

**Climate Risk Assessment and Adaptation
Plan for Goldfields-Esperance
Report**



Prepared for

Goldfields Voluntary Regional Organisation of Councils

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1. Executive Summary

Goldfields Voluntary Regional Organisation of Councils (GVROC) engaged Ironbark to support the development of a climate change risk assessment and adaptation plan for the Goldfields-Esperance Region. This project follows on from the Goldfields-Esperance Regional Net Zero Emissions Baseline Study, undertaken by Ironbark and a regional renewable energy assessment undertaken by 100% Renewables in 2022.

The first stage of the project focused on reviewing climate change trends and projections data for the Goldfields-Esperance region and developing two background papers to inform workshops held in Esperance and Kalgoorlie. The workshops aimed to engage key stakeholders of the region to identify priority climate change risks. The workshops were a hybrid in-person/online format. Workshop participants were also engaged to identify actions currently being undertaken as well as future actions needed to address the identified climate change risks in the region.

The final stage of the project was to develop a Climate Risk Assessment report (this document) including: a summary of the climate change trends and projections for the region; a summary and analysis of the workshop outcomes; a climate risk assessment based on all the information gathered; and recommended interventions to reduce these risks. As with the background paper and workshops, this report is separated into two sections for the Esperance and Goldfields regions.

The two regions have been roughly split into Esperance region (including the Shires of Esperance, Ravensthorpe and Dundas) and the Goldfields region (LGAs of Coolgardie, Kalgoorlie-Boulder, Menzies, Leonora, Laverton, Ngaanyatjarraku and Wiluna). This split was roughly based on climate projections cluster boundaries from CSIRO and BoM modelling, as well as to spread participant attendance across each workshop¹. Section 4 discusses key interventions to reduce risks for the region as a whole.

1.1 Overview of Climate Change in the Region

1.1.1 Esperance Region

Esperance, like many coastal regions in Australia, is facing significant risks from the impacts of climate change. The area is particularly vulnerable to the increasing frequency and intensity of extreme weather events such as storms, floods, and heatwaves, changes in temperature and rainfall patterns, and sea level rise.

As part of the first stage of the project, Ironbark conducted an analysis of climate change projections in the Esperance region. This information was presented to key stakeholders during the Esperance workshop and has been used to inform the Climate Risk Assessment conducted for the region. Key findings from this analysis include:

- The average maximum temperatures at Esperance have been above the long-term average every year since around 1995.

¹ The Shire of Dundas is on the southern boundary line of the Rangelands projection cluster (Goldfields region), but attended the Esperance region workshop, therefore would find relevance from information presented on both Esperance and Goldfields regions.

- The average minimum temperatures at Esperance have been above the long-term average every year since around 1970.
- Average temperatures are projected to continue to increase under all emissions scenarios. For example, under a high emissions scenario the average temperature in 2090 is projected to be 3.4 °C above the 1986–2005 average.
- The daily maximum temperatures are also projected to increase substantially. For example, under a high emissions scenario, the average number of hot days (days above 35 °C) is projected to increase by 40% by 2050 and double by 2090.
- The duration of heat wave events is expected to increase.
- Esperance has seen a slight decline in rainfall since 1970.
- Decreases in winter and spring rainfall are projected as the climate changes, with winter rainfall expected to decrease by 15% by 2030 and by up to 45% by late in the century, under a high emissions scenario.
- There is expected to be an increase in the intensity of extreme rainfall events across the region under all emissions scenarios. These types of events can be associated with flash flooding.
- Time spent in drought is expected to increase over the course of the century under all emissions scenarios. By 2030, agricultural drought months are predicted to increase by up to 20% over most of Australia. By 2070 the increase is expected to be as high as 80% in the south-west.
- Fire weather is increasing throughout the region and Esperance experienced major bushfires in 2015 and 2019, burning more than 300,000 hectares during each fire and resulting in the loss of four lives in 2015.

Water security, wind erosion and coastal erosion also emerged during the Esperance workshop as key issues for the region.

1.1.2 Goldfields Region

As with the Esperance region, an analysis of climate change observations and trends was also conducted for the Goldfields region and used to inform discussion of key risks and impacts as part of the Kalgoorlie workshop. This analysis found that the Goldfields region is projected to become much hotter as a result of climate change, with frequent extreme heat events, higher evaporation, an overall decline in rainfall, but increased variability of rainfall events. The likelihood and intensity of fires is also expected to increase. Key findings from this analysis include:

- The average maximum and minimum temperatures at Kalgoorlie-Boulder have been above the long-term average every year since around 2000.
- Average temperatures are projected to continue to increase under all emissions scenarios. Under a high emissions scenario the average temperature in 2090 could increase by 4.3 °C above the 1986–2005 average.
- The number of hot days (days above 35 °C) and very hot days (days above 40 °C) is projected to significantly increase under all emissions scenarios. For example, under the high emissions scenario, there are projected to be more than double the amount of very

hot days per year by 2050 compared to the 1981-2010 average at both Wiluna and Kalgoorlie-Boulder. This means there is projected to be 74 days above 40°C each year at Wiluna, and 22 days per year above 40°C at Kalgoorlie-Boulder.

- The average number of hot nights (days with minimum temperatures above 23°C) is also expected to increase substantially in Wiluna and Kalgoorlie-Boulder, doubling at both locations by 2050 under a high emissions scenario.
- The duration of heat waves is expected to increase.
- April – October rainfall in the region has been below average between 2000 and 2021.
- Winter rainfall is expected to decrease in most areas across the region by over 15% by 2050, under a high emissions scenario. A medium emissions scenario projects both increases and decreases in winter rainfall depending on the location.
- The intensity of extreme rainfall events is expected to increase under all emissions scenarios.
- Time spent in drought in the Goldfields region will increase by 2090 under the high emissions scenario.

1.2 Workshop Outcomes

1.2.1 Esperance Region

Of the 27 participants attending the Esperance region workshop, half were from Esperance Shire. The Dundas Shire CEO was in attendance but no representatives from the Shire of Ravensthorpe attended. Also in attendance were representatives for water (Water Corporation), agriculture (SEPWA and DPIRD), environment (South Coast NRM), Southern Ports, Fortescue Future Industries, Chamber of Commerce and Industry and GVROC. No participants representing Aboriginal Corporations were able to attend, and nor were there any health or emergency services representatives present, although invitations had been sent to all groups.

Session 1: Understanding the Region

The first session of the workshop looked at identifying social, environmental and economic assets within the Esperance region. The natural environment was particularly highly valued by stakeholders, with environment-related words such as “natural areas”, “coastal environment”, or “wetlands” comprising almost half of all value recordings. Within these, almost half were coast-specific, indicating the value of the coastal environment to the Esperance region. People and community were also highly valued by workshop participants.

When identifying assets of the Esperance region, environment-related words were again the most frequently listed. Assets related to infrastructure and the economy such as “agriculture”, “transport infrastructure” and “rare minerals” also made up a large proportion of listed assets.

When asked to consider current vulnerabilities that the region is facing, the list was highly diverse. However, the four main vulnerabilities identified were: water access and supply; lack of preparedness for extreme weather events; skills and people shortages; and remoteness. Some other common themes included: coastal erosion and sea level rise, economic and infrastructure-related vulnerabilities, food security concerns, increasing social inequality and

biosecurity threats. "Remoteness" or geographic isolation was discussed several times in Session 1 and was considered a value, an asset and a vulnerability.

Session 2: Climate Change in the Region

Following a summary presentation by Ironbark of the climate trends and future projections, participants discussed their personal observations and experiences of climate change to date and their main concerns in relation to future climate change.

Workshop participants shared a range of climate change experiences including experiencing extreme weather events such as flooding, the impact of climate change on farming and aquaculture, increased pests, and marine species range extensions. The most commonly raised observations were:

- Increased bushfire frequency and intensity
- Changing wind patterns²
- Drying climate.

Concerns about future climate change often involved the impact of a combination of climate hazards as well as the region's lack of preparedness and capacity to cope. Some of the concerns discussed included:

- Increased bushfire frequency and intensity
- The impact of less winter rain and dryer ground conditions on the environment, agricultural industry, and water security.
- Increased coastal erosion.
- Air quality decline.

Session 3: First Pass Climate Risk Assessment

In session 3, participants completed a first pass climate risk assessment. The identified risks were incorporated into the overall climate risk assessment, provided in Appendix B and summarized in sections 1.3.1 (Executive Summary) and 2.2.

Session 4: Action Identification

In the final session of the workshop, participants identified both existing (or previously completed) actions and potential future actions by councils and other groups to adapt to climate change. This information was incorporated into the risk treatment priorities and actions section of the report (Section 4).

Existing actions by local governments included a range of plans/strategies (e.g. sea level rise and emergency plans) and other activities, while actions by other groups included the WA climate adaptation strategy (in progress) as well as actions by the community and other groups, including government agencies and departments.

² Changing weather systems due to climate change is projected to push weather systems southward i.e. the Goldfields region may be more impacted by tropical storm systems pushing further south, potentially inhibiting the effect of the Esperance sea breeze ("Esperance Doctor") coming from the south and pushing north.

Potential future actions for both local government and other groups included a mixture of new actions as well as more of what is already being done. Potential future actions for councils included: stronger advocacy for funding and supporting legislation, amending the local planning scheme and community awareness raising. However, there was an overall sentiment that local governments have limited control and resources to implement necessary climate adaptation actions. The need for improved coordination across all levels of government and between all stakeholders was a common theme.

1.2.2 Goldfields Region

The Goldfields workshop had 24 attendees, including from: regional development, Aboriginal groups, the Water Corporation, Curtin University, the Growers Group Alliance, and emergency services. There was strong representation from the City of Kalgoorlie-Boulder, as well as representatives from the Shires of Coolgardie, Leonora and Ngaanyatjarraku. Council representatives from the Shires of Wiluna, Laverton and Menzies were unable to attend. Industry representatives from mining, as well as government and industry health representatives were also not able to attend the Goldfields workshop.

Session 1: Understanding the Region

As with the Esperance workshop the purpose of the first session was to identify social, environmental and economic assets within the Goldfields region. The natural environment was highly valued by stakeholders, with environment-related words such as "natural environment", "Great Western Woodlands", or "biodiversity" comprising of a third of all value recordings. Cultural and community-related values were also common with words such as "cultural heritage" and "people" and "rich history" being repeated. Participants also discussed the overall unique social culture of some parts of the Goldfields as a remote mining hub.

When identifying assets of the Goldfields region, environment-related words like "woodlands" and "dark skies" were again the most frequently listed, followed closely by assets related to infrastructure such as "road and rail network" and "water pipeline". People were also regarded as a crucial asset to the region.

When asked to consider current vulnerabilities of the region, the list was highly diverse. However, the five main vulnerabilities identified were: water access and security, vulnerabilities related to the ageing or lack of infrastructure, such as communications and power, current climate vulnerabilities like bushfires, flooding and extreme heat, social services vulnerabilities, such as low levels of health care and education, and remoteness/isolation.

Mining was identified as both an asset and a vulnerability to the region by different stakeholders. "Remoteness" or geographic isolation was a common theme throughout Session 1 and similar to Esperance was considered a value, an asset and a vulnerability.

Session 2: Climate Change in the Region

Session 2 of the workshop was an opportunity to discuss participants' personal observations and experiences of climate change to date and their main concerns in relation to future climate change.

The significant shared experience of climate change for this group was related to water. Participants have experienced inconsistent rainfall and less winter rain, and experiences of

drought were common. Participants have also experienced higher night-time temperatures (affecting people with poor health), and more bushfires. Other experiences and observations included increased invasive species, loss of native flora and fauna, and power generation issues.

The main shared climate change concerns for Goldfields participants centred around future extreme heat and water scarcity, and their impact on livelihoods and the environment. Participants expressed their concerns about the region's lack of preparedness and capacity to cope as these risks increase. Other concerns included: increased bushfire frequency and intensity, environmental and financial costs of dealing with climate change, and flash flooding.

Session 3: First Pass Climate Risk Assessment

In Session 3, participants completed a first pass climate risk assessment. The identified risks were incorporated into the overall climate risk assessment, provided in Appendix C and summarised in sections 1.3.2 (Executive Summary) and 3.

Session 4: Action Identification

In the fourth session of the workshop, participants identified both existing (or previously completed) actions and potential future actions by councils and other groups to adapt to climate change. This information was incorporated into the risk treatment priorities and actions section of this report (Section 4).

Existing adaptation actions by local governments included waste plans, water programs, education and a range of other activities. Existing actions by other groups included environmental awareness raising, emergency management plans and the Federal Government-funded Future Drought Fund, as well as many more.

There was a sentiment that councils have limited control and resources to implement necessary climate adaptation actions. However, future actions included: increasing availability of mental health services, more tree planting, bushfire preparedness, having disaster recovery centres for each town, boosting support for cultural events, flood-proofing roads and increasing exit/access routes. The need for improved coordination across all levels of government and between all stakeholders was a common theme, including the need for clear messaging and engagement.

1.3 Climate Risk Assessment

1.3.1 Esperance Region

A climate change risk assessment was undertaken to assess and prioritise the risks for the Esperance region, and examined the seven main climate-related hazards to which the region is exposed against five identified value groups/themes. Through this process, 78 potential climate change risks were identified for 2050, including four extreme, 15 very high and 29 high risks (Table 1). A summary of the highest climate change risks for the Esperance region is provided in Appendix B.

Bushfire was assessed as having the highest overall risk to the Esperance region. Extreme rainfall and flooding as well as ocean warming and acidification, were also assessed as posing a significant risk. Risks impacting on the environment were the most prevalent in number, making up almost a third of high, very high and extreme risks. This reflects results from

Session 1 of the workshop, indicating the natural land and coastal environment was the region’s stand-out asset. Other risks rated as extreme or very high, were often associated with the loss of human life and other health risks. Remoteness was identified as an additional risk factor for many identified risks as it often elevates the level of risk or adds increased challenges for adaptation measures.

Table 1: Climate risk assessment summary for the Esperance region, indicating the number of risks for each of the hazards within each value/asset group. Colours indicate the risk rating: extreme, (E, dark red), very high (VH, red), high (H, orange) and moderate (M, yellow), low (L, green).

Esperance region		Overall Risk No.	Health	Environment	Community	Economy	Infrastructure
Bushfire	E	2	1	1	0	0	0
	VH	3	1	1	0	0	1
	H	7	0	1	1	4	1
	M	2	1	0	0	1	0
	L	0	0	0	0	0	0
Flood	E	1	1	0	0	0	0
	VH	5	0	1	2	0	2
	H	6	1	0	1	3	1
	M	6	2	2	0	2	0
	L	0	0	0	0	0	0
Ocean Warming/ Acidification	E	1	0	1	0	0	0
	VH	1	0	1	0	0	0
	H	3	0	2	0	1	0
	M	2	1	0	1	0	0
	L	1	0	0	0	1	0
Drought	E	0	0	0	0	0	0
	VH	4	2	1	0	1	0
	H	7	1	0	4	2	0
	M	3	1	0	0	0	2
	L	0	0	0	0	0	0
Extreme Heat	E	0	0	0	0	0	0
	VH	1	1	0	0	0	0
	H	2	0	2	0	0	0
	M	12	1	1	5	3	2
	L	1	0	0	1	0	0
Sea Level Rise	E	0	0	0	0	0	0
	VH	0	0	0	0	0	0
	H	3	0	1	2	0	0
	M	4	0	0	2	0	2
	L	0	0	0	0	0	0
Wind Erosion	E	0	0	0	0	0	0
	VH	0	0	0	0	0	0
	H	1	0	1	0	0	0
	M	0	0	0	0	0	0
	L	0	0	0	0	0	0

1.3.2 Goldfields Region

The climate change risk assessment for the Goldfields region examined the four main climate-related hazards to which the region is exposed against five identified value groups/themes. Through this process, 79 potential climate change risks were identified, including five extreme, 19 very high and 37 high risks for 2050. A summary of the highest climate changes risks for the Goldfields region is provided in Appendix C.

Extreme heat posed one of the greatest overall risks to the Goldfields region with the potential health impacts of increased extreme heat days on vulnerable members of the community, such as those with existing health issues, low-income groups, children and pregnant women, assessed to have the greatest overall consequence.

Bushfire was assessed to be an equally significant hazard, particularly for wooded/vegetated regions of the Goldfields. Drought was also assessed as a highly significant hazard in the region, with water scarcity already marked as a significant vulnerability.

Combinations of hazards, while not presented in the climate risk assessment, are expected to exacerbate the level of risk. For example, extreme heat, drought and bushfire can be closely associated with prolonged dry and hot conditions increasing bushfire risk and severity. Similarly, the compounding effect of increasingly frequent climate events is expected to increase the consequence of risks. For example, extreme events occurring concurrently (e.g. drought and a bushfire), or back-to-back (e.g. a bushfire followed by a flood a few months later), may compound the impact and ability to recover.

Table 2: Climate risk assessment summary for the Goldfields region, indicating the number of extreme, (E, dark red), very high (VH, red), high (H, orange) and moderate (M, yellow) and low (L, green) risks, for each of the hazards within each value group.

Goldfields region		Overall Risk No.	Health	Environment	Community	Economy	Infrastructure
Extreme heat	E	3	2	0	1	0	0
	VH	3	0	2	1	0	0
	H	8	0	1	4	3	0
	M	6	0	0	3	1	2
Bushfire	E	2	1	1	0	0	0
	VH	5	1	1	2	0	1
	H	10	1	1	2	5	1
	M	1	0	0	1	0	0
Drought	E	0	0	0	0	0	0
	VH	5	2	2	0	1	0
	H	9	1	0	5	2	1
	M	3	1	0	0	0	2
Flood	E	0	0	0	0	0	0
	VH	5	2	0	2	0	1
	H	10	1	0	4	3	2
	M	8	1	3	0	4	0

1.4 Recommendations

The workshop results and climate risk assessment were used to develop a suite of recommendations of interventions for the Goldfields-Esperance Regional Climate Alliance and member councils to consider, to reduce current and future risks to the region. Recommendations have been grouped into six themes, however, a number of actions support risks reduction in multiple areas. Recommendation themes, include:

- Natural Environment
- Extreme Heat (Human Health)
- Emergency Preparedness and Disaster Resilience
- Public Health
- Infrastructure, and
- Water

A summary of recommendations has been provided below. For more information on recommendations, see Section 4.

1.4.1 Natural Environment

1. Work with Traditional Owners, Department of Fire and Emergency Services (DFES) and Shire Councils to expand Aboriginal ranger and cultural burning programs to reduce fire risk.
2. Reduce extreme heat impacts on the natural environment through reforestation programs.
3. Reduce extreme heat impacts on animals by providing heat refuges.
4. Maintain and enhance ecosystem resilience by reducing external pressures through integrated management.
5. Advocate for greater funding for critically endangered species in the region.
6. Advocate for the development of a marine-specific climate adaptation plan for WA's south coast.

1.4.2 Extreme Heat (Human Health)

7. Reduce extreme heat impacts in towns by increasing canopy cover of native drought tolerant species.
8. Development of heat wave management plans.
9. Identification of community members at high vulnerability to extreme heat.
10. Identification and enhancement of locations that can be used as "cool places" to reduce heat wave impacts on vulnerable community members.
11. Provision of information and guidance on how to look after yourself during extreme heat events.
12. Support Traditional Owner and other Aboriginal groups to conduct heatwave impact assessments in remote communities and identify culturally appropriate actions to reduce heatwave impact on vulnerable community members.

- 13. Advocacy to the State Government to improve the quality of social housing stock.

1.4.3 Emergency Preparedness and Disaster Resilience

- 14. Support the development of community-based emergency preparedness and response plans, including for remote Aboriginal communities.
- 15. Review location, capacity and accessibility of evacuation centres across the region.
- 16. Install solar and battery systems at evacuation centres.
- 17. Develop a database of remote residents.
- 18. Provide support and guidance for residents and businesses to develop personal disaster preparedness plans.
- 19. Undertake climate change scenario planning to identify critical emergency response capacity issues.
- 20. Improve early warning systems, including ensuring early warning information can be accessed by remote communities and residents, including Aboriginal communities.
- 21. Advocate for flood modelling to be updated to account for future extent of significant flood events.
- 22. Advocate to State/Federal Government and communication providers to increase resilience of communication networks.

1.4.4 Public Health

- 23. Increase monitoring and surveillance of disease transmission.
- 24. Provide information and education on preventing transmission of vector-borne diseases.
- 25. Improve drainage systems to prevent stagnant water.
- 26. Advocate for more funding for regional mental health services.

1.4.5 Infrastructure

- 27. Undertake climate impact assessments of critical infrastructure in the region.
- 28. Integrate climate change into Council asset management plans.

1.4.6 Water

- 29. Conduct water and energy efficiency audits at all council facilities.
- 30. Upgrade council parks and open space irrigation systems to be more water efficient and increase utilisation of recycled water.
- 31. Community education and engagement on water conservation
- 32. Advocate for the development of greater regional water storage capacity.

1.5 Conclusion

The workshops carried out with councils and other key stakeholders as part of this project highlighted some of the most valued aspects and assets of the region, as well as its vulnerabilities. These included the natural environment and the people, as well as the remoteness of the region, which was seen as a value, an asset and a vulnerability. The workshops also highlighted that climate change impacts are already being experienced in the Goldfields and Esperance regions and that there are a range of climate risks being faced.

The climate risk assessments developed for the Esperance and Goldfields regions built on this information, and were used to develop a suite of recommended interventions for reducing climate risks. These can be considered the first step in the identification of climate risks and appropriate actions for councils in the region. However, more work is needed. We recommend the development of more localised climate risk assessments as a next step. These could be developed at the LGA level, or even at a township level, given the vast and diverse areas covered by LGAs in the region.

There were a number of stakeholders that were invited to participate in the regional workshops or provide information on climate risks within their area of expertise but were unable to engage within the timeframe of the project. These include Traditional Owners, health service providers and representatives from the mining sector. It is recommended that the Goldfields Esperance Regional Climate Alliance further engages with these stakeholders to ensure that actions developed as part of this assessment align with work being undertaken in these areas and to provide opportunities for these stakeholders to provide input into future regional climate change assessments.

2. Esperance Regional Risk Assessment

2.1 Workshop Summary

The Esperance Workshop was held at the Esperance Civic Centre on 21 March 2023. The workshop included an introduction and welcome from Niki Curtis (Coordinator, Goldfield-Esperance Regional Climate Alliance), before Neil Aldum (Senior Climate Change Policy Officer, DWER) provided an overview of the WA State Government climate change adaptation policy context. A presentation on the process and outcomes of a recent climate change risk assessment undertaken by Southern Ports was also made by Catherine Field, Sustainability Coordinator at Southern Ports.

The 3.5-hour workshop was then split into four sessions:

1. Understanding the region
2. Climate change in the region
3. First-pass climate risk assessment
4. Identification of actions

Following the workshop format, the report summary is split into the same four sections.

2.1.1 Workshop participants

A broad range of key stakeholders were identified and invited to the Esperance region workshop (~50 people). This included: Traditional Owners and Aboriginal Corporation representatives; local business associations; industry representatives; environmental groups; district health representatives; and emergency services. Additionally, a range of representatives from the two southern-most GVROC Councils (Esperance and Dundas), as well as council representatives from the Shire of Ravensthorpe were invited to participate in the workshop.

Of the 27 participants attending the Esperance region workshop (in-person and online), half were from Esperance Shire including the CEO and Councillors, and staff representing environment, parks and waste; governance and corporate services; building and planning; and community development. The Dundas Shire CEO was in attendance and no representatives from the Shire of Ravensthorpe attended.

Also in attendance were representatives for water (Water Corporation), agriculture (SEPWA and DPIRD), environment (South Coast NRM), Southern Ports, Fortescue Future Industries, Chamber of Commerce and Industry and GVROC. No participants representing Aboriginal Corporations were able to attend in Esperance, and nor were there any health or emergency services representatives present.

2.1.2 Session 1 – Understanding the Region

The purpose of this session was to identify social, environmental and economic assets within the Esperance region. This step is crucial in setting the foundation for the risk assessment as it allows stakeholders to understand each other's values of the region and affects the level of consequence attributed to different risks.

Participants listed values and assets of the region (**Error! Reference source not found.** and Figure 2), as well as current vulnerabilities faced in the region (**Error! Reference source not found.**). In the word clouds displaying the results of this session, the size of the word indicates the number of times that word/phrase was recorded (i.e. larger words were recorded most frequently).



Figure 1: Word cloud of recorded values for the Esperance workshop, with font size reflecting the number of times that word or phrase was used.

The *values* word cloud for the Esperance region (Figure 1), indicates that the natural environment is highly valued by stakeholders, with environment-related words such as “natural areas”, “coastal environment”, or “wetlands” comprising almost half of all value recordings. Within in these, almost half were coast-specific, indicating the value of the coastal environment to the Esperance region. People and community were also highly valued by workshop participants.

When identifying assets of the Esperance region (Figure 2), environment-related words were again the most frequently listed. Assets related to infrastructure and the economy such as “agriculture”, “transport infrastructure” and “rare minerals” also made up a large proportion of listed assets.

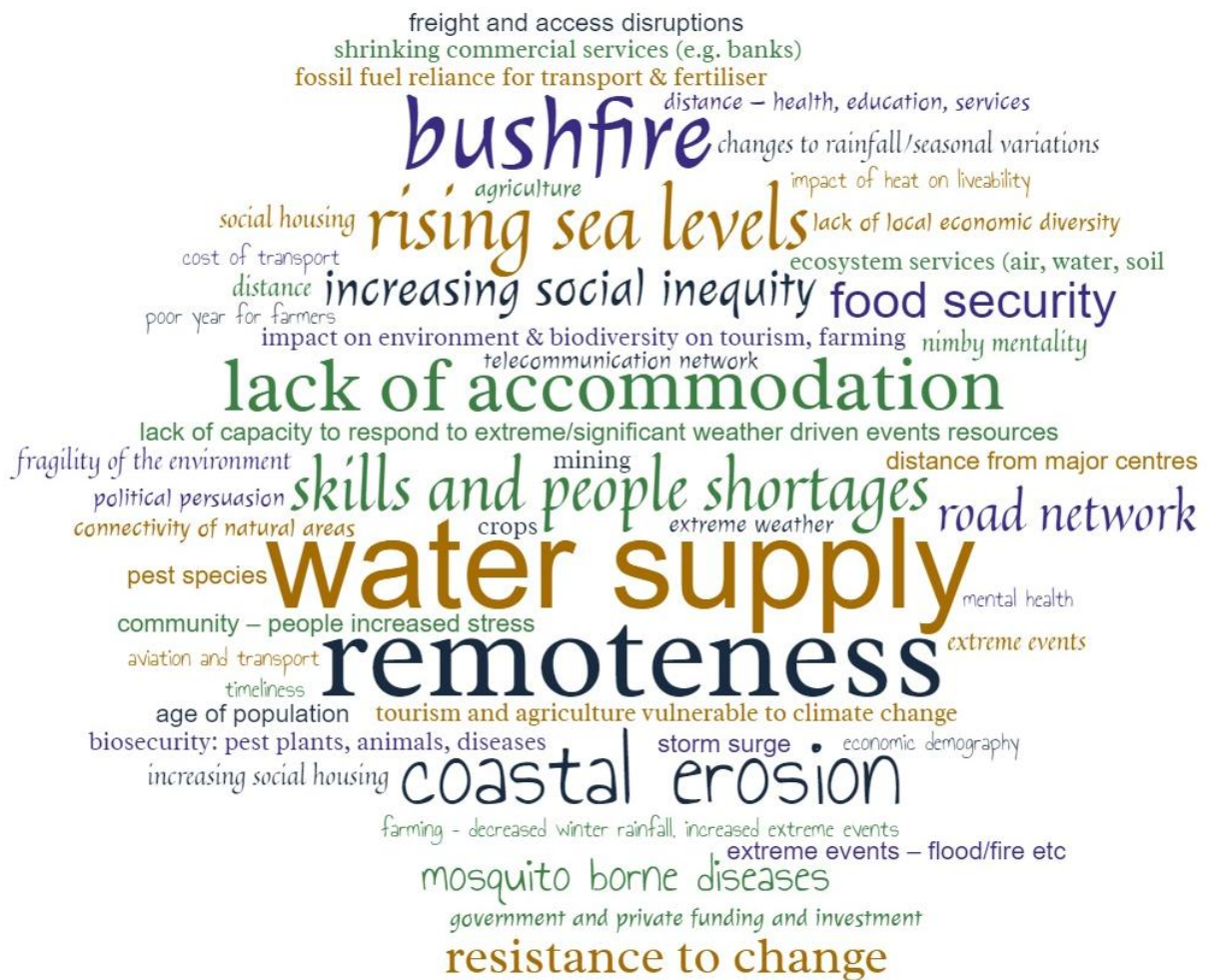


Figure 3: Word cloud of current vulnerabilities identified for the Esperance region.

From the discussions in Session 1, workshop participants identified seven categories or 'themes' for which to arrange risks and impacts for Sessions 3 and 4: Environment; Community; Economy; Culture; Health; Infrastructure; and Governance & Politics. These themes and discussions also formed the basis for the Esperance region climate risk assessment.

2.1.3 Session 2 – Climate Change in the Region

Session 2 of the workshop was an opportunity to discuss the findings of the background paper (climate trends and projections for the region summarised in Section 1.1.1), fill in any region-specific gaps and add local context from the GVROC regions.

Following a summary presentation by Ironbark of the climate trends and future projections, participants discussed:

1. Their personal observations and experiences of climate change to date; and
2. Their main concerns in relation to future climate change.

2.1.3.1 Personal experiences and observations of climate change

Workshop participants shared a range of climate change experiences including experiencing extreme weather events such as flooding, the impact of climate change on farming and aquaculture, increased pests, and marine species range extensions. The most commonly-raised observations were:

- *Increased bushfire frequency and intensity:* including an increase in bushfires caused by dry lightning strikes (particularly around Norseman).
- *Changing wind patterns:* Coastal participants have experienced increased wind erosion over the past three years and increased coastal erosion, while inland participants have experienced less wind coming from the coast⁴.
- *Drying climate:* experiencing less winter rain and dryer ground conditions.

2.1.3.2 Concerns about future climate change – Esperance region

Concerns about future climate change followed on from participants' current observations of climate change and often involved the impact of a combination of climate hazards as well as the region's lack of preparedness and capacity to cope. Some of the concerns discussed included:

- *Increased bushfire frequency and intensity:* the impact of this on the environment, as well as community safety and damage to property and infrastructure.
- *Drying climate:* the impact of less winter rain and dryer ground conditions on the environment, agricultural industry, and water security.
- *Increased coastal erosion:* Coastal erosion from increasing wind and extreme coastal sea levels⁵ (and exacerbated by coastal fires that destroy dune-stabilising vegetation), that damage fragile coastal ecosystems and infrastructure.
- *Air quality decline:* the potential for increased dust (from a combination of increased wind erosion and dryer ground conditions), and bushfire smoke, may lead to reduced air quality affecting respiratory health.

2.1.4 Session 3 – First Pass Climate Risk Assessment

After discussing the climate change projections and observations for the Esperance region, participants identified the potential impact and severity of specific risks on their value and asset themes identified in Session 1. The recordings from Session 3 of the workshops were incorporated into the climate risk assessment (Appendix B) and below is a short summation of what was discussed.

Impacts of climate change on the environment was of grave concern to workshop participants, particularly from bushfire, ocean warming and acidification, drought and coastal erosion. The critically endangered Western Ground Parrot for example, one of the rarest birds in the world

⁴ Changing weather systems due to climate change is projected to push weather systems southward i.e. the Goldfields region may be more impacted by tropical storm systems pushing further south, potentially inhibiting the effect of the Esperance seabreeze ("Esperance Doctor") coming from the south and pushing north.

⁵ Caused by a combination of factors including astronomical tides, storm surges and wind-waves, exacerbated by rising sea levels (<https://www.climatechangeinaustralia.gov.au/en/projections-tools/coastal-marine-projections/>)

and endemic to WA, lost 90% of its habitat in the 2015 bushfire⁶. The combination of climate impacts on existing environmental threats such as invasive species and loss of habitat was also discussed. For example, the impact of ocean warming and acidification on the invasion of tropical marine species and the flow-on effect to local fisheries.

The effect of multiple climate hazards such as drought, floods, extreme heat and bushfire on the regions' already-vulnerable water supply was a common thread throughout the session, which impacts all sectors of the region. Reduced water security and quality may exacerbate existing pressures on public health and particularly impact remote, low-income and vulnerable members of the community. A combination of multiple climate events and the compounding effects of increasingly frequent events was predicted to have a severe impact on mental health in the community, such as farmers being impacted by prolonged and recurring droughts.

The impact of extreme weather events on critical infrastructure and the flow-on effects to the local economy was recorded as highly severe. For example, communication and power infrastructure being damaged for prolonged periods impacting on business productivity and transactions. Another example was roads being cut off due to floods in this remote region, leading to food security issues, disruptions in specialist services (e.g. visiting health specialists) and reduced access to other supplies such as diesel.

Information from this session was then fed into the final session focussing on current and future adaptation actions.

2.1.5 Session 4 – Action Identification

In the fourth and final session of the workshop, participants identified both existing (or previously completed) actions and potential future actions by councils and other groups to adapt to climate change. This information was incorporated into the risk treatment priorities and actions section of the report (Section 4).

Existing adaptation actions by local governments included: the presence of a range of plans/strategies (e.g. sea level rise, coastal management and emergency plans); enforcing new, energy efficient and fire-safe building codes; emissions reduction plans (e.g. solar, EVs and LED street lights); installing larger road culverts; invasive species management funding; and training more volunteers. Existing actions by other groups included: the WA climate adaptation strategy (in progress) and planning (e.g. through DPIRD, DWER, Water Corp, Horizon Power, Southern Ports); community action groups; environmental health monitoring (e.g. mosquito, air and water quality); local mental health services (e.g. CAMHS, Centrecare, Headspace); and prescribed burning. Several actions were being achieved by both councils and other groups such as infrastructure planning for climate impacts and fire mitigation plans.

Potential future actions for both local government and other groups included a mixture of new actions as well as more of what is already being done. Potential future actions for councils included: stronger advocacy for funding and supporting legislation; amending local planning schemes to encourage renewable projects; and community awareness raising (e.g. driver education for extreme events). There was a longer list of recorded actions relevant to State and Federal Government compared with local government. This was consistent with overall group

⁶ <https://www.abc.net.au/news/2015-11-30/fears-for-rare-western-ground-parrot-after-esperance-fires/6987740>

sentiments that local governments have limited control and resources to implement necessary climate adaptation actions.

Future potential actions by other groups included: reviewing legislation that cause barriers to action; increasing marine and terrestrial nature reserves; easier immigration pathways for health workers, and community volunteer training in mental health support. The need for improved coordination across all levels of government and between all stakeholders was a common theme in Session 4, including the need for clear messaging and engagement.

Participants also recognised and discussed the need to address broader sustainability issues in the region to adapt to climate change and prevent high emissions scenarios from eventuating. Examples of such discussions for existing and future actions included:

- Water management strategy incl. reducing water use and water harvesting and recycling.
- Preventing vegetation clearing and promoting protection and revegetation of natural areas
- Energy efficiency measures and increased uptake of renewable energy and batteries
- Education on climate change and its impacts

2.1.6 Esperance region workshop summary

This workshop facilitated initial (and some ongoing) discussions on future climate change risks for the region, what is being done and what needs to be done. At the end of the workshop, each participant wrote down one take-home-message based on the four sessions. These comments confirmed the major concern from stakeholders around the impact of climate change on water security and quality. It also highlighted concern about local government having limited capacity to deal with climate change and the need to protect vulnerable community groups. Below are two examples:

“Provide information, support and incentives to enable households to be as self-sustaining as possible in terms of water collection and use (including greywater); energy production and use (home and car) and food production, all while living in homes that are designed for the new reality.”

“That state and federal govt are aware that local governments have a very limited capacity to deal with the range of climate change impacts and therefore need to be heard, supported, funded and given greater authority (devolved) to address climate change changes”.

2.2 Climate Risk Assessment Summary

The Esperance region is exposed to a range of climate change related hazards, which present the Esperance and Dundas councils and their communities with a high level of climate change risk. A climate change risk assessment was undertaken to assess and prioritise these risks, and examined the seven main climate-related hazards to which the Esperance region is exposed, against five identified value groups/themes⁷, as shown below:

⁷ Themes were based on those identified in Session 1 of the workshop, however the “Governance and Politics” theme identified in the workshop was removed and recordings moved to the Recommended Interventions section. The “Culture” theme recordings were very similar to, and thus incorporated into the “Community” theme.

Esperance Climate Change Hazards

- Extreme Heat
- Bushfire
- Extreme Rain and Flooding
- Low Rainfall and Drought
- Sea Level Rise
- Ocean Warming and Acidification
- Wind Erosion

Value/Asset Themes

- Environment
- Infrastructure
- Community
- Public Health
- Economy

Through this process, 78 potential climate change risks were identified for 2050, including four extreme, 15 very high and 29 high risks (Table 3). A summary of these climate changes risks is provided in Appendix B.

Bushfire was assessed as having the highest overall risk to the Esperance region, with two extreme, three very high and seven high risks identified. The highest were those associated with the loss of human life and the loss of environmental assets. With some of the Esperance and Dundas region being along a very rugged and remote coastline, as well as some highly-vegetated reserves such as Cape Arid National Park and reserves in the Great Western Woodlands, the consequence and likelihood of bushfire was high. This, in combination with increased winds and drying conditions projected for the region highlight bushfire adaptation measures as a strong focus.

Extreme rainfall and flooding were also assessed as significant risks to the region, with one extreme, six very high and six high risks identified. The greatest risks included: loss of life from flash flooding, damage/loss of critical infrastructure (water, power, communications, roads); communities being cut-off, exacerbated salinity impacts on the environment and agriculture; and loss of property. Again, the extreme remoteness of the region was identified as an additional risk factor when it comes to rebuilding, replacing and repairing damaged assets. Also, remoteness increased the flooding risks associated with support, for example access for visiting health care specialists.

Table 3: Climate risk assessment summary for the Esperance region, indicating the number of risks for each of the hazards within each value/asset group. Colours indicate the risk rating: extreme, (E, dark red), very high (VH, red), high (H, orange) and moderate (M, yellow), low (L, green).

Esperance region		Overall Risk No.	Health	Environment	Community	Economy	Infrastructure
Bushfire	E	2	1	1	0	0	0
	VH	3	1	1	0	0	1
	H	7	0	1	1	4	1
	M	2	1	0	0	1	0
	L	0	0	0	0	0	0
Flood	E	1	1	0	0	0	0
	VH	5	0	1	2	0	2
	H	6	1	0	1	3	1
	M	6	2	2	0	2	0
	L	0	0	0	0	0	0
Ocean Warming/ Acidification	E	1	0	1	0	0	0
	VH	1	0	1	0	0	0
	H	3	0	2	0	1	0
	M	2	1	0	1	0	0
	L	1	0	0	0	1	0
Drought	E	0	0	0	0	0	0
	VH	4	2	1	0	1	0
	H	7	1	0	4	2	0
	M	3	1	0	0	0	2
	L	0	0	0	0	0	0
Extreme Heat	E	0	0	0	0	0	0
	VH	1	1	0	0	0	0
	H	2	0	2	0	0	0
	M	12	1	1	5	3	2
	L	1	0	0	1	0	0
Sea Level Rise	E	0	0	0	0	0	0
	VH	0	0	0	0	0	0
	H	3	0	1	2	0	0
	M	4	0	0	2	0	2
	L	0	0	0	0	0	0
Wind Erosion	E	0	0	0	0	0	0
	VH	0	0	0	0	0	0
	H	1	0	1	0	0	0
	M	0	0	0	0	0	0
	L	0	0	0	0	0	0

Ocean warming and acidification poses a considerable risk to the marine environment particularly through loss of species and reduced abundance and diversity of species. One extreme, one very high and three high risks were identified for this hazard. Western Australia has been described by scientists as a global ocean-warming hotspot. CSIRO projections indicate high confidence on the rate of warming and acidification for this region, which increased the likelihood of these occurrences in the risk assessment. The south-west of Australia exhibits high

levels of marine species diversity and endemism. Increased extended marine heatwave events are projected with increased frequency and intensity of La Nina events. Western Australia has already experienced significant marine losses from the 2011 marine heatwave event. This marine heat wave led to mass mortality of seagrass and kelp forests (some of which have still not fully recovered), as well as significant impacts to fish, invertebrates and little penguins. Affected commercial and recreational fish species included blue swimmer crab, scallop and abalone. For example, 99% of Roe's Abalone were killed in Kalbarri, leading to a ban on fishing. Despite significant reseeding efforts by DPIRD, the population has, as yet, not recovered.

Finally, low rainfall and drought was also assessed as a significant risk for the Esperance region, with four very high and seven high risks identified. Given the importance of agriculture to the region, the economic impact of a major drought event is potentially major. Other high and very high risks related to drought included: the impact of drought on mental health, water scarcity and supply, habitat and biodiversity loss and food security impacts.

Extreme heat did not rank as highly in terms of risk because projections for extreme heat for this region are less severe than others. Average days over 35°C per year, for example, are expected to increase from 10 to 14 days by 2050. This being noted, future extreme heat is still a significant hazard as people in different locations have different vulnerabilities and temperature tolerances, as do locally-adapted flora and fauna species.

Risks impacting on the environment were the most prevalent in number, making up almost a third of high, very high and extreme risks. This reflects results from Session 1 of the workshop, indicating the natural land and coastal environment was the region's stand-out asset. Other risks rating extreme and very high in particular, were often associated with the loss of human life and other health risks. Remoteness was identified as an additional risk factor for many identified risks as it often elevates the level of risk or adds increased challenges for adaptation measures. A summary of the highest climate changes risks for the Esperance region is provided in Appendix B.

3. Goldfields Regional Risk Assessment

3.1 Workshop Summary

The Goldfields Workshop was held at the Kalgoorlie Overland Motel on 23 March 2023. The workshop included an introduction and welcome from Niki Curtis (Coordinator, Goldfield-Esperance Regional Climate Alliance), before Neil Aldum (Senior Climate Change Policy Officer, DWER) provided an overview of the WA State Government climate change adaptation policy context. A presentation on the process and outcomes of a recent climate change risk assessment undertaken by Southern Ports was also made by Catherine Field, Sustainability Coordinator at Southern Ports.

The 3.5-hour workshop was then split into four sessions:

1. Understanding the region
2. Climate change in the region
3. First-pass climate risk assessment
4. Identification of actions

Following the workshop format, the report summary is split into the same four sections.

3.1.1 Workshop participants

A broad range of key stakeholders were identified and invited to the Goldfields region workshop (over 65 people). This included: Traditional Owners and Aboriginal Corporation representatives; local business associations; industry representatives; environmental groups; district health representatives; and emergency services. Additionally, a range of representatives from the seven northern GVROC Councils were invited to participate in the workshop.

The Goldfields region workshop had a diverse range of 24 attendees (in-person and online) including from: regional development, Aboriginal groups, the Water Corporation, Curtin University, the Growers Group Alliance, and emergency services. Industry representatives from mining were not able to attend the Goldfields workshop. Government and industry health representatives were also absent.

Some Aboriginal Traditional Owners were unable to attend, although two representatives from Ngadju Conservation Aboriginal Corporation attended. There was strong representation for the City of Kalgoorlie-Boulder (including Acting CEO, Councillors, environment and waste officers, and environmental health), as well as representatives from the Shires of Coolgardie, Leonora and Ngaanyatjaraku. Council representatives from the Shires of Wiluna, Laverton and Menzies were unable to attend.

3.1.2 Session 1 – Understanding the Region

The purpose of this session was to identify social, environmental and economic assets within the Goldfields region. This step is crucial in setting the foundation for the risk assessment as it allows stakeholders to understand each other's values of the region and affects the level of consequence attributed to different risks. Participants discussed and recorded values and assets of the region (Figure 4 and 5), as well as the vulnerabilities currently faced in the region

(Figure 6 **Error! Reference source not found.**). In the word clouds displaying the results of this session, the size of the word indicates the number of times that word/phrase was recorded (i.e. larger words were recorded most frequently).



Figure 4: Word cloud of the recorded values for the Goldfields region workshop.

The *values* word cloud for the Goldfields region (Figure 4), indicates that the natural environment is highly valued by stakeholders, with environment-related words such as “natural environment”, “Great Western Woodlands”, or “biodiversity” comprising of a third of all value recordings. Cultural and community-related values were also common with words such as “cultural heritage” and “people” and “rich history” being repeated. The vast Goldfields region has rich and diverse First Nations cultural heritage. Some regional centres such as Kalgoorlie-Boulder are also highly valued for its European history, with historical buildings contributing to its cultural value. Also discussed was the overall unique social culture of some parts of the Goldfields as a remote mining hub.

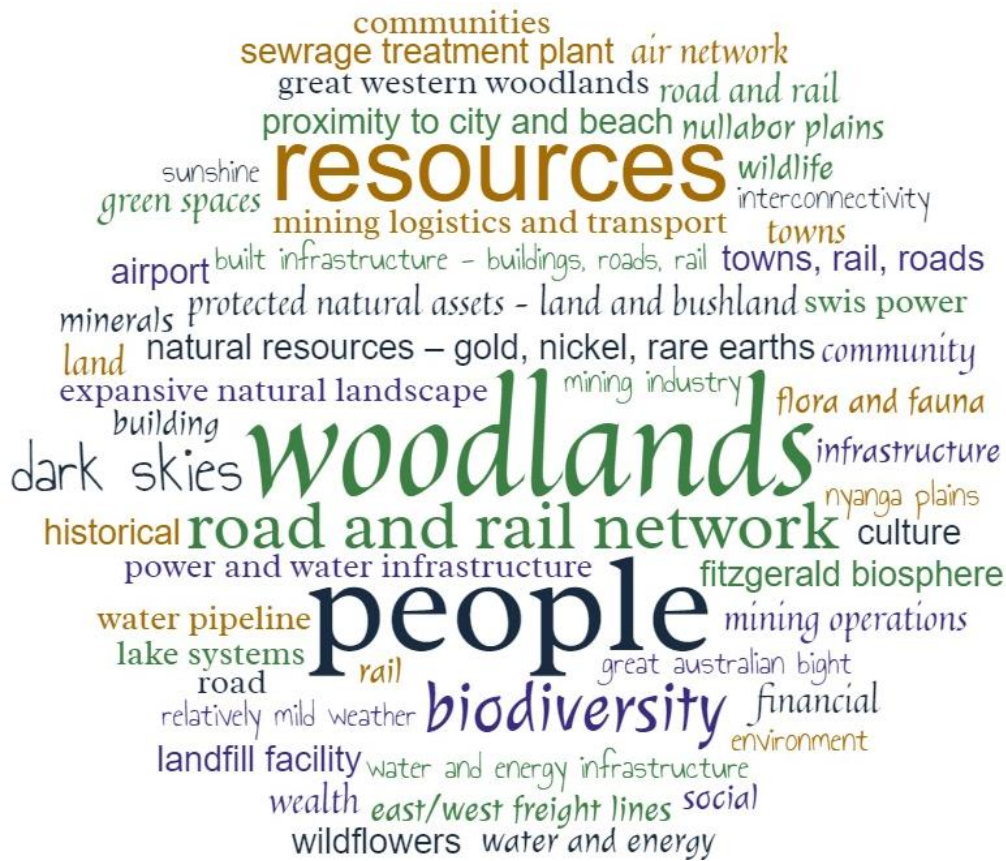


Figure 5: Word cloud of recorded assets for the Goldfields region workshop.

When identifying assets of the Goldfields region (Figure 5Figure 2), environment-related words like “woodlands” and “dark skies” were again the most frequently listed, followed closely by assets related to infrastructure such as “road and rail network” and “water pipeline”. With a very small population covering a vast land mass and with an extensive industrial sector, it’s unsurprising that “people” were also regarded as a crucial asset to the region.

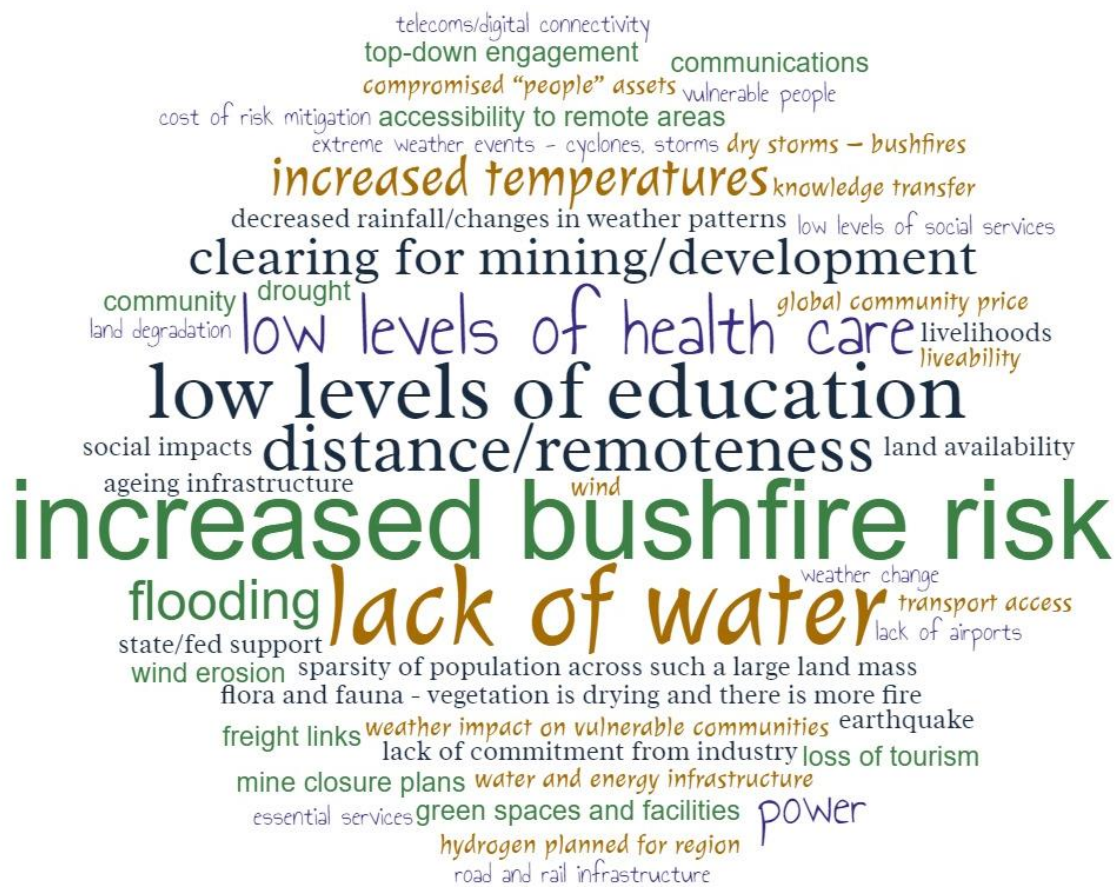


Figure 6: Word cloud of current vulnerabilities identified for the Goldfields region.

When asked to consider current vulnerabilities that the region is facing (Figure 6), the list was highly diverse. However, the five main vulnerabilities identified were:

- Water access and security;
- Vulnerabilities related to the ageing or lack of infrastructure e.g. communications and power;
- Current climate vulnerabilities: bushfires, flooding and extreme heat;
- Social services vulnerabilities e.g. Low levels of health care and education; and
- Remoteness/isolation

Other vulnerabilities raised included: clearing for mining and development; commodity prices; mine closure plans; lack of commitment and accountability from industry; and State and Federal disconnect (e.g. policies, funding). Mining was identified as both an asset and a vulnerability to the region by different stakeholders. On the one hand, it provides jobs and other economic opportunities, and on the other, mining uses precious power and water resources and has a negative impact on the Great Western Woodlands. "Remoteness" or geographic isolation was a common theme throughout Session 1 and was considered a value, an asset and a vulnerability.

From these discussions, workshop participants identified seven categories or 'themes' for which to arrange risks and impacts for the Sessions 3 and 4: Environment; Community; Economy; Culture; Health; Infrastructure; and Governance & Politics. These themes and discussions also formed the basis for the Goldfields region climate risk assessment.

3.1.3 Session 2 – Climate Change in the Region

Session 2 of the workshop was an opportunity to discuss the findings of the background paper (climate trends and projections for the region summarised in Section 0), fill in any region-specific gaps and add local context from the GVROC regions. Following a summary presentation by Ironbark of the climate trends and future projections, participants discussed:

1. Their personal observations and experiences of climate change to date; and
2. Their main concerns in relation to future climate change.

3.1.3.1 Personal experiences and observations of climate change

The significant shared experience of climate change for this group was related to water. In particular, participants have experienced inconsistent rainfall and less winter rain. Experiences of drought were common, particularly the drying of natural areas and the financial and mental health impacts of drought. Participants have also experienced higher night-time temperatures (affecting people with poor health), and increased electrical storms and dry lightning leading to increased bushfires. It was noted that night-time temperatures are no longer suppressing remote fires and therefore, these areas are now requiring greater intervention. Other experiences and observations included increased invasive species, loss of native flora and fauna, and power generation issues.

3.1.3.2 Concerns about future climate change

The main shared climate change concerns for Goldfields participants were centred around future extreme heat and water scarcity, and their impact on livelihoods and the environment. For example, both extreme heat and water insecurity are already affecting remote and vulnerable groups in the Goldfields. Participants expressed their concerns about the region's lack of preparedness and capacity to cope as these risks increase. In addition, concerns were raised about the equitable sharing of scarce water resources in the future. Other concerns included:

- *Increased bushfire frequency and intensity:* the impact of this on the environment, as well as community safety and damage to property and infrastructure. Additional concerns here included the region's ability to mitigate widespread fire events as well as increased fire risk from EV and battery systems.
- *Environmental and financial costs of dealing with climate change:* for example, the potential land clearing required for new power systems or increased power and water costs to maintain community services.
- *Flash flooding:* Increased summer rainfall increasing flashing flooding events and catching the community off-guard.

3.1.4 Session 3 – First Pass Climate Risk Assessment

In this section, participants identified the potential impact and severity of specific risks on their value/asset themes identified in Session 1. The results from Session 3 of the workshop were incorporated into the climate risk assessment (Appendix C) and below is a short summation of what was discussed.

The impact of all climate hazards on the health and wellbeing of people - and the flow-on effects of this to the community and prosperity of the region - was a major talking point. For example, the impact of extreme heat on Indigenous culture was considered severe in the Goldfields region because of the potential loss of life of vulnerable Aboriginal Elders in remote communities, which could threaten the future of Indigenous culture. Additionally, land-based Indigenous culture and heritage may be diminished due to lost or altered natural areas.

Impacts of climate change on the environment was of particular concern to workshop participants, particularly from bushfire, drought and extreme heat. For example, the Ngadju Conservation Aboriginal Corporation discussed in detail the fragility of one of the region's greatest treasures - the Great Western Woodlands. This stretch of woodlands is the largest Mediterranean climate woodland in the world (16m Ha) and holds enormous significance to the Aboriginal groups in this area. It holds a number of threatened flora and fauna species including endemic Eucalypts that are >600 years old. Climate change poses a serious threat to this entire ecosystem as these trees are not able to cope and recover from increasing fire and drought events (discussed further in Section 3.2). The combination of climate impacts on existing environmental threats such as invasive species and loss of habitat was also discussed.

As with the Esperance region, the effect of multiple climate hazards such as drought, flooding, extreme heat and bushfire on the Goldfields region's already-vulnerable water supply was a common thread throughout the session, impacting all sectors of the region. Reduced water security and quality may exacerbate existing pressures on public health and impact particularly remote, low-income and vulnerable members of the community. Again, the impact of extreme weather events on critical infrastructure and the flow-on effects to the local economy was discussed, including the impact of damaged infrastructure *during* emergencies e.g. communication towers down and road access cut-off during bushfire emergencies.

A combination of multiple climate events and the compounding effects of increasingly frequent events was predicted to have a severe impact on mental health in the community. For example, the effect of sustained heatwaves, and coping with loss, uncertainty, isolation and displacement. Information from this session was then fed into the final session focussing on current and future adaptation actions.

3.1.5 Session 4 – Action Identification

In the fourth and final session of the workshop, participants identified both existing (or previously completed) actions and potential future actions by councils and other groups to adapt to climate change. This information was incorporated into the Recommended Interventions section of the report (Section 4).

Existing adaptation actions by local governments included: waste plans (e.g. waste-to-energy, recycling programs and tip shop); water programs (e.g. water recycling, waterwise promotions and increasing storage capacity); emergency management committees and arrangements (LEMA, LEMC and DEMC); education, warning services and online information; and emissions reduction plans (e.g. solar, geothermal, EVs and LED street lights). Existing actions by other groups included: the ranger programs (incl. carbon planning, flora and fauna monitoring, environment awareness raising, environmental mapping); fire mitigation plans, emergency management plans and SES volunteers; renewables uptake, rebates, and emissions tax; and public information and warnings.

Participants also identified support provided by a range of groups including; DPIRD’s Climate Resilience Taskforce, Goldfields Esperance Development Commissions, Growers Group Alliance, the Foundation for Rural & Regional Renewal (FRRR) community drought resilience program, and the National Landcare Program. In particular, the Federal Government-funded Future Drought Fund was mentioned several times for providing adaptation opportunities for drought as well as extreme heat and other extreme weather events.

As with the Esperance workshop, there was a longer list of potential future actions relevant to State and Federal Government compared to local government. This was consistent with overall group sentiments that councils have limited control and resources to implement necessary climate adaptation actions. Future actions included: developing a carbon methodology; increasing availability of mental health services; more tree planting; increasing bushfire containment lines; adopting Indigenous fire management techniques; having disaster recovery centres for each town; boosting support for cultural events; flood-proofing roads; and increasing exit/access routes. As with the Esperance region workshop, the need for improved coordination across all levels of government and between all stakeholders was a common theme in Session 4, including the need for clear messaging and engagement.

Participants also recognised and discussed the need to address broader sustainability issues in the region to adapt to climate change and prevent high emissions scenarios from eventuating. Examples of such discussions for existing and future actions included:

- Water management strategy including reducing water use and water harvesting and recycling
- Reducing industrial and residential waste to landfill e.g. improving recycling systems
- Energy efficiency measures and increased uptake of renewable energy and batteries
- Education on climate change and its impacts

3.1.6 Goldfields region workshop summary

This workshop facilitated initial (and some ongoing) discussions on future climate change risks for the region, what is being done and what needs to be done. At the end of the workshop, each participant wrote down one take-home-message based on the four sessions. These comments confirmed a great need to improve accountability and cross-sector collaboration in order to deal with climate change effectively. Much needed State and Federal Government funding was also stressed, to implement strategies for waste, water, revegetation and energy projects, as well as greater funding support from the mining industry. Below are some examples:

“Activate a WHOLE of region program to drive participation in addressing how we can all contribute toward climate change”

“Carbon methodology for the Great Western Woodlands”

“Stop wasting water. Use the right quality of water for the job – fit for purpose”

“Greater commitment and tangible actions from LGAs, small/med business and mining. WE ARE IN THIS TOGETHER!”

3.2 Climate Risk Assessment Summary

The Goldfields region is exposed to a range of climate change related hazards, which present the councils in this region and their communities with a very high level of climate change risk. A climate change risk assessment was undertaken to assess and prioritise these risks, and examined the four main climate-related hazards to which the Goldfields region is exposed, against five identified value groups/themes⁸, as outlined below:

Goldfields Climate Change Hazards

- Extreme Heat
- Bushfire
- Extreme Rain and Flooding
- Low Rainfall and Drought

Value/Asset Themes

- Environment
- Infrastructure
- Community
- Public Health
- Economy

Through this process, 79 potential climate change risks were identified, including five extreme, 19 very high and 37 high risks for 2050. A summary of the 61 highest climate changes risks is provided in Appendix C. Table 4 summarises the number of risks identified for each climate hazard and value theme, distinguished by the assessed level of risk.

Extreme heat posed one of the greatest overall risks to the Goldfields region with three extreme, three very high and eight high risks. The potential health impacts of increased extreme heat days on vulnerable members of the community (such as those with existing health issues, low-income groups, children and pregnant women), was assessed to have the greatest overall consequence. For example, the effect of extreme heat on vulnerable Aboriginal Elders living in remote communities could threaten the future of Indigenous culture. Additional risk factors included poorly-insulated homes with no air conditioning, and remoteness limiting healthcare assistance. Also, low-income groups unable to afford upgrades to homes or affected by increased energy bills from air conditioning, may further perpetuate broader economic inequality. The remote town of Warburton for example, currently experiences ~27 days >40°C per year. By 2050, this is expected to increase to ~62 days per year. Some parts of Australia have already observed 'climate refugees' moving from remote areas to regional centres⁹ and the likelihood of some communities in arid parts of the Goldfields becoming unlivable, is possible.

⁸ Themes were based on those identified in Session 1 of the workshop, however the "Governance and Politics" theme identified in the workshop was removed and recordings moved to the Recommended Interventions section. The "Culture" theme recordings were very similar to, and thus incorporated into the "Community" theme.

⁹ <https://www.theguardian.com/australia-news/2019/dec/18/too-hot-for-humans-first-nations-people-fear-becoming-australias-first-climate-refugees>

Table 4: Climate risk assessment summary for the Goldfields region, indicating the number of extreme, (E, dark red), very high (VH, red), high (H, orange) and moderate (M, yellow) and low (L, green) risks, for each of the hazards within each value group.

Goldfields region		Overall Risk No.	Health	Environment	Community	Economy	Infrastructure
Extreme heat	E	3	2	0	1	0	0
	VH	3	0	2	1	0	0
	H	8	0	1	4	3	0
	M	6	0	0	3	1	2
Bushfire	E	2	1	1	0	0	0
	VH	5	1	1	2	0	1
	H	10	1	1	2	5	1
	M	1	0	0	1	0	0
Drought	E	0	0	0	0	0	0
	VH	5	2	2	0	1	0
	H	9	1	0	5	2	1
	M	3	1	0	0	0	2
Flood	E	0	0	0	0	0	0
	VH	5	2	0	2	0	1
	H	10	1	0	4	3	2
	M	8	1	3	0	4	0

Additionally, extreme heat impacts on local habitat and biodiversity was assessed to have a very high risk by 2050. Mental health, loss of agricultural produce, green space, reduced human resources and productivity, and Council services were assessed to be high-risk. A key risk factor that stands out for extreme heat is that its likelihood in the future is almost certain. The greater likelihood of extreme heat events elevates each of these risks.

Bushfire was assessed to be an equally significant hazard, particularly for wooded/vegetated regions of the Goldfields, with two extreme, five very high and 10 high risks identified. The potential for the loss of both human lives as well as flora and fauna species were assessed to be of catastrophic consequence and likely to occur by 2050, resulting in an extreme risk. The Goldfields region is home to many threatened and endemic species that are at high risk of bushfire due to the aridness of the region and its extreme remoteness. The Great Western Woodlands is the only place in the world that supports 20m tall trees with little rainfall¹⁰, indicating this ecosystem is already existing at the extreme end of its tolerance range. The old-growth gimlets and salmon gums endemic to this region are easily killed by fire and do not resprout. Living up to ~600 years, these trees (and the species that depend on them for food and habitat), are highly vulnerable to increasingly frequent and intense fire events¹⁰. Increased numbers of invasive species such as feral cats and grass weeds from bushfires was considered a very high risk, as grasses weeds pose as an additional fire threat and management efforts to mitigate invasive species are very costly. Other fire risks included community displacement, damage to critical infrastructure (e.g. communication and power lines), reduced emergency

¹⁰ <https://ecos.csiro.au/great-western-woodland/>

service capacity, increased trauma and mental health impacts, impact on cultural assets and history, and reduced air quality leading to respiratory illness.

Drought was assessed as a highly significant hazard in the region, with water scarcity already flagged as a significant vulnerability. Risks included habitat and biodiversity loss from drought, economic impacts on the high water-consuming mining industry, water insecurity in remote communities, and the mental health impacts of prolonged droughts. Finally, flooding was assessed to be a significant risk to the Goldfields region with six very high and nine high risks identified. Some very high risk scenarios included the potential loss of life, townships being cut-off for extended periods, increased vector-borne diseases and damage to property and critical infrastructure. Remote communities in the northern Goldfields such as Warburton have experienced the impacts of flash flooding and being cut-off previously¹¹, and with tropical weather systems shifting further south, the likelihood was assessed to increase from possible to likely by 2050.

Sectors most impacted by climate change in the region overall were the community, public health and the environment, with a far greater number of extreme and very high risks affecting these value/asset groups. Combinations of hazards, while not presented in the climate risk assessment, are expected to exacerbate the level of risk. For example, extreme heat, drought and bushfire can be closely associated such as prolonged dry and hot conditions increasing bushfire risk and severity (as observed in Australia's 2019/20 bushfires¹²). Water quality and availability may be impacted by all three climate hazards, with additional factors such as increased water requirements during extreme heat events. Similarly, the compounding effect of increasingly frequent climate events is expected to increase the consequence of risks. For example, a heatwave event occurring once a year may be something communities and services can cope with. However, extreme events occurring concurrently (e.g. drought and a bushfire), or back-to-back (e.g. a bushfire followed by a flood a few months later), may compound their impact and ability to recover.

It is important to note that as the Goldfields region climate risk assessment involved a far larger area than the Esperance region, it is to be expected that this region would pose greater overall climate risk. A vast area covers more extremes in vulnerability, hazards and exposure, leading to a higher risk. Ironbark considered the areas most vulnerable and exposed to a particular climate hazard to assess the risk.

¹¹ E.g. <https://www.perthnow.com.au/news/wa/sixty-people-relocated-as-flash-floods-hit-rural-wa-community-warburton-ng-6b960ed0cc82ab491b9dab8367f68f00>

¹² <https://www.abc.net.au/news/2020-02-19/australia-bushfires-how-heat-and-drought-created-a-tinderbox/11976134>

4. Recommended Interventions to Reduce Risks

Based on the climate risk assessment for the Esperance and Goldfield regions, the following risk actions have been identified for consideration by the Goldfields-Esperance Regional Climate Alliance and member Councils. These recommendations have been presented together as many of the actions identified apply to councils across the region. Some actions, however, are more relevant to certain Councils, for example Extreme Heat (Human Health) recommendations are more relevant to Councils in the Goldfields region, while recommendations relating to ocean warming and sea level rise are focused on the Shires of Dundas and Esperance.

These interventions respond to the extreme and very high risks identified. Further risk treatments are also provided in the full Climate Risk Assessment spreadsheet.

4.1 Traditional Owners and Aboriginal Communities

1. Work with State Government to engage Aboriginal communities and organisations on climate change issues and actions.

The identification of specific issues related to climate change impacts on Aboriginal communities within the region is seen as a gap in this project. While Traditional Owners and Aboriginal organisations from the Goldfields and Esperance regions were invited to participate in each of the climate risk assessments workshops, only Ngadjju Conversation was able to attend.

Climate change is, however, expected to have a significant impact on remote Aboriginal communities, in particular as a result of issues related to extreme heat and water. The significant increase in extreme heat projected for the northern areas of the Goldfields risks making remote communities unlivable. Climate change may also exacerbate existing health issues within these communities and significantly impact Country, which in turn could adversely impact cultural knowledge and practice.

To appropriately identify these issues, it is recommended to work with the State Government to engage Traditional Owners, Aboriginal organisations and remote Aboriginal communities on climate change. This will ensure climate change issues specific to these communities are accurately understood and relevant, and culturally appropriate actions are identified. This approach also supports self-determination of Aboriginal communities in the region.

2. Work with Traditional Owners, Department of Fire and Emergency Services and Councils to expand Aboriginal ranger and cultural burning programs to reduce fire risk.

To address bushfire risks, there is a need to take action that helps to reduce the intensity of potential fires and ensure that towns, settlements, infrastructure and critical habitats are easier to defend. Supporting and expanding Aboriginal ranger and cultural burning programs to increase management of natural landscapes in the region is being increasingly relied upon to reduce bushfire risk, while also enhancing local biodiversity. Indigenous landscape burning aims to reduce the frequency of high-intensity wildfires which reduces

greenhouse gas emissions, conserves key species and habitats and protects assets from bushfire¹³.

*"Fire in the right place keeps the country healthy, brings back the animals to the hunting grounds and encourages germination and resprouting of plants. It also cleans out thick scrub and facilitates access to important places. In the wrong place however, the bush can take hundreds of years to recover"*¹⁴.

Incorporating Indigenous fire management has many co-benefits in adapting to climate change including meaningful employment, invasive species control, rejuvenating Indigenous fire knowledge and culture, and improved decision-making power on traditional estates^{Error! Bookmark not defined.}. Protocols have been developed through CSIRO to guide non-indigenous partners in their support for Indigenous landscape burning activities and ensure that knowledge is shared appropriately¹⁵. A great example of such collaborations can be seen with the Ngadju, Traditional Owners of the Great Western Woodlands, who run Aboriginal ranger and cultural burning programs through Ngadju Conservation¹⁶. Representatives from Ngadju Conversation attended the Kalgoorlie Climate Risk Assessment workshop held as part of this project. The Goldfields Land Management Rangers also conduct fire management as well as biodiversity monitoring and research, feral animal control, weed management and site remediation and rehabilitation. DFES and many councils within the Esperance-Goldfields region already acknowledge the important role of cultural burn programs to bushfire management within WA.

4.2 Natural Environment

3. Reduce extreme heat impacts on the natural environment through reforestation programs.

Increasing tree and shrub coverage through reforestation or restoration programs can reduce extreme heat impacts on the natural environment and local habitats¹⁷. Increased shading helps to cool the ground and support ecosystem resilience. Air temperature can be significantly reduced in shaded areas. Soils with diverse native vegetation and microbiota improve soil structure and water-holding - as well as carbon storage - capacity. Even native ground cover, while not providing shade, helps to retain soil moisture, thus boosting overall resilience to climate change.

As tube stock can be particularly vulnerable within the first few years of revegetation, success may decline into the future as the climate continues to warm or require greater irrigation. As such, it is recommended that tree planting and reforestation projects are prioritised in the short term.

4. Reduce extreme heat impacts on animals by providing heat refugia.

¹³ <https://ecos.csiro.au/three-practical-ways-to-support-indigenous-landscape-burning-in-australia/>

¹⁴ Ngadju kala: Ngadju fire knowledge and contemporary fire management in the Great Western Woodlands <https://ngadjuconservation.org/media/1061/ngadju-kala-high.pdf>

¹⁵ <https://neslandscapes.edu.au/wp-content/uploads/2017/11/Protocols-for-Indigenous-fire-management-partnerships-wrap-up-factsheet.pdf>

¹⁶ <https://ngadjuconservation.org/>

¹⁷ <https://www.theguardian.com/environment/2022/mar/23/forests-climate-crisis-carbon-cooling-effect>

Climate refugia are areas where the local climate is cooler than the regional climate, providing a place for animals to escape to in times of extreme heat¹⁸. Providing heat refuges for animals in particularly exposed areas will support their survival during extreme heat events. This could include the use of a combination of natural (e.g. trees, water bodies) and human-made structures, including equipment to monitor the environmental conditions and animal visitation rates.

Together with the reforestation recommendation in 2., targeted reforestation to optimise the potential for wildlife corridors, north-south migration and heat refuges is key to maximising their benefit. Heat refuge locations may be selected based on greatest vulnerability and exposure to heat, as well as factors such as key biodiversity hotspots or migratory channels.

5. Maintain and enhance ecosystem resilience by reducing external pressures through integrated management.

Ecosystems and species seldom respond to pressures in isolation, with the most abrupt changes in ecosystems frequently arising from interactions among multiple pressures. For example, 86% of Australia's threatened species are subject to multiple threats that lead to habitat destruction and degradation, such as logging, mining, urbanisation and agriculture¹⁹. Compounding effects erode ecosystem resilience, leaving a system more susceptible to future climate change¹⁹.

Focusing efforts on reducing external pressures on the environment as much as possible, will improve the overall health of the systems and increase its resilience in coping with climate change. For instance, despite considerable external pressures such as historical clearing, mining and pastoral grazing, the Great Western Woodlands is still considered to remain as a relatively intact system, partly thanks to its vast size and remoteness. Research and workshop feedback indicate the GWW are now starting to buckle under the effects of climate change^{10,20}. Increasing integrated management efforts to retain and restore habitat, enhance diversity, and manage invasive species, dieback, fire and pollution is recommended to protect environmental assets. For example, encouraging mines, pastoralists and farmers to work with Aboriginal rangers and the wider community to conserve and rehabilitate their local environment. The Southern Rangelands Revitalisation is one such project, which supports pastoralists to establish long-term solutions for on-station improvements in rangeland condition and livestock profitability in WA's southern rangelands. The 16 participating stations (four of which are within the Goldfields region), receive training and support to improve livestock profitability while reducing grazing pressure and regenerating the landscape²¹.

6. Advocate for greater funding for critically endangered species in the region.

A range of climate change impacts, including extreme heat, bushfires, low rainfall and drought, present significant risks to threatened species in the Goldfields-Esperance region. Reducing other pressures such as habitat loss and impacts from invasive species, can help to build population resilience to climate change impacts, potentially avoiding the loss of

¹⁸ <https://www.csiro.au/en/news/All/Articles/2021/June/willow-trees>

¹⁹ Australia State of the Environment 2021: <https://bit.ly/42hkTKS>

²⁰ https://www.researchgate.net/publication/225497601_Facilitating_adaptation_of_biodiversity_to_climate_change_A_conceptual_framework_applied_to_the_world's_largest_Mediterranean-climate_woodland

²¹ <https://www.agric.wa.gov.au/southernrangelands>

species. This requires prioritising and advocating for funding for critically endangered species like the Western Ground Parrot, in order to protect remaining habitat, control invasive species and, where required, develop translocation strategies.

7. Advocate for the development of a marine-specific climate adaptation plan for WA's south coast.

Climate change is predicted to affect not only coastal zones on land, but the marine environment itself and the livelihoods that depend on it. GVROC includes some ~1,000 km of coastline, which will be impacted by ocean warming, acidification, changing ocean currents, sea level rise and increased ocean storm events in the future. The development of a marine-specific climate adaptation plan for WA's south coast, will help to identify and prepare for risks in a more comprehensive and targeted manner. This may include integrated marine management and data and identifying gaps in knowledge and preparedness. A marine adaptation plan in relation to marine heat waves, for example, may allow: fishers to reduce fishing pressure in the lead up to heat stress; conservation groups to delay/alter timing of restoration efforts; or tourism companies to prepare for the expected changes. Aquaculture facilities for example, may adapt by reducing the temperature (or increasing depth *in situ*) or reducing stocking densities to deal with heat and low oxygen levels. Locally-relevant adaptation strategies can be developed through the collaboration between a range of key Federal, State and Local Government stakeholders (e.g. DBCA, DPIRD, CSIRO and Councils) as well as other community groups, Traditional Owners and research institutions.

4.3 Extreme Heat (Human Health)

8. Reduce extreme heat impacts in towns by increasing canopy cover of native drought tolerant species.

Increasing canopy cover of trees in towns within the region can have a significant impact on reducing extreme heat impacts by increasing shading and lowering surrounding temperatures. Trees with large, healthy canopies provide large areas of shading, lowering surface temperatures, while also reducing air temperatures through evaporative cooling²². When undertaking programs to increase tree cover in towns, councils should maximise planting of native, drought tolerant species that will be better suited to future climate conditions.

9. Development of heat wave management plans.

Heatwave management plans aim to reduce the risk of extreme heat events on the local community, with a particular focus on identifying and reducing risks to vulnerable groups. Heatwave management plans typically include actions for councils before, during and after extreme heat events. Key elements of heatwave management plans include:

- Preparing information for residents on how to reduce health impacts of extreme heat,

²² Cool It: Addressing Heat Vulnerability in Regional Victorian Towns, https://www.cvga.org.au/uploads/9/8/3/8/9838558/cool_it_cvga_regional_summary_and_recommendations_final_oct_18.pdf

- Identifying members of the community that are particularly vulnerable to extreme heat, including the elderly and people with pre-existing health conditions,
- Identifying locations that can be used as heat refuges, including overnight,
- Identifying and training volunteers who can provide support to vulnerable community members during extreme heat events,
- Preparing early warning communication systems for extreme heat events, and
- Developing support plans for vulnerable people during extreme heat events.

Where councils or individual communities do not currently have heat wave management plans, the development of one could be effective at reducing extreme heat impacts in the community.

10. Identification of community members at high vulnerability to extreme heat.

Heatwaves and extreme heat are the natural hazards responsible for the highest number of deaths each year in Australia. The risk of heatwave related death is higher for the elderly, lower socio-economic groups, socially isolated individuals, people living in remote areas, and people with physical or mental disabilities²³. Identifying these individuals before an extreme heat event allows for the provision of proactive support, which can greatly reduce the risk of heat related health impacts. This may be done as part of the development of a heat wave management plan.

11. Identification and enhancement of locations that can be used as "cool places" to reduce heat wave impacts on vulnerable community members.

Heat-related health impacts occur when peoples' bodies are unable to properly cool down²⁴. Ensuring there are sufficient 'cool places' within communities can support people (particularly vulnerable people or people with inadequate housing), to escape the heat and avoid serious health impacts. Cool places can include existing public spaces, such as libraries, public parks, swimming pools, community halls, council buildings and health centres. Again, this may be undertaken as part of a heat wave management plan.

12. Provision of information and guidance on how to look after yourself during extreme heat events.

All community members are exposed to and can be impacted by extreme heat events. Ensuring people know how to protect themselves during extreme heat events can significantly reduce heat-related health impacts. Councils may develop their own or distribute existing materials to residents on how to look after themselves during a heatwave as part of early warning communications to residents about extreme heat events.

13. Support Traditional Owner and other Aboriginal groups to conduct heatwave impact assessments in remote communities and identify culturally appropriate actions to reduce heatwave impacts on vulnerable community members.

To reduce the risk of extreme heat in remote Aboriginal communities, it is recommended to engage with Traditional Owners, Aboriginal health service providers and other Aboriginal

²³ Coates, L. 2022, Heatwave fatalities in Australia, 2001–2018: An analysis of coronial records, <https://www.sciencedirect.com/science/article/pii/S2212420921006324/>

²⁴ Centers for Disease Control and Prevention, Protect Yourself From the Dangers of Extreme Heat, <https://www.cdc.gov/nceh/toolkits/extremeheat/default.html>

groups such as the NPY Women's Council. Supporting Aboriginal groups to conduct heatwave impact assessments within the communities they live and work in and in the identification of actions to reduce risks and impacts can help to ensure that actions are culturally appropriate and effectively targeted.

14. Advocacy to the State Government to improve the quality of social housing stock.

Social housing can often be of older housing stock and lack insulation and other basic features that provide passive cooling²⁵. Social housing residents also may be unable to afford to run air conditioners during heatwave events. With extreme temperatures projected to significantly increase in the Goldfields with climate change, improving the quality of social housing stock can have a significant impact on reducing heat related health impacts to vulnerable groups. This could include ensuring new housing stock is highly energy efficient or funding retrofits for existing homes to improve on energy efficiency and thermal comfort.

4.4 Emergency Preparedness and Disaster Resilience

15. Support the development of community-based emergency preparedness and response plans, including for remote Aboriginal communities.

Community emergency preparedness and response plans are an effective way of raising awareness of potential disaster risks for the community and identifying actions that can be taken before, during and after a disaster event to reduce disaster impacts and support recovery. Community emergency preparedness and response plans should include a wide range of community stakeholders and representatives to improve the identification of risks and ensure there is a shared understanding of roles and responsibilities before, during and after an emergency event. This is especially important for remote towns and communities which need to be more self-reliant during an emergency event. Community emergency plans should also take into account the potential increase in the frequency and severity of disasters as a result of climate change when undertaking emergency planning. Where relevant, planning should account for severe flooding or bushfire events which could result in isolation of townships.

16. Review location, capacity and accessibility of evacuation centres across the region.

Conduct a review of existing evacuation centres across the region, including the location and capacity of centres, to ensure they can sufficiently accommodate communities that could be displaced due to a significant fire event. Also, assess the accessibility of centres for differently abled people.

17. Install solar and battery systems at evacuation centres.

Install roof top solar and battery systems at evacuation centres to ensure that centres have reliable access to power during an emergency event. This will ensure that centres can continue to run air-conditioning, lighting and other basic functions even if power is lost to the region as a result of the fire, flooding or other extreme heat events.

²⁵ <https://www.watoday.com.au/national/western-australia/perth-s-social-housing-tenants-cooking-in-summer-with-no-ceiling-fans-or-air-conditioning-20230329-p5cwah.html>

18. Develop a database of remote residents.

Given the large geographic area that GVROC Councils cover, developing and maintaining a database of residents that live in remote areas away from town centres, to provide to emergency response agencies during emergency events could support more effective assistance and recovery efforts. Geographic isolation and communication vulnerabilities mean that remote residents can easily be cut off and unable to contact emergency service providers with calls for assistance. Such a database could enable response agencies to more quickly contact and account for remote residents, therefore improving the identification and delivery of critical assistance.

19. Provide support and guidance for residents and businesses to develop personal disaster preparedness plans.

In addition to preparing community-based emergency preparedness and response plans, it is recommended that individual households and businesses that are highly exposed to disaster risks develop their own personal disaster preparedness plans. Ensuring that residents and businesses have the knowledge and capacity to reduce their own risks is particularly important in remote and isolated areas. Information on how climate change is expected to change disaster risks is also recommended to be provided to residents and businesses as part of the support provided, to ensure personal preparedness plans account for increased risk levels.

20. Undertake climate change scenario planning to identify critical emergency response capacity issues.

Climate change is projected to increase the frequency and intensity of extreme weather events in Western Australia. An increase in major disaster events, or the occurrence of concurrent or successive disaster events may lead to a significant strain on emergency response resources. This could include human resources (paid and volunteer), equipment and emergency contingency stocks. Undertaking climate change scenario planning with Emergency Management Committees as part of contingency planning exercises can help to identify potential resource and capacity gaps in local or regional emergency response capacity and identify actions to ameliorate the issues.

21. Improve early warning systems, including ensuring early warning information can be accessed by remote communities and residents, including Aboriginal communities.

Clear and effective early warning systems are essential to reduce disaster risks to human life and assets by providing communities and individuals time to prepare and evacuate. This is particularly important with climate change increasing the intensity, and sometimes the speed in which disaster events unfold. It is also critical to ensure that early warning systems are accessible to all communities, including remote communities as well as groups that may face challenges in receiving warnings, for example people who don't have mobile phones, or may struggle to interpret warning messages, such as people with intellectual disabilities. This may require integrating early warning systems with community preparedness to ensure all members of the community receive the warning in a manner that is understandable to them.

22. Advocate for flood modelling to be updated to account for future extent of significant flood events.

A key impact of climate change is the increase in intensity and frequency of extreme weather events, such as heavy rainfall and flood events. For example, events that may previously have regarded as 1-in-100 year events (1% Annual Exceedance Probability (AEP)) may become 1-in-20 year events (5% AEP), while new 1-in-100 year floods represent much more significant flood events. Flood protection infrastructure is commonly constructed to a 1% AEP standard. Updating flood modelling to account for the new 1% AEP flood levels as a result of climate change is critical to ensure there is a clear understanding of the new risk level and that infrastructure is appropriately upgraded to keep communities safe.

23. Advocate to State/Federal Government and communication providers to increase resilience of communication networks.

Distance and remoteness of communities in the region make it highly vulnerable to communication failures as a result of extreme weather, bushfire or flood events. This action recommends undertaking advocacy to State and Federal Governments as well as telecommunication providers to increase the resilience of the network to make it less vulnerable to natural disasters and ensuring that communications can be maintained during emergency events.

4.5 Public Health

24. Increase monitoring and surveillance of disease transmission.

Research into the impact of climate change on disease transmission is extensive, but constantly evolving and with limited local context. Implementing an ongoing surveillance and monitoring program will allow the region to better-understand disease transmission patterns at the local scale and can use this information to trial tailored solutions. In connection with point **Error! Reference source not found.** below, this could be rolled out alongside a citizen science program to expand resources across the large region and embed disease prevention behaviours in the community.

25. Provide information and education on preventing transmission of vector-borne diseases.

Communities across the Esperance-Goldfields region are very isolated and spread out, making regular, localised monitoring and treatment of disease outbreaks more difficult. Educating communities about the risks, what to look out for, and how to reduce their chances of contracting a vector-borne disease will empower them to protect themselves, without relying entirely on availability of services. Providing toolkits to test water samples and interpret results, will help to develop long-term climate resilience within communities across the region.

Fight the Bite²⁶ is an initiative led by five councils in the south-west of WA and the Department of Health, to educate the local community about mosquito-borne diseases and inform them on what is being done. GVROC councils could piggy-back on this initiative or lead a similar initiative to protect the community against vector-borne diseases.

26. Improve drainage systems to prevent stagnant water.

Stagnant water can be dangerous for drinking as it is a better breeding ground for bacteria and parasites such as Legionnaire's disease. This is particularly relevant in remote communities where facilities and infrastructure is limited, or places exposed to microbiological pollutants such as faeces or farming activities.

Improved drainage will help to reduce flooding risk as well as prevent stagnant water. For example, revegetation of riparian zones and improving the health of the soils, which will increase its water-holding capacity, may assist to improve drainage. Collecting rain from roofs can assist drainage. Improving drainage along roads e.g. increasing roadside plants, as well as reducing potential pollutants going to stormwater may also contribute to improved drainage. Improved education on the health risks of stagnant water and tools for water testing is an additional measure to reduce this risk.

27. Advocate for more funding for regional mental health services.

Increased mental health issues, including increased trauma after significant or more frequent disaster events was identified as a major risk in both the Kalgoorlie and Esperance workshops. Increasing Mental Health practitioner numbers, training more community volunteers in mental health support and providing more online and telehealth mental health services were identified as further required actions by participants in the workshops.

²⁶ <https://www.fightthebite.com.au/>

Advocating to the State Government to provide more funding to the region to support mental health services such as these would help councils and regional services to significantly increase availability and capacity of mental health services.

4.6 Infrastructure

28. Undertake climate impact assessment of critical infrastructure in the region.

It is recommended that councils undertake climate change impact assessments for all critical infrastructure in their LGA to identify specific climate risks (e.g. flood, bushfire, sea level rise, extreme heat), to the asset and develop actions to reduce identified risks. This action should target infrastructure such as power stations, water treatment, roads, etc, that if damaged, would result in a significant negative impact to the community. A climate change impact assessment uses specific climate change data to assess the potential physical impact of climate hazards on the asset, for example the impact of projected 1-in-100-year flood level or sea level rise on a particular asset.

29. Integrate climate change into council asset management plans.

To ensure that all infrastructure and assets are resilient to climate change, councils are also recommended to integrate climate change risk assessments into all council asset management plans. This ensures that potential climate change risks are considered and accounted for when monitoring and developing maintenance plans for the asset. This action helps to integrate climate change as a business-as-usual consideration for councils.

4.7 Water

30. Conduct water and energy efficiency audits at all council facilities.

Water security was identified as a major issue for both Esperance and Goldfields region during the workshops and in the climate risk assessment. As major water users, councils are recommended to undertake water efficiency audits of all council facilities to identify where water savings could be made. This action could be combined with energy audits to improve energy efficiency and reduce costs. This type of action could also be used to demonstrate council leadership and encourage businesses and residents to undertake similar actions.

31. Upgrade council parks and open space irrigation systems to be more water efficient and increase utilisation of recycled water.

Irrigation of parks and open spaces is a significant use of water for most councils. It is recommended that councils modify irrigation regimes and upgrade systems to improve water efficiency and increase utilisation of recycled water. This may include automated and real-time water monitoring systems to efficiently detect leaks or other anomalies. As climate change is projected to lead to a hotter and drier climate there may be greater irrigation requirements to maintain public green spaces. This will require much more efficient water management practices.

32. Community education and engagement on water conservation

Treating water as a precious and limited resource is the first step to minimising use, both within industry and the community. Engaging and easily understood education campaigns explaining how the water cycle works and the importance of conserving water can prepare the region for future water shortages. A range of water-related content is already available through the Water Corporation²⁷, schools, and environmental groups. A single, unified campaign however, using existing resources and with increased support from all stakeholders in the region, can maximise the effectiveness and shift water conservation behaviours toward a social norm. With 40-50% of Australia's domestic water consumption used outdoors and agriculture consuming ~70% of Australia's water footprint²⁸, promoting waterwise gardens and reduced irrigation could be key focus points.

Embedding environmental stewardship into the community as a whole, is a key aspect to adapting to climate change. This action therefore, applies not only to water but protecting all environmental assets.

33. Advocate for the development of greater regional water storage capacity.

Increasing water storage capacity was flagged as a key adaptation action by workshop participants in both Esperance and Goldfields regions. The Water Corporation recently constructed a 32 million litre water storage tank in the Shire of Coolgardie to replace an open reservoir²⁹. This will contribute to improve water security through reduced evaporation and risk of water-borne diseases. The water source is still however, being pumped from Perth (which has its own water supply issues), and therefore is limited as a climate adaptive measure. With increased extreme rainfall events projected across the region, capturing rainwater during such events and storing it locally is one option. Rainwater harvesting can be implemented at large and residential scales and may also help to manage flooding in some areas. Innovative projects are being funded to improve water security. The Shire of Esperance for example, has recently received funding to line two farm-scale water catchments with repurposed tarpaulins to increase run-off into dams. This is expected to capture over three megalitres of water per year³⁰. Further advocacy to resource these kinds of projects is encouraged.

34. Engage key water stakeholders to identify water usage needs in remote regions and potential future solutions.

To improve water security in the Goldfields-Esperance region, the scope of the problem must be captured through engagement of a range of key water stakeholders. This will also improve knowledge transfer and accessibility of water data and information to decision makers. Once specific water usage needs have been identified, potential solutions specific to the remote communities of the region, may be more easily developed. One such engagement option is the formation of a working group or holding a series of forums. Stakeholders may include GVROC councils, Traditional Owners representing the remote communities, the Water Corporation, DWER, industry representatives from mining and agriculture, and experts and researchers in this field. For example, CSIRO have been

²⁷ <https://www.watercorporation.com.au/Waterwise>

²⁸ <https://www.nationalgeographic.com/environment/article/partner-content-how-australia-is-securing-its-water-future>

²⁹ <https://www.watercorporation.com.au/Outages-and-works/Ongoing-Works/Dedari-water-storage-tank>

³⁰ <https://www.mediastatements.wa.gov.au/Pages/McGowan/2023/05/Funding-boost-for-water-security-project-in-the-Shire-of-Esperance.aspx>

developing wastewater treatment solutions for inland, remote, water-stressed communities, which need to be customised to the specific needs and situation of each community³¹, which requires knowledge sharing and engagement with stakeholders.

³¹ <https://www.csiro.au/en/news/All/Articles/2022/October/wastewater-treatment-benefits-in-regions>

5. Assessment of Actions

All of the interventions outlined in Section 4 have been identified as actions that can reduce climate change risks within the Goldfields-Esperance region. To this end all actions could be considered by councils for implementation. However, the following analysis has been conducted by Ironbark to help identify which interventions should be given the highest priority based on impact and costs.

5.1 Assessment Criteria

A multicriteria analysis was used to assess and prioritise interventions. This analysis used six criteria; *impact on risk, reach of action, cost range, level of adaptation, targets vulnerable groups and impact on emissions.*

It is important to note that this analysis is high level and only intended to support the prioritisation of different possible interventions being considered by councils or the Goldfields-Esperance Regional Climate Alliance. A detailed cost-benefit analysis is recommended prior to any action being implemented.

Criteria 1: Impact on Risk

This criterion is assessed from low to high.

- *Low impact actions* are those that achieve minor gains relative to the issue. For example, providing information to community members on specific climate risks.
- *Medium impact actions* are typically those that help to directly reduce risks for a given period of time by increasing awareness or understanding of an issue.
- *High impact actions* are typically those that aim to directly reduce risks in the long term.

N.B. Impact of actions is assessed against the risks they seek to ameliorate.

Criteria 2: Reach of Action

This criterion is assessed from Individual to Community level benefit of the action. In general, actions that benefit the whole community is prioritised over actions that only benefit a smaller number of individuals, however, where risks are particularly acute or threaten life a focus on individuals is justified.

- *Individual actions* are those that primarily benefit individual residents, businesses or species within the region.
- *Sub-section actions* are those that primarily target certain sections of the community or system.
- *Community-wide actions* are those that provide benefits to the community at large.

Criteria 3: Cost Range

This criterion is assessed from low to high.

- *Low-cost activities* predominately require staff time, training or the development of strategies and plans.

- *Medium cost activities* typically involve smaller capital input and asset costs or community support costs.
- *High-cost activities* are likely to require larger capital works, such as building works.

Criteria 4: Level of Adaptation

This criterion assesses the degree to which the action attempts to change the underlying issues that result in expose or vulnerability to climate change.

- *Coping* actions aim to support people or resources to better cope with climate change but they do not significantly reduce vulnerability or exposure to climate change or build adaptive capacity.
- *Incremental* actions focus on making incremental changes to the way a system or asset operates or is managed to guard against climate change impacts.
- *Transformational* actions seek to address the root cause of vulnerability to climate change.

Criteria 5: Targets Vulnerable Groups

This criterion assesses whether the action specifically targets the most vulnerable groups to climate change risks and is simply assessed as yes or no.

Criteria 6: Impact on Emissions

This criteria assesses whether the action has any positive or negative impact on emissions. While adapting to climate change it is important not to create new risks through increased emissions. This is considered to be maladaptive. Actions are assessed according to the following five impact levels:

- Major Negative
- Minor Negative
- Neutral
- Minor Positive
- Major Positive

5.2 Intervention Ranking

Applying the criteria outlined in the previous section the action identified in Section 4 provides the following ranking.

Rank	Score	Intervention
1	80%	Work with State Government to engage Aboriginal communities and organisations on climate change issues and actions.
		Work with TOs, DFES and Shire Councils to expand Aboriginal ranger and cultural burning programs to reduce fire risk.
		Advocate for more funding for regional mental health services.

		Advocate for the development of greater regional water storage capacity.
2	73%	Reduce extreme heat impacts on the natural environment through reforestation programs.
		Advocate for the development of a marine-specific climate adaptation plan for WA's south coast
		Reduce extreme heat impacts in towns by increasing canopy cover of native drought tolerant species.
		Support TO or other Aboriginal groups to conduct heatwave impact assessment in remote communities and to identify cultural appropriate actions reduce heatwave impact to vulnerable community members.
		Engage key water stakeholders to identify water usage needs in remote regions and potential future solutions.
		Advocate for flood modelling to be updated to account for future extent of significant flood events.
		Advocate to State/Federal Government and communication providers to increase resilience of communication networks.
3	67%	Maintain and enhance ecosystem resilience by reducing external pressures.
		Advocate for greater funding for critically endangered species in the region.
		Development of community heat wave management plans.
		Advocacy to the State Government to improve the quality of social housing stock.
		Support the development of community-based emergency preparedness and response plans, including for remote Aboriginal communities
		Undertake climate change scenario planning to identify critical emergency response capacity issues.
4	60%	Identification and enhancement of locations that can be used as "cool places" to reduce heat wave impacts on vulnerable community members.
		Review location, capacity and accessibility of evacuation centres across the region.
		Install solar and battery systems at evacuation centres.
		Develop a database of remote residents.
		Improve early warning systems, including ensuring early warning information can be accessed by remote communities and residents, including Aboriginal communities.
		Increase monitoring and surveillance of disease transmission.
		Undertake climate impact assessment of critical infrastructure in the region.

		Integrate climate change into shire asset management plans.
		Community education and engagement on water
5	53%	Reduce extreme heat impacts on animals by providing heat refuges.
		Identification of community members at high vulnerability to extreme heat.
		Improve drainage systems to prevent stagnant water.
		Conduct water and energy efficiency audits at all council facilities.
		Upgrade council parks and open space irrigation systems to be more water efficient and increase utilisation of recycled water.
6	47%	Provision of information and guidance on how to look after yourself during extreme heat events.
		Provide support and guidance for residents and businesses develop personal disaster preparedness plans.
		Provide information and education on preventing transmission of vector borne diseases.

6. Conclusion

The workshops carried out with councils and other key stakeholders as part of this project highlighted some of the most valued aspects and assets of the region, as well as the vulnerabilities. These included the natural environment and the people, as well as the remoteness of the region, which was seen as a value, an asset and a vulnerability. The workshops also highlighted that climate change impacts are already being experienced in the Goldfields and Esperance regions and that there are a range of climate risks being faced.

The climate risk assessments developed for the Esperance and Goldfields regions built on this information, and were used to develop a suite of recommended interventions for reducing climate risks. These can be considered the first step in the identification of climate risks and appropriate actions for councils in the region. However, more work is needed, and we recommend the development of more localised climate risk assessments as a next step. These could be developed at the LGA level, or even at a township level, given the vast and diverse areas covered by LGAs in the region.

There were a number of stakeholders that were invited to participate in the regional workshops or provide information on climate risks within their area of expertise but were unable to engage in the timeframe of the project. These include Traditional Owners, health service providers and representatives from the mining sector. It is recommended that the Goldfields Esperance Regional Climate Alliance further engage with these stakeholders to ensure that actions developed as part of this assessment align with work being undertaken in these areas and to provide opportunities for these stakeholders to input into future regional climate change assessments.

Appendix A: Workshop Participants

Esperance workshop attendees

Name	Job title	Organisation
Shane Burge	CEO	Esperance Shire
Felicity Baxter	Director, Corporate Services	Esperance Shire
Richard Hindley	Manager Building, Planning and Land Projects	Esperance Shire
Shane Tobin	Community Development Events Coordinator, Visitors Centre	Esperance Shire
Mary Bidstrup	Governance & Corporate Support Officer	Esperance Shire
Dylan Gleave	Manager Parks and Environment	Esperance Shire
Georgia Ryan	Waste management coordinator	Esperance Shire
Katherine Walkerden	Environmental Officer	Esperance Shire
Ian Mickel	Shire President, Esperance	Esperance Shire
Leonie De Haas	Councillor	Esperance Shire
Wes Graham	Councillor	Esperance Shire
Jo-Anne O'Donnell	Councillor	Esperance Shire
Rob Horan	Councillor	Esperance Shire
Julie Waters	Senior Environment Officer	Esperance Shire
Peter Fitchat	CEO	Shire of Dundas
Michelle Handley	CEO	South East Premium Wheat Growers Association (SEPWA)
Dorothy Henderson	Communications Project Officer	South Coast NRM
Colin Ingram	Principal Project Officer	Department of Biodiversity, Conservation and Attractions (DBCAs)
Connor Davies	Community	Ridebeam
Brendan Nicholas	Manager	DPIRD
Catherine Field	Sustainability Coordinator	Southern Ports
Bronwyn McLeod	Executive Officer	Chamber of Commerce and Industry
Kylie Fletcher	Land and Water Program Manager	South Coast NRM
Andrew Mann	Executive Officer	GVROC
Tori Castledine	Senior Community Specialist	Forstescue Future Industries
Sasi Thamrongvoraporn	Principal, Integrated Water Cycle Planning	Water Corporation
Tiago Da Costa E Silva		Water Corporation

Goldfields workshop attendees

Name	Attendance	Organisation
David Trevaskis	CEO acting	City of Kalgoorlie-Boulder
Shamiso Chadyiwa	Waste and Sustainability Coordinator?	City of Kalgoorlie-Boulder
Kristy Lamont	Waste Services Coordinator	City of Kalgoorlie-Boulder
Alain Baldomero	Environmental Health & Ranger Services Team Leader	City of Kalgoorlie-Boulder
Kim Eckert	Councillor	City of Kalgoorlie-Boulder
Malcolm Cullen	Shire President	Coolgardie Shire

Tracey Rathbone	Councillor	Coolgardie Shire
Jim Epis	CEO	Shire of Leonora
Cary Green	Director, Governance and Strategic	Ngaanyatjarraku Shire
Sabina Shugg	Board Chair, GEDC; Director Kalgoorlie Campus; NED Resolute Mining Ltd	Goldfields-Esperance Development Commission, Curtin University, Resolute Mining Ltd
Shane Power	Regional Manager	Main roads - regional development
Lee Jacobsen	Chair Regional Development	Regional Development Australia Goldfields Esperance
Peter Rampellini	A/Manager - Low Carbon Futures Program	DPIRD
Damien Pumphrey	Superintendent (Goldfields Midlands)	DFES - Emergency Management
Yvette Grigg	District Emergency Management Advisor	Department of Fire and Emergency Services
Annette Balmer	Recovery Support Officer	National Emergency Management Agency (NEMA)
Darius Wicker	Traditional owner/Ranger	Ngadju Conservation Aboriginal Corporation
Helen Langley	CEO	Ngadju Conservation Aboriginal Corporation
Tanya Kilminster	Knowledge Broker	South-West WA Drought Resilience Adoption & Innovation Hub at Growers Group Alliance (GGA)
Sasi Thamrongvoraporn	Principal, Integrated Water Cycle Planning	Water Corporation
Amanda Mitchell	Senior Hydrologist	Water Corporation
Catherine Field	Sustainability Coordinator	Southern Ports
Andrew Mann	Executive Officer	GVROC
Laurence Dyer	Assoc Prof & Discipline Lead - Metallurgical Engineering	Curtin University

Appendix B: Esperance Climate Risk Assessment (Extreme and Very High Risks)

Risk ID	Themes	Hazard	Risk	Description	Risk Assessment at 2050		
					Consequences	Likelihood	Risk at 2050
RID-E7	Environment	Bushfire	Loss of threatened species	Increased frequency and severity of bushfires may have a significant impact on threatened species and could result in the extinction of extreme rare species endemic to the region. Over 70 rare and/or threatened flora and fauna species are found in the Esperance region. The Western Ground Parrot is one of the rarest birds in the world and critically endangered (<150 individuals). Since 2013, only found in a very small area near Cape Arid NP. This species is highly susceptible to extinction from fire events and has previously lost ~90% of its habitat due to bushfires.	Catastrophic	Likely	Extreme
RID-E12	Public Health and Wellbeing	Bushfire	Loss of life	Increased frequency and severity of bushfires could lead to loss of life as rural properties and townships are exposed to bushfires.	Catastrophic	Likely	Extreme
RID-E45	Public Health and Wellbeing	Extreme Rainfall and Flooding	Loss of life	Higher intensity rainfall events could lead to more flash flooding or rapid onset flood events, which could lead to a greater loss of life as people are caught unaware or unprepared.	Catastrophic	Likely	Extreme
RID-E66	Environment	Ocean Warming and Acidification	Loss of marine species, leading to reduced species diversity	Ocean acidification expected to affect the calcium structures of a range of organisms, while marine heatwaves can have significant impact on a range of organisms. The south-west of Australia is a marine biodiversity hotspot, particularly for marine plants and fishes. It also has a very high level of marine species endemism. The 2011 La Nina marine heat wave heavily impacted blue swimmer crabs, abalone, little penguins, seaweed, seagrass and fish.	Catastrophic	Likely	Extreme
RID-E10	Infrastructure	Bushfire	Damage to power and communication infrastructure due to bushfires	Increased frequency and severity of bushfires could lead to more frequent damage to power and communication lines. The flow-on impact to remote and regional communities could be significant especially during extreme heat or emergency events.	Major	Likely	Very High
RID-E29	Public Health and Wellbeing	Extreme Heat	Loss of life due to extreme heat events	Extreme heat and heatwaves are the leading cause of climate change related deaths in Australia. Heatwaves can lead to heat exhaustion and heatstroke, particularly in vulnerable populations such as the elderly, young children, and those with pre-existing health conditions.	Catastrophic	Possible	Very High

RID-E31	Community	Extreme Rainfall and Flooding	Townships cut off and isolated for extended periods due to flooding	Higher intensity rainfall events could increase the frequency and severity of significant flood events resulting in regional towns and communities being cut off and isolated for extended periods of time.	Major	Likely	Very High
RID-E42	Infrastructure	Extreme Rainfall and Flooding	Damage and loss of critical infrastructure.	Higher intensity rainfall events could increase the frequency and severity of significant flood events leading to greater loss or damage of critical infrastructure in the region, including power stations, transmission lines, water supply and communication network.	Major	Likely	Very High
RID-E54	Economy	Low Rainfall and Drought	Significant loss of agricultural produce and/or livestock	Increased frequency and severity of drought may have a significant impact on agriculture in the region, with crop losses or the necessary destocking or death of livestock. May also lead to greater input requirements, for example livestock feed and reduced run-off for dam replenishment.	Major	Likely	Very High
RID-E56	Environment	Low Rainfall and Drought	Habitat & biodiversity loss	Increased frequency and severity of drought may have major impacts on local flora and fauna, given the extremely dry environment they are in. The slow growing old-growth Eucalypts in the Great Western Woodlands such as Gimlets and Salmon Gums have been showing signs of extreme stress in response to drought events. The GWW is the only place in the world that supports such tall trees with such little rainfall. Some arid species are already operating at their physiological limits and increased droughts are expected to be a tipping point for some species. Many bird species are sensitive to the effects of drought, with less nesting during dry seasons, and colonies abandoning less productive habitats.	Major	Likely	Very High
RID-E59	Public Health and Wellbeing	Low Rainfall and Drought	Increased water insecurity for townships	Increased frequency and severity of drought exacerbate existing water issues in the region. Decreasing rainfall could also cause aquifers to become more saline, compounding water supply issues.	Major	Likely	Very High
RID-E67	Environment	Ocean Warming and Acidification	Reduced abundance of marine organisms	Marine organisms include both marine animals (fish, invertebrates, corals, sponges, mammals etc), plants (seagrasses, seaweed), microorganisms such as diatoms, phytoplankton, bacteria etc. While some species may still persist in smaller numbers, the overall abundance (or biomass) of marine organisms may drop significantly, affecting health of the ecosystems as well as flow-on effects on fisheries, tourism etc. Ocean acidification expected to affect the calcium structures of a range of organisms including corals and plankton. Marine heatwaves can have significant impact on a range of organisms. E.g. WA 2011 La Nina marine heat wave heavily impacted blue swimmer crabs, abalone, little penguins, seaweed, seagrass and fish.	Major	Likely	Very High

RID-E47	Public Health and Wellbeing	Extreme Rainfall and Flooding	Increased vector borne diseases	Water borne disease - increased Ross River and other mosquito borne viruses. Reduction in water quality from flooding events can also increase the chance of other diseases such as cholera.	Major	Likely	Very High
RID-E8	Environment	Bushfire	Increase in pests and invasive species	An increase in bushfires will offer new opportunities for invasive species to proliferate and spread – weeds colonise bare patches after droughts and fires; and foxes and cats prey on animals whose shelter is destroyed by those events.	Major	Likely	Very High
RID-E13	Public Health and Wellbeing	Bushfire	Increased trauma and mental health impacts	Increased frequency and severity of bushfires could lead to greater trauma and mental health impacts due to a range of issues including experiencing trauma of experiencing a bushfire or loss of loved ones, loss of assets and livelihoods, health and well-being impacts to the community, stress and exhaustion of volunteers, increased isolation if road and rail networks are cut off.	Major	Likely	Very High
RID-E32	Community	Extreme Rainfall and Flooding	Damage and loss of private property and assets	Higher intensity rainfall events could increase the frequency and severity of significant flood events leading to greater loss and damage of private property. More frequent flood events, even of lower-level flood events, could lead to cumulative and compounding impacts that increase long term negative impacts.	Major	Likely	Very High
RID-E39	Environment	Extreme Rainfall and Flooding	Increased salinity impacts on environment and agriculture	Greater flood events may result in increased salinity in the region. Flooding can raise the water table and mobilise salts stored in the soil, killing plants or affecting their nitrogen uptake, growth and reproduction. Rising groundwater trends and moderate-high salinity risk for the Esperance area may be exacerbated by flooding.	Major	Likely	Very High
RID-E43	Infrastructure	Extreme Rainfall and Flooding	Disruption and damage to road and rail network	Higher intensity rainfall events could increase the frequency and severity of significant flood events leading to greater damage or disruption to regional road and rail networks.	Major	Likely	Very High
RID-E60	Public Health and Wellbeing	Low Rainfall and Drought	Mental health impacts	Increased frequency and severity of drought may lead to greater mental health impacts may incl. loss of hope/confidence and potentially increased rates of suicide (e.g. farmers or pastoralists affected by ongoing drought)	Major	Likely	Very High

Appendix C: Goldfields Climate Risk Assessment (Extreme and Very High Risks)

Risk ID	Themes	Hazard	Risk	Description	Risk Assessment at 2050		
					Consequences	Likelihood	Risk at 2050
RID-G37	Public Health and Wellbeing	Extreme Heat	Loss of life due to extreme heat events	Extreme heat and heatwaves are the leading cause of climate change related deaths in Australia. Heatwaves can lead to heat exhaustion and heatstroke, particularly in vulnerable populations such as the elderly, young children, and those with pre-existing health conditions.	Catastrophic	Almost certain	Extreme
RID-G19	Community	Extreme Heat	Aboriginal culture diminished from health impacts from heat	Significant increases in extreme heat and heatwaves may result in remote communities becoming unliveable, resulting in migration into other regional centres. Potential for generational health impacts i.e. impacts of extreme heat on vulnerable Indigenous elders threatens the future of Indigenous culture.	Catastrophic	Almost certain	Extreme
RID-G16	Public Health and Wellbeing	Bushfire	Loss of life	Increased frequency and severity of bushfires could lead to loss of life as rural properties and townships are exposed to bushfires.	Catastrophic	Likely	Extreme
RID-G11	Environment	Bushfire	Loss of threatened species	A number of rare and/or threatened flora and fauna species are from the Goldfields region e.g. the mallee fowl, western quoll, western spiny-tailed skink and the arid bronze azure butterfly. These species are highly susceptible to extinction from fire events.	Catastrophic	Likely	Extreme
RID-G38	Public Health and Wellbeing	Extreme Heat	Heat-related health impacts on vulnerable groups.	Extreme heat can have a significant impact on human health, especially for vulnerable populations such as the elderly, young children, pregnant women, and people with pre-existing health conditions. Impacts include dehydration, heat exhaustion and respiratory and cardiovascular problems.	Major	Almost certain	Extreme
RID-G67	Economy	Low Rainfall and Drought	Economic impact on industry as a result of water supply issues and restrictions	Water supply is already an issue in the Goldfields region. With a very proportion of current water reserves being used in the mining industry, further water supply issues in the future may lead to major consequences to the economy.	Major	Likely	Very High

RID-G70	Environment	Low Rainfall and Drought	Habitat & biodiversity loss	Increased frequency and severity of drought may have major impacts on local flora and fauna, given the extremely dry environment they are in. The slow growing old-growth Eucalypts in the Great Western Woodlands such as Gimlets and Salmon Gums have been showing signs of extreme stress in response to drought events. The GWW is the only place in the world that supports such tall trees with such little rainfall. Some arid species are already operating at their physiological limits and increased droughts are expected to be a tipping point for some species. Many bird species are sensitive to the effects of drought, with less nesting during dry seasons, and colonies abandoning less productive habitats.	Major	Likely	Very High
RID-G71	Environment	Low Rainfall and Drought	Water scarcity and supply issues on the environment	There are already existing water supply concerns for the Goldfields region. Increased frequency and severity of drought may lead to the reduction of important freshwater sources for flora and fauna drying up or being reduced. Freshwater lakes and dams in the Goldfields region such as Niagara Dam in Menzies or Rowles Lagoon in Coolgardie provide important water sources for resident and migratory animals. Rowles lagoon is an important cultural site for local Aboriginal people. Water bodies in these arid and hot regions of the state are vulnerable to drying up with future drought events.	Major	Likely	Very High
RID-G1	Community	Bushfire	Community displacement due to bushfire	More frequent and severe bushfires may result in communities being displaced for longer. This is likely to have a greatest impact on towns located in areas where there is a significant amount of vegetation or smaller remote communities.	Major	Likely	Very High
RID-G12	Environment	Bushfire	Increase in pests and invasive species	An increase in bushfires will offer new opportunities for invasive species to proliferate and spread – weeds colonise bare patches after droughts and fires; and foxes and cats prey on animals whose shelter is destroyed by those events. A pattern of increased grass weeds after fire has been observed in the Goldfields region, which further increases future fire risk.	Major	Likely	Very High
RID-G14	Infrastructure	Bushfire	Damage to communication lines due to bushfires	Increased frequency and severity of bushfires could lead to more frequent damage to communication lines. The flow-on impact to remote and regional communities could be significant especially during extreme heat or emergency events.	Major	Likely	Very High
RID-G32	Environment	Extreme Heat	Biodiversity loss impacting effective ecosystem function	Increase in extreme heat could result in diminished water availability leading to rapid degradation of ecosystem function, resulting in diebacks and loss of biodiversity. Ecosystem function refers to the physical, chemical and biological processes that transform and translocate energy or materials in an ecosystem.	Major	Likely	Very High
RID-G33	Environment	Extreme Heat	Loss of native species due to extreme heat impacts on local habitat	Increase in extreme heat could lead to high levels of loss of native species in the region as extreme heat impacts on food and water sources, habitat and mobility of animals.	Major	Likely	Very High

RID-G39	Community	Extreme Rainfall and Flooding	Townships cut-off and isolated for extended periods due to flooding	Higher intensity rainfall events could increase the frequency and severity of significant flood events resulting in regional towns and communities being cut off and isolated for extended periods of time. Remote communities in the northern Goldfields region have already experienced this. Flooding may also cut-off access to visiting services such as specialised tradespersons, medical and mental health services and education.	Major	Likely	Very High
RID-G55	Infrastructure	Extreme Rainfall and Flooding	Damage and loss of critical infrastructure.	Higher intensity rainfall events could increase the frequency and severity of significant flood events leading to greater loss or damage of critical infrastructure in the region, including power stations, airports, transmission lines, water supply and communication network.	Major	Likely	Very High
RID-G58	Public Health and Wellbeing	Extreme Rainfall and Flooding	Loss of life	Higher intensity rainfall events could lead to more flash flooding or rapid onset flood events, which could lead to a greater loss of life as people are caught unaware or unprepared.	Major	Likely	Very High
RID-G59	Public Health and Wellbeing	Extreme Rainfall and Flooding	Increased vector born diseases	Strong evidence links heavy rainfall events with water contamination, resulting in gastro-intestinal diseases. With more extreme rainfall events likely, risks are likely to increase. E.g. previous incidences of Cryptosporidium spp. have occurred in Perth dams after heavy rainfall events. There is also strong evidence linking climate parameters with the incidence of mosquito vectors. Vectors already present in WA and may spread. Water borne disease - increased Ross River and other mosquito borne viruses. Reduction in water quality from flooding events can also increase the chance of other diseases such as cholera.	Major	Likely	Very High
RID-G2	Community	Bushfire	Reduced emergency service capacity to community	Reduced emergency service capacity from increasingly frequent fire events. Incl. lack of required resources for management, response and recovery	Major	Likely	Very High
RID-G17	Public Health and Wellbeing	Bushfire	Increased trauma and mental health impacts	Increased frequency and severity of bushfires could lead to greater trauma and mental health impacts due to a range of issues including: experiencing trauma of experiencing a bushfire or loss of loved ones, uncertainty, loss of assets and livelihoods, health and well-being impacts to the community, stress and exhaustion of volunteers, increased isolation if road and rail networks are cut off.	Major	Likely	Very High
RID-G40	Community	Extreme Rainfall and Flooding	Damage and loss of private property and assets	Higher intensity rainfall events could increase the frequency and severity of significant flood events leading to greater loss and damage of private property. More frequent flood events, even of lower level flood events, could lead to cumulative and compounding impacts that increase long term negative impacts. E.g. loss or damage to homes may require the availability of emergency accommodation	Major	Likely	Very High

RID-G75	Public Health and Wellbeing	Low Rainfall and Drought	Increased water insecurity for townships	Water insecurity in remote communities may include limited water for washing and flow-on hygiene-related health impacts. Facilities like swimming pools or ovals are very important to remote towns. Drought affecting the access/useability of pools/ovals may have both physical (limited ability to keep cool) and mental health impacts. Also, fresh water bodies are an important way of cooling down.	Major	Likely	Very High
RID-G76	Public Health and Wellbeing	Low Rainfall and Drought	Mental health impacts	Increased frequency and severity of drought may lead to greater mental health impacts including loss of hope/confidence and potentially increased rates of suicide (e.g. farmers or pastoralists affected by ongoing drought)	Major	Likely	Very High
RID-G57	Infrastructure	Extreme Rainfall and Flooding	Disruption and damage to road and rail network	Higher intensity rainfall events could increase the frequency and severity of significant flood events leading to greater damage or disruption to regional road and rail networks. E.g. flash flooding washing away portions of roads. This can lead to interconnectivity and access issues.	Major	Likely	Very High
RID-G20	Community	Extreme Heat	Rural communities becoming unliveable	Due to extreme heat particularly in the northern and remote parts of the Goldfields region, increased severity and duration of extreme heat days may mean communities are forced to leave permanently.	Catastrophic	Possible	Very High