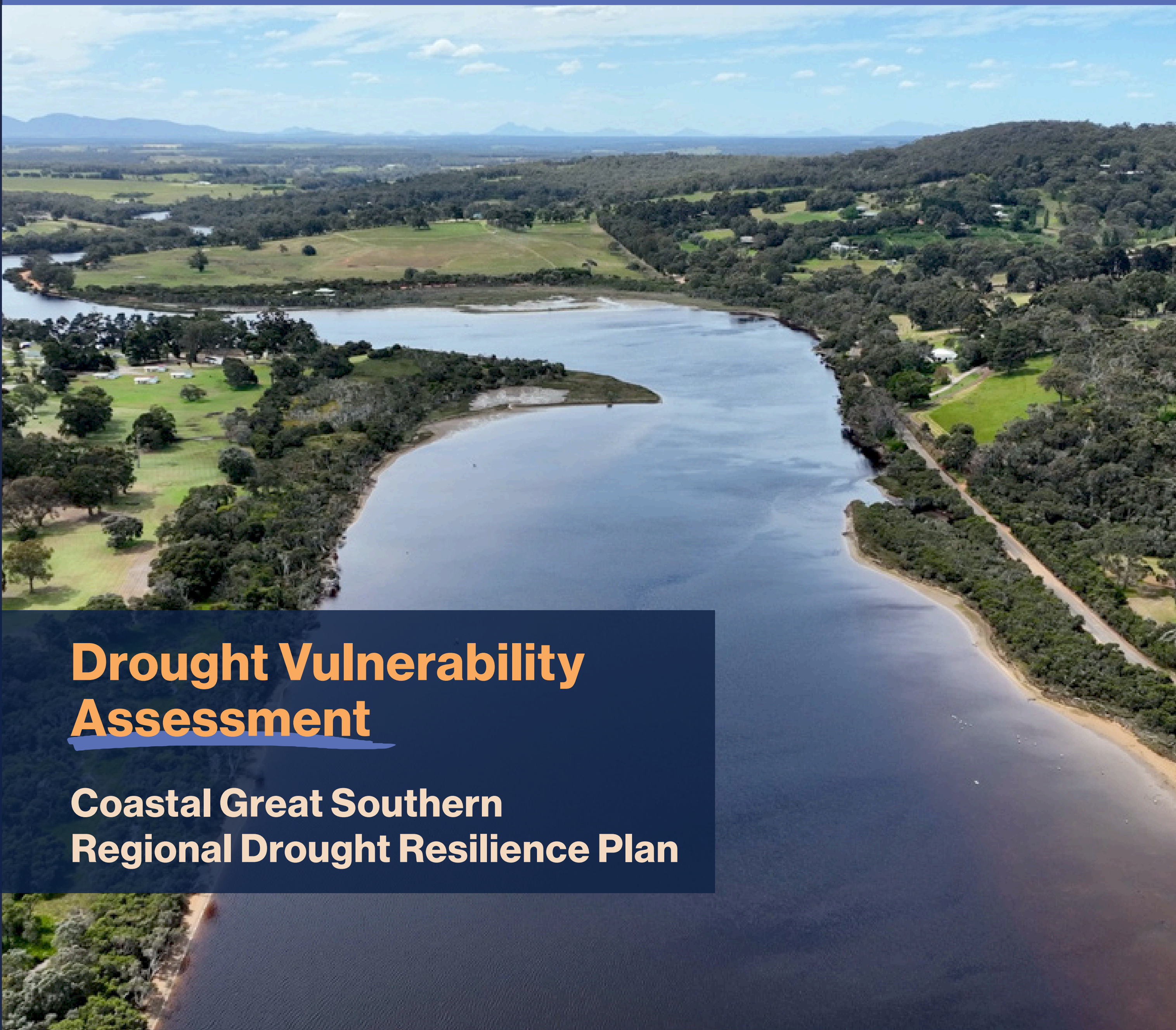
Australian Government
Department of Agriculture, Fisheries and Forestry

Future Drought Fund

Government of Western Australia
Department of Primary Industries and Regional Development

Great Southern Development Commission



Drought Vulnerability Assessment

Coastal Great Southern Regional Drought Resilience Plan

Great Southern
Development Commission

2025

Acknowledgement of Country

> *Ngala kattidj nidja Noongar moort boodja wer gorah-gorah wer yy-i wer mila. Ngala koort-kwab nidja boodja-k wer kattidj netingar wer bee-dee-eer wer gorah-gorah wer yy-i wer mila.*
>
> We acknowledge this is Noongar people's country from long, long ago to now to the future. We are happy to be on this country and acknowledge ancestors and elders from long, long ago to now to the future.

This report was prepared by LA.ONE economics and consulting Pty Ltd. on behalf of the Great Southern Development Commission (GSDC). This report supports the Coastal Great Southern Regional Drought Resilience Plan.

This report and any material sourced from it should be attributed to Anderton, L. (2024) Drought Vulnerability Assessment for the Coastal Great Southern Regional Drought Resilience Plan. Prepared for GSDC and the Department of Primary Industries and Regional Development.

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Executive Summary

The Drought Vulnerability Assessment (DVA) for the Coastal Great Southern Region comprehensively evaluates the region's susceptibility to drought and provides strategic insights for enhancing resilience. Commissioned by the Great Southern Development Commission and the Department of Primary Industries and Regional Development, this report is a crucial component of the Coastal Great Southern Regional Drought Resilience Plan, which aims to bolster economic, environmental, and social resilience across the region.

The Future Drought Fund (FDF) underpins three strategic priorities: fostering economic resilience for a profitable agricultural sector, promoting environmental resilience for sustainable farming landscapes, and enhancing social resilience for adaptable and resourceful communities.

This assessment identifies specific risks posed by drought to industries, communities, and the environment within the Coastal subregion.

Key Findings:

Climate Trends and Impact: Over the past century, the region has experienced significant climate changes, including rising temperatures, and altered rainfall patterns. A 15% decline in April to October rainfall since 1970, particularly in the South West, presents substantial challenges for agriculture and ecosystem sustainability.

Environmental Health Indicators: The environmental condition score for Western Australia in 2023 was 5.5, down from 5.9 in 2022. Indicators such as exposed soil, soil moisture, leaf area, and plant growth are critical for understanding drought's environmental impact.

Agricultural Vulnerability: Key vulnerabilities include inadequate water infrastructure, reliance on rain-fed pasture production, and a high prevalence of small businesses with low turnover. Addressing future rainfall patterns and investing in water harvesting infrastructure is essential.

Effects of Climate Variability: Climate variability is anticipated to reduce water availability for crops and livestock, potentially diminishing yields so challenging farming operations. This report underscores the need for adaptive management strategies to mitigate these effects and enhance water use efficiency.

Farming Systems and Agricultural Value: The Coastal Great Southern Region's farming systems are generally livestock dominant, although broadacre cropping is significant in some parts of the region. The agriculture sector, including the eastern side of the Shire of Cranbrook, is valued at $571.1 million. Livestock sales and broadacre cropping are major contributors, with livestock alone valued at almost $300 million in 2021.

Diversification: The Coastal Great Southern Region has a significant level of economic and agricultural diversification. This diversification plays a critical role in enhancing the resilience of the region's communities and industries against drought and other climate-related challenges.

Economic Impact of Drought: Can create severe financial hardship for farm businesses dependent on rainfall for productivity. Planning, preparedness and financial resources provide a buffer although ongoing dry conditions with declining terms of trade and high interest rates can impact severely on the financial viability of farm businesses.

Community Priorities: The Strategic Community Plans for each of the Local Government Authorities reveal that residents highly value the peaceful lifestyle, the natural environment, community spirit, safety, and supportive neighbours. These values are integral to this vulnerability assessment and resilience planning.

Social Impact: Drought's social impacts are extensive, affecting employment, education, family relationships, and community resources. These impacts lead to declines in health and well-being, highlighting the necessity for mental health support and community engagement strategies.

Adaptive Capacity and Social Capital: Enhancing adaptive capacity and social capital is crucial for resilience. Indicators such as education, gender inequality, mental health, and access to water resources are vital for assessing vulnerability and formulating effective mitigation strategies.

In summary, this report underscores the pressing need for comprehensive, multi-faceted strategies to address the challenges posed by drought. By prioritizing economic, environmental, and social resilience, the Coastal Great Southern Region will be better prepared for to manage future drought risks. Implementing the recommended adaptive management strategies and investing in critical infrastructure will be pivotal in securing the long-term viability and prosperity of the region's agricultural sector and communities.

By evaluating existing strategies and pinpointing gaps, this report highlights opportunities for building stronger drought resilience.

Recommendations

The Drought Vulnerability Assessment (DVA) report for the Coastal Great Southern Region provides several actionable recommendations based on its findings. The key recommendations distilled from the report:

1. **Invest in Water Infrastructure:**
   - Develop and upgrade water harvesting and storage systems to ensure a reliable supply for livestock, irrigation, and crop spraying.
   - Promote water-efficient technologies and practices to optimise usage in agricultural activities.

2. **Enhance Climate Monitoring and Forecasting:**
   - Use and improve climate monitoring systems for accurate and timely weather forecasts.
   - Utilise climate data to inform agricultural planning and decision-making processes, aiding farmers in adapting to changing rainfall patterns.

3. **Promote Sustainable Farming Practices:**
   - Encourage conservation tillage, mulching, and other soil moisture retention techniques to improve soil health and crop resilience.
   - Support the adoption of drought-tolerant crop varieties and diversified cropping systems to mitigate risks associated with climate variability.

4. **Strengthen Community Engagement and Support:**
   - Foster community programs that enhance social capital, such as local agricultural groups, workshops, and information-sharing platforms.
   - Provide mental health and well-being support services to assist farming families and communities in coping with the stress and impacts of drought.

5. **Develop Comprehensive Risk Management Plans:**
   - Create and implement risk management strategies tailored to the specific vulnerabilities of different agricultural sectors and regions.
   - Encourage farmers to adopt decision support tools and financial tools that help mitigate the economic impact of drought and improve preparedness.

6. **Support Research and Innovation:**
   - Invest in research initiatives exploring new technologies and methods for improving drought resilience in agriculture.
   - Facilitate collaboration between researchers, policymakers, and farmers to develop practical and scalable solutions.

7. **Improve Soil and Land Management:**
   - Promote practices that prevent soil erosion, such as maintaining ground cover and restricting grazing during vulnerable periods.
   - Encourage the use of soil amendments like lime and fertilizers to manage soil pH levels and improve fertility.

8. **Enhance Adaptive Capacity and Education:**
   - Provide training and educational programs to farmers and communities on adaptive practices and climate resilience.
   - Develop resources and tools that help farmers anticipate and respond to drought conditions effectively.

9. **Implement Environmental Conservation Measures:**
   - Protect and restore natural vegetation areas to enhance ecosystem resilience and biodiversity.
   - Support land management practices that maintain or improve the condition of natural resources and ecosystems.

10. **Facilitate Access to Financial Resources:**
    - Ensure farmers and agricultural businesses have access to financial support and incentives for implementing resilience-building practices.
    - Develop funding programs that support the adoption of innovative and sustainable agricultural practices.

These recommendations aim to build a robust framework for mitigating the impacts of drought and enhancing the resilience of the Coastal Great Southern Region's agricultural sector and communities.

1. Introduction

1.1. Future Drought Fund Overview

The Future Drought Fund (FDF) is an Australian Government initiative to help Australian farmers and regional communities become more prepared for, and resilient to, the impacts of drought[1]. The $5 billion fund invests $100 million a year into projects that will provide opportunities for farmers, allied industries and regional communities to adopt new technologies, improve their environmental and natural resource management, refine their drought resilience planning and decision-making abilities, and participate in a range of community resilience activities[2].

Through the Future Drought Fund, the Australian Government is working with state and territory governments to support regions in developing Regional Drought Resilience (RDR) Plans to prepare for and manage future drought risks[3].

These plans will:

- be community led and owned through partnerships of local governments, regional organisations, communities and industry.
- identify actions to prepare for future droughts, with a sharp focus on the agricultural sector and allied industries.
- bring people together to share their local knowledge and perspectives.
- recognise that no two regions are the same.
- be evidence-based.
- use leading practice approaches to resilience, adaptation and transformation.
- build on existing planning.
- draw out regional needs and priorities to inform future investments.

Plans must be evidence-based, informed by up-to-date information, research and climate science (projections, mapping, modelling and scenarios) for the region, and must be developed 'building on, complementing and taking account of existing strategic planning, to the extent it is available and relevant'. RDR plans must also be developed by harnessing 'diverse, region-specific knowledge and skills'.

1.2. Drought Vulnerability Assessment Overview

This Drought Vulnerability Assessment (DVA) for the Coastal Great Southern Region, commissioned by the Great Southern Development Commission and the Department of Primary Industries and Regional Development, evaluates the region's susceptibility to drought and offers strategic recommendations to enhance resilience. A drought risk assessment collates all the available data from the literature, the stakeholder engagement, and analysis to provide local decision-makers with a summary of vulnerabilities to drought in their region.

1 Department of Agriculture, Water and the Environment Future Drought Fund https://www.awe.gov.au/agriculture-land/farm-food-drought/drought/future-drought-fund
2 Great Southern Development Commission (2022) Inland Great Southern Drought Vulnerability Assessment
3 Maru Y, Grigg N, Merrin LE, Pirzl R, Fleming Munoz DA, Herr A, Loechel B, Page D, Bohensky, E, Capon, T, Oude Egberink I, Parish G, Snow S, Kelly J and Farbotko C (2023) Regional Drought Resilience Plans Independent Review Guide. Version 2. CSIRO, Australia.

This report is a crucial part of the Coastal Great Southern Regional Drought Resilience Plan. It provides the evidence base for the RDR Plan and addresses the key questions:

- What does drought look like for the Coastal subregion now and in the future?
- Where are the areas of most vulnerability?
- What gaps exist in current strategies?

By identifying risks and vulnerabilities, this report aims to develop effective mitigation strategies and build capacity within the Coastal Great Southern communities, businesses, and industries to adapt to the challenges posed by drought over the next 20 years and beyond.

1.3. Methodology

Regional drought vulnerability assessments are a key part of building the evidence base underpinning the Regional Drought Resilience Plans. Figure 1 presents the stages involved in the RDRP program, showing where the DVAs fit into its delivery.

Figure 1. Project Implementation for the Future Drought Fund's Regional Drought Resilience Planning Program in WA

A Drought Vulnerability Assessment is a science-based approach examining the evidence to measure a region's vulnerability to drought. By understanding the level of exposure, mitigation strategies can be developed.

This DVA has considered the impact of drought on the Coastal Great Southern Region communities from a social, environmental, and economic perspective. It has included looking at data and the impact of drought on different industries to identify those most vulnerable.

Diverse knowledge sources from stakeholder consultations in interviews, workshops and surveys have informed this DVA, and by using both qualitative and quantitative evidence we have gathered information on the effects of drought in these communities.

The conceptual framework for this Drought Vulnerability Assessment is adapted from the Australian Government Department of Agriculture and Water Resources Future Drought Fund. It is illustrated in Figure 2 and informs the structure for this report.

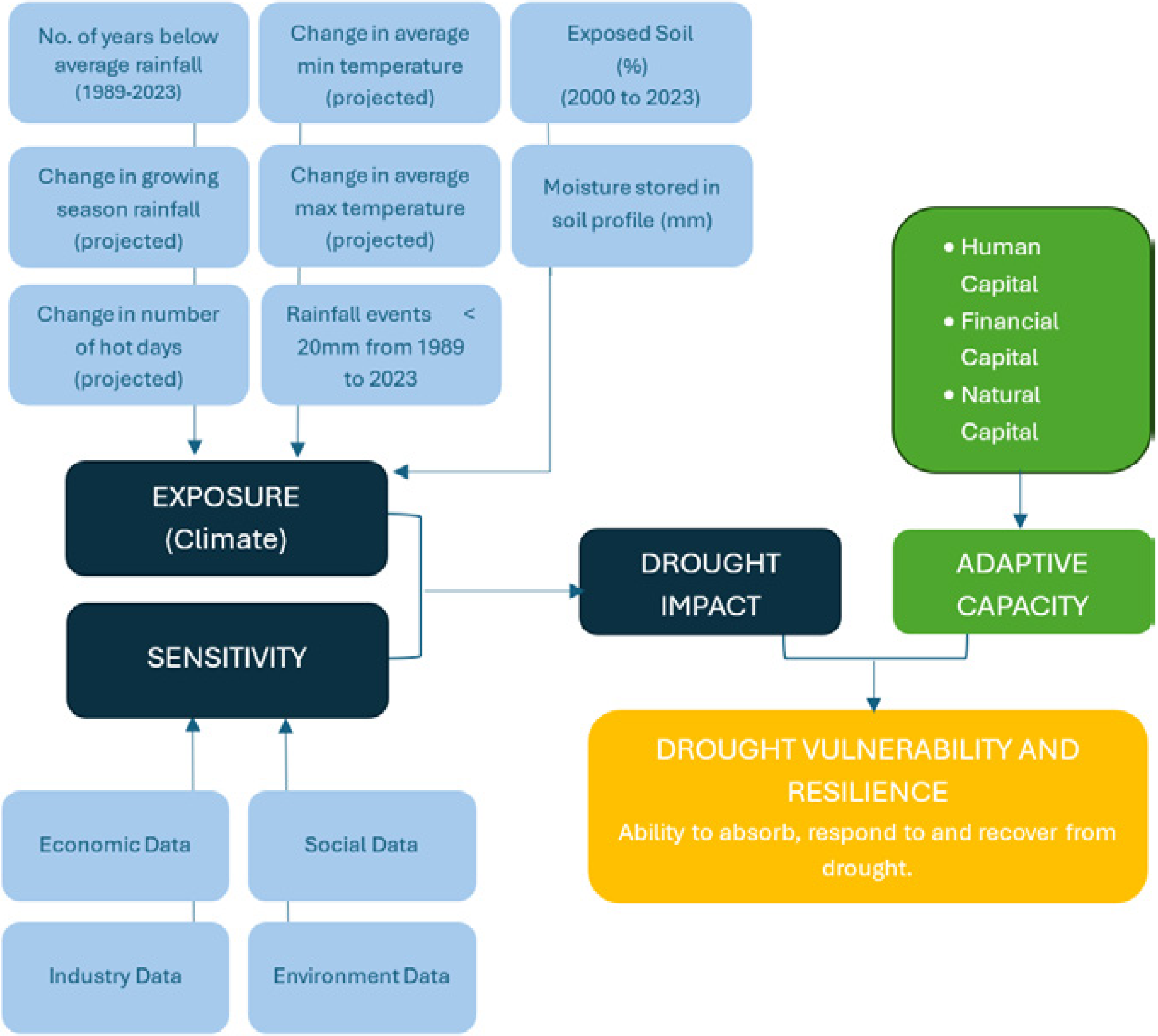

Figure 2. Conceptual Framework for Drought Vulnerability Assessment[4]

Regional drought vulnerability assessments require consideration of both the potential impacts of drought and the adaptive capacities of the people and systems in each region. Each element in this conceptual framework has a focus.

Exposure is the extent to which a given system, community or region will be subjected to a particular hazard. It is measured in terms of the extent to which a focus region will be exposed to drought and drought-related climate change processes such as increasing atmospheric temperatures and changes in rainfall patterns and soil moisture, Figure 2.

Sensitivity is the extent to which a given system, community or region will be affected by a particular hazard. For the Coastal Great Southern RDRP, sensitivity is about the ways in which this region is impacted by drought. It is measured in terms of the effect of drought on crops and animal production, and the influence of regional characteristics such as soil types and farming systems on the effect that a drought has in the region.

4 Adapted from the Australian Government Department of Agriculture and Water Resources, Future Drought Fund

Drought impact includes the degree of exposure to drought in the regions and each region's inherent sensitivity to drought conditions.

Adaptive capacity describes the internal features and characteristics of the regions that influence their ability to respond effectively to and withstand past and future droughts.

The conceptual framework worked as a guide to generate a Vulnerability Index for each Shire and agriculture Industry in the region by using both quantitative and qualitative data. The aim is to provide valuable insights into where resources and interventions are most needed by identifying the vulnerabilities in the regions.

An Index was applied to the Economic, Climate, Social, Environment and Industry quantitative data collated for this Drought Vulnerability Assessment, from the literature, Regional Context Report, and from Australian Bureau of Statistics herein.

Qualitative data from the community survey responses was scored to generate an objective measure for the index.

1.4. DVA Structure

This report is presented using the conceptual framework in Figure 2.

- Definitions – Defining Drought, Resilience and Vulnerability
- Regional Overview
- Exposure – Climate
    - Investigating the historical climate trends for the Coastal Great Southern Region by local government area (LGA)
    - Future climate predictions for the Coastal Great Southern Region
    - Data used for the Vulnerability Index
- Sensitivity – Characteristics of the South Coastal Region
- Land Use Activities by LGA
- Soil Types
- Value of Agriculture for each LGA
- Number of Businesses and their turnover
- Impact of Drought on the economy, productivity and environment
- Understanding the comparative vulnerabilities of drought for the LGA's in the Coastal Great Southern Region using a vulnerability Index.
- Case Studies looking at the impact of drought in depth on small businesses in the region.
- Conclusion and recommendations.

2. Definitions

2.1. Defining Drought

Drought presents a unique set of challenges distinct from other climatic risks due to its impact on several farm businesses simultaneously, and its slow onset with uncertain durations.[5] The prolonged nature of drought results in a multitude of ongoing effects, including disruption to cropping programs and reduction of breeding stock, which jeopardizes the profitability and long-term viability of farm operations.

Additionally, drought contributes to economic downturns at regional, state, and national levels, causing serious environmental degradation such as vegetation loss, soil erosion, and water contamination. Furthermore, the frequency of bushfires and dust storms tends to increase during drought periods.

Beyond these tangible impacts, drought takes a toll on farming families' physical and mental well-being, impairing decision-making abilities and community engagement. Moreover, rural businesses and communities experience a decline in vitality and viability because of prolonged drought conditions. Recovery from the effects of drought can be challenging due to its enduring consequences, making it difficult for both farming businesses and government agencies to identify triggers for assistance.

The problem with drought is that we don't know when it starts or ends, it often evolves slowly, and measuring or quantifying the impact is difficult, until after the event. It can be highly localized or widespread and the impact can be very farm specific.

It is further complicated because the outcome for some can be positive, with higher prices for produce like hay and grain increasing profits and allowing for increased investment into their business, whilst for others they can have low yields, increased costs for feeding livestock due to the high prices and long-term effect on productivity due to financial losses.

In Western Australia, drought is not an unexpected occurrence. Forecasts suggest that exceptionally low rainfall, high temperatures, and low soil moisture levels will occur four times more frequently in the future in the South West of the state.

While advancements in farming systems and technologies have enabled businesses in dryland farming areas to maintain viability, Ongoing proactive measures and comprehensive strategies are essential to mitigate the impacts of drought and build resilience within the agricultural sector.

In the Inland Great Southern Drought Resilience Plan, drought was defined as ***'Consecutive dry seasons where there is inadequate growing season rainfall over two or more seasons'***[6] . However, for the Coastal Great Southern region, drought is different.

Agricultural systems in this region focus on livestock due to the higher rainfall, ability to grow more pastures and issues with water logging for crops. Systems have evolved because the longer growing season and summer rainfall allow for perennial pasture growth and high levels of annual pasture growth. For the Coastal Great Southern region growing season rainfall (April to October) is important but equally important is the rainfall received outside this period.

The Project Advisory Group (PAG) defined drought for the Coastal Great Southern RDRP as follows:

"Drought: A prolonged period of abnormally dry conditions that impact negatively on water availability and diverse agricultural production in a region, and consequently impacts negatively on the economy and environment of the region and the health and wellbeing of its residents"

5 Department of Primary Industries and Regional Development, 2018, The evolution of drought policy in Western Australia, Climate, land and water, https://www.agric.wa.gov.au/drought-and-dry-seasons/evolution-drought-policy-western-australia?nopaging=1

6 GSDC (2023) Inland Great Southern Drought Resilience Plan. Great Southern Development Commission

At workshops held with the community and key stakeholders for the Coastal Great Southern Drought Resilience Plan participants defined drought as:

'Drought is unpredictable, local, below average rainfall over multiple seasons causing financial, social and environmental hardship on a region.'[7]

'Dry season, a period of dry conditions, seasonal or multi-year within a drying climate scenario'

2.2. Defining Resilience

Resilience in agricultural systems involves the ability to absorb shocks, avoid irreversible changes, and recover from disturbances. It encompasses environmental, social, and economic dimensions, with a focus on adaptation, learning, and self-organization.

The Department of Agriculture, Fisheries, and Forestry defines resilience as the capacity to anticipate and minimize environmental, financial, and social impacts through adaptive strategies. Cabell and Oelofse (2012) note that resilience is difficult to measure precisely but can be assessed by a system's ability to change, self-organize, and learn.

Greenhill et al. (2009) found eight key factors influencing resilience in South Australian farm families, including pre-existing financial viability, risk management and decision making, well-being, and generational change and the role of farm women. These factors align with the broader concept of resilience as the capacity to resist, adapt, and recover while maintaining essential functions.

2.3. Defining Vulnerability

Vulnerability research is closely linked to resilience research, focusing on the causes, scale, and actors involved in vulnerability, as well as identifying opportunities for risk reduction and adaptation. Unlike resilience studies, vulnerability assessments often overlook the interaction between short- and long-term ecological changes.[8]

Fussell and Klein (2005) argue that climate change vulnerability assessments aim to enhance scientific understanding, set mitigation targets, prioritise vulnerable sectors, and develop adaptation strategies.

Kelly and Adger (2000) distinguish between "outcome vulnerability" (a system's susceptibility to climate impacts) and "contextual vulnerability" (its exposure, sensitivity, and adaptive capacity). These concepts vary in their application to linear versus complex systems.

Safi et al. (2012) describe vulnerability as comprising three elements: physical vulnerability (the likelihood of hazards), sensitivity, and adaptive capacity, both influenced by the socioeconomic conditions of the affected communities.

Therefore, vulnerability is defined as to the degree in which a system, community, or individual is susceptible to harm or damage due to exposure to hazards or stressors, such as environmental, social, or economic challenges. It is determined by factors like exposure to risks, sensitivity to the impacts, and the ability to adapt or cope with the effects. For the Coastal Great Southern, vulnerability is about how susceptible our systems are to the adverse effects of changing climate conditions, including variability and extremes, and how well can we respond or recover from those impacts.

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7 Great Southern Development Commission (2024) Regional Drought Resilience Plan Workshop Albany 18th July 2024 Workshop Report.

8 Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Zierovogel, G., Walker, B., Birkmann, J., van der Leeuw, S., Rockström, J., Hinkel, J., Downing, T., Folke, C. and Nelson, D. (2010) Resilience and Vulnerability: Contemporary or conflicting concepts. Ecological and Society 15(3), 11

3. Regional Overview

The Coastal Great Southern Region, comprising of four local government areas (LGA's) shown in Figure 3, are part of the wider Great Southern Region of Western Australia (also shown in Figure 3).

The four LGA's are the City of Albany, Shire of Plantagenet, Shire of Denmark and the Frankland Rover region in the western part of the Shire of Cranbrook.

Albany is the main regional centre for the surrounding Great Southern Region and has a population of 40,949, the Shire of Denmark has a population of 6,618, the Shire of Plantagenet has a population of 5,669 and Shire of Cranbrook 1,149, Figure 3.[9]

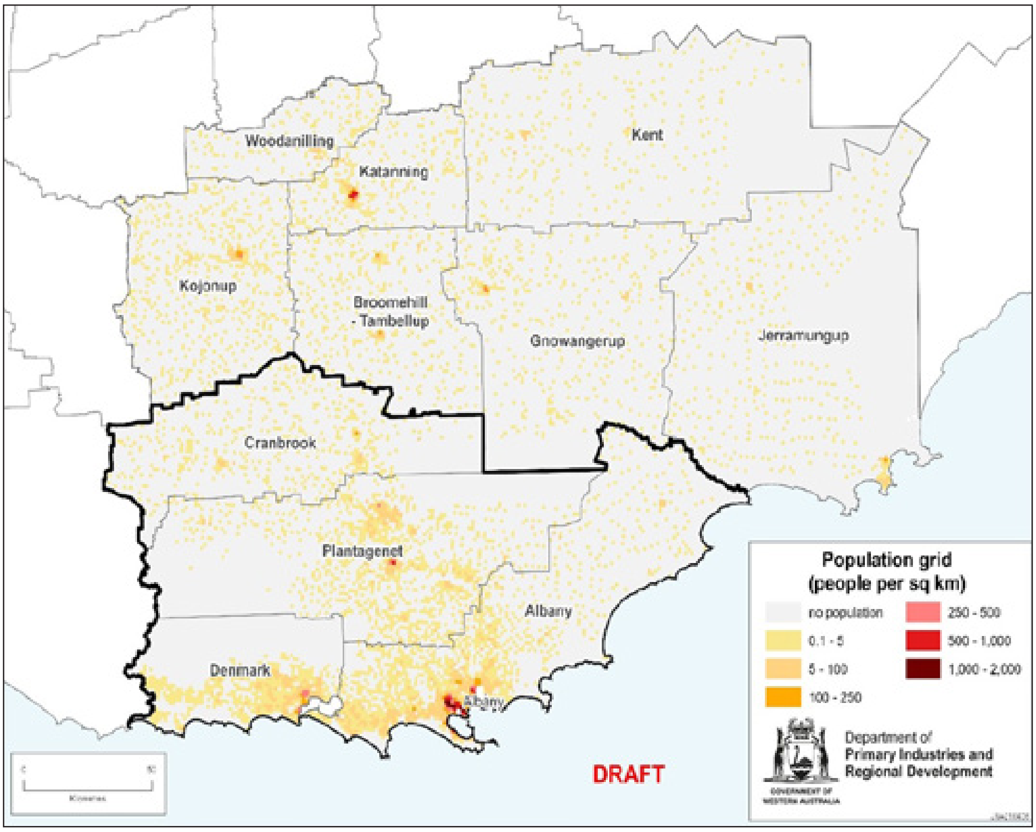


Figure 3. Population density for the Coastal Great Southern Region.

The area is renowned for its natural outstanding beauty and attractiveness. It is a tourist destination although distance from large populations and transport networks constrains growth.

The Regional Context Report by Keston Economics commissioned for the Coastal Great Southern RDR Plan provides an in-depth analysis of the geographics, demographics, economics and infrastructure in the region.

9 Keston Economics (2024), Regional Context Coastal Great Southern Regional Drought Resilience Plan. Great Southern Western Australia.

4. Exposure - Climate

4.1. Climate Trends in Western Australia

The climate in WA has undergone significant changes over the past century, characterised by rising average temperatures (Figure 4) and altered rainfall patterns (Figure 5), particularly evident in the South West region where there has been a decline of around 15 per cent in April to October rainfall since 1970, and from May to July rainfall has decreased by 19 per cent.[10]

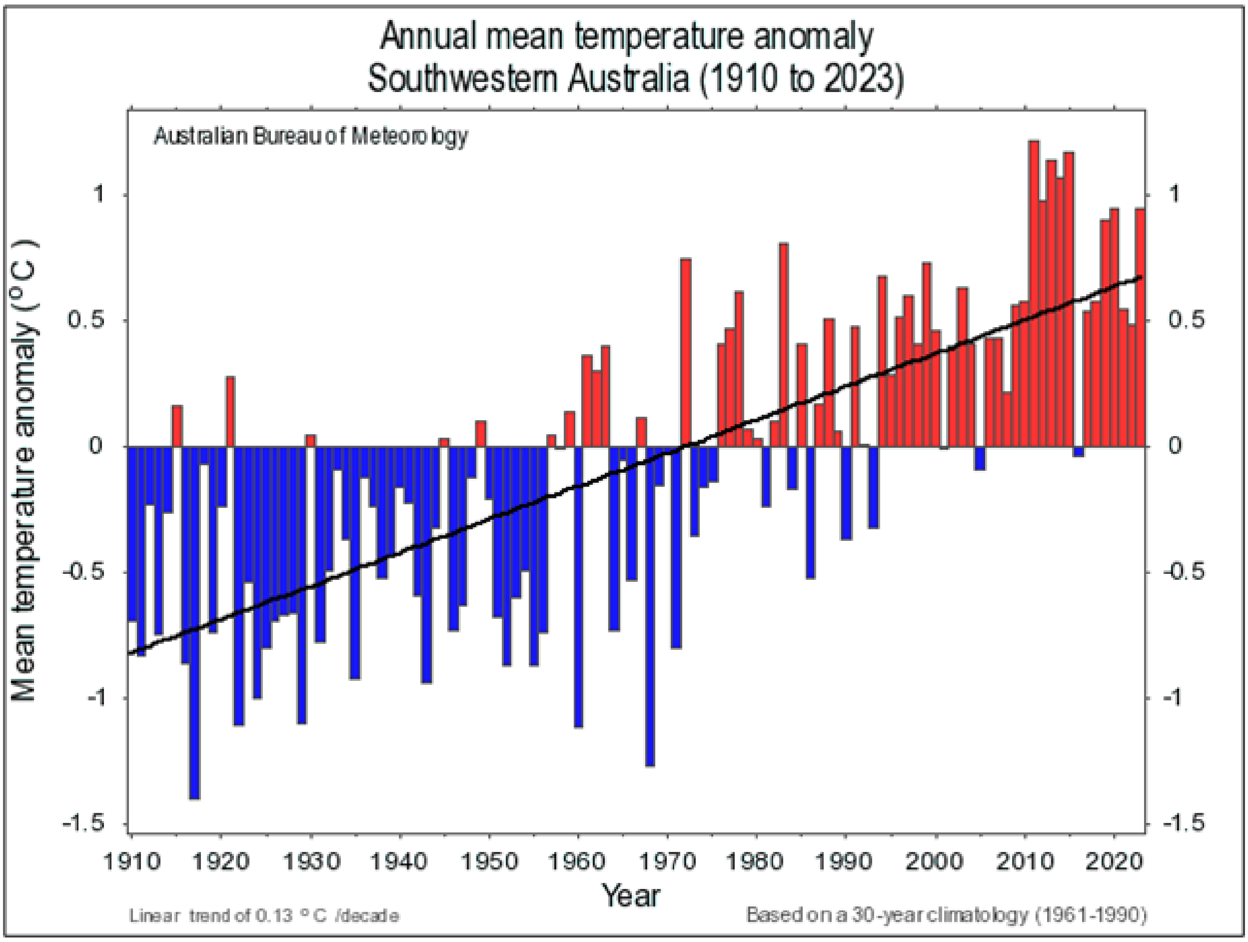


Figure 4. Annual mean temperature anomaly for South Western Australia

10 Department of Primary Industries and Regional Development, 2023, Climate trends in Western Australia, *Climate, land & water,* https://www.agric.wa.gov.au/climate-change/climate-trends-western-australia.

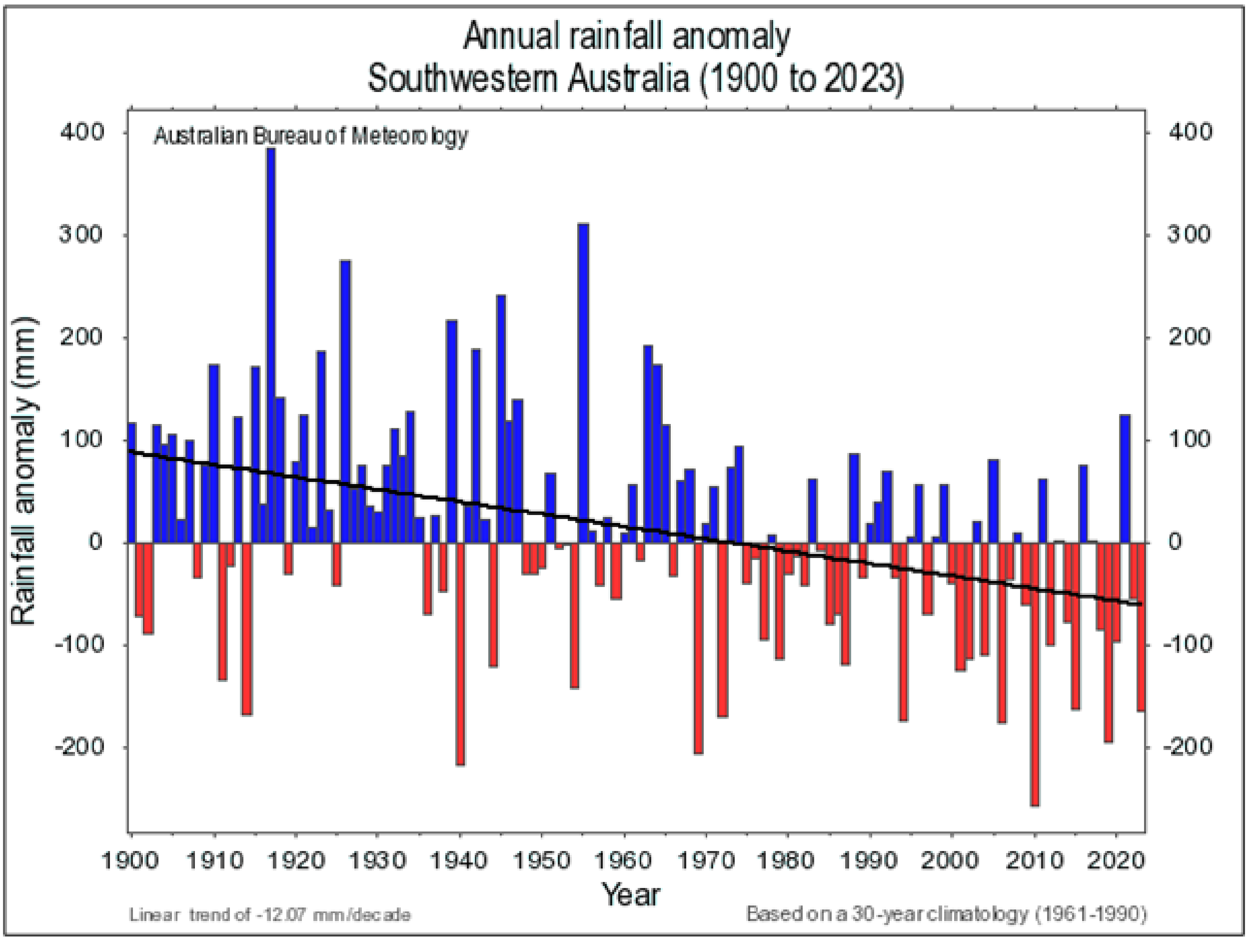


Figure 5. Annual rainfall anomaly for South Western Australia (1900 to 2023)

Australia has experienced a warming trend of 1.47 degrees since 1910, accompanied by an escalation in extreme heat events.[11] Each decade since 1950 has surpassed the preceding ones in terms of warmth, culminating in 2019 being the warmest year on record, with eight of the ten warmest years occurring between 2013 and 2020.4 These climatic shifts have contributed to an increase in extreme fire weather conditions and a prolonged fire season, particularly affecting southern regions.

Declining rainfall trends, notably during the critical growing season and cooler months, pose significant challenges to agricultural productivity, water resource management, and ecosystem sustainability. The observed reduction in rainfall has been attributed to higher atmospheric pressure, alterations in large-scale weather patterns, and decreased frequency of low-pressure systems bringing sustained rainfall to southern Australia.

Despite these trends, heavy rainfall events have intensified, increasing the risk of flash flooding and erosion.[12] These events are especially detrimental to agricultural areas reliant on fertile topsoil. The changing weather systems, influenced by climate drivers such as El Niño-Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), and Southern Annual Mode (SAM), further contribute to the complex dynamics of Australia's climate.[13]

Looking ahead, future climate predictions anticipate continued warming, decreased cool season rainfall, prolonged drought periods, and an increase in extreme weather events, posing significant challenges to agricultural resilience, natural disaster management, and coastal communities' vulnerability to inundation and erosion.

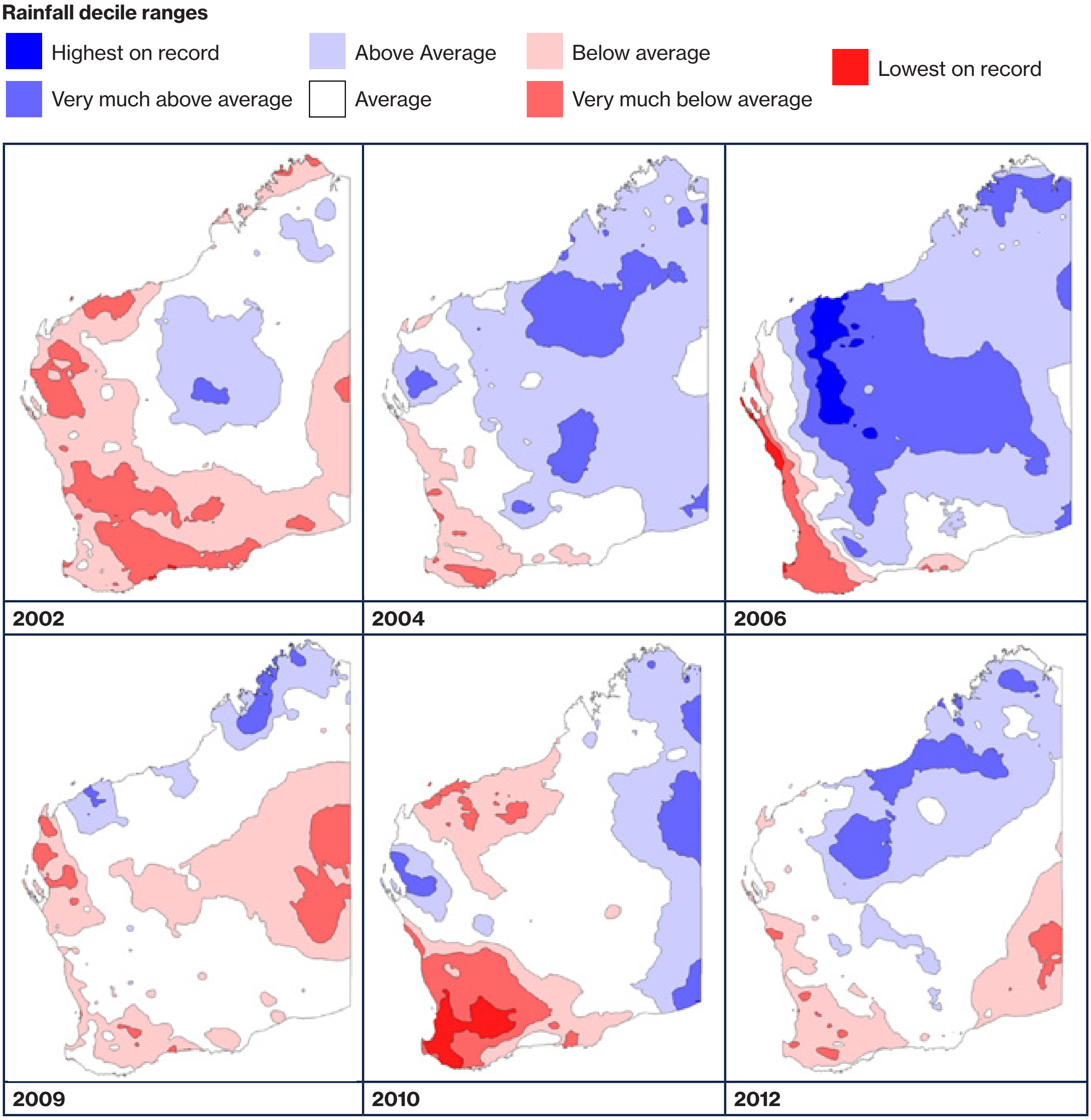
11 CSIRO, 2022, Australia's changing climate, State of the Climate, https://www.csiro.au/en/research/environmental-impacts/climate-change/state-of-the-climate/australias-changing-climate

12 CSIRO, 2021, Australia's changing climate, State of the Climate 2018, https://www.csiro.au/en/research/environmental-impacts/climate-change/state-of-the-climate/previous/state-of-the-climate-2018/australias-changing-climate

13 Australia State of the Environment 2021, Climate variability, Climate – Pressures, https://soe.dcceew.gov.au/climate/pressures/climate-variability

4.2. What does Drought look like?

The Bureau of Meteorology publishes the rainfall deciles for Australia annually. Deciles are used to give an element a ranking.[14] For example, the decile rainfall maps in Figure 6 show where the rainfall is above average, average, or below average for the period[15]. Selected from the years 2002 to 2023 shown in APPENDIX 1 these are where rainfall was below average for the Coastal Great Southern region. Some years, like 2006, 2010 and 2019 were severe and they are some of the driest years on record for this region.



14 http://www.bom.gov.au/climate/maps/rainfall
15 http://www.bom.gov.au/lam/glossary/deciled.htm

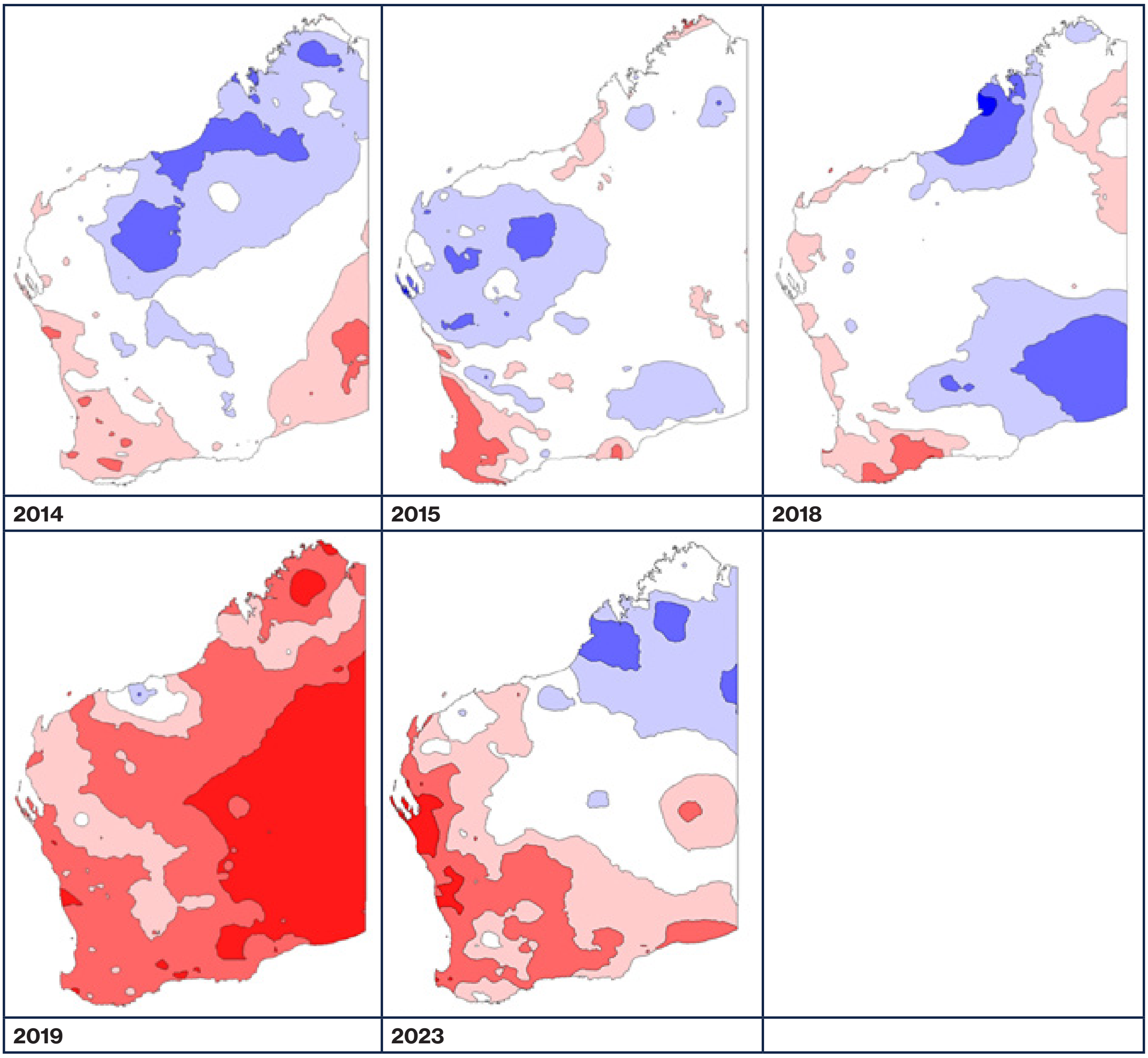


Figure 6. Years identified as below average rainfall for the Coastal Great Southern Region.

4.3. Regional Climate Trends

The Coastal Great Southern region is in the South Western region of WA and exposed to the changing conditions. Characterised as a very-high rainfall zone shown in Figure 7 with the darker shaded areas showing between 600 and 1000 millimetres of rainfall (mm).

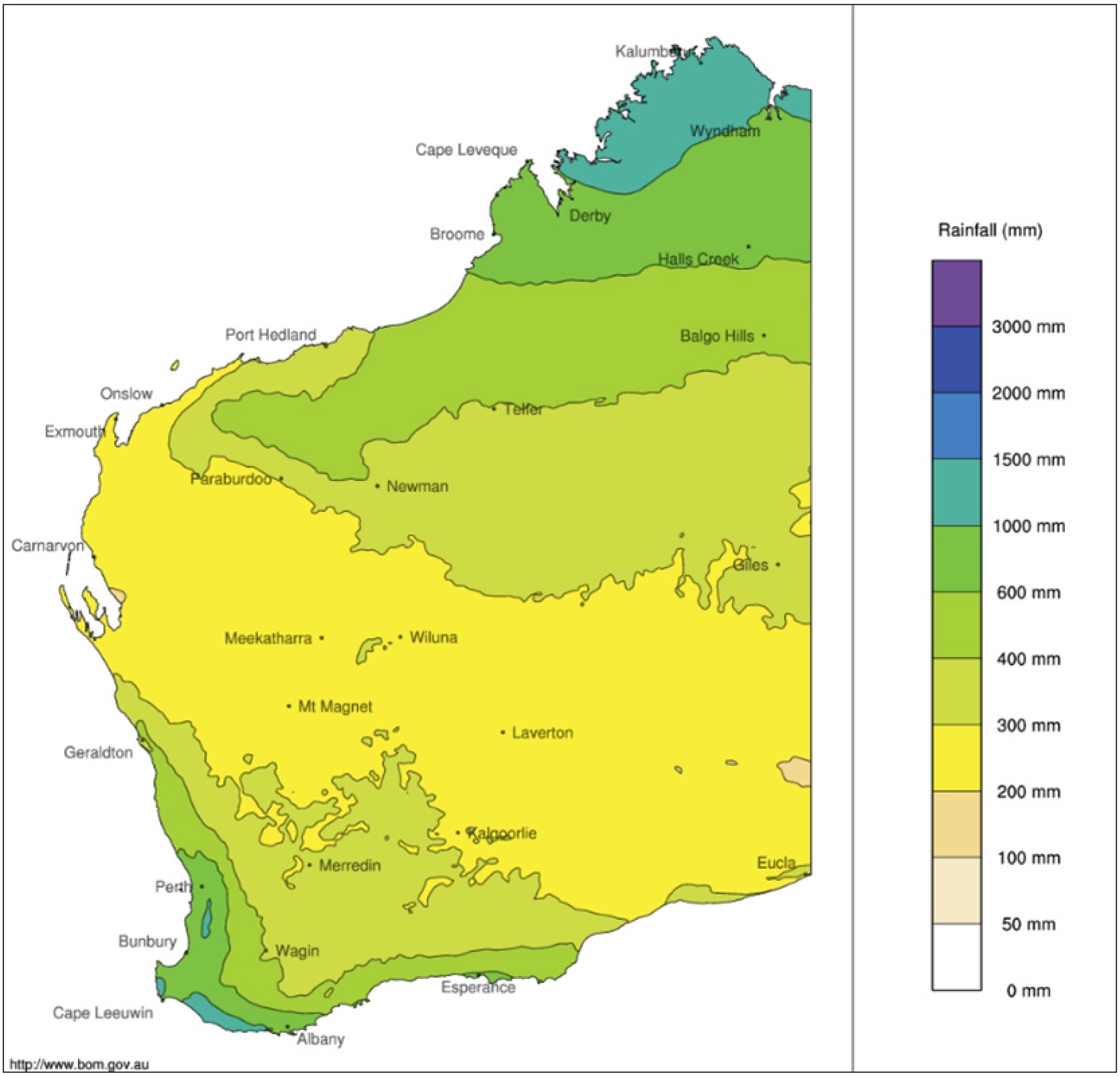


Figure 7. Average annual rainfall (1991 to 2020) [16]

4.4. The City of Albany

Weather patterns and conditions in the region can be highly variable, for example, the annual rainfall for Albany varies between 620 mm (2015) and 1,138 mm (2021), Figure 8. The evidence and future predictions suggest this variability will increase. An example of the extremes is where in 2015 the annual average rainfall was 620 mm; this is 30% below the average 872 mm.

This variability creates challenges for land use activities, for example, stocking rates for livestock are based on expected pasture growth rates. Lower-than-average rainfall, especially in the autumn and early winter months means pasture growth is slow, and more handfeeding of supplements like grain and hay is required. Whereas high rainfall events cause inundation, often reducing crop yields with waterlogged soil profiles.

16 http://www.bom.gov.au/climate/maps/averages/rainfall

Figure 8. Albany rainfall data (1989 to 2023)

The photographs in Figure 9 show the landscape after significant rainfall events in 2020. Low-lying landscapes take time to drain after high rainfall events.

Figure 9. Pictures of the coastal great southern landscape after significant rainfall events

The annual rainfall shown in Figure 8 for 2023 suggests a slightly below-average rainfall year with 853 mm. However, the monthly distribution of rainfall in Figure 10 shows how rainfall in June 2023 was above average. Almost 300 mm of rain (295.6 mm) which is the highest on record for June. This was followed by lower-than-average rainfall in July, September and October. The drier-than-normal spring months after a very wet June created challenging management conditions for both livestock farmers and cropping farmers. The high rainfall in June created waterlogging problems for pasture growth rates and the drier months in spring impacted crop yields and pasture growth rates.

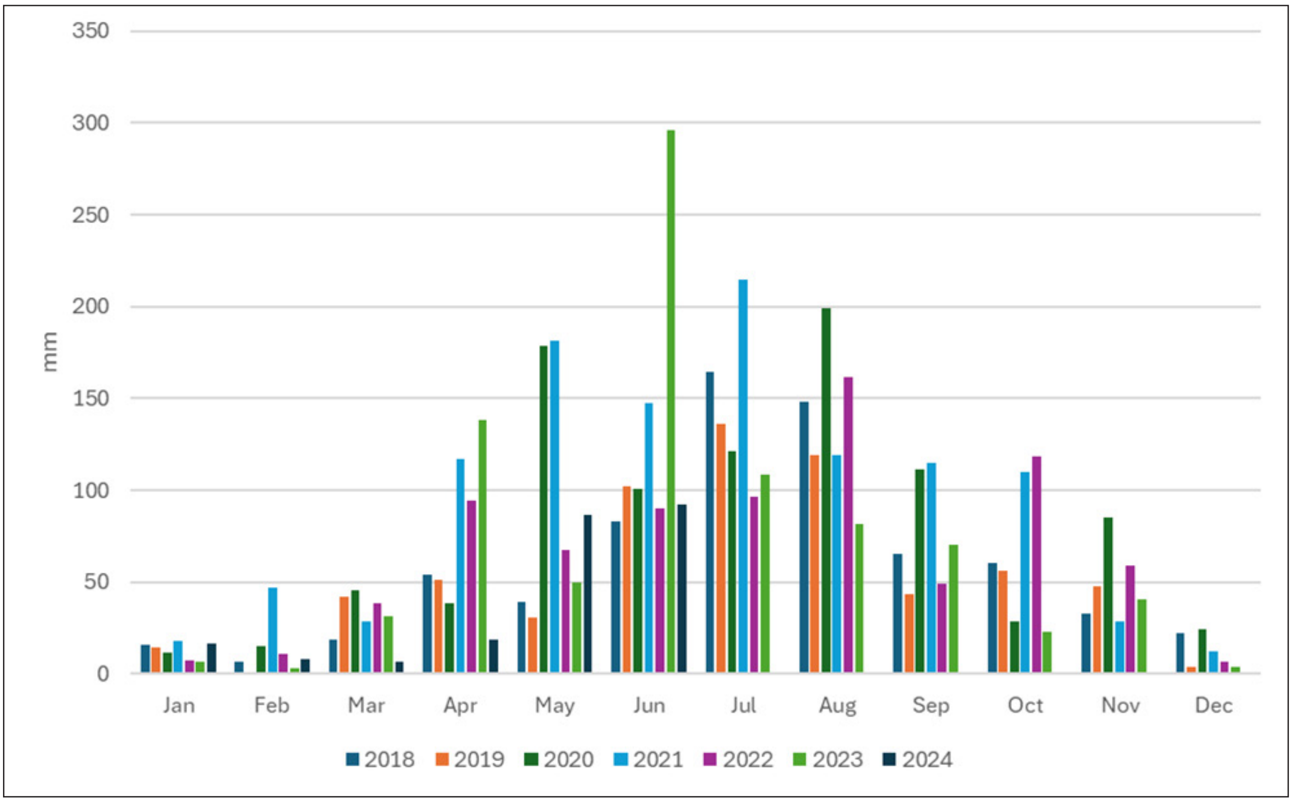


Figure 10. Albany monthly rainfall data (2018 to 2024)

4.5. The Shire of Plantagenet

The Shire of Plantagenet is characterized as a high rainfall zone with an average annual rainfall of 525 mm. Using rainfall data from the Carbarup station (Station number 009850) near Mount Barker, shown in Figure 11, annual rainfall ranged from 359 mm to 761 mm between 1989 and 2023.

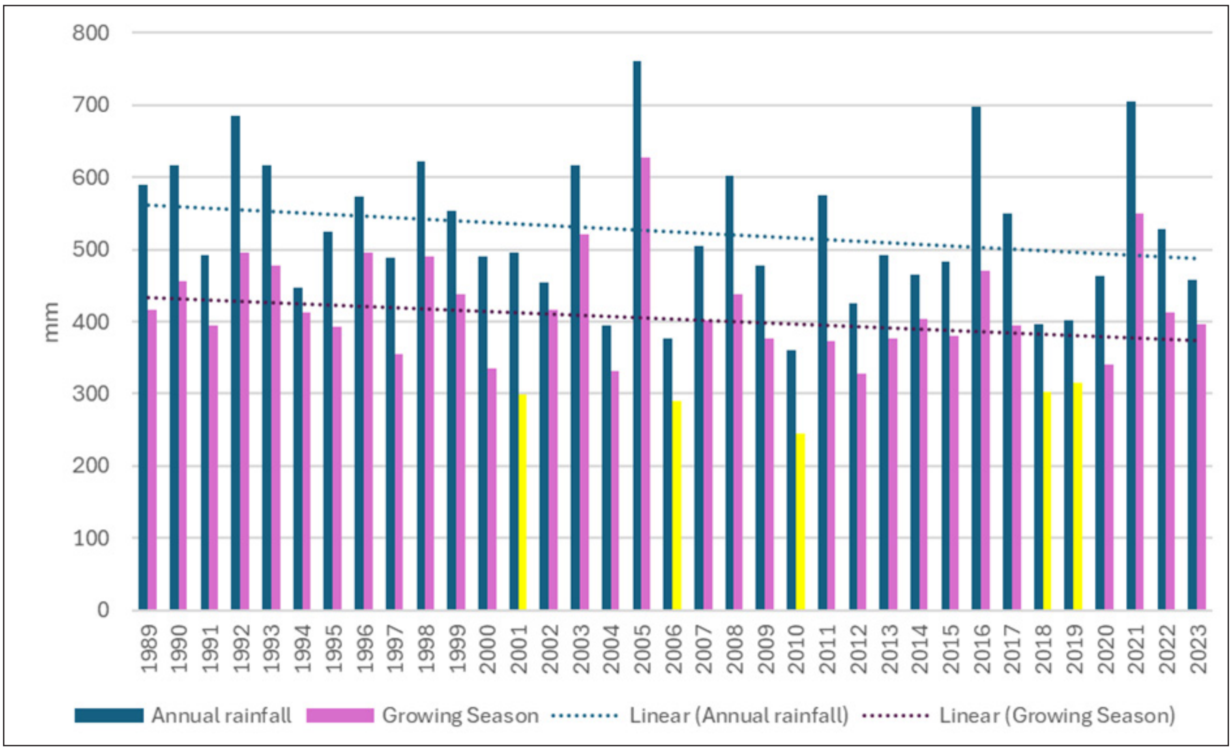


Figure 11. Mount Barker (Carbarup) annual rainfall data (1989 to 2023)

Growing season rainfall varies between 244 mm and 626 mm, however there were five years when growing season rainfall was below 300 mm. The lowest growing season rainfall (GSR) was in 2010 with 244 mm. The other years are identified by the yellow bars in Figure 11. These five low GSR years correspond with the drought years identified in Figure 6.

The changing trends in monthly distribution for the Shire of Plantagenet are shown using Mount Barker rainfall from My Climate View, a Climate tool available from the Bureau of Meteorology[17]. The circles on the bars show the months where the average monthly rainfall has decreased between the years 1964 to 1994 and 1994 to 2023. The circles highlighting the months show the months where rainfall averages have increased. The graph in Figure 12 also shows the increased level of variability in rainfall particularly in April.

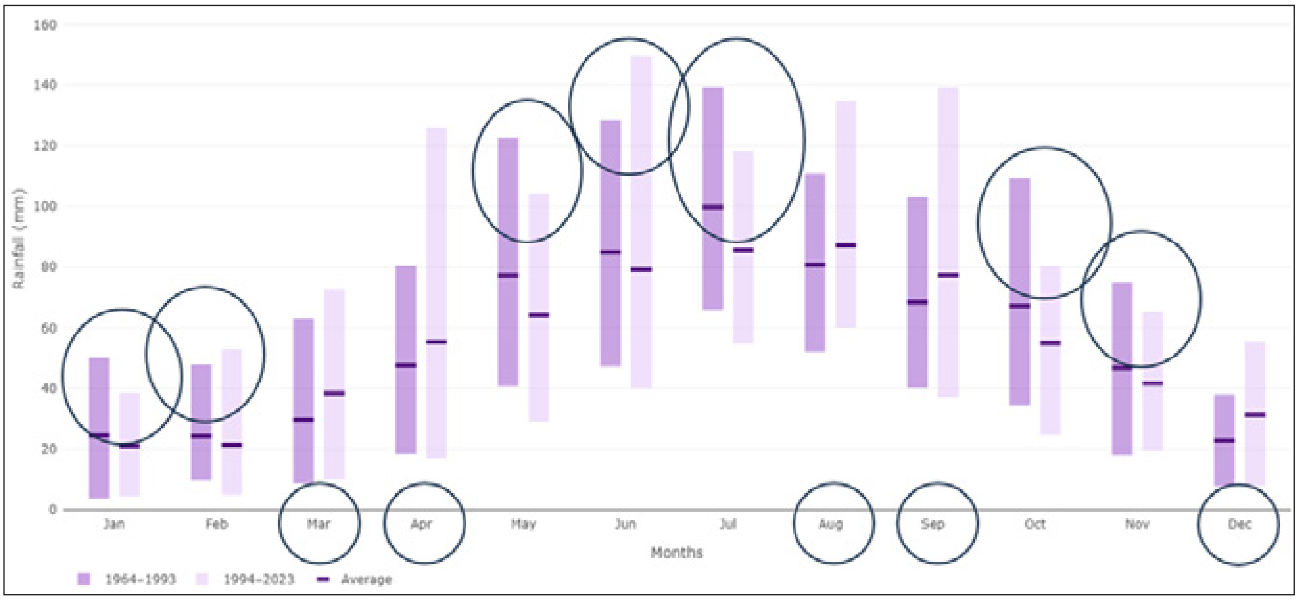


Figure 12. Changing trends in monthly distribution for Mount Barker

This changing distribution of rainfall increases the complexity of management for agriculture enterprises relying on rainfall at the start of the season in April, May, and June, particularly when managing livestock reliant on pastures to start growing in May and June.

An example of this is the year 2018 when rainfall was low in April and May (Figure 13).

17 https://myclimateview.com.au/climate-data

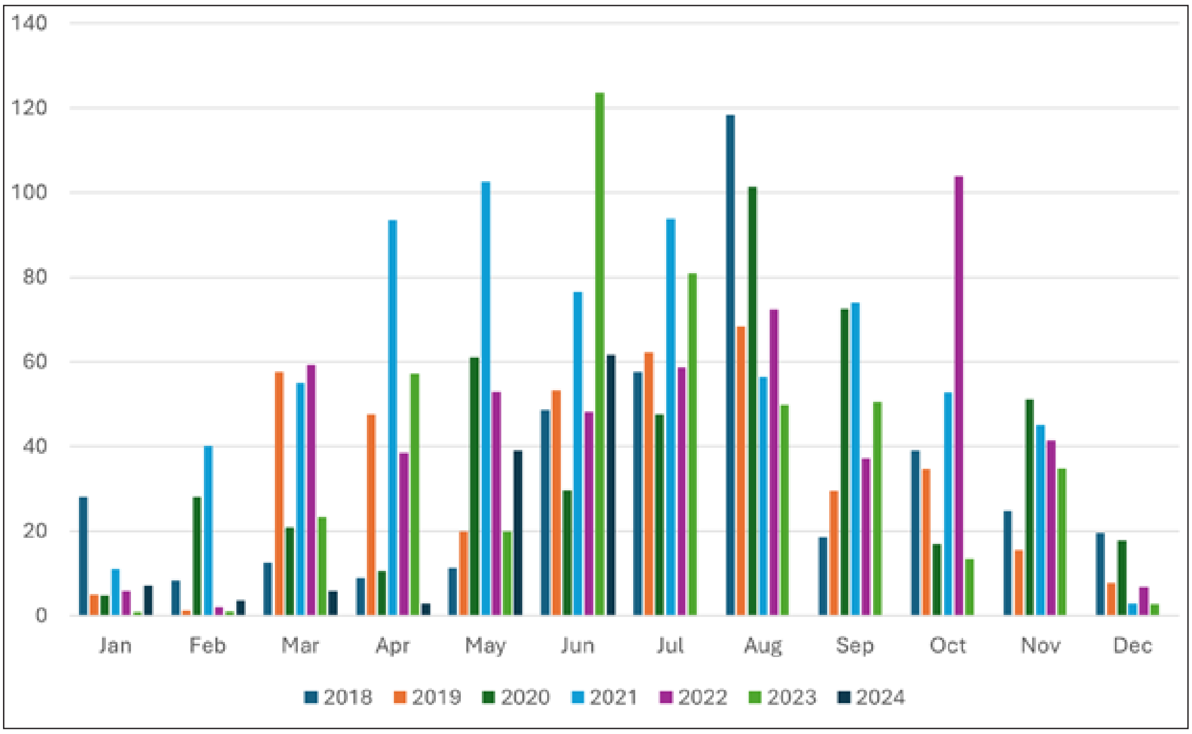


Figure 13. Mount Barker (Carbarup) monthly rainfall data (2018 to 2024)

This late start to the season significantly impacted the pasture growth rate in May and June. This often impacts overall pasture growth throughout the rest of the growing season.[18]

The pasture growth rates for a farm in the Shire of Plantagenet using the Pastures in Space Tool available from the Department of Primary Industries and Regional Development website shows the historical pasture growth rates as deciles. The shaded purple area in Figure 14 is the pasture growth in the lowest percentile years, the green shaded area is the average, and the blue is the 90th percentile. The orange line is PGR data for 2018 showing the impact of the dry April and May.

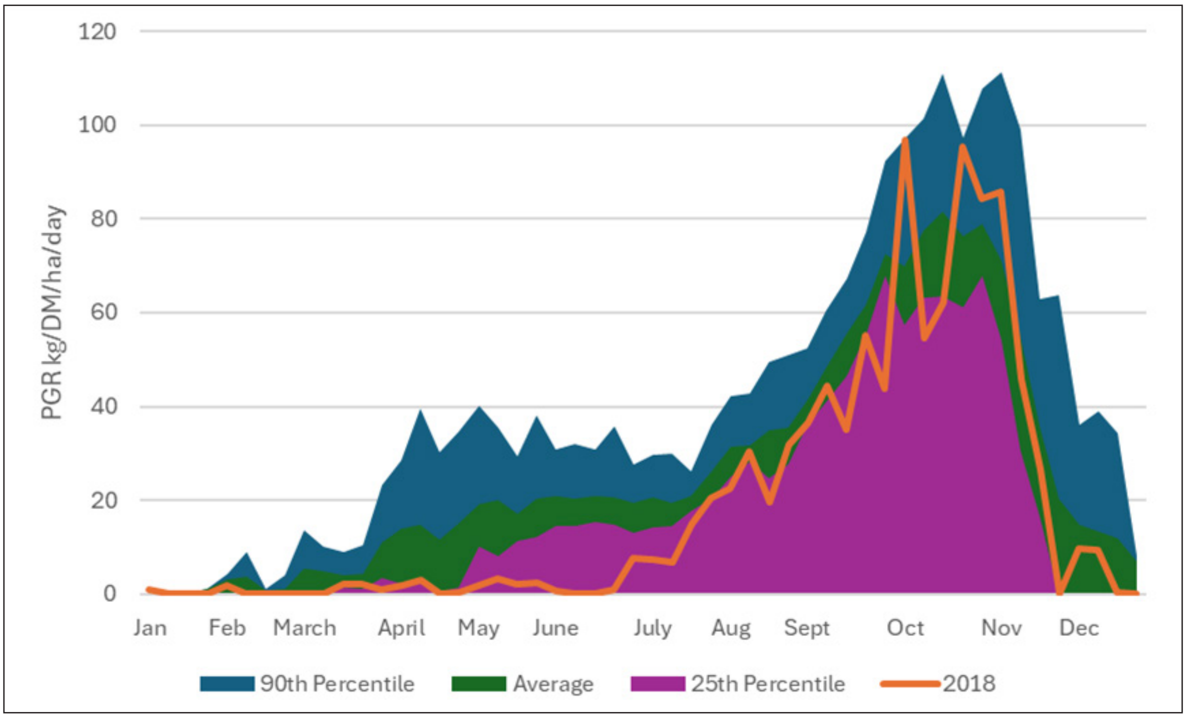


Figure 14. Pasture Growth Rates for a Farm in the Shire of Plantagenet

18 Pastures from Space, Department of Primary Industries and Regional Development https://pasturesfromspace.dpird.wa.gov.au/#/map

Soil type and soil water holding capacity have significant impact on growing conditions for crops and pastures. The water holding capacity for the sandy soils in the Coastal Great Southern Region is reliant on rainfall events above 20mm. Farmers regularly mention how rainfall events below 20-25mm are too low to have a significant impact on soil moisture in drier than average years.

Figure 15 shows the frequency of rainfall events below 20mm from 1989 to 2023. The drier years have more frequent rains when less than 20mm or 30mm fall at one time. The cumulative effect of consecutive years with a high number of rainfall events of less than 20mm impacts soil moisture and increases the severity of drought.

Figure 15 shows the increase in the number of rainfall events less than 20mm.

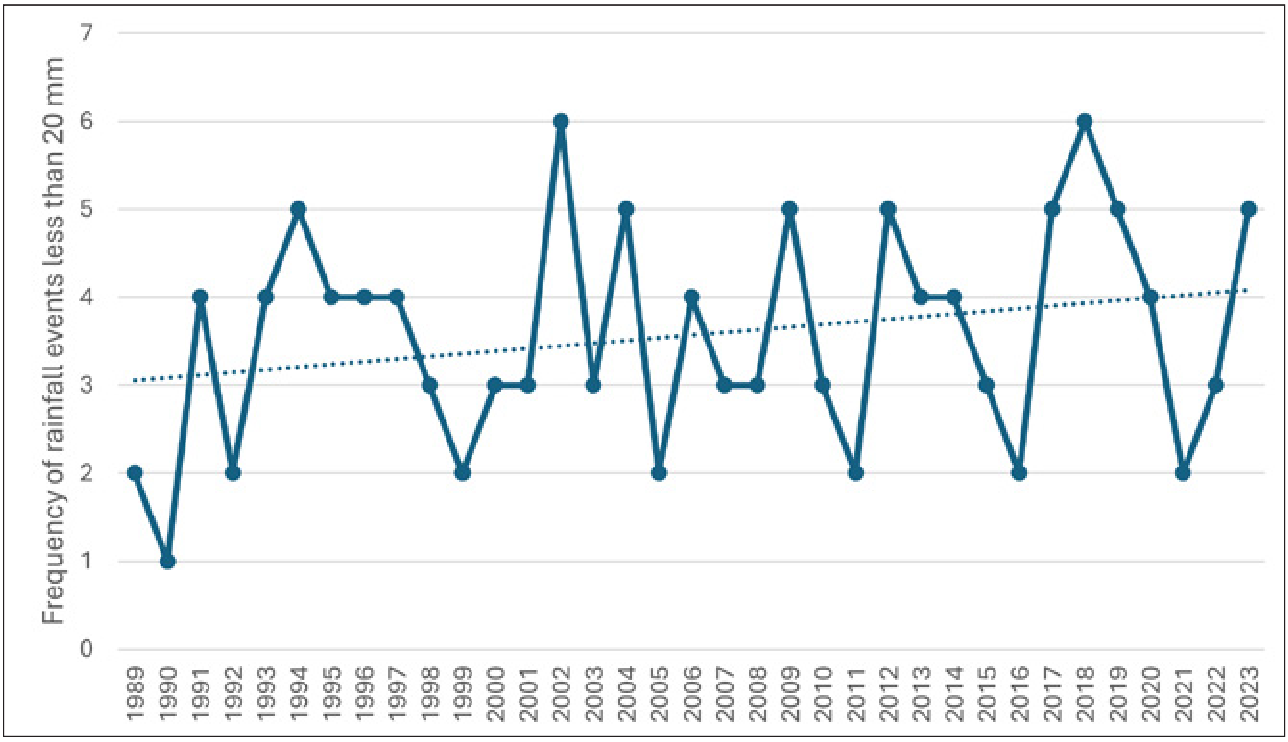


Figure 15. The number of rainfall events below 20 mm increased from 1989 to 2023.

4.6. The Shire of Denmark

Annual and growing season rainfall from 1989 to 2023 for the Shire of Denmark are shown in Figure 16. Denmark is in a very-high rainfall zone and average annual rainfall for this period is 997 mm, below the long-term average which is 1085 mm. The lowest amount of annual rainfall on record is 762 mm in 2015 after only 766 mm the previous year. The highest amount of annual rainfall is 1211 mm in 2005.

Before 1989 Denmark highest on record is 1709 mm The average growing season rainfall is 805 mm.

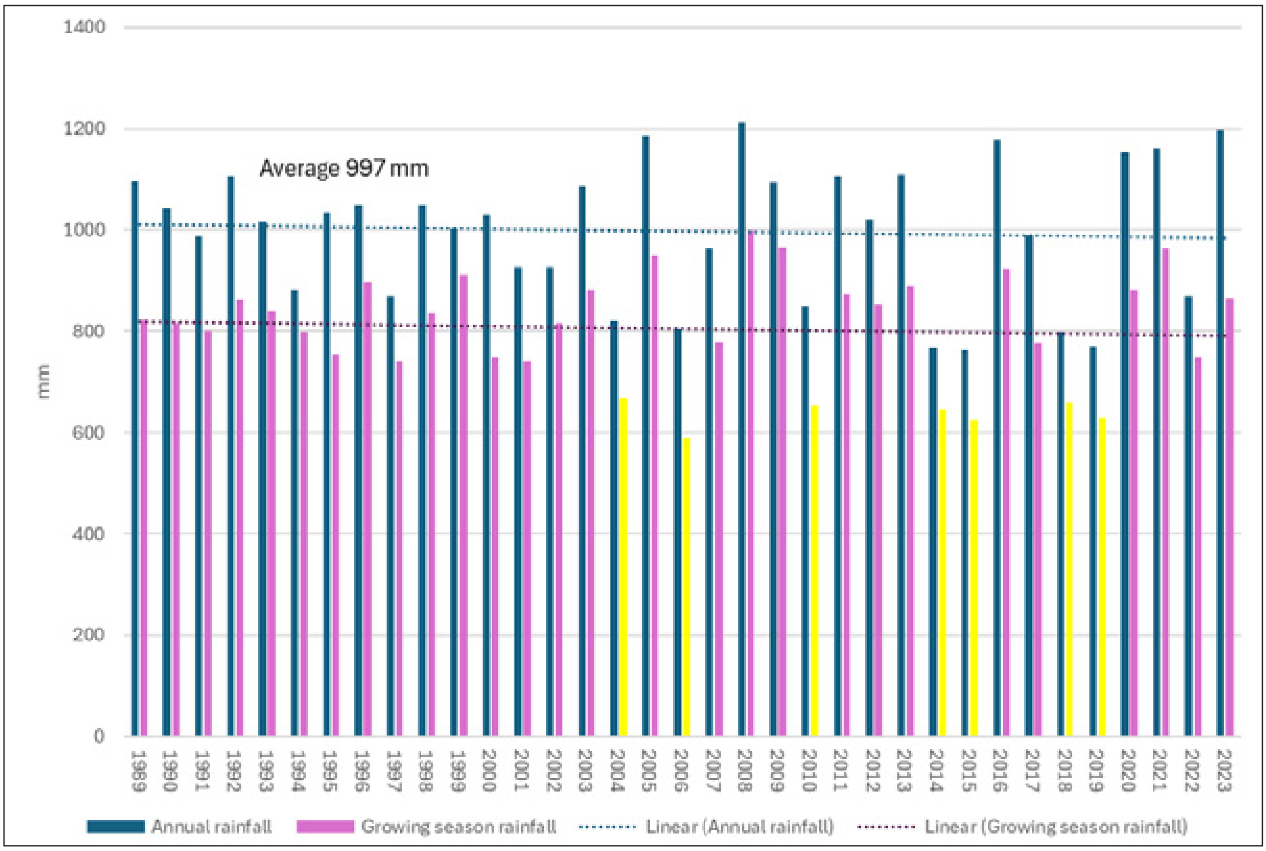


Figure 16. Denmark annual rainfall data (1989 to 2023)

The minimum amount of growing season rainfall is 740 mm, and since 1989 there have been seven years where the growing season rainfall fell below 740 mm, these years are highlighted in yellow in Figure 16 and interestingly they are all post 2003.

Like the Shire of Plantagenet and Albany, the distribution of monthly rainfall impacted Denmark in 2023. Annual rainfall looks adequate and is one of the highest rainfall years in the period we have looked at, however June rainfall was twice as much as the average for June with 300 mm, Figure17. The average for June is 140mm.

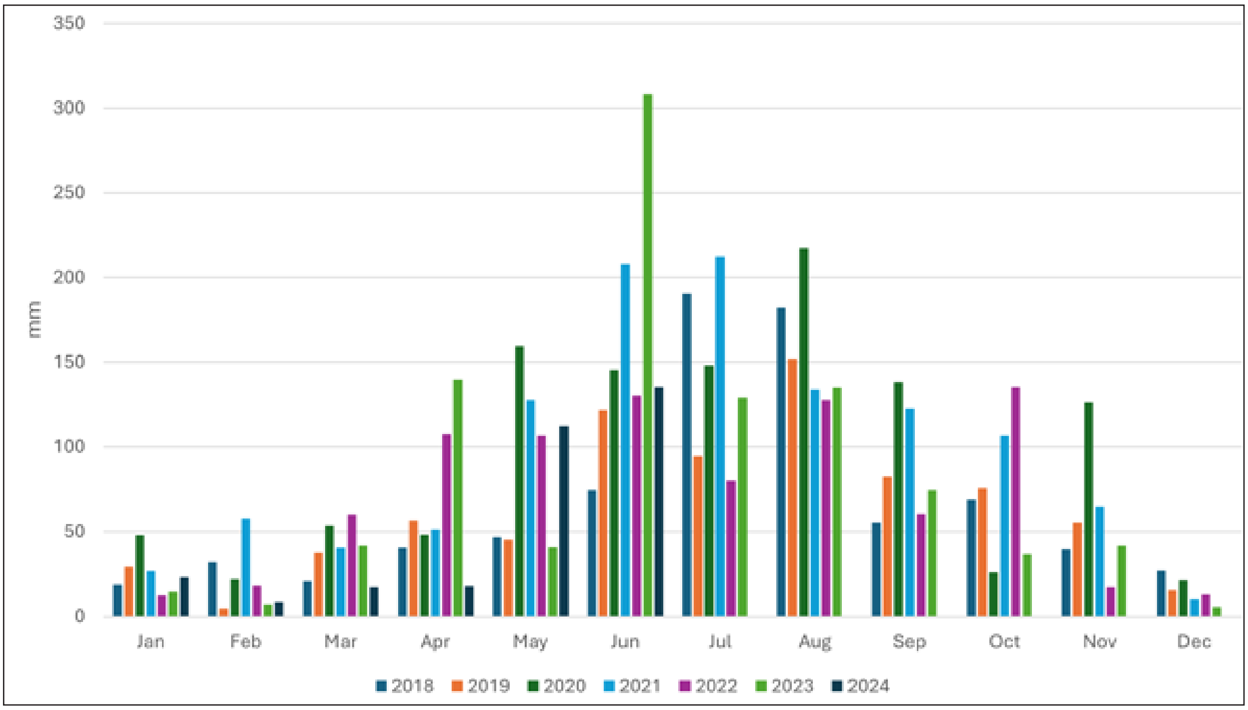


Figure 17. Denmark Monthly Rainfall Data (2018 to 2023)

However, the following month's rainfall was either average or below average and this trend continued into 2024. The impact of which can be seen using pasture growth rate data for Denmark. Figure 18 shows the how pasture growth rate for 2024 is well below the average.

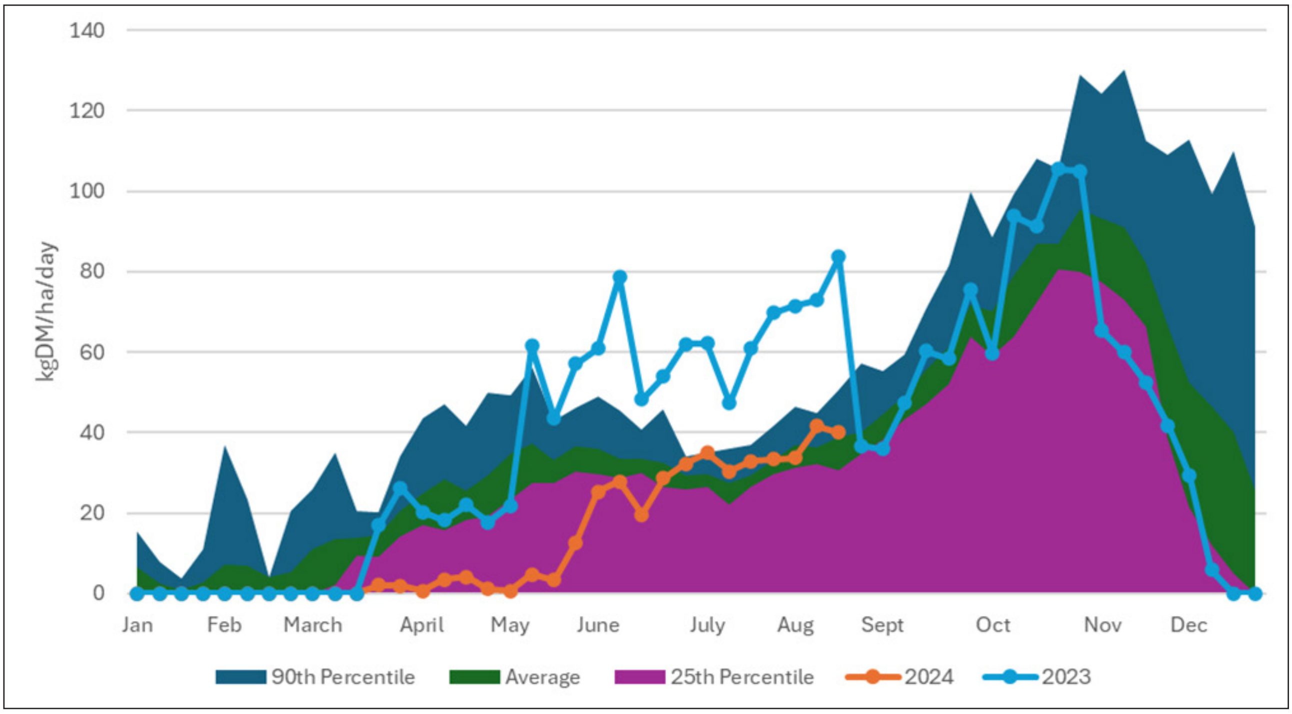


Figure 18. Pasture Growth Rate kg DM/ha/day for a farm in the Shire of Denmark

The data in Figure 19 shows when the average monthly rainfall distribution has altered, from the years 1964 to 1993 compared to the years 1994 to 2023. In March, July, October and November average monthly rainfall has decreased whilst it has increased in August, September and December.

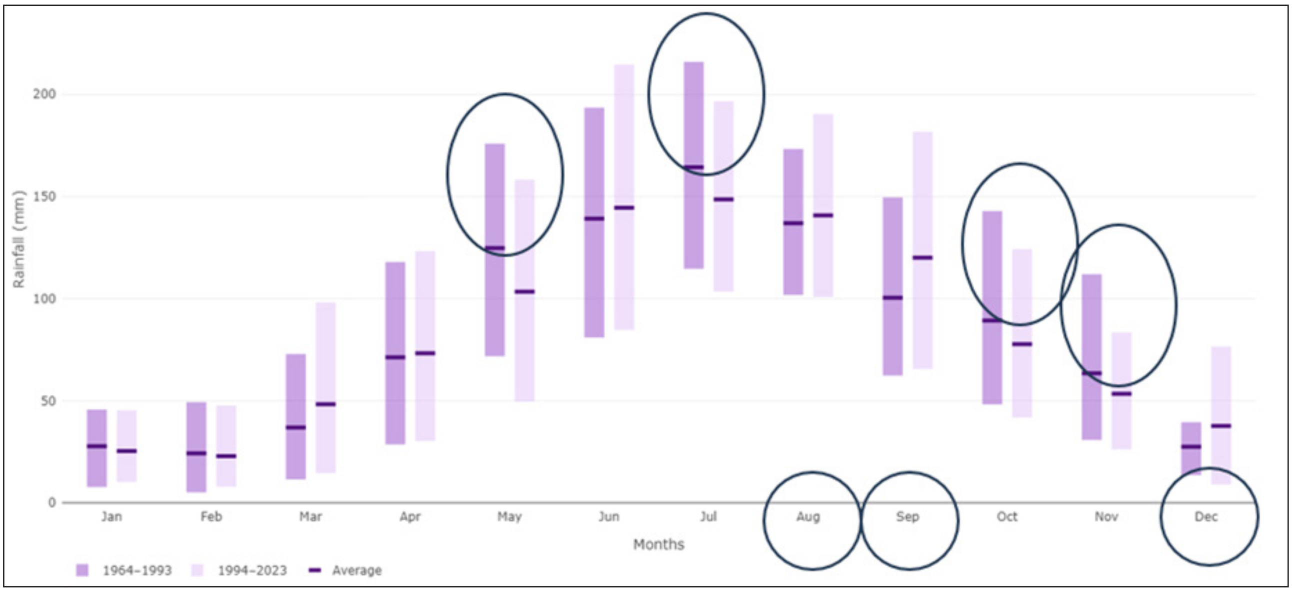


Figure 19. Historical monthly rainfall variability and change in Denmark

4.7. The Frankland River Region

The decline in the long-term average rainfall for the Great Southern Region is significant (P<0.01)[19]. This is demonstrated using data from the Frankland River region's long-term average annual rainfall. Since 1908 rainfall has declined by 162 mm, from 1908 to 1941, the average yearly rainfall was 765 mm, from 1942 to 1975, it was 711 mm and from 1976 to 2009 it was 603 mm.

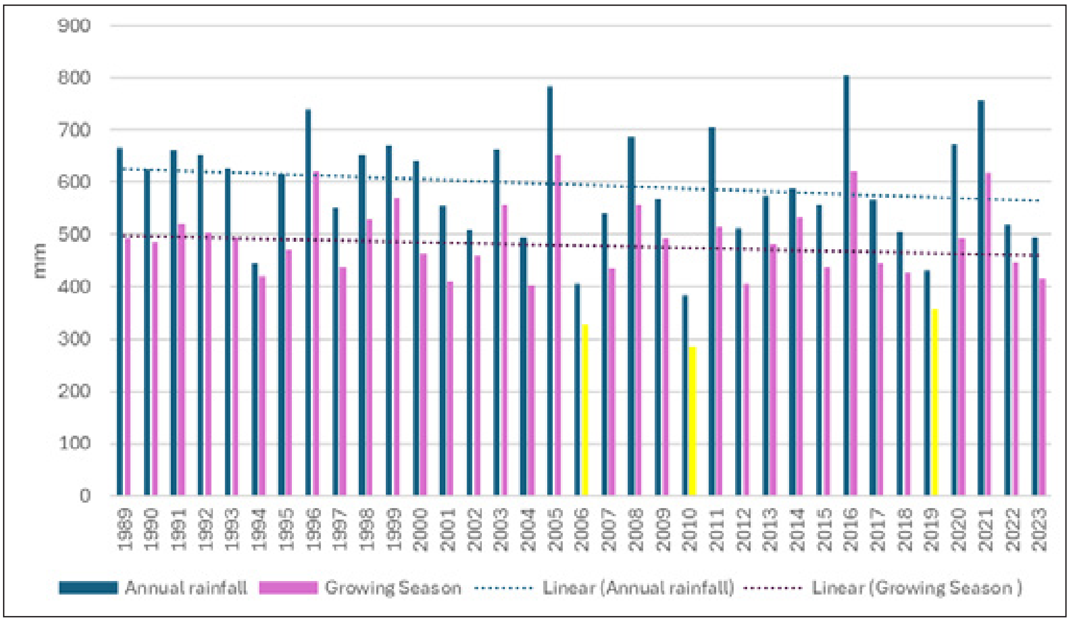
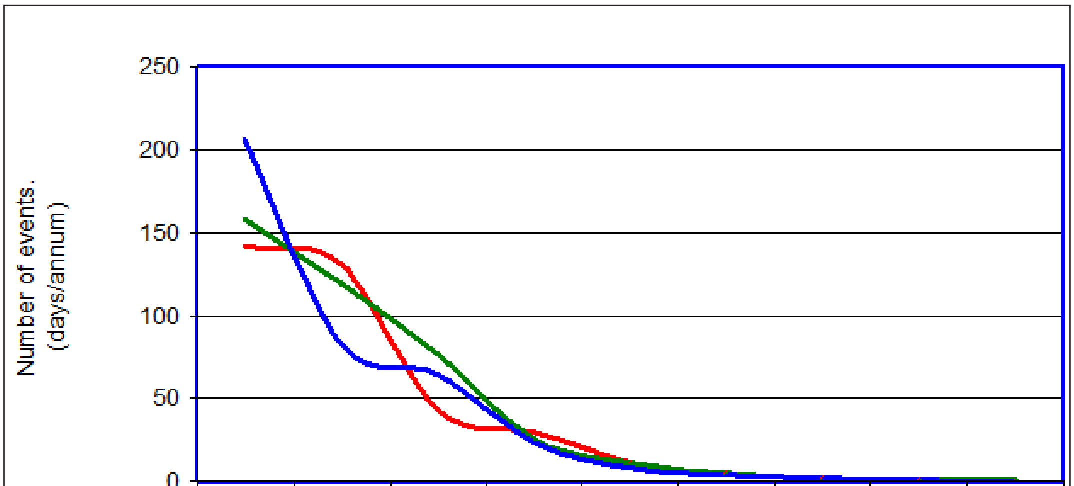


Figure 20. Frankland River annual rainfall data 1989 to 2023

Using data from 1989 to 2023 the annual average is 594 mm, and growing season average is 479 mm, Figure 20.

An analysis of the pattern of rainfall events (Figure 21) over time indicates that for the period 1976-2008, there is an increase in the average number of days that are dry and in the number of daily events which receive between 20mm and 25mm of rain relative to the period 1943-1975. However, the increased frequency in rainfall events from 20-25mm is not significant while the increase in the number of dry days is significant. In contrast, there is a decreased frequency of all other rainfall event sizes between the two-time periods.



	0mm	0.1-2mm	2-5mm	5-10mm	10-15mm	15-20mm	20-25mm	25-30mm	>30mm
1908-1941 Av.	142.12	130.91	43.12	29.09	11.26	4.74	2.18	0.94	0.32
1942-1975 Av.	158.44	119.79	76.26	25.91	10.79	4.91	1.59	0.85	0.65
1976-2009 Av.	205.94	83.15	64.29	23.71	8.35	3.85	1.79	0.62	0.47

Rainfall event grouping (mm)

Figure 21. Frequency of rainfall events per annum for a range of daily rainfall events for Frankland.

19 Lang, M, Hetherington, R., McDonald, C., (2010) Reducing evaporation and efficient water harvesting: - demonstration of evaporation control and benchmarking vineyards. Department of Agriculture and Food, Western Australia for the Grape and Wine Research and Development Corporation.

The Frankland River experienced a wet June in 2023 (Figure 22), like the other places in the Coastal Great Southern Region, followed by a drier-than-average Spring, resulting in reduced crop yields by up to 1 tonne to the hectare less than expected.

In the last decade, producers in the Frankland River have responded to a drier climate by increasing crop areas. Traditionally sheep were a significant focus for many producers and whilst they are still a part of many businesses, many producers have significantly increased their cropping programs whilst decreasing their sheep numbers. Improved technology, and drainage to manage water logging has seen significant productivity improvements. A drying climate has improved yields and profitability in this region.

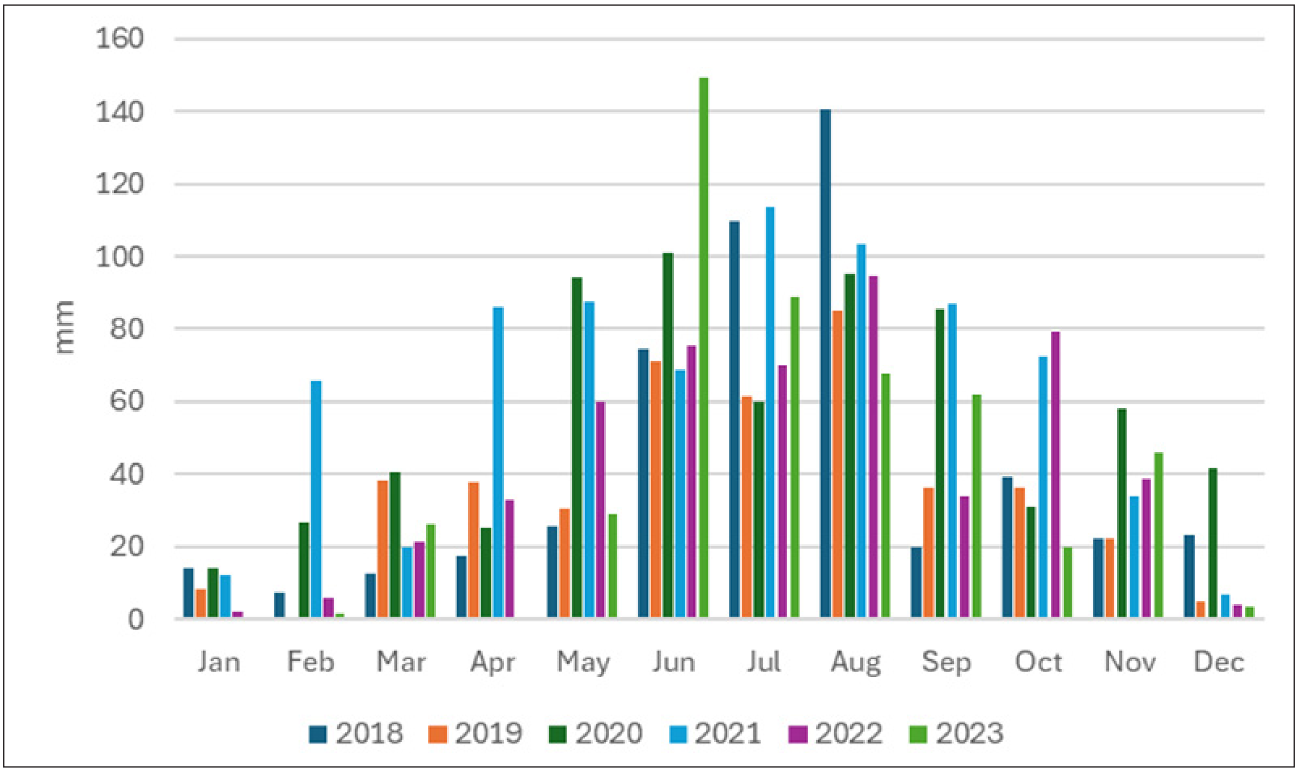


Figure 22. Monthly rainfall distribution for Frankland River region 2018 to 2023

4.8. Future climate predictions for the Coastal Great Southern

This analysis highlights the anticipated rainfall reductions in the Coastal Great Southern Region under a medium emissions scenario by 2050. Based on the forecast:

- **Albany** is expected to experience a significant reduction in mean annual rainfall, with a decrease of **106 mm,** particularly during the **Winter and Spring** months, Figure 23.
- **Denmark** is forecast to face an even larger reduction, with a decrease of **131 mm** annually by 2050, also predominantly in **Winter and Spring**, Figure 24.
- **Frankland River** and **Mount Barker** are predicted to see more modest decreases in rainfall, with reductions of **14 mm** and **28 mm** respectively in annual averages by 2050, Figure 25 & 26.

This data suggests that the coastal regions may face considerable changes in seasonal rainfall patterns, especially during key agricultural months, which could impact local ecosystems, farming, and water resources.

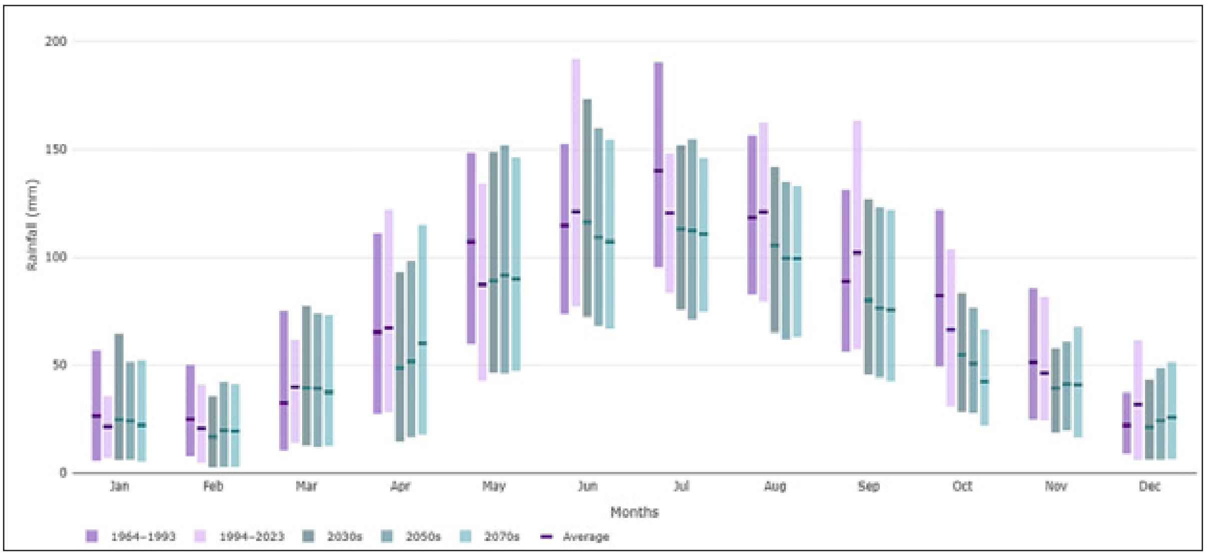


Figure 23. Future climate predictions for the City of Albany

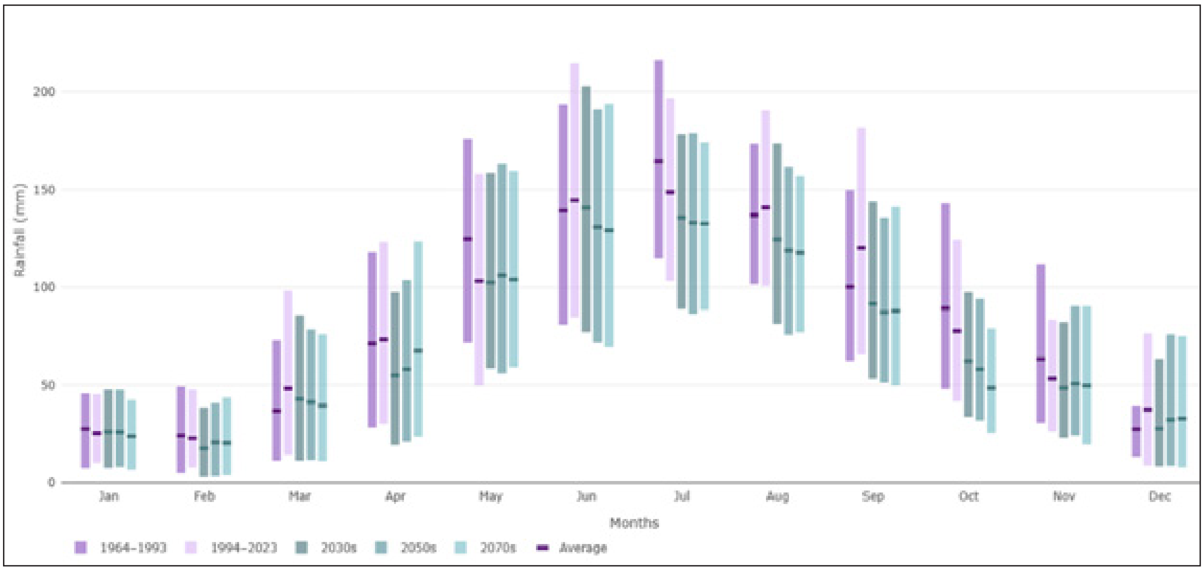


Figure 24. Future climate predictions for the Shire of Denmark

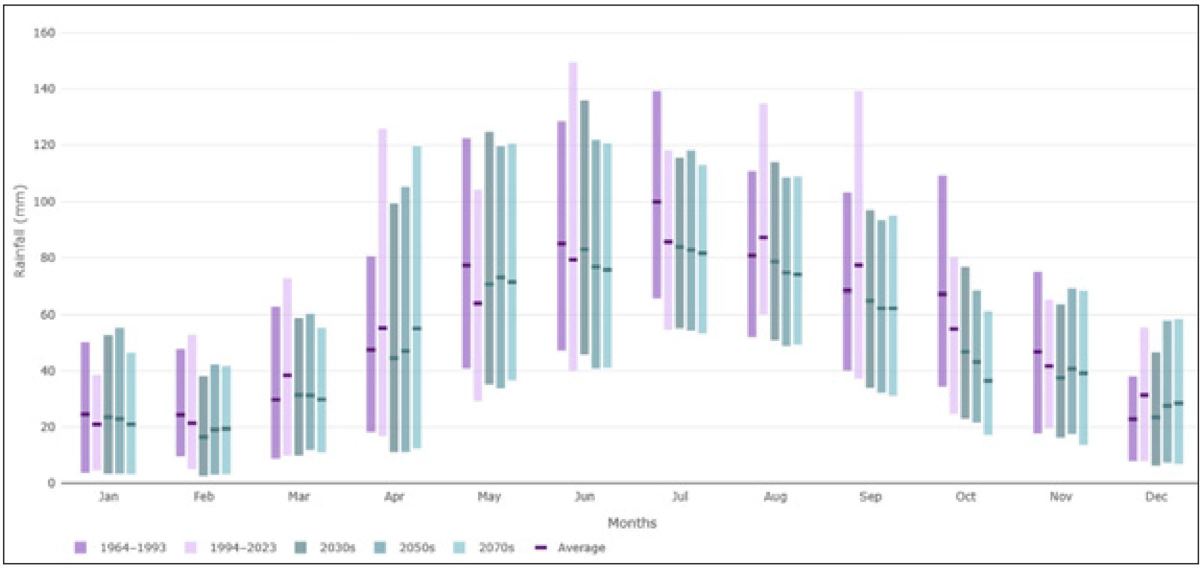


Figure 25. Future climate predictions for the Shire of Plantagenet

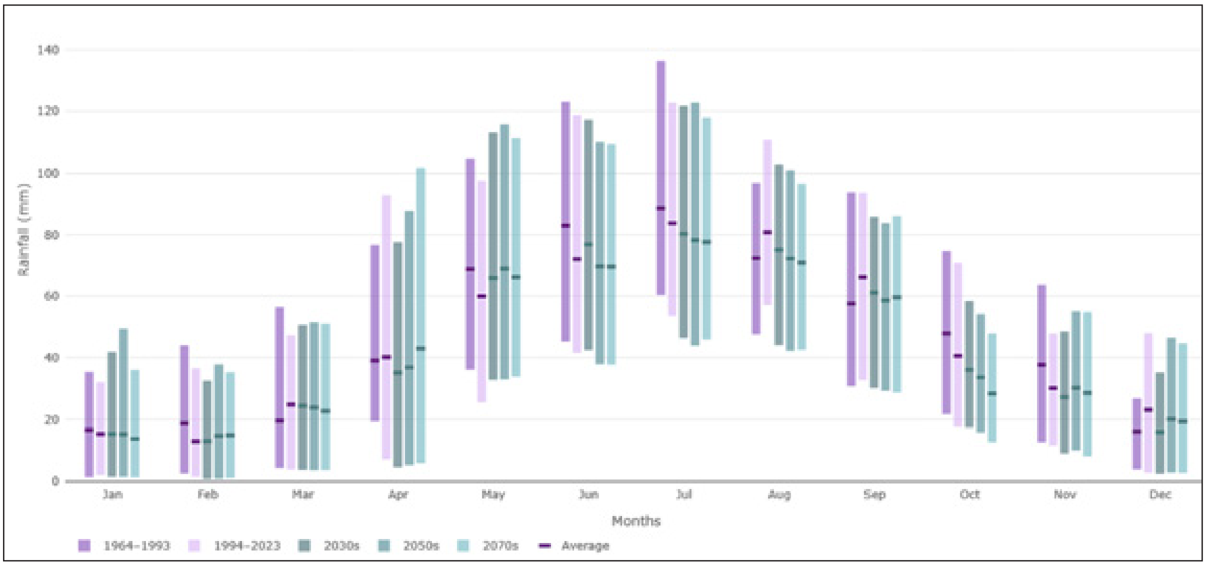


Figure 26. Future climate predictions for the Frankland River Region

5. Sensitivity - Characteristics of the Coastal Great Southern Region

5.1. Land use activities

Land use is determined by soil type, topography and rainfall. Other factors like distance to markets, individuals' preferences and skills influence land use activities and farm businesses.

Most agricultural land mass (excluding the rangelands) is used for extensive cropping and livestock grazing activities, which is defined as broadacre agriculture.[20] Most of this agricultural land is owned as private property and managed by individuals, and corporations, many are family-owned farming businesses. Whereas much of our Natural landscape and biodiversity is vested in Crown land which occupies 92 per cent of the State, its sustainable management is essential for effectively protecting biodiversity and heritage.[21] Crown land is all land in Western Australia for which there is no certificate of title under the Transfer of Land Act 1983 (TLA), or a memorial or grant registered under the Registration of Deeds Act 1832.

Several government State agencies are entrusted with varying degrees of management roles over Crown land, with the major roles being played by the Department of Biodiversity Conservation and Attractions, the Water Corporation, the Department of Mines, Industry Regulation and Safety, the Department of Water and Environmental Regulation and, to a lesser extent, the Department of Transport.

20 Anderton L (2017) Financial, Productivity and socio-managerial characteristics of broadacre farms in Western Australia: A decadal assessment. Master's Thesis.
21 Environmental Defenders Office of Western Australia (inc) 2010 Crown Land Management. Fact sheet

The South Western corner of Australia is internationally recognised as a biodiversity hotspot. It is known for its species diversity, although two-thirds of the vegetation has been cleared over much of the agricultural region with some areas having less than 5-10% of their original bushland remaining, leaving some species threatened.[22]

The Coastal Great Southern region has significant areas of natural vegetation. The Shire of Denmark is renowned for its natural beauty and environment, with 65% of its land mass natural vegetation and environments, Figures 27 and 28. It has the smallest area of dryland cropping with 160 km² or 9% of its land mass even though it is the second largest activity.

Other activities, often in the high rainfall areas like the Coastal Great Southern Region include viticulture, horticulture and forestry.

5.1.1. Land use activities in the Shire of Denmark

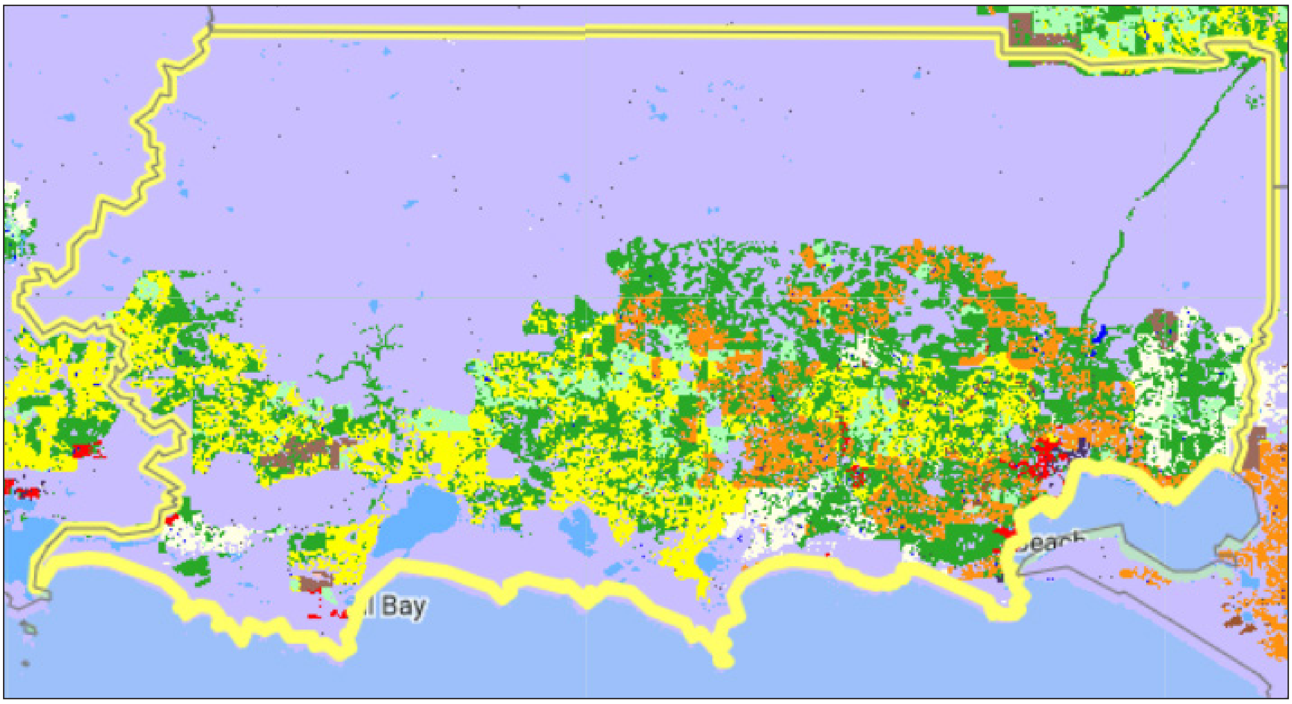
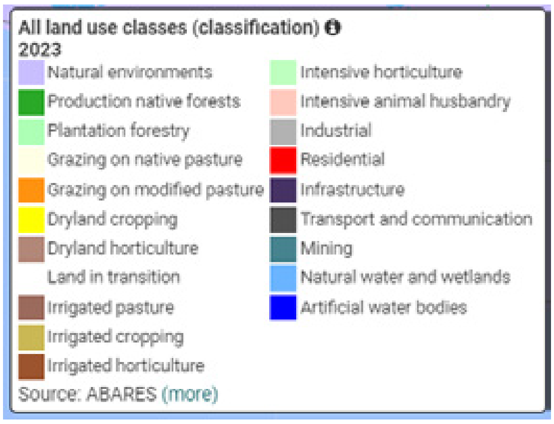


Figure 27. Land classification for the Shire of Denmark[23]

More information about land classification can be found on the ABARES website. Refer to Appendix 3



22 https://gondwanalink.org/about-us/why-gondwana-link/
23 https://www.agriculture.gov.au/abares/aclump/land-use/alum-classification

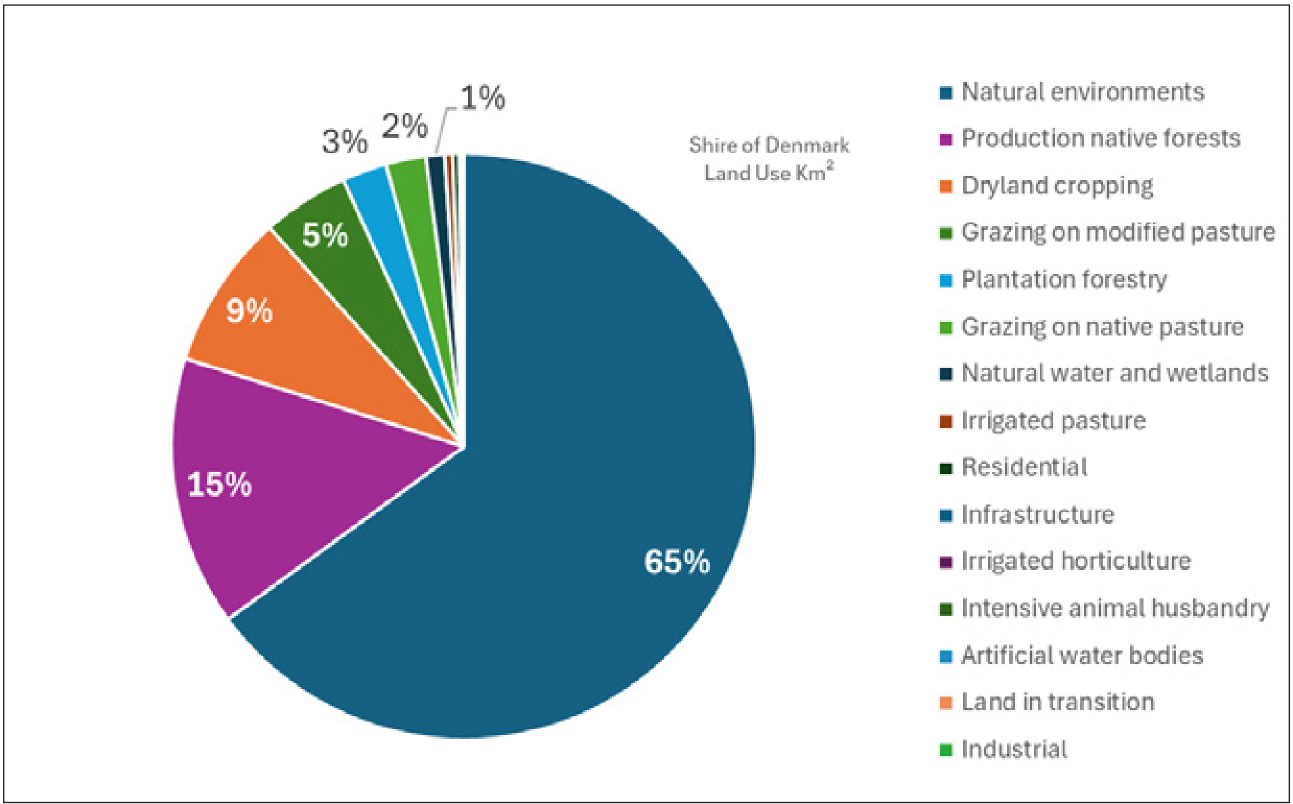


Figure 28. Shire of Denmark Land Use (% of Km²)

5.1.2. Land use activities in The Shire of Cranbrook – Frankland River

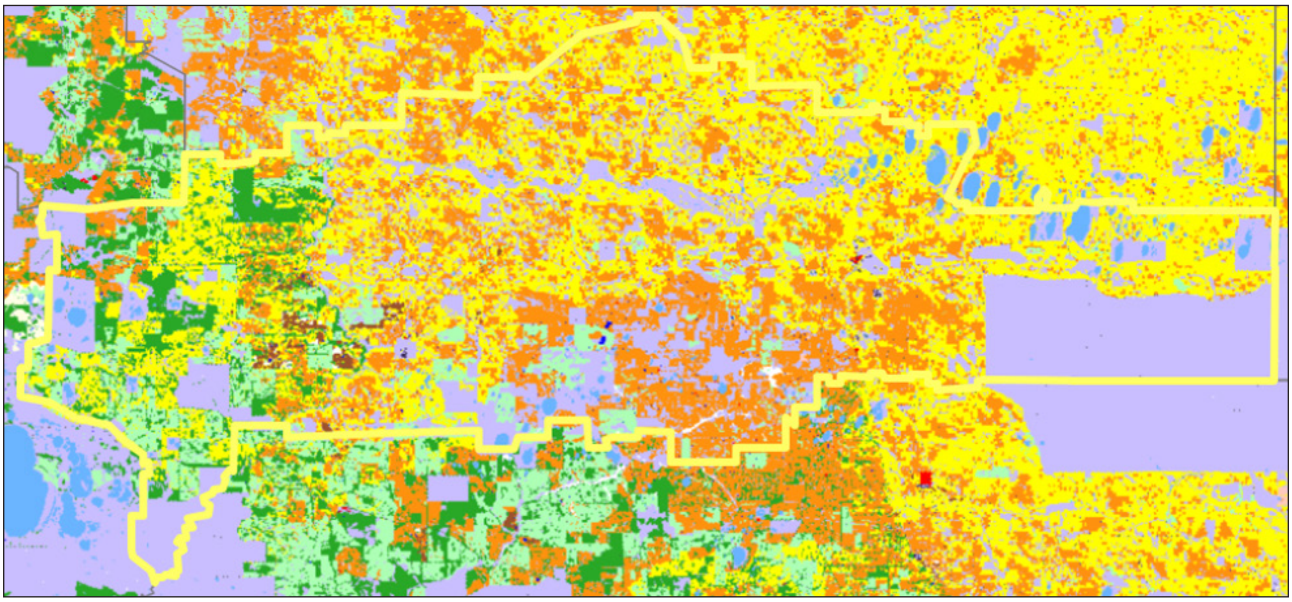


Figure 29. Land classification for the Shire of Cranbrook

Land use in the Shire of Cranbrook is dominated by dryland cropping and grazing on modified pasture. The natural environment is 917 km² which is 28 per cent of the land mass. Part of the Stirling Ranges are on the East side of the Shire of Cranbrook. Areas of blue gum plantations exist although these areas have reduced in recent years as land returns to broadacre agriculture production. This region is also the primary grape growing area, producing international recognition for outstanding wine production. The Great Southern region is the state's largest wine region by total area and 255 hectares of grapevines are in the Shire of Cranbrook, mostly in the west and in the Frankland River Region.

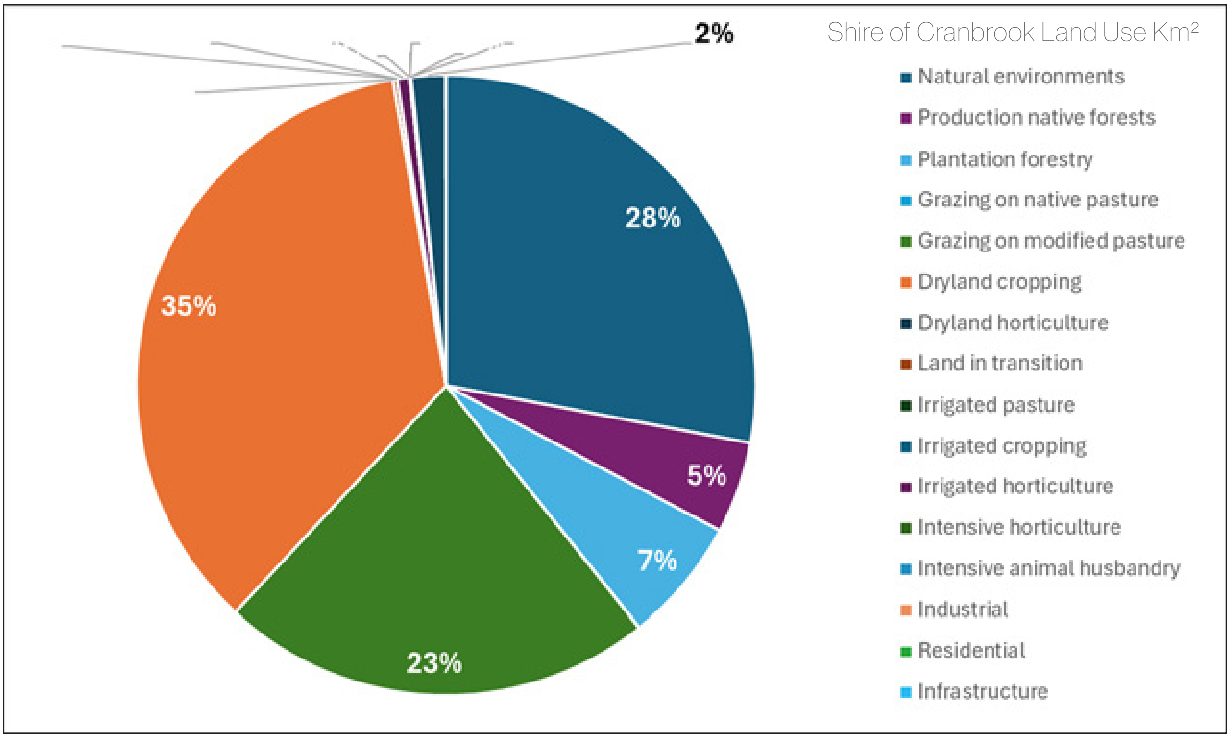


Figure 30. Shire of Cranbrook Land Use (% of Km²)

5.1.3. Land use activities in The Shire of Plantagenet

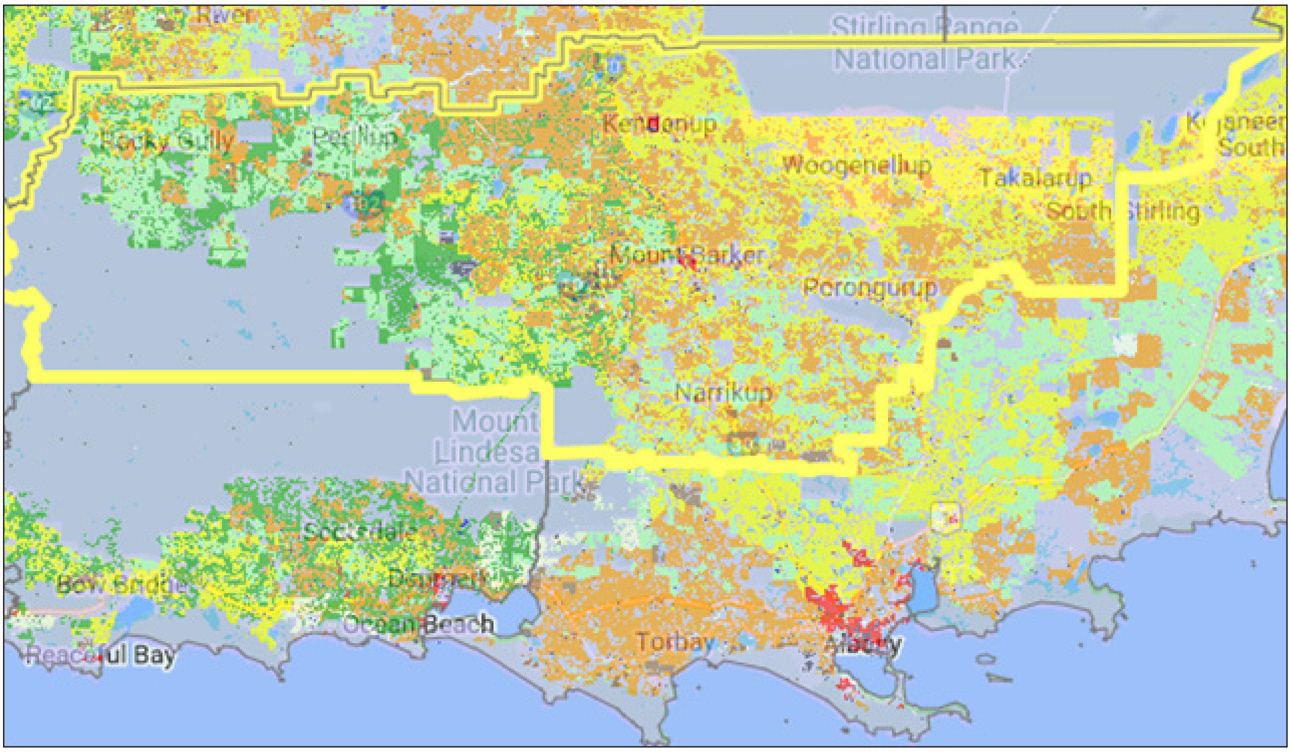


Figure 31. Land classification for the Shire of Plantagenet

Land use activities in the Shire of Plantagenet include 21 km² of irrigated horticulture, dryland cropping which is the largest activity using 1067 km² and grazing on modified pastures, 940 km². The natural environment shown in Figures 31 and 32 is 1210 km² which is 36 per cent of the land mass.

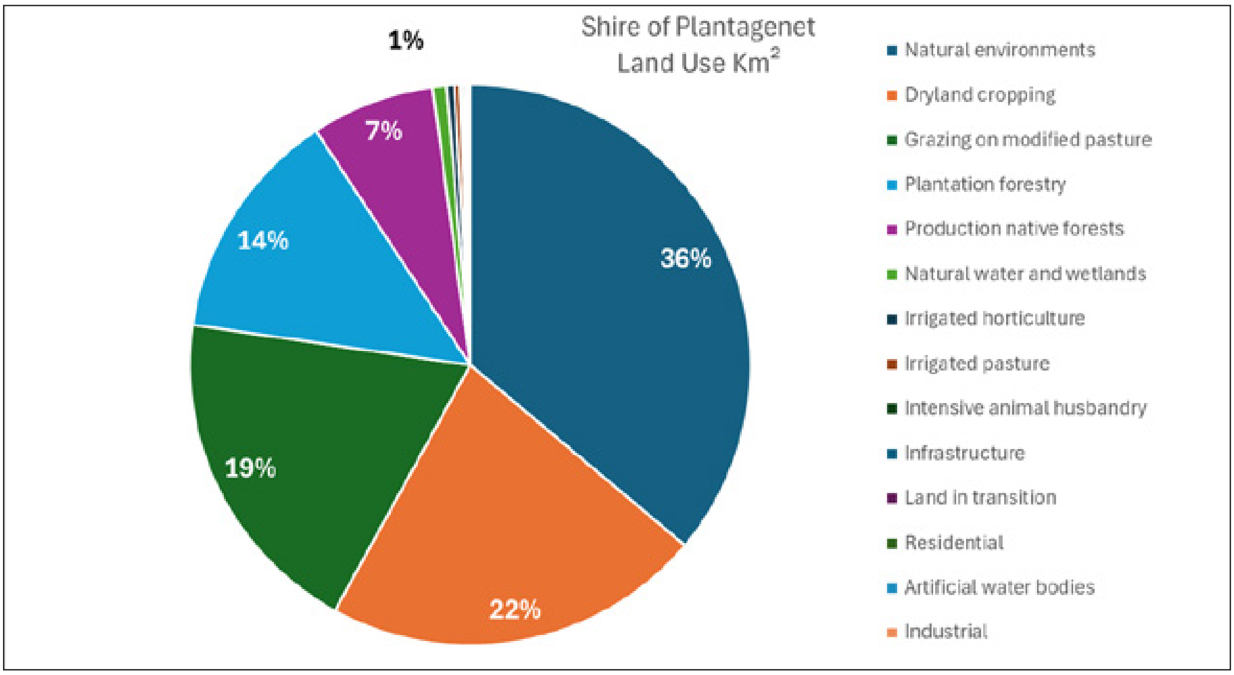


Figure 32. Shire of Plantagenet Land Use (% of Km²)

Plantation forestry is 656 km² (13.5 per cent), the second largest area of plantation forestry in WA, after Albany which has 733 km², Figure 34.

5.1.4. Land use activities in the City of Albany

Plantation forestry is the third largest land user for the City of Albany. Dryland cropping (27%) is the largest with grazing on modified pasture (18 per cent). In 2023 there is a small percentage of native forest production which was phased out in 2024.

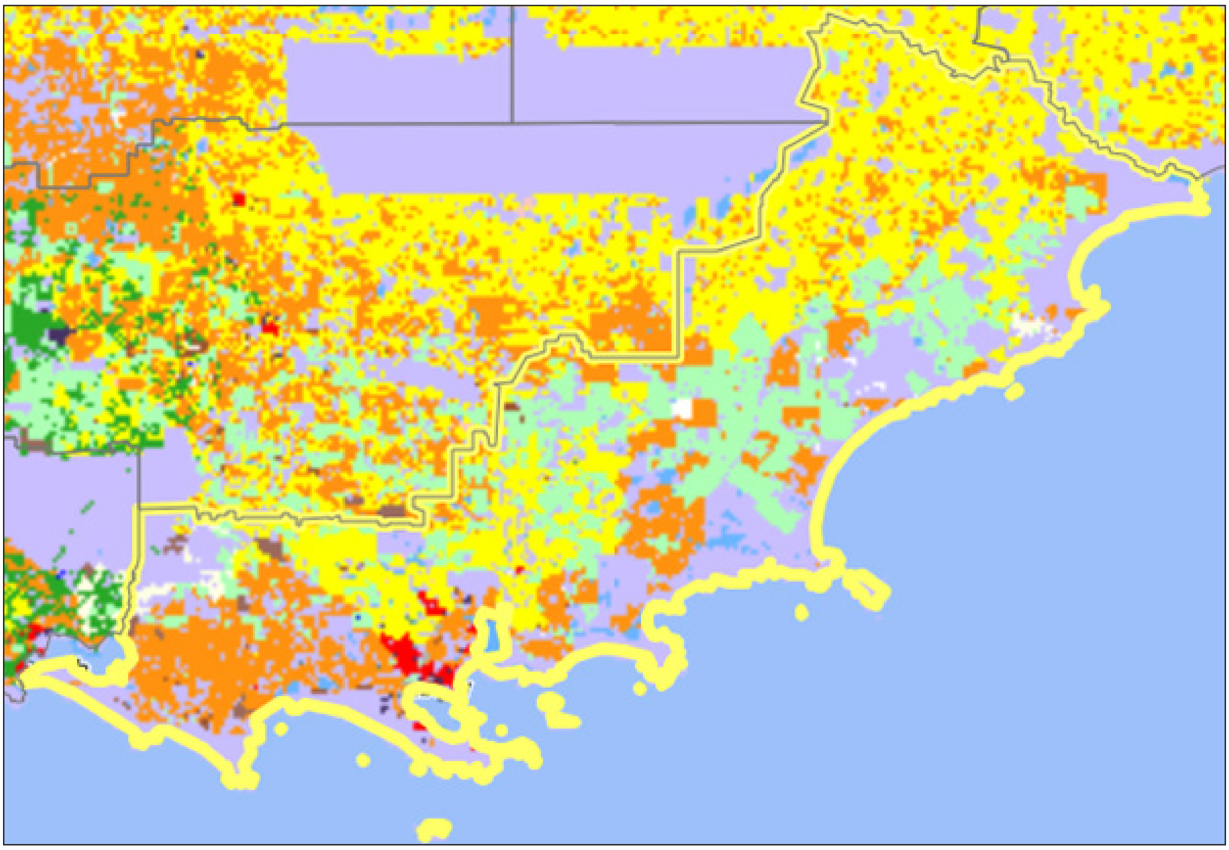


Figure 33. Land classification for the City of Albany

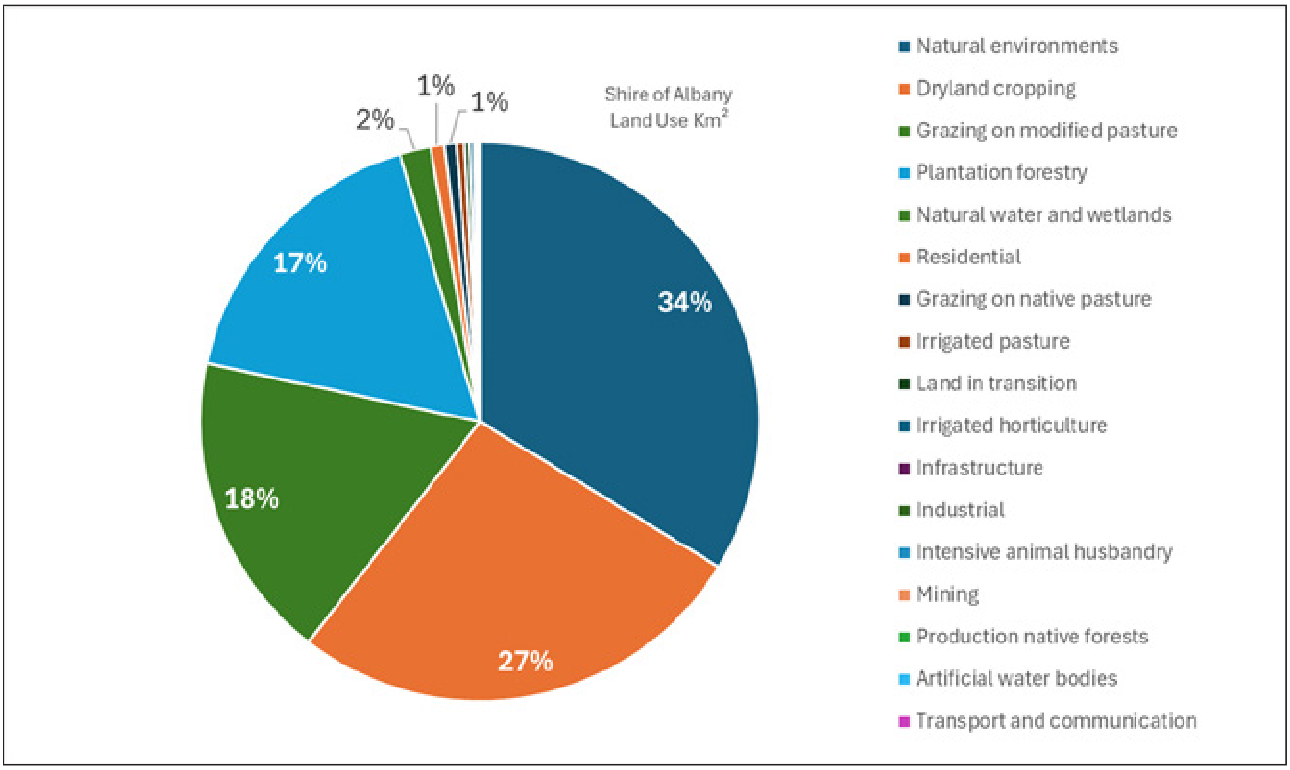


Figure 34. City of Albany Land Use (% of Km²)

In the Western part of the City of Albany livestock enterprises, beef, and dairy to a lesser extent graze on modified pasture, Figure 34. Irrigated horticulture (10.86 km²) is close to the Albany townsite. Land use activities change and diversify north and to the East of Albany with dryland cropping and plantation forestry. Overgrazing can also create problems with soil erosion from heavy rain events or wind events. Sandy soils are dominant in the landscape especially close to the coast where land is used for grazing enterprises.

5.2. Soil Types

The main soil types in the region are Deep Sandy Duplexes, Iron Stone Gravels, Pale Sands and to a lesser extent, shallow sandy duplexes, Figure 35. Using van Gool, et al., (2018) as a guide the soil types in Figure 35 are the predominant soil types. There are more types found but less significant and for more detail see van Gool, et al., (2018).

The soil types are largely infertile soil types requiring fertilizer and lime to manage pH levels. They tend to have low to moderately low soil water storage and are prone to water repellence (non-wetting)[24]. Soil erosion from wind events can occur if not managed with care. Claying is used as a management tool to improve water holding capacity and yields for dryland cropping. Management tools like no-tillage or minimum tillage, and conserving soil moisture by spraying summer weeds have all contributed to improving farming practices, preventing wind erosion and improving yields.

24 van Gool, D, Stuart-Street, A and Tille, P. (2018) Distribution of classified soils in south-west Western Australia, Resource management technical report 401, Department of Primary Industries and Regional Development, Perth

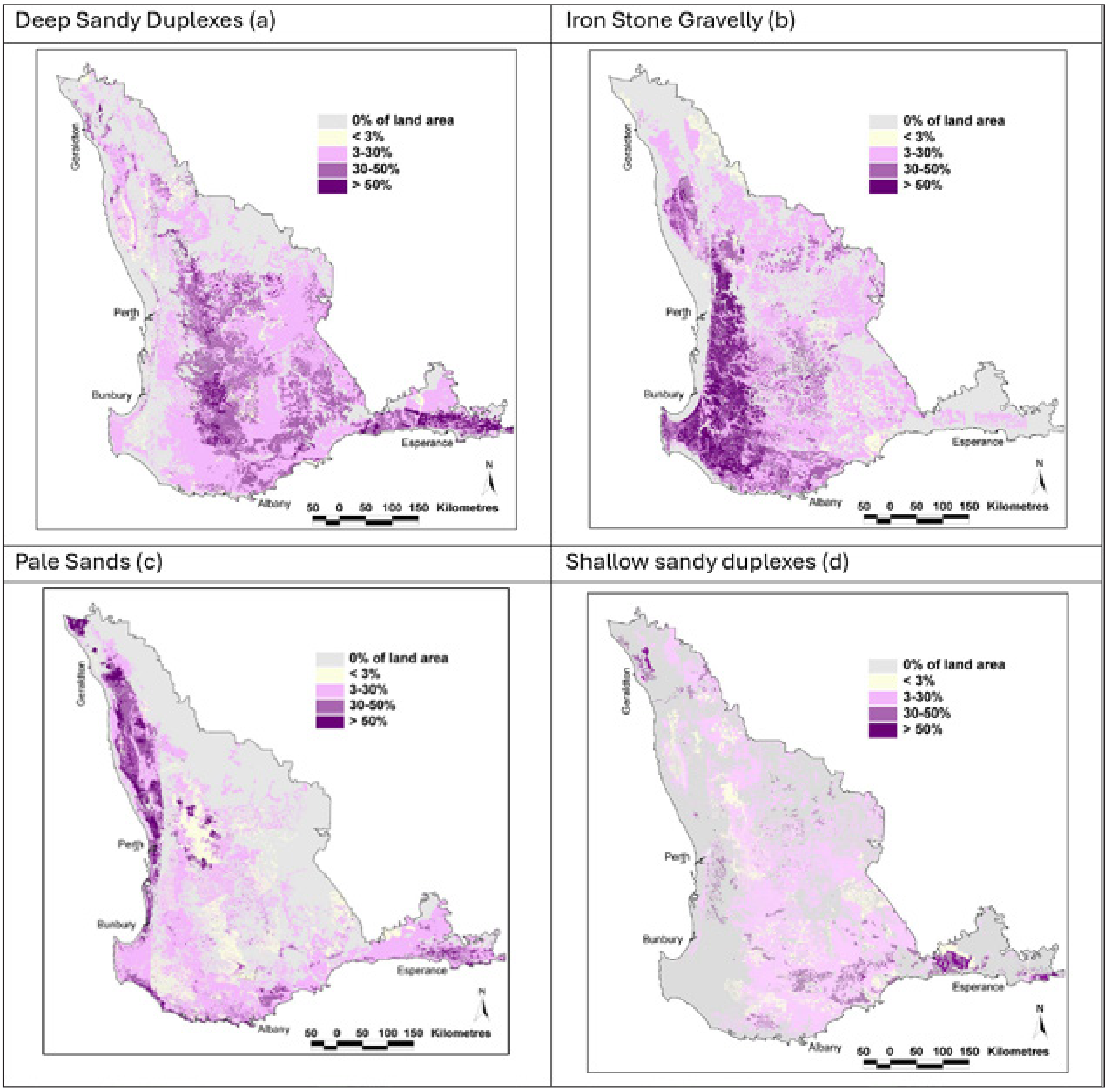


Figure 35. Dominant soil types found in the Coastal Great Southern Region

Deep sandy duplexes (Figure 35 a) defined by van Gool, et al., (2018) typically have low or moderate natural fertility and require fertiliser, they are prone to acidity and aluminium toxicity occurs and acid sandy topsoil is common. They have low to moderately low soil water holding capacity and are highly prone to wind erosion on exposed flats and rises. Water erosion can also be a problem on slopes receiving run-off. These soils can create complexities for management as many cannot be worked when too wet or are very hard when too dry.

The iron stone gravelly soils (Figure 35 b) can be prone to wind erosion too when they have sandy topsoil, but the presence of gravel on the surface can reduce the risk. They can have low to moderately low estimated water storage; however, crop performance seems to indicate this is better than estimated.

Shallow sandy duplexes (Figure 35 d) are usually deep but moderately shallow crop rooting is common on poor clays (sodic or saline). They have moderate natural fertility, but the sandy surface topsoil may be moderate to highly water repellent and often they have very low water storage capacity. They are highly prone to wind erosion on exposed flats and rises.

The risk of wind erosion and soil degradation for all these soil types increases in dry or drought conditions. Farming techniques used to prevent wind erosion are minimum tillage, stubble retention and restricted grazing in summer and autumn.

The environmental scorecard method and environmental data monitoring of several environmental measures are discussed in the following section of this report.

5.3. Value of Agriculture in Western Australia

Western Australia's south-west land division is divided into four subregions: the Mid-West, Wheatbelt, Goldfields-Esperance, and the Great Southern. Together, these regions contribute over $6 billion to the gross value of agriculture production through a diverse range of sectors, including grains, livestock and horticulture.[25]

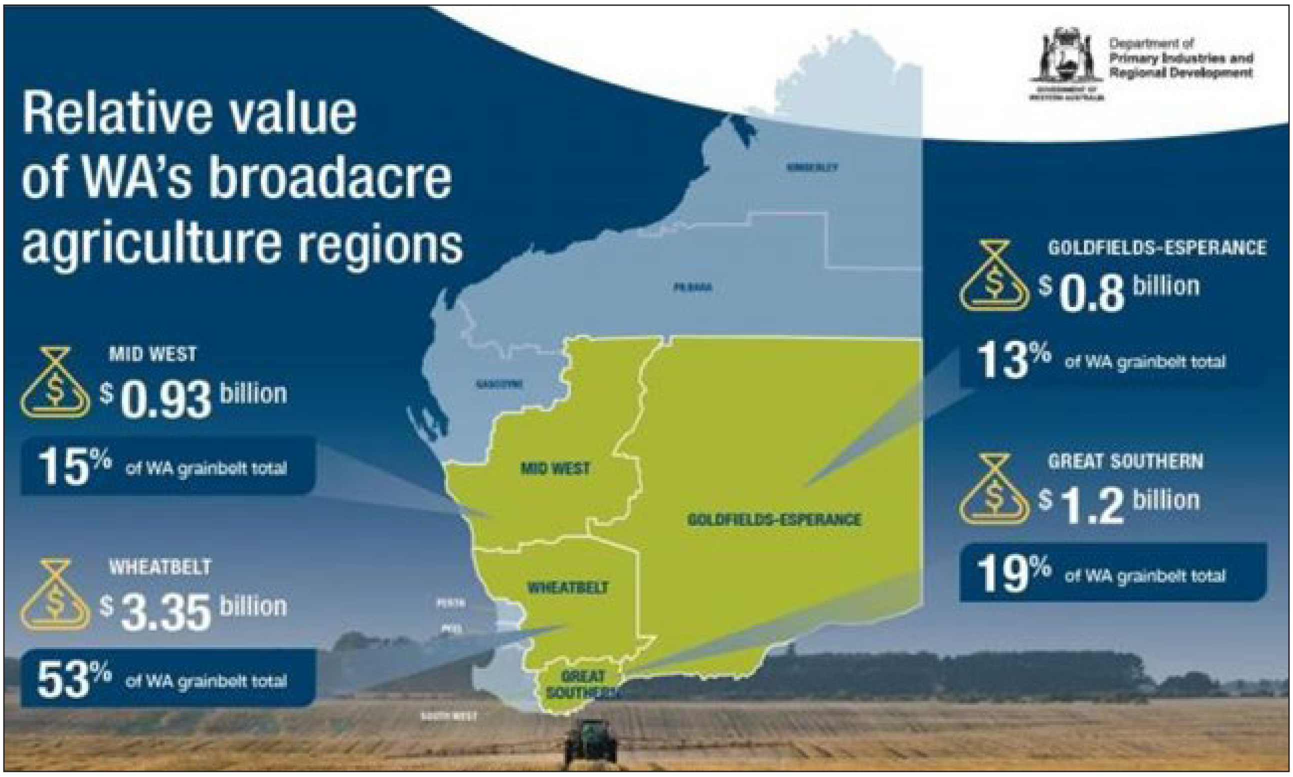


Figure 36. A map of the four broadacre agriculture subregions of Western Australia, and their relative value to the gross value of agriculture production.

Identifying how the Great Southern contributes to the WA economy and the Coastal Great Southern local government areas is the focus of the next section.

5.4. Value of Agriculture in the Great Southern[26]

Encompassing more than 3.9 million hectares, the Great Southern region supports a diverse array of primary industries, with approximately 2.2 million hectares, or 58 per cent of the area, designated as arable land. These fertile expanses contribute significantly to the region's agricultural value which totals around $ 1.2 billion annually and represents 19 per cent of the total value of WA's broadacre regions. The region experiences significantly diverse rainfall patterns, ranging from 900mm in the South West to 225mm in the northeast.

Broadacre cropping and livestock activities dominate the region, accounting for 96 per cent of the region's annual agricultural value. Notably, agriculture influences approximately 60 per cent of the region's entire economic activity directly or indirectly.

Grain production, including barley, oats, canola, wheat, and hay, constitutes about 56 per cent of the production value, with an annual grain production averaging 3,515,200 tonnes over the 2016-2020 period, representing 26 per cent of the total grain belt production. Wheat and barley emerge as primary crops, contributing to 36 and 42 per cent of the total grain production, respectively. This reflects a recent decline in wheat and an increase in barley cultivation. Additionally, a significant portion of canola grown in the region, around 70%, is non-GMO products.

25 https://www.agric.wa.gov.au/crops/regional-snapshots-value-broadacre-agriculture-south-west-wa

26 Department of Primary Industries and Regional Development, 2021, Great Southern, Western Australia broadacre agriculture regional snapshots, https://www.agric.wa.gov.au/crops/regional-snapshots-value-broadacre-agriculture-south-west-wa

Livestock farming accounts for 40 per cent of the total annual production value. The region recorded 3,160,000 head of sheep and 232,000 head of cattle in 2021, constituting 30 per cent and 36 per cent of the grain belt totals, respectively.

The value of agriculture for each local government in Western Australia, in Figure 38 shows the Shire of Plantagenet and Cranbrook as contributing high levels of agriculture product.

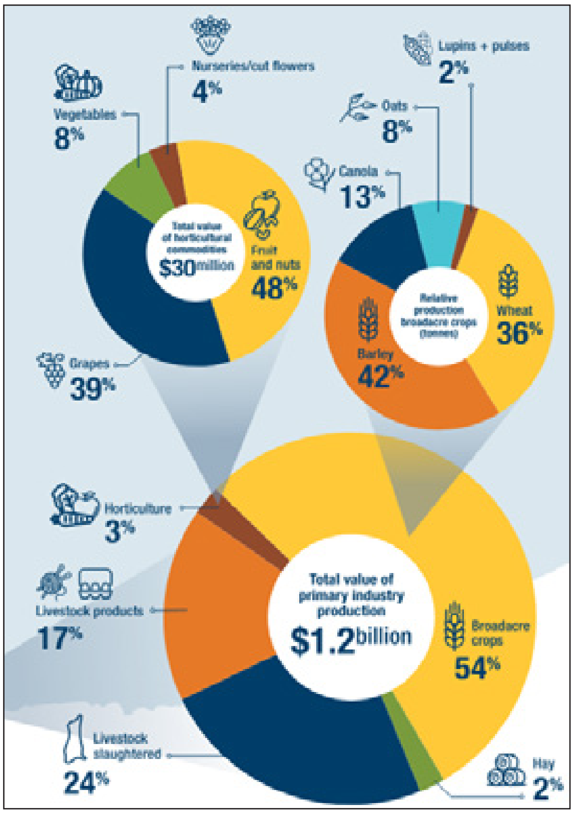


Figure 37. Total value of primary industry production of the Great Southern region of WA[26]

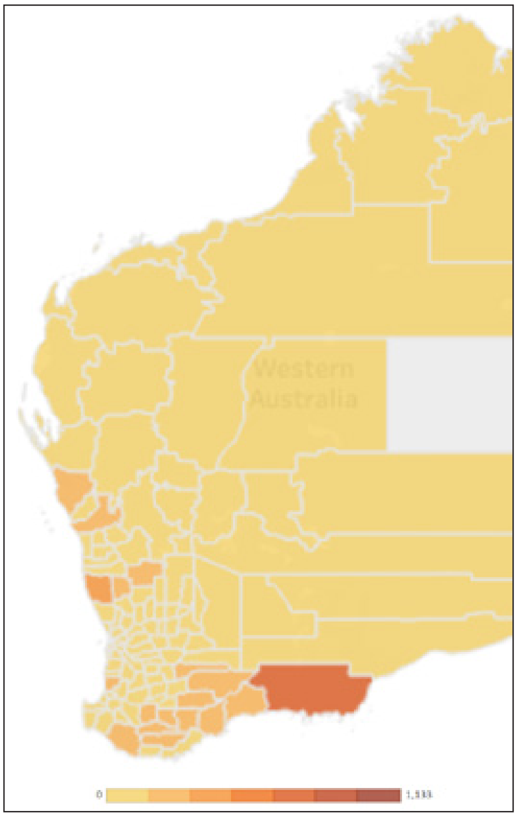


Figure 38. Gross value of Agriculture (total holdings) $M[27]

5.5. The Value of Agriculture for the Coastal Great Southern Region

The total value of agriculture for the Coastal Great Southern Region including the entire Shire of Cranbrook is $571.1 Million.

Figure 39 shows the breakdown of the total Gross Value of agriculture for the Coastal Great Southern Region in 2021 using Australian Bureau of Statistics Australian Census data.

27 https://www.agriculture.gov.au/abares/aclump/land-use/agriculture-census-dashboards-lga

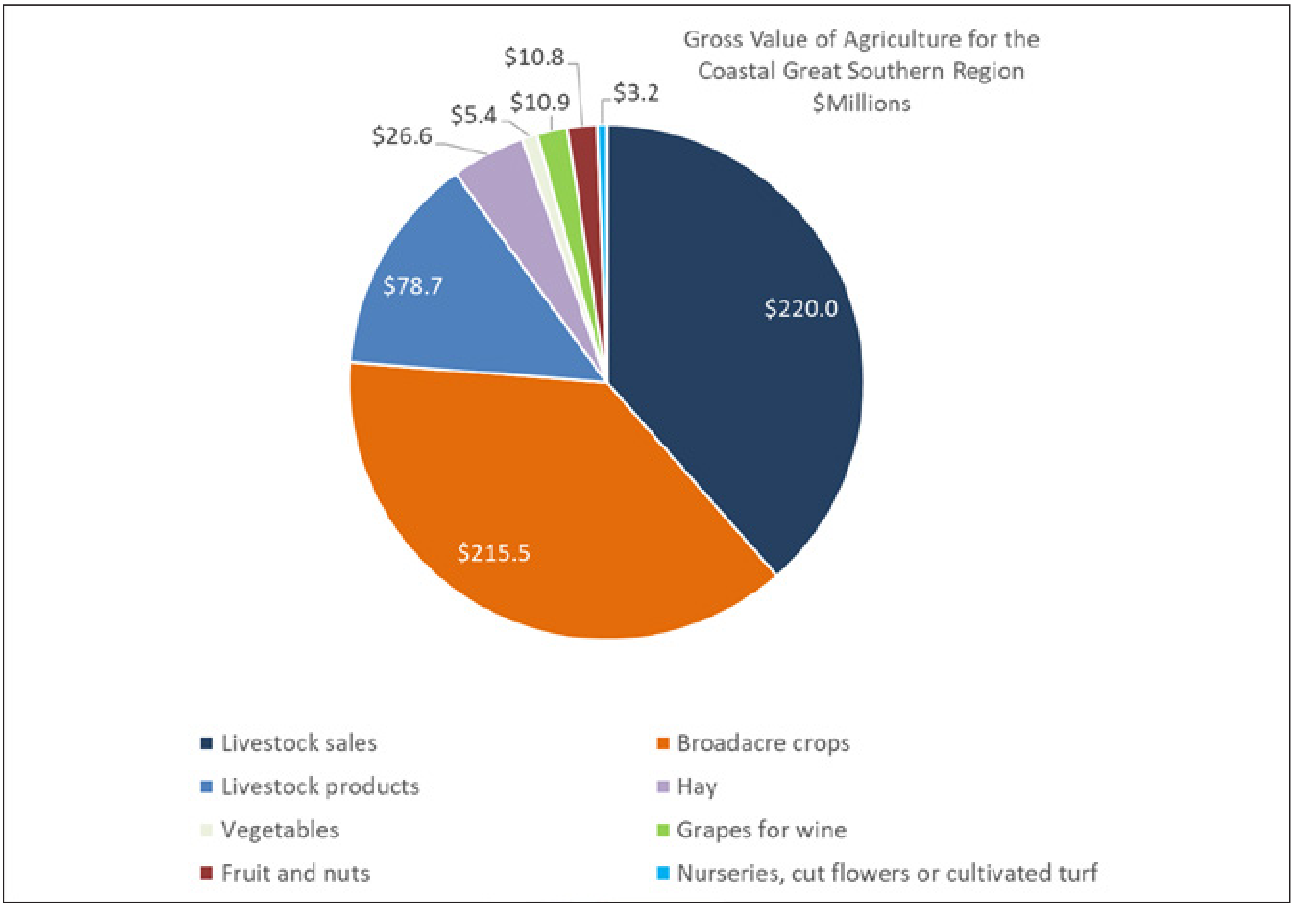


Figure 39. Gross Value of Agriculture for the Coastal Great Southern Region ($M)

Figure 39 shows that the livestock industry was valued at almost $300 Million in 2021. This is the combined value of livestock slaughtered and other disposals (livestock sales) and livestock products for the Coastal Great Southern Region. Broadacre cropping contributes $215.5 Million. In the Shire of Plantagenet and Cranbrook, broadacre cropping is valued at $79 Million and $82 Million of GVA respectively, and $53 Million GVA in Albany. Broadacre crops are not grown in Denmark. This verifies the land use maps in Figures 27, 29, 31 and 33.

Vegetables and nurseries, cut flowers or cultivated fruits have a strong presence in the Albany region and the viticulture industry is largest in the Shire of Plantagenet, Figure 40.

The Shire of Plantagenet contributes $223.7 Million, the highest compared to the other local government areas, Cranbrook GVA is $166 Million and Albany is $159 Million, Figure 41.

The value of agricultural activity is lowest in the Shire of Denmark, Figures 41 and 42. The total value of agriculture is $21 Million, this is not surprising as 63% of the Shire of Denmark land mass is natural environment. The main activities are livestock-producing products, with livestock sales from cattle and calves being the highest value.

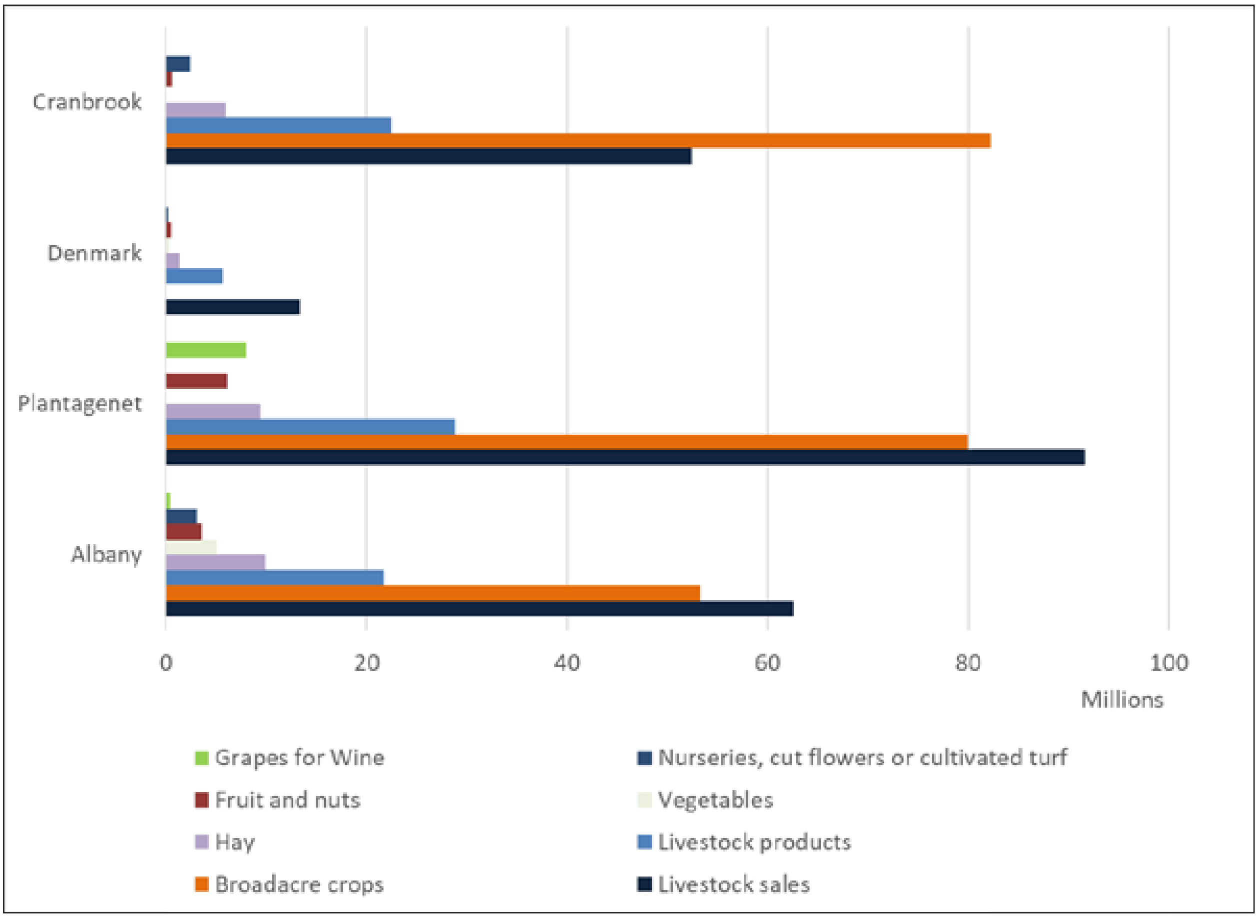


Figure 40. Gross Value for each industry by LGA ($M)

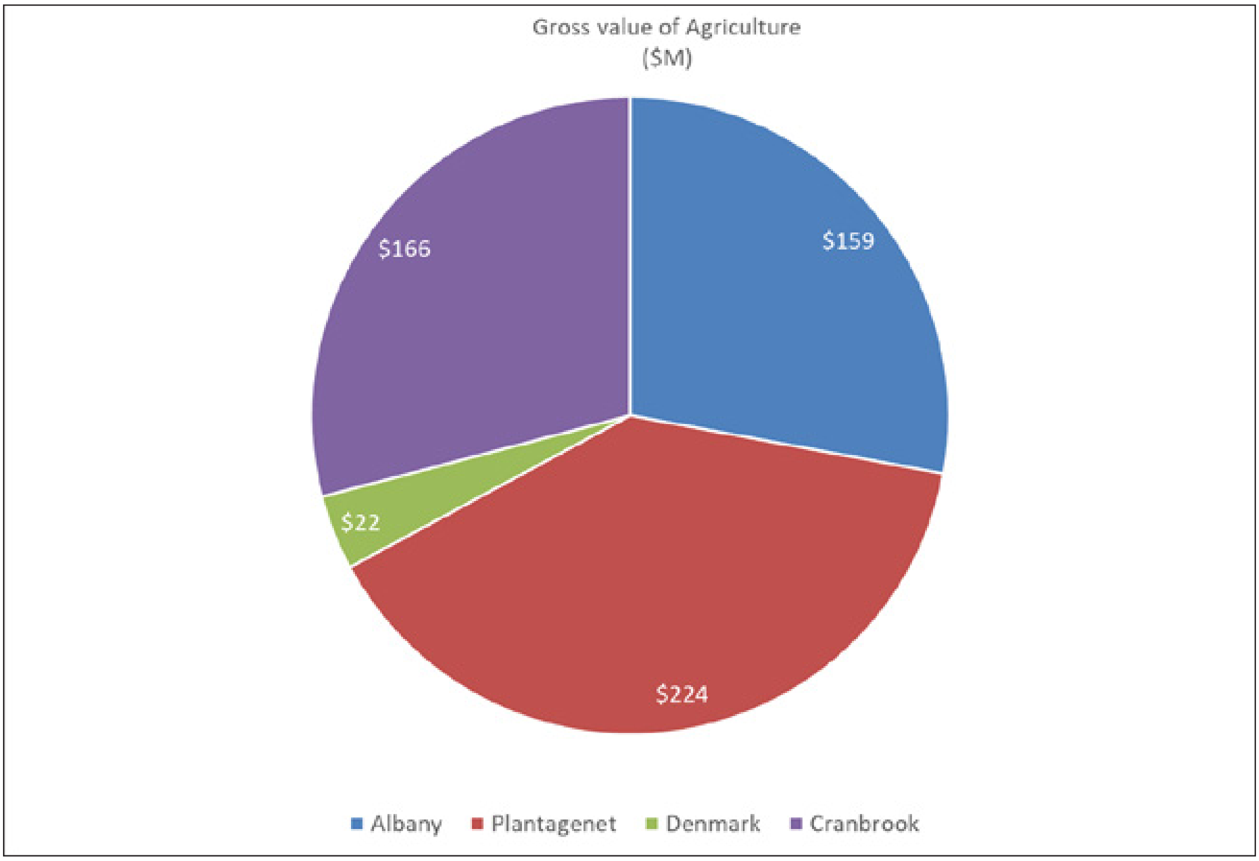


Figure 41. Total Value of Agriculture for the local government areas in the Coastal Great Southern Region ($M)

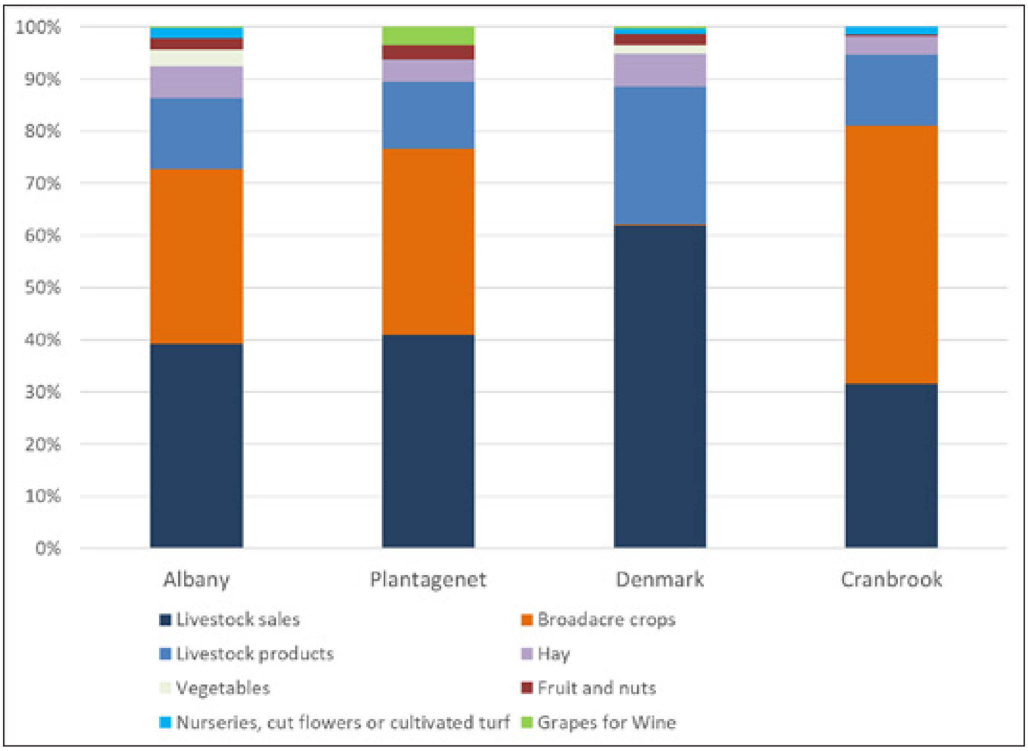


Figure 42. Contribution by industry for each Shire (%)

5.6. The City of Albany

The livestock industry has the highest value of agriculture in the City of Albany, the combined livestock sales and livestock products are valued at $84 Million for the City of Albany. When hay is included, which is grown for livestock fodder, this increases to $94 Million. Figure 43 breaks down the value of livestock products in the second pie showing the value of the wool, milk and eggs. The large pie in Figure 43 shows the value of broadacre crops ($53.2 Million), vegetables ($5 Million), fruit and nuts ($3.61 Million) and nurseries, cut flowers ($3 Million).

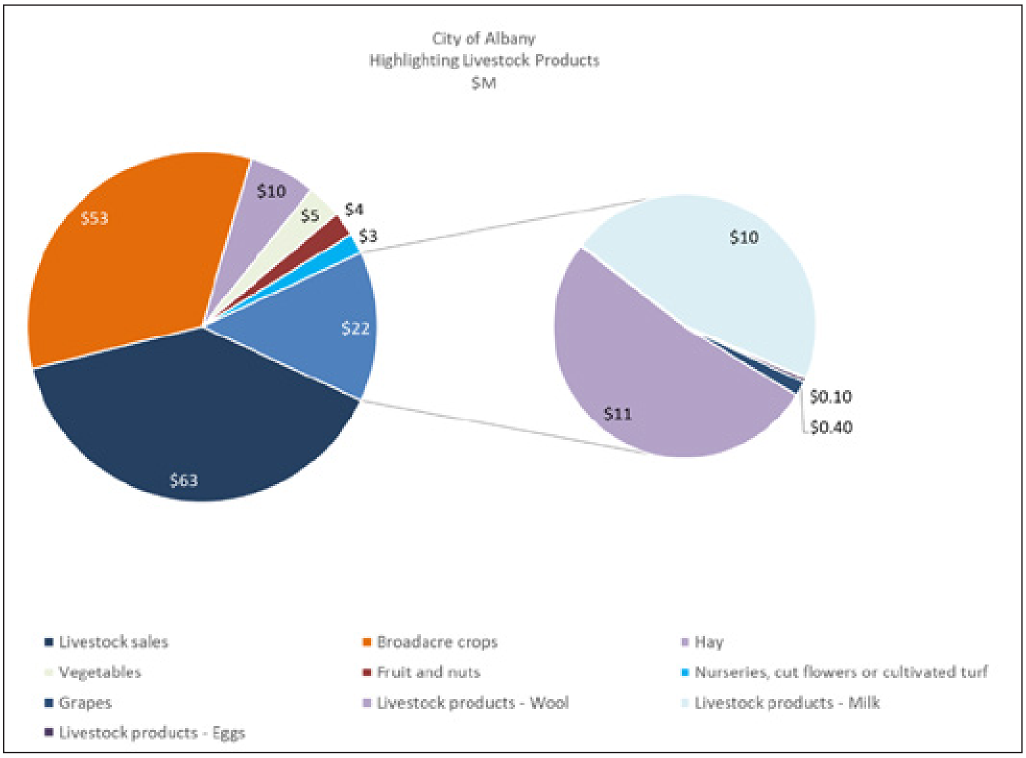


Figure 43. Gross Value of Agriculture commodities for the City of Albany – Livestock Products

The largest livestock industry in the City of Albany is the beef industry which can be seen in Figure in 44, where 57 per cent of the total livestock slaughter and disposal GVA ($35.7 Million of the total $62.5 Million) is from cattle and calf slaughter or sales (disposals).

There is only a small percentage of pigs slaughtered in the City of Albany specified in the data.

Broadacre crops are 33 per cent of the GVA for the City of Albany. The crops are canola ($25.65 Million), barley ($18.07 Million) and wheat ($7.86 Million) with small amounts of oats and legumes like lupins. Figure 45 shows the breakdown of the value of the grains industry in the small pie.

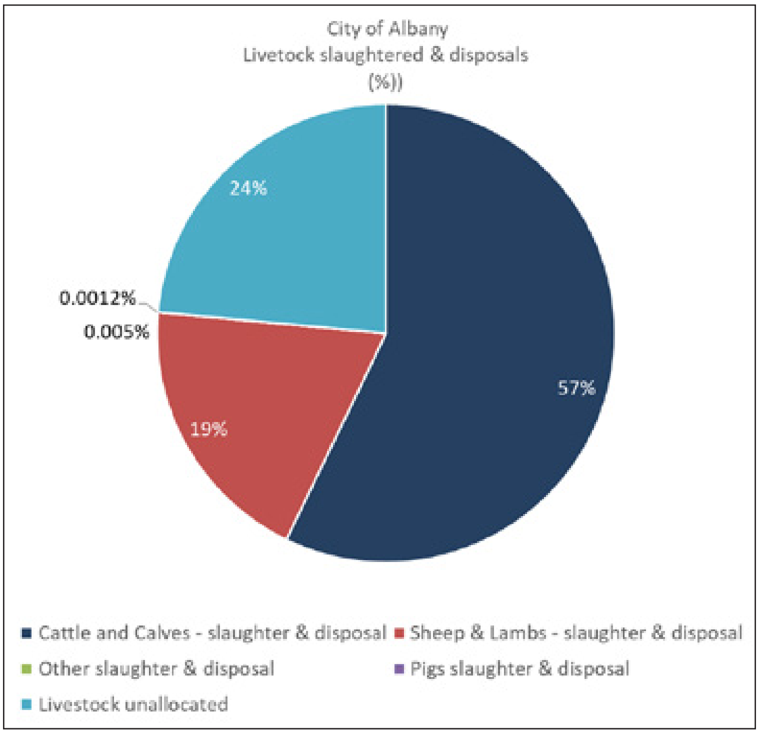


Figure 44. Livestock Slaughtered and other disposals for the City of Albany (%)

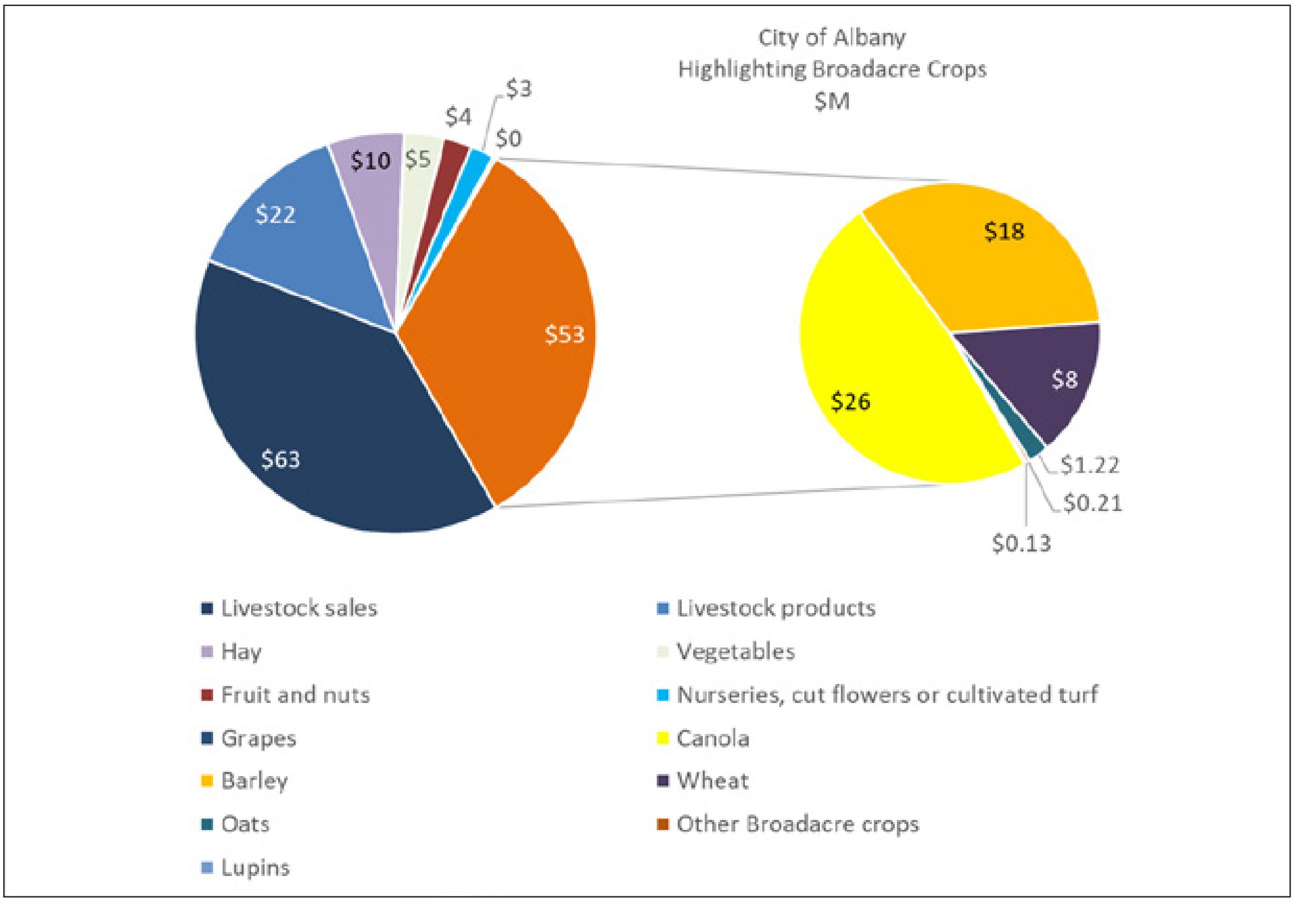


Figure 45. Gross Value of Agriculture commodities for the City of Albany – Broadacre crops

The GVA for vegetables in Albany is $5 Million, the largest vegetable growing industry compared to the other local government areas. Potatoes are the most significant vegetable grown, contributing $3.7 Million which is shown in the small pie in Figure 46. This also shows the variety of vegetables grown in Albany, which are broccoli, cauliflower and lettuce. They have a combined GVA of $147,000. Unspecified vegetables contribute $1.1 Million, shown in Figure 46. Pumpkin, Carrots and Cabbages are also grown with a combined value of $17,530.

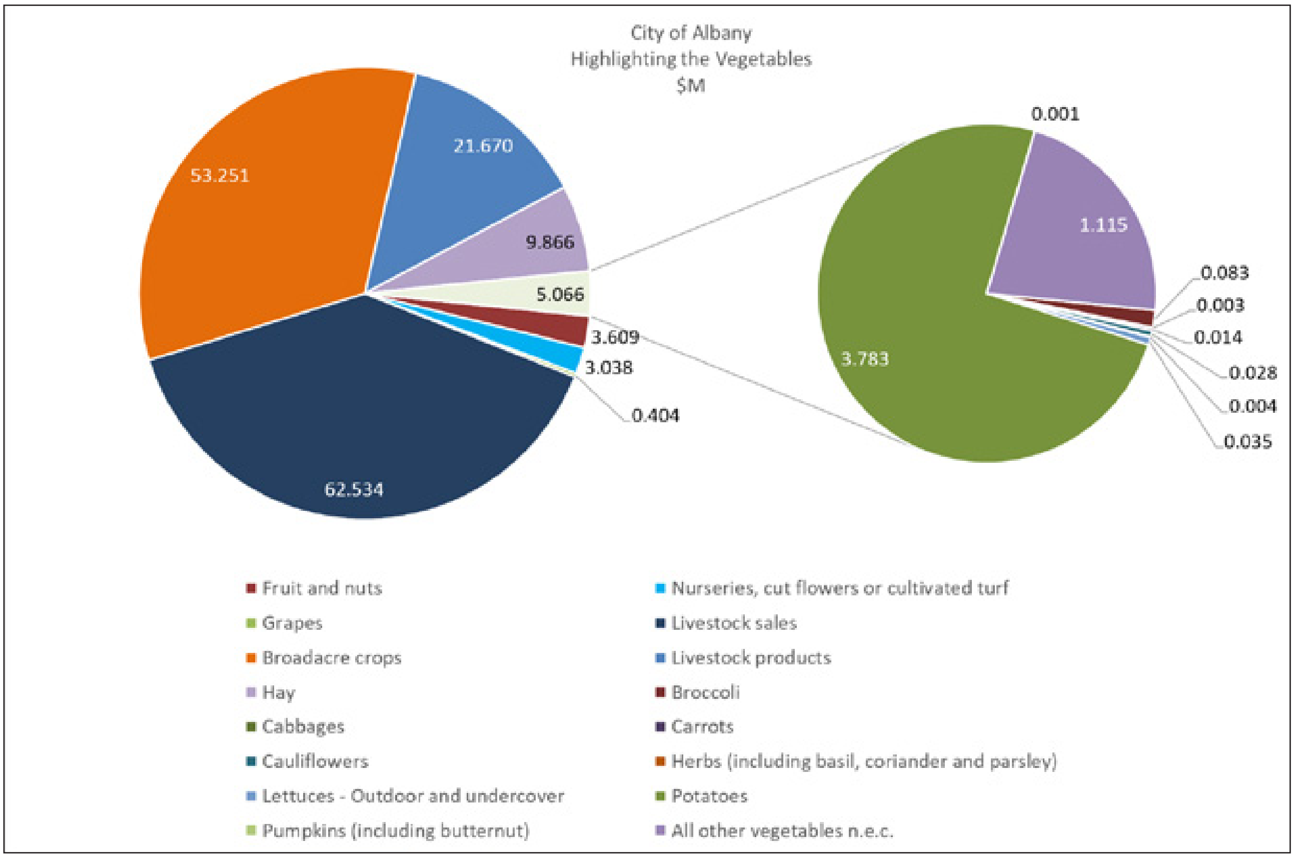


Figure 46. Gross Value of Agriculture commodities for the City of Albany – Vegetables

Albany has the largest cut flowers or cultivated turf industry with a total value of $3 Million. Figure 47 shows how this is derived from nurseries and cut flowers outside and undercover.

Interestingly there is more than $2 Million of Gross Value from outdoor cut flowers, potentially vulnerable to dry conditions or vulnerable to lack of water supplies for irrigation.

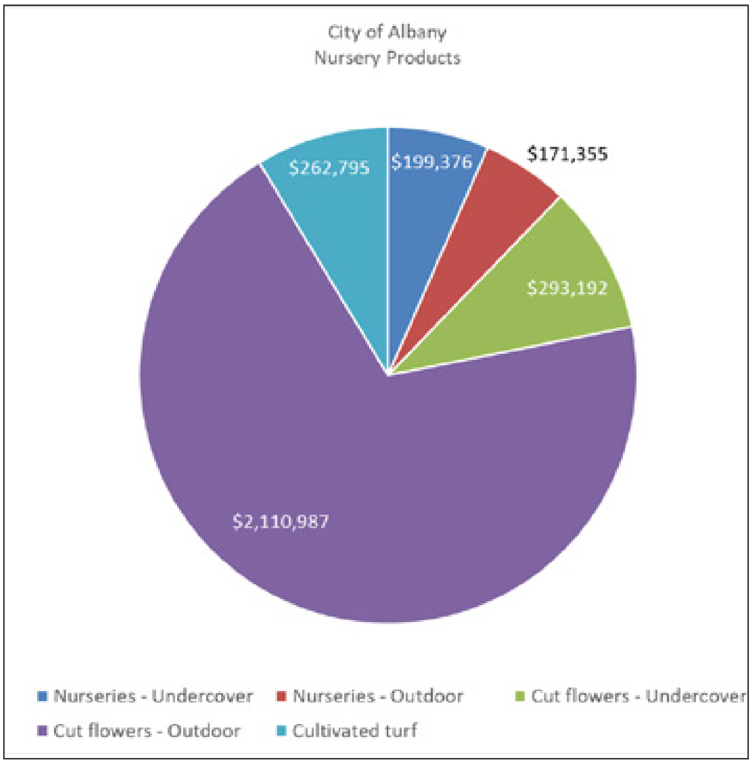


Figure 47. Gross Value of Agriculture commodities for the City of Albany – Nursery products

5.7. The Shire of Plantagenet

Livestock slaughtered and other disposals (Livestock Sales) combined with livestock products is the highest contributor to the Gross Value of Agriculture in the Shire of Plantagenet. Figures 48 and 49 show how important the livestock industry is to the economy. The small pie in Figure 48 breaks down the Livestock products to show the value of milk and wool. There are 123 businesses producing wool and 5 businesses producing $8.57 Million of milk, $1.7 Million each (Refer to Appendix 2, Table 5).

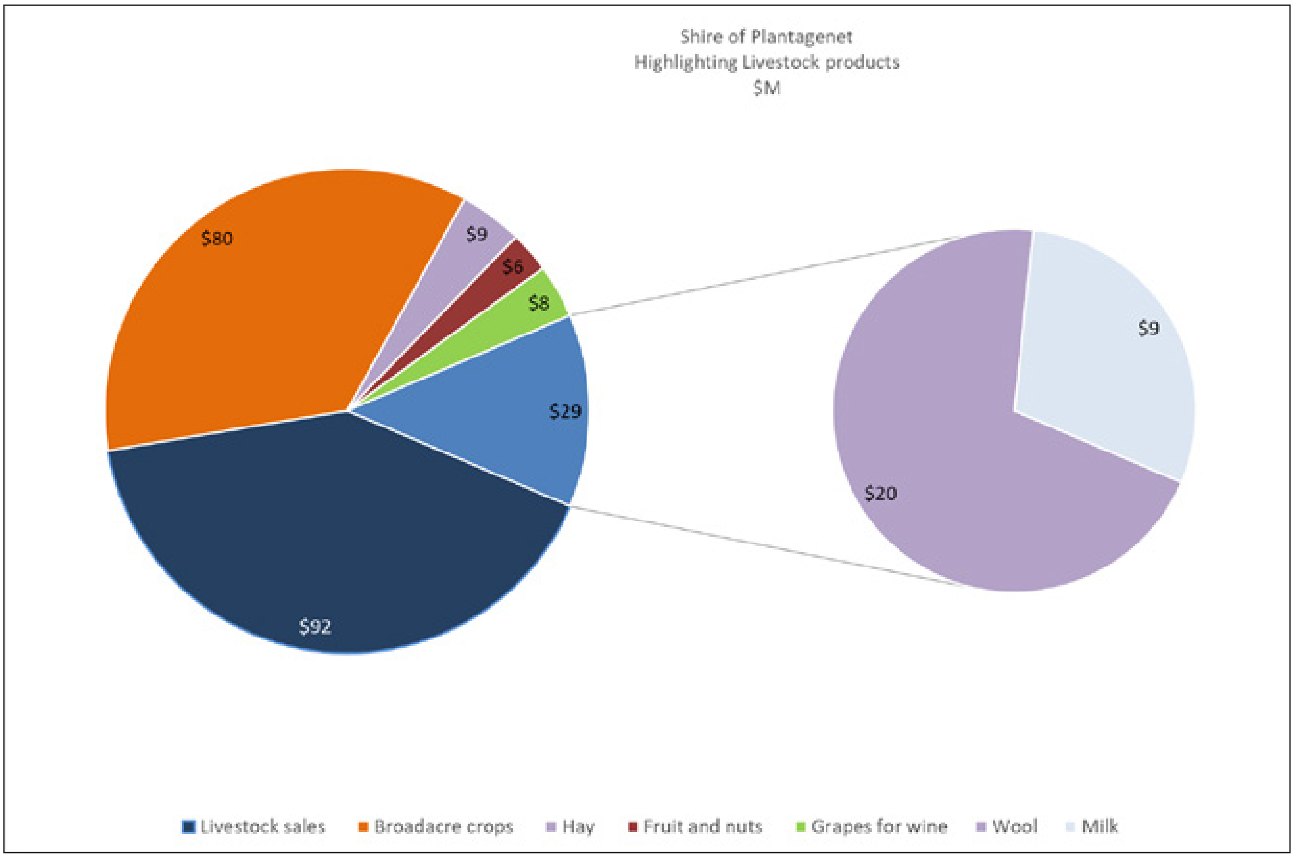


Figure 48. Gross Value of Agriculture Commodities for the Shire of Plantagenet – Livestock Products ($M)

Livestock slaughters and other disposals are valued at $91 Million for the Shire of Plantagenet. The data shows that 24 per cent of this is from sheep and lamb and 20 per cent from cattle and calves. There is $51.6 Million, which is 56 per cent of the total value for livestock slaughtered and sold which is not allocated to an industry. Part of or all of this could be from poultry and pigs slaughtered and sold but is not specified.

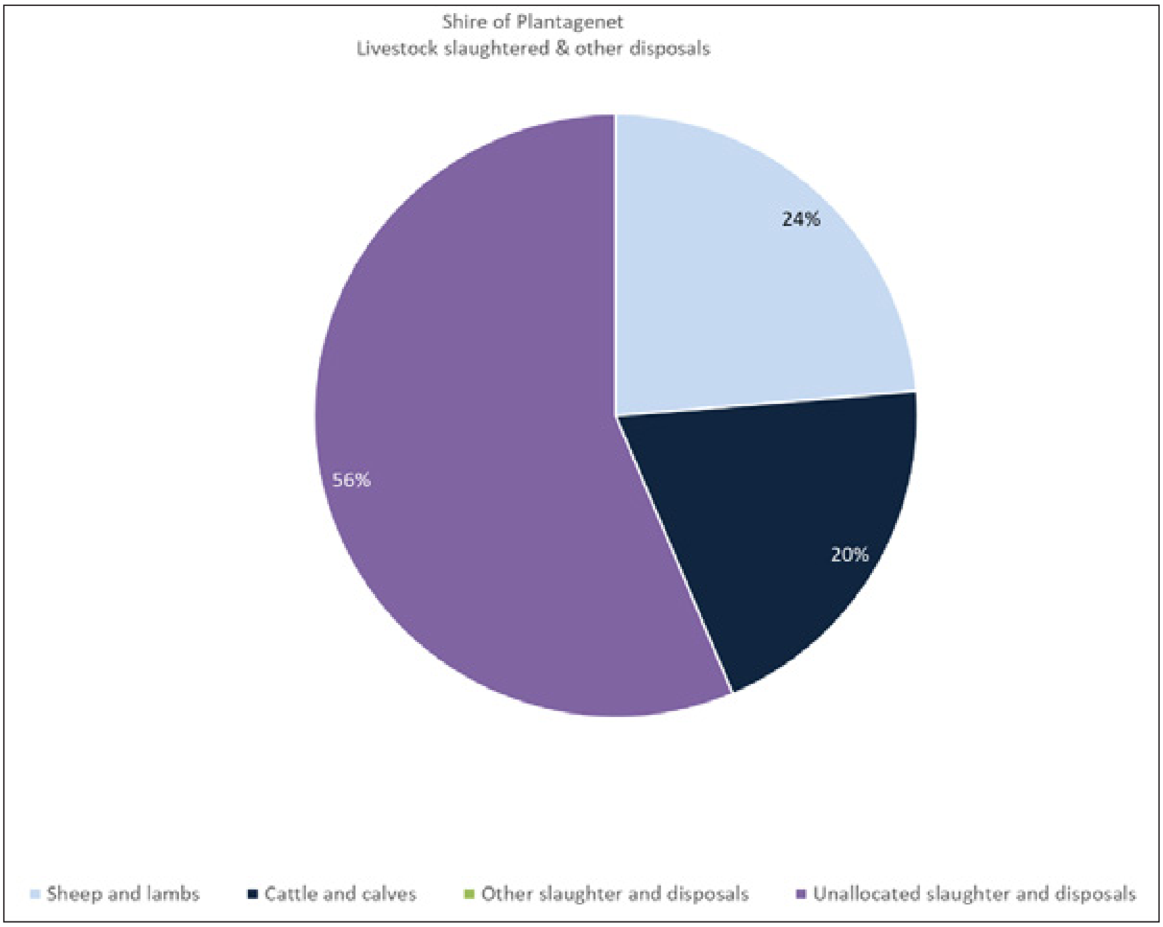


Figure 49. Livestock slaughtered & other disposals for the Shire of Plantagenet (%)

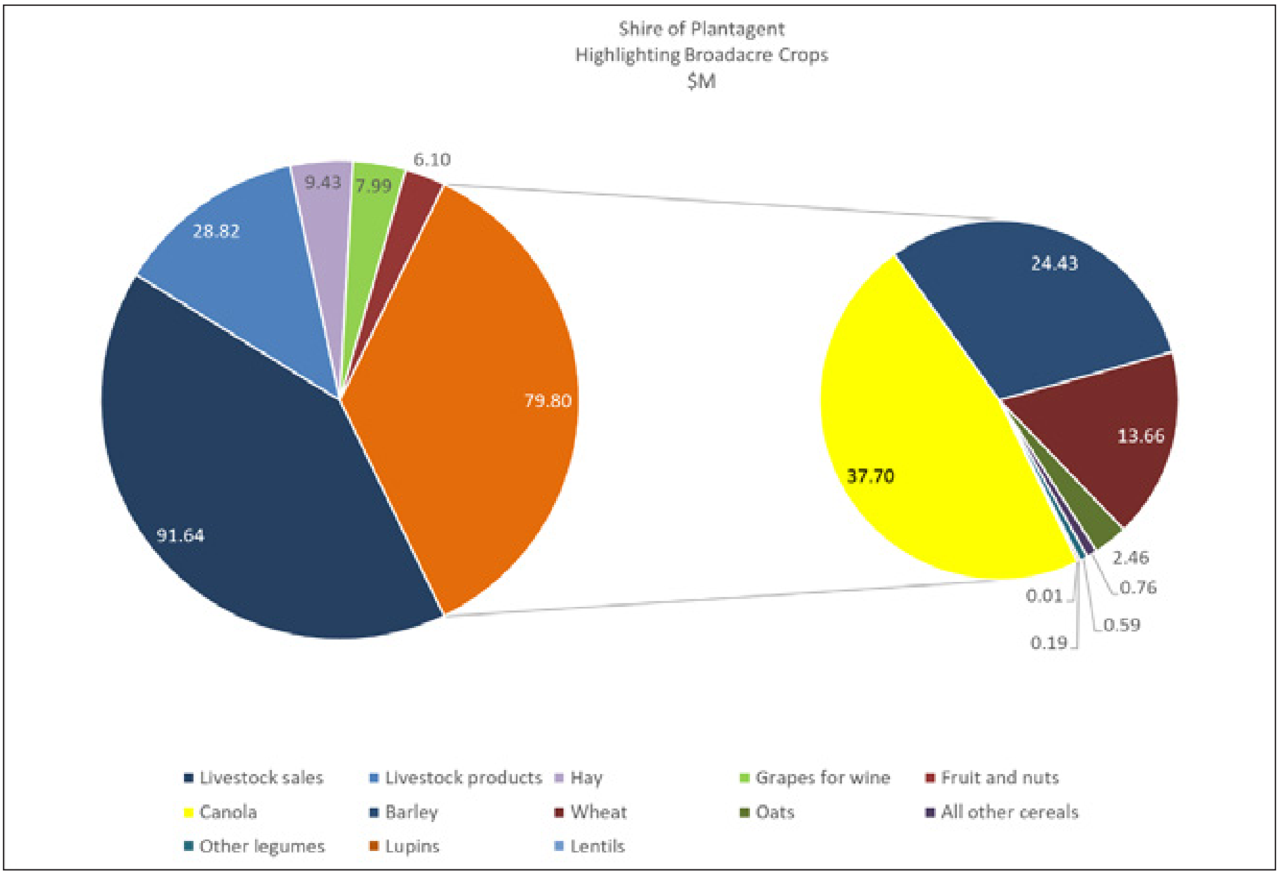


Figure 50. Gross Value of broadacre cropping in the Shire of Plantagenet

Figure 50 shows the breakdown of the value of the grains industry in the small pie. Broadacre crops are 35 per cent of the GVA for the Shire of Plantagenet. The crops are canola ($37.7 Million), barley ($24.07 Million), wheat ($13.6 Million), oats ($2.4 Million) and lupins ($0.5 Million). This information shows how important canola is to the farming system in the Shire of Plantagenet.

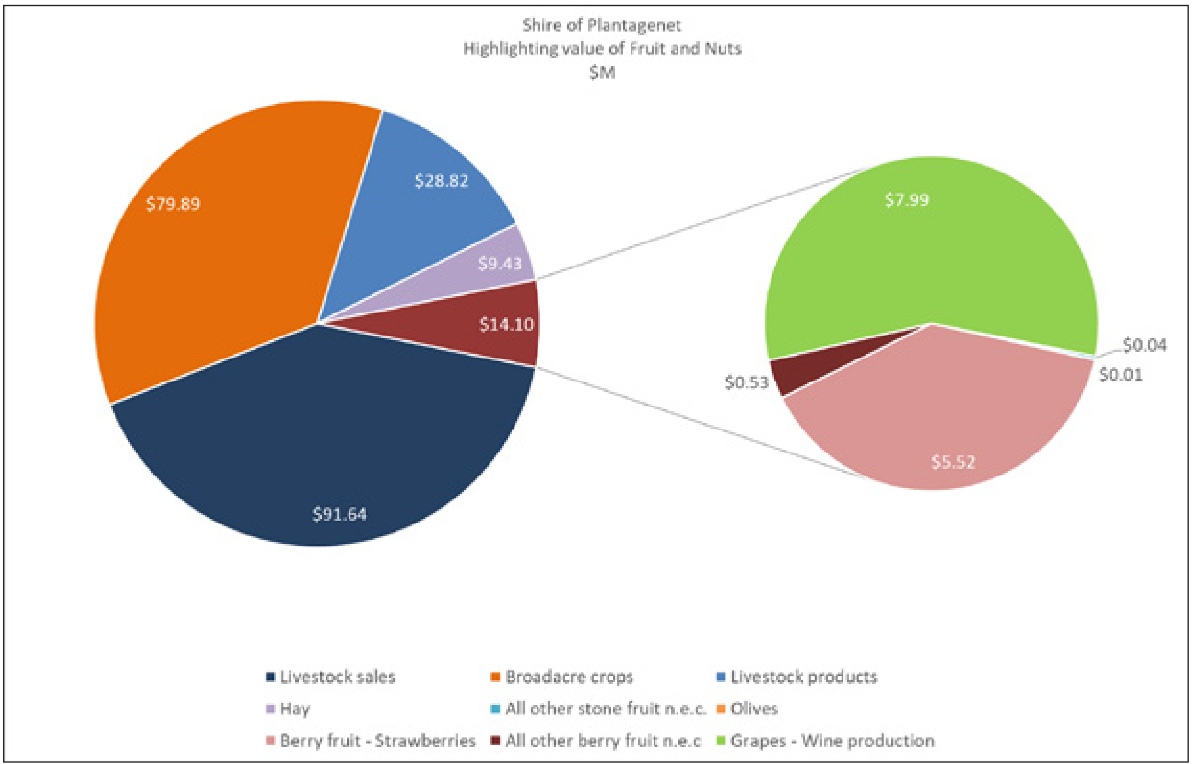


Figure 51. Gross Value of Fruit and Nuts in the Shire of Plantagenet.

The Shire of Plantagenet has the largest fruit and nut industry by value in comparison to the other three local government areas. Table 1 shows the values for these industries for each local government area. The highest-value activity is growing grapes for wine production. Strawberries are the second largest. Both the City of Albany and Shire of Plantagenet have a significant strawberry industry and their combined value is 24 per cent of the total value in Western Australia ($34.87 Million).

Table 1. Gross Value of Fruit and Nuts for the Coastal Great Southern Region (AU$)

	Total Value AU$	Shire of Plantagenet	City of Albany	Shire of Cranbrook	Shire of Denmark
Grapes - Wine production	10,906,038	7,993,877	403,893	2,425,667	82,601
Strawberries	8,407,152	5,522,345	2,884,807		
Other berry fruit	94,488	532,727	261,761		
Nectarines	14,302			14,302	
Peaches	1,393			1,393	
Other stone fruit	50,210	42,029		8,181	
Citrus fruit	5,166		5,166		
Apples	171,641			171,641	
Avocados	862,573		364,913		497,660
Olives	346,431	6,166		340,265	
Pears (including Nashi)	28,693			28,693	
All other fruit	91,923		91,923		
Total value	21,680,009	14,097,144	4,012,462	2,990,142	580,261

5.8. The Shire of Denmark

The highest value activity for the Shire of Denmark is livestock slaughtered and other disposals and beef cattle are 93 per cent of this value.

The size of the agriculture industry and value of agriculture for the Shire of Denmark is much smaller than the other local government areas in the Coastal Great Southern region. The data shown in Figures 40 and 41 illustrate how much smaller the value of agriculture is in comparison at $21.6 Millon. There are very few broad acre crops grown and mostly the land-use activities are either livestock focused or intensive vegetables, fruit and nuts.

Figure 53 illustrates the livestock products in the small pie, which is mostly milk produced from 5 businesses, suggesting a turnover of $965,000 per business.

The turnover of businesses is a good indicator of the size of business and understanding of viability, although other factors like the amount of debt a business is servicing has a large influence on viability. Understanding how many businesses, their size and turnover can help us identify vulnerabilities in the region.

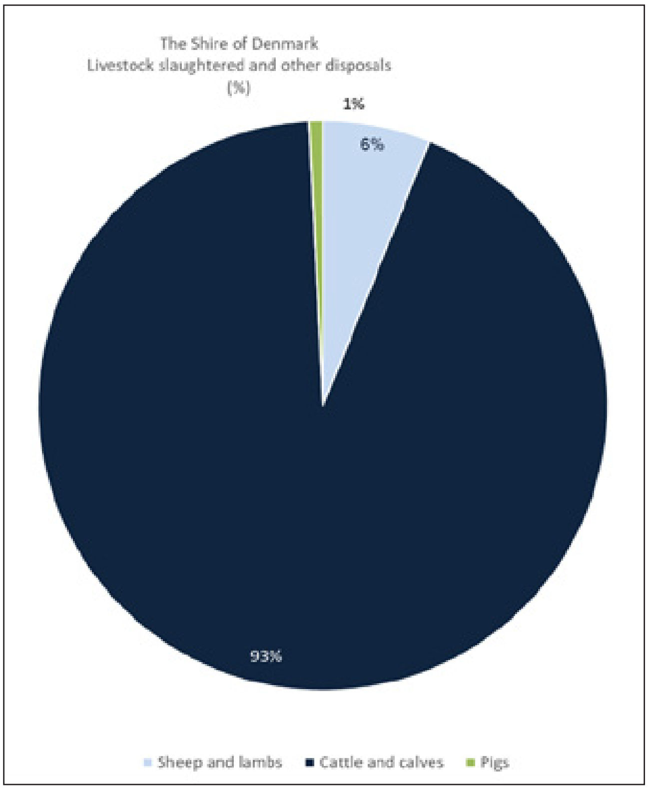


Figure 52. Livestock slaughtered & other disposals for the Shire of Denmark (%)

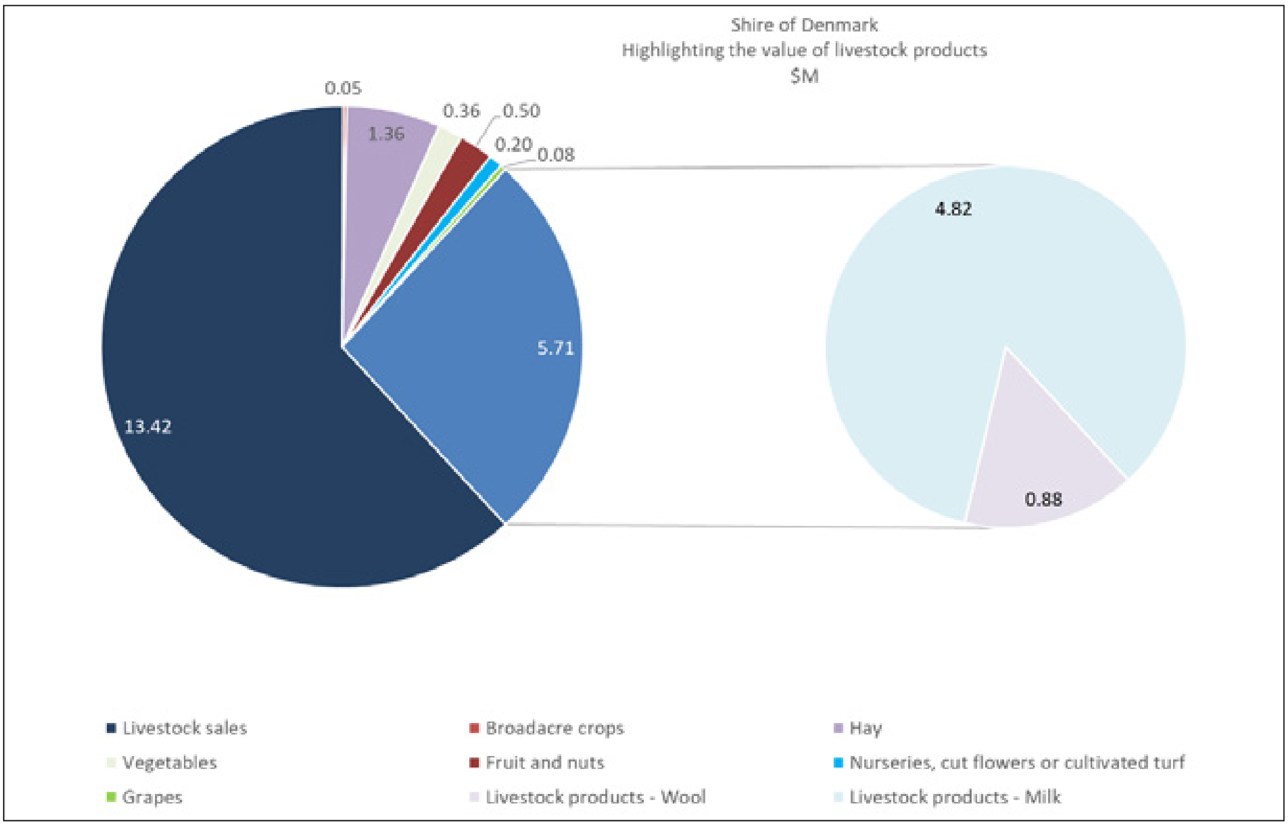


Figure 53 Gross Value for Livestock Products for the Shire of Denmark ($M)

5.9. The Shire of Cranbrook

The Shire of Cranbrook has a higher level of diversity compared to the other local government areas. The west part, the Frankland River Region and the focus area of this Vulnerability Assessment receives higher rainfall compared to the east of the shire. Vineyards and horticulture are mostly in this western part of the shire including olives with a significant grove west of the Frankland townsite. These two industries combined are 92 per cent of the total value of fruit and nuts for the Shire of Cranbrook, Table 1.

Broadacre cropping is the highest-value industry for the Shire of Cranbrook at $82.2 Million followed by livestock sales and products combined ($75 Million) shown in Figure 54. Although Cranbrook appears to have a high level of diversification with viticulture, olives and forestry, the broadacre farming system with cereals, pulses and sheep is the dominant land use.

Canola was the highest-value crop in 2021, although this needs to be considered with caution because during this period canola prices were around $900 per tonne reaching $1000 per tonne at times. These are decile 10 prices due to drought in Canada and worldwide supply shortages.

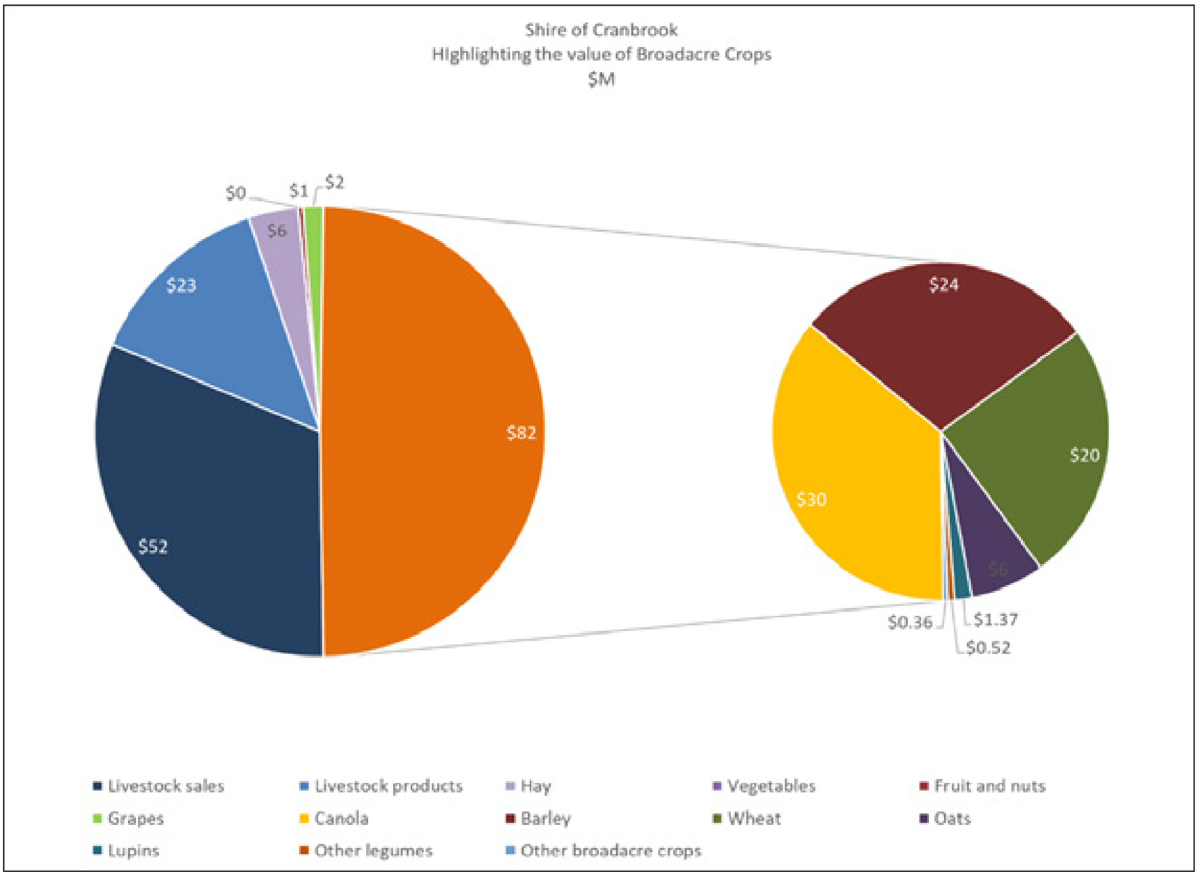


Figure 54. The value of broadacre crops in the Shire of Cranbrook

There are less beef cattle businesses in the Shire of Cranbrook compared to the other local government areas in the Coastal Great Southern region (Refer to Appendix 2, Table 5) and more sheep and lamb are slaughtered or sold compared to cattle and calves (Figure 55).

However, the value of beef cattle and calves sales generate $420,000 per business compared to $178,000 for the farms in Albany and $176,000 for Denmark cattle producers. This is a good indicator of the size of farming business in the Shire of Cranbrook compared to the other Shires.

The next section discusses this further using business turnover as an indicator for size of businesses.

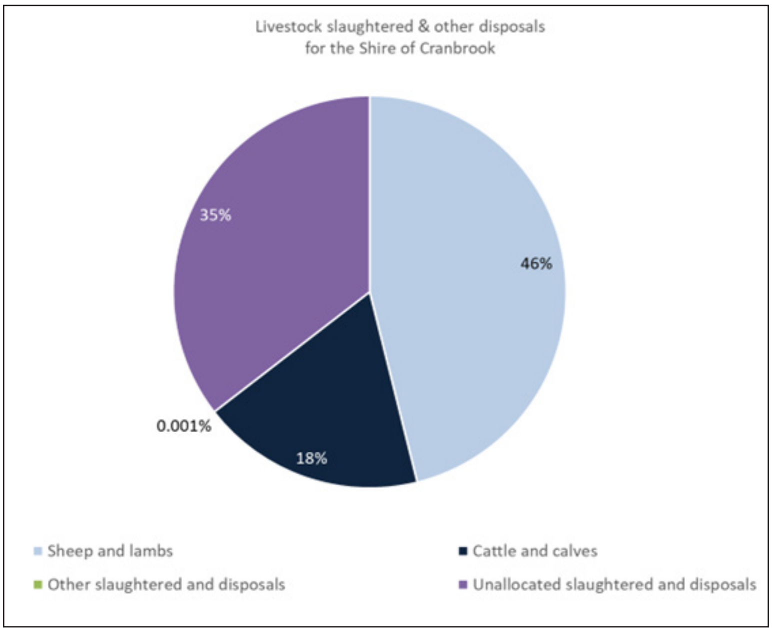


Figure 55. Livestock slaughtered & other disposals for the Shire of Cranbrook (%)

6. Number of Businesses and Turnover

Finding relevant and up-to-date data which represents the local government areas selected for the pilot study is challenging. Many data sources like the ABARES farm survey data or ABS agriculture statistics are amalgamated into larger geographical areas and were not suited to this study.

ABS business counts data provides an insight into the local government area, the dominant industry sector, the level of diversity and size of businesses. The number and types of businesses, and their size based on turnover provides an insight into potential vulnerability to drought for each LGA.[28]

The data presented is for financial year ending June 2023, which captures 2022-23 production. It is extracted from the Australian Bureau of Statistics Business Register (ABSBR), which is populated using administrative data from ABN registrations recorded in the Australian Business Register (ABR), and business data from the Australian Tax Office (ATO).

There are two significant observations that can be made from this data that informs us about the region's vulnerability to drought.

1. The high number of agriculture, forestry and fishing businesses show a high level of reliance on agriculture in the regions and the selected local government areas.
2. Understanding the number of businesses by turnover helps us to understand the size of the businesses in the selected pilot local government area and therefore the type of resources that might be required based on their profile.

28 https://www.abs.gov.au/statistics/economy/business-indicators/counts-australian-businesses-including-entries-and-exits/latest-release#data-download

For example, farm businesses require a turnover (gross farm income) above $600,000 to be viable and preferably nearer $1 million to support one family[29]. This depends on several factors; the level of debt, the level of personal expenses required for education fees and or the need to support intergenerational family members and the growth stage of the business. Off-farm income may provide additional income, but all these factors influence the required turnover and viability of a business.

6.1. Businesses in the City of Albany

Albany has the highest level of diversity in comparison to the other local government areas in the Coastal Great Southern Region which is not unexpected because it is the regional centre for the Great Southern servicing the surrounding areas. It has the greatest number of businesses and the most agriculture, forestry and fishing businesses. There are 6 businesses with a turnover greater than $10 Million, this is likely to include Fletchers International, an abattoir at Narrikup, not far from the Albany city centre. Other businesses this may capture are the machinery dealers and service centres.

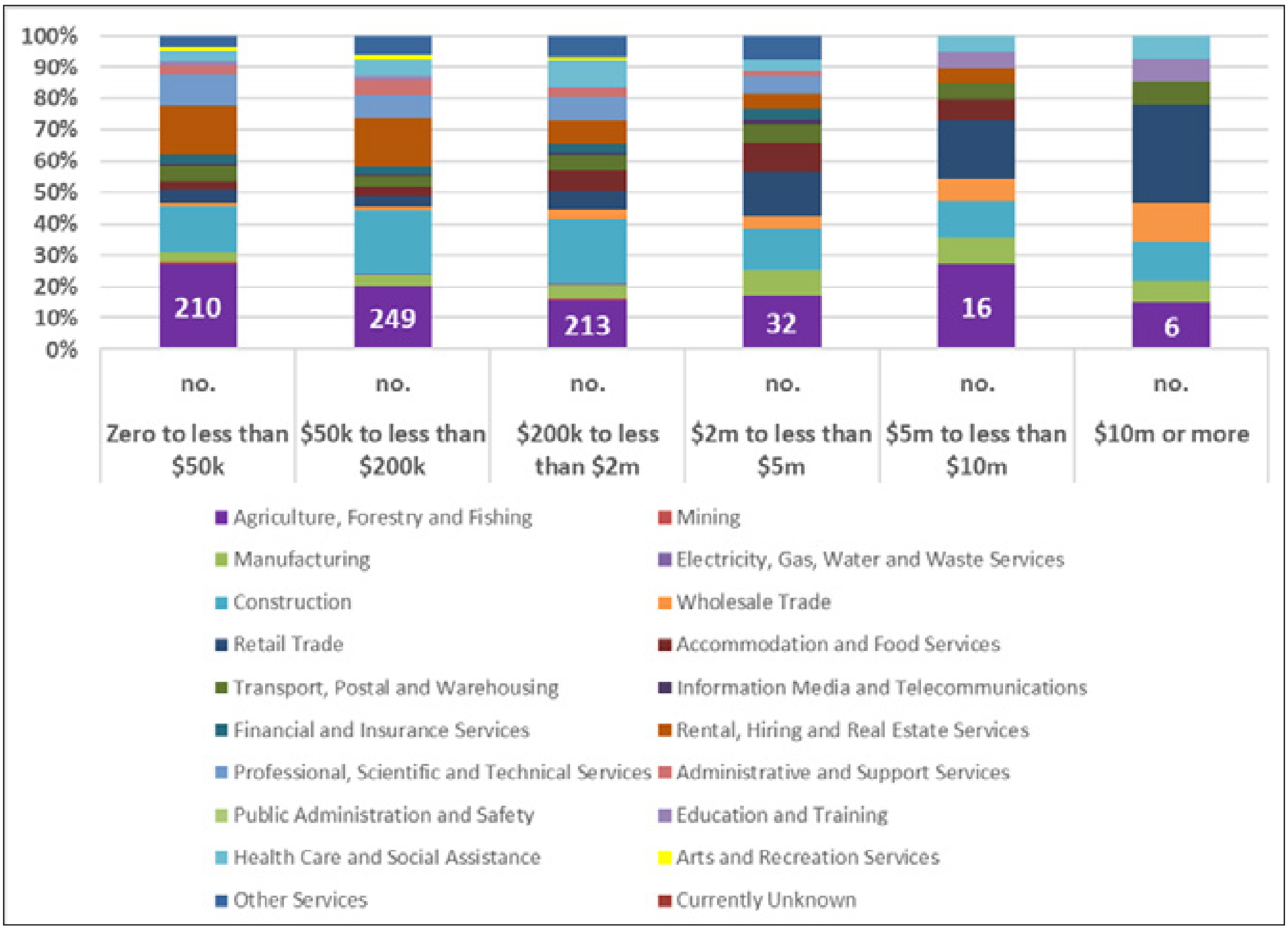


Figure 56. Albany businesses by industry and turnover June 2023

However, there are also many small agriculture businesses in the City of Albany. Figure 56 shows us there are 459 businesses with a turnover less than $200,000, and 210 of these have a turnover less than $50,000. These are small landholders, mostly with cattle and second jobs within the community. They are limited in their ability to invest in large capital items like storage sheds, water infrastructure or fodder. They are generally heavily reliant on rain-fed dams and all year-round pastures with a small amount of hay being fed towards the end of summer. They are extremely vulnerable to drought and at risk of suffering poor animal welfare outcomes.

29 Planfarm. (2022). Drought Vulnerability Report.

6.2. Businesses in the Shire of Plantagenet

In the Shire of Plantagenet there are fewer businesses and fewer small agricultural, forestry and fishing businesses. All the businesses with turnovers more than $10 Million are agricultural and 10 business have turnovers more than $5 Million. The larger farm sizes in the Shire and surrounding area are geographically spread and have properties in other parts of the region, which reduces risk to adverse weather conditions.

Most of the businesses in the Shire of Plantagenet have a turnover between $200,000 and $2 Million.

There are less agricultural businesses with turnovers less than $200,000 compared to Albany, although they have 216. It is likely they have limited capacity to grow and a limited capacity to invest in significant infrastructure or drought proofing systems.

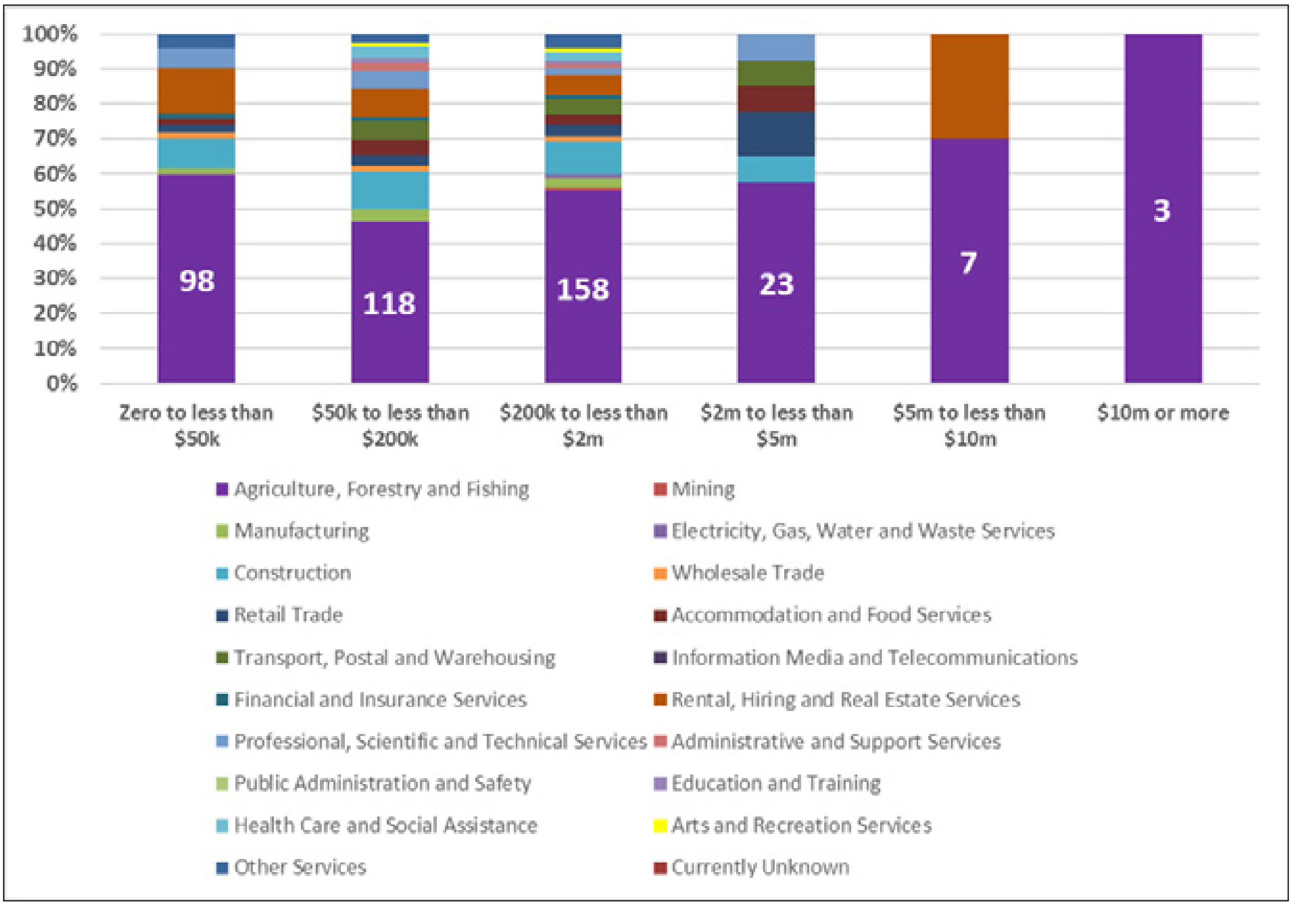


Figure 57. Shire of Plantagenet by industry and business turnover

6.3. Businesses in the Shire of Cranbrook

In the Shire of Cranbrook there are fewer businesses in total. Although some have turnover less than $200,000 there are only fifty. Many of the businesses are broadacre larger businesses with higher turnovers. Their viability would be influenced by the amount of debt the farm is servicing.

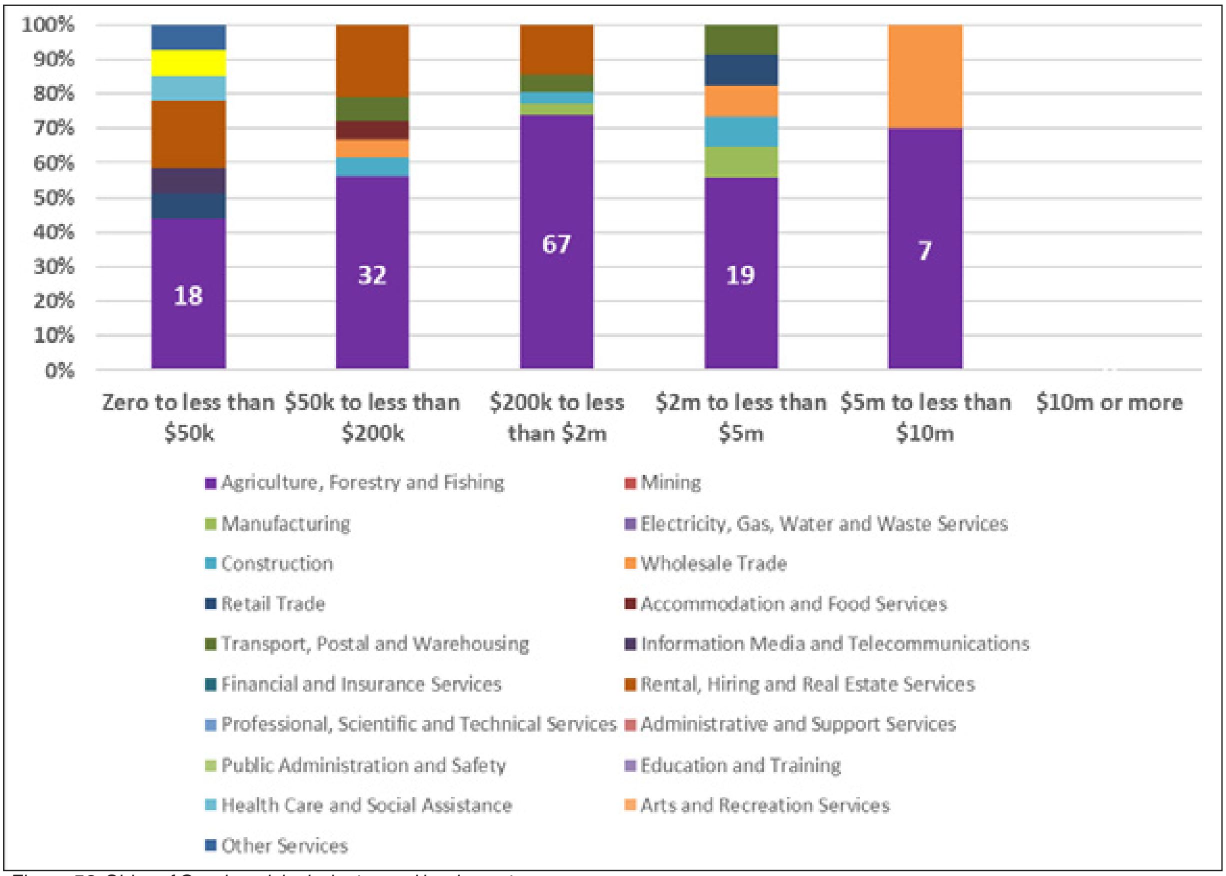


Figure 58. Shire of Cranbrook by industry and business turnover

6.4. Businesses in the Shire of Denmark

Denmark has 3 businesses with a turnover greater than $5 Million but less than $10 Million and there are no larger size businesses with a turnover greater than $10 Million.

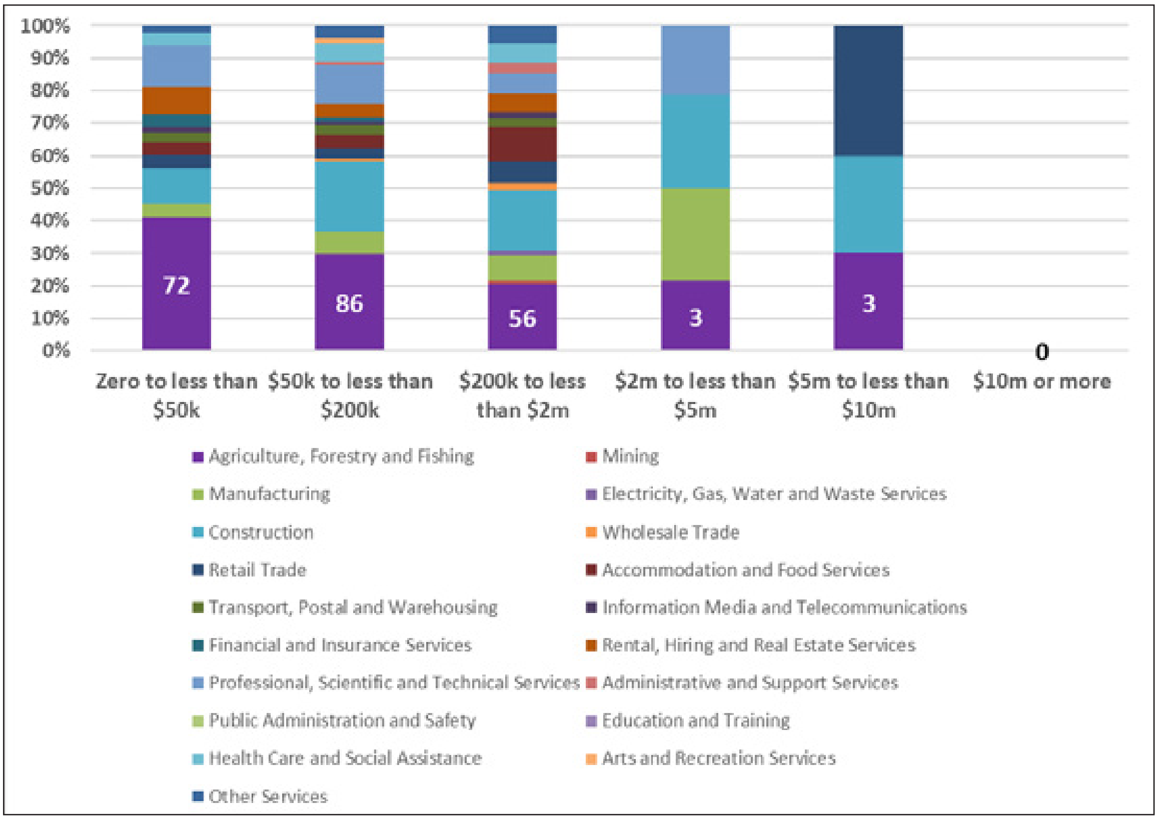


Figure 59. Shire of Denmark by industry and business turnover

There are 158 agriculture businesses with a turnover of less than $200,000. They are likely to be businesses with a second income, but they are also likely to be limited in their capacity to invest in infrastructure or to manage the risk from droughts.

Evidence from the community survey completed for this Vulnerability Assessment supports the data and assumption, many commented that they had to purchase fodder for the first time or much more than normal in 2024 and that for many it created financial hardship and they found it a stressful situation.

The impact of drought is discussed in the next section.

7. Impact of Drought

7.1. Impacts of drought on the economy

The largest impacts of drought are economic, with large effects on household income, including experience of financial hardship and deterioration in household financial positions.[30]

Unlike other natural hazards such as floods, cyclones, tornadoes, and earthquakes, which occur over finite periods of time and result in visually obvious damage, drought develops slowly and quietly, lacking highly visible and structural impacts. Emerging drought conditions often go unnoticed until precipitation shortages become severe, and impacts begin to occur. The slow pace and long duration of drought typically makes it difficult to quantity the overall economic impacts.[31]

For example, the 2019 drought in New South Wales (NSW), started in the northern parts of the state in 2017 and spread over much of the state in 2018 continuing into 2019. Initially, in 2017, the rainfall anomalies were not extreme, but maximum temperatures across Northern NSW were far above normal and reduced winter rainfall meant severe shortfalls in effective rainfall. By the end of 2019, the state was gripped in one of the worst droughts it had experienced, as were other parts of Australia like the Coastal Great Southern Region, Figure 60.

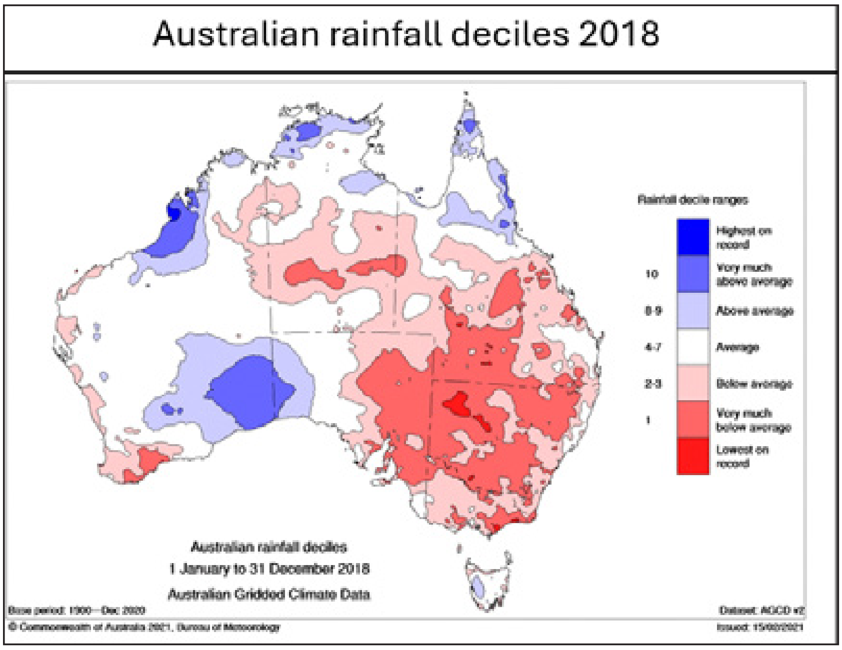


Figure 60. Australian rainfall deciles 2018 and 2019

30 Edwards, B., Gray, M., Hunter, B. (2008). Social and economic impacts of drought on farm families and rural communities. Australian Institute of Family Studies. Retrieved 13-04-2022 www.pc.gov.au

31 Ding, Ya, Hayes, M. J., and Widhalm, M. (2010). "Measuring Economic Impacts of Drought: A Review and Discussion". Papers in Natural Resources. 196. https://digitalcommons.unl.edu/natrespapers/196

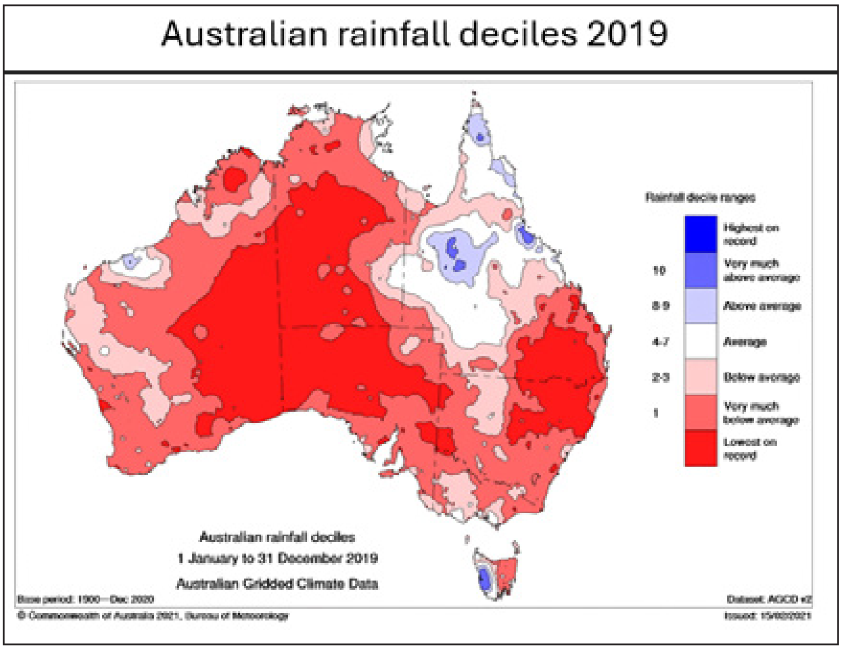


Figure 60 cont. Australian rainfall deciles 2018 and 2019

From the national perspective, there were substantial impacts on national productivity. It was sufficient to force real GDP to more than 1.0% below base in 2018-19 and 2019-20. The marginal contribution of drought to national real wages growth was as much as minus 1%.[32]

Managing for climate variability is not new for agriculture production. Droughts, floods, frosts, severe wind events and rain at harvest can all have the potential to cause significant losses on both a localised and broad scale. At times, the continuation of severe climatic events like drought have caused the failure of farm businesses.[33]

Edwards et al (2008) reports that drought has the most negative impact on farmers compared to others living in the rural and regional areas.[30] In their study on the social and economic impacts of drought on rural and regional families they found evidence that drought has a negative impact on farm workers and on people who were employed in rural areas but not in agriculture, "one would expect that drought is associated with the reduced employment opportunities historically associated with depressed regional economies". But the impact of drought on overall employment rates was found to be small when farmers were included, because they are not likely to lose their jobs, unless they are forced to sell their properties.

When farmers were excluded from the same analysis there was a statistically significant impact of drought on the employment rate, which was 4 or 5 percentage points lower in drought-affected areas than in above-average rainfall areas.

7.2. Impact of drought on productivity

In section 4 of this report, we outlined the climate conditions for the Coastal Great Southern Region. Most of the region is in high rainfall area and some is very-high rainfall with more than 900 mm of annual rainfall. There is however a high level of variation within the rainfall as explained herein.

This provides a level of complexity with managing agricultural enterprises reliant of rainfall, there is either too much or not enough. The impact of recent dry years on the horticulture and viticulture industries appears significant. A combination of rising costs, declining terms of trade and reduce yields are impacting on the financial viability of these businesses. Yield have been seriously impacted due to low rainfall, increased heat stress and reduced harvesting of water.

32 Wittwer. G (2020). "Estimating the Regional Economic Impacts of the 2017 to 2019 Drought on NSW and the Rest of Australia," Centre of Policy Studies/IMPACT Centre Working Papers g-297, Victoria University, Centre of Policy Studies/IMPACT Centre.
33 Hughes, N., Galeano, D., Hattfield-Dodds, S 2019, The effects of drought and climate variability on Australian farms, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. CC BY 4.0. http://doi.org/10.25814/5de84714f6e08.

It is difficult to quantify the impact of drought in isolation on productivity because other factors like frost also have an impact, often in the drier years, and yields in a wet year can sometimes be worse than in a dry year. Yields are dependent on the distribution of rainfall. The Frankland vineyards experienced very hot days in 2023 impacting fruit. That leads to greater need for water to keep soil moisture up on laterite soils from the area around Frankland and affects pruning techniques for foliage cover to protect fruit.

Data from 2016 to 2023 Crop Reports generated by the Grains Industry Association of Western Australia (GIWA) show tonnes of production from the Albany region in Figure 61.

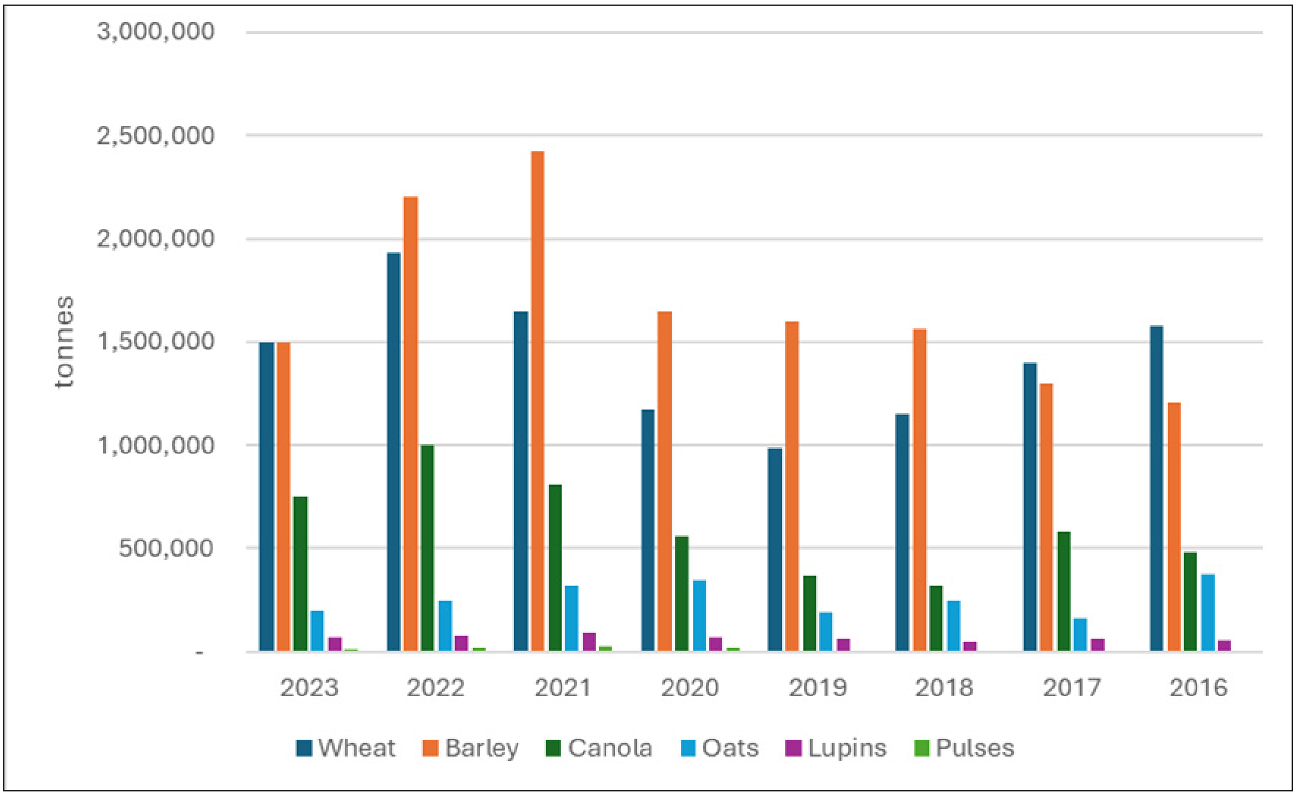


Figure 61. Tonnes produced in the Albany region.

These year's show a high level of variation between climatic conditions, 2016 was one of the wettest on record and 2019 one of the driest after a dry 2017 and 2018 for some areas.

Table 2 provides commentary from the GIWA Crop Reports to illustrate the production issues for broadacre farmers in these regions caused by seasonal conditions.

Table 2. Summary of seasonal conditions from the GIWA crop reports 2016 to 2023

Production Year	Southern Albany South Stirling's, Plantagenet, Kendenup	Western Albany Frankland River Region, West of the Shire of Plantagenet
2016 Feb 2017 GIWA report	Water logging and frost Best Barley yields at 3t/haa	Waterlogging and frost impacted the season. Wheat Average yield was 3 to 3.2 t/ha with a variation between 200 kg/ha and 5 t/ha
2017 Feb 2018 GIWA crop Report	Grain yields were well above average for wheat barley and canola. Areas of the western south coast suffered severe water logging	Yields were all above average due to the good start and long slow finish without too much waterlogging. Canola production for the zone increased by 25% and oil quality in the high 40's. Quality of Barley and Wheat higher than normal due to the drier conditions at harvest

Production Year	Southern Albany South Stirling's, Plantagenet, Kendenup	Western Albany Frankland River Region, West of the Shire of Plantagenet
2018 Feb 2019 GIWA Crop Report	The Southern Albany region bore most of the brunt of the **very windy conditions** at the start of the season and many growers were writing off the year as early as July. Just as many were looking to 2019 the **rain started in August** and the turn-around was incredible. Many cereals in the region ended up yielding close to average and whilst canola never really recovered, those areas that were re-sown to barley yielded well enough to recover much of the extra costs. Snails in canola are emerging as a concern for many of the growers in the region. Canola rotations are tight with many paddocks' barley/canola/barley/canola being the most profitable rotation. This rotation is at risk if snails are not controlled well enough to keep numbers down to very low levels in the sample.	Cereal crops in the West Albany region were excellent with some very high yields recorded in both wheat and barley. **The start to the season was difficult with several very severe wind events and good rains falling later** than in the northern regions of the state. The growing conditions were warm once crops emerged and when the rain cranked up in August most crops were able to handle the waterlogging better than normal. **Total growing season rainfall for the region was about average** or below average with most cereal crops yielding well above average. Grain protein was lower than normal simply due to dilution from the very high yields. **The canola suffered more from the difficult start to the season, as was the case for most of the southern regions it never recovered to yield anywhere near what would normally be expected.**
2019 Feb 2020 GIWA crop Report	The southern Albany region really was "one extreme to the other" as some growers had their best year ever close to the coast where they escaped the frost, whilst others further east had their worst year ever. Grain yields decreased as you moved east in the zone from **the lack of rainfall and frost**, with those sowing early getting roasted by the frost followed by **the hot conditions** which didn't allow any recovery in crops as is normally the case in the region. **A lot of canola returned 200 to 300kgs with the majority being baled.** A lot of wheat did not get baled; it should have as there was more frost than was thought at the time. The water deficient areas are working their way west with livestock being turned off and those retained on farm **needing to have water trucked in. Water for the cropping programs this year is also a concern for those areas that have not received decent run-off for two years.** Whilst snails in grain samples were not as much of a problem as they have been previously, due to the last two dry summers and an increase in windrow burning, they are now present over a very wide area of the region.	The best year ever for cropping in the high rainfall regions west of the Albany Highway, especially for the earlier sown paddocks. Barley was a real standout, consistently 1-1.5t/ha up on long term averages. Some canola yields were unbelievable and highlight what the region can produce if waterlogging is reduced. Wheat grown on pasture was very good, although still behind the top barley yields. **Dams are drying out from the lack of runoff and hot days**, and whilst not desperate yet, the situation will become so if there is not some substantial run-off in the next few months.

Production Year	Southern Albany South Stirling's, Plantagenet, Kendenup	Western Albany Frankland River Region, West of the Shire of Plantagenet
2020 Feb 2021 GIWA crop Report	Barley and canola crops were very good to exceptional. Barley crops out yielded wheat by 0.5t/ha to 2.0t/ha. The practice of delaying the sowing of wheat to mitigate against frost risk effectively puts a cap on the length of growing season whilst barley sown earlier has more time to set up higher grain yield potential. The season-saving rain in August and lack of waterlogging had the biggest impact on the final tonnage. Canola crops benefited from the long grain fill period with biomass bearing no relation to eventual grain yield, highlighting the plasticity of this species. Water use efficiencies for barley reached 29kg/ha/mm of rain, and canola 14kg/ha/mm of rain which is previously unheard of in these areas.	This zone had an exceptional year and even growers who are still getting the hang of being a 'serious grain grower' did well. The lack of waterlogging was the single biggest factor that impacted on the very high grain yield achieved in the region. Barley and canola crops returned the best paddock averages for growers ever. Grain yields were well above what was thought prior to harvest, in part due to the region never having had a season like 2020 since cropping took off in the region 20 or so years ago. The move to earlier planting **using soil wetters has given growers confidence that they can get crops out of the ground on low rainfall events and due to the cooler climate**, once up, crops rarely fail to survive a dry spell. This change in practice for the region has a two-fold effect of getting crops established early to better combat waterlogging and lengthens the growing season, giving higher grain yield potential. Frost can still be the elephant in the room, although strategic crop type selection has helped to minimise this.
2021 Feb 2022 GIWA crop Report	Snails and ergot posed difficult and expensive contamination problems. For snails, optimum baiting in autumn was compromised by early and persistent rain, while late maturing ryegrass was heavily infested with ergot because crop topping was made difficult as growers tried to avoid damage to late maturing tillers in the crop. Both snails and ergot required grain to be cleaned for delivery. The decision making needed for reseeding waterlogged paddocks was difficult, particularly in the Wellstead to South Stirling's to Kendenup area. Topdressing barley seed resulted in poor establishment and weedy crops, while waiting until late August to reseed resulted in very clean and profitable crops. Despite the late sowing date, these were mostly harvested by mid-January with barley yields at 2.5 to 3 t/ha and wheat at 2 to 4.5 t/ha, a very good, but unexpected result. These were sprayed-out canola paddocks which had high fertiliser applications at seeding. Winter wheat was very successful when sown in early April, out yielding traditional spring wheat crops sown in late May. Early crops did much better than those sown at the usual time because they were big enough to handle the waterlogged soils far better. In this regard, faba beans were also a stand-out for yields though a lot remains unsold with limited marketing opportunities. Some summer forage crops have gone in, but they are now in need of rain to maintain any potential.	Even though it was a good year financially, most growers are happy to see the back of 2021. Waterlogging made farming difficult in the winter and those that were impacted by frost had a slow harvest. There were big differences in grain yield between "wet" farms lower in the profile and "dry" farms higher in the landscape, with plenty of 5 to 6 t/ha barley and wheat on the dry farms graduating back to 3 to 4 t/ha on the wet farms. Canola was exceptional in the area, as it was across the state and many growers had 2 t/ha whole farm averages.

Production Year	Southern Albany South Stirling's, Plantagenet, Kendenup	Western Albany Frankland River Region, West of the Shire of Plantagenet
2022 Feb 2023 GIWA crop Report	Growers in the region eventually managed to get over the wet portions of paddocks and finish harvest in January, although plenty of grain was left behind with up to half a tonne of barley on the ground from wind, hail and heavy rainfall and at least 200kg/ha of canola lost in the same manner. Final harvested grain yields were still very good and above average in most cases. Canola/wheat/canola has been more profitable as the second-year barley has been costly to grow. Barley grain yields were down on wheat in 2022 and in some cases where there was difficulty in controlling net type net blotch and powdery mildew, the yields were grossly different.	The West Albany region has had a run of very good years and the success from the move towards more early sowing has been paying off when waterlogging inevitability cranks up in the winter. The area has sub-soil moisture carryover from 2022 and it will not take much rain to get the profile saturated. Wheat was brilliant in 2022 in the region, has outyielded barley in the last few years, and there will be a continued shift out of barley to wheat again in 2023. It is looking like the dominant cropping rotation will be canola/wheat rather than canola/barley this year. Fixed costs have been the big mover for most growers particularly for machinery, machinery parts, transport and interest if there have been recent financed land purchases. The recent drop in variable input costs has been a good thing, the costs of growing a crop in these high rainfall regions is putting the pressure on to keep the yields up.
2023 Feb 2024 GIWA crop Report	Most growers ended up the year in front without being exceptional as has been the case in recent years. There is more tempered optimism going into the 2024 growing season as the cost of growing crops in the high rainfall regions has climbed to a point where it is putting pressure on growers to keep hitting the more recent higher average yields more often. **Achieving the lower long term average yields is no longer profitable for many.** The region finished up with canola being the standout crop in 2023. Whilst canola crops did not yield as high as they looked with those looking like 2.5t/ha yielding closer to 1.8 to 2.0t/ha, due to the strong price, most returned a profit. Oil percentages were in the low to mid 40's rather than the high 40's in 2021 and 2022 which reduced price premiums to growers. Most growers in the region have the agronomy of growing canola well in hand and overall costs of growing canola have increased.	The run of exceptional years in the region came to a halt in 2023 with all c**rops back to more long-term averages of 2.0t/ha for canola and high 3.0t/ha to low 4.0t/ha for wheat** and barley. They are still profitable crops although **the breakeven yields are now closer to 1.7t/ha for canola and 3.2-3.7t/ha for cereals** which sounds high for growers in other regions of the state and for the rainfall achievable. Although a return to a greater influence from waterlogging and frost can see these average yields across whole paddocks quickly slip below profitable levels. Whilst grower sentiment is still very high for the region, there is a noticeable return to careful spending on input costs and less appetite to push for very high yields in all situations. Fixed costs have been the big mover particularly for machinery, machinery parts, transport and interest if there have been recent financed land purchases. **The costs of growing a crop in these high rainfall regions is putting the pressure on to keep the yields up.**

7.3. Impact on farm profitability

Farm businesses face a high level of risk due mostly to variations in weather conditions and commodity markets. Both sources of risk are particularly high in Australia[34] given our export focused and unregulated commodity markets and our variable climate with lower mean rainfall and higher variance than most other countries.[35]

Incidents of drought compound the risk and the financial impact of drought to farm businesses can be severe. Figure 62 demonstrates how the drought in 2019 severely impacted all rainfall zones profitability in Western Australia.

The time series in Figure 62 is from the Planfarm benchmark data and shows the Operating surplus (Gross Farm Income minus Total Operating Expenses (Variable + Fixed costs)) also known as earnings before interest and tax (EBIT). The operating surplus pays interest, tax and personal expenses as well as any business expansion, machinery replacement or capital improvements. When farm businesses are impacted by drought it becomes difficult to meet these financial commitments, instead they must rely on using equity or find an off-farm income.[36]

There are several observations about this data:

- The drought years of 2002, 2006, 2010 and 2019 are evident with low operating surplus for all regions (2002 being an exception for the high rainfall region)
- The operating surplus in the low rainfall regions are more often below $50 per hectare, in 2002, 2004, 2006, 2009, 2010 and 2019.
- There is a notable increase in variation between years in the last two decades compared to the first ten years.
- Operating surplus between the low rainfall region and the medium-high rainfall region diverges from 2010 onwards.
- An increasing trend in operating surplus for all regions.
- The significant decrease in operating surplus in 2019 for all regions including the high-rainfall region.

34 Keogh, M., 2012, 'Including risk in enterprise decisions in Australia's riskiest businesses', in, 56th annual conference of the Australian agricultural and resource economics society, Perth, Australia, pp 8-10

35 Peel, M.C, McMahon, T.A, and Finlayson, B.L., 2004, 'Continental differences in the variability of annual runoff-update and reassessment', Journal of Hydrology, vol.295, no. 1, pp. 185-197

36 Anderton, (2016). Financial, productivity and socio managerial characteristics of broadacre farms in Western Australia: A decadal assessment, Unpublished MSc thesis, University of Western Australia, Perth, Australia.

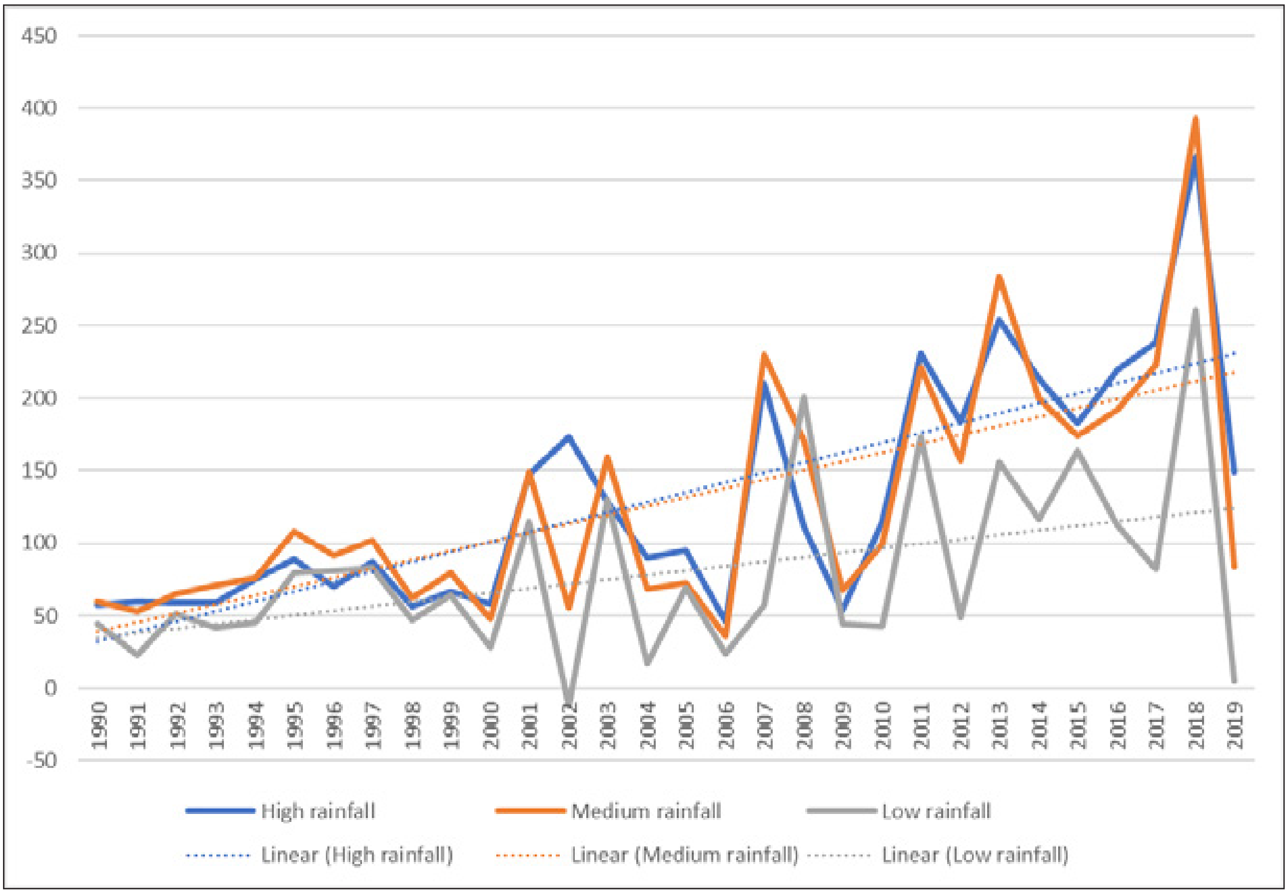


Figure 62. Operating surplus for WA farms 1990 to 2019[37]

The likely reasons for the increase in variation in the operating surplus between years is the combination of increasing variation between seasonal conditions and increased area of cropping. It is this year-to-year change in seasonal conditions and variability within seasons that farming communities must manage whilst keeping a view on the medium and long-term risks to achieve longevity in business.

Typically, during drought years the operating surplus is not sufficient to support all business expenses resulting in increased debts to pay for inputs the following year.

The significant drop in operating surplus in 2019 (Figure 62) resulted in the worst financial outcome for farms in this data set. The reason for this significant loss was drought, but also the complexity in decision making compounded the outcome. The 2018 year was extremely profitable, and in 2019 confidence was high, producers had surplus cash and invested in more fertiliser, lime, and potassium. Early seeding often before rains to achieve optimum yields means 80% of inputs are at the start of the season. Further nitrogen and potassium, due to confidence in the seasonal conditions were applied, however the lower-than-average rain in August and September reduced yields significantly. The combination of low yields and high costs reduced margins and operating surplus, Figure 62. (R. Grima, personal communication, June 13, 2022)

The increasing trend for increased spending on fertiliser and chemicals continued into 2021, 2022 and 2023, Figure 63. High levels of profit before tax were achieved in 2020, 2021 and 2022, however the seasonal conditions with a very dry finish at the end of 2023 resulted in significant losses.

37 Bankwest-Planfarm benchmarks and Planfarm benchmark publications since 1990, the average of each region e.g., High rainfall operating surplus is the average of High rainfall region 1, 2, 3, 4 and 5.

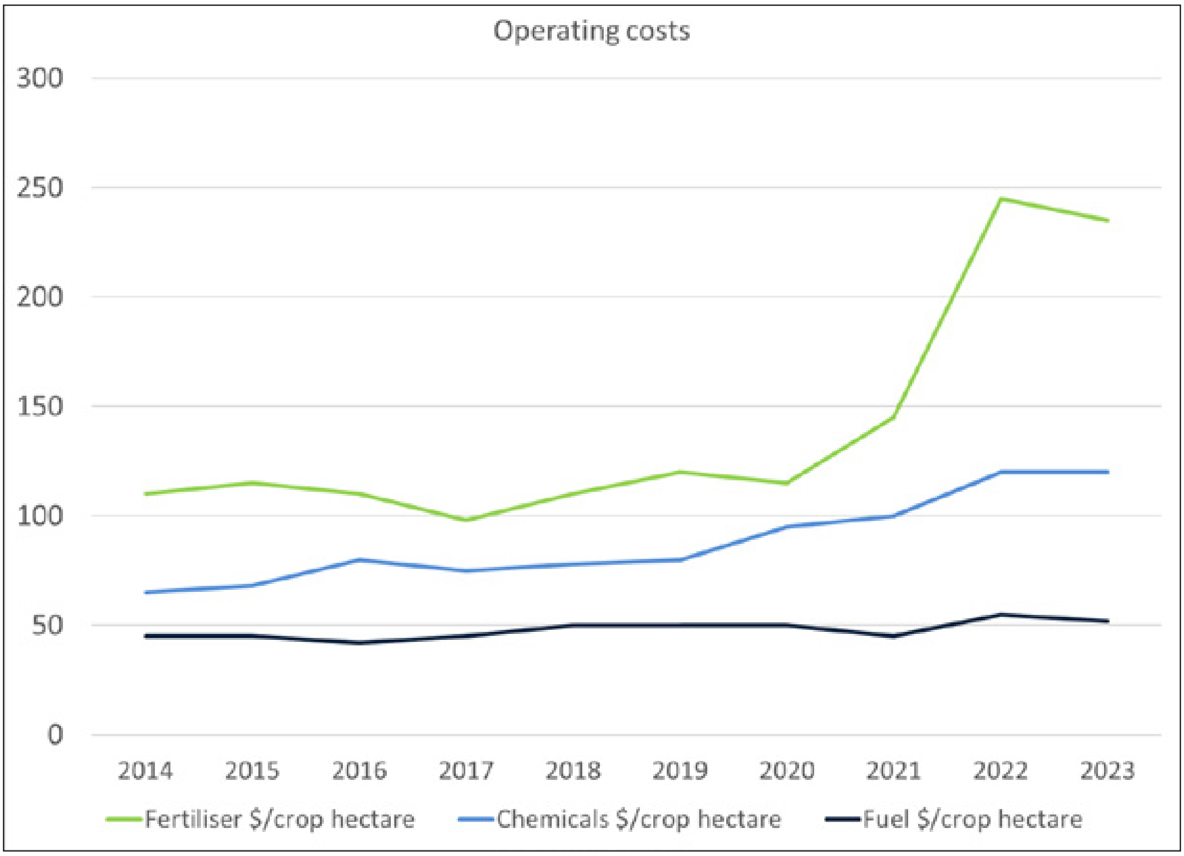


Figure 63. Fertiliser and Chemical costs $/crop ha from 2014 to 2023[38]

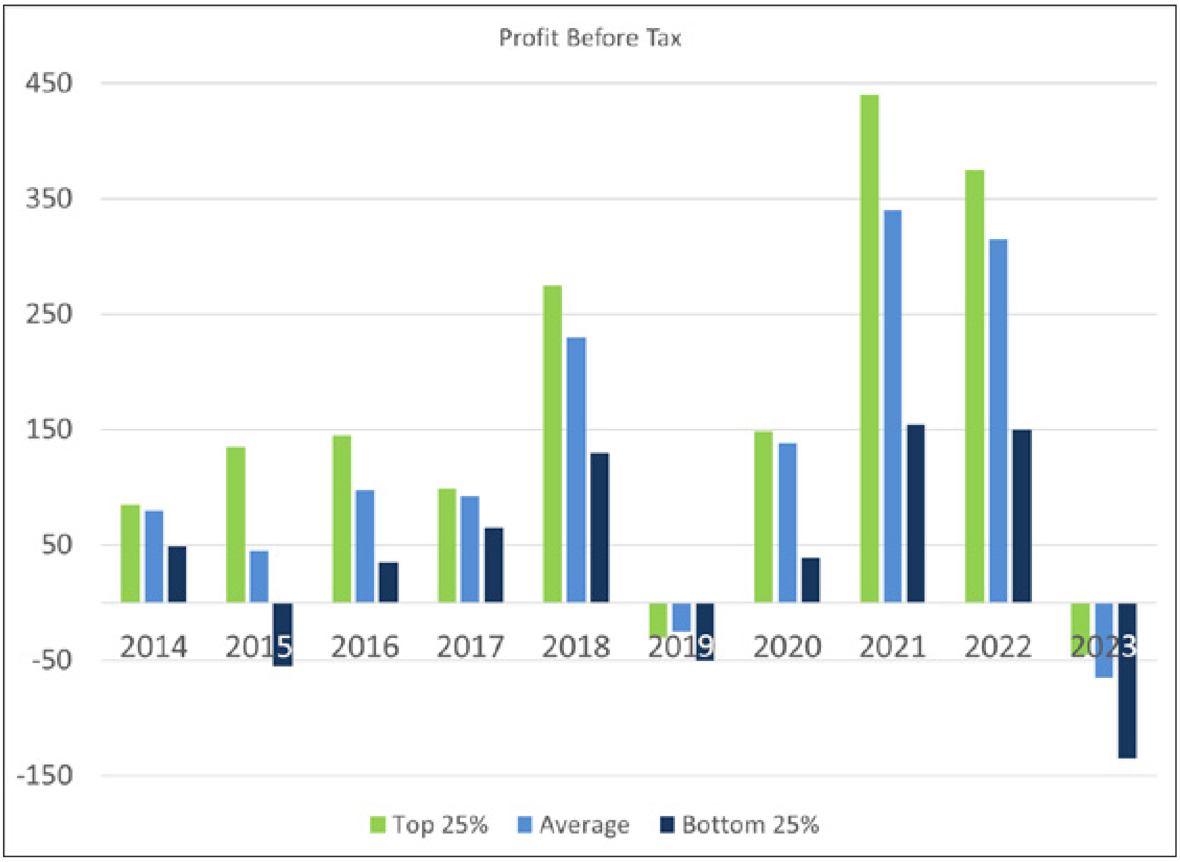


Figure 64. Profit Before Tax from 2014 to 2023

38 PlanFarm Benchmarks 2023 Season, presentation slides September 2024

ABARES research using farmpredict, a micro-simulation model of Australian broadacre farms that controls for non-climate factors uses farm business profit to show changes in climate conditions over the last 20 years. The results show an adverse effect on the productivity of Australian cropping farms. Changes in climate over the period 2000 to 2019 (relative to the period 1950 to 1999) have had a negative effect on the profitability of broadacre farms in Australia including both cropping and livestock sectors, shown in Figure 65 and Figure 66.

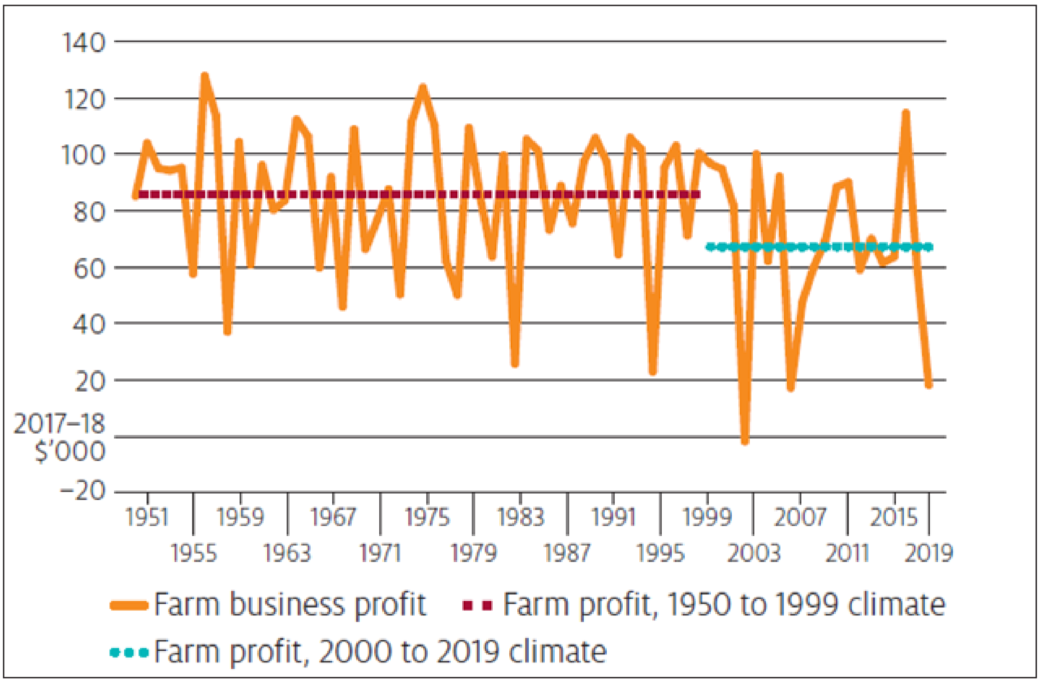


Figure 65. Effects of climate variability on average farm business profit 1949-50 to 2018-19 assuming current farms and commodity prices.

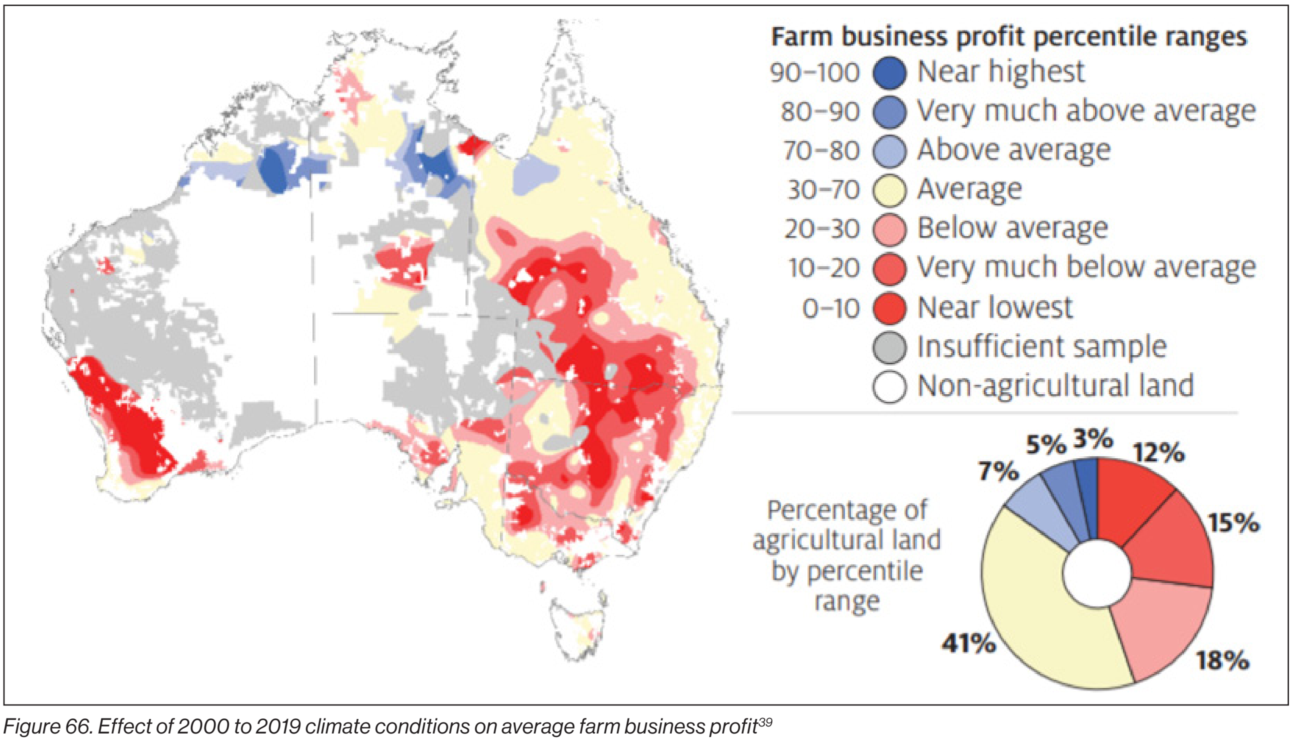


Figure 66. Effect of 2000 to 2019 climate conditions on average farm business profit[39]

39 Simulated broadacre farm business profit with current farms and commodity prices (2015–16 to 2017–18). Percentiles for the 20-year period 1999-2000 to 2018–19 relative to the reference period 1949–50 to 2018–19. Farm business profit is calculated at market prices for all inputs and outputs, including unpaid family labour, as well as changes in the value of stocks (including inventory and livestock). Pie chart percentages do not add due to rounding error.

These results show changes in climate since 2000 have reduced average annual broadacre farm profits by 22%, or around $18,600 per farm.

In Western Australia average annual broadacre farm profit from 1950-1999 was $226,000, from 2000 to 2019 this decreased by 25.8% to (-$58,000) to $167,600. This was the largest decrease out of all States. The cropping sector was impacted the most, with a reduction in average profits of 35% or $70,900 for a typical cropping farm, which seems counter intuitive when looking at data from WA, however the increase in farm size and associated efficiencies mask the climatic impact ABARES identify.

7.4. Impact of drought on the Environment

As the climate is expected to become drier and warmer, the accumulative effect of this warming has potential to increase the risk to the environment through drought.

Drought leads to reduced water and habitat availability, impacting water quality and increasing algal blooms, including harmful algae blooms (HABs) that produce toxins detrimental to aquatic life and animals. These conditions are exacerbated by low water flows and higher temperatures, which can result in reduced oxygen levels and nutrient build-up, stressing the entire ecosystem.

Vegetation and biodiversity are also threatened by drought, particularly in regions like Western Australia, which has several biodiversity hotspots including the natural environment in the Shire of Denmark and the Stirling Ranges. Drought conditions lead to reduced vegetation productivity, increased plant mortality, and long-term impacts on species diversity, especially for those unable to adapt or migrate. The loss of vegetation can cause irreversible changes in ecosystem structure and affect essential services like soil fertility and water purification.

Drought also heightens risks such as wildfires, which can devastate ecosystems but may also play a role in regeneration. However, recurrent fires can reduce a forest's ability to recover. Additionally, drought affects the populations of feral animals, which are pests that disrupt native ecosystems. While droughts reduce their populations, post-drought conditions may lead to a rapid population increase, further harming the environment.[40].

The impact of future droughts could be more severe. This means, more wind erosion and damage to the vegetation and biodiversity.

Vegetation and biodiversity underpin a range of ecosystem services including:

- Provisioning Services – food, fibre and fuel, genetic resource, biochemicals, freshwater
- Cultural Services – spiritual & religious services, recreation, knowledge, education, and inspiration
- Supporting Services – primary production, provision of habitat, nutrient cycling, soil formation and retention, atmospheric oxygen production, water cycling
- Regulatory Services – invasion resistance, pollination, herbivory, seed dispersal, climate regulation, pest and disease regulation, natural hazard protection, erosion regulation, water purification

The Summary Score gauge and graph in Figure 67, displays the environmental health of Western Australia using the ANU environmental score card, this can be observed down to the shire region level.[41] Using data captured largely from satellite imagery and ground data verifying the satellite data for regions are scored for their presence of seven categories out of fifteen. Inundation, streamflow, vegetation growth, leaf area, soil ground cover, tree cover (canopy), and the number of hot days experienced[42]. These seven categories are then combined and given a score out of ten. [43]

40 Anderton, L. (2024) Drought Vulnerability Assessment for the Coastal Great Southern Regional Drought Resilience Plan. Prepared for GSDC and DPIRD

41 Van Dijk, A.I.J.M. and Rahman, J. (2019) Synthesising multiple observations into annual environmental condition reports: the OzWALD system and Australia's Environment Explorer. In Elsawah, S. (ed.) MODSIM2019, 23rd International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2019, pp. 884–890.

42 Australian National University (ANU), & Terrestrial Ecosystem Research Network (TERN). (2020, February 8). Summary Indicators. Australia's Environment Report. https://www.wenfo.org/aer/summary-indicators/

43 Australian National University (ANU), & Terrestrial Ecosystem Research Network (TERN). (2020, February 8). Summary Indicators. Australia's Environment Report. https://www.wenfo.org/aer/summary-indicators/

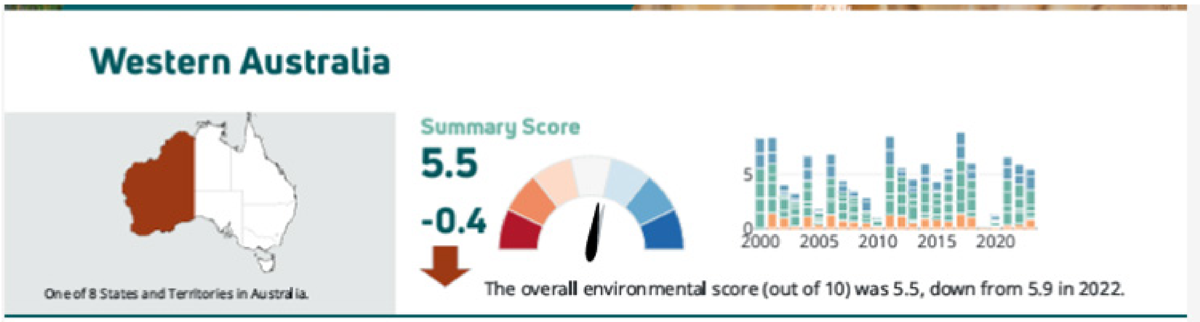


Figure 67. Western Australia summary score for the environment with the components of the score

The final score is then compared to the score of the previous year to show the growth or impact this year's weather and human activities have had on the environment. Further details about the method and collection of data refer to Appendix 4.

The environmental condition scorecard summarises observations on our natural resources and ecosystems and reports on several measures to give an overall environmental score between 0 and 10 relative to previous years.

It is calculated as the average of the ranking of component scores.

The summary score for Western Australia in 2023 is 5.5, lower than 2022's 5.9.

Table 3 refers to the drier than average years for the Coastal Great Southern Shires using annual rainfall and growing season rainfall data.

Table 3. Drier than average years for the local government areas in the Coastal Great Southern Region

City of Albany	Shire of Denmark	Shire of Plantagenet	Frankland River
2004	2004	2001	2006
2006	2006	2006	2010
2007	2010	2010	2019
2010	2014	2018	2023
2015	2015	2019	
2019	2018	2023	
2023	2019		
	2023		

These years are referenced to assist with understanding how the environment responds to these dry years using key indicators from the environmental scorecard.

Four key indicators were selected to investigate and understand the impact of drought, these are the **Leaf Area Index, Vegetation Growth, Soil Moisture** and **Exposed Soil** (soil protection).

The leaf area index (LAI) is calculated from the amount of foliage measured in the tree canopy[44]. This measurement can give an estimate on the average biomass, photosynthetic activity and water and nutrient uptake. Measurements are taken by handheld devices at the TERN Ecosystem Surveillance plots (there are over 750 TERN monitoring sites), and by hemispherical photography at the SuperSites3 These results are used to ground truth the satellite data and create models for the rest of the State and Nation which allows for future predictions based on historical results and trends. The National data then comes from the MODIS satellite imagery and the OzWALD model data fusion system[45].

Vegetation Growth is calculated by the natural biomass changes observed by satellites, some of the data collected looks at the Gross Primary Production (GPP) measurements which come from the carbon uptake of plants through photosynthesis are used to calculate the environments Vegetation Growth, which are also ground truthed from the TERN sites. This data then is used by the OzWALD model data fusion system to create future predictions.

Soil moisture is the average amount of the stored profile during the year, estimated by the OzWALD model-data fusion system.

Exposed soil is measured using an annual mean percentage of soil unprotected by living vegetation or litter, derived from MODIS imagery and CSIRO mapping by the OzWALD model -data fusion system.

Soil is a non-renewable source that is critically vulnerable to loss and degradation, particularly during periods of extreme climatic conditions like drought. Erosion is one of the greatest risks to soil health, as it strips away the fertile top layers of soil and organic matter[46] taking with it most of the fertility and organic matter of the soil.[47]

The impact drought has on soil is complex. Reduced rainfall and higher temperatures dry out the soil, creating cracks that reduce the moisture and volume of the soil, affect the activity of soil organic matter reducing soil particle cohesion, change soil texture decreasing its water holding capacity, and limits plant growth reducing vegetation and crop residue cover. This leaves soil vulnerable to erosion through water runoff and wind.

Wind erosion can cause significant environmental and economic damage and can have a detrimental impact on human health. Major dust storms can sandblast vegetation and crops, and deposit unwanted nutrients threatening plants and animals and causing harmful algal blooms. They also pose a risk to human health by polluting the air causing asthma and other health problems.

Increasing climate variability indicates that rainfall events will become more extreme and intense.[48] This, combined with drought affected soils that have a lower water holding capacity leads to greater surface water movement, resulting in water soil erosion.[49] Erosion from drought breaking rainfall has the potential to make up 90% of total soil loss in a 20–30-year cycle.[50] The cost of water erosion to dryland faming in WA is estimated to be approximately $10 million annually.[51]

Soil erosion has a profound effect on both natural resources, and the agri-environment. Agricultural productivity is affected by the loss of the most fertile layers of the soil. Water quality is also degraded because of eutrophication, siltation, and sedimentation.

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44 National Climate Change Adaptation Research Facility. (n.d.). TERN Supersites | General. Nccarf.jcu.edu.au. Retrieved April 21, 2022, from https://nccarf.jcu.edu.au/terrestrialbiodiversity/index.php/General/tern-supersites.

45 Australian National University, & TERN. (2016). Australia's Environment Explorer. Wenfo.org. http://wenfo.org/ausenv/#/2021/Environmental_Condition%20Score/Region/Actual/Local_Government%20Areas

46 NSW Department of Planning and Environment (30 Jan 2020), Wind erosion, NSW Government. https://www.environment.nsw.gov.au/topics/land-and-soil/soil-degradation/wind-erosion Retrieved 30 May 2022

47 Agriculture Victoria (18 June 2021), Protecting the land in dry times, Victoria State Government, https://agriculture.vic.gov.au/farm-management/managing-for-and-during-drought/protecting-the-land-in-dry-times Retrieved 30

48 Howden, M (11 May 2022), Climate change science and Australian agriculture and food, WA Climate Smart Agricultural Fellowship 2022, Australian National University, Institute of Climate

49 Masroor, M, Sajjad, H et al, (2022), Analysing the relationship between drought and soil erosion using vegetation health index and RUSLE models in Godavari middle sub-basin, India, Geoscience Frontiers 13 (2) 1-9

50 Department of Primary Industries (DPI), (April 2020), Soil management – drought recovery, Prime fact 367(2), NSW Government. Retrieved 30 May 2022

51 Department of Primary Industries and Regional Development (4 April 2022), Water erosion in the south-west of Western Australia, Government of Western Australia, https://www.agric.wa.gov.au/water-erosion/water-erosion-south-west-western-australia Retrieved 30 May 2022

Figure 68 shows the percentage area of exposed soil in 2023 for the local government areas in the Coastal Great Southern Region. The graph in Figure 69 shows the percentage area of exposed soil from 2000 to 2023. The Shire of Denmark has the lowest area of exposed soil which remains relatively constant. The most severe year for nearly all local government areas was in 2000 which is shown in Figure 69 and Figure 70.

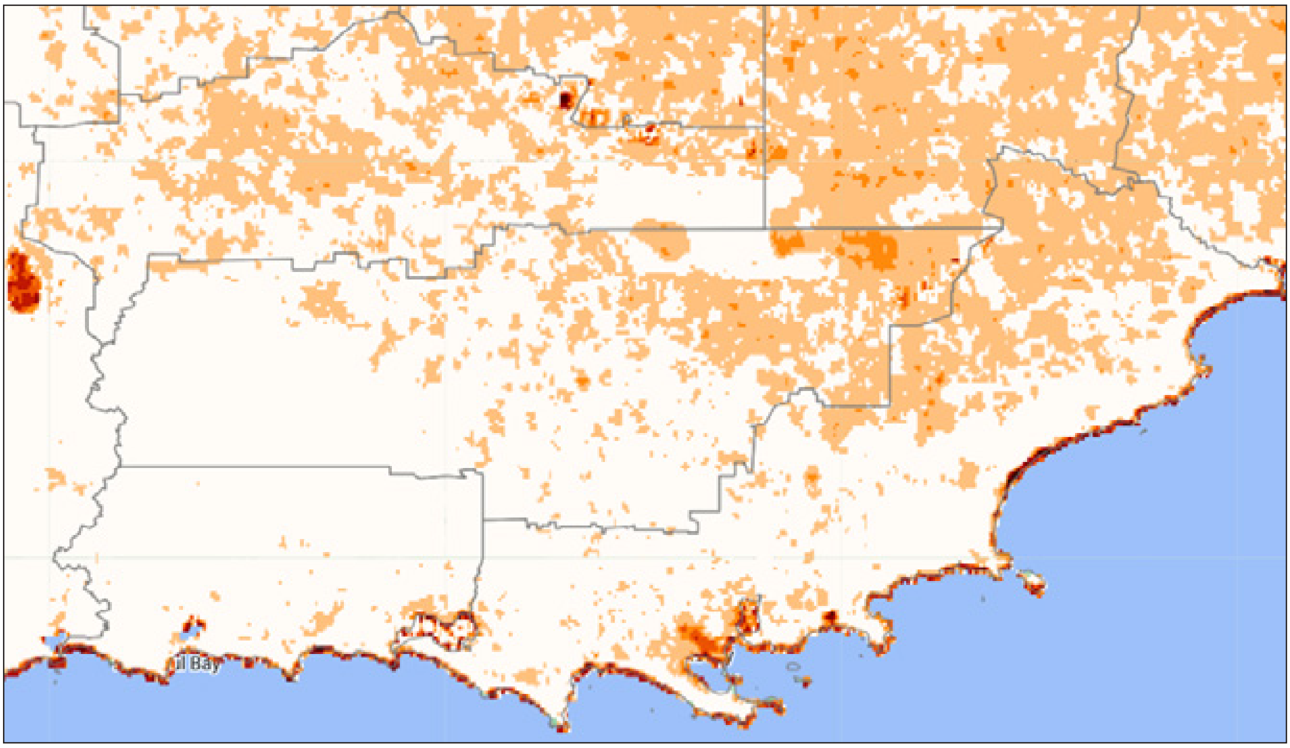


Figure 68. Exposed soil for 2023 (%)

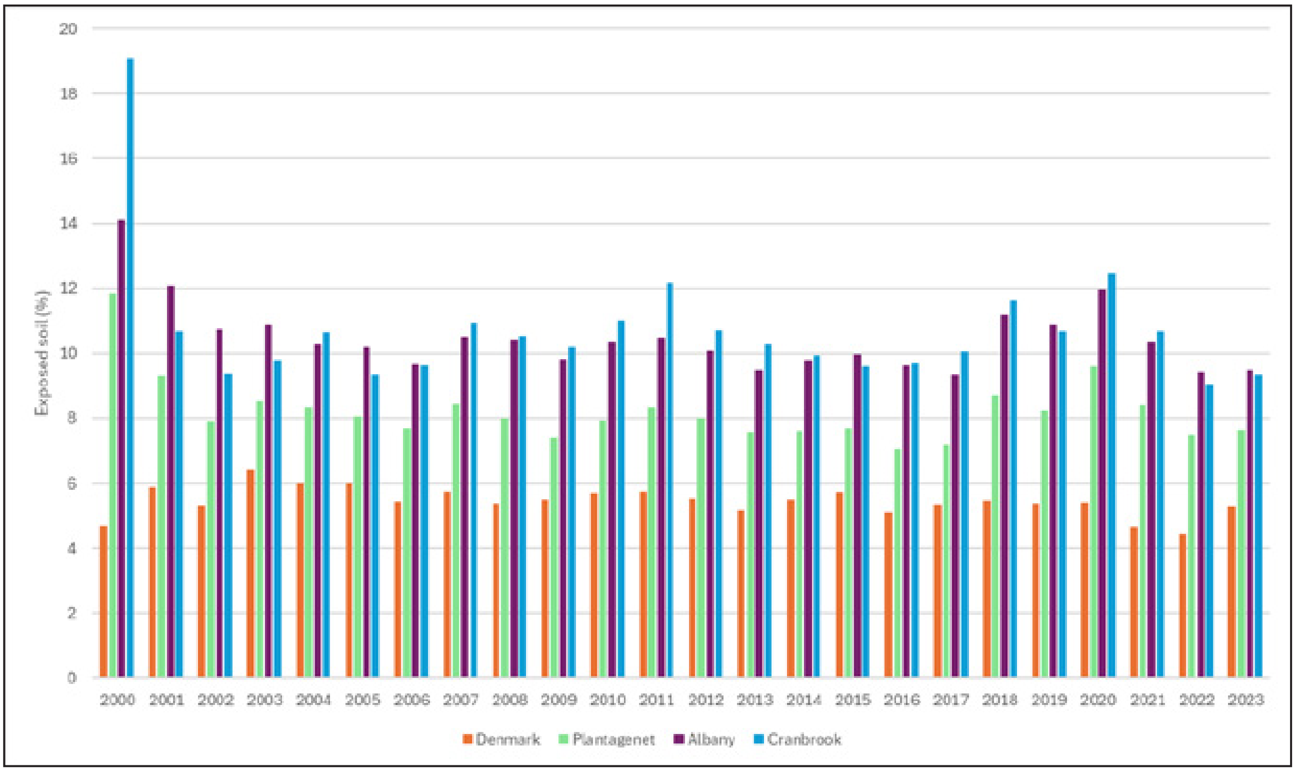
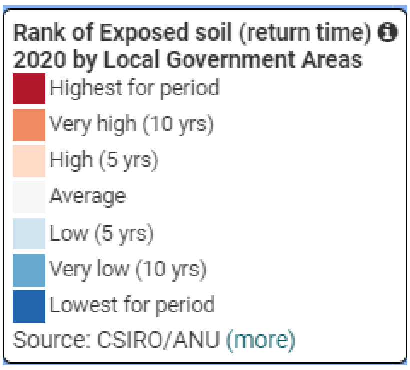
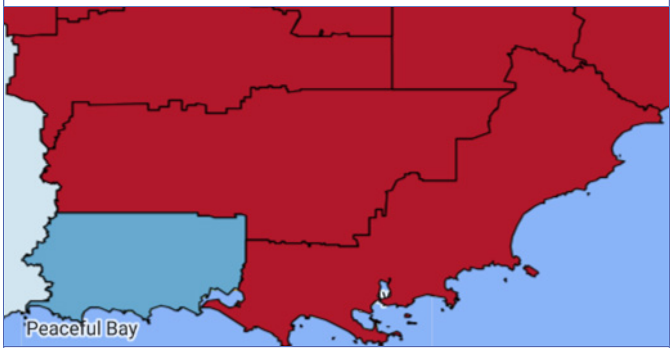
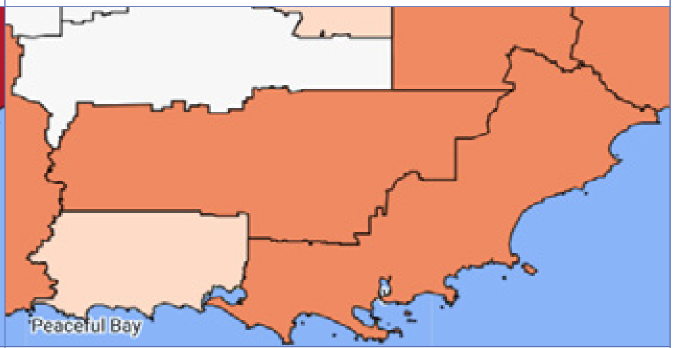
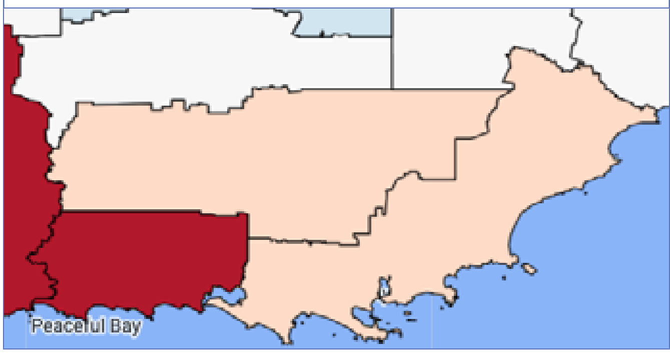
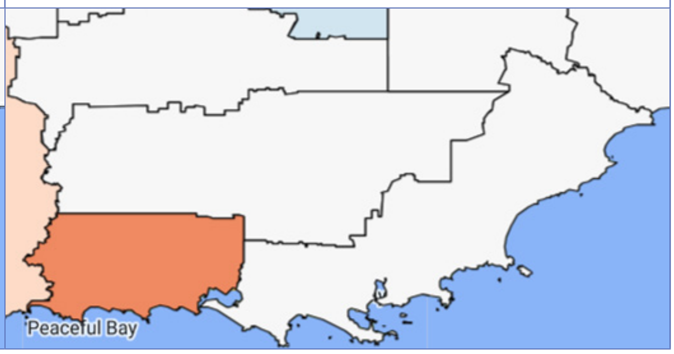


Figure 69. Exposed soil for the local government areas in Coastal Great Southern (%)

Figure 69 shows how the level of exposed soil in the Shire of Denmark is relatively low compared to the other local government areas in the Coastal Great Southern region. The level is relatively consistent from 2000 to 2023. The year 2003 is the most severe year and the graphs in Figure 70 further explain the bar chart in Figure 69.

Rank of exposed soil (return times) Annual mean percentage of soil unprotected by living vegetation or litter, derived from MODIS imagery and CSIRO mapping by the OzWALD model-data fusion system.	
Average	**Average years**
	**2002, 2006, 2007, 2008,2009, 2012, 2014, 2015, 2019**
Below Average Years	
2000	**2001**
	
2003	**2004**
	

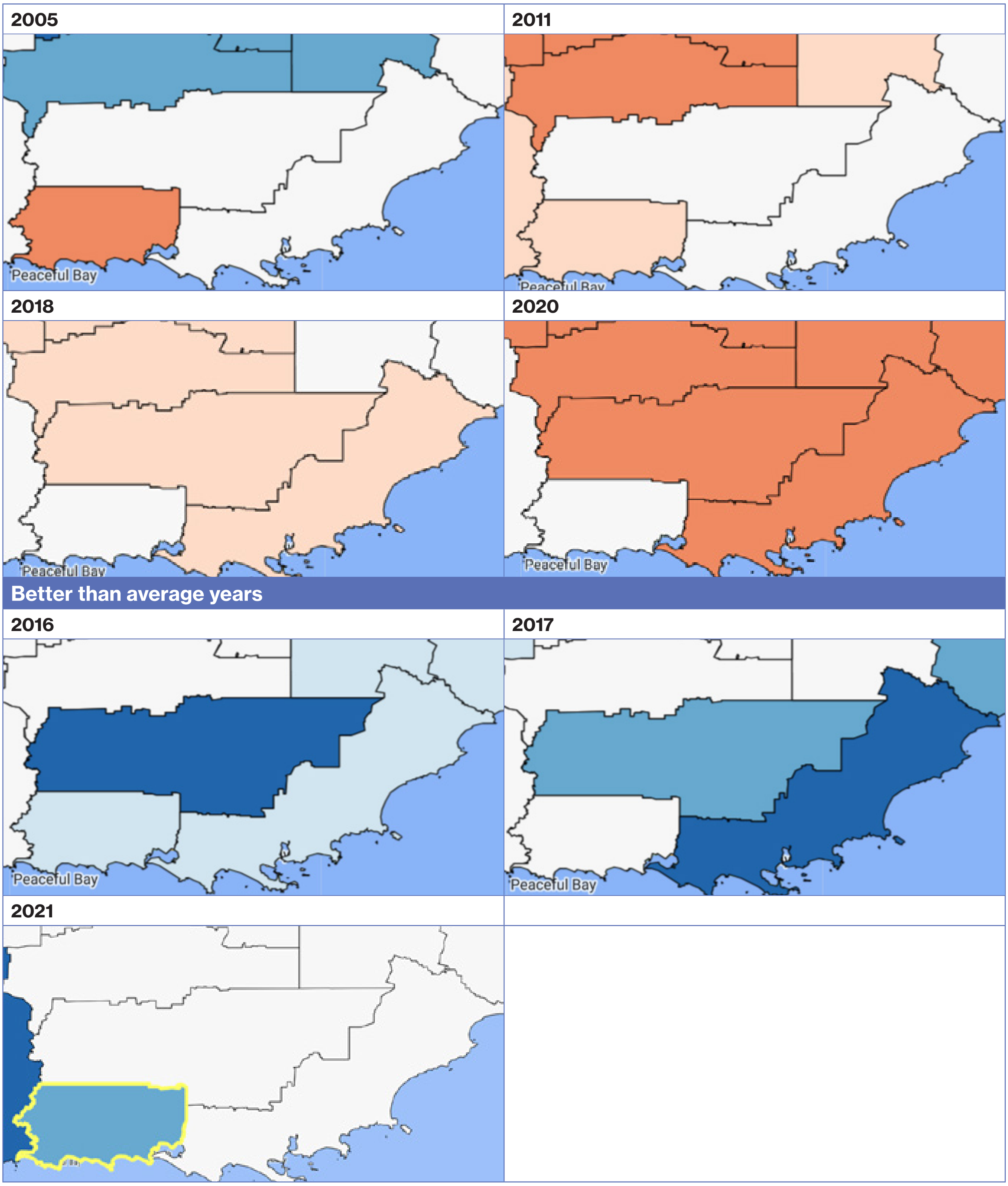


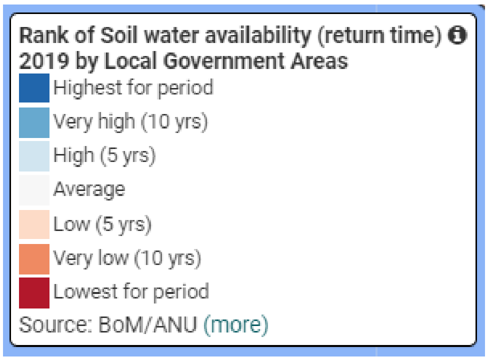
Figure 70. Rank of exposed soil for the Coastal Great Southern Region 2000 to 2023

Often the exposed soil is below average the year after a dry year, for example when you follow the exposed soil in Denmark each year, it is above average for 2000 because 1999 was a year with above-average rainfall, however, 2000 was below average and 2001 exposed soil was the lowest for 5 years. Because Denmark has a high proportion of natural environment its exposed soil is naturally low compared to the Shire of Cranbrook. The Shire of Cranbrook has much less vegetation with large areas of dryland broadacre cropping and livestock grazing.

The exposed soil indicator and the soil water availability indicators show the variability within the Coastal Great Southern Region. When some local government areas have good soil moisture availability others can be ranked quite differently. This illustrates how the conditions can change significantly between these local government areas and even within them.

Soil water availability

The average amount of water (mm) stored in the soil profile during the year is estimated by the OxWALD model data fusion system.



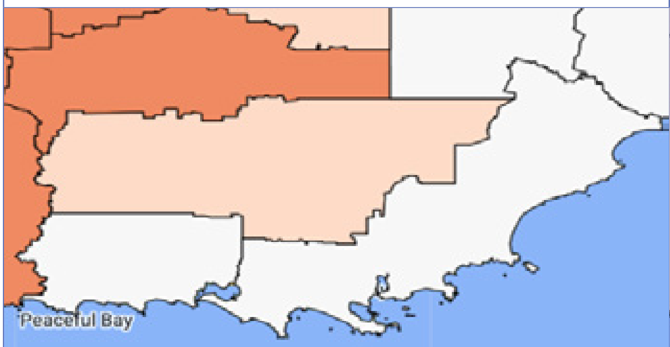
Average

Average years

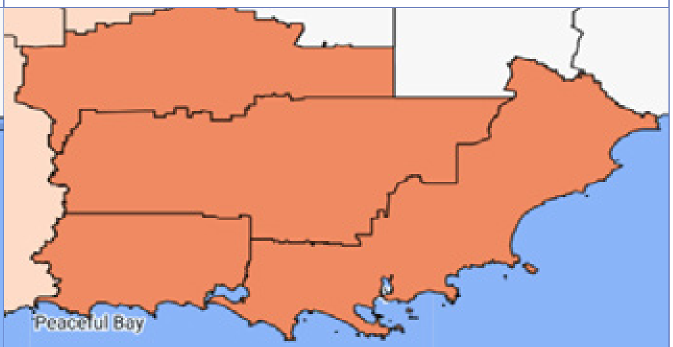
2000, 2002, 2003, 2004, 2008, 2012, 2013, 2015, 2018, 2020, 2022

Below Average years

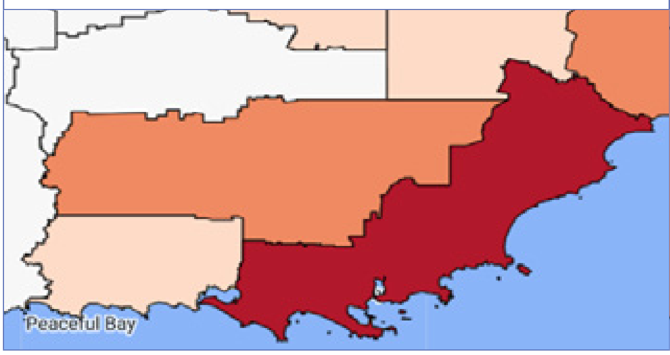
2001



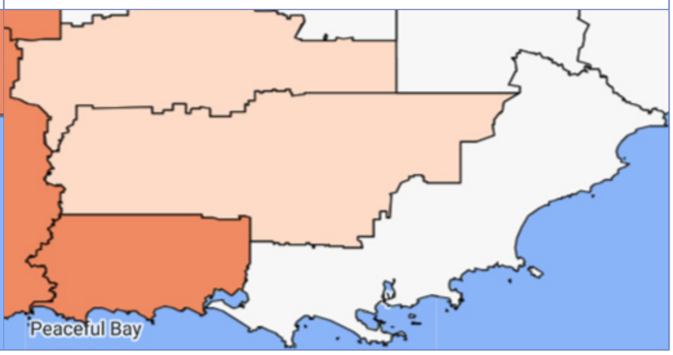
2006



2007



2010



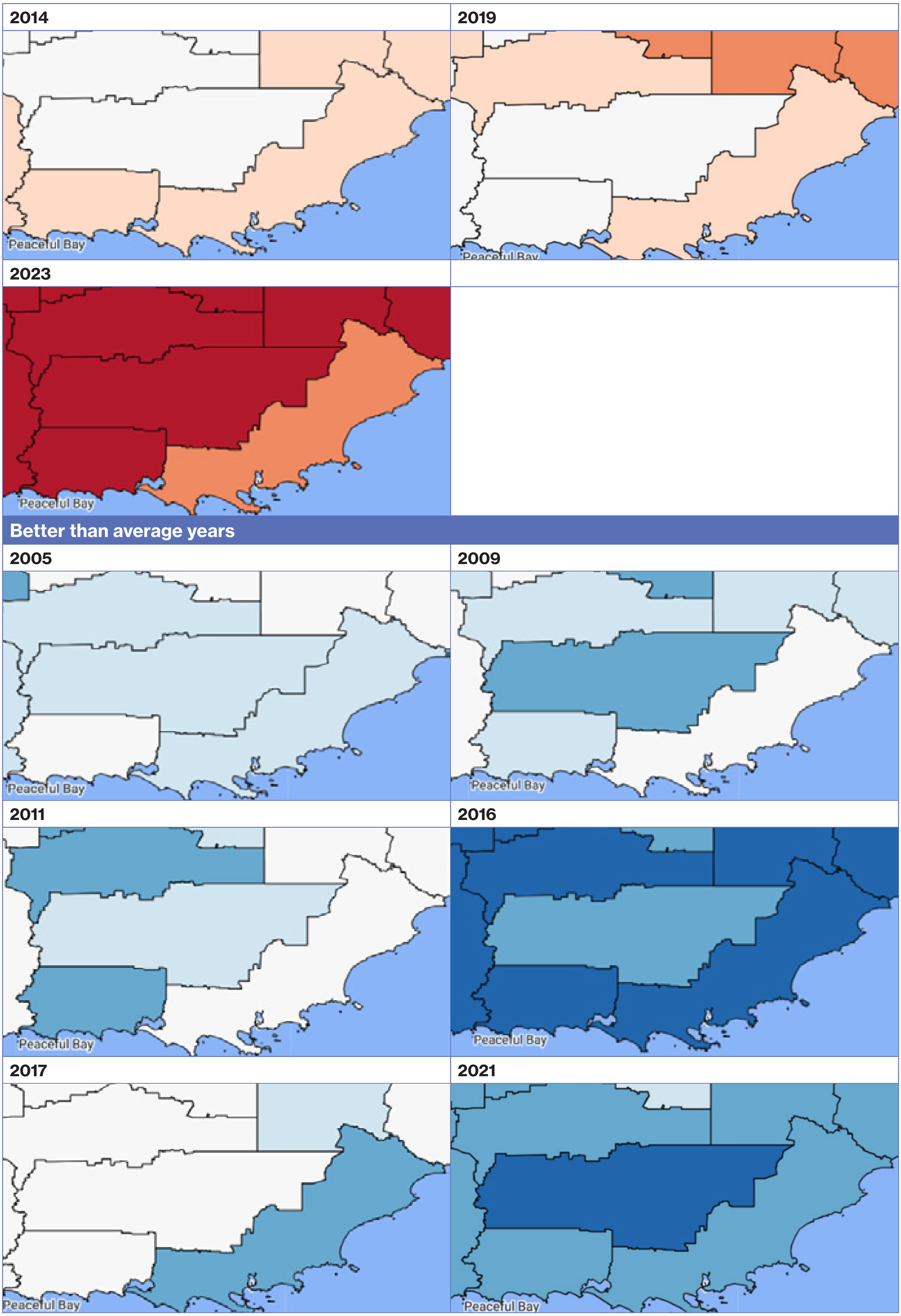


Figure 71. Rank of soil water availability for the Coastal Great Southern Region 2000 to 2023

The soil water availability in 2023 was lowest for the period for nearly all the local government areas and corresponds with the data and evidence within this report.

The mean leaf area was also used to show the impact of drought on the vegetation. Figure 72 shows a satellite image from the OzWALD model for the annual mean leaf area showing the actual for 2023. Denmark has the highest mean leaf area compared to the other local government areas. This is not unexpected considering the area or natural environment.

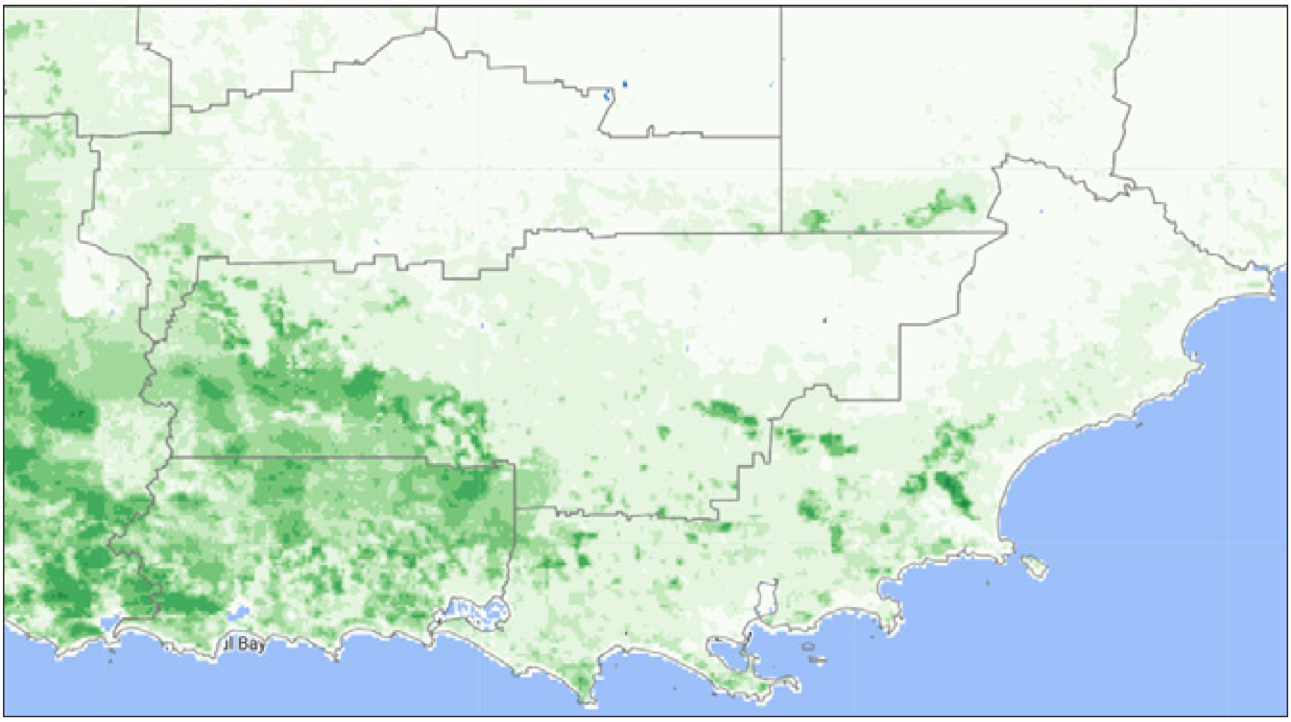


Figure 72. Annual mean leaf area, derived from MODIS satellite imagery by the OzWALD model-data fusion system. Actual for 2023 (Km²)

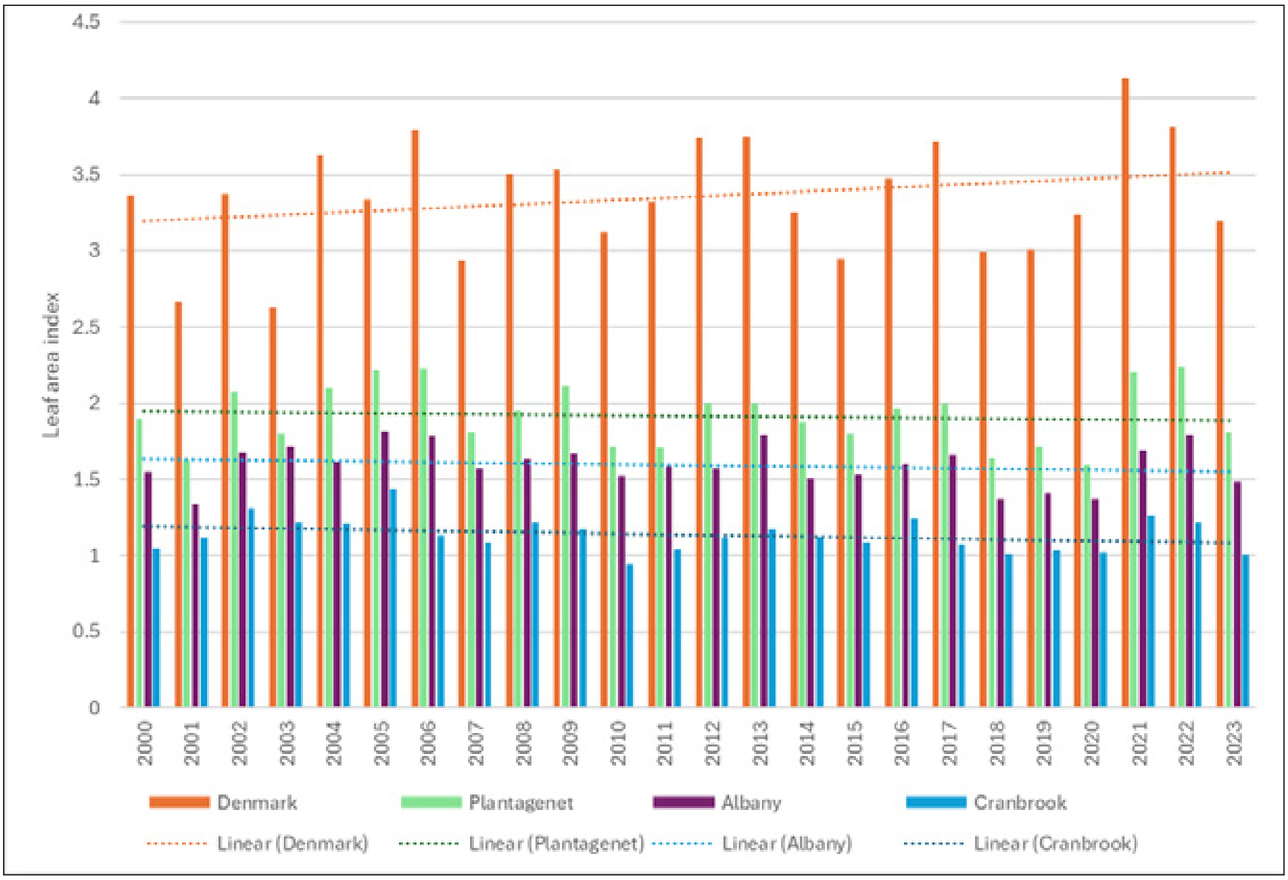
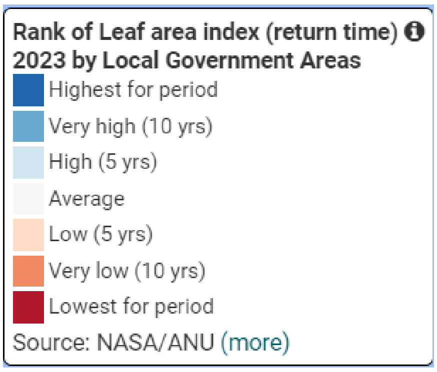


Figure 73. Leaf Area Index for the local government areas in the Coastal Great Southern Region (m^2/m^2)

Vegetation leaf area

Annual mean percentage of vegetation leaf area, derived from MODIS imagery and CSIRO mapping by the OzWALD model-data fusion system.



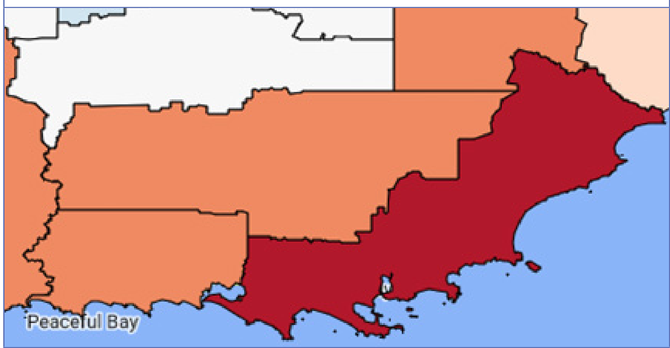
Average

Average years

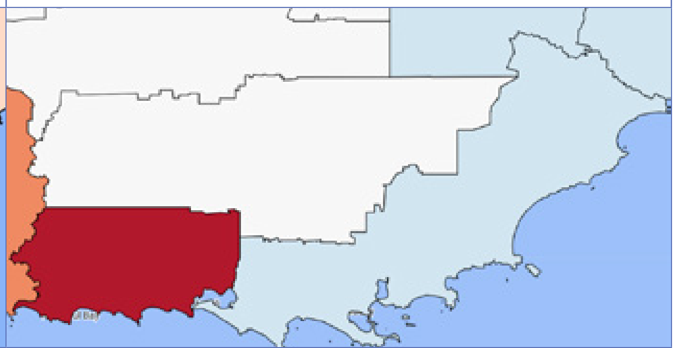
2000, 2004, 2008, 2014, 2017

Below Average Years

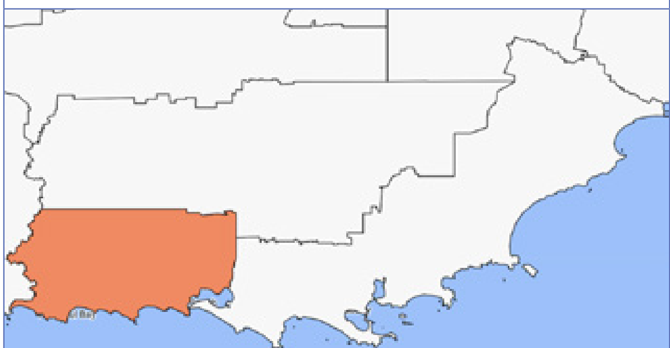
2001



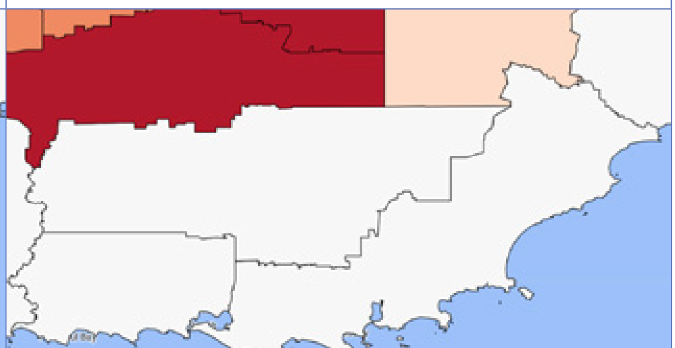
2003



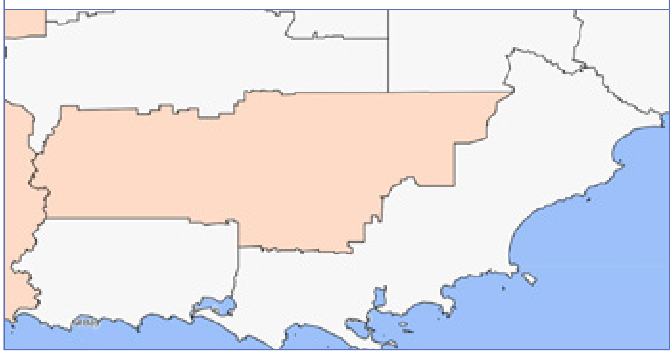
2007



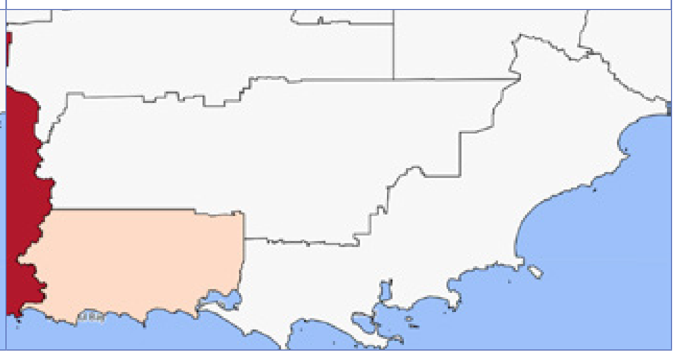
2010



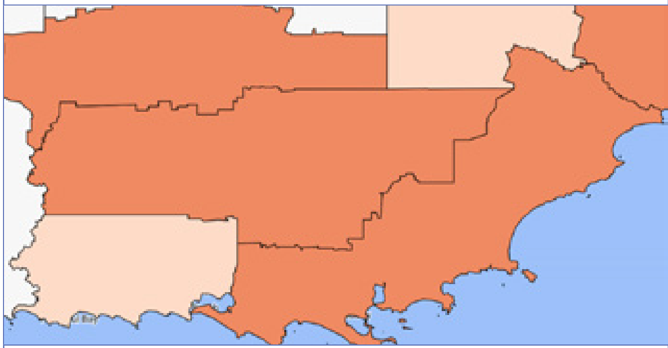
2011



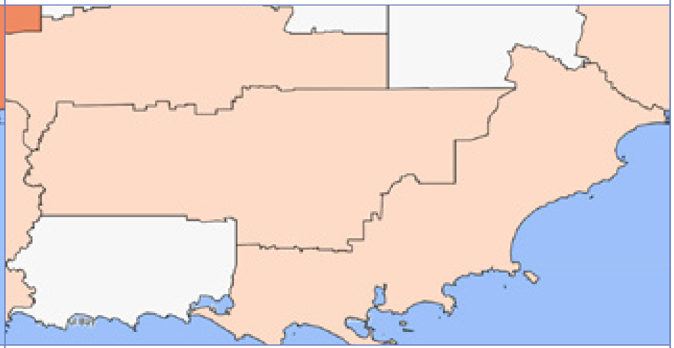
2015



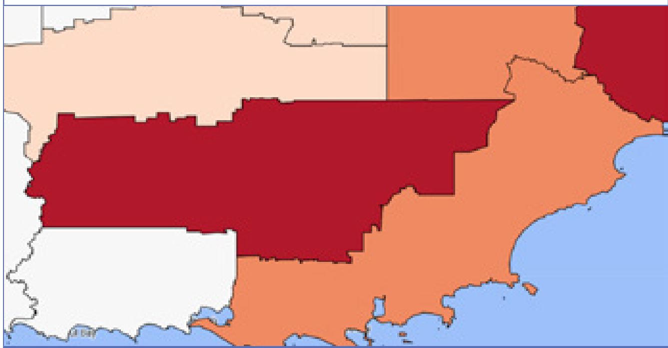
2018



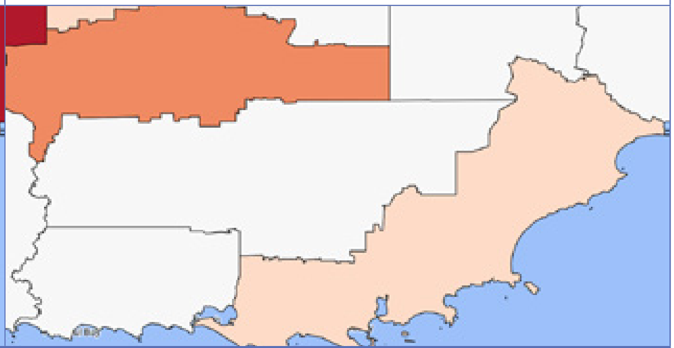
2019



2020

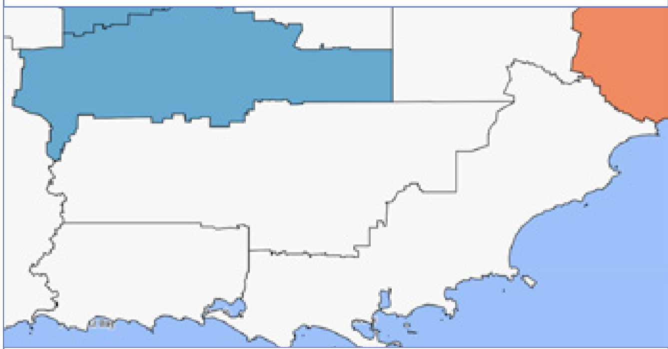


2023

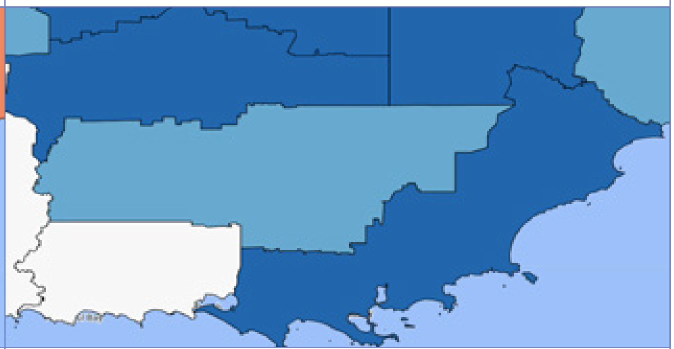


Better than average years

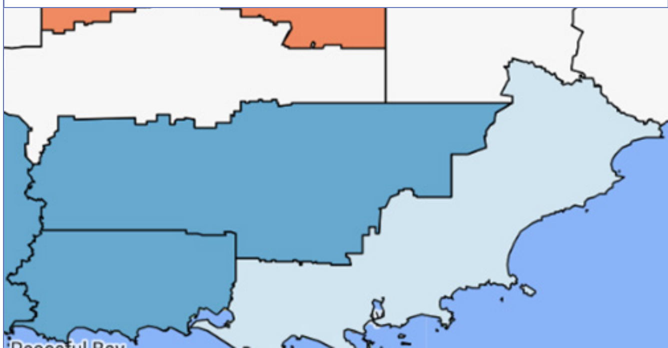
2002



2005

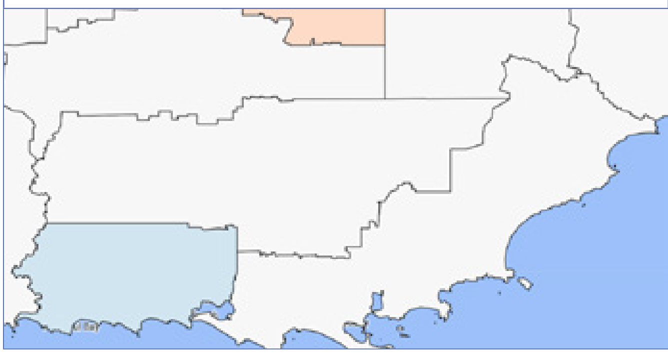


2006

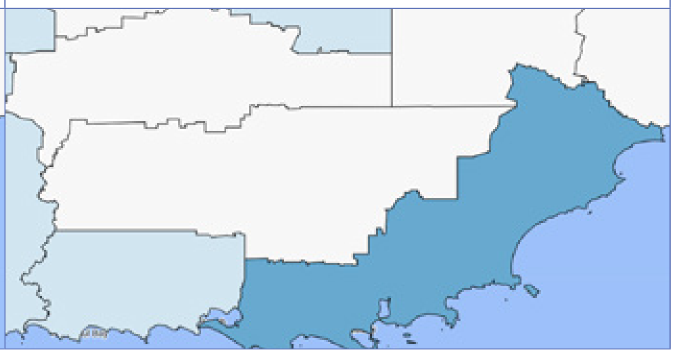


2009

2012



2013



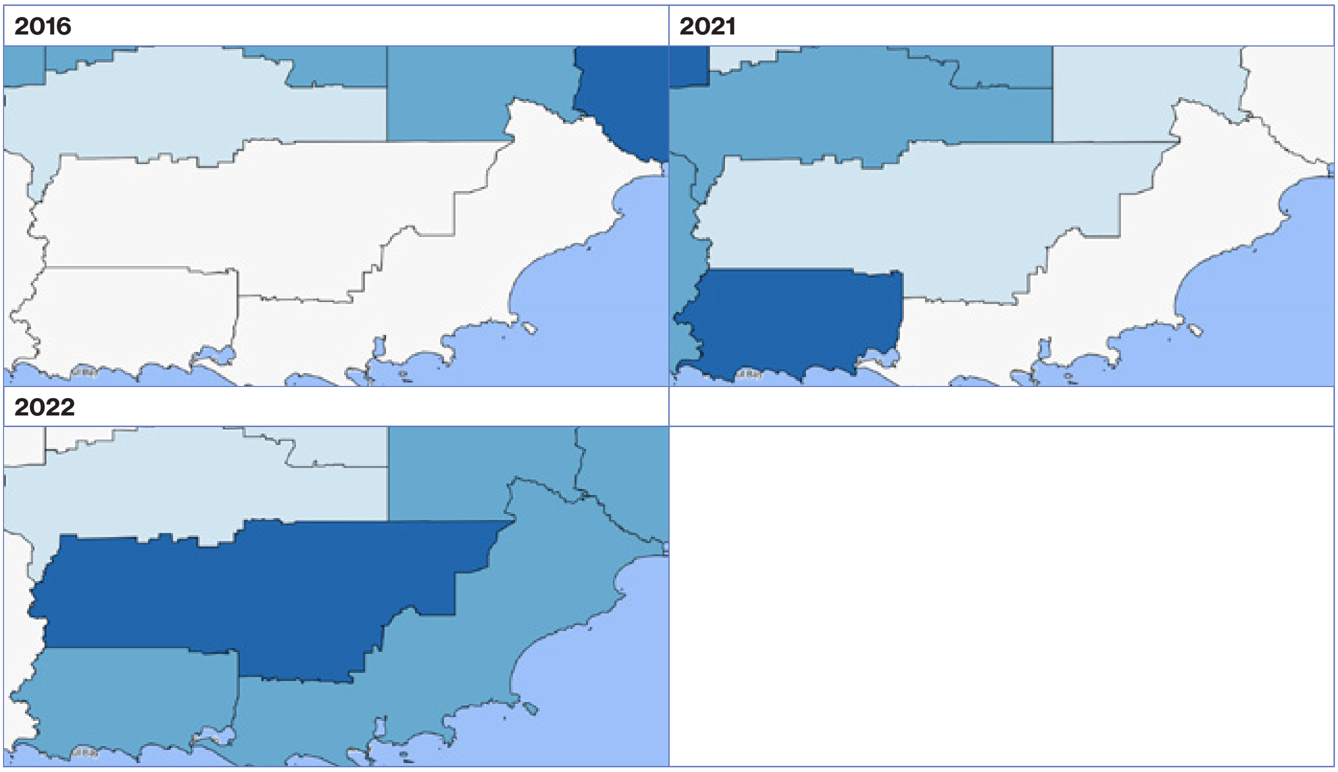


Figure 74. Rank of Vegetation Leaf Area for the Coastal Great Southern Region 2000 to 2023

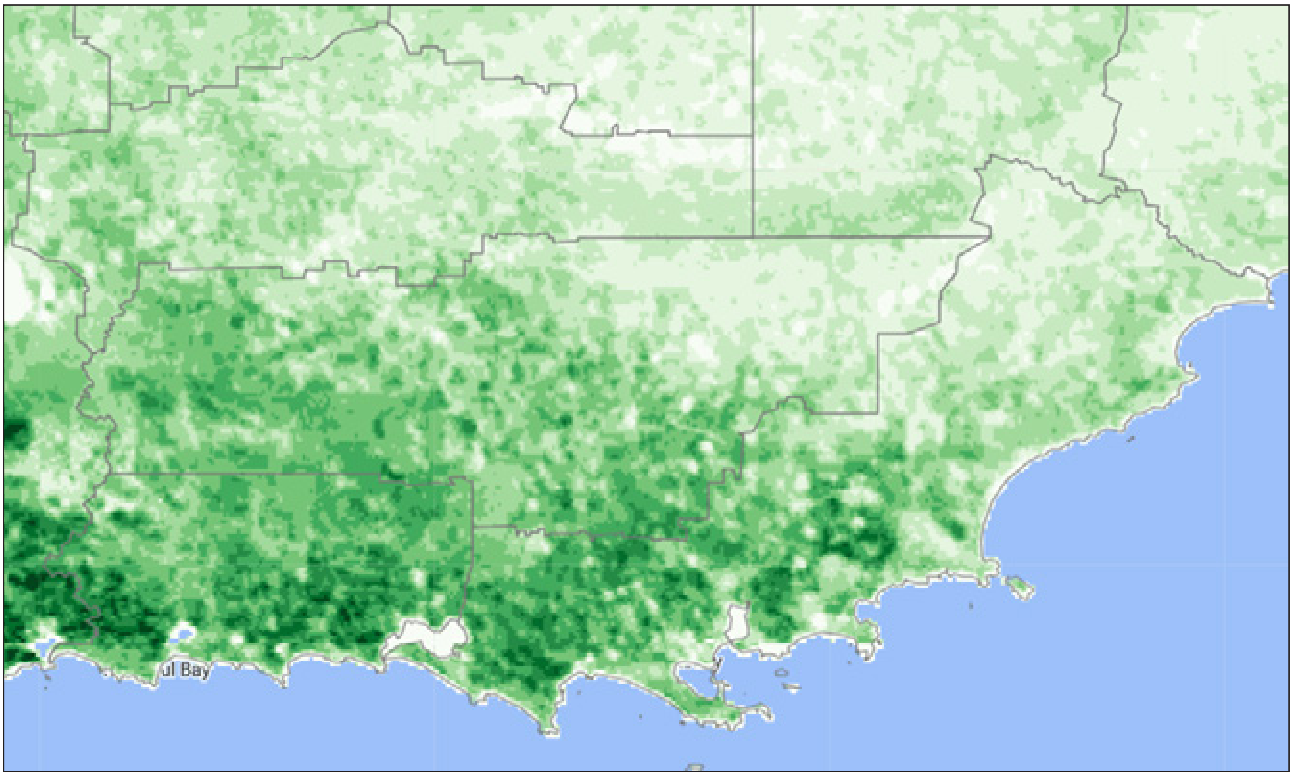


Figure 75. Vegetation growth, gross primary production, the amount of carbon taken up by the vegetation through photosynthesis, as estimated by the OzWALD model-data fusion system (gC/m2)

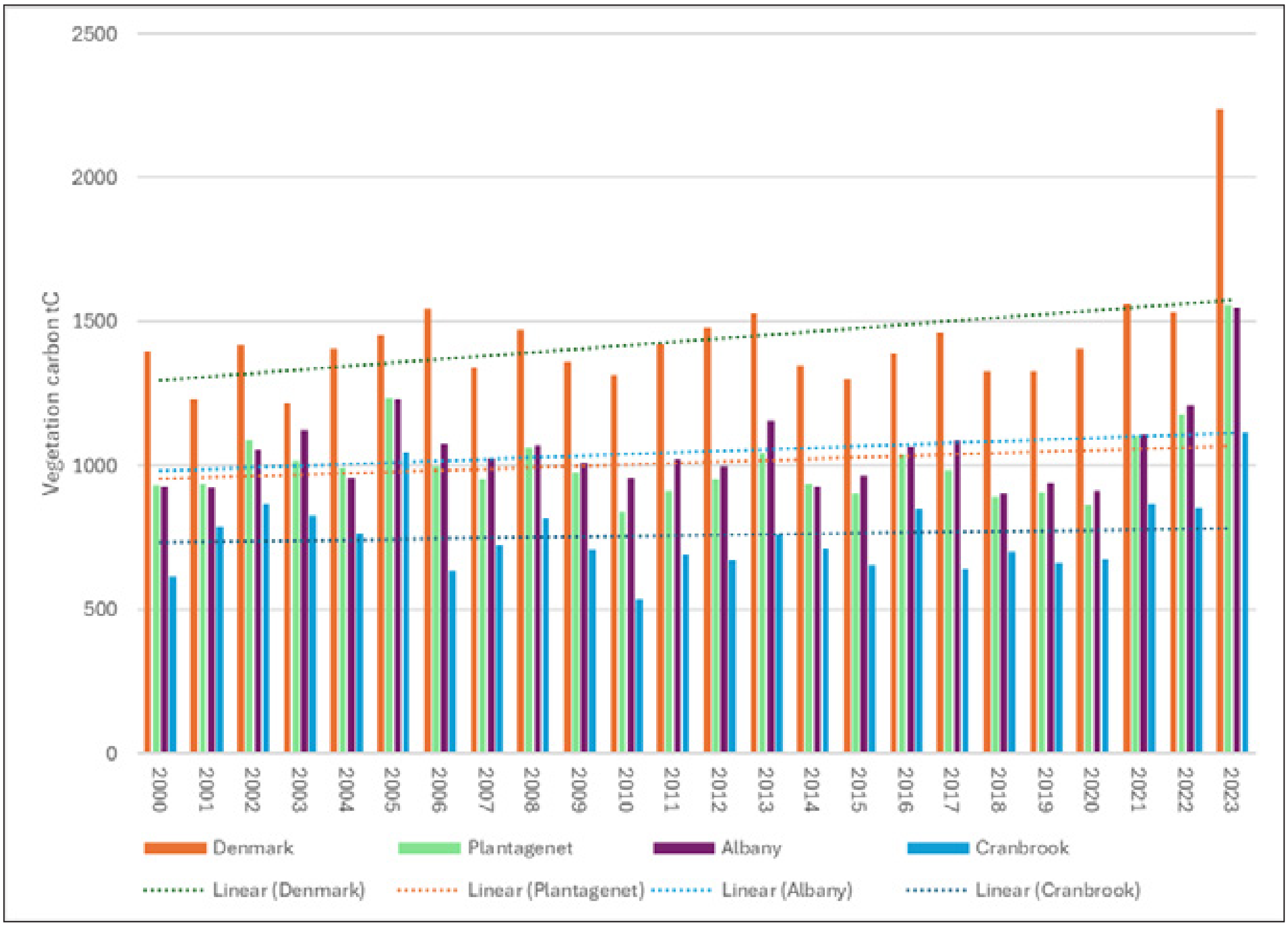
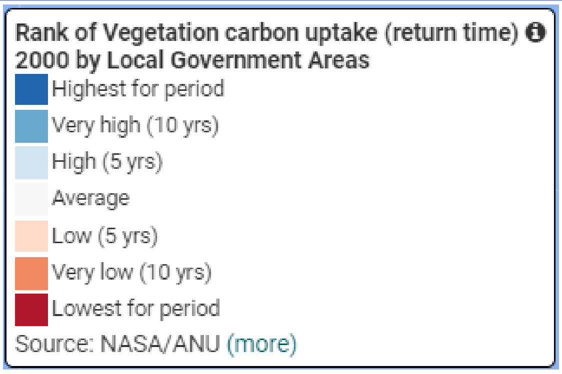


Figure 76. Vegetation growth tC

Vegetation Growth

Annual mean percentage of vegetation growth, derived from MODIS imagery and CSIRO mapping by the OzWALD model-data fusion system.



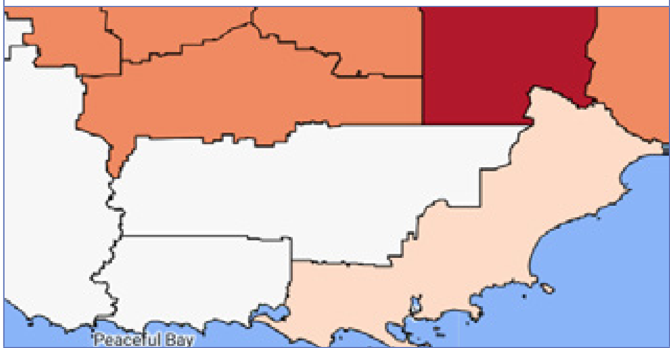
Average

Average years

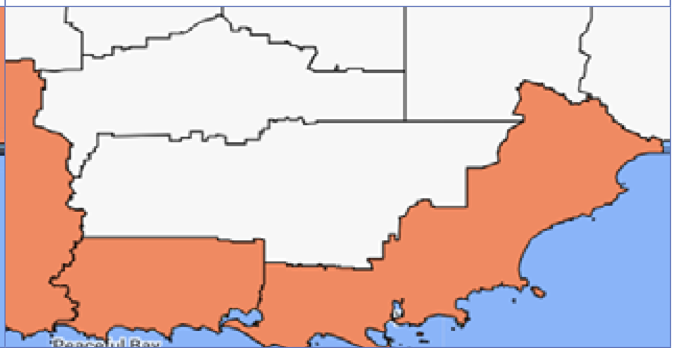
2004, 2007, 2008, 2009, 2011, 2012, 2016

Below Average Years

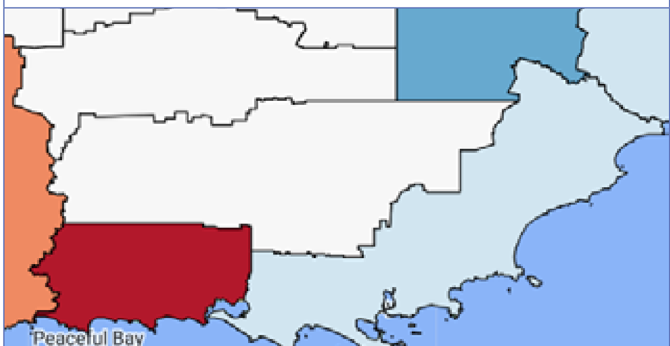
2000



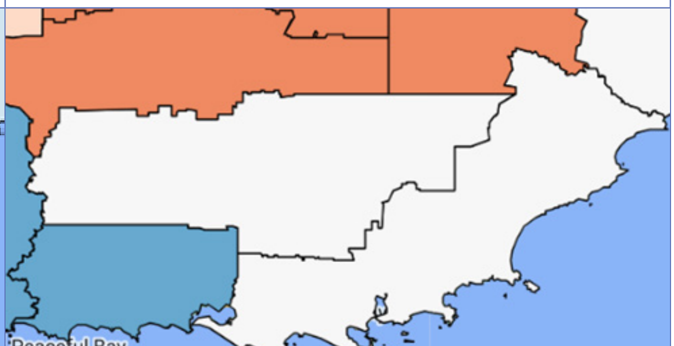
2001



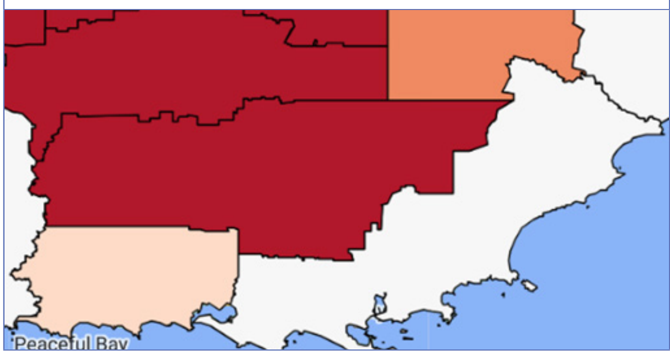
2003



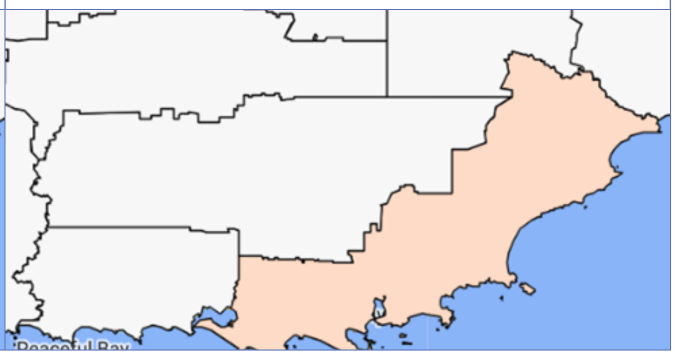
2006



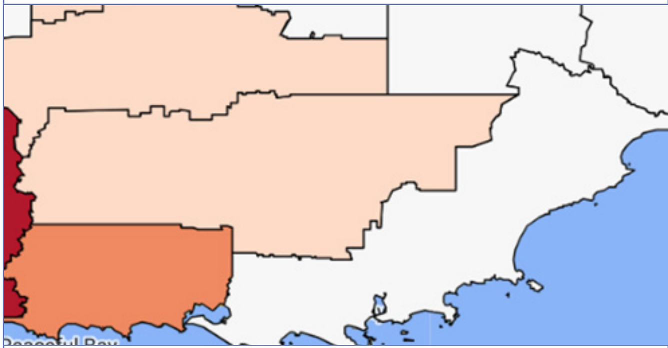
2010



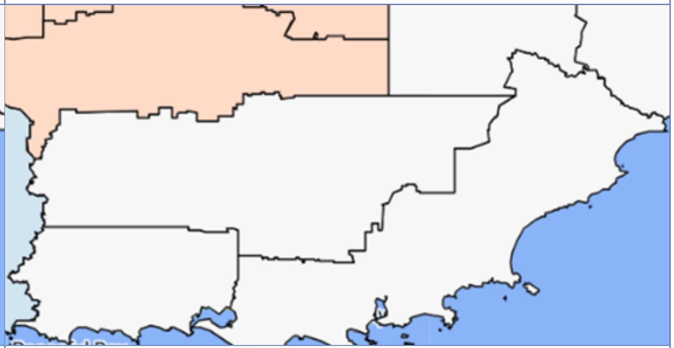
2014



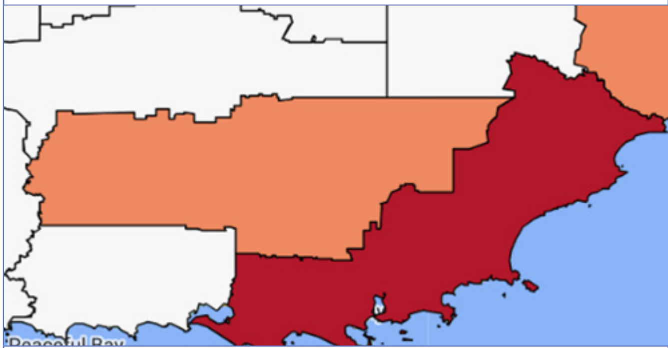
2015



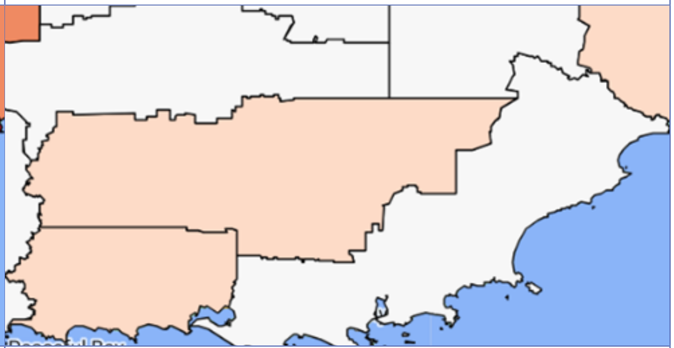
2017



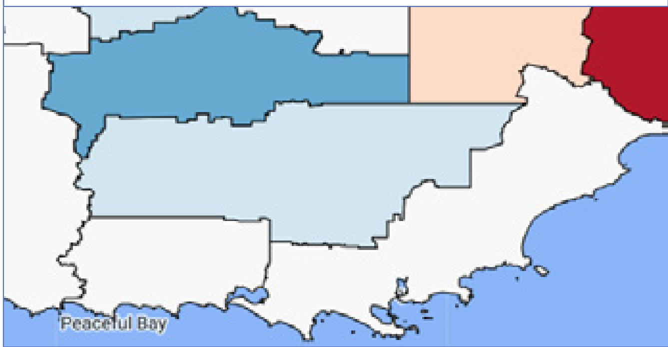
2018



2019

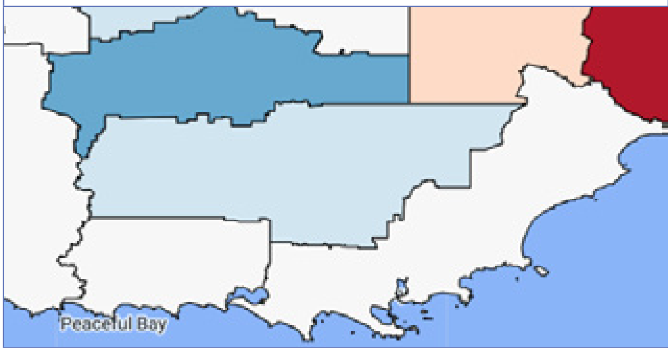


2020

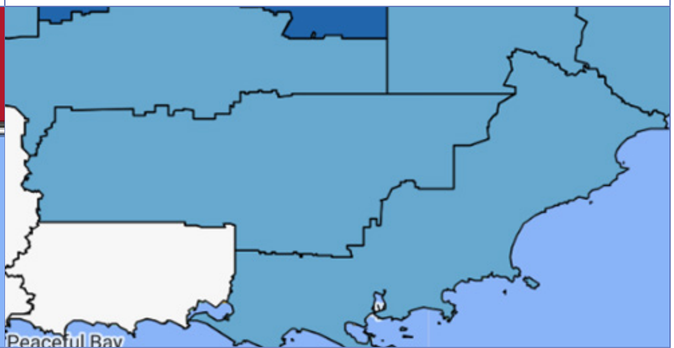


Better than Average Years

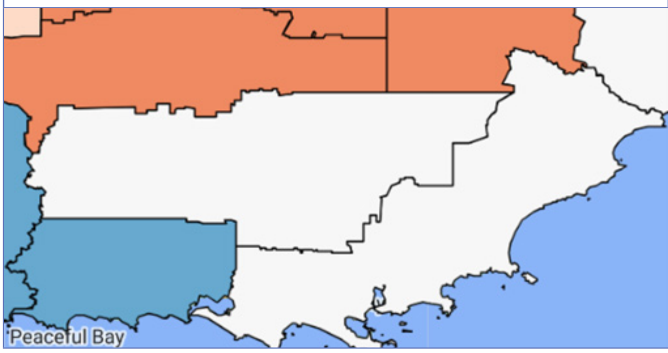
2002



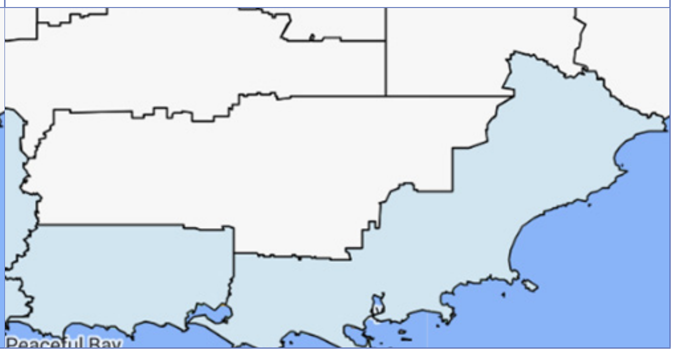
2005



2006



2013



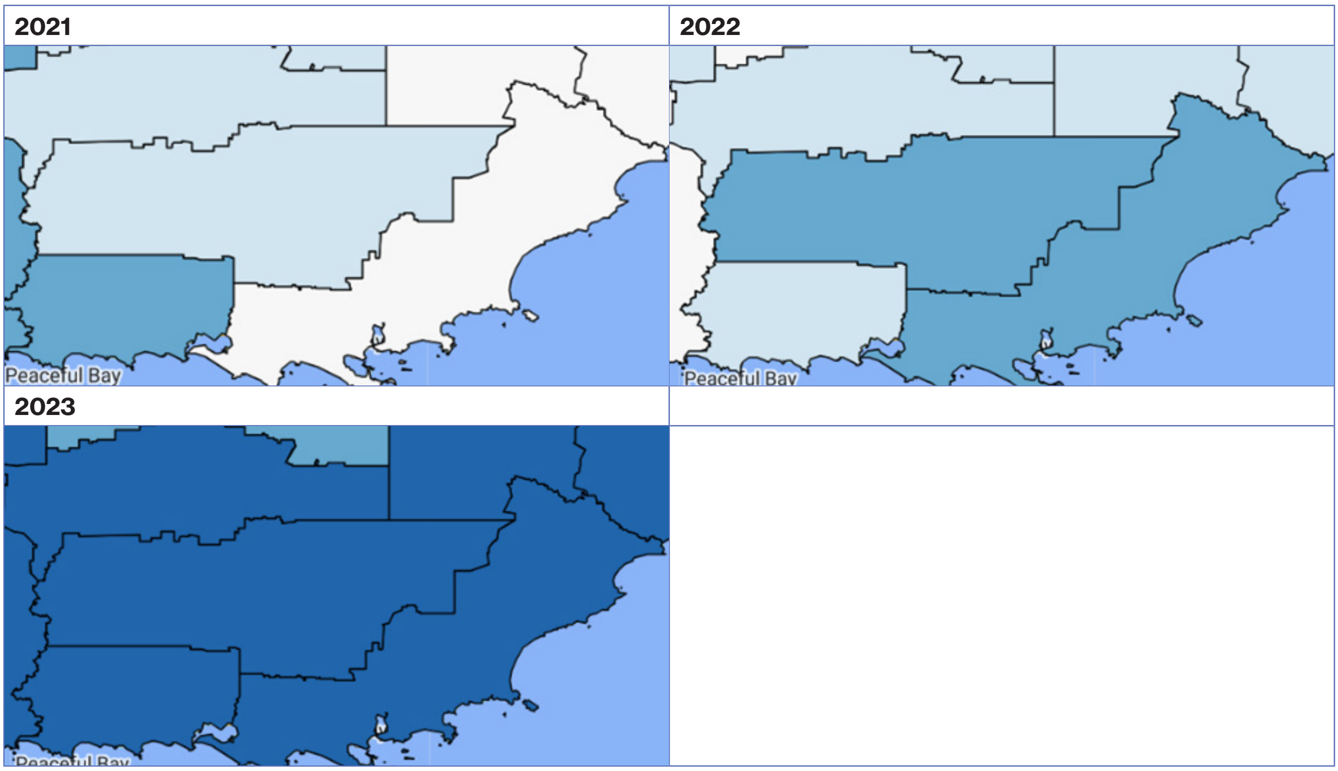


Figure 77. Rank of Vegetation Growth tC for the Coastal Great Southern Region 2000 to 2023

7.5. Impact on Communities

From a social impact perspective, drought is conceptualised as a socio-economic phenomenon. The emphasis is on the impact that a lack of precipitation has on human activities at the individual, household, and community levels. A key driver by which drought affects social outcomes (including health and well-being) is the economic impact. But drought itself also directly impinges on social outcomes and there are significant indirect consequences from the various first-round social consequences.[52]

Workshops were held with communities to members to discuss the impacts of drought, many of the issues identified are supported by the literature and analysis.[53]

Impact of drought from a community's perspective[54]:

- Smaller land holders not being prepared, they have less resources to manage a drought. They have less grain and hay storage facilities and less ability to respond quickly.
- Increasing debt loads.
- Accessing professional help is expensive when there is no income/money.
- The inability to sell livestock when you need to before they lose too much condition and the animal welfare implications.
- Ceasing of the live sheep trade means this market avenue to sell livestock is lost, this was a traditional market that helped when drought conditions existed.
- The significant cost of hay and stock feed when it is in short supply compounds the financial situation and animal welfare situation.
- The need to work off-farm to financially support families and farm debt.
- The lack of water for livestock and spraying.
- Additional resources required to manage water requirements.

52 Lester, L., Flatau P., & Kyron M (2022). Understanding the social impacts of drought. Perth: The University of Western Australia.
53 Bourne, A. (2021). Notes from Regional Drought Resilience Planning Program Presentation to Council Shire of Chapman Valley.
54 GSDC, (2024) Regional Drought Resilience Plan Workshop Albany 18th July 2024 and Mount Barker 19th July Workshop Reports

- Looking after community spaces such as ovals and parks is appreciated during a drought.
- Increase time to manage a drought situation and the significant negative effect on mental health as stress levels increased to extremes.
- Other industries are impacted like tourism.
- Small businesses supported by farm businesses struggle, reducing services, skilled workers, and long-term employment opportunities.
- Impacts on the natural environment where trees and bush are dying.
- There is increased risk for bush fires.

The more severe the drought the larger the social and economic impacts for farming families and local communities. Lester et al., (2022) report that the immediate and medium-term direct and indirect impacts of drought are diverse: Employment, education, out-migration, family relationships, mistrust of government, uncertainty over the future, community resources and support systems. All these factors either directly or indirectly impact health and well-being; physical, mental, social, and emotional well-being.

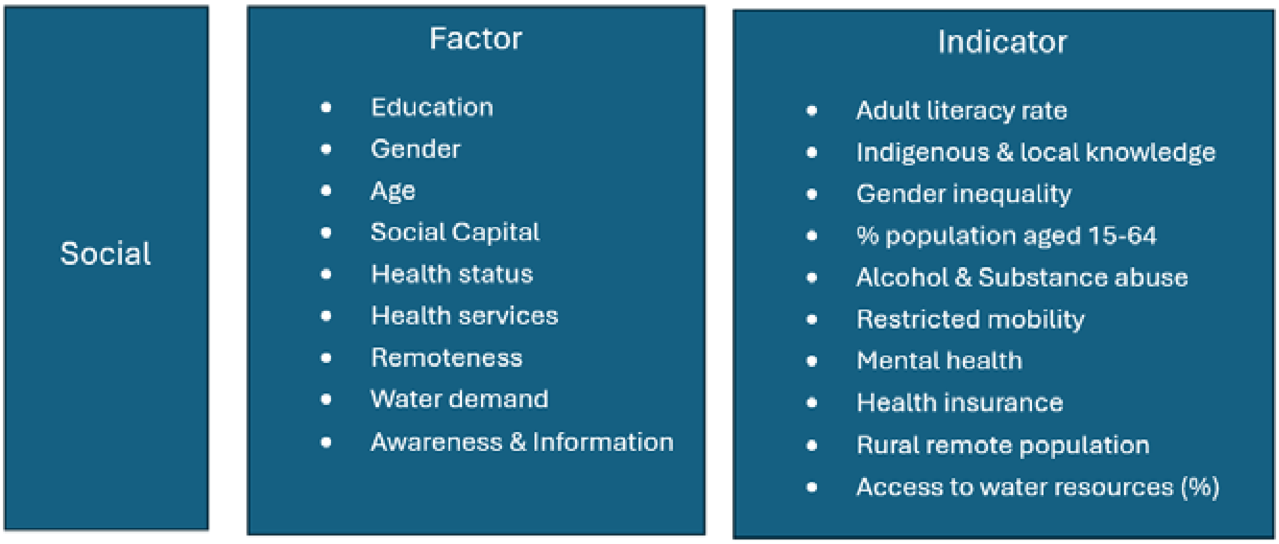


Figure 78. Measures for a drought vulnerability assessment on social capital.

The indicators outlined in the model in Figure 78 are a guide for a drought vulnerability assessment of social indicators. It is adapted from Ahmadalipour & Moradhkhani, 2018 and Carra et al.,2016.

The Strategic Community Plans for each Shire were used as a guide to understand what the communities value as their priorities for this vulnerability assessment. The peaceful lifestyle, location close to the south coast and Stirling ranges, community spirit, safety and security, caring and supportive neighbours and community facilities, were recurring reasons that people value living in the Shire of Plantagenet.[55]

A risk matrix was used to assess the risk drought poses to the Coastal Great Southern Region communities' lifestyles, values and priorities which they identified in Strategic Community Plans. Table 4, 5 and 6 are the results for this risk assessment.

55 Community Strategic Plan, Shire of Plantagenet

Table 4. Top Five Priorities and Values for the communities in the Coastal Great Southern Region

	High	Medium	Low
Legend	● (red)	● (orange)	● (green)

	City of Albany	Denmark	Plantagenet	Cranbrook
Reference: Strategic Community Plan	2022-2032	2022-2033	2022-2032	2021-2031
% of Community engagement for Strategic & Future plans (% percentage)	**3.6%**	**26%**	**6%**	**30%**

Top 5 priorties/values		Projected Impact of Drought: City of Albany	Denmark	Plantagenet	Cranbrook
City of Albany	Access to housing	● Low			
	Community safety and crime prevention	● Low			
	Sealed roads	● Medium			
	Health and community services	● High			
	Waste collection services	● Low			
Denmark	Better services & facilities for Youth		● Low		
	Increased road network maintenance		● Low		
	Housing availablity & affordability		● Low		
	Economic development		● Low		
	Environment protection		● High		
Plantagenet	Peaceful lifestyle, supportive community, safety, and security			● High	
	Importance of road and footpath construction and maintenance			● Medium	
	Community safety, bushfire prevention, and control			● High	
	Access to high-quality health services and wellbeing improvement			● High	
	Retain country lifestyle with high-standard community facilities			● High	
Cranbrook	Business & Economic success			● High	● High
	Civil construction				● Medium
	Safety				● Medium

Table 5. Top Five Priorities and Values for the Future of the Coastal Great Southern Region

Top 5 priorties/values in the Future plan		Projected Impact of Drought: City of Albany	Denmark	Plantagenet	Cranbrook
City of Albany	Promote and adopt sustainable practices to combat climate change	● High			
	Services and facilities for youth	● Low			
	Footpaths and cycleways	● Low			
	Building and maintenance of sealed roads	● Low			
	Economic development, job creation	● High			
Denmark	Building and maintaining local roads		● Low		
	Conservation and environmental management		● High		
	Youth services and facilities		● Low		
	Sustainable practices / climate change		● High		
	Sport and recreation facilities and services		● High		
Plantagenet	Provide and promote facilities and activities for youth.			● Medium	
	Advocate for family support services			● Low	
	Ensure services and facilities meet aging population needs			● Low	
	Advocate for regional medical and hospital services			● Low	
	Promote a healthy and active community			● High	
Cranbrook	Strong and sustainable business region				● Medium
	Strong and sustainable tourist industry				● Medium
	Attractive visual destination for new residents				● High
	Have a point-of-difference with one outstanding theme per diverse town				● Low
	Keeping new residents in the area Facilites, housing, schools, sport				● High

Table 6. Top Five Strategic Objectives for the Future of the Coastal Great Southern Region

Future Strategy Objectives		Projected Impact of Drought			
City of Albany	Social - Aspire to be a welcoming, healthy and inclusive community	🟢			
	Economic - A strong, diverse and resilient economy with work opportunities for everyone	🟠			
	Environment - Balance conservation, access, climate action, and disaster resilience	🔴			
	Leadership - A well governed city that uses resources wisely to meet local needs and values	🟢			
Denmark	Social - Enhance community connection and well-being		🔴		
	Economic - Support local jobs, businesses, and sustainable development		🟠		
	Environment - Operate as environmental custodians for the future		🔴		
	Leadership - A desire for better connection between Council and community		🟢		
Plantagenet	Social - Build community pride, safety, well-being, and involvement through services			🟢	
	Economic - Develop a strong local economy with diverse services and jobs			🔴	
	Environment - Maintain infrastructure supporting services and protecting the environment			🔴	
	Leadership - To Engage with locals and offer clear, consistent guidance			🟢	
Cranbrook	Social - Be respected for our friendly, vibrant, safe and connected community				🟠
	Economic - Be an innovative, diverse, prosperous and growing economy				🔴
	Environment - Improve, preserve, and promote our infrastructure and natural environment				🔴
	Leadership - To demonstrate and partake in strong government and leadership.				🟠

8. Drought Vulnerability

The map in Figure 79 was developed by DPIRD's GIS team for the Inland Great Southern Drought Vulnerability Assessment and Drought Resilience Planning. By spatially integrating relevant economic, environmental and social data for Local Government Authority's (LGA) they created a GIS-based multi-criteria analysis (MCA).[56 57 58 59 60]

The map (Figure 79) shows how areas in the Great Southern and Coastal Great Southern vary from 'very low' to 'very high' vulnerability to drought. This assessment is based on temperature, rainfall and production data, access to infrastructure, population demographics and environmental characteristics. The inputs into the MCA, follow the RDRP conceptual framework outlined in Figure 2.

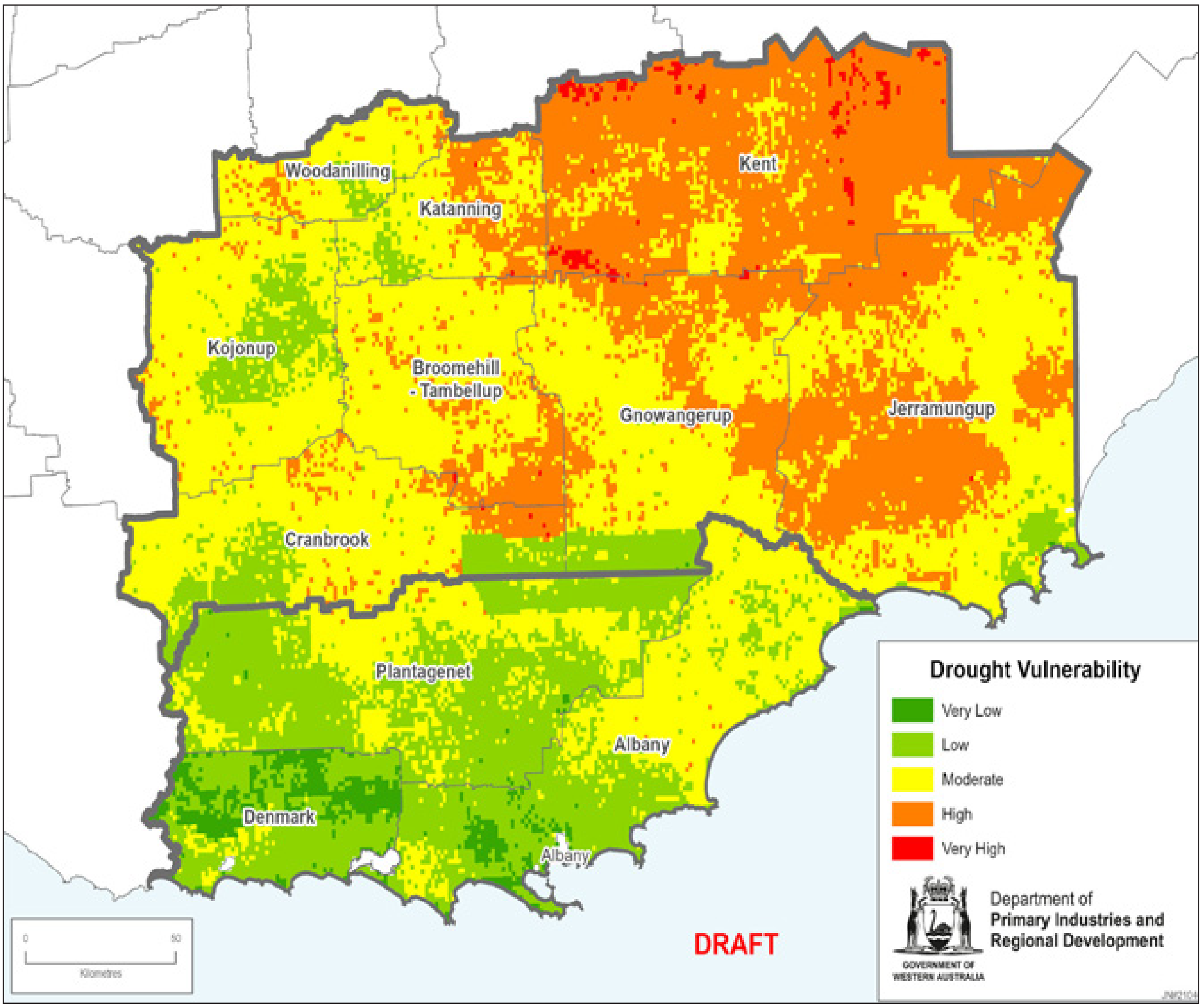


Figure 79. Draft Analysis of Drought Vulnerability for Coastal Southern and Inland Great Southern

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56 Ajibade F.O., O.O. Olajire, T.F. Ajibade, N.A. Nwogwu, K.H. Lasisi, A.B. Alo, T.A. Owolabi, J.R. Adewumi. 2019. Combining multicriteria decision analysis with GIS for suitably siting landfills in a Nigerian state. Environmental and Sustainability Indicators, 3–4(October)

57 Chandio I.A., A.N.B. Matori, K.B. WanYusof, M.A.H. Talpur, A.L. Balogun, D.U. Lawal. 2013. GISbased analytic hierarchy process as a multicriteria decision analysis instrument: A review. Arabian Journal of Geosciences, 6(8), 3059–3066.

58 Holness Stephen D. & H.C. Biggs. 2011. Systematic conservation planning and adaptive management. Koedoe, 53(2)

59 Joerin F. & A. Musy. 2000. Land management with GIS and multicriteria analysis. International Transactions in Operational Research, 7(1), 67–78

60 Malczewski J. 2006. GIS-based multicriteria decision analysis: A survey of the literature. International Journal of Geographical Information Science, 20(7), 703–726.

The Coastal Great Southern LGA's appear to be rated either low or moderately vulnerable to drought with some small areas either high or very highly vulnerable.

However, this spatial analysis is limited in its ability to include social and economic data[61]. The Inland Great Southern Vulnerability Assessment team investigated several methods to test whether social and economic impacts of drought (indicators) can be predicted from more readily measurable environmental and economic variables. The CSIRO were commissioned to do an analysis using two machine learning methods, random forests and regression trees. They modelled three social and five economic indicators as a function of environmental and economic variables for the broadacre cropping regions of South West WA.

The results detected a clear signal relating environmental predictors (rainfall, temperature, vegetation cover, soil moisture etc.) coupled with temporally stable economic predictors (proportion employed in agriculture, EDI, SEIFA Index) to social and economic indicators. The relationships were, however, highly non-linear and difficult to interpret, with often contradictory results where one pathway to negative impacts may be drought related but others were clearly not. This inconclusive result highlights that there are many factors influencing mental health in addition to drought.

They concluded that further work is required to unpack the described relationships and further understand the links between social and economic impacts and environmental and economic predictors in the context of drought.

8.1. Drought Vulnerability Index

The approach taken by this study was to develop a Drought Vulnerability Index using the conceptual framework outlined in Figure 2. Qualitative and quantitative data was gathered for this Drought Vulnerability Assessment.

Purpose: The framework aims to assess vulnerabilities in and between the Local Government Areas for the Coastal Great Southern region. It also identifies the vulnerabilities to drought for the agricultural industries in these areas.

The conceptual framework in Figure 2 was adapted from the Inland Great Southern Regional Drought Resilience Plan. Most of the data was sourced from ABS, ABARES and the community survey responses.

Data Sources:

- **Quantitative Data:** Includes Economic, Climate, Social, Environment, and Industry data.
  - **Sources:** Data was gathered from various literature, the Regional Context Report, and the Australian Bureau of Statistics (ABS) much of which is in this report
- **Qualitative Data:** Derived from community survey responses, which were scored to generate objective measures for the index.

61 Great Southern Development Commission (2022) Inland Great Southern Drought Vulnerability Assessment

8.2. Components of the Vulnerability Index

1. **Climate Vulnerability:** Measures the exposure to drought, rainfall variability, temperature changes, and long-term climate forecasts.
2. **Economic Vulnerability:** Considers economic resilience factors such as income, employment in agriculture, and financial stability of the local economy.
3. **Environmental Vulnerability:** Includes data on soil health, water availability, and the impact of environmental degradation on agricultural productivity.
4. **Social Vulnerability:** Considers factors like population demographics, access to social services, and community support systems in the face of drought.
5. **Industry Vulnerability:** Focuses on the specific challenges faced by different agricultural sectors (e.g., livestock, cropping, horticulture) and their capacity to adapt to drought.

8.3. Methodology

- **Index Calculation:** The index was established by combining both quantitative and qualitative data.
- **Logarithmic Transformation (Quantitative Data):** A logarithmic ($\log_{10}$) transformation was applied to the differences in the quantitative data. This helped normalize the distribution of values and minimized the impact of outliers, creating a more stable basis for comparison.
- **Scoring (Qualitative Data):** Survey responses were assigned scores ranging from 1 (lowest) to 5 (highest). For example, “Extremely impacted” scored 5, “Somewhat impacted” scored 4, and “No impact” scored 1. These scores were multiplied by the number of respondents for each category and then divided by the total number of participants in that region.
- **Normalisation:** After scoring and transforming the data, each variable was divided by the difference between the maximum and minimum values across the combined quantitative and qualitative datasets. This ensured that all variables were placed on a comparable scale.
- **Objective:** The purpose of this methodology is to provide actionable insights into the vulnerabilities of different local government areas and agricultural sectors. By highlighting where risks are most pronounced, it supports decision-makers in allocating resources and interventions effectively to enhance drought resilience.

The detailed data used for each component is outlined in Tables 7, 8, 9 and 10. The tables in Appendix 5 show the results for the indices.

Table 7. Index for Climate Vulnerability

Index Variable	Unit of measure	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
Is there a change in rainfall pattern	Yes/no	1	1	1	1
Is future annual rainfall predicted to be lower	Yes/no	1	1	1	1
How much is it expected to be lower?	mm	-106	-131	-56	-14
Rainfall change predicted for Autumn by 2050	mm	0	0	0	0
Rainfall change predicted for Winter by 2050	mm	-42	-51	0	0
Rainfall change predicted for Spring by 2050	mm	-46	-55	-28	-14
Rainfall change predicted for Summer by 2050	mm	0	0	0	0
Change in growing season rainfall	mm	-88	-106	-28	-14
Change in average minimum temperature by 2050	°C	0	0.9	1	0
Change in average maximum temperature by 2051	°C	0	0.7	0.7	0
Number of hot days	days	2	3	4	9
Additional hot days	days	1	2	2	3
Events <20 mm from 1989 to 2023	Number	72	59	125	110
How many below average years in 35	Years	6	7	5	3
What is the likelihood of drought	5 to 1	5	5	5	5
What is the impact/significance on the environment	5 to 1	3	5	5	5
Rank of exposed soil - frequency - Highest for the Period (2000-2023)	number	1	1	1	1
Rank of exposed soil - frequency of years Very High (2000-2023)	number	2	2	2	2
Rank of exposed soil - number of years High	number	2	2	2	1
Rank of exposed soil - number of years average	number	13	12	13	15
Rank of exposed soil - number of years low	number	1	1		
Rank of exposed soil - number of years very low	number		2	1	1
Rank of exposed soil - number of years Lowest for period	number	1	0	1	0
Exposed Soil - Min % of soil unprotected (average 2000-2023)	Average	10.47	5.45	8.21	10.73
Exposed Soil - annual mean % of soil unprotected (average 2000-2023)	Min	9.35	4.43	7.06	9.06
Exposed Soil - Max % of soil unprotected (average 2000-2023)	Max	14.11	6.42	11.85	19.09
Moisture stored in the soil profile 2000-2023	Average	379.03	375.30	415.75	435.79
Moisture stored in the soil profile 2000-2024	Min	315.68	312.89	342.48	348.61
Moisture stored in the soil profile 2000-2025	Max	432.67	416.52	480.18	483.23

Table 8. Economic Vulnerability

Index Variable	Unit of measure	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
Unemployment rate (2024)	%	2.7	2.7	2.8	2.4
Highest unemployment rate since 2010	%	7.0%	6.8%	9.0%	5.50%
Proportion of workforce employed by Agriculture Forestry and Fishing	mm	7.0%	9.7%	27.0%	60.2%
Proportion of workforce in Agriculture	mm	72.3%	88.1%	90.3%	90.2%
Proportion of workforce in Forestry and Logging	mm	11.9%	1.6%	1.7%	0.0%
Agriculture Forestry and Fishing Support Services	mm	8%	4.10%	5.90%	0%
Median Age	mm	50	54	49	51
Industry wages & salaries per employee	mm	$48,611	$32,031	$35,693	$32,219
Average for all industries	°C	$98,052	$57,302	$88,493	$74,869
Ag industry % of wages	°C	50%	56%	40%	43%
Number of businesses in Agriculture	days	726	220	407	143
Percentage of Businesses in Agriculture	days	19.8%	28.5%	54.3%	63.3%
Diversity in the economy by the number of businesses	Number	1	3	4	5
Reliance on Agriculture (% value)	Years	5%	5%	46%	116%
Total number of agriculture FF businesses under $50,000	5 to 1	210	72	98	18
Total number of agriculture FF businesses under $200000	5 to 1	249	86	118	32
Total number of agriculture FF businesses under $200000 to $2M	number	213	56	158	67
Total number of agriculture FF businesses under $2M to $5M	number	32	3	23	19
Total number of agriculture FF businesses under $5M to 10M	number	16	3	7	7
Total number of agriculture FF businesses under >$10M	number	6	0	3	0
Percentage of ag businesses under $50,000	number	27%	40%	60%	47%
Percentage of businesses under $200000	%	20%	30%	47%	59%
Percentage of businesses under $200000 to $2M	%	16%	20%	56%	69%
Percentage of businesses under $2M to $5M	%	17%	20%	56%	73%
Percentage of businesses under $5M to 10M	%	27%	38%	78%	88%
Percentage of businesses under >$10M	%	15%	0%	60%	0%
Community Survey Question: In the past 15 years, how impacted have you been by drought/drying climate? Response Extremely (5) Somewhat (4) No Impact (1)		3.13	3.54	3.58	3.75
Community Survey Question: What the impact is on business/industry - scored using a 1 (low) to 5 (high) rating		2.31	3.26	2.95	3.00

Table 9. Environmental Vulnerability

Index Variable	Unit of measure	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
Land Degradation – no visible degradation (1), Minor (2) (moderate (3) Significant (4) Severe (5)		3	5	3	4
Water Availability – no visible degradation (1), Minor (2) (moderate (3) Significant (4) Severe (5)		3	4	3	5
Biodiversity Loss– no visible degradation (1), Minor (2) (moderate (3) Significant (4) Severe (5)		4	4	4	4
Community Survey: What were the impacts of drought/drying climate on your: Environment		2.33	2.81	2.44	1.88
What is the likelihood of drought	5 to 1	4	4	5	4
What is the impact/significance on the environment	5 to 1	5	5	4	4
Rank of exposed soil - frequency - Highest for the Period (2000-2023)	number	1	1	1	1
Rank of exposed soil - frequency of years Very High (2000-2023)	number	2	2	2	2
Rank of exposed soil - number of years High	number	2	2	2	1
Rank of exposed soil - number of years average	number	13	12	13	15
Rank of exposed soil - number of years low	number	1	1		
Rank of exposed soil - number of years very low	number		2	1	1
Rank of exposed soil - number of years Lowest for period	number	1	0	1	0
Exposed Soil - Min % of soil unprotected (average 2000-2023)	Average	10.47	5.45	8.21	10.73
Exposed Soil - annual mean % of soil unprotected (average 2000-2023)	Min	9.35	4.43	7.06	9.06
Exposed Soil - Max % of soil unprotected (average 2000-2023)	Max	14.11	6.42	11.85	19.09
Moisture stored in the soil profile 2000-2023	Average	379.03	375.30	415.75	435.79
Moisture stored in the soil profile 2000-2023	Min	315.68	312.89	342.48	348.61
Moisture stored in the soil profile 2000-2023	Max	432.67	416.52	480.18	483.23
Leaf area index 2000-2023	Average	1.14	3.35	1.92	1.59
Leaf area index 2000-2023	Min	0.94	2.63	1.59	1.34
Leaf area index 2000-2023	Max	1.44	4.13	2.23	1.81
Vegetation carbon 2002-2023	Average	757.20	1011.61	1435.84	1048.97
Vegetation carbon 2002-2023	Min	535.86	837.44	1217.60	903.57
Vegetation carbon 2002-2023	Max	1113.60	1555.70	2236.60	1546.90
What is the percentage of natural vegetation	%	34%	65%	36%	28%
Is the natural environment vulnerable to drought	Yes/no	1	1	1	1
High value natural assets		1	1	1	1

Table 10. Social Vulnerability

Index Variable	Unit of measure	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
SEIFAS_2: SEIFA Index of relative socio-economic disadvantage (IRSD): Rank within State or Territory (decile)		6	7	3	4
SEIFAS_3: SEIFA Index of relative socio-economic advantage and disadvantage (IRSAD): Rank within State or Territory (decile)		5	7	3	5
SEIFAS_4: SEIFA Index of education and occupation (IEO): Rank within State or Territory (decile)		5	9	5	7
SEIFAS_5: SEIFA Index of economic resources (IER): Rank within State or Territory (decile)		6	6	5	5
In the past 15 years, how impacted have you been by drought/drying climate? (b) Local community		1.42	2.35	2.44	2.56
Access to Resources	1 to 5	1	3	3	4
Migration		1	1	3	4
Mental Health		2	4	3	4
Top 5 priorities/values		Impact of Drought – 1 is low 5 is high			
Access to housing		1			
Community safety and crime prevention		1			
Sealed roads		3			
Health and community services		5			
Waste collection services		1			
Better services & facilities for Youth			1		
Increased road network maintenance			1		
Housing availability & affordability			1		
Economic development			1		
Environment protection			5		
Peaceful lifestyle, supportive community, safety, and security				3	
Importance of road and footpath construction and maintenance				3	
Community safety, bushfire prevention, and control				5	
Access to high-quality health services and wellbeing improvement				5	
Retain country lifestyle with high-standard community facilities				5	
Business & Economic success				5	5
Civil construction					3
Safety					3
Top 5 priorities/values in the Future plan		Impact of Drought – 1 is low 5 is high			
Promote and adopt sustainable practices to combat climate change		5			
Services and facilities for youth		1			
Footpaths and cycleways		1			
Building and maintenance of sealed roads		1			
Economic development, job creation		5			
Building and maintaining local roads			1		

Index Variable	Unit of measure	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
Conservation and environmental management			5		
Youth services and facilities			1		
Sustainable practices / climate change			5		
Sport and recreation facilities and services			5		
Provide and promote facilities and activities for youth.				3	
Advocate for family support services				1	
Ensure services and facilities meet aging population needs				1	
Advocate for regional medical and hospital services				1	
Promote a healthy and active community				3	
Strong and sustainable business region					3
Strong and sustainable tourist industry					3
Attractive visual destination for new residents					5
Have a point-of-difference with one outstanding theme per diverse town					1
Keeping new residents in the area facilities, housing, schools, sport					5
Future Strategy Objectives		Impact of Drought – 1 is low 5 is high			
Social - Aspire to be a welcoming, healthy and inclusive community		1			
Economic - A strong, diverse and resilient economy with work opportunities for everyone		3			
Environment - Balance conservation, access, climate action, and disaster resilience		5			
Leadership - A well governed city that uses resources wisely to meet local needs and values		1			
Social - Enhance community connection and well-being			5		
Economic - Support local jobs, businesses, and sustainable development			3		
Environment - Operate as environmental custodians for the future			5		
Leadership - A desire for better connection between Council and community			1		
Social - Build community pride, safety, well-being, and involvement through services				3	
Economic - Develop a strong local economy with diverse services and jobs				5	
Environment - Maintain infrastructure supporting services and protecting the environment				5	
Leadership - To Engage with locals and offer clear, consistent guidance				1	
Social - Be respected for our friendly, vibrant, safe and connected community					3
Economic - Be an innovative, diverse, prosperous and growing economy					5
Environment - Improve, preserve, and promote our infrastructure and natural environment					5
Leadership - To demonstrate and partake in strong government and leadership.					3

8.4. Results from the Drought Vulnerability Index

Results from the Index shown in Table 11 identify the most vulnerable aspects for that local government area in comparison to the other local government areas.

The maximum values mean this is where the highest level of vulnerability lies in comparison to the other values in the index. The minimum value are the least vulnerable areas in comparison to the other local government areas.

Table 11. Results from the Drought Vulnerability Index

	Climate Exposure Index	Social Vulnerability Index	Environmental Vulnerability Index	Economic Vulnerability Index	Regional Industry Vulnerability index
City of Albany	0.26	0.33	0.67	0.96	4.43
Shire of Denmark	0.29	0.36	1.05	0.82	1.01
Shire of Plantagenet	0.19	0.56	0.69	0.97	5.49
Shire of Cranbrook	0.13	1.07	1.03	0.89	4.36

LEGEND: Minimum Maximum

Table 12. Results of the Drought Vulnerability Index for the Industries in the Coastal Great Southern Region ranked by the average index.

Ranked by Average	Average	Total
Dairy	4.20	46.20
Grapes	2.17	56.33
Fruits & Nuts	1.80	32.75
Vegetables	1.69	46.90
Sheep & Lambs	1.62	426.46
Meat Cattle	1.50	414.46
Pigs	1.40	32.20
Hay & Silage	1.25	382.49
Nurseries, cut flowers or cultivated turf	1.16	23.61
Poultry	1.15	13.20
Eggs	1.15	9.20
Broad Acre	0.75	237.57

Table 13. Results of the Drought Vulnerability Index for the Industries in the Coastal Great Southern Region ranked by the Total value of the index.

Ranked by Total Index	Average	Total
Sheep & Lambs	426.46	1.62
Meat Cattle	414.46	1.50
Hay & Silage	382.49	1.25
Broad Acre	237.57	0.75
Grapes	56.33	2.17
Vegetables	46.90	1.69
Dairy	46.20	4.20
Fruits & Nuts	32.75	1.80
Pigs	32.20	1.40
Nurseries, cut flowers or cultivated turf	23.61	1.16
Poultry	13.20	1.15
Eggs	9.20	1.15

The results tell us that:

- The Shire of Denmark is most vulnerable to climate exposure, which is due to the predicted decline in rainfall by 2050.
- The area of natural vegetation in the Shire of Denmark makes it the most vulnerable from an environmental perspective.
- The Shire of Plantagenet's economic profile is the most vulnerable because it has the highest value agriculture of all the local government areas.
- The Shire of Cranbrook social vulnerability index is the highest due to its low population and high reliance on agriculture employment with low diversity in its economy.
- The Dairy industry is the most vulnerable to drought.
- The Sheep and Beef sector is a much larger industry with many more businesses in the region and is more vulnerable to drought when the number of businesses are considered.

Conclusion:

The Vulnerability Index appears to align with intuition and logic. It seems logical that the Shire of Denmark would be the most vulnerable from an environmental perspective and the Shire of Plantagenet is most exposed from a Regional Economic perspective because it has the highest value of agriculture. Likewise the Shire of Cranbrook is the most vulnerable in a social context because of its lowest population. When the Index is tested it appears to make sense, for example, by decreasing the percentage area of natural vegetation in Denmark the index decreases for Denmark. Another example by decreasing the number of small businesses with a turnover of less than $50,000, the economic index for Albany decreases.

The index aligns with expectations (pers comm, Project Advisory Group, September 10, 2024) although testing against other LGA's would build confidence in the results and weighting criteria could be considered.

The index identifies the most serious vulnerabilities for each Shire, in comparison to each other. It does not mean they are not vulnerable, but it does rank their vulnerability against one another and highlights the key areas of concern. The Index provides an objective guide for recognizing priorities for these local government areas.

9. Case Studies on selected industries

9.1. Case Study 1: A Horticulturist's Approach to Drought Resilience

Background:

Operating on a 1000-hectare mixed production model, including horticulture, protected cropping, and livestock, the farm has faced varying climatic conditions, particularly drought, over several decades. The experience of drought has been a significant factor shaping the farm's water management, preparedness, and resilience strategies.

Experience of Drought:

The farm has experienced "dry years" rather than complete droughts, with notable fluctuations in rainfall patterns. In years like 2007, when rainfall was scarce until October, the farm managed to salvage the season thanks to timely rains, leading to an average crop. The farm has learned that rainfall patterns have shifted, with drier winters followed by brief periods of rain. Despite this unpredictability, the farm has not had to destock completely due to their preparedness and robust water management systems.

Key to their success is recognizing the variability of rainfall over the decades, with significant variations in water availability affecting crop and livestock production. Preparedness has been vital, as the farm has consistently held feedstock in reserve to ensure that livestock can be sustained even during dry periods.

Challenges and Concerns:

Looking forward, the farm is particularly concerned with how climate change will affect water availability and crop viability. While they have not faced severe, prolonged drought like in some eastern states, they have seen intermittent dry spells that stress both crops and water reserves. A core concern is the changing pattern of rainfall, which has shifted significantly from what it was 50 years ago. This has introduced unpredictability in crop planning and livestock management, requiring adaptive strategies to ensure consistent productivity.

Another challenge has been ensuring that water storage systems can meet future demands. Despite implementing large water-holding capacities, the farm recognizes that if a drought were to extend beyond two years, they would likely face the need to destock due to lack of water in paddocks.

Key Drought Resilience Strategies:

The farm has implemented several key strategies to mitigate the impacts of drought and changing climate patterns:

1. Water Infrastructure Investment:

The farm has built larger dams and reservoirs, with holding capacities ranging from 2000 to 3000 cubic yards. These have proven essential in ensuring water availability for livestock and irrigation during dry periods. Additionally, they have developed a 35-hectare roaded catchment system to capture surface water effectively.

2. Surface Water Management:

In the mid-nineties, the farm invested heavily in expanding water storage and drainage systems. More recently, with the introduction of covered cropping, the farm installed a gutter system to capture water from 4 hectares of hard surface cover. This system captures approximately 80,000 m^3 of water annually, which accounts for about half of the farm's needs for production.

3. Partnerships and Resource Sharing:

The farm has explored unconventional solutions, such as negotiating with neighboring landowners for access to disused dams. These arrangements provide additional water resources, which are piped and maintained by the farm, ensuring flexibility in times of drought.

4. Feed and Stock Management:

The farm always prepares for dry starts by holding extra feedstocks. If the feed is not needed, they sell it later, ensuring that they are not caught off guard by dry conditions. This has allowed them to maintain livestock through dry periods, unlike in the past when they might have had to reduce herd sizes.

Adaptation to Climate Change:

The farm recognises that climate variability is now a part of normal farming operations. As a result, they have adjusted their practices, such as reassessing water storage needs every few years and budgeting for repairs and maintenance to keep their infrastructure in good condition. This strategic approach to long-term planning has allowed the farm to remain resilient even as climate patterns shift.

Additionally, the farm has explored desalination and reverse osmosis systems to ensure that mildly saline water can still be used for irrigation, particularly in protected crop production where water quality is critical.

Lessons Learned and Future Planning:

1. Strategic Water Planning: Having reliable water sources, both on-farm and within the broader community, is crucial for drought resilience. The farm suggests using aerial imaging to identify potential emergency water supplies for firefighting and drought preparedness.

2. Forward Planning and Preparedness: The farm emphasises the importance of preparing for dry years every year. Their approach involves maintaining higher than necessary feed and water stocks to mitigate the impacts of unpredictable weather patterns. They are planning for what could happen in February.

3. Innovation and Resourcefulness: Thinking outside the box has allowed the farm to thrive in challenging conditions. This includes unconventional resource sharing agreements and investment in water-efficient technologies that reduce strain on existing systems.

Conclusion:

This approach to drought resilience showcases the importance of long-term planning, water management, and adaptability in farming operations. By investing in water infrastructure, adopting flexible strategies, and anticipating dry conditions, the farm has been able to mitigate the impacts of drought and ensure continued productivity. As climate variability increases, their experience offers valuable lessons for other horticultural farms facing similar challenges.

9.2. Case Study 2: Drought Resilience in Viticulture

Grape vines are tolerant to dry conditions and drought, however even though grapevines can survive a dry spell with minimal watering, they will start to shed their leaves when their ability to circulate water and nutrients is reduced by 50 per cent. This is due to lower water pressure in their stems and roots. Under stress, the vines push hard to draw water and can form air bubbles in tissues that circulate water from the roots. These air bubbles stop the sap from flowing into the vines so they start losing leaves and can eventually kill the vine. There is also a direct correlation between the amount of water a vine receives and the fruit it will yield. Eighty per cent less water means eighty per cent less fruit, so impacting on productivity and cost of producing wine.62

A dry year means a dry subsoil and a reduced canopy which is the engine room for ripening. This results in reduced yields and increased sugar levels in the fruit which accelerate quickly making picking time difficult because it needs to be determined on sugar levels instead of taste. The high sugar levels impact on fermentation and wine quality.

According to a viticulturist in the Coastal Great Southern region, a lower-than-average rainfall year is 450 mm of rainfall. Evaporation rates on dams increase from 22-30% in a normal year to 40-45% in a dry year. In a below-average rainfall season, there is an increased risk of frost in spring which can be even more damaging if it occurs at bud bursting time.

Background

Vineyard owners interviewed in the Coastal Great Southern region report facing increased challenges due to climate change and drought, particularly in relation to erratic weather patterns and drought, water availability, vine health, and overall production. Adopting various innovative water management strategies have been fundamental to mitigating the effects of drought, ensuring the vineyards' long-term sustainability in an increasingly unpredictable climate.

Key Drought-Resilience Strategies:

Catchment and Water Diversion: One vineyard relies on a large-scale catchment system covering 70 hectares to capture runoff during the winter and spring rains. This water is stored in a series of seven satellite dams, providing a buffer during the dry months. However, recent consecutive years of reduced rainfall (dropping from 600 mm to 450 mm) have severely impacted the vineyard's ability to capture and store adequate water.

Another common key strategy is to consider diversifying water sources to mitigate the risks posed by increasingly unreliable rainfall.

Polymer Spray on Catchment Areas: To improve water retention, one vineyard applies a polymer spray on catchment areas, reducing water absorption into the soil and maximizing the amount of water that can be captured. However, it is also commonly acknowledged that maintaining catchment areas come at a high cost, involving roller and grader services to ensure the catchment remains functional.

Irrigation Management: Developing a sophisticated irrigation system is key. However, the prolonged dry years and a dry spell from February to April 2024, have left young vines in one vineyard without water, leading to weakened growth. Shiraz yields, which typically average 8-10 tons per hectare, dropped to just 3.5 tons per hectare due to the heat.

In the 2019-2020 vintage year, one viticulturist experienced a 40% reduction in yield due to a dry growing season and low water availability. In some areas, particularly where young vines were planted, the lack of water during critical periods has led to long-term damage, weakening the vines' ability to survive future dry seasons.

Adaptation to Market Demands: Climate change is compelling some vineyards in the Coast Great Southern region to reconsider which varietals to plant. A common strategy is to remove a percentage of its lowest-yielding vines to preserve resources for the higher-producing areas of the vineyard. Some viticulturists notice that red grapes, like Shiraz and Grenache, fare better under dry conditions than white varietals, but market shifts often complicate long-term planning.

Challenges and Outcomes:

For one viticulturist the ongoing challenge is the diminishing ability to catch water. A shortage of rainfall in the catchment area has led to critically low dam levels which is illustrated from the photograph in Figure 80. In 2020, the main irrigation dam was overflowing, but recent seasons have seen it at dangerously low levels, threatening the viability of the vineyard.

In response to these challenges, the vineyard has had to remove 20% of its lowest-yielding vines to preserve resources for the higher-producing areas of the vineyard. Additionally, there is growing concern about the impact of consecutive dry seasons, which increases the risk of frost, further affecting yields.

Figure 80. Level of water in a main dam at a Coastal Great Southern vineyard in July 2024

Conclusion:

Vineyards in the Coastal Great Southern region exemplify the complexities of managing viticulture in the face of climate change and drought. While some vineyards have implemented strong drought-resilience strategies, ongoing dry seasons are testing the limits of these approaches. The future success of these vineyards will depend on their ability to continue adapting, particularly in securing water resources and adjusting to market demands.

Community and Economic Resilience:

To ensure long-term resilience, there are advocates for increased collaboration within the viticulture industry and support for innovative water management solutions. Additionally, financial assistance and mental health support for growers will be crucial as they navigate the financial and emotional tolls of climate change.

Beyond just vineyard management, viticulture plays a significant role in local economies. For example, in Frankland River, vineyards support approximately 85 permanent staff, many of whom live locally and contribute to the town's economic vitality. A continued decline in viticulture would have cascading negative effects on the broader community.

Addressing these climate impacts is crucial not only for vineyard owners but also for maintaining the economic stability of the surrounding regions.

9.3. Case Study 3: Drought and Cultural Resilience in the Wagyl Kaip Southern Noongar Community

Background

The Wagyl Kaip Southern Noongar Corporation is a community facing growing challenges due to prolonged drought and climate change, which threaten both their cultural heritage and the environmental integrity of their traditional lands. The community plays a vital role in coordinating efforts to preserve cultural heritage while adapting to the impacts of increasingly severe droughts and changing weather patterns.

Impact of Drought and Climate Change

Cultural Heritage at Risk

The community has observed both physical and non-physical losses of cultural heritage due to extended dry seasons and more intense bushfire cycles. The non-physical loss involves the challenges in passing on Traditional Ecological Knowledge (TEK) from elders to younger generations. This knowledge is essential for managing the land and responding to environmental changes.

The physical loss includes the bush-fire destruction of and/or disrupted access to cultural sites, both documented and undocumented. The loss of flora, fauna, and archaeological opportunities have impaired the study and conservation of significant sites. The loss of bush foods is threat to diet and food-security, and a negative impact for indigenous enterprises.

Economic Impacts on Indigenous Enterprises

Indigenous-run enterprises are focused on revegetation projects and seed cultivation through community nurseries. Water scarcity and the lack of consistent rainfall are disrupting seed cultivation, revegetation projects, and threatening the economic sustainability of the enterprises.

Tourism Disruptions

Indigenous tourism, which involves sharing the natural and cultural significance of the land with visitors, has also been affected. The increasing frequency and intensity of bushfires, as well as drought-induced water scarcity, have made it harder for tourists to access key cultural and natural sites. This has had a negative impact on tourism-related income for the community.

Community Concerns and Challenges

Mental Health and Community Well-Being: One of the community's key concerns is the impact of climate change on mental health. The cumulative effects of drought, bushfires, and the potential loss of cultural heritage have placed immense strain on the community. This has led to calls for more mental health support services for those managing and working on the land.

Capacity Building for Fire and Land Management: The community has identified the need for greater investment in fire mitigation strategies that integrate TEK. Traditional burning practices, which have long been part of the community's land management, are seen as critical to managing bushfires in a way that protects cultural sites and restores ecological balance. However, the lack of resource and support backing TEK into current fire management plans is a significant gap in preparedness for drought and climate change.

Prescribed Burns and Fire Mitigation: The community believes that more resources are needed to increase the frequency of prescribed burns, particularly cool burns that help manage fuel loads without causing widespread damage to the land. This approach requires training more rangers and volunteers, which would allow the community to better manage the land and prepare for longer fire seasons.

Adaptive Strategies and Tools

Integration of TEK in Fire Mitigation: One of the key strategies for adapting to drought and climate change is the integration of Traditional Ecological Knowledge into fire management practices. The community is advocating for TEK-based fire mitigation to be included in training programs for rangers and volunteers. Additionally, schools are starting to incorporate cultural land management into their curriculums, ensuring that younger generations are equipped with the knowledge to continue these practices.

Resource Allocation and Training: The community emphasizes the need for more resources to fund ranger programs and build fire management capacity. The development of a register of trained individuals who can be mobilized for fire mitigation efforts would allow for a more effective response to the increasing number of bushfires while also helping preserve cultural heritage.

Collaborations and Partnerships: The community recognises the importance of collaboration with government agencies such as the Department of Biodiversity, Conservation, and Attractions (DBCA) to improve fire mitigation efforts. By working together with wider organisations, the Wagyl Kaip Southern Noongar Corporation community aims to develop more effective land management strategies that integrate both scientific approaches and traditional knowledge.

Future Directions and Recommendations

Support for TEK and R&D: The community recommends investing in research and development that focuses on substantiating the use of TEK in modern farming and land management practices. This would not only validate the effectiveness of TEK but also increase its acceptance among the broader agricultural and scientific communities.

Economic Opportunities through TEK: There is potential for turning drought preparedness into economic opportunities. For example, the community sees value in promoting agri-tourism, bush foods, and native plant cultivation as part of a broader strategy to connect the public with sustainable farming practices that incorporate TEK. This could also bridge the gap between urban and rural areas, creating a greater understanding of the importance of traditional land management.

Conclusion

The Wagyl Kaip Southern Noongar Corporation community faces numerous challenges as they adapt to the impacts of drought and climate change. These challenges threaten both their cultural heritage and economic sustainability. However, through Traditional-Ecological-Knowledge-led fire mitigation efforts and the development of partnerships with government and scientific communities, the community is working towards a more resilient future. Continued investment in capacity building, mental health support, and research will be key to ensuring that cultural heritage is protected, and that the community remains resilient in the face of ongoing environmental changes.

9.4. Case Study 4: A Small Landholder's Challenges in Drought and Climate Change

Background

One experienced Coastal Great Southern farmer manages a small landholding of approximately 65-80 hectares and has seen the effects of drought firsthand. His farm has experienced what is referred to as a "green drought" in the Southwest region of Australia, where despite the appearance of greenery, there is insufficient water and feed for livestock. 2024 was a particularly challenging year for him, with multiple factors exacerbating the effects of the drought.

He is part of a community of small-scale farmers with significant combined-supply to the Western Australian fresh meat market. Despite their significant contribution to the food supply, individually, these small farmers face growing challenges due to prolonged droughts and changing climate conditions.

This case study explores this farmer's experiences and concerns regarding drought, highlighting the urgent need for adaptive strategies and targeted support for small landholders.

Impacts of Drought and Climate change

Hay and Fodder Shortages: 2024 marked the first time this farmer had to purchase hay due to a lack of on-farm fodder. The experience highlighted the difficulty of sourcing quality hay, especially when reliant on suppliers located far away. There were challenges with managing the different shaped bales.

Destocking Challenges: The decision to destock livestock due to drought has long-term consequences. Rebuilding the herd can take more than two years, affecting not only an individual farmer's financial stability but also the broader supply chain of fresh meat in Western Australia.

Reliance on Off-Farm Income: Like many small landholders, off-farm income is necessary to maintain operations, with most small farmers in the region working part-time jobs outside their farms to cover costs. This reliance on external income creates additional stress and is not sustainable long-term.

Key Concerns for the Future

As the climate continues to change, this farmer and other small farmers in the area are increasingly worried about the future viability of their farms. He raises several concerns regarding the long-term effects of drought.

Generational Farming at Risk: The traditional model of generational farming is under threat. As farming becomes less profitable and more reliant on external income, the younger generation is discouraged from continuing family farming operations. The increasing challenges of drought and climate change make it difficult for the average person to buy into farming.

Economic Viability of Small Farmers: Small farmers, despite their significant contribution to the fresh meat supply, face pricing pressures that undermine their cash flow and financial viability. Practical support is needed to help small farmers remain resilient, assistance with early warning/data/support.

Challenges in Drought Preparedness

In this farmer's view, current drought preparedness and response strategies fall short, particularly for small landholders. Several gaps in preparedness and response need to be addressed:

Pricing and Cashflow Management: Most small farmers are struggling to afford basic operational costs, and the reliance on off-farm income is not a sustainable model. Practical assistance is needed to improve cash flow, such as targeted financial support for small farmers based on their output and size.

Early Identification of Triggers: Farmers need access to early-warning systems and data that can alert them to the risks associated with drought. Providing this information early would help farmers prepare for the potential impacts and make informed decisions about destocking, water management, and financial planning.

Recognition of Small Farmers' Contributions: Small landholders are often dismissed as "hobby farmers," even though their collective contribution to the fresh meat supply is substantial. More recognition is required of the role that small farmers play in the local food supply chain and for policies that provide practical support, such as better pricing mechanisms and financial assistance.

Key Actions

Some of the key actions that would assist small landholders include:

Tools for Increasing Adaptive Capacity: It is important to provide the right tools and support to help small farmers increase their adaptive capacity in the face of drought.

Grading Systems for Hay Quality: Implementing a grading system for the quality of hay would help small farmers make informed decisions when purchasing fodder during dry seasons. This would reduce the risk of buying poor-quality feed that is less effective for livestock.

Practical Financial Support: Government programs should focus on providing practical financial assistance that directly improves cash flow for small farmers. This support should be proportional to farm size and output, ensuring that small farmers receive the help they need to remain resilient.

Early Warning and Data Support: Developing early-warning systems and providing farmers with real-time data on drought conditions would enable them to make proactive decisions. This could include alerts on water shortages, fodder availability, and potential risks to livestock health.

Reducing Reliance on Off-Farm Income: Policy change is needed to make farming more financially viable, allowing small farmers to reduce their dependence on off-farm jobs. This could involve subsidies, improved pricing mechanisms for agricultural products, and investment in infrastructure that supports small-scale farming.

Conclusion

Experiences of small landholders highlight the urgent need for adaptive strategies and targeted support for small farmers facing the impacts of drought. With increasing reliance on off-farm income, poor cash flow, and the long-term challenges of rebuilding livestock herds, small farmers require practical solutions that address both their financial needs and their role in the local food supply chain. By recognizing the contributions of small landholders and providing early-warning systems, better pricing mechanisms, and practical financial assistance, the agricultural sector can help ensure the resilience and sustainability of small farms in the face of climate change.

Improving productivity on these farms is an opportunity to manage climate variability, manage risk and animal welfare outcomes. Capacity building programs tailored to this market would decrease the vulnerabilities identified for small landholders and farmers.

10. Conclusion

The Drought Vulnerability Assessment for the Coastal Great Southern Region highlights the critical need for adaptive strategies to mitigate the impacts of drought. The assessment reveals significant challenges posed by climate variability, including reduced rainfall, altered weather patterns, and their consequent effects on agriculture, ecosystems, and community well-being. By investing in water infrastructure, sustainable farming practices, and enhanced climate monitoring, alongside fostering community resilience, the region can better withstand future droughts.

Implementing the recommended strategies will be pivotal in securing the long-term viability of the region's agricultural sector and preserving the social and environmental fabric of the Coastal Great Southern Region.

The key findings and recommendations of this report emphasize the importance of proactive measures for resilience. The following recommendations prioritise actions and strategies from and economic, environmental, and social perspective.

10.1. Recommendations for Future Economic Resilience

1. Invest in Water Infrastructure:

Impact: Reliable water supply is critical for agricultural productivity. Investing in water harvesting, storage systems, and efficient irrigation technologies will enhance the resilience of the agriculture sector, ensuring consistent crop and livestock production even during drought periods.

Actions: Develop and upgrade water infrastructure projects, promote water-saving technologies, and support farmers in implementing efficient irrigation systems.

2. Enhance Climate Monitoring and Forecasting:

Impact: Improved climate monitoring and forecasting will enable better planning and risk management, helping farmers make informed decisions using data from climate models and decision support tool for crop and livestock management. This can reduce losses and increase productivity. There are many new tools available.

'It would be beneficial to have access to consolidated weather data which links together broader climatic trend data (e.g. Indian Ocean Dipole and El Nino/La Nina predictors) to regional data predictions and trends to the locality of the producer. This is about being able to have validated and reliable data to forward plan and make decisions about crop management or business decisions. To have consistent regular reporting at predictable times. There are large gaps in data even from BOM managed sites so validating the data will be necessary if such an initiative were to be reliable.'

(Stakeholder interview-response on the subject of: key tools and/or actions that would assist you and your community in increasing adaptive capacity)

Actions: Invest in advanced weather stations, develop localized climate models, and provide regular climate updates and advisories to farmers and agribusinesses. Opportunities for learning and extension of the new tools and data analysis.

3. Promote Sustainable Farming Practices:

Impact: Adopting sustainable farming practices will improve soil health, increase crop yields, and reduce the environmental footprint of agriculture. This will contribute to long-term agricultural sustainability and profitability.

Actions: Encourage practices such as conservation tillage, crop rotation, and agroforestry. Provide training and incentives for farmers to adopt these practices, particularly small land holders.

4. Develop Comprehensive Risk Management Plans:

Impact: Comprehensive risk management plans will help mitigate the financial risks associated with drought and other climatic events, ensuring the stability and continuity of agricultural businesses. Case study 1 in Section 9 is a great example of forward planning and risk management.

Actions: Promote the adoption of decision support tools and weather tools to manage risks and create contingency plans for extreme weather events. Assist small landowners to plan for risk and understand how they can improve their productivity.

5. Support Research and Innovation:

Impact: Investing in research and innovation for local solutions will drive the development of new technologies and methods to enhance agricultural productivity and resilience. This can lead to breakthroughs that significantly improve economic outcomes for the agriculture sector.

Actions: Fund research projects focused on local solutions for drought-resistant crops, advanced irrigation systems, and sustainable farming techniques. Foster collaboration between groups like the Stirlings to Coast, South Coast NRM, DPIRD and people working in research institutions, government agencies, and the private sector.

Summary

By implementing these recommendations, the Coastal Great Southern Region can strengthen its agricultural sector, enhance economic resilience, and secure long-term economic growth. Investments in water infrastructure, climate monitoring, sustainable practices, risk management, and research will collectively boost productivity, reduce vulnerability to drought, and support a more sustainable and profitable agricultural industry.

10.2. Recommendations to Protect the Natural Environment

1. Vegetation and Habitat Protection:

Impact: Vegetation and biodiverse habitats are vital as they provide a range of ecosystem services such as clean air, water filtration, carbon storage, and soil fertility. They support biodiversity by offering food, shelter, and breeding grounds for countless species as well as creating spaces for cultural heritage, education and activities.

Action: Implement programs to protect and restore native vegetation, including reforestation and afforestation projects.

Action: Create and maintain wildlife corridors to support species movement and reduce habitat fragmentation.

2. Soil Conservation Practices:

Impact: Good soil health is critical for farming practices and natural habitats. Our soil is fragile but an essential asset for production of food and protection of ecosystems for future generations.

Action: Promote soil conservation techniques such as mulching, cover cropping, and maintaining ground cover to prevent soil erosion.

Action: Implement erosion control measures such as building terraces, check dams, and planting deep-rooted vegetation to stabilize soil.

3. Water Management and Conservation:

Impact: Drought severely impacts natural aquatic ecosystems, with the major impacts being the loss of water and habitat availability, it can not only have a negative impact on water availability, but also the quality of the water remaining in these systems. Low flows and water levels increase the residence time of water and reduce flushing rates.

Action: Develop and implement water management plans that prioritize the needs of natural ecosystems.

Action: Enhance water retention in the landscape through the creation of wetlands, ponds, and riparian buffers to support aquatic habitats during dry periods.

4. Bushfire Management:

Impact: The Mediterranean-type climate in the southwest of WA is characterised by conditions that are conducive to ignition and spread over a 4–8-month period. There are various weather factors that influence the fire environment including coastal sea-breezes, strong easterly winds, abrupt wind changes, and regular lightning storms. Fires that tear through forests and bushland can cause serious loss of vegetation and biodiversity, as plants are burnt off, and animals are killed both from the fire, and from the loss of their home and food source following. Farmland is scorched, destroying pastures crops, and infrastructure, and killing livestock. Ash pollutes both the air and waterways, causing issues to human health, and depositing unwanted nutrients that can stimulate Harmful Algae Blooms.

Action: Develop and implement bushfire management plans that include controlled burns, fuel reduction strategies, and community education on fire prevention.

Action: Enhance early warning systems and firefighting capabilities to respond quickly to bushfire threats.

5. Biodiversity Conservation:

Impact: Without proper protection, the loss of vegetation and habitats can lead to ecosystem collapse, reduced agricultural productivity, and diminished quality of life for both humans and wildlife.

Action: Establish conservation areas and protected zones to safeguard critical habitats and species at risk from drought.

Action: Monitor and manage the health of ecosystems, conducting regular assessments to identify and mitigate emerging threats.

6. Adaptive Management and Research:

Impact: Investing in adaptive management and research to protect the environment is crucial because it allows for flexible, science-based responses to evolving environmental challenges, such as climate change, habitat loss, and biodiversity decline. Using real-time monitoring and feedback to adjust strategies as conditions change will ensure more effective resource conservation. Research drives innovation, helping to develop new technologies and practices that improve ecosystem resilience, optimize resource use, and mitigate human impact. This investment will safeguard natural systems, support sustainable development, and enhance the long-term well-being of both ecosystems and communities.

Action: Invest in research to understand the impacts of drought on local ecosystems and develop adaptive management strategies.

Action: Engage with local Noongar communities, local communities, landowners, and stakeholders to implement and monitor conservation practices.

7. Community Involvement and Education:

Impact: The communities in the Coastal Great Southern Region are passionate about protecting the environment in which they live, many opportunities exist to engage with them to create action.

Action: Foster community involvement in conservation efforts through education and participation in local environmental programs.

Action: Provide resources and training to landowners and community groups on sustainable land and water management practices.

Summary

Healthy ecosystems enhance resilience to climate change, help regulate natural cycles, and protect against natural disasters like floods and droughts. Without proper protection, the loss of vegetation and habitats can lead to ecosystem collapse, reduced agricultural productivity, and diminished quality of life for both humans and wildlife.

By implementing these recommendations, the Coastal Great Southern Region can enhance the resilience of its natural environment to the impacts of drought, preserving its rich biodiversity and ecological integrity for future generations.

10.3. Recommendations for Vibrant Communities to Build Resilience

Based on the Drought Vulnerability Assessment (DVA) report and general principles of community resilience, the key recommendations for the communities in the Coastal Great Southern Region to remain vibrant are:

1. Enhancing Social Capital and Community Engagement:

Impact: Strong social networks and community engagement are crucial for fostering a sense of belonging, mutual support, and collective action during challenging times.

Actions: Promote local events, social gatherings, and community groups. Encourage volunteerism and active participation in community projects. Strengthen communication channels within the community.

2. Ensuring Access to Quality Education and Training:

Impact: Education and training are vital for building a skilled and adaptable workforce, enabling individuals to pursue diverse economic opportunities.

Actions: Support local schools and educational programs. Provide vocational training and adult education opportunities. Partner with educational institutions to offer courses tailored to the community's needs.

3. Improving Health and Well-being Services:

Impact: Access to quality health services and mental health support is essential for maintaining a healthy and resilient community.

Actions: Enhance healthcare infrastructure and services. Provide mental health resources and support programs. Promote healthy lifestyles through community fitness programs and health education.

4. Fostering Economic Diversification and Employment Opportunities:

Impact: Economic diversification reduces dependence on a single industry and creates a more stable economic environment, providing varied employment opportunities.

Actions: Encourage the development of local businesses and entrepreneurship. Support sectors such as tourism, retail, and services. Provide incentives for businesses to invest in the community.

5. Protecting and Enhancing the Natural Environment:

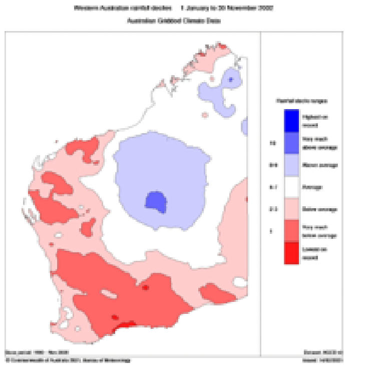
Impact: A healthy natural environment contributes to the community's well-being, recreational opportunities, and tourism potential. It also provides essential ecosystem services.

Actions: Implement conservation projects and sustainable land management practices. Promote environmental education and awareness. Support community-led environmental initiatives and stewardship programs.

Summary

By focusing on these recommendations, the communities in the Coastal Great Southern Region can enhance their vibrancy and resilience. Strengthening social capital, ensuring access to education and health services, fostering economic diversification, and protecting the natural environment will contribute to the overall well-being and sustainability of the community. These recommendations align with the values and strategic objectives identified in the Drought Vulnerability Assessment and are essential for building a robust and adaptable community capable of thriving despite challenges.

Appendix 1



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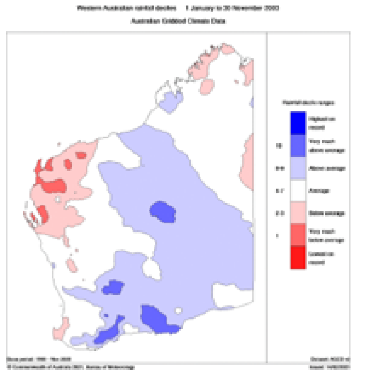

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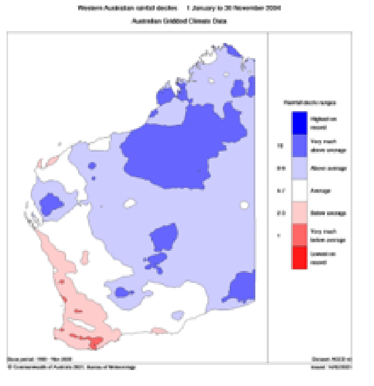

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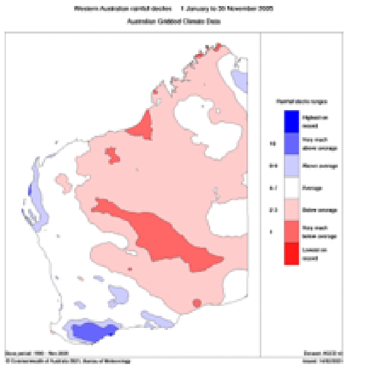

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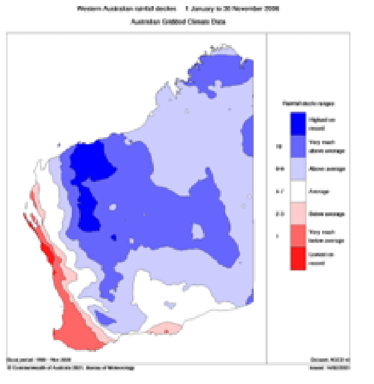

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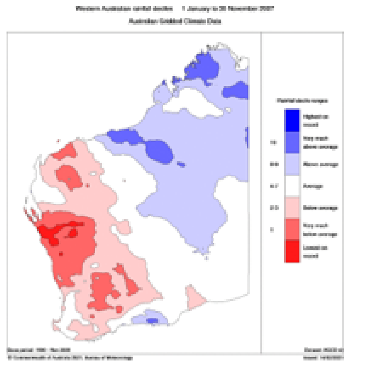

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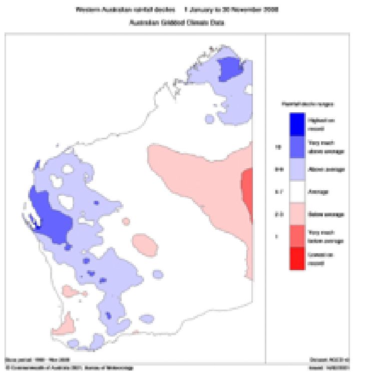

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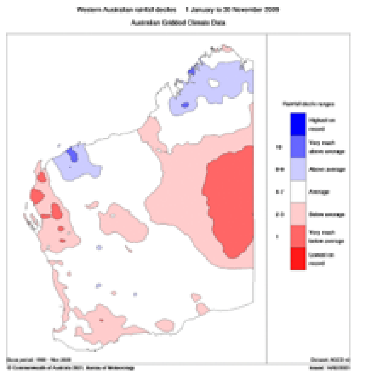

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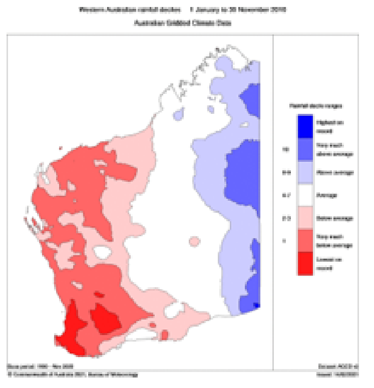

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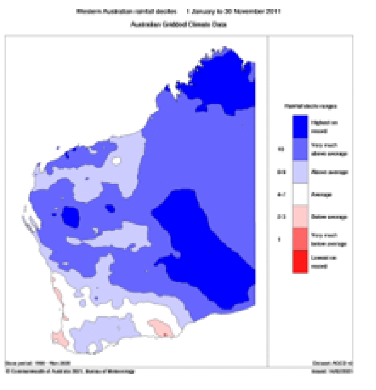

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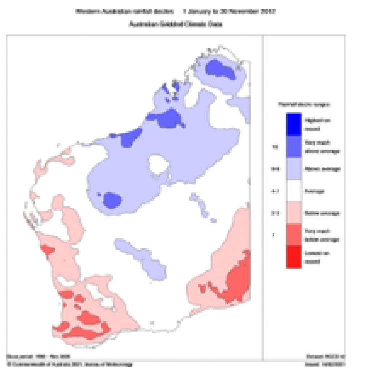

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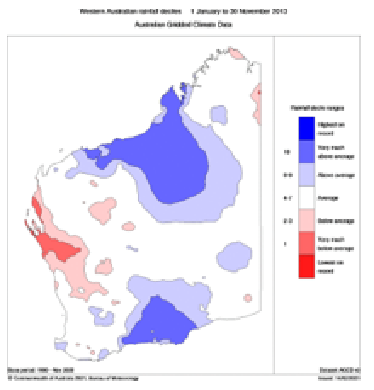

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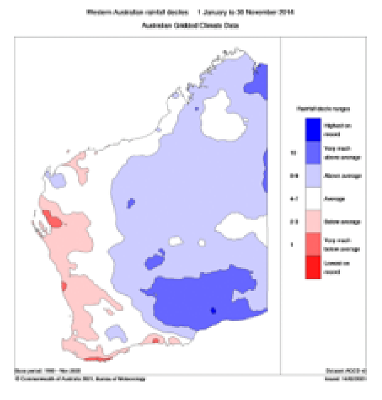	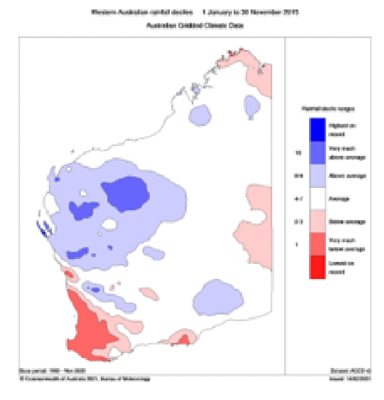	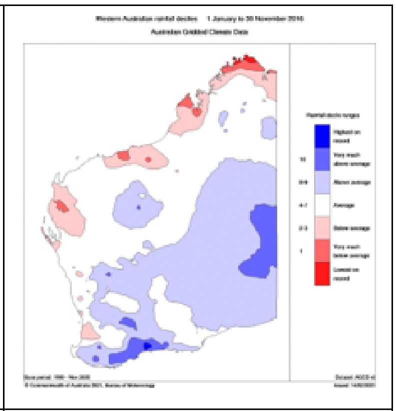
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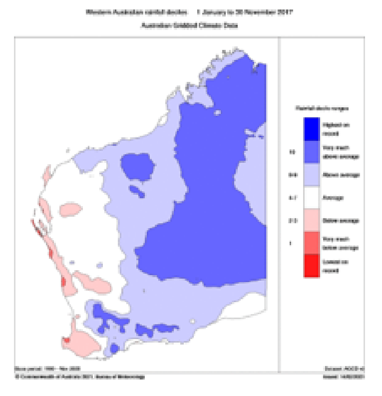	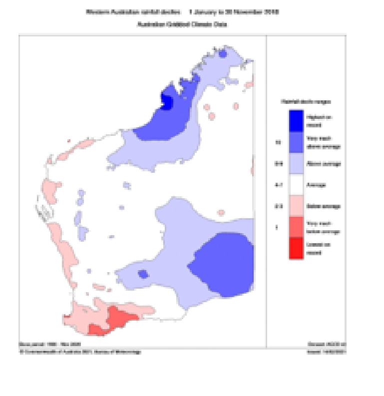	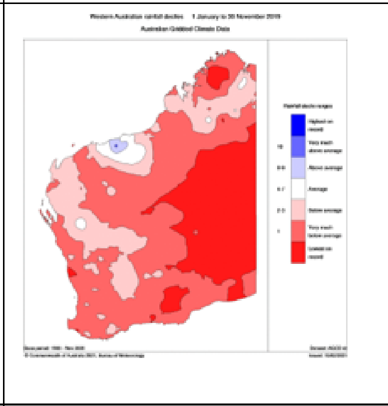
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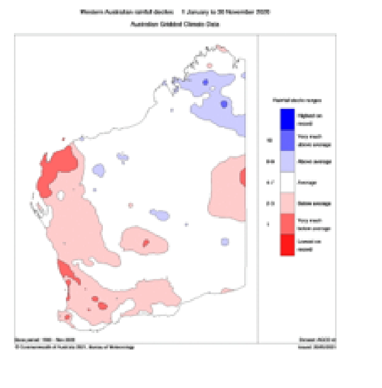	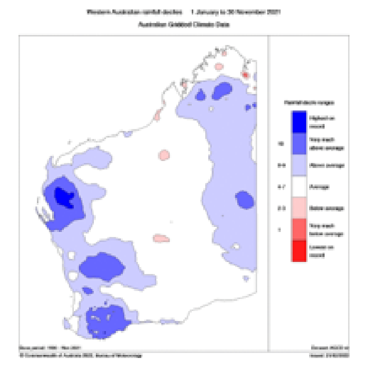	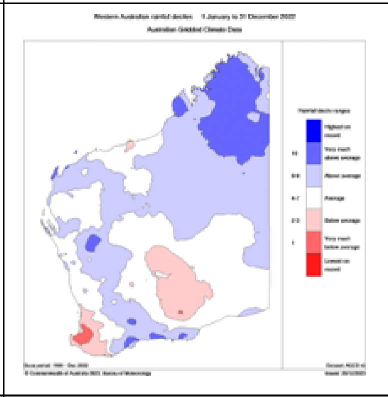
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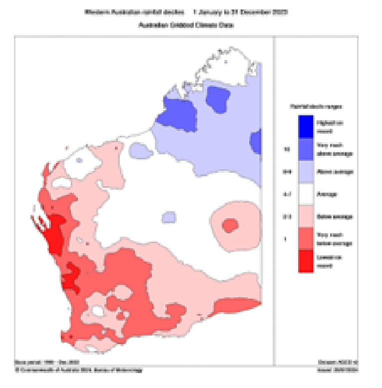		
2023		

Appendix 2

Table 1. Gross Value of Agriculture for the Coastal Great Southern Region (Million AU$)

	Total Value M (AU$)	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
Livestock sales	**220.0**	62,533,673	13,424,445	91,640,354	52,423,660
Broadacre crops	**215.5**	53,250,877	50,843	79,888,387	82,274,986
Livestock products	**78.7**	21,670,289	5,706,322	28,819,436	22,528,386
Hay	**26.6**	9,866,028	1,362,485	9,432,773	5,948,571
Vegetables	**5.4**	5,065,948	356,306	0	8,357
Grapes for wine	**10.9**	403,893	82,601	7,993,877	2,425,667
Fruit and nuts	**10.8**	3,608,569	497,660	6,103,267	564,476
Nurseries, cut flowers cultivated turf	**3.2**	3,037,706	201,377	0	0
		159.4 M	21.6 M	22.4 M	16.7M

Table 2. Value of Livestock & Livestock Products for the Coastal Great Southern Region (Million AU$)

	Total Value M (AU$)	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
Wool	**55.1**	11,424,878	884,546	20,245,578	22,527,908
Milk	**23.5**	10,140,729	4,821,776	8,573,858	0
Sheep and lambs	**58.8**	12,063,933	817,833	21,723,682	24,170,886
Cattle and calves	**76.2**	35,750,399	12,503,450	18,275,959	9,655,263
Pigs	**0.1**	738	102,281	0	0
Poultry	**0.0**	0	0	0	0
Eggs	**0.1**	104,681	0	0	0
Other n.e.c	**0.0**	2,924	0	2,160	620
		69.5 M	19.1 M	68.8 M	56.3 M

Table 3. Area of Agriculture for the Coastal Great Southern Region (Hectares)

	Total Hectares	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
Total area of holding	**726,088**	219,896	27,197	242,435	236,560
Area broadacre crops	**202,211**	53,021	201	74,168	74,821
Hay and silage	**24,050**	10,552	2,223	7,881	3,394
Grapes	**1,164**	66	28	815	255
Fruit and nuts	**270**	76	14	31	149
Nurseries, cut flowers or cultivated turf	**139**	128	11	-	-
Total area of vegetables (ha)	**196**	189	7	-	-
Total area of crop	228,030	64,031	2,484	82,895	78,620

Table 4. Number of Animals for the Coastal Great Southern Region (head)

	Total Number Head	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
Total dairy cattle	**13,759**	6,399	2,730	4,631	-
Total meat cattle	**649,392**	79,978	27,156	39,957	502,302
Total sheep & lambs	**747,711**	254,739	19,723	451,413	21,837
Total pigs	**105,481**	23,769	166	61,339	20,207
Total meat chickens	**182,427**	-	-	-	182,427

Table 5. Total number of Businesses

Type of Business	Total Number of Businesses	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
Dairy	**22**	12	5	5	-
Meat cattle	**398**	183	71	121	23
Sheep and lambs	**409**	123	34	148	104
Pigs	**21**	7	1	10	3
Poultry	**4**	2	-	2	-
Grapes	**32**	6	6	17	3
Fruits and Nuts	**12**	8	4	-	-
Vegetables	**27**	12	5	9	1
Nurseries, cut flowers or cultivated turf	8	7	1	-	-
Hay and Silage	365	131	46	126	62
Broadacre crops	227	36	2	95	94
Total Businesses[62]	1,525	527	175	533	290

62 Data by region 2011-2023, by Local Government Areas 2021 (ASGS Edition 3 (2021 – 2026))

Appendix 3

Land use

- 1.1.0 Nature conservation
- 1.2.0 Managed resource protection
- 1.3.0 Other minimal use
- 2.1.0 Grazing native vegetation
- 2.2.0 Production forestry
- 3.1.0 Plantation forestry
- 3.2.0 Grazing modified pastures
- 3.3.0 Cropping
- 3.4.0 Perennial horticulture
- 3.5.0 Seasonal horticulture
- 3.6.0 Land in transition
- 4.1.0 Irrigated plantation forestry
- 4.2.0 Grazing irrigated modified pastures
- 4.3.0 Irrigated cropping
- 4.4.0 Irrigated perennial horticulture
- 4.5.0 Irrigated seasonal horticulture
- 4.6.0 Irrigated land in transition
- 5.1.0 Intensive horticulture
- 5.2.0 Intensive animal husbandry
- 5.3.0 Manufacturing and industrial
- 5.4.0; 5.4.1 Urban residential
- 5.4.2-5.4.5 Rural residential and farm infrastru
- 5.5.0 Services
- 5.6.0 Utilities
- 5.7.0 Transport and communication
- 5.8.0 Mining
- 5.9.0 Waste treatment and disposal
- 6.1.0 Lake
- 6.2.0 Reservoir/dam
- 6.3.0 River
- 6.4.0 Channel/aqueduct
- 6.5.0 Marsh/wetland
- 6.6.0 Estuary/coastal waters

Appendix 4

Environmental scorecard method

Scores are calculated from a combination of the data collected from satellite data, surveys and biophysical modelling as well as sixteen field stations - TERN SuperSites around Australia . Three of the TERN SuperSites are in southern Western Australia. These are the Great Western Woodlands SuperSite, the Gingin Banksia Woodland SuperSite, and the Boyagin Wandoo Woodland SuperSite. The SuperSites range from 10 -200km in size[63], and include environmental monitoring towers and in hand devices to collect detailed, on ground truthing of fauna, flora and biophysical processes[64].

The Summary Score gauge and graph in Figure 67, displays the environmental health of a region and can be observed down to the shire region level. Regions are scored for their presence of seven categories out of the fifteen above, they are the inundation, streamflow, vegetation growth, leaf area, soil ground cover, tree cover (canopy), and the number of hot days experienced[65]. These seven categories are then combined and given a score out of ten. The final score is then compared to the score of the previous year to show the growth or impact this year's weather and human activities have had on the environment.

The leaf area index (LAI) is calculated from the amount of foliage measured in the tree canopy. This measurement can give an estimate on the average biomass, photosynthetic activity and water and nutrient uptake[66]. These measurements are taken by handheld devices at the TERN Ecosystem Surveillance plots (there are over 750 TERN monitoring sites in Australia), and by hemispherical photography at the SuperSites. These results are used to ground truth the satellite data and create models for the rest of the State and Nation which allows for future predictions based on historical results and trends. The National data then comes from the MODIS sateliite imagery and the OzWALD model data fusion system.

Vegetation Growth is calculated by the natural biomass changes observed by satellites, some of the data collected looks at the Gross Primary Production (GPP) measurements which come from the carbon uptake of plants through photosynthesis, are used to calculate the environments Vegetation Growth, which are also checked from the TERN sites. This data then is used by the OzWALD model data fusion system to create future predictions.

Exposed soil is observed from the lack of living and dead vegetation that is observed by the MODIS satellite imagery as well as the mapping done by the CSIRO using the OzWALD model data fusion system.[67]

Further details on the methods can be accessed https://www.wenfo.org/aer/data/

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Appendix 5

Drought Vulnerability Index

Climate Exposure Index

Table 6. Index for Climate Vulnerability

Index Variable	Unit of measure	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
Is there a change in rainfall pattern		0.20	0.24	0.11	0.03
Is future annual rainfall predicted to be lower		0.20	0.24	0.11	0.03
How much is it expected to be lower?		0.00	0.00	0.00	0.00
Rainfall change predicted for Autumn by 2050		0.20	0.24	0.10	0.03
Rainfall change predicted for Winter by 2050		0.12	0.15	0.10	0.03
Rainfall change predicted for Spring by 2050		0.11	0.14	0.05	0.00
Rainfall change predicted for Summer by 2050		0.20	0.24	0.10	0.03
Change in growing season rainfall		0.03	0.05	0.05	0.00
Change in average minimum temperature by 2050		0.20	0.24	0.11	0.03
Change in average maximum temperature by 2051		0.20	0.24	0.11	0.03
Number of hot days		0.20	0.24	0.11	0.05
Additional hot days		0.20	0.24	0.11	0.03
Events <20 mm from 1989 to 2023		0.33	0.35	0.34	0.25
How many below average years in 35		0.21	0.25	0.11	0.03
What is the likelihood of drought		0.21	0.25	0.11	0.04
What is the impact/significance on the environment		0.20	0.25	0.11	0.04
Rank of exposed soil - frequency - Highest for the Period (2000-2023)		0.20	0.24	0.11	0.03
Rank of exposed soil - frequency of years Very High (2000-2023)		0.20	0.24	0.11	0.03
Rank of exposed soil - number of years High		0.20	0.24	0.11	0.03
Rank of exposed soil - number of years average		0.22	0.26	0.13	0.06
Rank of exposed soil - number of years low		0.20	0.24	0.10	0.03
Rank of exposed soil - number of years very low		0.20	0.24	0.11	0.03
Rank of exposed soil - number of years Lowest for period		0.20	0.24	0.11	0.03
Exposed Soil - Min % of soil unprotected (average 2000-2023)		0.22	0.25	0.12	0.05
Exposed Soil - annual mean % of soil unprotected (average 2000-2023)		0.21	0.25	0.12	0.05
Exposed Soil - Max % of soil unprotected (average 2000-2023)		0.22	0.25	0.13	0.07
Moisture stored in the soil profile 2000-2023		0.90	0.92	0.88	0.90
Moisture stored in the soil profile 2000-2024		0.78	0.81	0.74	0.73
Moisture stored in the soil profile 2000-2025		1.00	1.00	1.00	1.00

Table 7. Economic Vulnerability

Index Variable	Unit of measure	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
Unemployment rate (2024)		0.57	0.57	0.58	0.53
Highest unemployment rate since 2010		0.03	0.03	0.04	0.02
Proportion of workforce employed by Agriculture Forestry and Fishing		0.03	0.04	0.10	0.20
Proportion of workforce in Agriculture		0.24	0.27	0.28	0.28
Proportion of workforce in Forestry and Logging		0.05	0.01	0.01	0.00
Agriculture Forestry and Fishing Support Services		0.03	0.02	0.02	0.00
Median Age		1.71	1.74	1.70	1.72
Industry wages & salaries per employee		4.69	4.51	4.55	4.51
Average for all industries		4.99	4.76	4.95	4.87
Ag industry % of wages		0.17	0.19	0.15	0.16
Number of businesses in Agriculture		2.86	2.34	2.61	2.16
Percentage of Businesses in Agriculture		0.08	0.11	0.19	0.21
Diversity in the economy by the number of businesses		0.30	0.60	0.70	0.78
Reliance on Agriculture (% value)		0.02	0.02	0.17	0.34
Total number of agriculture FF businesses under $50,000		2.32	1.86	2.00	1.28
Total number of agriculture FF businesses under $200000		2.40	1.94	2.08	1.52
Total number of agriculture FF businesses under $200000 to $2M		2.33	1.76	2.20	1.83
Total number of agriculture FF businesses under $2M to $5M		1.52	0.60	1.38	1.30
Total number of agriculture FF businesses under $5M to 10M		1.23	0.60	0.90	0.90
Total number of agriculture FF businesses under >$10M		0.85	0.00	0.60	0.00
Percentage of ag businesses under $50,000		0.10	0.15	0.21	0.17
Percentage of businesses under $200000		0.08	0.11	0.17	0.20
Percentage of businesses under $200000 to $2M		0.06	0.08	0.19	0.23
Percentage of businesses under $2M to $5M		0.07	0.08	0.19	0.24
Percentage of businesses under $5M to 10M		0.10	0.14	0.25	0.27
Percentage of businesses under >$10M		0.06	0.00	0.20	0.00
Community Survey Question: In the past 15 years, how impacted have you been by drought/drying climate? Response Extremely (5) Somewhat (4) No Impact (1)		0.62	0.02	0.66	0.68
Community Survey Question: What the impact is on business/industry - scored using a 1 (low) to 5 (high) rating		0.52	0.63	0.60	0.60

Table 8. Environmental Vulnerability

Index Variable	Unit of measure	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
Land Degradation – no visible degradation (1), Minor (2) (moderate (3) Significant (4) Severe (5)		0.60	0.78	0.60	0.70
Water Availability – no visible degradation (1), Minor (2) (moderate (3) Significant (4) Severe (5)		0.60	0.70	0.60	0.78
Biodiversity Loss– no visible degradation (1), Minor (2) (moderate (3) Significant (4) Severe (5)		0.70	0.70	0.70	0.70
Community Survey: What were the impacts of drought/ drying climate on your: Environment		0.52	0.58	0.54	0.46
What is the likelihood of drought		0.70	0.70	0.78	0.70
What is the impact/significance on the environment		0.78	0.78	0.70	0.70
Rank of exposed soil - frequency - Highest for the Period (2000-2023)		0.30	0.30	0.30	0.30
Rank of exposed soil - frequency of years Very High (2000-2023)		0.48	0.48	0.48	0.48
Rank of exposed soil - number of years High		0.48	0.48	0.48	0.30
Rank of exposed soil - number of years average		1.15	1.11	1.15	1.20
Rank of exposed soil - number of years low		0.30	0.30	0.00	0.00
Rank of exposed soil - number of years very low		0.00	0.48	0.30	0.30
Rank of exposed soil - number of years Lowest for period		0.30	0.00	0.30	0.00
Exposed Soil - Min % of soil unprotected (average 2000-2023)		1.06	0.81	0.96	1.07
Exposed Soil - annual mean % of soil unprotected (average 2000-2023)		1.02	0.74	0.91	1.00
Exposed Soil - Max % of soil unprotected (average 2000-2023)		1.18	0.87	1.11	1.30
Moisture stored in the soil profile 2000-2023		2.58	2.58	2.62	2.64
Moisture stored in the soil profile 2000-2023		2.50	2.50	2.54	2.54
Moisture stored in the soil profile 2000-2023		2.64	2.62	2.68	2.69
Leaf area index 2000-2023		0.33	0.64	0.47	0.41
Leaf area index 2000-2023		0.29	0.56	0.41	0.37
Leaf area index 2000-2023		0.39	0.71	0.51	0.45
Vegetation carbon 2002-2023		2.88	3.01	3.16	3.02
Vegetation carbon 2002-2023		2.73	2.92	3.09	2.96
Vegetation carbon 2002-2023		3.05	3.19	3.35	3.19
What is the percentage of natural vegetation		0.13	0.22	0.13	0.11
Is the natural environment vulnerable to drought		0.30	0.30	0.30	0.30
High value natural assets		0.30	0.30	0.30	0.30

Table 9. Social Vulnerability

Index Variable	Unit of measure	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
SEIFAS_2: SEIFA Index of relative socio-economic disadvantage (IRSD): Rank within State or Territory (decile)		6	7	3	4
SEIFAS_3: SEIFA Index of relative socio-economic advantage and disadvantage (IRSAD): Rank within State or Territory (decile)		5	7	3	5
SEIFAS_4: SEIFA Index of education and occupation (IEO): Rank within State or Territory (decile)		5	9	5	7
SEIFAS_5: SEIFA Index of economic resources (IER): Rank within State or Territory (decile)		6	6	5	5
In the past 15 years, how impacted have you been by drought/drying climate? (b) Local community		1.42	2.35	2.44	2.56
Access to Resources	**1 to 5**	1	3	3	4
Migration		1	1	3	4
Mental Health		2	4	3	4
Top 5 priorities/values		**Impact of Drought – 1 is low 5 is high**			
Access to housing		1			
Community safety and crime prevention		1			
Sealed roads		3			
Health and community services		5			
Waste collection services		1			
Better services & facilities for Youth			1		
Increased road network maintenance			1		
Housing availability & affordability			1		
Economic development			1		
Environment protection			5		
Peaceful lifestyle, supportive community, safety, and security				3	
Importance of road and footpath construction and maintenance				3	
Community safety, bushfire prevention, and control				5	
Access to high-quality health services and wellbeing improvement				5	
Retain country lifestyle with high-standard community facilities				5	
Business & Economic success				5	5
Civil construction					3
Safety					3
Top 5 priorities/values in the Future plan		**Impact of Drought – 1 is low 5 is high**			
Promote and adopt sustainable practices to combat climate change		5			
Services and facilities for youth		1			
Footpaths and cycleways		1			
Building and maintenance of sealed roads		1			
Economic development, job creation		5			

Index Variable	Unit of measure	City of Albany	Shire of Denmark	Shire of Plantagenet	Shire of Cranbrook
Building and maintaining local roads			1		
Conservation and environmental management			5		
Youth services and facilities			1		
Sustainable practices / climate change			5		
Sport and recreation facilities and services			5		
Provide and promote facilities and activities for youth.				3	
Advocate for family support services				1	
Ensure services and facilities meet aging population needs				1	
Advocate for regional medical and hospital services				1	
Promote a healthy and active community				3	
Strong and sustainable business region					3
Strong and sustainable tourist industry					3
Attractive visual destination for new residents					5
Have a point-of-difference with one outstanding theme per diverse town					1
Keeping new residents in the area facilities, housing, schools, sport					5
Future Strategy Objectives		**Impact of Drought – 1 is low 5 is high**			
Social - Aspire to be a welcoming, healthy and inclusive community		1			
Economic - A strong, diverse and resilient economy with work opportunities for everyone		3			
Environment - Balance conservation, access, climate action, and disaster resilience		5			
Leadership - A well governed city that uses resources wisely to meet local needs and values		1			
Social - Enhance community connection and well-being			5		
Economic - Support local jobs, businesses, and sustainable development			3		
Environment - Operate as environmental custodians for the future			5		
Leadership - A desire for better connection between Council and community			1		
Social - Build community pride, safety, well-being, and involvement through services				3	
Economic - Develop a strong local economy with diverse services and jobs				5	
Environment - Maintain infrastructure supporting services and protecting the environment				5	
Leadership - To Engage with locals and offer clear, consistent guidance				1	
Social - Be respected for our friendly, vibrant, safe and connected community					3
Economic - Be an innovative, diverse, prosperous and growing economy					5
Environment - Improve, preserve, and promote our infrastructure and natural environment					5
Leadership - To demonstrate and partake in strong government and leadership					3

Drought Vulnerability Assessment
Coastal Great Southern Regional Drought Resilience Plan

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