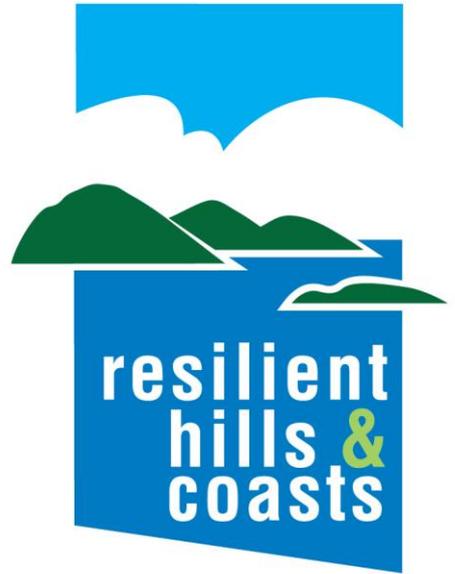


# Consolidated Integrated Vulnerability Assessment Report for the Adelaide Hills and Fleurieu Peninsula



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A report prepared for the Resilient Hills and Coasts project

**Prepared by**

Seed Consulting Services  
106 Gilles Street, Adelaide, SA 5000  
[www.seedcs.com.au](http://www.seedcs.com.au)



**Together with**

URPS  
Suite 12/154 Fullarton Rd, Rose Park, SA 5067  
[www.urps.com.au](http://www.urps.com.au)



**Prepared for** Resilient Hills and Coasts

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Project Director	Mark Siebentritt		
Written By	Mark Siebentritt		03/11/15
Checked	Andy Chambers		03/11/15
	Jenni Garden		04/02/16

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# Acronyms

BOM - Bureau of Meteorology

ENSO - El Niño Southern Oscillation

IOD - Indian Ocean Dipole

IPCC – Intergovernmental Panel on Climate Change

IVA – Integrated Vulnerability Assessment

LGA SA - Local Government Association of South Australia

RCP – Representative Concentration Pathway

RDA - Regional Development Australia

RH&C - Resilient Hills and Coasts

## Executive summary

Resilient Hills & Coasts (RH&C) is a partner project between Local Government, NRM Boards and State and Federal Governments to develop a Regional Climate Change Adaptation Action Plan (the Adaptation Plan) for Adelaide Hills, Fleurieu Peninsula and Kangaroo Island region. As part of this process an Integrated Vulnerability Assessment (IVA) was undertaken to identify priority features or systems in the region that are most vulnerable to the impacts of climate change so as to help focus adaptation planning. This report presents the results of the IVA for the Adelaide Hills and Fleurieu Peninsula part of the region. An IVA assessment for Kangaroo Island has previously been completed (Resilient Hills and Coasts, 2014a). The findings from both IVA assessments will be combined in the next project stage in order to produce a single climate change adaptation plan for the whole region.

The IVA was undertaken for 53 indicators covering 10 sectors relevant to the following four domains:

- social and community;
- assets and infrastructure;
- regional economy; and
- environment and natural resources.

The IVA was based on the most up-to-date available climate projections to 2070 for the intermediate emissions scenario (representative concentration pathway RCP4.5)<sup>1</sup>. 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. IVA assessments were underpinned by information derived from a combination of literature reviews and interviews, focus groups and workshops with subject matter experts.

The assessment found the sectors that will be most affected as a whole are from the social and community, and environment and natural resources domains. However, there were also many combinations of indicators and individual climate variables outside of these sectors that resulted in high vulnerability scores, such as the impact of sea level rise on coastal zone communities and public coastal assets. As such, a broad range of indicators were found to be potentially highly vulnerable to the impacts of climate change.

The IVA results were used to develop “key areas of decision making” that will become the focus of the adaptation plan in the next stage of the project. The context for setting key areas of decision making for the Adelaide Hills and Fleurieu Peninsula differs somewhat from other regions of the State, as climate change impacts in this region will also include a number of opportunities due to the current more favourable climate and expected population growth. For example, the already cooler weather experienced in the region compared to other parts of the State is likely to lead to benefits for the tourism and retail industries as visitors and residents are likely to increase across the region as people seek refuge from increasing

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<sup>1</sup> 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.

temperatures and extreme heat days in other parts. Such opportunities presented by climate change are not necessarily captured well by the IVA process but will be specifically considered in the following adaptation plan stage of the project.

Based on the results of the IVA together with consideration of emerging opportunities, the following 10 key areas of decision making are proposed as the basis for further adaptation planning:

1. **Agriculture** - How do we maintain agricultural productivity and water security, especially for horticulture, viticulture and dryland grazing, given projected declining rainfall and increasing temperature?
2. **Water-dependent ecosystems** - How do we protect water-dependent ecosystems given projected declining rainfall and increasing temperature and fire risk?
3. **Natural landscapes** - How do we maintain the condition of natural landscapes (plains, flanks, uplands) given projected declines in rainfall and increasing temperature and fire risk?
4. **Coastal ecosystems** - How do we maintain the condition and extent of sedimentary coastal ecosystems given projected increases in sea levels?
5. **Public coastal assets** - How do we maintain the condition of **public coastal assets** given projected increases in sea levels?
6. **Vulnerable members of the community** - How do we enhance the health, safety and well-being of vulnerable members of the community as the risk of extreme events such as fire, extreme heat and flooding (as a consequence of rainfall intensity and sea level rise) increases?
7. **Emergency management services** - How do we respond to the growing demand for emergency management services across multiple sectors as the risk of extreme events such as fire, extreme heat and flooding (as a consequence of rainfall intensity and sea level rise) increases?
8. **Community facilities and open space areas** - How do we maintain and expand community facilities and open space areas for sport and recreation to meet a growing community's demands given projected declines in rainfall and increasing temperature and fire risk coupled with increasing population and development?
9. **Infrastructure assets** - How do we maintain and expand infrastructure assets, such as roads and energy networks, given projected declines in rainfall and increasing temperature and fire risk?
10. **Homes and buildings** - How do we maintain the condition of existing homes and buildings (public and private) and enhance their effective operation as the risk of extreme events such as fire, extreme heat and flooding as a consequence of rainfall intensity and sea level rise increases?

The next stage of the RH&C project is to prepare the Climate Change Adaptation Plan for the whole region (i.e. Adelaide Hills, Fleurieu Peninsula and Kangaroo Island). The primary aim of the adaptation planning process will be to consider the key areas of decision making

identified above and identify adaptation actions that reduce or address these sectors' vulnerability and/or enable the region to best take advantage of emerging opportunities.

A summary of the values identified for the region across multiple sectors and the key areas of decision making resulting from the IVA are presented in the figure below.

REGIONAL PROFILE, LOCAL KNOWLEDGE AND VALUES				
DOMAIN	CLIMATE CHANGE PROJECTIONS			
	REGIONAL ECONOMY	ENVIRONMENT & NATURAL RESOURCES	ASSETS & INFRASTRUCTURE	SOCIAL & COMMUNITY
SECTOR (aka IMPACT AREA)	Agriculture Fisheries & aquaculture Forestry Manufacturing & services Minerals & energy Tourism	Biodiversity (aquatic & terrestrial) Coastal management Water resources (considered across all)	Infrastructure & urban areas	Community health & wellbeing Emergency management
INTEGRATED VULNERABILITY ASSESSMENT				
KEY AREAS OF DECISION MAKING	Agriculture <ul style="list-style-type: none"> <li>maintaining agricultural productivity &amp; water security, especially for horticulture, viticulture &amp; dryland grazing</li> </ul>	Biodiversity <ul style="list-style-type: none"> <li>protecting wetlands &amp; riparian zone communities</li> <li>maintaining the condition of native vegetation communities</li> </ul> Coastal management <ul style="list-style-type: none"> <li>maintaining the condition &amp; extent of coastal zone communities</li> </ul>	Infrastructure & urban areas <ul style="list-style-type: none"> <li>maintaining the condition of public coastal assets</li> <li>maintaining &amp; expanding community facilities &amp; open space areas for sport &amp; recreation</li> <li>maintaining &amp; expanding infrastructure assets, such as roads &amp; energy networks</li> <li>maintaining condition of existing homes &amp; buildings (public &amp; private) &amp; enhance their effective operation</li> </ul>	Community health & wellbeing <ul style="list-style-type: none"> <li>enhancing the health, safety and well-being of vulnerable members of the community</li> </ul> Emergency management <ul style="list-style-type: none"> <li>responding to growing demand for emergency management services</li> </ul>
ADAPTATION PLANNING				

# 1 Introduction

## 1.1 Resilient Hills and Coasts overview

Resilient Hills and Coasts (RH&C) is a climate change adaptation planning project covering the Adelaide Hills, Fleurieu and Kangaroo Island Regional Development Australia (AHFKI RDA) region (Figure 1). The RH&C name is also used to refer to the region covered.

The project partners are:

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

As a collective, project partners, with input from community, business, government, industry and academia, undertook the initial phase of the RH&C project in 2014, completing:

- a “Knowledge Audit” describing the regional profile;
- community workshops summarised in a report that describes stakeholder issues and values; and
- an “Integrated Vulnerability Assessment for Kangaroo Island”.

The second stage is building on the work completed in 2014 and will consider social, economic, environmental, and cultural factors to present a holistic set of adaptation actions and recommendations. In particular, it will focus on regional priorities that will benefit from multi-organisation cohesion and cooperation, and provide a strong evidence-base for localised planning and action.

During the second stage, Resilient Hills & Coasts, with stakeholder input, will produce and share:

- up-to-date climate change projections for the region;
- a vulnerability assessment describing the key sectors; and
- a regional Climate Change Adaptation Plan.

## 1.2 Study region

The study region, for the purposes of this Integrated Vulnerability Assessment (IVA), covers only the mainland portion of the RH&C project area (Figure 1), with an IVA previously being conducted separately for Kangaroo Island (Resilient Hills and Coasts, 2014a). The study region therefore covers a land area of approximately 4,354km<sup>2</sup> characterised by a highly variable topography and geology, from coastal dunes and rocky escarpments to inland fertile hills and pasturelands.

The human population is approximately 120,000 people and is currently growing and aging, which is changing the region's demographics, though not consistently across all local Council areas (Resilient Hills and Coasts, 2014b). For example, population growth rates tend to be highest in Victor Harbor local government area and lowest in the Adelaide Hills area, and the aging population is particularly prevalent in coastal townships on the Fleurieu Peninsula, which present particularly attractive retirement destinations. Other local government areas however, such as Mount Barker, are experiencing a growing younger population, due largely to population growth from inland migration by working-aged people and young families (Resilient Hills and Coasts, 2014b).

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

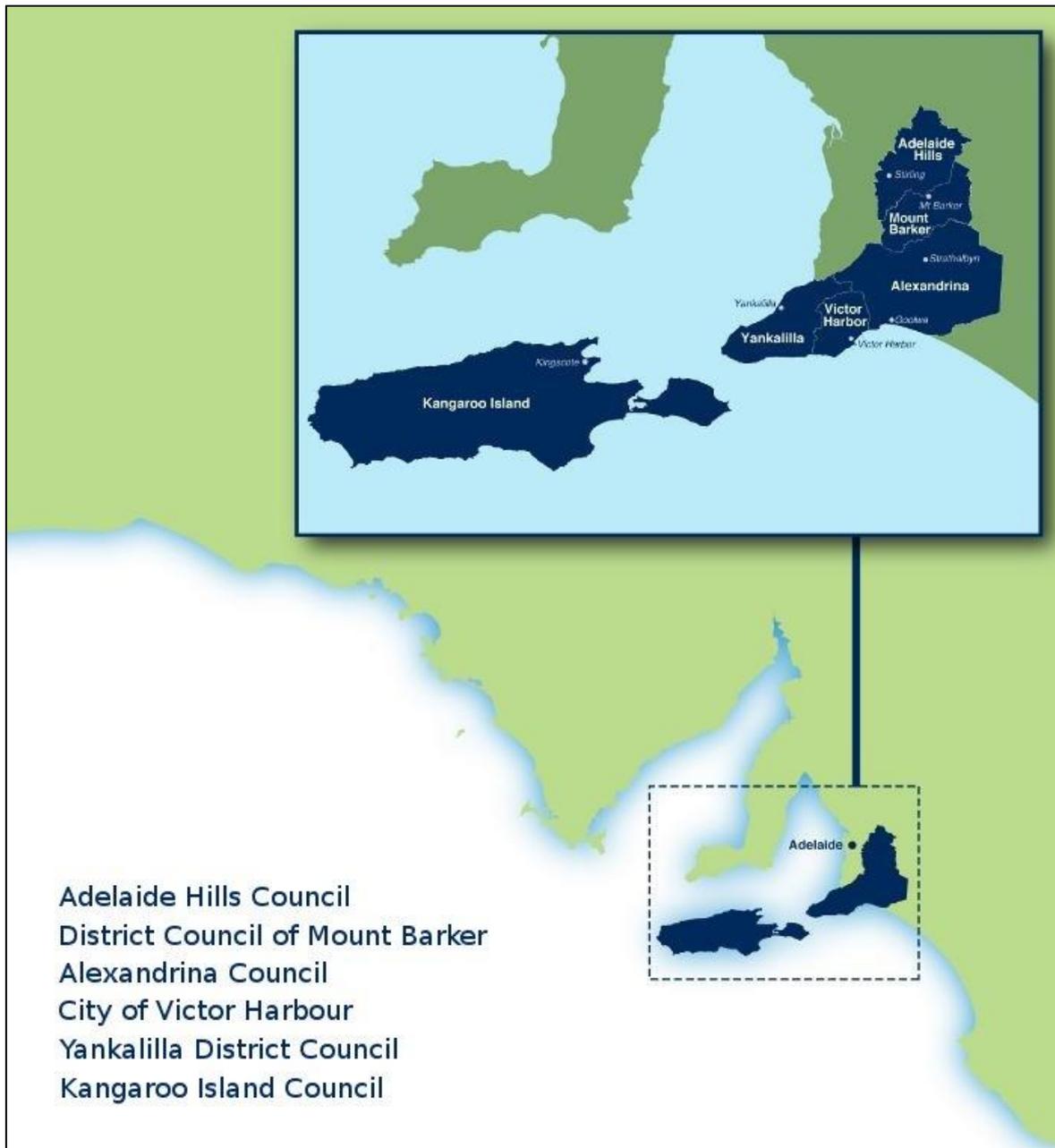
The region also supports a successful economy, with a strong and diverse primary production sector, including dryland cropping, irrigated cropping, horticulture, viticulture and livestock grazing. Forestry and commercial precincts, together with an increasingly growing tourism industry add to the region's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

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

The RH&C region has a Mediterranean climate and as such experiences natural variability in weather during the year, characterised by hot dry summers and cold wet winters. Climate patterns vary year to year as well with major climate influences including the (Bureau of Meteorology 2015):

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

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



**Figure 1.** Location of Local Government Areas that comprise the Adelaide Hills, Fleurieu and Kangaroo Island RDA region (RDA Adelaide Hills, Fleurieu & Kangaroo Island, 2014).

### **1.3 Purpose and structure of this report**

This report presents the consolidated results of the IVA conducted for 10 priority sectors (Table 1) selected for the Adelaide Hills and Fleurieu Peninsula parts of the RH&C region. An IVA assessment for priority sectors relevant to Kangaroo Island was previously completed in 2014 (Resilient Hills and Coasts, 2014a).

Further information on the vulnerability scores for individual sectors and the information used as the basis for his scoring is provided in the following reports:

- High priority sector Integrated Vulnerability Assessment report for the Adelaide Hills and Fleurieu Peninsula - Infrastructure and urban areas;
- High priority sector Integrated Vulnerability Assessment report for the Adelaide Hills and Fleurieu Peninsula – Emergency management;
- High priority sector Integrated Vulnerability Assessment report for the Adelaide Hills and Fleurieu Peninsula – Biodiversity;
- High priority sector Integrated Vulnerability Assessment report for the Adelaide Hills and Fleurieu Peninsula – Agriculture;
- Medium Priority Sectors Research Paper for the Adelaide Hills and Fleurieu Peninsula - Coastal management, community health and well-being, and tourism; and
- Low Priority Sectors Research Paper for the Adelaide Hills and Fleurieu Peninsula - Fisheries and aquaculture, forestry, and manufacturing and services.

## 2 Approach to assessing vulnerability

### 2.1 Integrated Vulnerability Assessment (IVA) overview

An IVA is a tool that helps to identify domains of a system that are vulnerable to the impacts of climate change, and assists with identifying and prioritising adaptation actions. It differs from a standard vulnerability assessment because it specifically considers together the social, economic, built and environmental domains of a system, as opposed to any one of these in isolation (Table 1).

The IVA approach described here and used for regional adaptation planning in South Australia is consistent with the approach presented in the Local Government Association of South Australia’s (LGA SA) Climate Adaptation Planning Guidelines (Local Government Association of South Australia, 2014). This approach begins by project partners selecting sectors to represent the social, economic, built and environmental domains of the region (Table 1). Sectors are selected based on their relative importance to the region and perceived risk from climate change impacts.

To help guide the IVA, a preliminary vulnerability assessment was conducted to prioritise sectors as high, medium, or low (Table 1). Priority levels reflect the result of the preliminary vulnerability assessment, not the priorities for adaptation, which will be discussed in the final adaptation plan. The RH&C project conducted its IVA with different levels of resourcing depending on whether sectors were categorised as high, medium or low priorities.

A subset of indicators representing each sector is then selected (see Appendix A for selected indicators) by the project partners and these are assessed for their relative vulnerability to climate change impacts. An indicator can describe the sectors and domains of interest in a study region. For example, ‘the amount of land available for urban development’ was assessed as an indicator for the Infrastructure and Urban Areas sector.

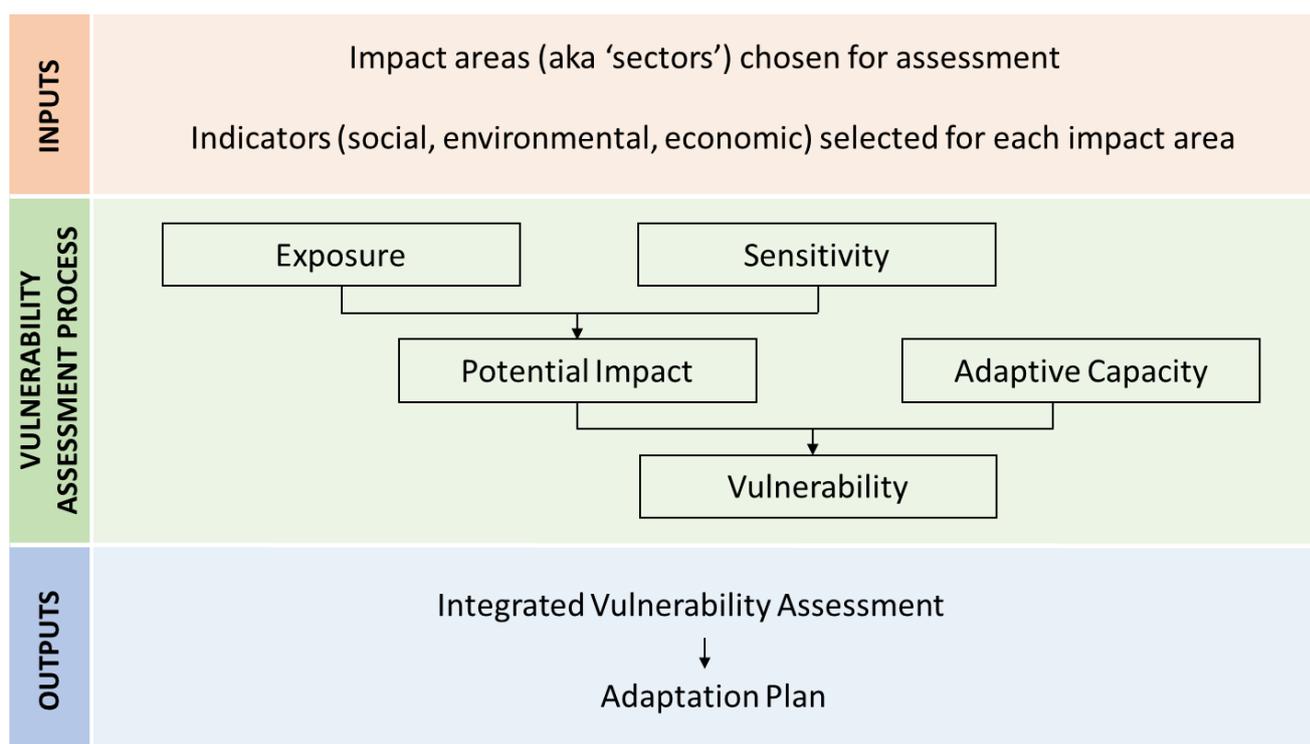
Indicators were assessed separately under respective sectors and then consolidated into a single IVA spreadsheet to conduct the analysis that forms the basis of this report.

**Table 1.** Domains, sectors and relative sector priority selected for the Resilient Hills and Coasts project.

DOMAIN	SECTORS	PRIORITY
<b>Social and community</b>	<ul style="list-style-type: none"> <li>Community health &amp; well being</li> </ul>	Medium
<b>Assets and infrastructure</b>	<ul style="list-style-type: none"> <li>Infrastructure &amp; urban areas;</li> <li>Emergency management</li> </ul>	High High
<b>Regional economy</b>	<ul style="list-style-type: none"> <li>Manufacturing &amp; services;</li> <li>Fisheries &amp; aquaculture;</li> <li>Forestry;</li> <li>Tourism;</li> <li>Agriculture;</li> </ul>	Low Low Low Medium High
<b>Environment &amp; natural resources</b>	<ul style="list-style-type: none"> <li>Coastal management;</li> <li>Biodiversity (marine, aquatic, terrestrial)</li> </ul>	Medium High

Five main elements are considered when calculating the vulnerability of indicators to climate change: exposure, sensitivity, potential impact, adaptive capacity, and vulnerability (Figure 2). These were originally defined by the Allen Consulting Group (2005), with the modified definitions for exposure and sensitivity provided below taken from the Resilient South IVA report (Resilient South, 2014):

- **exposure:** considers the likelihood of a feature or its function being subjected to a climate variable. For example, beaches are exposed to coastal inundation, but not exposed to increased frequency of bushfires;
- **sensitivity:** considers the degree to which a feature or its functions are affected by a climate variable;
- **potential impact:** is the combined effect of exposure and sensitivity;
- **adaptive capacity:** is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. The more adaptive a system, the less vulnerable it is; and
- **vulnerability:** the degree to which systems are susceptible to, and unable to cope with, the adverse impacts of climate change. It is a function of potential impact and adaptive capacity.



**Figure 2.** Schematic of elements comprising an integrated vulnerability assessment.

## 2.2 Sectors and indicators

The IVA assessed 53 indicators across 10 selected sectors relevant to four domains (Appendix A). Two additional sectors were also acknowledged as important in the region but were not specifically considered for assessment in the IVA, these were:

- water resources – while water was considered a priority for the region, it is also understood to have direct importance for underpinning a number of the other sectors and as such, water-related indicators were spread across other sectors. For example, surface water and groundwater systems were considered under the agriculture sector while infrastructure for potable and wastewater were considered under the infrastructure an urban areas sector;
- cultural heritage – this sector will be considered separately as part of developing the adaptation plan with advice from Indigenous representatives.

This IVA was conducted with different levels of resourcing depending on whether sectors identified by project partners were considered to be high, medium or low priorities (Table 1). Priority levels were determined according to the results of a preliminary vulnerability assessment and do not imply priorities for adaptation. Priorities for adaptation will be informed by the IVA and broad consultation that will occur during the adaptation planning phase of the project. The approach to the three priority levels was as follows:

- high priority sector: literature search combined with interviews and/or a focus group with subject matter experts;
- medium priority sector: workshop with subject matter experts; and
- low priority sector: literature review.

## 2.3 Calculating vulnerability

The IVA was undertaken by scoring each sector's indicators for exposure, sensitivity and adaptive capacity in relation to a selection of the climate variables (see Sections 2.3.1-2.3.3). Together these are used to generate an overall average vulnerability score for each indicator and sector.

In order to identify areas of high vulnerability for the entire region, the indicator scores were consolidated and assessed in four ways: average indicator vulnerability score; average sector vulnerability score, average vulnerability score per climate variable, and individual combined scores for indicators and climate variables (see Section 3,0).

### 2.3.1 Climate change projections

Climate change projections used in this project were based on the intermediate representative concentration pathways (RCPs) defined in the latest report by the Intergovernmental Panel on Climate Change (IPCC, 2013). Hereafter, representative concentration pathways will be generically referred to as emissions scenarios. Although the IPCC report also indicates the Earth is currently tracking on the high emissions scenario (RCP8.5) (IPCC, 2013), the project partners chose to use the intermediate emissions scenario (RCP4.5) data based on the assumption that global mitigation efforts will avoid the high emissions scenario. Project partners also acknowledged that while the intermediate emissions scenario will be used to guide the IVA, ongoing management and implementation of actions will naturally respond and adapt according to evidence available at the time. The

timeframe of 2070 was chosen based on the recognition that many of the decisions made by Project Partners in the region have decision lifetimes<sup>2</sup> of at least 30-50 years.

Climate change projections for the region are detailed in the “Climate Change Projections for the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island Region” report (Resilient Hills and Coasts, 2015). The full range of climate variables examined and their projected changes in the region presented in Section 3. In general, the region will experience warmer to hotter average temperatures, with most models also showing a drier to much drier climate and rising sea levels.

### 2.3.2 Exposure scores

Exposure scores are generated using climate projection data for specified combinations of emissions scenarios and future time periods. For the purposes of this IVA, the intermediate emissions scenario (RCP4.5) to 2070 was used to generate exposure scores for the nine main climate variables identified in the “Climate Change Projections for the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island Region” report (Resilient Hills and Coasts, 2015).

Scores are generated using the scales presented in the LGA SA’s “Climate Adaptation Planning Guidelines” report (Local Government Association of South Australia, 2014; Table 2). As exposure scores are linked to climate variables, they remain unchanged regardless of the indicator being assessed.

The full range of climate variables examined, their projected changes in the region, and the relevant exposure scores are presented in Table 3. The climate variables most relevant to the indicators being assessed for the priority sectors are identified in each of the individual sector reports.

**Table 2.** Exposure scores (1-5) allocated to scales used to define changes in different climate change variables. Modified from Table 1.5.1 in the LGA SA’s “Climate Adaptation Planning Guidelines” report (Local Government Association of South Australia, 2014).

SCALE	SCORE				
	1	2	3	4	5
General description for qualitative data (%)	0-20%	21-40%	41-60%	61-80%	81-100%
Absolute change in temperature (°C)	0.01-0.4	0.41 - 0.8	0.81 - 1.2	1.21 - 1.6	1.61 - 2.0
Change in rainfall from baseline (%)	1-5%	5-10%	10-15%	15-20%	20-25%
Increase in sea level (m)	0.0-0.1	0.11-0.2	0.21-0.3	0.31-0.4	0.41-0.5

<sup>2</sup> The concept of decision lifetimes is further described in Stafford Smith et al. (2010).

**Table 3.** Projected changes and associated exposure scores for climate variables impacting the study region in 2070 under an intermediate emissions scenario (RCP4.5).

CLIMATE VARIABLE	PROJECTED TREND	PROJECTED CHANGE BY 2070*	EXPOSURE SCORE
<b>Rainfall</b>			
Annual median	Decreasing	5.7%	2
Spring median	Decreasing	16.4%	4
Summer median	Decreasing	9.6%	2
Autumn median	Decreasing	3.2%	1
Winter median	Decreasing	6.0%	2
Intensity	Increasing	11%	3
<b>Temperature (atmospheric)</b>			
Annual median maximum	Increasing	1.5°C	4
Annual median minimum	Increasing	1.2°C	3
Annual number of days above 35°C	Increasing	57%	3
Annual number of days above 40°C	Increasing	150%	5
Spring median maximum	Increasing	1.9°C	5
Summer median maximum	Increasing	1.5°C	4
Autumn median maximum	Increasing	1.5°C	4
Winter median maximum	Increasing	1.3°C	4
Spring median minimum	Increasing	1.2°C	3
Summer median minimum	Increasing	1.1°C	3
Autumn median minimum	Increasing	1.2°C	3
Winter median minimum	Increasing	1°C	3
<b>Fire</b>			
Annual number of severe fire risk days	Increasing	65%	5
<b>Gulf and ocean</b>			
Ocean acidity	Increasing	41% by 2090	3
Sea level rise	Increasing	33 cm	4
Sea surface temperature	Increasing	1.2°C by 2090	3

\* Projections are those for the 2070 future time period, unless otherwise indicated.

### 2.3.3 Sensitivity and adaptive capacity scores

Sensitivity and adaptive capacity scores are generated for each of the indicators based on the scales presented in the LGA SA's "Climate Adaptation Planning Guidelines" report (Local Government Association of South Australia, 2014; Table 4) and information derived from existing research and expert knowledge. For the purposes of this research paper, that

information was sourced from the individual sector reports which used varying methods to collate relevant information including: desktop literature reviews, targeted workshops, expert focus groups, and one-on-one interviews with specific experts.

The scores are combined as follows to produce a vulnerability score (Table 5) for each indicator:

$$\text{Vulnerability} = (\text{Potential Impact} - \text{Adaptive Capacity}) + 10$$

where,

$$\text{Potential Impact} = \text{Exposure} + \text{Sensitivity}.$$

**Table 4.** Scales used to describe sensitivity and adaptive capacity of indicators to climate change, and the associated score allocated for use in calculating vulnerability.

SENSITIVITY SCALE	ADAPTIVE CAPACITY SCALE	ALLOCATED SCORE
Low	Low	1
Low to Moderate	Low	2
Moderate	Low to Moderate	3
Moderate to High	Low – Moderate	4
High	Moderate	5
-	Moderate	6
-	Moderate to High	7
-	Moderate to High	8
-	High	9
-	High	10

**Table 5.** Scales used to describe vulnerability of indicators to climate change. Calculated from exposure, sensitivity, and adaptive capacity scores.

VULNERABILITY SCALE				
Very Low	Low	Medium	High	Very High
2-3	4-7	8-11	12-15	16-19

## 3 Results of the Integrated Vulnerability Assessment

This section presents the consolidated result of the Resilient Hills and Coasts IVA. Experience shows that taking a simple average of indicators tends to mask what is influencing vulnerability scores. Therefore, a four-way analysis is presented here to explore potential conclusions regarding vulnerability and the underlying drivers.

Across the 53 indicators a total of 403 assessments were undertaken, resulting in 2,015 individual exposure, sensitivity, potential impact, adaptive capacity and vulnerability scores.

### 3.1 Indicator vulnerability

The impact of multiple climate variables was assessed for each indicator. Average vulnerability scores for each indicator were then calculated as the average scores for all climate variables assessed for an indicator. The highest 10% of average indicator vulnerability scores exceeded 15.5 and the top 25% exceeded 14.2; the lowest 25% had scores of lower than 10.9. Fifteen indicators represented the top 25% and all had adaptive capacity scores of three or less and potential impact scores of more than 6.6. Additional details of indicator scores can be found in the individual sector reports.

The 15 indicators comprising the top 25% of indicator scores represented five sectors:

- community health and well-being (5 indicators);
- biodiversity (5 indicators);
- infrastructure and urban areas (3 indicators);
- agriculture (1 indicator);and
- coastal management (1 indicator).

The health and well-being of vulnerable members of the community was consistently one of the most vulnerable types of indicator, with specific areas of concern being in relation to people living in low income households, people aged over 75 and less than 15 years, and people living with a disability. The other indicator from the community health and well-being sector was community services and facilities meeting needs of all community members, which is also relevant to infrastructure and urban areas.

The biodiversity indicators cover terrestrial and freshwater environments. The two terrestrial indicators are condition and natural recruitment of scattered trees and condition and extent of forest communities. It was noted during the biodiversity IVA focus group that in addition to climate change related threats, scattered trees are highly vulnerable to threats from adjacent livestock farming land-uses, mainly because of the exposure of seedlings to grazing pressure. The freshwater ecosystem indicators were for riparian zone communities and wetlands. All of these indicators were influenced by temperature, rainfall and fire related climate variable scores.

The infrastructure and urban area indicators were diverse and relate to effective operation of the road network, effective functioning, viability and vibrancy of retail and commercial centres in towns, and condition of State and local heritage items (built items). The adaptive capacity was low for all indicators and potential impact was moderate to high. The major driver of higher vulnerability scores was projected extreme heat and fire risk.

The other high vulnerability indicators were demand for emergency management services, condition of reef areas in marine habitats and the condition (quality and quantity) of surface water systems. Emergency management services and the condition of surface water systems are relevant to multiple sectors, such as agriculture and infrastructure and urban areas.

**Table 6.** Average IVA indicator scores for: E= Exposure; S = Sensitivity; PI = Potential Impact; AC = Adaptive Capacity; V = Vulnerability. Vulnerability colour coding: ■ = very high; ■ = high; ■ = medium; ■ = low.

INDICATOR	E	S	PI	AC	V
Health, safety and well-being of low income households	4.0	4.5	8.5	2.0	16.5
Condition and (natural) recruitment of scattered trees	3.8	4.5	8.3	2.0	16.3
Health, safety and well-being of vulnerable members of the community (aged over 75)	3.8	4.2	8.0	1.8	16.2
Condition and extent of forest communities	3.4	4.4	7.9	1.9	16.0
Condition and extent of riparian zone communities	3.3	4.1	7.4	1.9	15.6
Demand for emergency management services	4.0	4.3	8.3	2.8	15.5
Health, safety and well-being of vulnerable members of the community (aged under 15)	4.0	3.3	7.3	2.0	15.3
Health, safety and well-being of people with disability	3.6	4.6	8.2	3.0	15.2
Condition and extent of wetland ecosystems	2.9	4.1	7.0	1.9	15.1
Effective operation of road network	4.0	2.8	6.8	2.0	14.8
Condition of marine habitats - reef areas (off shore and intertidal)	3.3	3.8	7.0	2.5	14.5
Effective functioning, viability and vibrancy of retail and commercial centres in towns	4.0	3.5	7.5	3.0	14.5
Community services and facilities (incl. health and education) meet needs of all community members	3.6	3.8	7.4	3.0	14.4
Condition (quality and quantity) of surface water systems	2.4	4.2	6.6	2.4	14.2
Condition of State and local heritage items (built)	3.6	3.6	7.2	3.0	14.2
Amenity and character provided by open space and public realm	3.7	3.4	7.1	3.0	14.1
Effective operation of stormwater management infrastructure	4.0	3.0	7.0	3.0	14.0
Condition and extent of woodland communities	3.9	4.4	8.3	4.6	13.7

INDICATOR	E	S	PI	AC	V
Condition of ground water systems	2.5	3.5	6.0	2.3	13.7
Recreation opportunities provided by outdoor facilities including open and green space	3.7	3.0	6.7	3.2	13.5
Community participation in clubs, organisations and groups	3.7	3.5	7.2	3.7	13.5
Condition and extent of marine habitats - sea grass	3.3	4.0	7.3	3.8	13.5
Health services and facilities meet needs of all community members	4.0	4.0	8.0	4.5	13.5
Effective operation of electricity supply network	4.0	4.3	8.3	5.0	13.3
Effective operation of onsite wastewater treatments	3.3	2.8	6.0	3.0	13.0
Regional economic contribution of the health care sector	3.5	2.5	6.0	3.0	13.0
Condition and extent of grassland communities	2.8	4.8	7.6	4.6	13.0
Productivity of forestry land uses	3.3	4.6	7.9	4.9	13.0
Condition of residential housing	4.0	4.0	8.0	5.0	13.0
Condition of Aboriginal heritage items and places	3.8	4.0	7.8	5.0	12.8
Effective operation of public transport services	4.0	3.5	7.5	5.0	12.5
Condition and extent of coastal zone communities	3.1	4.4	7.6	5.1	12.4
Availability of land for urban development	3.7	4.7	8.3	6.0	12.3
Regional economic contribution of the manufacturing sector	3.5	4.0	7.5	5.3	12.2
Productivity of fisheries (commercial and recreational)	3.3	4.0	7.3	5.7	11.7
Effective operation of telecommunications infrastructure	4.0	3.5	7.5	6.0	11.5
Condition of sandy coasts	3.5	3.8	7.3	6.0	11.3
Volunteering to support emergency management	4.0	3.0	7.0	6.0	11.0
Education services and facilities meet needs of all community members	4.0	4.0	8.0	7.0	11.0
Productivity of cropping activities - dryland	3.4	2.7	6.1	5.2	10.9
Regional economic contribution of the construction sector	3.4	3.6	7.0	6.1	10.9
Productivity of viticultural land uses	3.3	3.7	7.0	6.2	10.8
Wealth, vibrancy and participation in events, celebrations and activities	3.6	3.7	7.2	6.7	10.6
Productivity of horticultural land uses	3.3	3.2	6.4	6.2	10.3
Condition of public coastal assets	3.5	2.5	6.0	5.8	10.3
Regional economic contribution of tourism sector	3.4	3.0	6.4	7.0	9.4
Productivity of livestock - irrigated	3.3	2.3	5.5	6.4	9.1
Productivity of intensive livestock activities	3.3	2.3	5.6	6.7	8.9

INDICATOR	E	S	PI	AC	V
Capacity of landholders to actively undertake sustainable natural resource management	3.3	1.9	5.2	7.4	7.8
Effective operation of potable water supply	3.6	3.2	6.8	9.0	7.8
Effective operation of SA Water wastewater treatment network	3.6	2.8	6.4	9.0	7.4
Productivity of extensive livestock / grazing	3.4	1.9	5.2	8.0	7.2
Regional economic contribution of food processing	3.3	1.5	4.8	8.5	6.3

### 3.2 Sector vulnerability

Average vulnerability scores for each sector were calculated by averaging the exposure, sensitivity, potential impact, adaptive capacity and vulnerability scores for each related sector indicator (Table 7).

At the sector scale, biodiversity, community health and well-being, and emergency management had the highest average vulnerability scores (75th percentile) and so are considered the most vulnerable sectors within the region. While the average potential impact score was the same for each (7.6), and not the highest which was for forestry (7.9), these three sectors had the lowest average adaptive capacity, which acted to increase the relative vulnerability.

The lowest average sector vulnerability scores were for agriculture, tourism, and manufacturing and services. For agriculture and tourism this was driven by the lowest potential impact scores (5.8 and 6.8) and high adaptive capacity scores (6.5 and 6.8) for any sector. The results do not imply that some sectors such as agriculture and tourism are not vulnerable to the impact of climate change, instead that they are relatively less vulnerable than other sectors assessed in the region, especially biodiversity and community health and well-being.

**Table 7.** Average IVA sector scores for: E= Exposure; S = Sensitivity; PI = Potential Impact; AC = Adaptive Capacity; V = Vulnerability. Where, vulnerability scores are:  = high;  = medium.

SECTOR	E	S	PI	AC	V
Biodiversity	3.3	4.3	7.6	2.7	14.9
Community health & well-being	3.8	3.8	7.6	3.5	14.2
Emergency management	4.0	3.6	7.6	4.4	13.3
Forestry	3.3	4.6	7.9	4.9	13.0
Infrastructure & urban areas	3.8	3.3	7.1	4.6	12.5
Coastal management	3.3	3.8	7.1	4.7	12.4
Fisheries & aquaculture	3.5	4.0	7.5	5.3	12.3
Manufacturing & services	3.5	3.8	7.2	5.8	11.5
Tourism	3.5	3.3	6.8	6.8	9.9
Agriculture	3.2	2.5	5.8	6.5	9.3

### 3.3 Climate variables

Another option for analysing the results of the integrated vulnerability assessment is to determine which climate variables contribute the most to high vulnerability scores. The results of this analysis are presented in Table 8. Six climate variables were identified as contributing the most to high vulnerability scores, being annual days above 40°C, fire, spring and winter median rainfall, rising sea levels and ocean acidity. The strong influence of extreme heat and fire in particular was because of high potential impact and low adaptive capacity scores.

Despite having moderate potential impact, ocean acidity had a major influence on vulnerability scores because the adaptive capacity was assessed as being the lowest for all climate variables. This conclusion while supported by stakeholders, was widely considered as having low confidence given that there was virtually no known research available to support assessment of adaptive capacity in relation to ocean acidity.

**Table 8.** Average IVA climate variable scores for: E= exposure; S = sensitivity; PI = potential impact; AC = adaptive capacity; v = Vulnerability. Vulnerability colour coding: ■ = high; ■ = medium; ■ = low.

SECTOR	E	S	PI	AC	V
Temperature - annual days above 40°C increasing	5.0	4.1	9.1	4.3	14.7
Fire - annual number of severe fire days increasing	4.0	4.3	8.3	4.2	14.1
Rainfall - spring median declining	4.0	4.0	8.0	4.2	13.9
Sea level increasing	4.0	3.7	7.7	4.2	13.5
Ocean acidity increasing	3.0	3.1	6.1	3.4	12.7
Rainfall - winter median declining	2.0	4.1	6.1	4.2	11.9
Temperature - sea surface increasing	3.0	4.0	7.0	5.3	11.8
Rainfall - intensity increasing	3.0	3.3	6.3	4.8	11.5
Temperature - annual days above 35°C increasing	3.0	3.6	6.6	5.2	11.4
Temperature - summer median maximum increasing	4.0	3.5	7.5	6.1	11.4
Temperature - spring median maximum increasing	5.0	2.9	7.9	6.6	11.3
Temperature - annual median maximum increasing	4.0	3.0	7.0	6.2	10.9
Rainfall - annual median declining	2.0	3.1	5.1	4.9	10.2
Rainfall - summer median declining	2.0	3.1	5.1	5.5	9.6
Temperature - autumn median maximum increasing	4.0	2.3	6.3	7.2	9.1
Temperature - winter median maximum increasing	4.0	2.2	6.2	7.3	8.9
Temperature - annual median minimum increasing	3.0	1.9	4.9	7.1	7.8
Temperature - spring median minimum increasing	3.0	1.7	4.7	7.1	7.6
Temperature - autumn median minimum increasing	3.0	1.7	4.7	7.4	7.2
Temperature - winter median minimum increasing	3.0	1.4	4.4	7.2	7.2
Rainfall - autumn median - declining	1.0	2.1	3.1	6.0	7.1
Temperature - summer median minimum - increasing	3.0	1.4	4.4	7.4	7.0

### 3.4 Indicators and climate variables

Individual combinations of indicators and climate variables can be analysed to determine whether average indicator vulnerability scores are masking important drivers of vulnerability. The results of this analysis are presented in Table 9.

Thirty three combinations of indicators and climate variables had scores of 17 or greater, covering 22 indicators. The highset possible vulnerability score is 19, being a result of exposure and sensitivity scores of 5 and an adaptive capacity score of 1. Only two combinations had scores of 19, which related to the condition of forests and woodland communities in relation to extreme heat:

The next highest score was 18, which occurred for the following combinations:

- Condition and (natural) recruitment of scattered trees \* Fire risk - increasing
- Condition and extent of riparian zone communities \* Fire risk - increasing
- Condition and extent of coastal zone communities \* Sea level - increasing
- Condition of public coastal assets \* Sea level - increasing
- Community participation in clubs, organisations and groups \* Temperature - annual number of days above 40°C - increasing
- Health, safety and wellbeing of low income households \* Temperature - annual number of days above 40°C - increasing
- Health, safety and wellbeing of vulnerable members of the community (aged over 75) \* Temperature - annual number of days above 40°C - increasing
- Health, safety and wellbeing of vulnerable members of the community (aged over 75) \* Fire risk - increasing

The analysis identified 11 indicators with a high vulnerability in relation to one or more climate variables (>17) that did not feature in the most vulnerable average indicators. This demonstrates the masking of high vulnerability scores that can occur where only average indicator scores are considered. Examples of indicators of this type were the condition and extent of coastal zone communities and the condition of public coastal assets such as jetties and boat ramps. Both indicators had high vulnerability to sea level rise but were also assessed against rainfall and temperature, for which scores were low resulting in lower indicator average scores.

While the analysis of combinations of indicators and climate variables identified high vulnerability scores that had been masked out, it also re-enforced the reason why some average indicator scores were high, such as the health, safety and wellbeing of people aged over 75 which was highly vulnerable (scores of 18) to extreme heat and fire risk.

**Table 9.** Average IVA scores for each paired combination of indicators and climate variables with vulnerability scores greater than or equal to 17. E= Exposure; S = Sensitivity; PI = Potential Impact; AC = Adaptive Capacity; V = Vulnerability.

SECTOR	INDICATOR	CLIMATE VARIABLE	E	S	PI	AC	V
Biodiversity	Condition and extent of woodland communities	Temperature - annual number of days above 40°C - increasing	5	5	10	1	19
Biodiversity	Condition and extent of forest communities	Temperature - annual number of days above 40°C - increasing	5	5	10	1	19
Biodiversity	Condition and (natural) recruitment of scattered trees	Fire - annual number of severe fire risk days - increasing	4	5	9	1	18
Biodiversity	Condition and extent of riparian zone communities	Fire - annual number of severe fire risk days - increasing	4	5	9	1	18
Coastal management	Condition and extent of coastal zone communities	Sea level - increasing	4	5	9	1	18
Coastal management	Condition of public coastal assets (e.g. jetties, boat ramps)	Sea level - increasing	4	5	9	1	18
Community health & well-being	Community participation in clubs, organisations and groups	Temperature - annual number of days above 40°C - increasing	5	5	10	2	18
Community health & well-being	Health, safety and wellbeing of low income households	Temperature - annual number of days above 40°C - increasing	5	5	10	2	18
Community health & well-being	Health, safety and wellbeing of vulnerable members of the community (aged over 75)	Temperature - annual number of days above 40°C - increasing	5	5	10	2	18
Community health & well-being	Health, safety and wellbeing of vulnerable members of the community (aged over 75)	Fire - annual number of severe fire risk days - increasing	4	5	9	1	18
Agriculture	Condition of ground water systems	Rainfall - spring median - declining	4	5	9	2	17
Agriculture	Condition (quality and quantity) of surface water systems	Rainfall - spring median - declining	4	5	9	2	17

SECTOR	INDICATOR	CLIMATE VARIABLE	E	S	PI	AC	V
Agriculture	Productivity of cropping activities - dryland	Rainfall - spring median - declining	4	5	9	2	17
Agriculture	Productivity of horticultural land uses	Rainfall - spring median - declining	4	5	9	2	17
Agriculture	Productivity of viticultural land uses	Temperature - annual number of days above 40°C - increasing	5	5	10	3	17
Biodiversity	Condition and (natural) recruitment of scattered trees	Temperature - spring median maximum - increasing	5	5	10	3	17
Biodiversity	Condition and extent of grassland communities	Rainfall - spring median - declining	4	5	9	2	17
Biodiversity	Condition and extent of woodland communities	Temperature - annual number of days above 35°C - increasing	3	5	8	1	17
Biodiversity	Condition and extent of forest communities	Temperature - annual median maximum - increasing	4	5	9	2	17
Biodiversity	Condition and extent of wetland ecosystems	Rainfall - intensity - increasing	3	5	8	1	17
Biodiversity	Condition and extent of wetland ecosystems	Temperature - annual median maximum - increasing	4	5	9	2	17
Biodiversity	Condition and extent of wetland ecosystems	Fire - annual number of severe fire risk days - increasing	4	5	9	2	17
Emergency management	Demand for emergency management services	Temperature - annual number of days above 40°C - increasing	5	5	10	3	17
Emergency management	Demand for emergency management services	Fire - annual number of severe fire risk days - increasing	4	5	9	2	17
Coastal management	Condition and extent of marine habitats - sea grass	Rainfall - intensity - increasing	3	5	8	1	17
Community health & well-being	Community participation in clubs, organisations and groups	Fire - annual number of severe fire risk days - increasing	4	5	9	2	17

SECTOR	INDICATOR	CLIMATE VARIABLE	E	S	PI	AC	V
Community health & well-being	Health, safety and wellbeing of low income households	Fire - annual number of severe fire risk days - increasing	4	5	9	2	17
Community health & well-being	Health, safety and wellbeing of low income households	Sea level - increasing	4	5	9	2	17
Community health & well-being	Health, safety and wellbeing of people with disability	Temperature - annual number of days above 40°C - increasing	5	5	10	3	17
Community health & well-being	Health, safety and wellbeing of vulnerable members of the community (aged over 75)	Sea level - increasing	4	5	9	2	17
Community health & well-being	Health, safety and wellbeing of vulnerable members of the community (aged under 15)	Temperature - annual number of days above 40°C - increasing	5	4	9	2	17
Fisheries & aquaculture	Productivity of land based aquaculture	Temperature - annual number of days above 40°C - increasing	5	5	10	3	17
Manufacturing & services	Regional economic contribution of the construction sector	Temperature - annual number of days above 40°C - increasing	5	5	10	3	17

## 4 Discussion

### 4.1 Priority areas of vulnerability

The aim of the IVA is to identify features or systems in the region that are most vulnerable to the impacts of climate change. In addition, the focus is to identify issues that are regional in scale and where possible, impact multiple sectors. Understanding these priority areas of vulnerability can then inform the focus of the adaptation plan. The IVA results suggest that climate change will affect all sectors assessed in the Adelaide Hills and Fleurieu Peninsula, but to differing degrees.

Sectors assessed to be most affected as a whole are those from the social and community, and environment and natural resources domains. The prominence of community health and well-being and biodiversity indicators reflects a prevailing view of these areas as having low to very low adaptive capacity. This result has been echoed in other regions in South Australia (e.g. Southern Metropolitan Adelaide, the South Australian Murray-Darling Basin). Whether it reflects sector bias in some way (i.e. experts from a given sector consistently scoring vulnerability higher or lower) can only be speculated on, but can be accounted for in selecting key areas of decision making (Section 5.2) by ensuring a wide spread of sectors.

By considering both the average indicator scores, and combinations of indicators and climate variables, the following areas of high vulnerability emerged from the analysis (in no particular order):

1. Agricultural productivity, mostly in relation to horticulture, viticulture and dryland grazing
2. Condition of wetlands and riparian zone ecological communities
3. Condition of native vegetation (woodlands, forests, grasslands, scattered trees)
4. Condition of reefs and sea grass in marine habitats
5. Condition and extent of coastal zone ecological communities
6. Condition of public coastal assets
7. Health safety and well-being of vulnerable members of the community, defined as people aged over 75 years and under 15 years, people with a disability, and people from low income households
8. Demand for emergency management services
9. Community participation in clubs, organisations and groups
10. Community services and facilities meet the needs of all community members
11. Condition and effective operation of public and privately owned buildings, including State and local built heritage items and retail and commercial centres in towns
12. Effective operation of road network

As outlined in the results section, there were several climate variables that consistently led to higher vulnerability scores, including extreme heat (annual days over 40°C), fire risk, sea level rise and to a lesser extent intense rainfall, with the latter two contributing to flood risk. All of these variables relate to extreme climatic events and will create demand for emergency management services, reflecting the importance of this issue as a cross sectoral priority area of vulnerability.

Despite having higher vulnerability scores, not all of the areas identified above necessarily need to be a focus for the adaptation plan. For example, they could relate to lower priority

issues, make only a small economic contribution to the region, could be localised in nature or there may be a dearth of available adaptation options for them within the region.

The first high vulnerability area not recommended as a focus for the adaptation plan is land-based aquaculture. This was assessed as having high vulnerability in relation to increasing fire risk and extreme heat. The relatively small contribution that this sector makes to the region's economy means that while impacts may occur, it's hard to see this area as a regional priority. Adaptation options may still be pursued by businesses operating in this industry but this can occur through working with research and development organisations such as the South Australian Research & Development Institute.

The second high vulnerability area that does not need to be a focus of the adaptation plan is the regional economic contribution of the construction sector. This area received a high vulnerability score because of concerns about extreme heat impacts on working conditions. Despite this, the average vulnerability score for the indicator was moderate and in the lower 25% of all vulnerability scores. This was because the construction sector will also likely benefit from warmer and drier winters which will reduce the number of days off site during cooler months and so offset potential lost days due to extreme heat. Another opportunity which may offset negative impacts of climate change is that the construction sector may benefit from continued population growth in the region, which is expected to underpin continued expansion of residential housing as well as buildings and infrastructure at key sites such as Victor Harbor, Goolwa and Mount Barker.

The third area of high vulnerability that does not require further detailed consideration in the adaptation plan is the condition of reefs and sea grass in marine habitats. The high vulnerability scores for these indicators were influenced by the risk of increasing rainfall intensity, which could lead to increased turbidity either as a result of additional discharge from creeks and rivers or as a consequence of run-off from cliffs. During the assessment there was conjecture as to the extent to which this is a localised issue (e.g. confined to areas in immediate proximity to the point of discharge) or whether it is mainly a consequence of current land management practices and will not be exacerbated significantly by climate change. It was also unclear whether winter-spring rainfall was a greater contributor to discharges of highly turbid water or whether intense rainfall during summer was more important. For these reasons this issue is not recommended as one of the priority areas of vulnerability to focus on in the adaptation plan. However, monitoring may be warranted to better understand the relationship between changing rainfall patterns, turbidity and the condition of reefs and sea grass.

In addition to areas of high vulnerability, the IVA also identified areas with low vulnerability, or, arguably, high resilience. This included a number of agriculture, water supply and tourism related indicators. The reasons for the lower vulnerability scores differed, for example, livestock production received low scores because despite the potential for declining availability of feed it was determined that the climate of the Adelaide Hills and Fleurieu Peninsula will still remain favourable for animal health compared to other parts of the State. The regional economic contribution of the tourism sector on the other hand was considered to have lower vulnerability because of the diversity of tourism experiences in the region and because extreme heat and fire risk impacts during the summer period could be offset by warmer and drier winters, which could directly benefit the region's tourism economy.

## 4.2 Opportunities

Being a risk-based process, the IVA is not designed to identify opportunities and as such these need to be considered separately. Whilst the region faces significant challenges in adapting to climate change, it is better placed than many other regions in the State due to its naturally cooler climate, and diversity of industries across the region. Another important factor for the region is that the population is expected to grow further, especially in locations such as Mount Barker, Victor Harbor and Goolwa.

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

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

## 4.3 Identifying key areas of decision making

Key areas of decision making describe the focus of an adaptation plan. They are typically based on priority areas of vulnerability or emerging opportunities. A key area of decision making should:

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

For RH&C, additional research conducted by AMLR NRM independently of this project was also taken into consideration in developing the key areas of decision making. This independent research (DEWNR, 2015) was relevant for informing key areas of decision making related to biodiversity and summarises the vulnerability of different aspects of natural landscapes in the region using a landscape scenario assessment.

Based on the results of the IVA together with consideration of emerging opportunities and the results of the AMLR NRM landscape scenario assessment, the following key areas of decision making are proposed as the basis for further adaptation planning:

1. How do we maintain agricultural productivity and water security, especially for horticulture, viticulture and dryland grazing, given projected declines in rainfall and increasing temperature?
2. How do we protect water-dependent ecosystems given projected declines in rainfall and increasing temperature and fire risk?
3. How do we maintain the condition of natural landscapes (plains, flanks, uplands) given projected declines in rainfall and increasing temperature and fire risk?

4. How do we maintain the condition and extent of sedimentary coastal ecosystems given projected increases in sea levels?
5. How do we maintain the condition of public coastal assets given projected increases in sea levels?
6. How do we enhance the health, safety and well-being of vulnerable members of the community as the risk of extreme events such as fire, extreme heat, flash flooding and sea level rise related coastal inundation increases?
7. How do we respond to the growing demand for emergency management services across multiple sectors as the risk of extreme events such as fire, extreme heat, flash flooding and sea level rise related coastal inundation increases?
8. How do we maintain and expand community facilities and open space areas for sport and recreation to meet growing community demand given projected declines in rainfall and increasing temperature and fire risk?
9. How do we maintain and expand infrastructure assets, such as roads and energy networks, given projected declines in rainfall and increasing temperature and fire risk?
10. How do we maintain the condition of existing homes and buildings (public and private) and enhance their effective operation as the risk of extreme events such as fire, extreme heat, flash flooding and sea level rise related coastal inundation increases?

#### **4.4 Next steps**

This report has presented the consolidated results of the IVA conducted for Stage 2 of the Resilient Hills and Coasts project. It was informed by the outputs of Stage 1, which included a knowledge audit (Resilient Hills and Coasts, 2014b) and climate projections analysis (Resilient Hills and Coasts, 2015). The report has outlined a clear list of priority key areas of decision making relevant to the Adelaide Hills and Fleurieu Peninsula. When combined with the results of the Kangaroo Island IVA, they will form a consolidated set of focal areas for adaptation planning across the RH&C region.

The next stage of the RH&C project will focus on using a series of stakeholder forums to identify, assess and prioritise adaptation options. The focus of identifying and assessing adaptation options will be in relation to each of the key areas of decision making described in Section 4.2. This will be undertaken at each forum by groups of subject matter experts and key stakeholders with knowledge of and an interest in each of the key areas of decision making. Assessment will include consideration of when options need to be implemented, noting that as the impacts of climate change increase in the future, some options will no longer be required and new options will need to commence.

The prioritisation of options, which will occur after the forums, will consider which options are relevant to current funding opportunities, regional priorities (risk and opportunity based) and what is best coordinated and implemented at a whole of region versus local scale.

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## Appendix A - Indicators used for IVA

Indicators used for the Adelaide Hills and Fleurieu component of the Resilient Hills and Coasts Integrated Vulnerability Assessment. An “x” indicates which of the sectors the indicator was chosen to represent. While not marked as such, many of the indicators are relevant to multiple sectors.

Indicators	Sectors									
	High				Medium			Low		
	Agriculture	Biodiversity	Emergency management	Infrastructure & urban areas	Coastal management	Community health & well being	Tourism	Fisheries & aquaculture	Forestry	Manufacturing & services
Amenity and character provided by open space and public realm				x						
Capacity of landholders to actively undertake sustainable natural resource management	x									
Community participation in clubs, organisations and groups						x				
Community services and facilities (incl. health and education) meet needs of all community members						x				
Condition and (natural) recruitment of scattered trees		x								
Condition and extent of riparian zone communities		x								
Condition and extent of coastal zone communities					x					
Condition and extent of grassland communities		x								
Condition and extent of woodland communities		x								
Condition and extent of forest communities		x								
Condition and extent of marine habitats - sea grass					x					
Condition and extent of wetland ecosystems		x								
Condition of Aboriginal heritage items and places						x				
Condition of ground water systems	x									
Condition of marine habitats - reef areas (off shore and intertidal)					x					
Condition of public coastal assets (e.g. jetties, boat ramps)					x					

Indicators	Sectors									
	High				Medium			Low		
	Agriculture	Biodiversity	Emergency management	Infrastructure & urban areas	Coastal management	Community health & well being	Tourism	Fisheries & aquaculture	Forestry	Manufacturing & services
Condition of sandy coasts					x					
Condition of State and local heritage items (built items)				x						
Condition (quality and quantity) of surface water systems	x									
Demand for emergency management services			x							
Effective functioning, viability and vibrancy of retail and commercial centres in towns				x						
Effective operation of electricity supply network				x						
Effective operation of onsite wastewater treatments (septic tanks)				x						
Effective operation of potable water supply				x						
Effective operation of road network				x						
Effective operation of SA Water wastewater treatment network (e.g. WWTP, pipes and pumps)				x						
Effective operation of stormwater management infrastructure				x						
Health, safety and wellbeing of low income households						x				
Health, safety and wellbeing of people with disability (e.g. people needing assistance with core activities, physical disabilities, mental health issues)						x				
Health, safety and wellbeing of vulnerable members of the community (aged over 75)						x				
Health, safety and wellbeing of vulnerable members of the community (aged under 15)						x				
Productivity (economic) of forestry land uses									x	
Productivity of cropping activities - dryland	x									
Productivity of extensive livestock / grazing	x									
Productivity of fisheries (commercial								x		

Indicators	Sectors									
	High				Medium			Low		
	Agriculture	Biodiversity	Emergency management	Infrastructure & urban areas	Coastal management	Community health & well being	Tourism	Fisheries & aquaculture	Forestry	Manufacturing & services
and recreational)										
Productivity of horticultural land uses	X									
Productivity of intensive livestock activities	X									
Productivity of livestock - irrigated	X									
Productivity of viticultural land uses	X									
Recreation opportunities provided by outdoor facilities including open and green space				x						
Regional economic contribution of food processing	X									
Regional economic contribution of the construction sector										x
Regional economic contribution of the manufacturing sector										x
Regional economic contribution of tourism sector							x			
Volunteering to support emergency management			x							
Wealth, vibrancy and participation in events, celebrations and activities						x				
Availability of land for urban development				x						
Effective operation of public transport services				x						
Regional economic contribution of the health care sector						x				
Condition of residential housing				x						
Effective operation of telecommunications infrastructure				x						
Health services and facilities meet needs of all community members						x				
Education services and facilities meet needs of all community members						x				