faced in attending workshops, an extensive interview process was conducted which included phone interviews and face to face meetings in Port Augusta, Quorn, Hawker, Roxby Downs and Coober Pedy.

3.2 Identifying priorities for adaptation planning

Focussing on the sectors identified in the Knowledge Audit, an Integrated Vulnerability Assessment (IVA) was 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*.

The integrated vulnerability assessment was undertaken for 55 indicators covering nine sectors that are relevant to the following three domains:

- 1. social and community;
- 2. regional economy and infrastructure; and
- 3. environment and natural resources.

The IVA was based on the most up-to-date available climate projections to 2070 for a mid-range (intermediate) emissions scenario (representative concentration pathway (RCP) 4.5)¹. This timeframe was chosen because many decisions made in relation to key sectors for the region were identified as having lifetimes of at least 50 years.

Increasing temperatures, especially extreme heat, had the greatest effect on vulnerability scores. The assessment found that the sectors that will be most vulnerable to climate change were spread relatively evenly across the three domains with the three most vulnerable being pastoralism, emergency management and biodiversity. Nearly half of all indicators selected had high vulnerability results, driven primarily by the projected impact of increasing temperature.

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. A key area of decision making:

- explains what is important for a region, making a connection between something of value or importance to stakeholders such as an asset or service;
- identifies what responses are possible; and
- describes how what is valued could be impacted by climate change.

The key areas of decision making that are the focus of this Plan are presented in **Table 1**. These were drafted by the Project Team and reviewed and approved by the Project Steering Committee.

In addition to the IVA process, applied adaptation pathways were developed for each sector following the approach outlined in Siebentritt and Stafford-Smith (2016). This approach recognises that rather than being limited to identifying the best single set of adaptation options for a limited set of climate change scenarios, decision makers can consider a range of possible adaptation options and how they will be impacted by various climate change scenarios through time.

The resulting regional adaptation pathway is presented in Section 6.2 to guide sequencing of the adaptation response in the region. An overview of the development and interpretation of pathways maps is provided in Attachment B. Sector specific pathway maps are available for key sectors that want to progress their own adaptation planning.

¹ In the most recently updated reports released by the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2013), representative concentration pathways (RCPs) replace the emissions scenarios (e.g. A1, B2, A1FI) used in previous report.

Table 1. Key areas of decision making for the Far North and Outback SA region.

Theme	Key area of decision making
Coastal development	How do we maintain the condition of coastal developments in Port Augusta and the surrounding region given the increasing flood risk caused by rising sea levels?
Essential services	How do we maintain effective operation of essential services (water and electricity) given increasing average temperature, extreme heat, and continued variability in the timing and intensity of rainfall?
Health and safety of the community	How do we maintain and enhance the health, safety and wellbeing of the community, workers and visitors to the region as the risk of extreme events such as heat waves increases?
Mining and extractive industries	How do we maintain the productivity of mining and extractive industries in the region given projected impacts of extreme heat and rainfall on workers and infrastructure?
Pastoralism	How do we maintain the economic contribution of pastoralism in the region given increasing average temperatures and extreme heat, reduced average rainfall and continued variability in the timing and intensity of rainfall?
Aquatic ecosystems	How do we maintain and build the resilience of riparian zones and wetland systems as the climate becomes warmer and drier?
Terrestrial ecosystems	How do we maintain the condition of terrestrial ecosystems given the increasing average temperature, extreme heat, and continued variability in the timing and intensity of rainfall along with threats posed by pest plants and animals?
Transport services and infrastructure	How do we maintain and enhance transport services given increasing average temperature, extreme heat, and continued variability in the timing and intensity of rainfall?

4 How will climate change impact the region?

4 How will climate change impact the region?²

4.1 What is climate change?

Climate is the average weather conditions over long periods of time. The World Meteorological Organization defines the climate as the average weather over a 30-year period (IPCC, 2013). 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 (one to ten 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 BoM, 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.

4.2 Regional impacts

The Far North and Outback SA region already experiences extreme climate conditions, including long periods of time with no rain, high temperatures for much of the year and periods of intense heat through to intense rainfall and flooding events. While the underlying variability of the region's climate will continue, the broad trend will be for warmer conditions, declining average rainfall, and continued variability in the timing and quantity of intense rainfall events.

Box 1. What is a climate change projection?

A climate change projection describes the possible response of the climate to a given scenario of future greenhouse gas emissions. Projections also vary depending on the climate model used to generate the data and the timeframe for the model outputs (e.g. 2030, 2070). There are four main emissions scenarios used for developing climate change projections: a low emission scenario (referred to as representative concentration pathway (RCP) 2.6), to intermediate emissions scenarios (RCP4.5 and RCP6) and a high emission scenario (RCP8.5).

The following sections provide further detail on the climate projections for the region based on information from two of the most relevant data sources for South Australia: the Goyder Institute's SA

² This Plan presents an overview of the potential impacts of climate change for the Far North region. More detailed information is available in the Far North and Outback SA Region Knowledge Audit, including an explanation of the sources of variability in climate projections.

Climate Ready (SACR) project and CSIRO and BoMs Climate Change in Australia. These projects present a range of climate variable projections, RCPs, and future timeframes. Given differences in available data and for simplicity of communication, projections described for the region are based on:

- the intermediate emissions scenario (the Intergovernmental Panel on Climate Change (IPCC) representative concentration pathway RCP4.5); and
- two future timeframes (2030, 2070).

Rainfall and temperature information are based on SACR data. Extreme heat, fire weather, sea level rise, sea surface temperatures and ocean pH are provided by Climate Change in Australia (CCIA) data as this information is not available from the SACR project.

The projections presented here are considered indicative for the region with trends in the direction of change in the respective variables provided in Attachment C.

Rainfall

The Far North covers three broad rainfall zones: the north with summer-dominant rainfall, a central zone with aseasonal rainfall, and the south with winter dominant rainfall (Wiseman & Bardsley, 2015). In addition to this, is the boom and bust of dry and wet cycles.

SACR projections suggest rainfall declines for both the 2030 and 2070 time periods. By 2030, annual rainfall is projected to decline in the Far North by 4.9 % compared to baseline conditions. The percentage decrease would result in Port Augusta's annual rainfall declining from 255.1 mm (baseline) to 242.7 mm, Maree from 161.7 mm to 154.0 mm, and Oodnadatta from 173.7 mm to 165.3 mm. Under the 2070 intermediate emissions scenario, annual rainfall is projected to decline by 8.1%. For Port Augusta, Maree, and Oodnadatta this decline will result reduction in annual rainfall to 234.6, 148.7, and 157.9 mm respectively from the baseline figures.

The results of CCIA modelling suggest a more mixed response for future rainfall and recommends that given these contrasts, there is a need to consider the risk of both a drier and wetter climate in regional impact assessments.

The region will also be influenced by rainfall changes that occur outside of the Far North SA boundaries. For example, rainfall in the Northern Territory and Queensland influence flood pulses onto the Finke and Copper floodplains while the rate of recharge of the Great Artesian Basin is influenced by rainfall in New South Wales and Queensland.

Rainfall intensity

Rainfall intensity changes were not assessed directly by SACR, but were described for the CCIA project for the entire Rangelands Cluster by Watterson, et al. (2015). This study found that the intensity of heavy

rainfall events will increase, but that there remains uncertainty about the magnitude of change and the time when any change may be evident against natural variability.

The frequency of larger, typically more intense rainfall events was assessed by two studies undertaken for the Far North, one for each of the NRM regions. Gibbs, et al. (2013) concluded for the SAAL NRM region that:

- reductions in the magnitude of extreme rainfall events (i.e. the first percentile daily rainfall), compared to the 1990 historic baseline period, are projected for both the 'worst' and 'most-likely' future climate cases for both high and low emissions scenarios;
- the 'best' future climate case indicates small increases in annual average and first percentile rainfall, for both high and low-emissions scenarios;
- a reduction in the frequency of rainfall events that are expected to lead to recharge (months of rainfall greater than 100 mm) is projected for the 'most-likely' and 'worst' futures climate cases, whilst the 'best' case suggests that there may be an increase; and
- in the north of the region, where these large, recharge-generating rainfall events are the most frequent, the frequency of these events is projected to decrease by 21% under a low-emissions scenario for 2030 and by 47% under a high-emissions scenario for 2070.

Alcoe, et al. (2012) concluded for the AW NRM region that:

- reductions in the magnitude of extreme rainfall events, compared to the 1990 historic baseline period, are projected for all combinations of climate futures cases and emissions scenarios across the whole AW NRM Region;
- when results are averaged across the whole AW NRM Region, a reduction in the frequency of rainfall events that are expected to lead to recharge (months of rainfall greater than 100 mm) is projected; and
- in the north of the region, where these large, recharge-generating rainfall events are the most frequent, the frequency of these events is projected to decrease by 22% under a low-emissions scenario for 2030 and 38% under a high-emissions scenario for 2070.

In addition to these studies, Wiseman & Bardsley (2015) state that future rainfall trends in the region are 'highly uncertain' and show that over the last few decades' average rainfall has been increasing not decreasing.

Collectively, these reports suggest that there is uncertainty as to exactly how rainfall intensity will change in the region. As such, adaptation planning needs to proceed on the basis that the region will continue to experience high variability in the frequency and magnitude of large rainfall events.

Maximum temperature

SACR projections show an increasing trend in annual mean maximum temperatures through to 2070. By 2030, annual mean maximum temperature is projected to increase compared to baseline conditions (i.e. 1986 to 2005) by 1°C. This projected increase will result in Port Augusta's annual mean maximum temperature increasing from 24.7°C (baseline) to 25.7°C, Maree from 28.8°C to 29.8°C, and Oodnadatta from 29.1°C to 30.1°C.

By 2070 annual mean maximum temperatures are projected to increase by 1.8°C from baseline conditions. This would increase annual mean maximum temperatures at Port Augusta, Maree, and Oodnadatta to 26.5 °C, 30.6°C, and 30.9°C, respectively.

As with rainfall, increases in maximum temperatures vary seasonally. The seasonal variation is minimal in 2030 with summer, autumn and winter all recording a 1ºC increase compared to spring recording a 1.1ºC increase. By 2070 the seasonal differences become more pronounced with winter recording a 1.5ºC increase compared to spring at 2ºC.

Heat extremes

The Far North region is likely to experience an increase in extreme heat (i.e. number of days over 35°C or 40°C) in the future. Projections of changes in extreme heat using CCIA results are available for Port Augusta, Maree and Oodnadatta.

By 2030, the number of days over 35°C in Port Augusta is projected to increase from 43 per year to 51 (19% increase). By 2070, the number of days over 35 °C is projected to increase to 61 (41% increase). A greater increase occurs for the number of days over 40°C. By 2030 the number of days over 40°C is projected to increase from 13 per year to 17 (31% increase). By 2070, the number of days over 40°C is projected to increase to 22 (69% increase).

The trend of increased extreme heat days is similar for Marree. By 2030 the number of days over 35°C is projected to increase from 95 per year to 108 (13% increase) and by 2070, this figure increases to 122 days per year over 35°C (27% increase). As with Port Augusta, the increase in days over 40°C is greater. For example, by 2030 the number of days over 40°C is projected to increase from 35 per year to 45 (27% increase). By 2070, the number of days over 40°C is projected to increase to 57 (61% increase).

By 2030, the number of days over 35°C in Oodnadatta is projected to increase from 101 per year to 114 (12% increase). By 2070, the number of days over 35 °C is projected to increase to 132 (30% increase). By 2030 the number of days over 40°C is projected to increase from 37 per year to 48 (28% increase) whereas by 2070, the number of days is projected to increase to 64 (73% increase).

Fire weather

Fire weather projections were estimated for 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 Woomera is the most relevant to the Far North. The other locations in South Australia are Adelaide (Kent Town), Ceduna, and Mt Gambier.

The FFDI projections suggest increased fire weather in the future for Woomera. In 2030 severe fire danger days are projected to increase 31 % from the baseline of 17.7 days per year to 23.2 days per year. By 2070 severe fire danger days are projected to increase to 24.7 days per year (40 % increase from baseline) (CCIA, 2015).

Ocean and Gulf waters

For Ocean and Gulf waters, under an intermediate emissions pathway, projections suggest a:

- rise in sea levels of 33 cm by 2070;
- rise in sea surface temperatures of 1.2°C by 2090; and
- decline of 0.15pH units by 2090.

Box 2. What is the evidence that the Earth's climate is changing?

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

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

5 Potential impacts of climate change and adaptation options

5 Potential impacts of climate change and adaptation options

Adaptation options identified in this section are based on findings from studies relevant to the region or from the experience of project participants collected via the interview and workshop processes. Given that the primary purpose of this Plan is to identify regional, cross sectoral adaptation priorities these options are a starting point for further more detailed analysis by each sector.

Options are identified for either immediate implementation (i.e. within five years), or at some point in the future, with the extent of delay based on an estimate of when changes in the climate will require action.

5.1 Coastal development

Key area of decision-making

How do we maintain the condition of coastal developments in Port Augusta and the surrounding region given the increasing flood risk caused by rising sea levels?

The coastline in Port Augusta and the surrounding region is vital for the community and supports a range of economic and social activities. There are many residential and business premises along the coastline, significant areas of open space, environmental assets and important infrastructure such as roads and the Augusta Boat Harbour.

Climate change impacts

Based on the IVA (RDA Far North, 2016), the condition of coastal developments in the region will be impacted by sea level rise over the coming century. Without adaptation, this will lead to greater risk of flooding and erosion during periodic storm surge events. The normal response of beaches, mudflats and mangroves under sea level rise will be to move inland to higher elevations, however, where hard infrastructure exists (e.g. sea walls, levees) this will not be possible.

While the focus of this Plan in relation to coastal adaptation has been on Port Augusta and its immediate surrounds, the coastline along the Nullabour Plain is also arguably vulnerable. The combination of eroding cliffs and sea level rise could create a risk to people's safety and tourism activities, such as camping on the coast and driving along the cliffs top.

Adaptation options

Responding to sea level rise is a priority for coastal regions across South Australia. A variety of strategies have been developed nationally and internationally to respond to this threat, which largely focus on defending, retreating or abandoning natural and built assets. Any adaptation response to sea level rise in the region should be consistent with the *Coast Protection Board Strategic Plan 2012-2017*, which has three strategic priorities:

- 1. adaptation of existing development to coastal hazards and the impacts of climate change;
- 2. ensure new development is not at risk from current and future hazards; and
- 3. plan for resilience in coastal ecosystems to adapt to the impacts of climate change.

The priority adaptation options for the next five years for Port Augusta and the surrounding region should be to:

- develop and implement policies for assets in areas at high risk of flooding and erosion, especially from storm surge events;
- implement guidelines for coastal management design to ensure that new assets and facilities are built in locations that minimise the risk of future impact from sea level rise;
- utilise modelling and mapping to identify assets at risk from sea level rise and storm surge related erosion and flooding;
- maintain living shorelines, such as vegetated areas, to provide for natural defence barriers that reduce wave energy and erosion; and
- ensure that future development does not prevent the migration of coastal ecosystems.

Within 5 to 10 years, on-ground action will need to focus to a greater extent on how to re-purpose assets and open space areas so as to reduce the damage caused by storm surge events. This will be enhanced by greater investment in establishing additional areas of living shorelines and in key locations, building additional hard infrastructure or raising existing sea walls and levees to protect key assets.

As sea levels continue to rise over coming two to three decades, the effectiveness of hard infrastructure as coastal defences will need to be assessed. Future adaptation responses may in turn require relocating some coastal assets (e.g. beach access, jetties) and the removal of some assets in high risk areas.

Key points

In the next five years, adaptation for coastal developments in Port Augusta and the surrounding region should focus on the development and revision of policies and coastal management guidelines, mapping of high risk areas and maintaining living shorelines. In 5-10 years, on-ground work will be required to improve natural and built defences. In the coming two to three decades, the effectiveness and appropriateness of coastal defences will determine the extent to which built and natural assets need to be relocated or abandoned.

5.2 Essential services

Key area of decision-making

How do we maintain effective operation of essential services (water and electricity) given increasing average temperature, extreme heat, and continued variability in the timing and intensity of rainfall?

Communities and industries in the region rely heavily on essential services to support daily life and operations in often isolated and sometimes harsh environments. Power supplies and power distribution networks vary throughout the region with some of the larger towns connected to the SA Power Networks grid. Smaller towns and communities are powered by off grid diesel generators and/or hybrid plants using a combination of diesel, gas, solar or wind (RDA Far North, 2014; Anangu Pitjantjatjara Yankunytjatjara, 2010; Maralinga Tjarutja South Australia, 2015).

There is no region-wide water reticulation network across the region, instead communities are supplied from a range of sources and distribution groups (DEWNR, 2013a; DEWNR, 2013b). Some locations are serviced by the Morgan-Whyalla pipeline (e.g. Port Augusta, Woomera and Pimba) whereas several towns in the eastern part of the region (e.g. Maree, Marla, Cockburn, Blinman, Mannahill, Olary and Yunta) utilise ground water and surface water. In contrast, the District Council of Coober Pedy accesses groundwater which is desalinated and then supplied to the town through a reticulation network. Eleven communities within the AW NRM region are supplied by groundwater through the Aboriginal land owner's infrastructure and assets. Pastoral properties and some smaller towns, (e.g. William Creek) rely mostly on rainwater for household use, and groundwater for stock/grounds use.

Climate change impacts

Based on the Integrated Vulnerability Assessment (RDA Far North, 2016), essential services were found to be susceptible to projected changes in extreme heat. This will increase the demand for power across the region, especially for air-conditioning, by increasing both the total period of time over the year that air-conditioning is required, and peak demand during heat wave conditions.

Electricity distribution network infrastructure is considered vulnerable to extreme heat because of the need to maintain temperatures in the lines for effective operation. The ability for ground crews to service distribution network infrastructure is also impacted. As witnessed in South Australia during the September 2016 storms, extreme storm events which are projected to increase with climate change could also cause direct damage to distribution network infrastructure and lead to extended periods without power, which have flow on economic and social impacts for businesses and the community.

Extreme heat will influence potable water supplies in the region by increasing the demand for water for drinking and general domestic use, placing greater demand on an already scarce and precious resource. Power outages that occur during heat waves could disrupt pumping and treatment of water supplies and infrastructure could be impacted as pipelines and pumps are exposed to higher operating temperatures. Managing potable water supplies will continue to be made difficult by the ongoing variability in the timing and intensity of rainfall.

Adaptation options

Adaptation options for essential services are well scoped based on work already undertaken elsewhere in South Australia and interstate. However, developing these options in the region needs to be in the context of the limitations of existing energy and water infrastructure in supporting economic development.

In the next five years, the following range of adaptation options need to be considered:

- develop a socio-economic policy to guide actions of regional importance, with an emphasis on how the provision of essential services will need to be adapted as climate conditions change;
- review and update design standards and asset management plans to allow for climate change.
 This will ensure that essential services infrastructure with long decision lifetimes are designed with future climate conditions built in, or are readily capable of being retrofitted at some point in the future;
- develop a policy to support standard service delivery in the region, with a requirement to maintain this level of service as climate changes and infrastructure operation is affected;
- investigate internal capacity building regarding the impacts of climate change on assets and procurement;
- develop and trial innovative local solutions to meet water and energy demands, such as greater use of solar desalination technology and solar PV combined with battery back-up;
- develop and update modelling and mapping to assist with risk management. This will be an extension to existing practice and likely focus on coastal risk zones, vulnerable communities at risk from extreme heat and infrastructure and communities at risk from flooding; and
- increased remote monitoring and improvements to functioning of engine-generators.

After initial emphasis on planning, mapping and standards development, adaptation will need to move into a stronger focus on implementation within 5 to 10 years. It will include increased installation of appropriately scaled renewable energy and battery storage technologies and the use of desalination units that draw on renewable (wind, solar) energy.

Over a period of two to three decades, adaptation will need to address more fundamental issues about energy and water delivery in the region. This may require relocating water and energy infrastructure to lower risk areas away from sites that are at a high risk from flood. A further, more systemic change will be to modify essential services distribution systems to cope with seasonal shutdowns of communities and towns in response to greater frequency, duration and intensity of extreme heat.

Key points

Adaptation for essential services requires further planning, capacity building, risk mapping and standards development in the next five years. However, within 5 to 10 years the emphasis will need to shift toward implementing on-ground actions that build adaptive capacity, such as solar powered desalination and solar PV-battery back-up installations. As the long-term effects of climate change are experienced over the next two to three decades, the region will need to consider moving some essential services infrastructure and possibly determine how best to manage periodic shutdowns of communities and towns.

5.3 Health, safety and well-being of the community

Key area of decision making

How do we maintain and enhance the health, safety and well-being of the community, workers and visitors to the region as the risk of extreme events such as heat waves increases?

The Far North and Outback is home to a vibrant and resilient community that has learned to cope with the region's often harsh and extreme climate and environment. This experience extends from Traditional Owners' ongoing relationship with country over tens of thousands of years to current members of the community who live in regional towns and work in the pastoral, tourism, and mining and extractive sectors.

The health and well-being of the region's community is supported by hospitals, health services and health centres located in major centres in the region (RDA Far North, 2014). Remote consultations are undertaken by telephone and radio where information is provided to health care workers, patients and family members (RDA Far North, 2014). Remote communities and families are also supported by the Royal Flying Doctor Service when local treatment is not sufficient or available. This is a consequence of the sparse population, meaning that not all people in the region have equal access to adequate healthcare.

Climate change impacts

Based on the IVA (RDA Far North, 2016), the health and safety of the community will be impacted by increasing periods of high temperatures, especially extreme heat. While the region is accustomed to higher temperatures when compared with other parts of South Australia, climate change will see this stress rise.

The immediate impact of higher temperatures will be on the health and well-being of individuals, especially vulnerable members of the community such as the elderly, people with mental health issues, and people with conditions such as cardiovascular diseases, cancer, chronic respiratory diseases (such as chronic obstructed pulmonary disease and asthma) and diabetes. There will be flow on effects to businesses with the potential for reduced work hours. Communities will be affected by greater cancellation of outdoor community events and impacts on educational services.

Extreme heat will also impact the operation of many health services. For example, increased demand during periods of extreme heat will stretch the resources of hospitals, health services and health centres. The delivery of remote health services such as the Royal Flying Doctor Service will also be impacted given limitations to flights during extreme temperatures (e.g. planes are not able to land under extreme maximum temperatures 50°C). Extreme heat will also lead to an increase in demand for

potable water supplies, placing greater pressure in particular on towns reliant on rain water or groundwater that is recharged from local rainfall.

The health and well-being of the community will continue to be affected by extreme events such as flooding, although the impact will be in the access to health services more so than directly affecting human health.

Adaptation options

Improving the well-being of people living, working and visiting the Far North and Outback is already a priority for many of the region's peak organisations. Responding to climate change will require efforts that build on existing programs. In the next five years, the focus of adaptation should be to:

- improve notification systems in relation to extreme events, to ensure that people have an early warning of high risk conditions;
- increase the amount of education and awareness raising in the region on how to respond during extreme events (for locals and visitors). In relation to extreme heat, this can build on existing advice from SA Health³;
- increase preventative health care during cooler periods of the year in order to build the resilience of people, especially vulnerable members of the community;
- upgrade airstrips to increase connectivity in the region, making it easier for the Royal Flying Doctor Service to operate and service remote communities and stations;
- expand the delivery of virtual health services. This is already a feature of health service delivery in the region but could be enhanced, requiring more effective internet services. This would aid in preventative and treatment based health care;
- modify the timing of community and sporting events to avoid periods of extreme heat (daily and seasonally);
- monitor and manage current and new users of groundwater resources; and
- increase coupled solar PV and battery storage to support greater cooling through use of air conditioning. This will require consideration of how to provide such systems to people on low incomes.

After an initial focus on enhancing many existing initiatives, greater attention will be required within 5 to 10 years on how the built environment can be made more resilient. This will involve designing and constructing community facilities that can better operate as heat refuge locations (e.g. libraries) and adopting more climate sensitive building designs to support preventative health. With respect to potable water infrastructure, there will need to be more rainwater harvesting to supplement bore water supplies and an exploration of options to treat groundwater of poor quality.

³ http://www.sahealth.sa.gov.au/healthyintheheat

In two to three decades, more substantial adaptation measures may be required. This could include changing the school year to avoid hot weather and supporting some communities to leave parts of the region during extreme conditions. While seasonal movements of people already occur, there could become a more systematic approach whereby health and emergency management service delivery systems are designed to cope with seasonal shutdowns of towns.

Key points

In the next five years, work is required to build on existing programs and actions to improve the health, safety and wellbeing of the community, such as building capacity and awareness about weather extremes, developing early warning systems, enhancing virtual health care delivery, and upgrading infrastructure. Further adaptation in 5 to 10 years will need to focus on the built environment and construction of more climate sensitive buildings. In two to three decades' greater consideration will need to be given to how the region's health and emergency management services will operate with the potential for greater movements of people during the summer period.

5.4 Mining and extractive industries

Key area of decision making

How do we maintain the productivity of mining and extractive industries in the region given projected impacts of extreme heat and rainfall on workers and infrastructure?

Mining and extractive industries are a key pillar of the Far North and Outback SA's economy. The region is home to 72% of the State's mineral resource projects producing approximately 70% of South Australia's mining outputs, which in 2006-07 equated to around \$2.2 billion (SACES, 2012; RDA Far North, 2014; Econsearch, 2009). All five of the priority mining regions in South Australia are found in the Far North (Hodgkinson, et al., 2014).

A variety of commodities are mined from 18 major operating mines in the region including uranium, copper, gold, iron-ore, silver, coal, mineral sands and opal (Hodgkinson, et al., 2014; SACES, 2012). Extractive industries in the region focus on oil and gas production from the Cooper and Eromanga basins.

Climate change impacts

The mining sector in the Far North already operates in the face of extremes in climate such as heat and flooding. However, based on the IVA (RDA Far North, 2016), the projected increasing frequency and severity of extreme events into the future threatens to exacerbate these impacts, potentially affecting the overall profitability of the sector. Impacts in the region could include (Hodgkinson, et al., 2014):

- interruptions to production along the supply chain including during extraction, processing and distribution;
- increased production costs from damages to infrastructure;
- reduced stakeholder confidence; and
- reduced productivity.

Extreme heat in particular will impact upon the health and well-being of mine site workers, potentially reducing the number of hours per day that can be worked during the hotter times of the year. Extreme heat will also increase the demand for water in the region, which is already a scare resource. Flooding already impacts mine site operations and further uncertainty in the timing and intensity of rainfall will continue to present challenges for the industry. The combined impact of hotter and drier conditions could increase the threat of fire for mine sites.

Adaptation options

The mining and extractive industries sector already has well-advanced strategies in place for managing extreme events. The need for these to be further modified to account for future climate change will depend largely on the lifetime of different mining operations. For example, mines with lifetimes of 10-15 years will need to plan for operating in different conditions than those with lifetimes of greater than 50 years, when the long-term effects of climate change and increasing temperatures are likely to be experienced. Mines also need to consider post-mine lifetime activities, such as managing tailings dams after operations have ceased.

In the next five years, adaptation will need to build on existing measures, with a focus to:

- improve early warning notification systems for extreme weather events;
- promote work, health and safety policies and education for workers during periods of extreme weather (e.g. heat, heavy rain, storm);
- improve responses to emergency situations and disasters, determining the role of emergency service providers versus company resources;
- ensure that current and future decision-making, in regard to mining operations, considers climate change projections, and recognises that various mines have different lifetimes, giving consideration to the projections for different timeframes;
- conduct further research into water resource availability including alternatives to the Great Artesian Basin;
- monitor and manage current and new users of groundwater resources; and
- increase investment in new technologies for reducing water and energy use.

Within 5 to 10 years, the trend of automating mine site operations will likely increase as a way to reduce the number of workers at risk from extreme heat. This will require changes to workforce training and housing, with greater use of staff located outside of the region. Over this timeframe, greater collaboration will be required with other industries on the use and improvement of common infrastructure and resources (e.g. roads, water). In two to three decades there is expected to be greater self-reliance of mines in remote regions. This will be influenced by the way that essential services are delivered and how communities function in response to more extreme heat.

Key points

The mining and extractive industries will continue to build on existing initiatives to prepare for climate change, such as helping people and infrastructure prepare, respond and recover from extreme events. Over the next 5 to 10 years, the focus on automating mine site operations will likely increase leading to a reduction in the presence of mine site workers in the region. In two to three decades' time, there is likely to be greater self-reliance of mines operating in remote regions.

5.5 Pastoralism

Key area of decision making

How do we maintain the economic contribution of pastoralism in the region given increasing average temperatures and extreme heat, reduced average rainfall and continued variability in the timing and intensity of rainfall?

Pastoralism is a key sector in the region and shapes much of the Far North and Outback's economy and community. It is the dominant land use, accounting for approximately 52 % (411,000 km²) of the total land mass of the RDA Far North region (RDA Far North, 2014).

Pastoralism consists of a mixture of cattle and sheep grazing, with cattle grazing being more common (RDA Far North, 2014). In addition to its contribution to employment and economic development in the region, pastoralists are key land managers helping to actively manage natural assets such as the region's unique biodiversity. As such, the sector is central to objectives for the region that focus on *vibrant communities and industries using and managing natural resources within ecologically sustainable limits* (SAAL NRM Management Board, 2010).

Climate change impacts

Pastoralism in the Far North and Outback SA must be responsive to extreme climatic conditions, which can seasonally change from extensive flooding to prolonged drought and extreme heat. However, based on the IVA (RDA Far North, 2016), the productivity of the pastoral sector is likely to be negatively impacted by climate change if further adaptation does not occur.

Hotter temperatures and longer, more frequent heatwaves will increase the need for constant and reliable sources of water as more is consumed by stock during hot weather. This combined with an increase in evapotranspiration of surface water supplies will place more pressure on the water resources of the region (Bardsley & Wiseman, 2012; Alcoe, et al., 2012). Hot weather will also test the physiological limits of animals potentially leading to reduced health and greater susceptibility to disease. Extreme heat will place limits on the ability of pastoral property workers to perform essential duties during parts of the year.

Changes in rainfall and increases in temperatures will also impact livestock through changes to pasture growth. For example, reductions in rainfall by 5 % can reduce pasture growth by 7 % (Bastin, et al., 2014). Combined with increasing temperatures that could lead to a decrease in water use efficiency of pasture, greater variability and reductions in pasture production over the region can be expected along with a reduction in carrying capacity (Bardsley & Wiseman, 2012). Changes in vegetation may also occur from more suitable grasses to more woody species and invasive flora. The extent to which increasing levels of

CO₂ will benefit pasture production is unclear because of the counter impact of declining water availability.

A major source of uncertainty for pastoralism will be how rainfall patterns change. The region covers three broad rainfall zones: the north with summer-dominant rainfall, a central zone with aseasonal rainfall, and the south with winter dominant rainfall (Wiseman & Bardsley, 2015). While there is a drying trend projected for the southern regions, the extent to which the north could benefit from greater monsoonal activity is unclear. As such, there is a need to consider the impact of both a drier and wetter climate.

Adaptation options

The pastoral sector in Australia has considered adaptation options in detail, in response to changing temperatures and rainfall patterns. In many instances adaptation measures will focus on enhancing existing practices and learning from animal and land management practices from elsewhere in Australia and overseas. Adaptation responses for the pastoral sector often focus on improving infrastructure that will be of benefit to the broader community and economy e.g. roads and telecommunications infrastructure.

The focus of adaptation measures in the next 5 years will be to:

- increase awareness amongst pastoralists on the risks of climate change in the coming 10 to 20 years;
- improve seasonal forecasting to support better decision making. This will require closer work with the Bureau of Meteorology to inform their development of forecasting tools and identifying where additional weather stations are required. Increasing awareness amongst pastoralists as to what tools are available is also necessary;
- improve invasive flora management, such as Buffel grass and wheel cactus;
- manage total grazing pressure involving feral herbivore management and stock control;
- increase education of land managers regarding monitoring and maintenance of soil surface cover including the importance of perennial vegetation;
- increase rainwater harvesting to supplement bore water supplies, and monitor and manage current and new users from across all sectors; and
- improve energy, water, transport and telecommunications infrastructure, which are essential to the effective operation of pastoral businesses. While landscape productivity may decline, businesses may be able to offset this impact through more efficient operation of their businesses.

With planning work to commence now, facilitating the transformation of land use across the rangelands is also a high priority. This needs to consider the extent to which flexibility in the pastoral lease system is sufficient to respond to a changing climate (this is described in further detail in Section 6.2).

Within 5 to 10 years, actions will need to focus on capacity building and improving general farm efficiency, and explore options to:

- diversify production to alternative meats and animal-based products (e.g. kangaroos, feral camels, feral goats);
- increase ability to monitor and rapidly move stock during extreme heatwaves to protect animal welfare; and
- amend State policies to facilitate and incentivise carbon farming on pastoral lease land.

In one to two decades, pastoral properties will need to further explore breeds that may be more climate appropriate and review vegetation management systems to maintain palatable fodder production. In some instances, a transition to alternative land use may be required in areas where pastoralism is no longer viable because of extreme temperatures or inconsistent availability of suitable pasture and fodder.

Key points

Pastoralism will need to continue expanding on practices for managing livestock and the land in extreme conditions. In the next five years this will require further investigation into alternate breeds and fodder production systems and consideration of whether polices regarding pastoral land management need changing. The adaptive capacity of pastoralism will also be influenced by underpinning business support infrastructure, such as energy, water, transport and telecommunications. In one to two decades, a transition to alternative land use may be required in areas where the viability of pastoralism is declining.

5.6 Aquatic ecosystems

Key area of decision making

How do we maintain and build the resilience of riparian zones and wetland systems as the climate becomes warmer and rainfall patterns change?

Despite the harsh environment and highly variable rainfall, the Far North and Outback SA region is home to some of Australia's most significant aquatic ecosystems including permanent, semi-permanent and ephemeral wetlands, rivers, springs, waterholes, gilgais, soaks and lakes (SAAL NRM Management Board, 2010). Unlike many other parts of Australia, the flow regimes of these systems are unaltered by infrastructure such as dams, weirs, roads, and extraction for irrigation.

Many catchments flow into inland terminal lakes, such as Cooper Creek and the Warburton River, which flow into Kati Thanda – Lake Eyre. Key groundwater-dependent ecosystems include the Great Artesian Basin mound springs. The extent of groundwater-surface water interaction is not well known but is highly likely in many permanent waterholes.

Areas that contribute to biodiversity conservation under the *South Australian National Parks and Wildlife Act 1972* and *Wilderness Protection Act 1992* that are relevant to aquatic ecosystems include:

- Elliot Price Conservation Park;
- Ikara-Flinders Ranges National Park;
- Innamincka Regional Reserve;
- Lake Eyre National Park;
- Lake Frome Regional Reserve;
- Lake Torrens National Park;
- Malkumba-Coongie Lakes National Park;
- Strzelecki Regional Reserve;
- Vulkathunha-Gammon Ranges National Park;
- Wabma Kadarbu Mound Springs Conservation Park;
- Witjira National Park; and
- Yumbarra Conservation Park.

Climate change impacts

Based on the IVA (RDA Far North, 2016), riparian zones and wetland systems were found to be highly vulnerable to the effects of climate change. Due to the importance of the water regime (i.e. connectivity, persistence and water quality), the projected vulnerability is influenced by their water source. Wetlands that depend mainly on rainfall for their water supply are highly vulnerable, whereas those that depend on discharge from groundwater (either regional or local) systems are less vulnerable, because of the greater buffering capacity of groundwater systems to changing temperature and hydrogeology (Davis, 2014).

Climate change impacts will be exacerbated by other stresses, including groundwater drawdown, surface water impoundments and the impacts of livestock, feral grazing animals, invasive fishes, exotic plants, recreation and tourism. Increased drawdown in the Great Artesian Basin is of concern, depending on the groundwater connectivity, because it reduces pressure in nearby bores, reduces flow to wetlands and could result in the loss of Great Artesian Basin mound springs which require sufficient pressure for water to flow over the mound to surrounding area. (SAAL NRM Management Board, 2010)

Adaptation options

An ongoing priority adaptation option for the region should be to maintain the flow, connectivity and water quality of aquatic ecosystems by avoiding flow impediments caused by improperly placed roads, tracks and culverts, and ensuring stock impacts are minimised. Other priorities for the next five years are to continue to increase the control of pest fauna and flora species and to identify, manage and protect priority aquatic refugia. Davis (2014) suggests that priority aquatic refugia include:

- Evolutionary refugia for fish, aquatic invertebrates and plants in mound springs fed by the Great Artesian Basin;
- Ecological refugia for fish and waterbirds in permanent waterholes (waterholes of the Lake Eyre Basin) with cease-to-flow depths > 4 m;
- Ecological refugia for waterbirds in large ephemeral lakes (freshwater and salt) in the Lake Eyre Basin, including Lake Eyre and Lake Torrens; and
- Ecological refugia for waterbirds in ephemeral waterholes in river networks in the Lake Eyre Basin and Flinders Ranges.

Over the next 5 to 10 years, adaptation will need to continue to focus on managing water regimes. A key issue will continue to be monitor and manage competing demands on groundwater between the needs of conservation, mining and pastoralism. This is an area of potential maladaptation⁴ given that access to water will be a key adaptation measure for all sectors.

⁴ Maladaptation can occur where actions taken by one sector to improve its adaptive capacity have a negative impact on other sectors.

In 10-20 years' time, adaptation will need to consider protecting populations of species at risk from climate change (e.g. through seed banking and captive population breeding programs), prepare for potential transitions in ecological communities and acquire land with important ecological assets.

Key points

In the next five years, adaptation should focus on maintaining the connectivity, persistence and water quality of priority aquatic refugia'. Over the next two to three decades adaptation measures will need to protect species at risk through seed banking, captive breeding and acquiring land with important ecological assets.

5.7 Terrestrial ecosystems

Key area of decision making

How do we maintain the condition of terrestrial ecosystems given the increasing average temperature, extreme heat, and continued variability in the timing and intensity of rainfall along with threats posed by pest plants and animals?

The Far North and Outback SA is a geographically large and diverse landscape hosting a wide array of terrestrial plants and animals that are endemic to the region. These biodiversity features shape the character, amenity and experience of the region.

Habitats within the region include dune fields, sand plains, mountain springs, gibber plains and gypsum plains (DPLG, 2010; SAAL NRM Management Board, 2010). Biodiversity in the region is managed and protected under the *Natural Resources Management Act 2004* and the *Pastoral Land Management and Conservation Act 1989*. Areas that contribute to biodiversity conservation include:

- Elliot Price Conservation Park;
- Ikara-Flinders Ranges National Park;
- Innamincka Regional Reserve;
- Lake Eyre National Park;
- Lake Frome Regional Reserve;
- Lake Torrens National Park;
- Mamungari Conservation Park;
- Nullarbor Regional Reserve and Nullarbor National Park;
- Pureba Conservation Park;
- Simpson Desert Conservation Park and Regional Reserve;
- Strzelecki Regional Reserve;
- Tallaringa Conservation Park;
- Vulkathunha-Gammon Ranges National Park;
- Witjira National Park;
- Yellabinna Regional Reserve; and
- Yumbarra Conservation Park.

There are also several non-government organisation-managed and Aboriginal-managed pastoral leases in the region that are conservation based, such as Bon Bon Station Reserve and Boolcoomatta Reserve that are managed by Bush Heritage Australia.

Climate change impacts

Terrestrial ecosystems in the region have already been impacted by a range of threatening processes, including excessive total grazing pressure, invasive plants and altered fire regimes. Based on the IVA (RDA Far North, 2016), terrestrial ecosystems were found to be highly vulnerable to the effects of climate change. Like many natural systems, they are highly exposed and sensitive to a changing climate, but likely to have limited adaptive capacity, especially where systems are already degraded. At a landscape level this could lead to movements in native vegetation communities (e.g. shrubland, perennial grassland woodland) in response to changing temperature and rainfall patterns. Amongst native animals, recent research (Pavey, 2014) suggests that reptiles and snails will be particularly vulnerable to the impacts of climate change.

Specific impacts of changing temperature and rainfall patterns that are likely to result in changing ranges of native and introduced species include (Bardsley & Wiseman, 2012):

- changes in timing of key breeding and flowering cycles due to changes in rainfall;
- key refuge areas in the Central Ranges becoming altered;
- habitat reduction due to altered fire regimes;
- stronger competition from exotic plant and mammal species (e.g. Buffel grass and Wheel cactus); and
- large changes in ecosystem composition if thresholds of aridity are passed.

Adaptation options

The high vulnerability of many natural ecosystems means that much work has been undertaken to explore adaptation responses (e.g. CSIRO's AdaptNRM). This Plan presents an overview of the types of adaptation responses that will need to be considered in the SAAL and AW NRM regions, however, implementation will need to be tailored to specific plant and animal communities and threatening processes.

In the next five years, adaptation measures should seek to:

- improve the monitoring of systems and better utilise data collected to inform on-ground management activities. Monitoring data should be tied to understanding of triggers and thresholds of change in natural systems;
- increase the control of pest plant and animal fauna and flora species including through the use of biocontrols. This will need to focus on pest plants such as Buffel grass and Wheel cactus and animals like camels, donkeys and goats;

- manage, restore, and increase connectivity to support migration and range shifts of flora and fauna especially between climate refugia;
- increase soil surface cover to avoid erosion. This can be delivered through existing programs that are being delivered by NRM organisations with pastoralists;
- implement more patch burning to decrease the risk of large wild fires; and
- increase the number of people working on the land such as through developing funding models for indigenous workers.

Within 10-20 years, greater effort will need to be made to maintain important ecological assets and processes through financial incentives such as conservation stewardship, strategic heritage agreements, or land acquisition. This will need to align with work to manage, restore, and increase connectivity and to protect climate refugia. In some parts of the region this could focus on areas of land no longer viable for pastoralism under a different future climate.

Where ecosystems cannot be maintained in their current locations, effort will be required to protect populations of species at risk from climate change through more intensive measures such as seed banking and captive population breeding programs. Determining whether this is a priority for the region will need consideration of whether ecosystems at risk are unique to the Far North and Outback or spread more widely across the Australian rangelands.

Key points

Terrestrial ecosystems in the region are highly vulnerable to climate change, especially plants, reptiles and snails. In the next five years, actions will be required that build resilience such as reducing threatening processes (e.g. pest plants and animals, total grazing pressure) and better monitoring to make more informed management decisions. In the coming two to three decades, greater effort will need to be made to maintain important ecological assets and processes through the use of financial incentives. Seed banking and captive population breeding provide more intensive options for species at risk.

5.8 Transport services and infrastructure

Key area of decision making

How do we maintain and enhance transport services and infrastructure given increasing average temperature, extreme heat, and continued variability in the timing and intensity of rainfall?

The large area covered by the Far North and Outback SA means that transport services and infrastructure are essential to the resilience of the community and economy. The region is serviced by sealed and unsealed roads, with an estimated 10,000 km of unsealed roads in the RDA Far North alone (RDA Far North, 2014). Road access is vital for the transportation of goods to remote communities and mine sites. Any disruption to the provision of essential goods and services to communities could greatly affect the health and well-being of communities in the region.

Rail transport is significant, with Spencer Junction in Port Augusta one of the busiest railway junctions in the Nation. Rail transport is used for a range of purposes including passenger transport and freight transport for mining operations and general freight. Extractive industries utilise the Adelaide to Darwin line to transport their products to ports in Darwin to supply international markets. (RDA Far North, 2014; DPLG, 2010).

Due to the remoteness, and often large distances that need to be travelled, air transport in the region is common. There are commercial and privately owned airports in the region that are utilised for an array of purposes including servicing the mining industry, defence, tourist purposes, and for providing access to remote indigenous and non-indigenous communities, especially for access to critical health care (RDA Far North, 2014; DPLG, 2010).

Climate change impacts

Based on the IVA (RDA Far North, 2016), transport services and infrastructure, especially sealed roads were found to be highly vulnerable to the effects of climate change. Sealed roads will be impacted by extreme heat which will deteriorate the road surface, and sea level rise which could impact on low lying roads close to the coast.

Although not identified as having high vulnerability in the IVA, unsealed roads will be highly sensitive to changing rainfall patterns. Reduced rainfall will dry out the road base and encourage corrugation while more intense rain could lead to erosion. During flood events major unsealed roads are already closed to prevent damage to the road's surface and to prevent vehicle accidents and/or motorists becoming stranded in remote regions (RDA Far North, 2014).

Rail and airport infrastructure is already susceptible to flood impacts which can cause damage to rail bridges and prevent landing of aircraft as well as damaging airstrips. Extreme heat can also impact the

operation of trains and planes, affecting the conditions under which transport staff can work. Any disruptions to the rail sector of the region could cause nationally significant economic impacts due to the amount of goods transported through the region.

Adaptation options

Maintaining and enhancing transport services and infrastructure as the climate changes will be essential for building the resilience of the region's community and economy. Priority adaptation options in the next five years will be to review and update design standards for road and rail infrastructure to allow for climate change impacts and upgrade airstrips to minimise isolation in the region.

A broader range of options need to be considered over the coming 5 to 10 years, in the coming five years, such as to:

- increase installation of small scale renewables to reduce fuel transport requirements;
- increase expenditure for the road network including better maintenance and sealing more of the unsealed network (e.g. Strzelecki Track);
- increase use of the internet to support the delivery of financial, education and health services, thereby reducing the need for vehicles using roads, especially during periods of extreme weather;
- research and development into road surface binders that can withstand higher temperatures in the region; and
- strengthen creek crossings and floodways to enable vehicle movements during periods of flooding.

In two to three decades, there will need to be greater consideration of what transport solutions are required to assist the community in leaving parts of the region during extreme conditions (e.g. periods of hot weather). Decisions will be required as to whether all roads in the region need to be maintained to the same level given servicing costs may increase.

Key points

Maintaining and improving upon transport services and infrastructure is vital for supporting the resilience of the community and economy in the region. In the next five years adaptation planning will need to review and update design standards for road and rail infrastructure to allow for climate change impacts and upgrade airstrips to minimise isolation in the region. In 5 to 10 years, adaptation measures will need to reduce demand for transport services and infrastructure and implement actions that build the resilience of the network. In two to three decades, transport services and infrastructure will need to accommodate for potentially large movements of people across the region on a seasonal basis.

Far North and Outback SA Climate Change Adaptation Plan

6 Implementing the Plan

6 Implementing the Plan

6.1 Cross sectoral priorities

The development of this Plan has focused on identifying what sectors are important to the region's community and economy and understanding how they will be impacted by climate change. In doing so, the Plan aligns with the Outback Communities Authority Region Economic Growth and Investment Strategy and addresses the region's opportunities for growth, such as mining, agriculture and tourism. By building adaptive capacity in these sectors this Plan can contribute to the long-term growth of the region.

The primary purpose of this Plan is to identify regional, cross sectoral adaptation priorities. These were identified by reviewing sector specific options, determining those that were:

- of regional scale or relevance;
- common to more than one key decision area (i.e. are cross-sectoral);
- will deliver multiple benefits; and
- would benefit from a coordinated, regional response across key regional stakeholders.

These were then tested and refined at a workshop with key stakeholders and resulted in the identification of nine cross sectoral adaptation priorities for the region (refer below and Table 2).

It is not intended that these are the only adaptation options to be considered in the Far North and Outback SA region, but rather, they provide a starting point to focus initial regional, cross-sectoral action. The remainder of the options identified by the Plan are still considered critical to ensuring the Region remains resilient and productive and need to be further progressed by each sector.

Establish a regional governance model

Establishing a regional governance model to support the implementation of the Plan is critical in the region, given the large geographical area and the number of different governance arrangements in place compared to other regions (e.g. Councils, out of Councils, Aboriginal Lands Trusts). Such a model should:

- identify member organisations
- ratify commitment through some form of agreement (e.g. Climate Change Sector Agreement), to become the platform for a multi-party Committee to oversee the implementation and review of the Plan. The Plan can provide the foundation for agreement and working together to implement regional/ cross sectoral priorities for adaptation;
- designate a lead organisation/group charged with driving implementation;
- establish a regional coordinator role;
- facilitate coordination and collaboration between all levels of government and stakeholders;
- identify clear roles and responsibilities for adaptation actions;

- establish resources;
- provide the basis for shared accountability for implementation; and
- identify other initiatives that will be required to support implementation including the development of a monitoring and review framework.

Lead organisations: RDA Far North, OCA, SAALNRMB, AWNRMB

Establish a forum for engaging Aboriginal communities

Aboriginal people will bring new, different and important knowledge to the table that will enhance the Region's response to climate change, however it is also recognised that culturally appropriate methods are required to do so.

Establishing a 'forum' or approach for engaging with Aboriginal communities about climate change and opportunities for adaptation is therefore identified as a cross sectoral priority and one that will be ongoing and linked with other discussions given the way in which Aboriginal people do not consider issues in isolation. An initial step involves investigating organisations best suited to lead the engagement with Aboriginal communities in the region and identifying opportunities to integrate discussion about climate change. Significant work has already been undertaken in relation to climate change planning and indigenous engagement in the region (see Bardsley and Wiseman (2012) and Nursey-Bray et al (2013)) and this should be built upon in the future.

Lead organisations: In partnership with Aboriginal communities

Build the capacity of people in the region to adapt

This cross sectoral priority comprises two key aspects. The first relates to the ongoing importance of raising awareness and building individual capacity in relation to climate hazards such as extreme heat, flooding from intense rainfall and sea level rise and how to plan for, respond and recover from extreme events.

Although many people living in in the region are used to living with highly variable conditions, with many already implementing a range of strategies that enable adaptation, there is still the need to ensure that people are aware of climate hazards and opportunities to respond. Capacity building initiatives should be focussed on key sectors/ target audiences as follows:

- vulnerable members of the community, particularly regarding heatwaves and extreme heat;
- people living in isolated areas of the region or that have the propensity to be cut off during an extreme event (e.g. flooding, bushfire);
- tourists travelling in or through the region, particularly during times of the year when bushfire, extreme heat or intense rainfall are more likely;
- broader community, particularly regarding extreme heat and periodic flooding from intense rainfall and storm surge; and

• pastoralists, business and industry, particularly in relation to understanding the risks of climate change and the need to plan for emergencies associated with heatwave and flooding from intense rainfall events and storm surge.

An important component of this capacity building involves making sure that people living, working or visiting the region are aware of the ways in which extreme weather warnings are made available and respond accordingly.

Improvements in systems providing public warnings regarding extreme weather events have been made this year with the establishment and release of the Alert SA website (www.alert.sa.gov.au) and mobile app. Alert SA aims to provide the most comprehensive view of event and warning information in South Australia and is managed by the South Australian Fire and Emergency Services Commission (SAFECOM). Data is sourced from a variety of sources including the Bureau of Meteorology, SES, SA Police and CFS.

A variety of formats of Alert SA have been developed including a "Light Website" with restricted functionality to cater for users with slower internet connection and text only website for users with accessibility needs and slow internet connections. Promotion of this website across the region to residents and visitors is required to increase awareness of this source of information.

The second aspect relates to building the capacity of decision makers/influencers in the Region to advocate for issues that are of regional importance such as climate change adaptation, as well as other issues more generally that are critical to the ongoing viability and sustainability of the Region. This includes making sure that key decision makers and influencers are aware of the interlinked nature of climate impacts with other aspects of regional importance such as economic development or health and wellbeing, and are able to advocate and raise the profile of the challenges facing the region as well as the opportunities and benefits that regional areas contribute to the State and beyond. This is of importance given the way in which other decisions that are made 'outside' of the Region impact the functioning and vitality of what occurs 'in' the Region.

One key action that can assist with coordinating and 'pushing' this messaging out and ensuring that climate change adaptation is high on the regional agenda both within and outside the region is to formalise commitment to the regional adaptation plan and establish a dedicated resource to drive implementation.

Lead organisations: RDA Far North, OCA, SAALNRMB, AWNRMB

Use risk assessment approaches to prioritise adaptation responses

The high cost of some adaptation options (such as sea walls, bridges, sealing of roads, maintenance of unsealed roads), funding and resource constraints, and the need for a staged approach to infrastructure development means the Region needs a comprehensive understanding of the priorities for adaptation and the timing over which these should occur. Risk assessment approaches applied to individual asset types (e.g. roads and bridges) or considering climate impacts (e.g. intense rainfall or sea level rise) can ensure investment is targeted and prioritised appropriately.

Risk assessment approaches require a detailed understanding of the likelihood of assets being impacted by climate change such as flooding and sea level rise. Undertaking modelling and mapping of flood inundation and sea level rise considering projected increases in rainfall intensity and sea level rise is essential for better understanding which assets are at risk and what response options should be considered. Such risk assessment should be used to inform reviews of asset management plans. This modelling and mapping will also assist the region to determine those areas where it may not be appropriate to develop/build, or those assets and/or locations where protection infrastructure may be required (e.g. seawall).

Lead organisations: RDA Far North, OCA, SAALNRMB, AWNRMB

Embed climate considerations into design standards and asset management plans

Across the region a range of design standards and asset management plans apply to a diversity of assets. This includes built assets such as public buildings and infrastructure including stormwater management systems, sport and recreation facilities, jetties, roads and public realm areas, utilities such as electricity, telecommunications, sewerage and water and natural assets such as trees, watercourses and native vegetation.

The majority of design standards and asset management plans however, do not consider climate impacts. This is an issue given that asset management plans often relate to infrastructure that has a long lifespan and therefore is likely to be impacted by changes in climate. Climate change considerations therefore should be embedded in design standards and asset management plans so that adaptation becomes part of everyday practices.

This cross sectoral adaptation priority can be progressed by embedding climate change considerations into design standards and asset management plans. This would involve:

- identifying future projected climate impacts within relevant design standards and asset management plans; and
- managing assets in a way that considers these future conditions (particularly in relation to intense rainfall, bushfire, sea level rise and extreme heat).

The embedding of these considerations into everyday practices needs to be coupled with the capacity building of relevant staff.

It may also need to be supported by updating modelling and mapping for example for stormwater management by considering changes in rainfall intensity and ARI or for assets located along the coast, by considering changes in sea level. This modelling and mapping will assist the region to determine those areas where for example, it may not be appropriate to build or those assets/locations where protection infrastructure may be required (e.g. seawall).

Lead organisations: OCA, regional councils

Prepare a 'Climate Ready Roads' Strategy

Road infrastructure is critical to the region as it enables:

- the people who live there to traverse the region, including during emergency situations;
- the transport of goods and services in and out of the region; and
- tourists to travel throughout the region.

In the more remote parts of the Far North and Outback SA, there are only one or two key routes in and out and much of the road network is unsealed.

Already the region experiences intense rainfall events which result in sealed and unsealed roads and bridges being washed out, and in some areas, people and places being cut off from the rest of the State for extended periods of time.

During extreme heat, road surfaces melt and the road's lifetime is reduced, requiring more frequent maintenance/replacement. In some locations along the coast such as at Port Augusta, storm surge exacerbated by increasing sea levels is resulting in some roads being inundated. This impacts the economic viability of towns and businesses reliant on tourists, socially isolates people living in the region, reduces the ability for business to function effectively, including those that transport goods to, from and via the region.

To support the effective functioning of the road network into the future, sealed and unsealed road infrastructure needs to take into account the changing climate conditions so that they are 'climate ready'. Climate ready roads are those that are designed and constructed to take into account anticipated climate change and assist with mitigating climate change impacts such as extreme heat, flooding and sea level rise.

The preparation of a Climate Ready Roads strategy for the region is an initial step that would assist the region to build resilience of its road infrastructure and is consistent with key regional priorities.

Key aspects to be addressed by the strategy include identification of:

- strategic framework for the provision of climate ready road infrastructure in the region including the need to use a climate lens for road design and construction;
- priorities for investment. To assist with determining priorities for investment, an evaluation process should be undertaken. Assessment criteria could include those locations that:
 - are commonly washed out during flooding events, impacted by extreme heat and/or inundated by storm surge;
 - o provide the only route in/out of a locality;
 - o support existing or open up new economic activities; and
- design and construction techniques that can address projected climate impacts (e.g. hard paving some creek/river beds to reduce repair work required following flooding).

Lead organisations: OCA, regional councils, DPTI

Increase installation of small scale renewable energy and battery storage

The installation of small scale renewable energy and battery storage will reduce reliance on diesel power and therefore reduce emissions and the need for fuel transportation while at the same time improving reliability of energy sources in the region, particularly during power outages. This may be particularly focussed on places that are used as refuges or for people living in more isolated locations in the region.

Critical to such an initiative will be the ability for such technology to be serviced by appropriately qualified and trained maintenance services. This is a current challenge in parts of the region, in that appropriate technicians are not accessible, available or it is cost prohibitive to pay them to attend some locations to fix renewable energy installations. Another potential barrier of such an initiative is the subsidy currently available for diesel which may mean the installation of small scale renewable energy generation may not be seen as cost effective, at least in the short term.

Lead organisations: RDA Far North, OCA, regional councils

Increase provision of communications infrastructure to support the delivery of financial, education and health services

Communications in the region are very limited other than in the significant urban centres such as Port Augusta and Roxby Downs. In some locations business operations are still utilising facsimile machines to undertake pay roll tasks or travel to nearby towns to utilise internet services available there and many areas are without mobile phone coverage.

Facilitating access to the internet and/or mobile phone coverage across the Region will have wide reaching and positive impacts for all sectors and members of the community and in particular, financial, education and health services. Access to the internet will facilitate social connection, enable educational and business opportunities and support health services. Coupled with better mobile phone coverage, improved communications will also benefit travellers and support their safety as well as the broader community that live and work in the Region.

One opportunity to initiate action on this cross sectoral priority is to develop a business case for the establishment of optic fibre from Hawker to Marree, with the view to using WIFI to 'hang off' this network to provide internet to local communities in proximity.

Lead organisation: RDA Far North

Facilitate transformation of land use across the rangelands

The region is characterised by pastoral leases which sees vast amounts of land used for grazing either cattle or sheep. Currently, stakeholders in the region understood there to be limitations regarding what activities can and cannot be undertaken on pastoral leases. These restrictions are believed to reduce flexibility, particularly in response to adapting to extreme events such as flooding, extreme heat or drought and limit the ability to innovate (noting that grazing can and does adapt to these events currently).

By reviewing and reimagining the use of rangelands, including the land tenure system and use of pastoral leases, opportunities may be facilitated that enable adaptation as the climate changes. For example, by expanding the activities that may be undertaken, new activities or industries could emerge relating to different species (e.g. goats or camels) or the 'production' of biodiversity outcomes (e.g. the Crown 'pays' leaseholders to facilitate biodiversity improvements on the land).

An initial action could involve developing a paper that:

- investigates why the existing pastoral lease system is currently in place (i.e. the drivers);
- evaluates the efficacy and relevancy of the current system given current drivers (including climate change);
- consider different systems or models for land tenure, including an assessment of the pros and cons; and
- identifies opportunities for change.

Lead organisation: DEWNR

Table 2. Proposed key stakeholders and lead organisations for implementation of cross sectoral adaptation priorities.

Cross sectoral priority	Relevant sectors	Key stakeholders	Suggested lead
Establish a regional governance	All	Far North Regional Development Australia (RDA)	RDA Far North, OCA,
model		Outback Communities Authority (OCA)	SAALNRMB,
		District Council of Coober Pedy	AWNRMB
		Flinders Ranges Council	
		City of Port Augusta	
		Roxby Downs Council	
		South Australian Arid Lands Natural Resources	
		Management Board (SAALNRMB)	
		Alinytjara Wilu <u>r</u> ara Natural Resources Management Board	
		(AWNRMB)	
		Upper Spencer Gulf Common Purpose Group	
		Department for Planning, Transport and Infrastructure	
		(DPTI)	
		SA Health	
		SAFECOM	
		Department for State Department (DSD)	
		Department for Communities and Social Inclusion (DCSI)	
		Traditional owners	
Establish a forum for engaging	All	SAALNRMB	In partnership with
Aboriginal communities		AWNRMB	Aboriginal
		Anangu Pitjantjatjara Yankunytjatjara (APY) Lands	communities

Cross sectoral priority	Relevant sectors	Key stakeholders	Suggested lead
		Department of Premier and Cabinet (DPC)	
		Traditional owners	
		Aboriginal communities	
Build the capacity of people in the	All	Far North RDA	RDA Far North, OCA,
region to adapt		OCA	SAALNRMB,
		District Council of Coober Pedy	AWNRMB
		Flinders Ranges Council	
		City of Port Augusta	
		Roxby Downs Council	
		Department of Environment, Water and Natural Resources	
		(DEWNR)	
		SAALNRMB	
		AWNRMB	
		Upper Spencer Gulf Common Purpose Group	
		DPTI	
		SA Health	
		South Australian Tourism Commission	
		SAFECOM	
		DSD	
		DCSI	
		APY Lands	
		Traditional owners	

Cross sectoral priority	Relevant sectors	Key stakeholders	Suggested lead
Use risk assessment approaches to	All	Councils	RDA Far North, OCA,
prioritise adaptation responses		DPTI	SAALNRMB,
		Infrastructure owners and managers	AWNRMB
Embed climate considerations into	Coastal development	Councils	OCA, regional
design standards and asset	Essential services	DPTI	councils
management plans	Health and safety of	Infrastructure owners and managers	
	the community	DEWNR	
	Transport services	Coast Protection Board	
Prepare a 'Climate Ready Roads'	Transport services	Councils	OCA, regional
Strategy	Health and safety of	DPTI	councils, DPTI
	the community	South Australian Tourism Commission	
	Pastoralism		
	Mining		
Increase installation of small scale	Health and safety of	DSD	RDA Far North, OCA,
renewable energy and battery	the community	DEWNR	regional councils
storage	Pastoralism	Department of Premier and Cabinet (DPC)-Low Carbon	
		Economy Unit	
		Tourism operators	
		Councils	
Increase provision of	Essential services	OCA	RDA Far North
communications to support the	Health and safety of	RDA	
	the community	Zone Emergency Management Committee (ZEMC)	

Cross sectoral priority	Relevant sectors	Key stakeholders	Suggested lead
delivery of financial, education and	Transport services	Tourism operators	
health services		South Australian Tourism Commission	
Facilitate transformation of land use	Pastoralism	DEWNR	DEWNR in
across the rangelands		Pastoral lease holders	conjunction with the
		Primary Producers SA (PPSA)	AW and SAAL NRM
		Aboriginal corporations	Boards
		Pastoral Board	
		Crown Lands	
		RDA	
		DSD	

6.2 Cross sectoral adaptation pathway

Adaptation pathways identify the range of potential adaptation options for a given key area of decision making and describe how their implementation can be sequenced through time. This recognises that some options should be implemented immediately to build resilience and adaptive capacity. However, other, often more strategic or transformational, adaptation options will not be required for several decades until more significant changes in the climate have occurred.

A regional applied adaptation pathways map has been developed for this Plan based on the approach presented in the User Guide for Applied Adaptation Pathways (Siebentritt & Stafford-Smith, 2016). The options featured on the pathway map are based on the cross sectoral priorities presented in Section 6.1 above, as well as a number of additional more transformational options (Figure 3)^e.

Cross sectoral priorities for immediate implementation focus on establishing a regional governance model and forum for engaging Aboriginal communities, thereby addressing a potential barrier to implementation. While not in place at present, the regional governance model could become the vehicle for ongoing delivery of all options under this plan. Both of these options should be completed within 5 years.

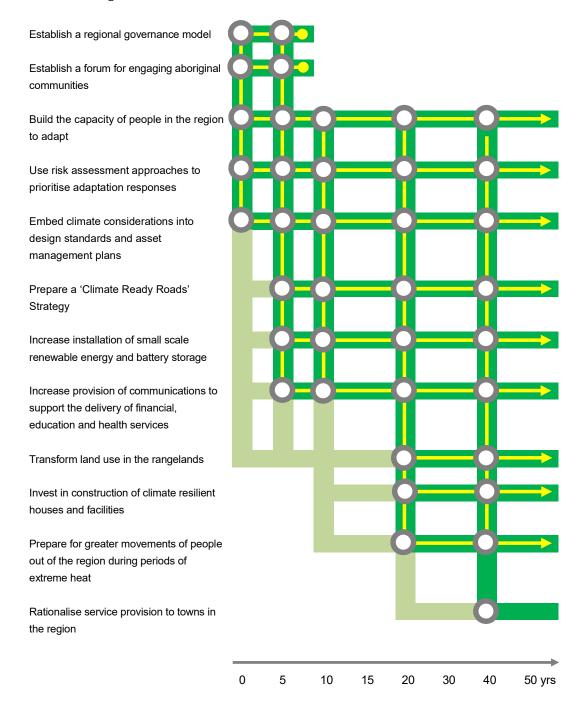
Also for immediate implementation is to work with leaders in the community, business sector and government agencies in the region to build capacity and understanding of how to adapt, use risk assessment approaches to prioritise adaptation responses and embed climate considerations into design standards and asset management plans.

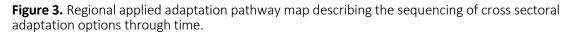
Within 5 years a further raft of adaptation options should be implemented. The 5 year delay to these options recognises that while their implementation will build resilience and adaptive capacity, time is required to prepare and plan for implementation to ensure that the required policy settings and funding arrangements are in place. These options are to prepare a 'Climate Ready Roads' Strategy, increase installation of small scale renewable energy and battery storage, and increase provision of internet access to support the delivery of financial, education and health services.

^e The final three options on the pathway map are not listed in Table 2 because they have a delayed commencement.

Although the region has adapted to the high variable and at times harsh environment, within 20 years a greater emphasis will shift to adaptation responses that more fundamentally influence how the community and economy function, responding to what are expected to be more significant changes in the region's climate by this time. Transformation of how the rangelands are managed will have already commenced but more significant changes in determining what areas are viable to continue pastoralism on will need to be assessed. Similarly, the region will need to prepare for what are expected to be greater movements of people in response to more extreme events, especially extreme heat. Decisions about seasonal closures of some towns will need to be balanced with the inherent value of people living and working as custodians of the land, which will lead to greater investment in construction of more climate resilient houses and community facilities.

If the adaptation and mitigation responses are not as comprehensive as required there may be a need to conduct an assessment of the balance between people living and working on the land and rationalising which towns should continue to be supported with essential services. This will require consideration of social (e.g. population decline, health impacts) and economic factors (e.g. cost of continue service delivery and maintenance of infrastructure). **Key area of decision making** - How do we build the resilience and productivity of the region as the climate changes?





6.3 Barriers and enablers to adaptation

While the urgency of climate change adaptation is well established, the implementation of options does not always occur how they are proposed in adaptation plans. This is due, in part, to a range of barriers to the decision making context. Gorddard et al. (2016) describe these barriers as either relating to values, rules or knowledge.

Key values to consider when designing adaptation strategies are the community aspirations to remain living in the area and the strong connection to country for both Aboriginal and intergeneration families. An enabler of change will be to better understand regional and shared values and how they align with proposed adaptation initiatives. A continuing barrier that should be addressed through capacity building is ongoing questions about the extent to which climate change is occurring.

Rules relate to governance, policy and legislative arrangements. A key enabler of change is a revised governance model that is informed by regional values, not those of decision makers in Adelaide. This should build on a community capacity building model that leads to greater remote management and operation (see Section 6.1 for further description). Creating policies that present financial incentives and grants will also be important in stimulating adaptation action.

A range of knowledge-based enablers and barriers were identified to support adaptation in the region. Principal amongst these was capacity building with decision makers and visitors to the region to improve their understanding about what conditions are like in the Far North and Outback (e.g. lack of mobile phone coverage, travel time). A further knowledge-based enabler for the future is the need for more tradespeople to be able to support new technologies (e.g. solar PV).

6.4 Periodic review, monitoring and evaluation

This Plan has identified sectoral and cross sectoral adaptation options based on a review of relevant literature and the expertise of key stakeholders in the region. However, the relative priorities of adaptation options may change trough time as the climate changes. As such, this Plan should be regularly reviewed to coincide with the planning timeframes of key regional organisations and should consider new data on climate change projections, such as from IPCC, which occurs about every five to six years.

Periodic review of the plan should be informed by monitoring and evaluation of indicators that assess whether actions are being implemented and whether triggers for decision making are being met. A range of indicators and triggers were discussed by the region's stakeholders at a project workshop that relate to features of the climate, community, economy and infrastructure, and environment. Key indicators should consider:

- climate average temperature, night time temperatures, annual and extreme rainfall, extreme heat, sea level rise, frequency of catastrophic fire danger days;
- community mortality and morbidity driven by extreme events, cancellation of outdoor events, population declines (especially in small towns);
- economy and infrastructure condition of infrastructure, property damage, change in operating costs, power outages, road surface melting; and
- environment changes in weed species, invasive fauna, land degradation including erosion.

Better understanding of indicators, triggers and thresholds is essential for implementing an effective adaptation strategy and should be the focus of significant additional work in the region by lead organisations for each sector.

Future reviews should also consider when adaptation will need to move beyond continuing with existing best practice and moving toward greater transformational responses.

6.5 Next steps

The next steps in implementation of this Plan need to focus on preparing an Action Plan and agreed list of responsibilities amongst regional organisations for progressing cross sectoral adaptation priorities, especially those identified on the regional adaptation pathways map for immediate implementation.

The focus of this plan has been on cross sectoral priorities, and hence more work is required to determine sector specific adaptation priorities. This will be enhanced by using an adaptation pathways approach to identify adaptation options for immediate implementation compared with those that are not required until the future.

As described in Section 6.4, the further development of indicators, triggers and thresholds for decision making will help ensure that the region adopts a measured approach to sequencing implementation of this Plan through time.

Far North and Outback SA Climate Change Adaptation Plan

7 References

7 References

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Attachment A – Project participants

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Colin Greenfield	Billa Kalina				
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John Banks	Port Augusta City Council				
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Paul Dickson	SES				
Paul Hodges	DEWNR				
Rachael Hilder	Sheep grazing property near Hawker				
Rob Brandle	DEWNR				
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Sandy Morris	Gawler Ranges NRM Group				
Sharn Gilmour	Natural Resources SA Arid Lands				
Sharon Oldfield	Cowarie				
Stephen Lyons	Kingoonya NRM Group				
Sue Chase	Cowell Electrics				
Thomas Hammereister	Coober Pedy Retail, Business and Tourism Association				
Troy Grover	RDA Far North				

Attachment B – Adaptation pathways

The use of '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-Smith, 2016)

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 4 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 the climate changes, some options will become less suitable as adaptation measures and that 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, for example see Figure 3) 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.

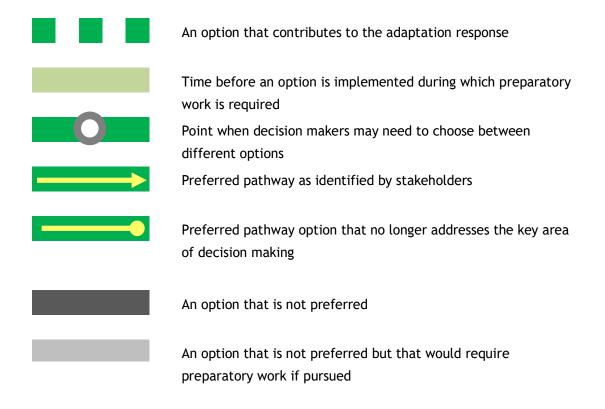


Figure 4. Adaptation pathways map legend.

Attachment C – Climate projections

Climate projections for the Far North and Outback to 2030 and 2070 under an intermediate emissions scenario for three locations: Port Augusta, Marree, Oodnadatta. The change in rainfall is a percentage. Temperature changes relate to annual mean maximums.

	Baseline	2030		2070	
		Change	Projected	Change	Projected
Port Augusta					
Rainfall					
Annual (mm)	257.0	-8.8	234.5	-9.9	231.5
Summer (mm)	58.0	-3.1	56.2	-6.0	54.6
Autumn (mm)	58.2	-9.1	52.9	-13.1	50.6
Winter (mm)	71.4	-6.8	66.5	-5.2	67.7
Spring (mm)	70.2	-14.6	59.9	-14.2	60.2
Temperature					
Annual (ºC)	24.7	1.0	25.7	1.8	26.5
Summer (ºC)	31.3	0.9	32.3	1.8	33.1
Autumn (ºC)	25.0	1.0	26.0	1.8	26.8
Winter (ºC)	17.7	0.9	18.6	1.6	19.2
Spring (ºC)	25.0	1.1	26.1	2.0	26.9
Days > 35⁰C	43 days	19% incrs.	51 days	41% incrs.	61 days
Days >40ºC	13 days	31% incrs.	17 days	69% incrs.	22 days
Marree			1		
Rainfall					
Annual (mm)	161.8	-8.8	147.7	-9.9	145.8
Summer (mm)	54.8	-3.1	53.1	-6.0	51.5
Autumn (mm)	38.7	-9.1	35.1	-13.1	33.6
Winter (mm)	32.7	-6.8	30.5	-5.2	31.0
Spring (mm)	35.3	-14.6	30.2	-14.2	30.3
Temperature					
Annual (ºC)	28.8	1.0	29.8	1.8	30.6
Summer (ºC)	37.0	0.9	37.9	1.8	38.7
Autumn (ºC)	28.5	1.0	29.5	1.8	30.3
Winter (ºC)	20.1	0.9	21.0	1.6	21.7
Spring (ºC)	29.5	1.1	30.6	2.0	31.5
Days > 35ºC	95 days	13% incrs.	108 days	28% incrs.	122 days
Days >40ºC	35 days	27% incrs.	45 days	61% incrs.	57 days

		2030		2070					
	Baseline	Change	Projected	Change	Projected				
Oodnadatta									
Rainfall									
Annual (mm)	174.7	-8.8	159.4	-9.9	157.4				
Summer (mm)	71.1	-3.1	68.9	-6.0	66.9				
Autumn (mm)	38.0	-9.1	34.5	-13.1	33.0				
Winter (mm)	29.2	-6.8	27.2	-5.2	27.7				
Spring (mm)	35.5	-14.6	30.3	-14.2	30.4				
Temperature									
Annual (ºC)	29.1	1.0	30.1	1.8	30.9				
Summer (ºC)	36.9	0.9	37.9	1.8	38.7				
Autumn (ºC)	28.5	1.0	29.5	1.8	30.3				
Winter (ºC)	20.6	0.9	21.5	1.6	22.1				
Spring (ºC)	30.3	1.1	31.4	2.0	32.3				
Days > 35ºC	101 days	12% incrs.	114 days	30% incrs.	132 days				
Days >40ºC	37 days	28% incrs.	48 days	73% incrs.	64 days				