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Future Drought Fund

Department of Primary Industries and Regional Development
GOVERNMENT OF WESTERN AUSTRALIA

Inland Great Southern Drought Vulnerability Assessment

Great Southern Development Commission

2022

GREAT SOUTHERN Development Commission

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1. Acknowledgements

We respectfully acknowledge the Wagyl-Kaip People of the Noongar Nation, who are the Traditional Owners and original natural resource managers of the lands and waters in the Great Southern Inland Region. We pay our respect to their Elders and leaders - past, present and emerging.

We would like to thank the different organisations, businesses and individuals in the region who contributed to the development of this Drought Vulnerability Assessment (DVA) through participation in interviews, surveys, meetings and workshops. Their insight, experience and ground truthing of the technical work undertaken was invaluable.

The in-kind contribution of the Climate Science and Geographic Information Systems teams at the Department of Primary Industries and Regional Development (DPIRD) and the work of the consultants who undertook literature reviews and data syntheses on our behalf were integral in the development of this document. This program is jointly funded through the Australian Government's Future Drought Fund (FDF) and the Western Australian Department of Primary Industries and Regional Development, and led at the regional level by the Wheatbelt Development Commission (WDC), Midwest Development Commission (MDC) and Great Southern Development Commission (GSDC).

This report was compiled by Kaylene Parker and Jarrad Gardner from the GSDC and Renee Manning from the WDC, with significant contribution from Dr Amanda Bourne (formerly of the Northern Agricultural Catchment Council). The report also includes summaries of work undertaken by a suite of technical experts to ensure it is underpinned by evidence-based research. A list of the reports and consultants is included in section 15 of this document. We would like to thank our consultants for their contribution and support. Likewise, we thank our valued stakeholders in the Great Southern Region.

We also acknowledge and thank the program Steering Committee and Technical Working Group which contributed to review and refinement of elements of the DVA and Great Southern Inland Drought Resilience Plan (DRP).

2. Executive Summary

2.1 Purpose

The Australian Government has established the Future Drought Fund (FDF) to provide secure, continuous funding for drought resilience across Australia. Through this fund, the Australian Government is supporting regions to develop Regional Drought Resilience Plans (RDRPs) that will ensure regions are prepared for, and resilient to, future drought risks.

The development of the Drought Vulnerability Assessment (DVA) is a key component in the delivery of the Regional Drought Resilience Planning program for the Southern Wheatbelt, Midwest and Inland Great Southern regions. The DVAs have been informed by a range of technical analyses, a comprehensive geospatial multicriteria analysis, and extensive community and technical expert engagement. Outcomes of the DVA process include:

- an excellent understanding of the impacts of drought in the region achieved through extensive stakeholder engagement;
- a synthesis of program and policy initiatives related to drought at a local, regional, State and Federal level;
- an investigation of alternative definitions of drought, based on growing season rainfall, better suited to the broadacre cropping areas in the Inland Great Southern region;
- in depth analyses of the economic, environmental, social and water impacts of drought, including the impacts of drought on Aboriginal communities;
- development of a multi-criteria mapping methodology that synthesises many datasets into a single decision-support tool highlighting priority areas for investment in resilience building activities;
- an exploration of how readily measurable biophysical and socio-economic factors, often publicly available data, might serve as indicators of drought and be used to understand and / or predict the impacts of drought; and
- a drought vulnerability index using the data collected to create the drought risk priority areas map.

2.2 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.

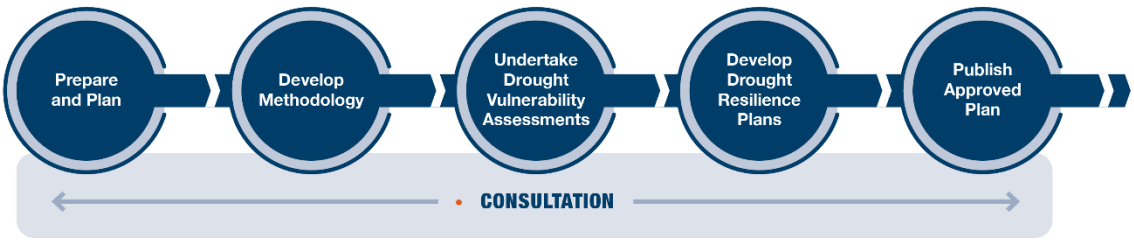


Figure 1 Project Implementation for the Future Drought Fund's Regional Drought Resilience Planning Program in WA

Consultation with stakeholders and a review of existing data on drought impacts in the focus regions during the vulnerability assessment phase provided the opportunity to better understand how the regions have been affected by drought in the past and how they are likely to be affected by drought in the future.

The vulnerability assessment also reviewed what has already been done to mitigate the impacts of future droughts and how effective these measures have been. This DVA includes a technical analysis of the potential social, economic and environmental impacts of future drought based on the latest available information, including climate change scenarios. Figure 2 illustrates the conceptual framework used in the development of this document.

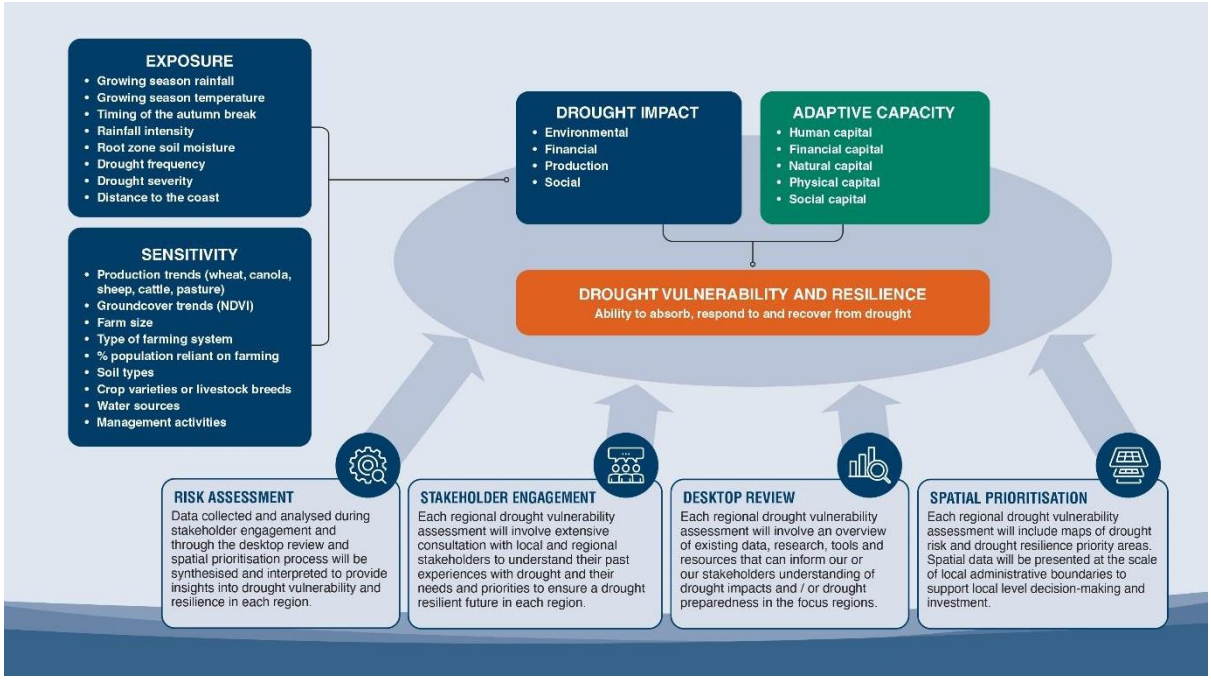


Figure 2 Conceptual Framework for Regional Drought Resilience Vulnerability Assessments

Our drought vulnerability assessment approach uses existing social, economic and environmental data representing current and historical conditions and contextualises these data within the latest available climate science for the regions.

It is assumed, based on past research in Western Australia[1, 2], that existing vulnerabilities will be exacerbated by drought. The same level of drought will affect more and less vulnerable people and systems differently. A focus on known current social, economic and environmental vulnerability is less sensitive to uncertainties in climate projections than modelled approaches and aligns more readily with Australian policy priorities around economic growth and production.

As part of the development of this Drought Vulnerability Assessment, a spatial multi-criterion analysis of economic, environmental and social data relevant to drought was undertaken by DPIRD to create a drought risk vulnerability map (Figure 3) which provides context specific information to support local level decision making and planning.

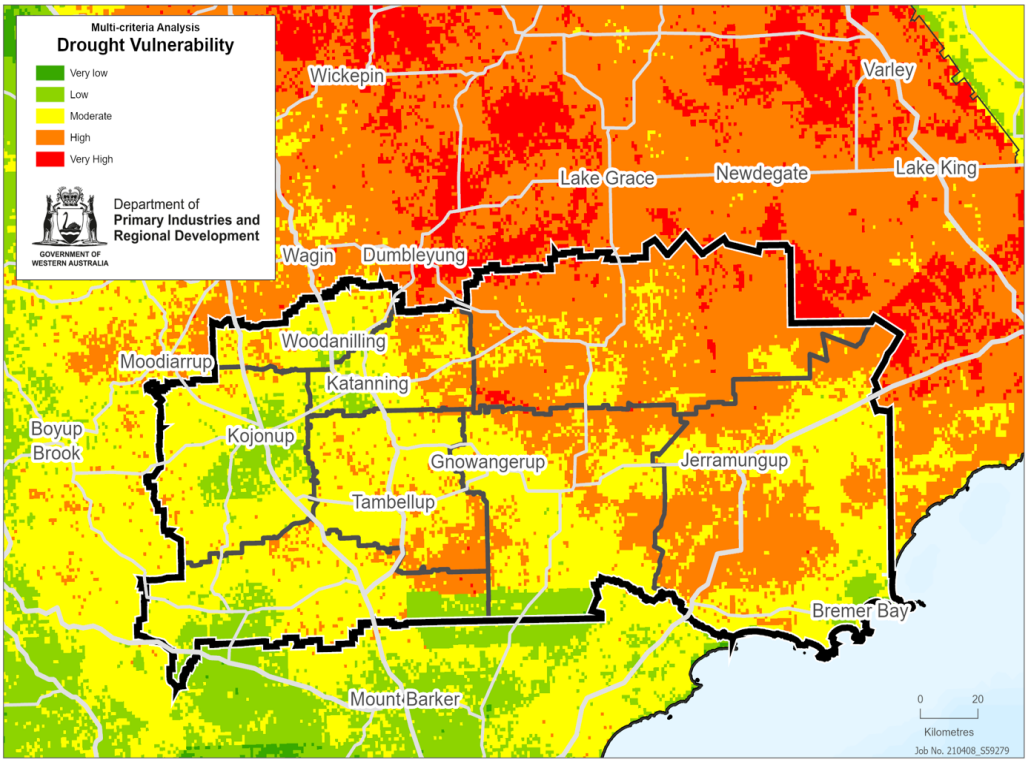


Figure 3 Analysis of Drought Vulnerability in the Inland Great Southern Region

This map has been developed using Local Government Authority boundaries and shows the areas in the Inland Great Southern region that are most vulnerable to drought. Vulnerability varies between moderate to very high vulnerability. Very high vulnerability in the Great Southern region often correlates to proximity to water supplies – either scheme or non-potable supplies.

The map highlights drought risk priority areas in the Inland Great Southern region based on temperature, rainfall and production data, access to infrastructure, population demographics and environmental characteristics. Brown and red areas are considered most vulnerable to drought and should be treated as the highest priority for drought resilience interventions.

2.3 Conclusions

2.3.1 Climate Data

Australia has experienced significant drought events over the last decade in several regions, which have led to widespread impacts on the agricultural sector and rural and regional communities. With climate variability predicted by scientists to continue, research is being undertaken in Australia and around the world into how to mitigate the risks of drought and reduce its social, environmental and economic impacts. This scientific research is informing policy development and providing direction on adaptation measures based around pro-active risk mitigation and preparedness.

The latest climate projections for WA show the number of dry days is likely to increase over all of WA. Agricultural drought months (defined as a month of extremely low soil moisture) are projected to increase by up to 20% over most of Australia by 2030, and up to 80% in the South West by 2070.

The projected duration and frequency of droughts in the South West increased for all emission scenarios, with a high level of confidence in these projections. One study found that there is more than a 66% probability that drought will affect twice as much of southern Western Australia and/or twice as often by 2030.

These changes will be superimposed upon, and increase, WA's already naturally large climate variability. Consequently, the intensity and duration of hot spells is projected to increase across WA, wet years are likely to become less frequent, and dry years (and drought) are likely to become more frequent.

Analysis of rainfall and temperature data highlighted a potentially concerning trend, with the composite hazard of hot drought beginning to occur in recent years. Combined high temperatures and low rainfall can be devastating and, given global climate trends, are likely to occur more frequently and over larger areas in future. [3]

Appropriate steps must be taken to anticipate and mitigate the potentially devastating effects of hot droughts, which have been relatively unknown in WA until 20 years ago. They are now increasingly common and severe. The data in Figure 4 indicates a significant increase in hot drought between 1980 and 2020.

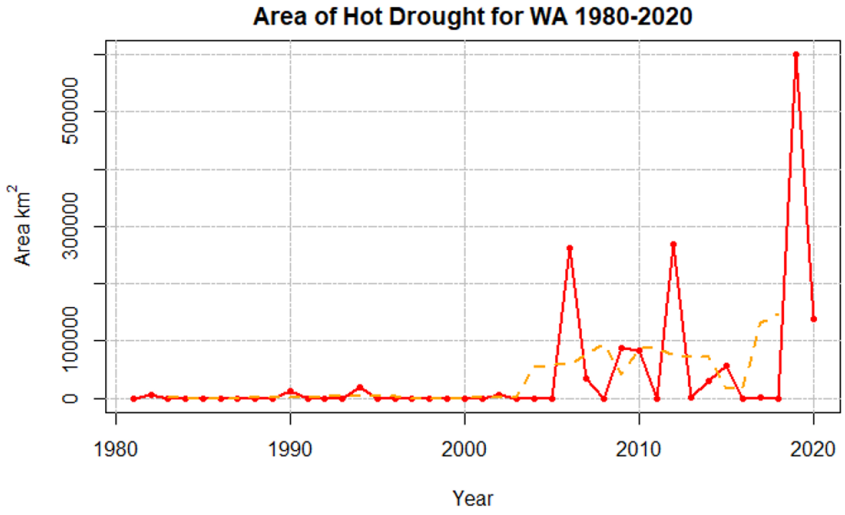


Figure 4 Frequency of hot droughts between 1980 and 2020

2.3.2 Defining Drought

Following consultation with regional stakeholders and technical experts, a working definition of drought for the RDR Planning Program in WA was developed as

> "…a prolonged period of abnormally dry conditions that impacts negatively on water availability and agricultural production in a region and, consequently, impacts negatively on the economy and environment of the region and the health and well-being of its residents."

A review[4] of meteorological definitions of drought revealed a definition based on growing season rainfall (between April to October). This is considered more appropriate for the Inland Great Southern region than a definition based on total annual rainfall, as growing season rainfall better represents agricultural drought in the region.

2.3.3 Drought Impacts

Despite high resilience in terms of agricultural production capability, the region is highly exposed to the impacts of climate change (increasing temperatures, decreasing rainfall, changes in the timing of rainfall and increasingly frequent drought). It faces several general resilience challenges including economic diversification and access to infrastructure, services and reliable, good quality water. Improving our understanding of and responses to these challenges should be the focus of drought resilience action in the region.

Stakeholder engagement and the technical review process undertaken as part of this assessment identified that drought impacts cut across the following key areas in the Inland Great Southern:

Economic impacts

Agriculture is the primary land use in the region and Inland Great Southern stakeholders reported experiencing financial stress due to failed production during dry seasons. Farming families sell livestock, liquidate assets, or increase their debt to survive, with non-agricultural businesses in regional areas suffering from reduced off farm spending and the impact this has on employment opportunities and cash flows. Targeted investment in water infrastructure for ongoing agricultural resilience, diversifying clientele, income, value adding commodities and servicing multiple industries were identified as economic opportunities for regional businesses – both agricultural and non-agricultural. Improved understanding and advocacy for region-enabling infrastructure that will support economic functioning needs is considered essential to building drought and climate resilience.

Environmental impacts

Drought can have serious, long-term consequences for soil health, vegetation cover and biodiversity. Reduced vegetation cover and drier soils increase the risk of erosion and invasion by weeds, pests and diseases. Plant mortality becomes more pronounced in drought years. This impacts on biodiversity, ecosystem services and reduces the ability to sequester carbon. Environmental stewardship programs, informed participation in carbon farming and extension and adoption programs were identified as opportunities to improve environmental resilience.

Impacts on water resources

Dry seasons result in increased pressure on scheme water and strategic community water supplies, triggering water deficiency declarations. Water supply development occurs sporadically and is undertaken by multiple organisations. Improved planning and coordination of future water needs was identified as a key opportunity for industry and community.

Social impacts

The uncertainty and financial stress associated with drought negatively affects mental health in regional areas. Drought contributes to failed businesses, causing people to move away, a reduction in population, access to skills and services and the availability of community services and support networks in the region. The small communities that are a feature of the Inland Great Southern are particularly exposed to drought impacts, given their high dependence on agriculture and volunteerism that support social connection.

Cultural impacts

Aboriginal community members in the Inland Great Southern expressed concern about the impact of drought on vegetation, water and fire regimes in the region, as well as the impact of land transformation and climate change.

Noongar community members saw drought in the context of wider changes to the natural environment including land clearing, damage to rivers and creeks, changing climate and ecological responses. Drought was noted as one of several linked factors that have damaged the foundation of Noongar identify and well-being. Participation in landscape conservation and restoration activities were identified as economic opportunities for Aboriginal people. A Noongar led framework of action to support improved engagement in land management was suggested as a way forward.

3. Introduction

3.1 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[5]. 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.

3.2 Regional Drought Resilience Planning Program

The Regional Drought Resilience Planning (RDRP) program is one of the foundational programs under the FDF in 2021-22, under the 'Better Risk Management' theme. Its focus is on developing regional drought resilience plans, based on sound planning principles and practices. These plans identify priority actions to build resilience to drought in agriculture and allied industries across different regions.

In Western Australia, the program will deliver three Regional Drought Resilience Plans in the foundational year, with a focus on the Great Southern, Mid-West and Wheatbelt. This report is for the Inland Great Southern region, incorporating the Shires of Broomehill-Tambellup, Cranbrook, Gnowangerup, Jerramungup, Katanning, Kent, Kojonup and Woodanilling.

3.3 DVA Overview

This Drought Vulnerability Assessment (DVA) informs the Inland Great Southern Drought Resilience Plan and provides the evidence base for the Regional Drought Resilience Plans (RDRPs) for each of the three consortia regions in Western Australia. It forms part of the Regional Drought Resilience Planning of the Australian Government's Future Drought Fund (FDF) initiative.

In this report, we present a summary of the likely economic, environmental and social impacts of future drought, based on the latest available climate change scenarios for the Inland Great Southern. We also report on results gathered from our regional stakeholders, looking at how they have been affected by drought in the past and what has already been done to mitigate the impacts of future droughts. This has enabled the identification of specific drought resilience actions which have been presented in the Inland Great Southern RDRP.

This project strongly aligns with the following key regional strategies:

- Great Southern Development Commission's strategic priorities of Strong and Diverse Economy, Regional Liveability and Strong Communities
- Strategic Community Plans for the Shires of Broomehill-Tambellup, Cranbrook, Gnowangerup, Jerramungup, Katanning, Kent, Kojonup and Woodanilling.

Extensive consultation and technical review informed the development of the maps within this report. As such, the maps produced should only be used in relation to the regions that participated in the WA RDRP Pilot.

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. 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.

Exposure is the extent to which a given system, community or region will be subjected to a particular hazard. For the RDRP, exposure 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.

Sensitivity is the extent to which a given system, community or region will be affected by a particular hazard. For the RDRP, sensitivity is fundamentally about the ways in which regions are impacted by drought. It is measured in terms of the effect of drought on crop 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.

Adaptive Capacity is the extent to which a system is able to exploit opportunities and resist or adjust to change. For the RDRP, adaptive capacity is measured in terms of historical response to droughts in the regions or estimated according to a set of vulnerability proxies such as income, education, community participation rates and drought resilience natural features (ground cover, topography).

Resilience refers to the region's ability to absorb disturbance and to effectively maintain, reorganise or make changes to sustain lives and livelihoods[6]. The RDRP drought vulnerability assessment conceptual framework draws on past studies in Australia[7,8,9,10] and around the world[11,12,13] to ensure that sufficient attention is paid to all important aspects of drought vulnerability and resilience in the affected regions. Planning for resilience is about building:

- absorptive capacity for maintaining the system;
- adaptive capacity for modifying the systems when needed;
- transformative capacity for systemic change when maintaining and modifying existing system are untenable; and
- developing new configuration of networks and institutions to implement these capacities.

3.4 DVA Methodology Components

3.4.1 Stakeholder Engagement

Stakeholder engagement is a critical component of any vulnerability assessment process. In this case, a stakeholder mapping process was undertaken for each region to identify groups and individuals to consult on the development of the regional drought resilience plans. Stakeholders identified through this process included local government authorities, farmers and their representative bodies, agribusiness, Traditional Owners, community groups, not for profit organisations, research institutions, and the regional offices and technical teams of State and Federal government agencies.

Consultation with stakeholders is critical in understanding how those living and working in the regions have experienced and responded to drought in the past, what they have undertaken to mitigate drought risk, how they perceive future drought risk and understanding priority actions they consider important in building resilience to drought in the future.

Strong stakeholder engagement generates buy-in from the community and stimulates interest in the project. It sets a level of accountability for the project team and builds and strengthens relationships across and within the region that will outlive this program. In the Inland Great Southern region, stakeholder engagement occurred between August 2021 and August 2022. A range of methods were used to engage stakeholders across all levels of government, key agricultural and natural resource management groups, traditional owners, businesses and community organisations.

A Technical Working Group (TWG) was established and provided opportunity for input and review of the key elements of the DVA model, including identification of important datasets to inform the assessment process. Membership of the TWG membership included DPIRD climate scientists, CSIRO, University of Western Australia's Centre for Social Impact, Curtin University's Centre for Crop Disease Management, Murdoch University's Harry Butler Institute, Planfarm and Noongar Land Enterprises

A Steering Committee provided high level support and direction to the project team and was chaired by the CEO of the Wheatbelt Development Commission, with representation from the participating RDCs and local governments, and the Director of the SWWA Drought Resilience and Adoption Hub.

South Coast Natural Resource Management (SCNRM) was contracted to assist with consultation with Grower Groups, farm advisors, farming champions and SCNRM Reference Groups. They also worked in cooperation with Gillamii Centre and Keogh Bay to consult with First Nation representatives across the region. They used a range of methods including participatory workshops, interviews and regional surveys.

This consultation focused on identifying ways in which the local community understands and defines drought, how they have been impacted by drought in the past, and how they responded in the most recent droughts 2018-2019. From April onwards, consultation has focused on identifying key actions and priorities to include in the final drought resilience plan.

Consultation sessions focused on reviewing emerging technical analyses, sharing the results of earlier consultation efforts and identifying drought resilience project ideas for inclusion in the RDR Plan. In the Great Southern Region, engagement occurred with 24 farming businesses, six Grower groups, community members, two agronomists, eight LGA's, South Coast NRM and over 25 Aboriginal community members and industry representatives.

As the project includes the Wheatbelt and Midwest regions, collaboratively the program consulted with more than 330 people representing at least 180 separate organisations and businesses. with 19 state agencies, six peak bodies (agricultural), 34 agribusiness, three universities and CSIRO and over 300 stakeholder engagement meetings.

Locally, the project was overseen by the Great Southern Development Commission (GSDC) whose role is to coordinate and support endeavours that build the economy and promote growth in the Great Southern region of Western Australia. Project updates were regularly provided to GSDC's Board of Management, with the opportunity to provide input and feedback into the DVA and final Inland Great Southern RDR Plan (see Appendix 1 and 2 for a snapshot summary of the stakeholder engagement activities). Consultation reports for Agriculture and Natural Resource Management Stakeholders and Aboriginal Stakeholders are available on request.

3.4.2 Desktop Review

Desktop review is a critical component of any vulnerability assessment process. It involves identifying, summarising and interpreting what is already known about the impacts of the hazard on drought. The desktop review followed the development of the RDRP conceptual framework, and investigated aspects of exposure, sensitivity, impact and adaptive capacity and the ways in which each of these relate to and inform vulnerability and resilience to drought in the regions.

The desktop review included an overview of existing data, research, tools and resources that informed our stakeholders' understanding of drought impacts and drought preparedness across the focus regions. It included a socio-economic and land-use profile of each region, describing the population, major land-uses and economic activities, the threatening processes they face and what that means in terms of drought resilience.

The review identified those actively working to support drought resilience in the region with regards to drought, including their respective roles and relationships between them, and summarised existing and past drought resilience policies and plans across a range of levels, from local to international, and the suite of drought resilience programs currently operating in Western Australia and Australia as a whole.

3.4.3 Spatial Prioritisation

The spatial component of the RDRP regional drought vulnerability assessments used mapping software to map drought resilience priority areas. All spatial data was prepared and presented at the scale of local administrative boundaries, to best support local level decision-making and investment.

The first set of spatial products included drought risk in terms of historical and projected changes in rainfall, temperature, soil moisture and the frequency and severity of drought, and is intended to build local capacity to understand historical drought and work with a range of plausible future drought climate scenarios using climate projections.

Inputs into the multi-criteria analysis (MCA) were determined following the development of the RDRP conceptual framework, and include exposure, sensitivity, impact and adaptive capacity and the ways in which each of these relate to and inform vulnerability and resilience to drought in the regions. Spatial data layers include:

- climate data (historical and projected change in rainfall, temperature, soil moisture and drought frequency and severity);

- environmental data (soil type, topography, ground and surface water resources, native vegetation extent, ground cover, NDVI);
- production data (crop yields, animal production, type of farming system);
- financial data (household income, farm profitability, use of farm management deposit schemes);
- social data (population trends, access to services, community participation rates); and
- infrastructure data (roads, water supplies).

Composite maps showing how different features of drought risk and resilience are overlaid in the regional landscapes are created using a standard multi-criterion GIS analysis (MCA)[14,15,16,17,18]. Priority areas for investment in drought resilience projects or programs are highlighted at the overlap between spatial datasets that highlight where drought is likely to occur, where there are features are likely to provide resilience to the impacts of drought (e.g. high ground cover, lots of water resources, drought resilient farming systems) and where vulnerable communities of people are likely to be impacted by drought (e.g. remote communities with limited access to services).

3.4.4 Risk Assessment

A drought risk assessment collates all the data collected and analysed from the stakeholder engagement, desktop review and spatial prioritisation components, and provides local decision-makers with a summary of vulnerability to drought in their region. Synthesis of the data into a risk assessment followed the development of the RDRP conceptual framework and investigated aspects of exposure, sensitivity, impact and adaptive capacity and the ways in which each of these relate to and inform vulnerability and resilience to drought in the regions.

The aim of a risk assessment summary is to assist local decision makers and managers in the rapid evaluation of drought vulnerability for the region and enable tracking of change over time. Data in each drought impact category (i.e., social, financial, production, environmental) can be scored along a sliding scale and assessed over medium and long-term timeframes in terms of drought risk and resilience[19,20].

3.5 DVA Structure

This report is presented in sections as outlined below:

1. Summary of the drought vulnerability assessment process and conceptual framework;
2. Background and context: information about the region, including where it is located, socio-economic analysis, land use, institutional and policy context;
3. Climate data - an analysis of historical and projected drought events; a summary of the available historical climate data and the latest future climate projections as sourced from Climate Services for Agriculture. This section includes a review of appropriate definition of drought for the region;
4. Economic impacts drought;
5. Environmental impacts of drought;
6. Social impacts of drought;
7. Impact of drought on Aboriginal Communities;
8. Impact of drought on regional water supplies;
9. Impact of drought on stakeholders Inland Great Southern – key findings;
10. Drought risk priority area mapping: a drought resilience priority areas map to guide investment in the region;
11. Drought vulnerability assessment: including different ways in which drought impact, resilience and vulnerability could be measured. In this section, we discuss how all the above information could be synthesised into standardised indices to enable

comparison with other regions and to allow for tracking change over time. We also present an index of drought vulnerability based on the data collected to generate the drought risk priority areas map;
12. Vulnerability index for the Inland Great Southern Region;
13. A review of transformative solutions for drought resilience;
14. A summary of the report, actionable results and way forward; and
15. List of technical reports from consultants who provided expertise into the drought vulnerability assessment.

4. National Research Insights

4.1 Policies & Plans

National drought policy in Australia has shifted from crisis management and financial assistance to preparedness, risk management and supporting the agricultural sector to become more self-reliant in dealing with the effects of drought. In the early 1970s, Australia fell into line with the global approach to drought which classified it as a natural disaster, and its response was to expand irrigation to prevent future drought. This opened the door for the provision of government financial support through the Commonwealth-State Natural Disaster Relief and Recovery Arrangements[21].

By 1989, these arrangements were discontinued, and a review of drought policy was undertaken by the Commonwealth. Findings revealed that financial assistance was ineffective and discouraged farmers from taking responsibility for managing and preparing for drought. This review recommended the development of a new national drought policy with a particular focus on self-reliance, which led to the 1992 National Drought Policy. This policy set out specific objectives around:

- self-reliance
- managing climate variability
- maintaining and protecting natural resources
- supporting the recovery of agriculture industries in a sustainable way.

Under this policy, the following assistance programs were introduced in 1997:

- exceptional Circumstances (EC) Interest Rate Subsidy;
- EC Relief Payment.

Policy review findings indicated that, to encourage self-reliance and sustainability, farmers should be given primary responsibility for managing drought risks. As a result, the EC assistance measures were ceased in 2012 and the WA Drought Pilot and Review (2010-12) was undertaken with the following seven elements:

- farm planning
- building farm businesses
- family support
- social support
- stronger rural communities
- farm exit support
- beyond farming

The Intergovernmental Agreement on National Drought Program Reform (IGA) 2013 introduced a new approach to drought planning, resilience and response with a focus on farm businesses preparing for drought rather than relying on government financial assistance. The 2013 Farm Assistance Package offered:

- access to concessional loans
- rural Financial Counselling Service
- Nationally consistent approach to debt mediation.

According to this agreement, the role of the Commonwealth government in terms of drought support includes:

- funding and delivery of the Farm Household Allowance (FHA)
- establishment of the Future Drought Fund (FDF)
- providing continued Farm Management Deposits Scheme[22].

The National Drought Agreement (NDA) 2018 was signed by the Council of Australian Governments (COAG) and is in place until 2024. This agreement supports the development of measures that encourage farming access to incentives that support farm business risk management. Under this agreement, the role of states and territories includes:

- encouraging the delivery and uptake of programs to improve farm businesses' skills and decision-making
- ensuring animal welfare and land management issues are managed during drought
- the Commonwealth, states and territories also have several shared roles and responsibilities
- drought preparedness, response and recovery programs
- capability building programs
- tools and technologies
- rural financial counselling services
- health and wellbeing support
- sharing relevant drought policy information
- making available drought assistance information
- contributing to the development of quality data
- having input into drought policy and programs.

Current context

Recent government policies have been developed with a focus on measures that foster preparedness, adaptation and self-reliance. The 2019 Drought Response, Resilience, and Preparedness Plan describes the Australian Government's strategies for helping farming communities prepare for and manage drought, with three key focus areas:

- immediate action for those in drought
- support for the wider communities affected by drought
- long term resilience and preparedness

4.2 Key Drought Actors Nationally

Some of the key actors in relation to drought in Australia are outlined in Table 1.

Table 1: Snapshot of National Drought Actors

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)	Focuses on understanding and measuring the effects of climate variability and change on agricultural industries with a focus on drought from the farmers' perspective.
Australian Centre for International Agricultural Research (ACIAR)	Fosters strategic partnerships with key research institutions to improve the productivity and sustainability of agricultural systems and the resilience of food systems in partner countries.
Australian Export Grains Innovation Centre (AEGIC)	An investment of the Australian Government through the Grains Research and Development Corporation and the WA Government through DPIRD, with the aim of increasing value in the Australian grains industry.
Australian Institute for Disaster Resilience	Develops, maintains and shares knowledge and learning to support disaster resilience in Australia.
Australian Institute of Family Studies (AIFS)	AIFS is the Australian Government's key research body in the area of family wellbeing. It's involved in research and provision of resources and publications relating to the effects of drought on families and communities.
Australian Research Council (ARC)	The ARC fosters excellence, partnerships and the highest ethical standards in research and research training in all fields of science, social sciences and the humanities.
Bureau of Meteorology (BoM)	The Bureau contributes to national social, economic, cultural and environmental goals by providing observational, meteorological, hydrological and oceanographic services and by undertaking research into science and environment related issues in support of its operations and services.
Centre for Australian Weather and Climate Research (CAWCR)	Established in 2007 - research partnership between CSIRO and the Bureau of Meteorology, focused on the Earth's climate system.
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Focus on broad megatrends, environmental resilience; farm resilience; forecasting and monitoring; smart agriculture; social and urban resilience.
Department of Agriculture, Water and the Environment (DAWE)	Supporting stewardship and sustainable management of Australia's environment and improving sustainable management of Australia's water resources for agriculture, the environment and communities.

Grains Research and Development Corporation (GRDC)	Involved in research and development to support Australian grain growers.
International Universities Climate Alliance (IUCA)	Represents the leading research universities in climate research with members from world-leading research institutions.
National Climate Change Adaptation Research Facility (NCCARF)	2008 – 2019 NCCARF - climate change adaptation publications, set up and supported national climate change adaptation networks, built a nation-wide website with countless resources of its own and held six national and international conferences.
National Drought and North Queensland Flood Response and Recovery Agency (NDNQFRRA)	Works hand-in-hand with communities, all levels of government, charities and agricultural organisations to support farmers and other rural and regional Australians living through the immediate and longer-term effects of drought and flood.
Natural Resource Management Regions Australia (NRMA)	Communicates with Australian Government Ministers (alongside other organisations) on behalf of all regional NRM bodies to help ensure that NRM policy is coordinated strategically and effectively.
Queensland Climate Change Centre of Excellence (QCCCE)	The only state-based climate science research centre in Australia.
Regional Development Australia (RDA)	The RDA network, shares information, and collaborates to develop innovations and solutions that can be adapted across the country.
Research and Adoption Innovation Hubs (RAIH)	Support farmers and communities to get ready for drought. They connect farmers with regional agricultural experts, innovation and new practices.
The Australian Research Council's Centre of Excellence for Climate System Science (CECSS)	International research consortium funded by the Australian Research Council and made up of five Australian universities and Partner Organisations with the aim of expanding on existing modelling of regional climates to improve adaptation to climate change.
The Future Farm Industries CRC (Cooperative Research Centre)	Took the place of the CRC for Plant-Based Management of Dryland Salinity (2001-2007) with a 7-year grant. Areas of expertise included farming systems research; research in crop and animal production; new industry development involving farm grown biomass; bio-energy and wood products, plant breeding; animal psychology; nutrition and behaviour.

Additional key actors involved in the national drought space include rural consultants, private consultants, farming and grower groups, and agribusiness companies[53]. Universities across Australia are also key players in drought related research (see appendices).

Australia's climate is changing with increases in temperatures, more frequent hot weather and variable rainfall patterns. Australian average temperatures have increased by about 1^{o} Celsius since 1950 and the South West and South East of Australia are seeing a trend towards lower average winter rainfall[23].

The impacts of this change are posing a major challenge for the agricultural industry in rural and regional Australia. Research on risk management in agriculture has grown significantly over the last two decades and has largely been focused on the agricultural and biological sciences, expertise around planning and prediction tools, environmental sciences (water management/sustainable agriculture, drought resistant crops), economics, econometrics and finance (e.g. farm planning).

Due to Australia's variable climate, the drought risk for farmers is high. In their report 'Measuring Drought Risk', Hughes et al identify regions with a high level of cropping activity and more variable climates as being at higher risk of drought. This includes New South Wales, Northern Victoria, South Australia Eyre Peninsula and the Western Australia North and Eastern Wheatbelt regions. Larger farms with greater profitability and a younger demographic of managers (less than 50 years old) have been found to be at a lower risk of drought[24].

Research shows that whilst Australian farmers are very competent in adapting to climate variability, there remains a number of challenges to be met. This will require the adoption of new and alternative methods of farming to support drought resilience[60].

4.3 National Adaptation Strategies

The literature shows that Australian farmers have a proven track record in adapting and responding to drought and are undertaking a range of measures to mitigate its effects. A recent survey by ABARES examined farm practices from a sample of 2,355 farms across all industries[25]. This survey looked at Natural Resource Management (NRM) and other farming practices, farm planning and management (drought resilience), along with awareness and participation in government programs.

The results showed that drought resilience was rated very high as a motivating factor for NRM practice. The highest rating occurred in the broadacre industry and engagement in NRM where evidence of drought practices was high[62]. Some of these practices include:

- retained stubble (84%)
- reduced reliance on pesticide and optimisation of fertiliser use (68%)
- minimising tillage or cultivation (65%).

In terms of drought resilience measures, Coelli found that the agricultural sector is engaging in measures that involve increased non-farm income, diversified agricultural activities and written farm plans with business objectives[62]. The survey showed that content and use of farm plans is promising, with more than 30% of farms having a written farm plan in place with identified business objectives.

Specific drought resilience practices included de-stocking early in low rainfall periods to preserve groundcover (68%), improving soil water retention (64%), and increasing fodder and grain storage (58%). However, the greatest barrier to changing farming practices was time, followed closely by funds[62].

According to the NRM Regions Australia[26], the level of farm resilience is dependent on what is being produced and other external factors like commodity prices and regional circumstances. They concluded that risk planning rather than drought planning was the stronger predictor of drought resilience, which includes consideration of all risks facing farms – not just drought. The research identified the following needs:

- helping farmers to plan for and manage risk
- control of feral animals
- improved water use efficiency
- supporting graziers to manage groundcover and build feed reserves.

While these adaptation measures go a long way towards mitigating drought risk, other risk transfer strategies are recommended going forward. In their publication, 'Creating Positive Synergies Between Risk Management Transfer to Accelerate Agricultural Climate Resilience', Mushtaq et al[27] emphasise the importance of combining adaptation strategies with risk transfer strategies. They recommend the following:

- investing in farmer climate adaptation rather than reactive disaster relief
- structuring government subsidies around insurance and climate disaster relief to encourage adaptation
- rewarding efforts towards adaptation by offering lower insurance premiums.

4.4 National Programs & Initiatives

National drought programs currently in place support preparedness and resilience or encourage re-examining operating models and risk management approaches. Underpinning most of this work is the government's $5 billion Future Drought Fund, supported by the Drought Resilience Funding Plan which includes:

- Drought Resilience Research and Adoption Program
- Farm Business Resilience Program
- Regional Drought Resilience Planning
- Climate Services for Agriculture
- Drought Resilience Self-Assessment Tool (DRSAT)
- Networks to Build Drought Resilience
- Drought Resilience Leaders
- NRM Drought Resilience
- Drought Resilient Agricultural Landscapes.

Key Federal government initiatives currently under development include:

- Drought Indicators
- Shared responsibilities in drought support
- Evaluation of farm management deposit scheme
- National Climate Resilience and Adaptation Strategy
- Australian Climate Service
- National Mental Health Reform
- CSIRO Drought Resilience Mission
- Communities combating pests and weed impacts during drought.

Science is playing a key and ongoing role in the collection, maintenance, distribution and analysis of climate data and is shifting towards developing science-based measures that

encourage adaptability and risk management[51]. At a general level, national science-based drought initiatives include:

- provision of training for strategic business planning and decision making
- methods of managing uncertainty
- delivery of climate data and methods to integrate into meaningful information
- increasing fodder and grain storage
- water use efficiency strategies.

More specifically, science is enabling the farming community to facilitate innovative on-farm strategies in drought risk management including:

- minimum tillage
- canopy management
- dry sowing
- drought-tolerant varieties and breeds
- climate sensitive stocking rate adjustment
- expansion of cropping into the previously higher rainfall zones.

The Australian Government Department of Agriculture, Water and the Environment (DAWE) administers a range of programs aligning with the three themes of the Drought Response, Resilience, and Preparedness Plan. Details of Australian government drought support measures are shown in the attached appendices.

4.5 Tools and Resources

The information presented in Table 2 is a selection of key drought related tools and resources available nationally.

Table 2: National Drought Related Tools and Resources

Agency websites	The government organisations involved in the delivery of the drought response each have a website with factsheets, links, guidelines, and other information about the programs they deliver.
Australian Climate Service (ACS) -Australian Government – BoM, Geoscience, Australia, CSIRO and ABS	Federally funded initiative that targets the emergency management sector with a focus on increasing customer understanding of threats posed by climate change and natural hazards to limit their impacts.
Australian Disaster Resilience Knowledge Hub (Australian Government National Recovery and Resilience Agency) (ADRKH)	A national, open-source platform that supports and informs policy, planning and decision making and good practice in disaster resilience. Links national guidelines with research, information source on historical Australian disasters. Managed by the Australian Institute for Disaster Resilience.
Australian Wool Innovation (AWO)	AWI has a range of drought planning, management and recovery resources available for woolgrowers going into, enduring and recovering from drought.

Climate Resilient Water Sources (BOM)	Provides detailed, plant scale data and information on public and privately owned and operated desalination and recycling plants across Australia.
Dairy Australia (DO)	Dairy Australia has comprehensive Feed Shortage campaign resources.
Drought Community Outreach Program (DCOP)	Provided by the National Recovery and Resilience Agency (RRA), in partnership with Rotary, this program offers one-stop-shop events that provide information and support to those dealing ongoing effects of drought - specifically, low interest loans, farm household allowance, on-farm emergency water infrastructure rebate scheme and Rotary household vouchers.
Drought Resilience Self-Assessment Tool (DRSAT)	An online self-assessment tool for farmers to self-identify drought risks based on a range of social, economic and environmental indicators, and take action to build the drought resilience of their farm business.
Meat and Livestock Australia (MLA)	MLA provides a comprehensive link to drought and support services from a national and state/territories perspective.
National Environmental Information Infrastructure (NEII)	An information platform designed to improve discovery, access and re-use of nationally significant environmental data.
Recover Support Officers (RSO)	Provided by the National Recover and Resiliency Agency (NRRA) to support those in drought affected communities.
Recovery Connect	A proposed recovery assistance locator application developed in collaboration with Services Australia to connect people with drought assistance available in their area.
Red Cross Drought Resilience Program (RCDRP)	Focuses on wellbeing and is led by communities themselves. Currently runs across NSW, Victoria, Queensland and South Australia. Offers workshops and training in psychological first aid, training in Farm First Aid, a mentor program, and practical assistance.
The Bureau of Meteorology (BoM)	Provides information on water resources to support policy and planning. Its Australian Water Resources Assessment, National Water Account and Urban National Performance Report provide information on surface water, groundwater and alternative water resources.

5. International Research Insights

Globally, drought resilience research makes up one third of all existing drought-related research and has been steadily increasing since 2008. While most of this research is coming from the United States of America (USA), China and Australia follow closely behind[28]. Some of the key actors in the international drought space are summarised in Table 3:

Table 3: Drought Actors in the International Space

Columbia Climate School: The International Research Institute for Climate and Society (IRICS)	Works with global partners to develop strategic and applied research, education, and capacity building in relation to effectively managing climate impacts.
International Centre for Agricultural Research in the Dry Areas (ICARDA)	Undertakes research to support innovative, science based agricultural solutions involving climate smart crops, resilient crop livestock systems, sustainable land, soil and water management.
International Water Association (IWA)	The international reference for the water and sanitation industry, comprised of a network of water professionals from over 140 countries including scientists, researchers, technology companies and water and wastewater utilities.
The Food and Agriculture Organisation of the United Nations (FAOUN)	Specialised agency of the UN which works with over 130 countries around the world to address issues around food security and hunger.
The Global Water Partnership (GWP)	International network with over 3,000 partner organisations in 179 countries with a focus on improving water management at a global, regional, national and local level.
The Intergovernmental Panel on Climate Change (IPCC)	The UN's body for assessing the science related to climate change.
The National Drought Mitigation Centre in Nebraska, USA (NDMC)	Capabilities include climatology, social science and public engagement.
The World Meteorological Organisation (WMO)	Provides essential weather and climate information internationally.
United Nations Convention to Combat Desertification (UNCCD)	Focus areas include land and drought, land and biodiversity, land and climate, land and sustainable development goals, and land and youth.
World Health Organisation (WHO)	Works with partners to respond to drought-related disasters.

According to the World Economic forum, water shortage is one of the greatest risks facing the globe in the next 10 years, with four billion people in Africa, Asia and Latin America facing severe shortages of water and drought.

Drought hazard/exposure is highest in regions with a high density of irrigated land and high irrigation water requirements such as the western part of USA, central Asia, northern India, northern China and southern Australia.

A significant number of scientific studies have been undertaken internationally to examine how the characteristics and impacts of droughts will evolve into the future. These show that droughts are likely to increase in severity over time, along with increased human demands for water.

To help mitigate drought risk, drought monitors that track and forecast drought have been developed by a range of government agencies and institutes around the globe. This information allows governments to undertake preventive measures, while also providing information to the public on existing conditions.

Examples of these include the Princeton Flood and Drought Monitors for Latin America and Africa, the U.S. Drought Monitor and the European Drought Observatory. he Australian Combined Drought Indicator (CDI) is a scaled down version of the US Drought Monitor and uses four selected drought indicators[29] which are described in more detail in the table summary for National Drought Initiatives later in this report.

Improving monitoring and forecasting is an important and viable short-term solution that supports increased preparedness. However, a greater understanding of human impacts on the water cycle is needed and is currently an area of growing interest needing further study.

A common theme in the literature is also the importance of responding to drought by improving water management efficiencies including irrigation systems, sewage systems for rainwater wastewater usage and cultivating crops with low water demand.

5.1 Policies & Plans

From an international perspective, the literature shows that the crisis management policy approach which has been commonly used across the globe is ineffective. Research from the National Drought Mitigation Centre (NDMC) in Nebraska USA, a key player in the international drought research space, shows that there has been a global shift away from reacting to drought, to developing proactive risk management strategies that create resilience to drought. This requires looking at past trends, future projections, and analysing exposure and vulnerability[81].

International policy drivers include costs/impacts of drought, far reaching impacts into other sectors, increase in social and environmental effects and competing demands for limited water resources. However, it appears that the lack of a universal definition of drought and challenges around classifying severity means preparedness and policy development have been slow[81].

To support the shift towards proactive risk mitigation, the United Nations Convention to Combat Desertification is supporting "…proactive, coordinated and holistic drought risk management" based on three key pillars:

- early warning and monitoring systems
- vulnerability and impact assessment
- drought risk mitigation measures.[30]

5.2 Programs & Resources

Most of the drought initiatives around the world are centred around mitigation, preparedness and planning. Evidenced in the literature is Australia's recognition of a global collaborative approach to addressing climate change and it is involved with the international community in supporting climate adaptation. A summary of international drought programs and resources is included in Appendix 3. Three international initiatives in which the Australian government is involved include:

- member of the global Adaptation Action Coalition (AAC) – practical climate adaptation strategies that deliver on ground support for vulnerable communities;
- member of the Coalition for Climate Resilient Investment (CCRI) as an observer member;
- contributor to Paris Conference initiatives including $5 million over four years (2016-2020) to the Climate Risk and Early Warning System (CREWS) initiative[31].

6. State and Regional Research Insights

6.1 Overview of WA State Government Policies & Plans

Drought assistance measures in WA are guided by the Australian Government's drought policy and (guided by The National Drought Policy 1992 and the Intergovernmental Agreement on Drought Reform (IGA)). The WA Government's policy decisions focus on improving preparedness through business training, risk management tools and improved social support for farm families[32]. Specific assistance measures in WA currently include:

- farm household payments
- farm finance concessional loans
- support for farm business training
- rural financial counselling
- access to farm management deposits
- funding for social support.

The WA Natural Resource Management Framework was developed in 2018 and focuses on partnerships that protect and manage WA's natural resources. It has six key priorities for coordinating NRM in WA[33]:

- sustainable management of land resources;
- maintain and enhance water assets;
- protect and enhance the marine and coastal environment;
- conserve and recover biodiversity;
- enhance skills, capability and engagement; and
- deliver high quality planning that leads to effective action.

WA's drought assistance measures have also been developed within the context of the Pilot of Drought Reform Measures - a project undertaken in partnership with the Australian Government.

In 2020, the WA government developed its Climate Policy which outlines the government's commitment to climate change adaptation and achieving zero greenhouse gas emissions by 2050. The following key climate resilience initiatives are identified as part of this policy:

- Climate Resilience Action Plan 2022-25
- Climate Science Initiative
- Climate Risk Framework
- Pilot Sectoral Adaptation Plan

The Climate Science Initiative is aimed at understanding how future global emissions will affect WA's climate. As part of this initiative, climate projections will be provided along with communications material that support agribusinesses and government.

Regional Planning and Infrastructure Frameworks (RPIFs) have also been developed for each of WA's regions. They identify each region's vision and provide an important foundation for future decision making, outlining key planning initiatives for each region.

These frameworks have been developed through a partnership between the WA Planning Commission (WAPC), Regional Development Commissions (RDCs), Regional Development Australia (RDA) and local governments and are important in the context of future drought resilience planning and identifying key issues associated with climate change and variability. Inland Great Southern Initiatives, Plans and Priorities.

The RPIFs have been developed for each of WA's regions. They identify each region's vision and provide an important foundation for future decision making, outlining key planning initiatives for each region.

The RPIFs were developed through a partnership between the WAPC, RDCs, RDA and local governments and are important in the context of future drought resilience planning, identifying key issues associated with climate change and variability. The Great Southern Development Commission's Strategic Plan 2022-2025 identifies the following strategic themes that are relevant to drought resilience:

- grow existing, and find and develop new regional industries
- enhance and normalise regional living standards
- build strong, inclusive communities and normalise Aboriginal economic development.

The Regional Investment Blueprint 2015 for the Great Southern outlines four regional imperatives that are fundamental to the region's economic and social development, growth and prosperity. This includes economic growth and diversification; essential infrastructure and services; knowledge and innovation; and community and environment.

The Blueprint outlines that the region needs more sustainable and reliable water supplies and improved water management. It also acknowledges that climate change is expected to have an impact on the water available for dryland agriculture.

The South West Native Title Settlement has been described as the most comprehensive Native Title Agreement negotiated in Australian history and involves around 30,000 Noongar people covering approximately 200,000 square kilometres of the South West region.

It recognises the Noongar people as the Traditional Owners of the region and will allow for a range of Noongar-held land assets, including further arrangements for access to and co-management of Crown land with the WA Government. A Noongar governance structure will operate with high level accountability and transparency to deliver the major assets provided through the Settlement, with six Noongar Regional Corporations to be established.

The WA Natural Resource Management (NRM) Framework[34] focuses on partnerships that protect and manage WA's natural resources, contributing to improved drought resilience in regional and remote areas. The framework outlines six natural resource management

priorities, namely sustainable management of land resources, maintaining and enhancing water assets, protecting and enhancing the marine and coastal environment, conserving and recovering biodiversity, enhancing skills, capability and engagement and delivering high quality planning that leads to effective action.

The regional NRM Strategy for the South Coast Region – Southern Prospects, emphasises the importance of continued efforts in 'developing capacity, new knowledge and provision of technical advice and support to landowners'. It recommends total farm planning, including soil management planning, as a valuable means of supporting farm sustainability and points out that this has not been taken up on a large scale yet [35].

SCNRM prepared a series of background papers and reports as part of the 2016 Climate Adaptation Addendum to Southern Prospects 2011-2016. These detailed potential impacts of climate change and what adaptations are being made, noted in particular challenges noted identified by Rees[36] include:

- identifying and securing future public water sources – availability of water in the region is fundamental in order to support the increase in diversity and resilience of agricultural and forestry land management systems;
- smaller towns rely on harvested surface water (bitumen or road catchments) and may require cartage of water during dry season;
- water repellence – high risk to agriculture (mostly stable);
- water use efficiency is a major issue for broadacre farms; and
- vulnerability of cropping income to dry seasons and increasing frequency of dry seasons.

> *"The challenge for the whole region is to provide water for people and the environment in an even drier climate, with an increased population and with less environmental impact."* [37]

Key adaptation measures identified by SCNRM include:

- improving the resilience of the farm system;
- creating value-add industries or farm products;
- ensuring existing risks of groundwater, salinity and soil health continue to be manage;
- better water balance using management options for containment, adaptation or restoration of hydrological systems in priority catchments;
- reducing threats from declared pest plants and animal species and diseases;
- use of best-management practices that improve soil health;
- ensuring primary production systems and practices are appropriately matched to land capability;
- increasing the range of commercial land use options;
- value-adding opportunities that enhance the financial capacity of farmers;
- potential for perennial vegetation in relation to carbon farming and sequestration;
- improved understanding of data regarding water resource systems to support sound water planning[38].

The region has highly valued grower groups who are actively involved in activities that support the production, profitability and sustainability of their members through farmer-led collaboration, participatory research and peer to peer learning.

The Shires of Broomehill -Tambellup, Cranbrook, Gnowangerup, Katanning and Kojonup are in the Southern Link Voluntary Regional Organisation of Councils (VROC). VROC's focus is building advocacy strength as a sub-regional bloc and in their current strategic plan they state that their vision is aligned with the current directions of the GSDC207. An increased focus on water security is one of seven critical trends VROC outline for 2021-2024 and one of six priority projects is development of a Regional Water Security Strategy with "institutional support (e.g., DWER, Water Corp, DFES, DPIRD)"[39].

The Integrated Planning and Reporting framework and Guidelines were introduced in Western Australia as part of the State Government's *Local Government Reform Program.* Integrated planning and reporting give local governments a framework for establishing local priorities and to link this information to operational functions. All local governments are required to produce a plan for the future under S5.56 (1) of the *Local Government Act 1995*.

Adopting Integrated Planning is potentially the most important performance improvement initiative available to local governments. A successful integrated planning process will deliver the following outcomes:

A Strategic Community Plan which is a 10+ year time frame reviewed every four years that clearly links the community's aspirations with the Council's vision and long-term strategy. A Corporate Business Plan integrates resourcing plans and specific Council plans with the Strategic Community Plan. This is reviewed annually to deliver the Annual Budget. A clearly stated vision for the future viability of the local government area. A summary of the LGA strategic plans is provided below.

The Shire of Broomehill-Tambellup has a Strategic Community Plan 2018 – 2028. This includes three broad outcomes:

1. To have a cohesive, diverse and inclusive community supported by quality services and facilities;
2. To maintain an environment in the towns and rural areas of the Shire that is conducive to tourism, business and population retention and growth;
3. To have appealing town centres and surrounding rural areas that reflect their unique history and culture, connected by quality transport infrastructure and well managed natural environments.

The Shire of Cranbrook has a strategic Community Plan 2021 – 2031. It includes two pillars – Live (community, utilities, health and priority amenities) and Work (business engagement, stimulated economy, enabled economy and business attraction).

The Shire of Gnowangerup has an Integrated Strategic Plan which incorporates the Strategic Community Plan 2021 – 2031 and the Corporate Business Plan 2021 – 2025. The Shire vision is "A progressive, inclusive and prosperous community built on opportunity". The five key themes include community, economy, infrastructure, natural environment and our organisation.

The Shire of Jerramungup the Shire's Local Planning Strategy was updated in 2018 and aims to provide general planning direction for the Shire of Jerramungup for the next 30 years. The Council generally supports rural diversification into other rural or related ventures, but the Shire's prime consideration is continued protection of traditional agriculture as the main industry in the area, and ongoing support for farming[40].

The Shire of Katanning has a Local Planning Strategy, endorsed by the WAPC in 2013. The Katanning SuperTown Growth and Implementation Plan comprises Part 2. As the population centre, the Katanning townsite is the focus of the Scheme however a specific aim for the Shire

is to 'protect rural land for agricultural production and provide for a broad range of rural and ancillary land use opportunities'[41]. The Strategic Community Plan 2017 – 2027 outlines the vision for the Shire and identifies community priorities in five key areas including economic, natural environment, build environment, social and leadership.

The Shire of Kent Strategic Community Plan 2017 – 2027 includes a mission to provide leadership, direction and opportunities for the community.

The Shire of Kojonup Strategic Plan "Kojonup 2027+ Smart Possibilities", was developed with the input of around 200 residents. The vision is: "Kojonup is a smart region featuring a technologically advanced agricultural community, an educational and historical destination, and a healthy and enviable lifestyle"[42]. The Plan runs from 2017-2027 and was due for minor review in 2019 and major review in 2021.

The Shire of Woodanilling Strategic Community Plan 2012 – 2022 includes themes and objectives including social (community facilities and community wellbeing), environment, civic leadership and economic (roads and transport).

6.2 Key WA Drought Response Actors & Initiatives

There are a wide range of government departments and agencies, university institutions and private organisations involved in the WA drought space at a State and regional level and these are provided in greater detail in the attached appendices.

6.3 DPIRD Tools & Resources

The WA Department of Primary Industries and Regional Development (DPIRD) plays a key role in providing essential drought related services and support in Western Australia and provides the following tools and resources, presented in Table 4 below:

Table 4: DPIRD Tools and Resources (not an exhaustive list)

Extreme weather events tool	Uses weather station data to map areas where possible frost or heat stress has occurred within critical growing periods.
FarmHub	Connects Australian farmers with services and support
National Drought Map	Provides access to spatial data from Australian government agencies.
Plant available soil water app	Graphs rainfall from the start of summer through the grain growing season
Potential yield tool	Calculates potential wheat yield to location.
Rainfall to date tool	Graphs and data for grain belt weather stations.
Seasonal weather information	Includes rainfall forecasts, plant available soil moisture maps, potential yield calculator and frost risk maps.

Seasonal weather outlook newsletter	Produced each month.
Weather stations	Real-time data from more than 170 weather stations around the state
Farm business training	Free call for targeted training to improve business management
Farm Debt Mediation	Assists farm and pastoral businesses and financial institutions resolve disputes about business financial arrangements.
Farm Household Allowance	Free call number for household support payment from the Australian Government.
Regional Men's Health Initiative	Focus is on raising awareness of men's wellbeing and health.
Rural West	Free call for free financial counselling services
Support directory	Covering: ● recovery after fire on rural properties ● 24-hour crisis counselling support ● family counselling support ● ancillary services – youth, drugs, mental health ● financial services ● general health ● information services ● water support services ● emergency contacts.

7. The Inland Great Southern Region

The 2021-2022 foundation year of the RDRP program is being piloted in the Great Southern, Mid-West and Wheatbelt regions of WA. Figure 5 presents the geographic scope of the Future Drought Fund Regional Drought Resilience Planning Program in Australia during the foundation year.

Together, the three pilot regions cover over 82,000 km^2 of WA's grain belt, the largest agricultural producing area in WA and a key contributor to the State economy. In addition to large scale broadacre cropping and livestock production, these regions support a diverse range of other primary production activities, with small and medium businesses servicing agricultural and mining, with government and population services prevalent in larger population centres.

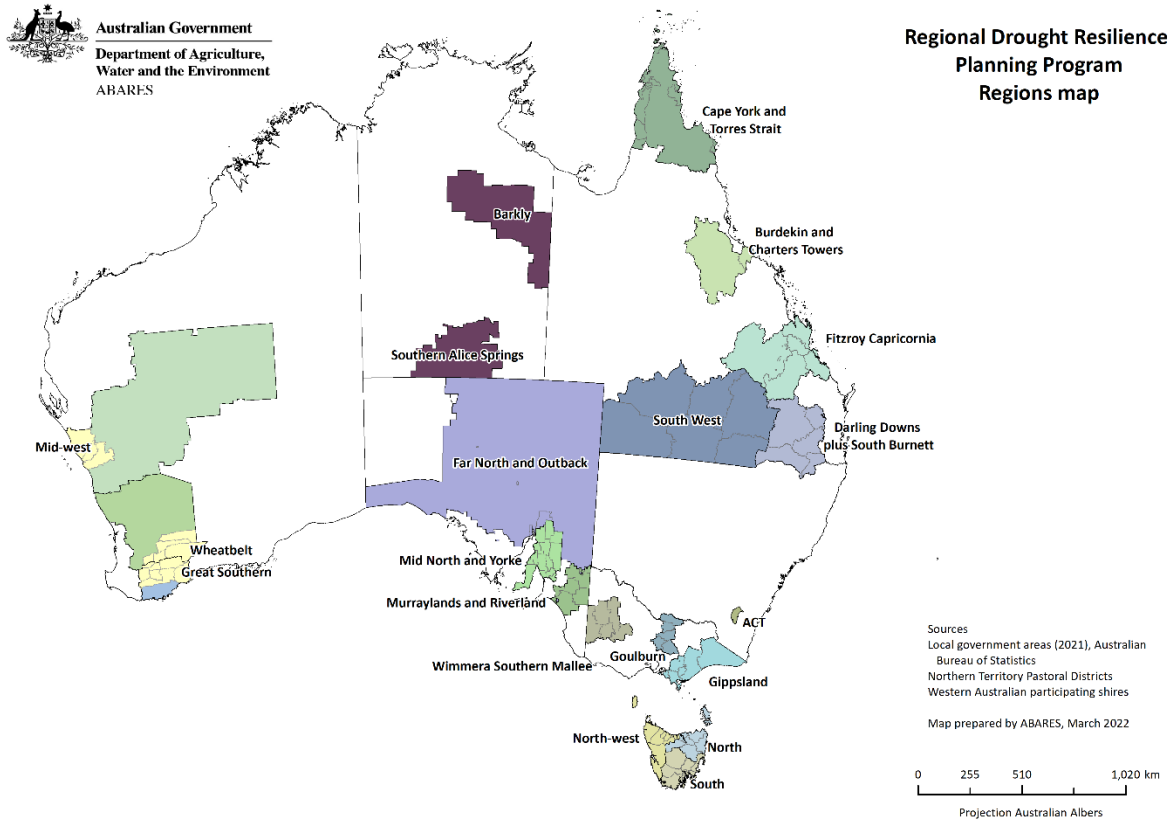


Figure 5 Map Showing the geographic scope of the Future Drought Fund Regional Drought Resilience Planning Program in Australia during the foundation year

The three pilot regions all fall within the Bureau of Meteorology's South West Land Division forecasting area. The South West Land Division is amongst the regions most impacted by climate change in Australia, experiencing consistent reduction in rainfall over the last several decades. Rainfall in South West WA continues to decline with projections showing a further decrease in annual rainfall of up to 15% by 2030.

7.1 Regional Overview

The Great Southern Inland Consortia covers an area of 27,871 km^2 in the Great Southern region of Western Australia and includes the Shires of Broomehill-Tambellup, Cranbrook, Gnowangerup, Jerramungup, Katanning, Kent, Kojonup and Woodanilling (Figure 6).

The region is home to 11,324 people. Key characteristics of the Inland Great Southern region include:

- largest population is in the Shire of Katanning, which is the regional key centre for the Inland Great Southern;
- all areas have a median age above the WA median, with the largest variance in Cranbrook;
- all areas had negative in-migration between 2017-2020;
- Shires of Broomehill-Tambellup and Katanning have more disadvantage than greater regional WA;
- Shires of Jerramungup and Kent have more advantage than both greater regional WA and greater WA;

- Shires of Broomehill-Tambellup, Cranbrook, Jerramungup, Kent and Kojonup Agriculture accounts for 50% or more of economic output.

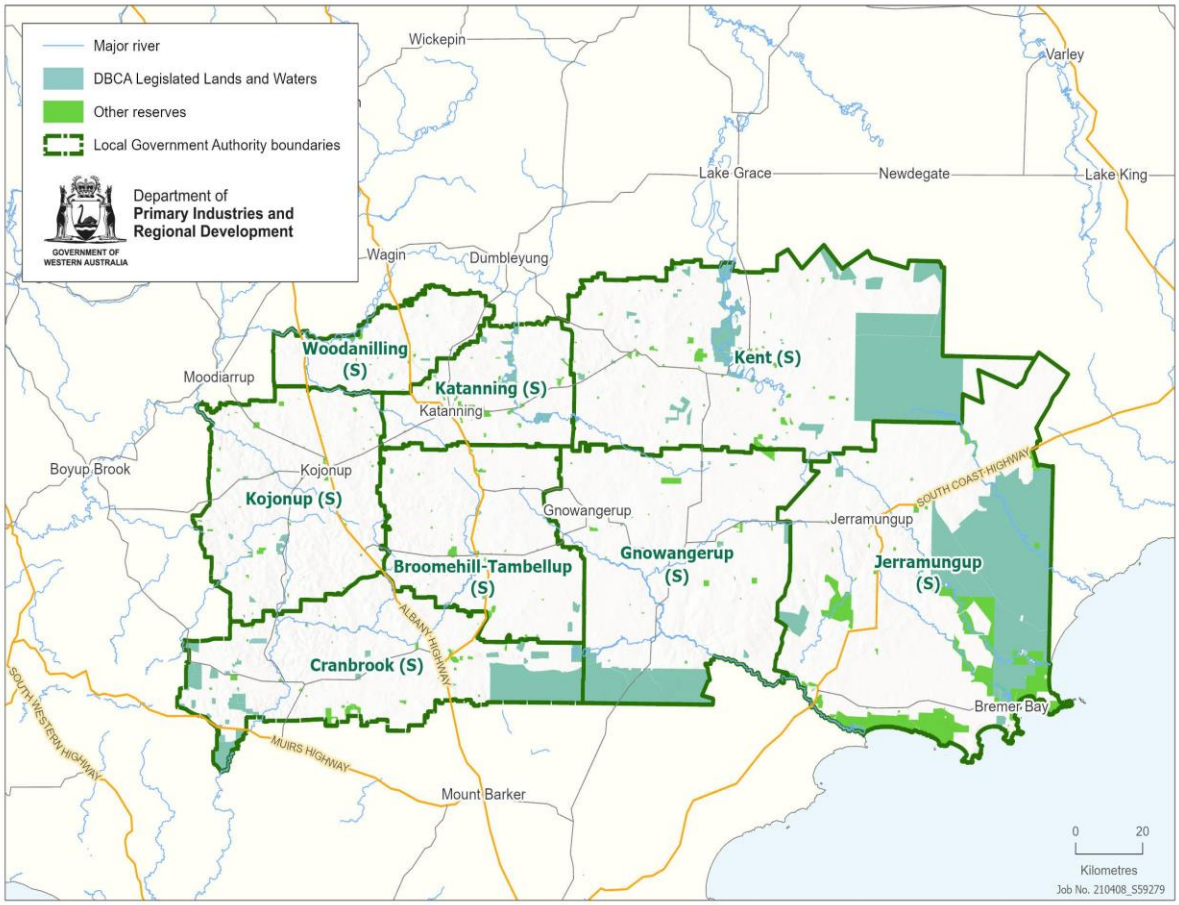


Figure 6 Map showing the geographic scope of the Regional Drought Resilience Plan in the Inland Great Southern

A snapshot of the combined Consortia and each local government area is summarised in the following table.

Table 5: A snapshot summary of the combined consortia and each local government area

Shire	Area (km^2)	Population	Median Age	SEIFA	DOTE	Annual Economic Output	Agri-culture	Agri-culture
Measure	(km^2)	ERP 2020	Years	(greater regional WA 965; WA 1,015	Index Score	$M	% of Economic Output	% of Jobs
Broomehill-Tambellup	2,609	1,088	39	950	2	$137M	65.2%	66.1%
Cranbrook	3,276	1,044	46	972	3	$222.2M	53.4%	60.6%
Gnowangerup	4,266	1,200	40	990	3	$258.2M	45.3%	46.6%
Jerramungup	6,507	1,045	41	1,017	3	$235.6M	57.9%	60.0%
Katanning	1,518	4,046	40	907	1	$717.5M	12.8%	12.6%
Kent	5,630	559	39	1,046	2	$102.7M	75.6%	74.6%
Kojonup	2,937	1,912	44	991	1	$357.5M	49.9%	48.6%
Woodaniling	1,128	430	43	1,005	1	$82.4M	46.7%	57.5%
Total	**27,871**	**11,324**	**-**	**-**	**1-3**	**$2,100M**	**40.1%**	**40.9%**

7.1.1 History, Geography and Climate

The Consortia is within the Wagyl Kaip / Southern Noongar (Ganeang, Goreng and Minang) Agreement for Native Title[43] and the northern section is Ballardong Noongar[44], both in the South West Native Title Settlement. The Wagyl Kaip / Southern Noongar Corporation recently elected its inaugural Board of Directors and cultural advice committee.

In the revised Köppen Climate Classification System all areas are in temperate (Mediterranean)[45]. As part of the Southern and South Western Flatlands West sub-cluster, projections are for average temperatures to continue to increase in all seasons, more hot days and warm spells, a continuing reduction in rainfall and a significant reduction in cool season (April – October) rainfall, increased extreme rainfall events, mean sea level rise and a harsher fire-weather climate.

7.1.2 Agricultural Production and Land Use

Agriculture output accounts for around $870 million or 40.1% of economic output in the Consortia. The Shire of Kojonup had the largest output from Agriculture at $178.5 million, while the Shire of Kent had the largest percentage of total economic output at 75.6% attributable to agriculture, followed by Shire of Broomehill-Tambellup at 65.2%.

Broadacre crops (wheat for grain) are the largest crop by value, accounting for around 75% of gross value in each Shire except Broomehill-Tambellup and Cranbrook, where broadacre accounts for 44% of output. In the Great Southern Region, mixed farming enterprises are typical.

The average crop percentage has increased, and sheep numbers have declined since the peak in the late 80's, mostly due to the collapse of the wool industry in the 1990's in addition to improvement in technology and productivity for the cropping enterprise. A significant trend in the Great Southern is the increase in the area planted for canola[46].

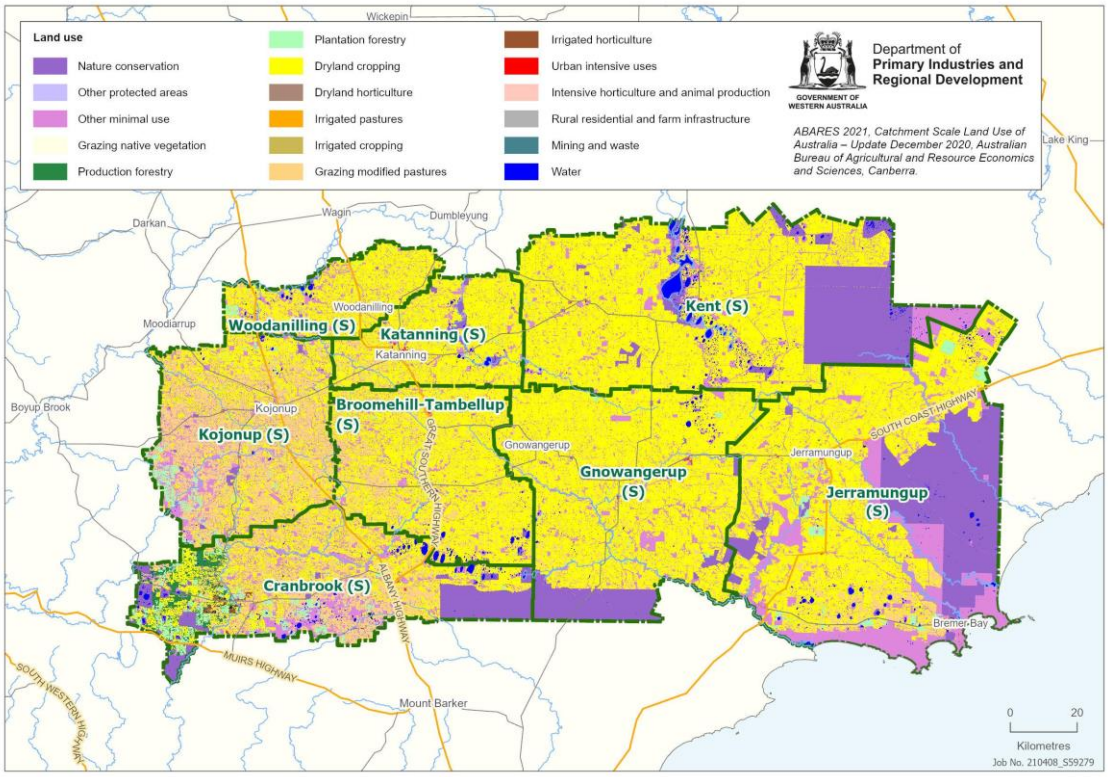


Figure 7 Land Use in the Inland Great Southern

7.1.3 Population and Social Determinants

The Great Southern Inland Consortia is home to 11,324 people. The median age is highest in the Shire of Cranbrook at 46, all above the WA median of 36. Between 2017 and 2019, all local government areas in the Consortia had negative in-migration.

Key social determinants for health and wellbeing are socioeconomic position, early life circumstances, social exclusion, social capital, employment and work, housing, and the residential environment[47]. Between one third and one half of the differences in life expectancy are considered to be explained by differences in the social determinants of health. In the Great Southern region the last available figures show an average wait time of 85 weeks for public housing, with 514 people on the waitlist.

The IRSAD SEIFA score, which measures both advantage and disadvantage, gives the local government areas in the Consortia differing scores. The Shires of Broomehill-Tambellup and Katanning have more disadvantage than greater regional WA. The Shires of Jerramungup and Kent have more advantage than both greater regional WA and greater WA.

The Index of Disadvantage DOTE gives a score by SA2 area. The Consortia covers three SA2 areas: Katanning SA2 (Katanning, Woodanilling) had an overall score of 1 (highest disadvantage); Kojonup SA2 (Kojonup, Broomehill-Tambellup, Cranbrook) had an overall score of 2; Gnowangerup (Gnowangerup, Jerramungup, Kent) had an overall score of three.

Common areas of vulnerability across all three SA2 areas are: no post-school qualification, family violence, psychiatric admissions and no access to recreation parks. Variations between the areas discussed within each local government below.

Within the Consortia region, Katanning and Tambellup are considered locations of priority health need in the Great Southern, based on analysis of social determinants, health indicators, service gaps and stakeholder feedback.

7.1.4 Services and Accessibility

Hospitals and GPs in the Consortia are located in Kojonup, Katanning, Tambellup, Gnowangerup and Jerramungup.[48]. The WA Primary Health Alliance note that health services in the region are concentrated in more populated centres, particularly the regional city of Albany, with 77% of registered GPs in Albany. Those living remotely have long distances to travel to access regional health services.

In 2009-2010, the rates of mental health care plans developed by GPs under the Better Access program were less than one half of the State rate (6,722 per 100,000 persons) in: Gnowangerup, Woodanilling, Jerramungup, Cranbrook, Katanning and Kojonup.

WACHS implemented the Southern Inland Health Initiative (SIHI) to address high rates of acute medical admissions, high health needs in the population and an ageing population. The percentage of older people (over 65 years) is projected to increase from 18.8% to 22.3% between 2015 and 2025 in the region. SIHI implemented programs that supported primary and community care, including implementing telehealth and emergency telehealth.

State Government priorities for the freight network in the Great Southern region are road infrastructure investments to manage the greater Albany area's increasing freight circulation task, improve port access and renew the region's ageing arterial roads[49].

7.1.5 Economy and Employment

There are 1,124 agriculture, forestry and fishing businesses in the Great Southern LGA pilot region. No mining businesses or public administration and safety businesses exist. Rental, hiring and real estate businesses are more frequent than other businesses besides agriculture and most of them have a turnover less than$2 million and 61% less than $200,000. It seems likely that many of these are individual investors with rental properties not necessarily within the regional location.

Katanning has a higher level of diversity in comparison to the other LGA's with a higher number of businesses besides agriculture. This is understandable given Katanning is a regional centre that services the surrounding areas.

There are some large and significant businesses located in its town including an abattoir, WA Meat Marketing Cooperative (WAMMCO), several machinery dealers like Macintosh & Son

with the largest parts warehouse in Australia. There are six agriculture, forestry and fishing businesses with a turnover greater than $10 million. Other business sectors with turnovers greater than $10 million include Manufacturing (6), Construction (3), Wholesale trade (3) Retail trade (6).

Kojonup has the greatest number of businesses (108) in the agriculture, forestry and fishing businesses with a turnover less than $200,000. They are likely to be agriculture businesses and most likely farms or contract servicing businesses. The other LGA's with agriculture businesses with a turnover less than $200,000 are Cranbrook 56, Gnowangerup 54, Broomehill-Tambellup 36, Jerramungup 41, Katanning 51, Woodanilling 45 and Kent 24.

Three agriculture businesses with turnover more than $10 million are situated in Gnowangerup and three are in Kojonup. The 23 agriculture businesses with a turnover greater than $5million are situated in Gnowangerup (5), Kent (5), Jerramungup (3), Kojonup (4), Woodanilling (3), and Cranbrook (3). There are 190 businesses in total with a turnover of between $200,000 and $2million.

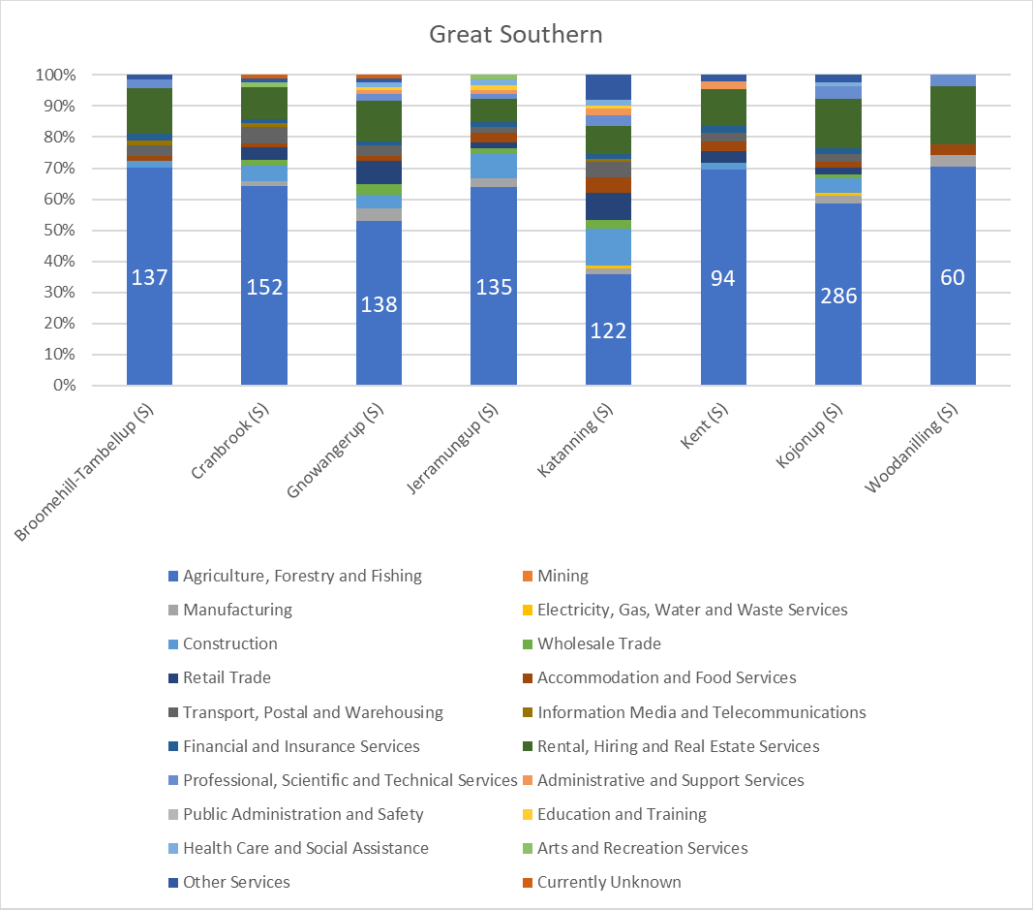


Figure 8 Total number of businesses by type for the selected pilot LGA's for the Great Southern

Tables 6 and 7 present the Gross Value of Agriculture Production for the Consortia. Wheat is the highest value product with Barley and Canola also dominating the farming system. Generally, for these LGA's they have mixed farming systems with livestock products, mostly wool and animal sales. Sheep and lamb sales are the dominant product but there are some cattle and calves in the Great Southern.

Table 6 GVAP for Jerramungup, Kent, Cranbrook and Gnowangerup

	Jerramungup	Kent	Gnowangerup	Cranbrook
Total GVAP ($)	**171,053,626**	**160,709,792**	**111,267,952**	**17,911,388**
Wheat	60,605,294	56,300,725	39,038,087	16,636,086
Barley	35,994,526	33,680,445	23,353,520	14,015,754
Canola	26,150,515	23,693,450	16,428,687	6,955,399
Livestock slaughtered - Total	18,624,153	18,425,903	12,776,247	2,785,791
Livestock products – wool & eggs	18,615,515	17,923,705	12,428,031	2,485,864
Oats	3,841,684	3,828,710	2,654,771	767,678
Lupins	3,228,682	3,267,535	2,265,660	299,741
Hay - Total	2,482,399	2,399,770	1,663,965	234,781
Other pulses	797,377	611,671	424,124	56,400
All other broad acre crops	240,433	239,973	562	37,610
Chickpeas	227,192	223,665	155,086	25,791
Other Oil seeds	72,332			1,590
Faba beans	56,682	35,060	24,310	
Triticale	54,980	36,313	25,179	62,213,871
Sorghum	43,338	42,867	29,723	
Nurseries	17,720			
Lentils	804			

Table 7 GVAP for Kojonup, Broomehill-Tambellup, Katanning and Woodanilling

	Kojonup	Broomehill-Tambellup	Katanning	Woodanilling
Wheat	17,418,785	15,511,009	9,134,064	6,788,062
Canola	16,178,556	14,406,615	6,740,031	5,008,915
Barley	13,630,289	12,137,445	5,016,744	3,728,239
Oats	6,764,110	6,023,278	2,590,035	1,924,808
Fruit and nuts - Total	2,709,175	2,412,294		
Hay - Total	2,417,497	2,152,723	1,334,623	991,837
Lupins	746,565	664,798	527,696	392,162
Other pulses	291,498	259,572	21,054	15,647
All other	228,324	203,317		
Faba beans	54,848	48,841		
Triticale	36,575	32,569		
Other oilseeds	25,081	22,334		
Lentils	1,546	1,377		
All other cereals	19	17		
Total GVAP crops	60,502,870	53,876,190	25,364,249	18,849,670

There are 2,824 jobs in the Consortia, 9.5% of employment in the broader Great Southern Region. Agriculture, forestry and fishing is the largest employer with 1,261 jobs which represents 40.9% of total jobs in the selected areas.

The Shire with the largest proportion of jobs in Agriculture is the Shire of Kent with 74.6%, followed by Shire of Broomehill-Tambellup with 66.1%. The Consortia area had an economic output of $2.1 billion and the agriculture, forestry and fishing sector had the largest percentage of output with 40.1% of total output.

Within the Consortia region, Katanning and Tambellup are considered locations of priority health need in the Great Southern, based on analysis of social determinants, health indicators, service gaps and stakeholder feedback.

The region had scores from 2-3, indicating high disadvantage and highlighting areas of vulnerability across the area including low family incomes, no internet at home, juvenile convictions, prison admissions, air quality and heat vulnerability (days over 38 degrees)

The full report on the population demographics, drought risk characteristics and strategic priorities for each participating local government authority can be provided on request.

8. Defining Drought

Defining drought is an ongoing challenge globally due to the lack of a universally agreed definition. This is due to the complexities around measurement, its relatively slow onset, the different types of droughts, and variabilities in geographical contexts.

Definitions of drought are restricted to the Western Australian South West Land Division as rainfall patterns and requirements for the WA rangelands and tropical north are markedly different from those of the focus regions for the RDRP Program.

The term 'drought' refers to a prolonged, abnormally dry period when the amount of available water is insufficient to meet our normal use[50,51,52]. It is not simply about low rainfall but refers to how conditions in a given season or year compare to normal conditions[53]. Meteorological definitions focus on rainfall deficiencies, or shortages, compared to average rainfall over a preceding period.

In Western Australia to date, rainfall deficiencies have been determined by comparing annual rainfall over a given year or two with the average annual rainfall[54]. Given the importance of growing season rainfall in April to October for grain production in the region, we proposed meteorological definitions of drought focused on total rainfall in the April to October growing season:

- Drought year: total rainfall (mm) during the April to October growing season is in decile 1 (the lowest 10%);
- Severe drought: total rainfall (mm) during the April to October growing season is in decile 1 for two or more consecutive years; and
- Hot drought: total rainfall (mm) during the April to October growing season is in decile 1 AND daily maximum air temperatures during the August to November maturing season are in decile 9 (the hottest 10%).

Declining rainfall in the grain belt has resulted in a westward shift in rainfall zones by up to 100 kilometres in some areas[55].

According to the above definitions, drought years occurred in the Great Southern in 1980, 2000, 2002, 2006, 2010, 2012, 2015, 2018, 2019, with no incidence of severe drought.

Meteorological definitions of drought are useful because they are readily quantifiable and lend themselves well to analyses of historical climate trends and future climate projections.

A drought is also defined in terms of its impact on primary production, surface and groundwater levels and regional communities[21,56,57,58]. The following expanded definition of drought was used for overall communications and analyses in the drought resilience plans:

"The term drought refers to a prolonged period of abnormally dry conditions that impact negatively on water availability and agricultural production in a region and, consequently, impacts negatively on the economy and environment of the region and the health and well-being of its residents."

9. Redefining Drought for WA

The way that drought is defined has implications for drought policy and, therefore, important consequences for Australian farmers[59]. The need for a regionally-appropriate definition of drought was raised frequently during stakeholder consultation for this project. Curtin University's Centre for Crop and Disease Management was commissioned to compare different definitions of meteorological drought, based on seasonal versus annual rainfall percentiles, and identify which approach to defining drought is most appropriate for the wheat-producing areas of South West WA.

While other methods such as remote sensing are gaining popularity for monitoring drought[60], rainfall percentiles are widely used in Australia[61,62] and have been adopted by the Australian Bureau of Meteorology, as well as state and federal government agencies, to inform decision-making around drought support programs[75].

Meteorological definitions of drought based on rainfall percentiles were therefore considered suitable for the analyses presented here. Consultation with farmers and agribusiness indicated that growing season rainfall was most important for their regions, and that most farm businesses are set up to withstand only a single dry season.

It was noted that two or more consecutive dry seasons can have severe consequences for their lives and livelihoods, with hot droughts identified an emerging threat with potentially serious consequences[63,64]. This feedback was incorporated into the drought definitions that were tested (Table 8).

Table 8: Drought definitions tested

Term	Definition	Source
Annual drought	Total rainfall (mm) for the calendar year is in decile 1 (lowest 10%).	Based on Australian Bureau of Meteorology rainfall deficiencies. This is how drought is typically defined in Australia and Western Australia at the moment.
Severe annual drought	Total rainfall (mm) for the year is in decile 1 (lowest 10%) for two or more consecutive years.	Based on discussions with farmers and agribusiness in the regions, two or more consecutive droughts are considered severe.
seasonal drought	Total rainfall (mm) during the April to October growing season is in decile 1 (lowest 10%).	Based on discussions with a 22-member expert Technical Working Group and all regional project advisory groups, growing season rainfall was considered more relevant than annual rainfall.
Severe seasonal drought	Total rainfall (mm) during the April to October growing season is in decile 1 (lowest 10%) for two or more consecutive years.	Based on discussions with farmers and agribusiness in the regions, two or more consecutive droughts are considered severe.
Hot drought	Total rainfall (mm) during the April to October growing season is in decile 1 (lowest 10%) and temperatures (°C) during the August to November maturing season are in decile 9 (highest 10%).	Based on recent studies in the global literature and research that the project team have been involved in, high maturing season temperatures were considered a potentially concerning compounding risk in combination with drought.

10. Climate Data for WA

Analysis of climate data for the South West of WA exposes six key messages relevant to the sustainable and profitable management of our agricultural land:

- Mean temperatures are rising;
- Annual rainfall is declining;
- Autumn and winter rainfall is declining;
- Spring and summer rainfall is increasing;
- Predictions indicate that these trends will continue; and
- In the short term, year-to-year climate variability may be more important than the longer-term trends.

A definition of drought based on rainfall during the growing season is therefore preferred over definitions based on annual rainfall for the Inland Great Southern region. A seasonal definition will better represent agricultural drought in the region, where dryland cropping in autumn and winter is the primary land use. More closely representing agricultural drought is important because agriculture makes a significant contribution to the regional economy.

In the last twenty years, four significantly dry years stand out, these are 2002, 2006, 2010 and 2019. They are widely recognised as drought years in Western Australia, where dry conditions were experienced by most regions across the State Dry conditions were also experienced by more localised regional locations in other years, for example the Northern Agricultural Region experienced dry conditions in 2007 after 2006 which had a severe accumulative effect the

same as 2018 and 2019 in the Great Southern Region where dry conditions prevailed for two years. This accumulative effect meant these dry years were even more severe for these regions.

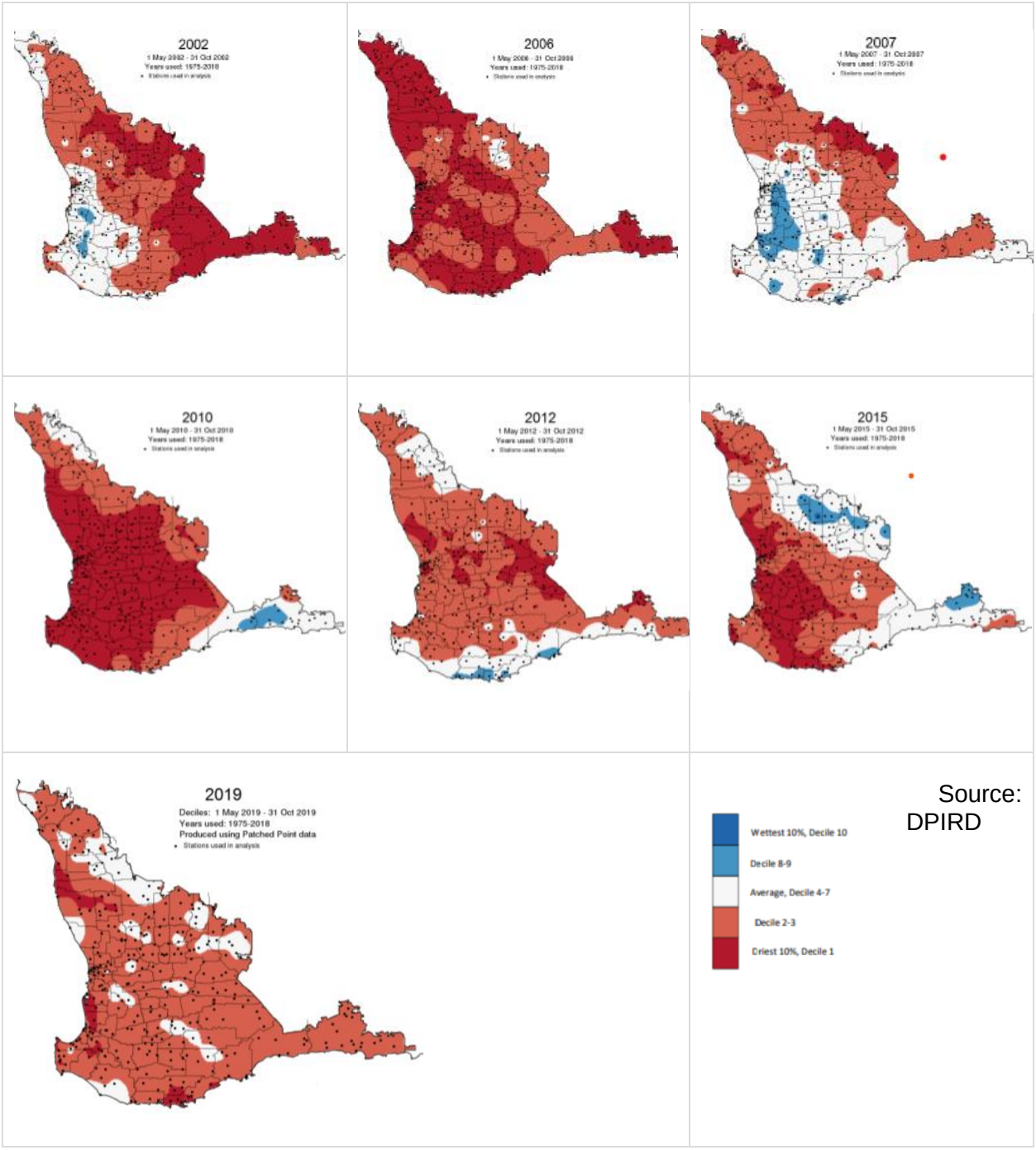


Figure 9 Selected rainfall decile maps between 2002 and 2020

The analysis highlights a potentially concerning trend, with the composite hazard of hot drought beginning to occur in recent years. Combined high temperatures and low rainfall can be devastating for the environment and societies[82,83] and are likely to occur more frequently and over larger areas in future given global climate trends[65]. Appropriate steps must be taken to anticipate and mitigate the potentially devastating effects of hot droughts.

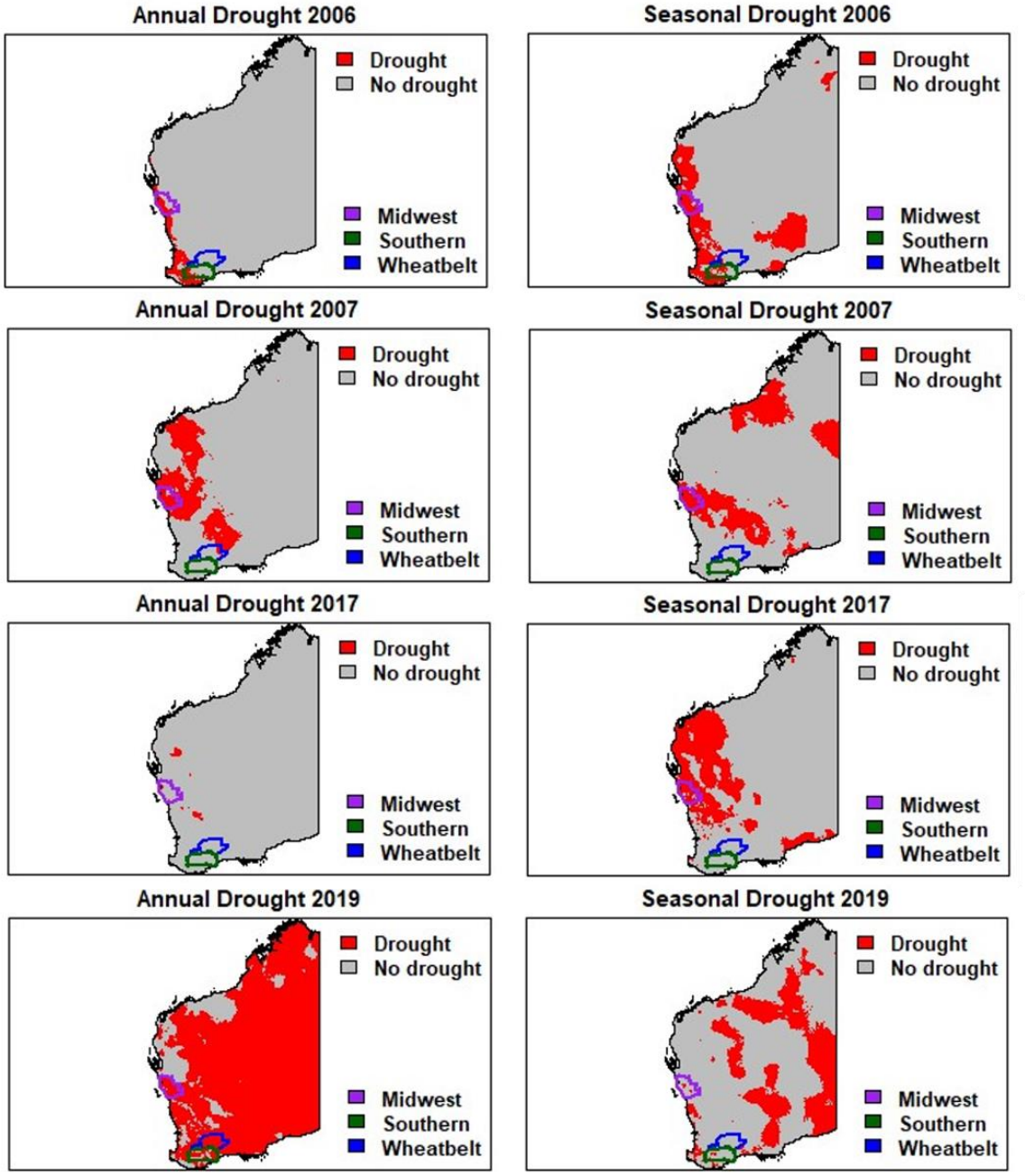


Figure 10 Comparison of the spatial extent of drought when using a definition of drought based on total annual rainfall (annual drought, maps on left) and a definition of drought based on growing season rainfall (seasonal drought, maps on the right)

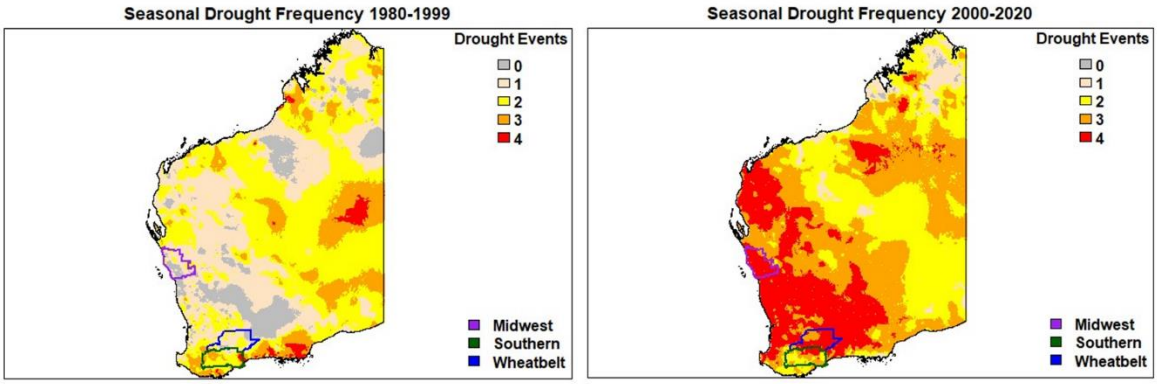


Figure 11 Frequency of seasonal drought for the period between 1980 and 1999 (left) and between 2000 and 202 (right for WA

10.1 Historical Drought

The Inland Great Southern region has a Mediterranean climate, with warm dry summers and cool wet winters. In Australia, average temperatures have increased by 1.4°C since 1910 leading to an increase in the frequency and severity of extreme heat events and heat waves[66]. In recent years, the average number of hot days (daily maximum air temperature > 34°C) during the wheat maturing season per year has increased by almost 25%[21]. The years 2015 and 2019 were the hottest on record[22].

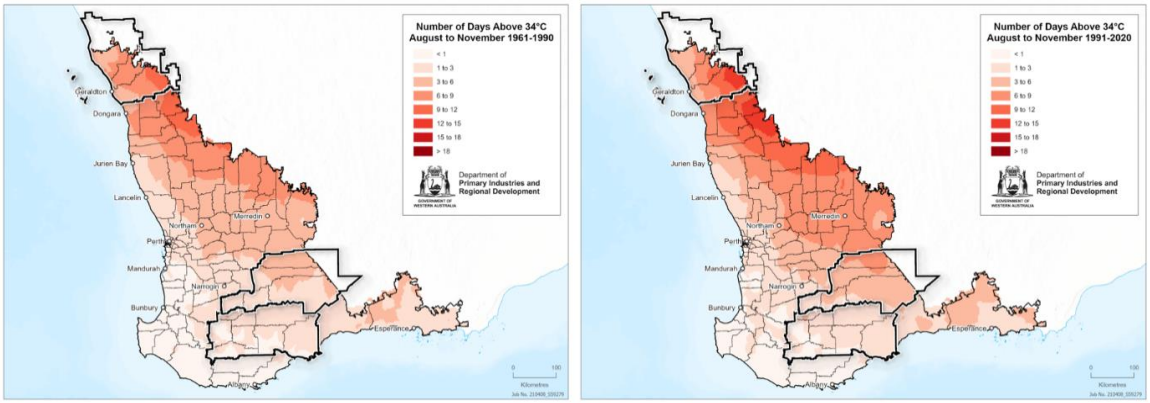


Figure 12 Maps showing the number of hot days during the wheat maturing season from August to November for period 1961-1990 (left), compared with the period 1991-2020 (right)

There has been a prolonged period of extensive drying in the region since the 1970s. In the last 30 years, autumn and early winter rainfall has decreased by around 20% and average annual rainfall has decreased by 8% when compared to the previous 30 years.

Dry years (lowest 30% within the range of natural variability) have occurred 12 times and wet years (highest 30%) four times, compared to nine dry years and eight wet years during the previous 30-year period. Winter rainfall over the period 2000 to 2020 is the lowest on record[23].

Across the entire region, the autumn break now occurs up to 3 weeks later than it did in the previous 30-year period.

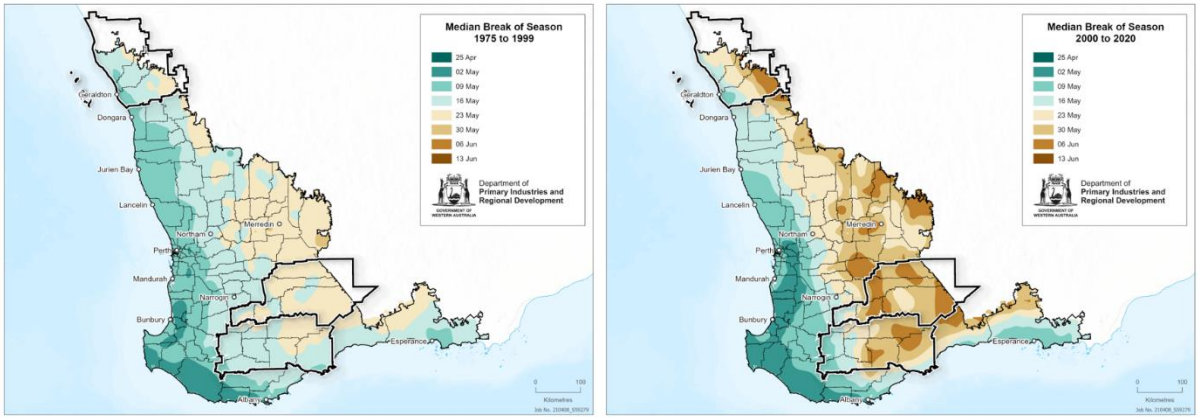


Figure 13 Maps showing the timing of the autumn break when at least 25mm of rainfall occurs over the three days prior to commencement of sowing for the period 1975-1999 (left) compared with the period 2000-2020 (right)

In addition to this, the average rainfall during the growing season from April to October in the period 1975-1999, compared to the current period 2000-2020 shows a significant decline.

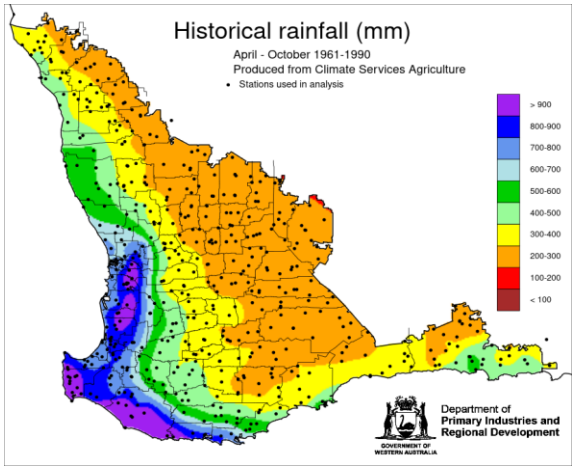
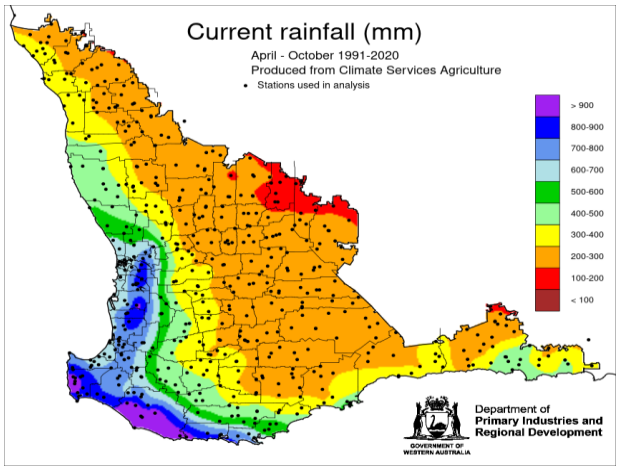


Figure 14 Historical and Current Rainfall



10.2 Future Drought

By 2030, annual average temperatures across all emissions scenarios are expected to increase by a further 0.5 to 1.2°C above the 1986-2005 climate[67,68]. Towards the end of the

century (2090), temperatures are projected to be 2.6 to 4.2°C warmer than they are now on average under a high emissions scenario, and 1.1 to 2.1°C warmer under intermediate emissions scenarios. Accordingly, the number of hot days (daily maximum air temperature > 34°C) during the wheat maturing season is expected to continue to increase.

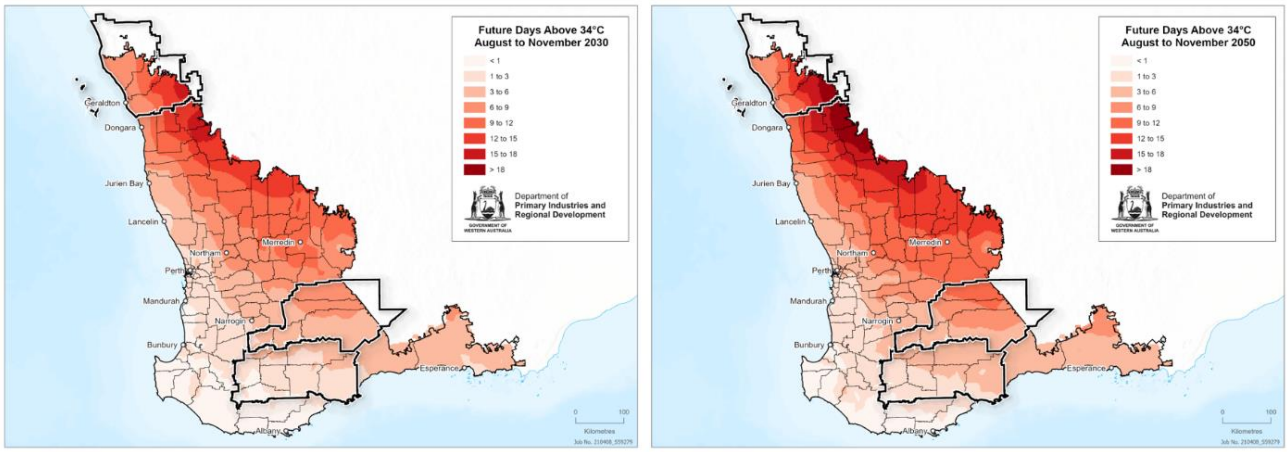


Figure 15 Maps showing the project number of hot days during the wheat maturing season from August to November by 2030 (left) and by 2050 (right)

Winter and spring (growing season) rainfall is very likely to continue to decrease across the region in future as climate change progresses. The time spent in meteorological drought, where conditions are significantly drier than the average over the preceding 30 years, will increase over the course of the century and across the region.

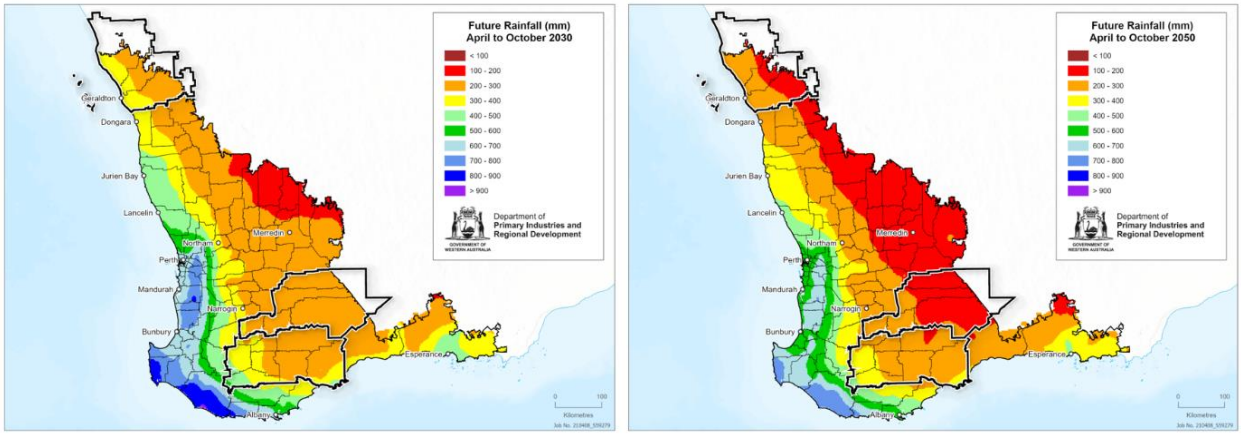


Figure 16 Maps showing the projected rainfall during the wheat growing seasonf rom April to October by 2030 (left) and by 2050 (right)

Crop and livestock farms in the region will be adversely affected by climate change[69,70]. Climate change will give rise to an increased number of adverse seasonal conditions and result in poorer production and reduced profitability over time. Projected increases in extreme events such as droughts and floods could also trigger increases in insect outbreaks and weed prevalence as the climate becomes more inhospitable for native vegetation and the competitive advantage of weeds increases.

Broadacre crop and pasture production may also decline in drier, warmer northern and eastern areas. Average potential yield (t/ha) has declined across the Inland Great Southern region because of declining temperature and increased evapotranspiration. The amount of water

available for industry and community purposes will be affected by reduced surface water flows into farm dams and community waters supplies[71].

Livestock welfare risks may increase if higher temperatures reduce the availability of feed and increase heat stress prevalence. Higher temperatures can also affect livestock productivity by reducing reproductive rates, growth rates and milk production[29].

While water erosion and salinisation may reduce due to declining rainfall, wind erosion may increase in regions as declining rainfall limits groundcover.

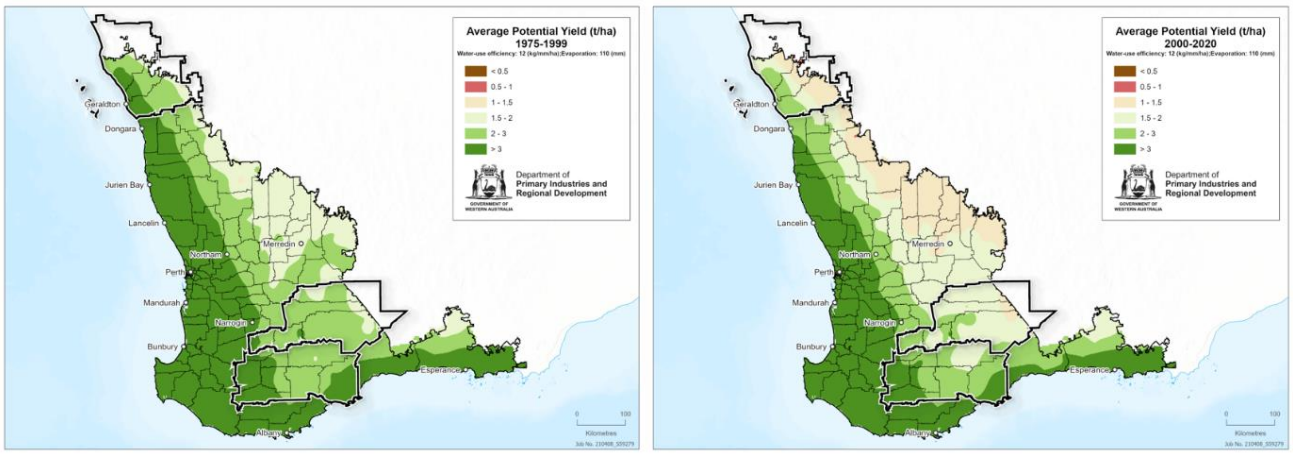


Figure 17 Maps showing average potential wheat yield in tonnes per hectare for the period 1975-1999 (left) compared with the period 2000-2020 (right)

11. Mapping Drought Vulnerability

11.1 The Mapping Process

Using GIS-based multi-criteria analysis (MCA) [72,73,74,75,76], DPIRD's GIS team have spatially integrated relevant economic, environmental and social data at a scale appropriate to inform local level political, administrative and operational decision-making (LGA boundaries).

A set of maps were produced identifying high priority drought risk areas, taking into consideration farm water supply, agricultural production, soil health and erosion potential along with a range of socio-economic and landscape features that contribute to drought resilience or exacerbate drought risk in the Great Southern region. These features include water-related ecological infrastructure, high value agricultural land and areas of higher socio-economic vulnerability.

The approach consolidates complex information into user-friendly spatial products designed to enable fine-scale, local-level decision making on drought resilience. The maps will be included in the Regional Drought Resilience Planning Program (RDRP) DVAs, forming part of the evidence base for RDR Plans.

Inputs into the MCA follow the RDRP conceptual framework, investigating aspects of exposure, sensitivity, impact and adaptive capacity. Our understanding of the ways in which each of these components relate to and inform vulnerability and resilience to drought in the regions was guided by a comprehensive regional stakeholder engagement process.

Drought resilience priority areas maps are made up of a set of composite maps for i) exposure, ii) sensitivity, iii) impact (combining exposure and sensitivity and iv) adaptive capacity. Forty-four variables and ten composite maps were weighted according to their likely influence on drought resilience, based on literature review, expert opinion and feedback from regional stakeholders, and combined to create the final drought priority map. The analysis was performed using the Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S) tool developed by ABARES[77]. Drought resilience priority areas lie at the intersection of all categories, where exposure, sensitivity and adaptive capacity overlap.

The overlapping areas highlight where droughts are likely to occur most frequently and have the largest impact on water resources and agricultural production. They also identify locations where regional communities may be more vulnerable to the impacts of drought due to socio-economic factors including relative remoteness, access to infrastructure and income.

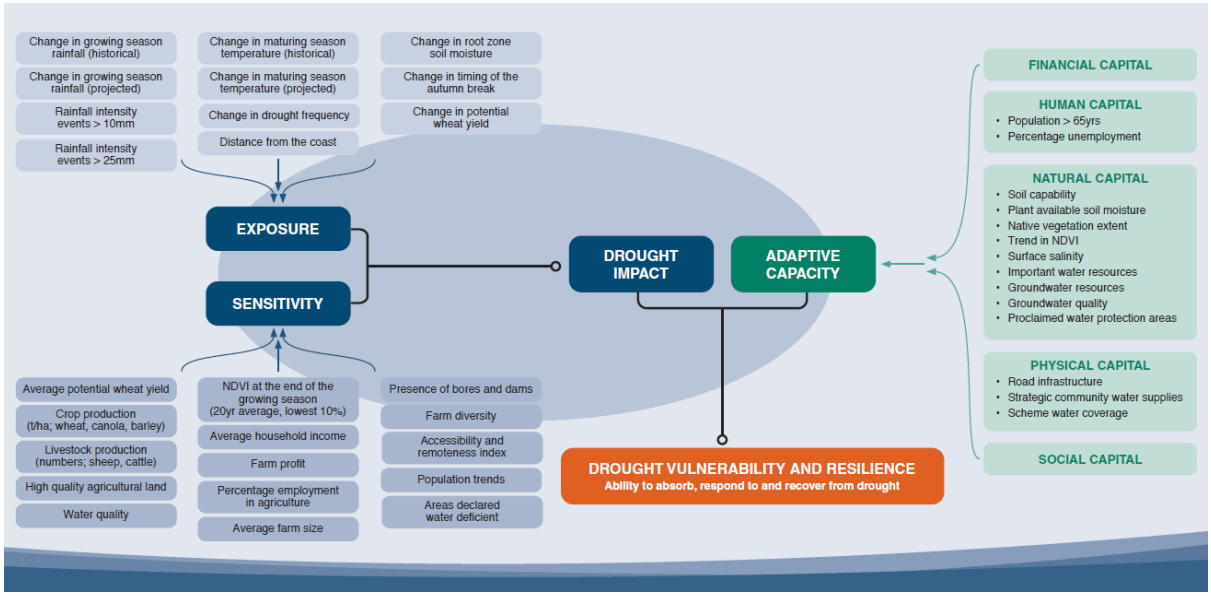


Figure 18 Data sets included in the analysis, showing how each data set fits within the over-arching program conceptual framework (data sets provided in the attached appendices)

The maps were ground-truthed with the community and the technical working group and feedback was incorporated into the final products.

The composite drought priority areas map has the potential to be a powerful decision-support tool for the South West of WA. There is a high level of confidence in the analysis as many of the included datasets are robust, regularly collected and available at high spatial and temporal resolution across South West WA, including the participating Shires in the Inland Great Southern.

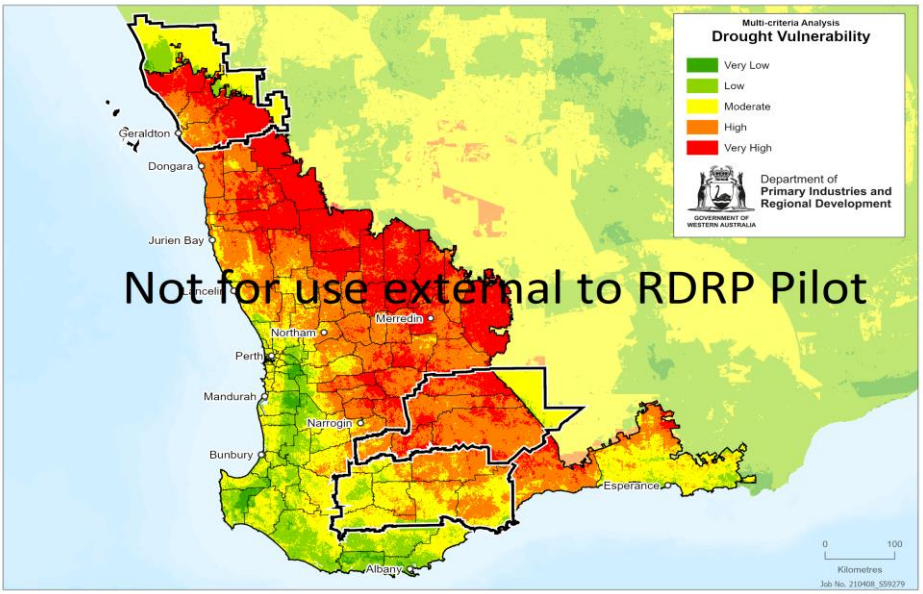


Figure 19 Final drought vulnerability map showing that the areas in WA most vulnerable to drought are in the north and east of the region

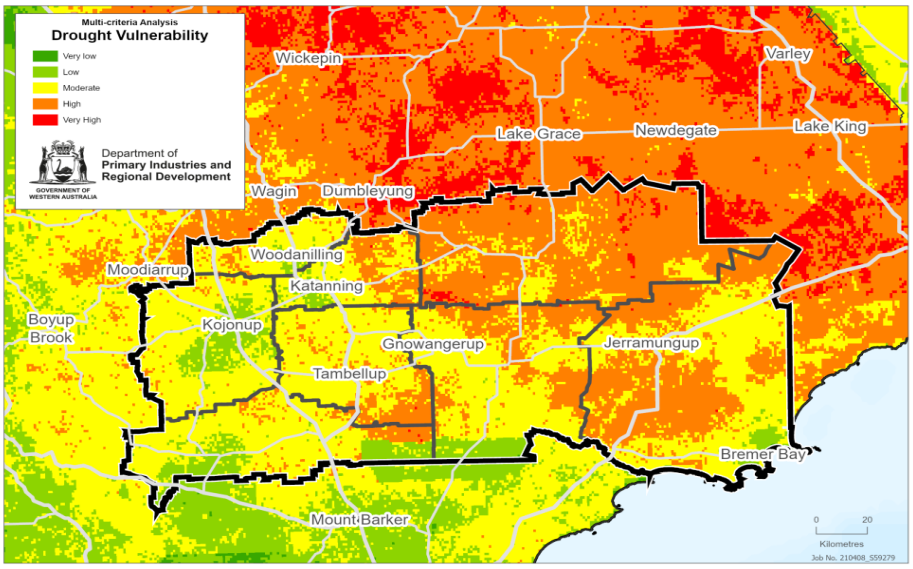


Figure 20 Final drought vulnerability map zoomed in tot he Great Southern region showing high to very high vulnerability across the region

The links between the component datasets and impacts of drought well understood, for example low rainfall exacerbates drought risk, as does a shorter or warmer growing season; drought is associated with reduced production and farm income; problems with water quality or infrastructure can leave regional communities more vulnerable to the effects of drought.

The included datasets align well with regional communities' perceptions of how they are affected by drought, specifically low rainfall, high temperatures, compromised agricultural production, financial stress and shrinking regional communities. Those datasets in which we have lower confidence, either in terms of data quality and resolution or the link between the indicator and impacts of drought, are accounted for through the weighting structure applied throughout the analysis. There is a high level of agreement between the priority areas highlighted in the final map and those identified through participatory mapping with regional stakeholders.

Presenting information at the scale of the sub-national administrative unit enables direct embedding of the priority areas identified into wider government and institutional processes[78]. Spatial products such as the drought risk and resilience priority areas maps can provide significant support to decision-makers by collating complex climate, ecological, and socio-economic information into a single powerful image. These maps, developed together with regional stakeholders, are widely replicable.

As a next step, spatially defined priority areas need to be linked explicitly with clear, site-specific implementation activities, through participatory and stakeholder-engaged engaged planning and implementation.

A report detailing the analysis conducted by the DPIRD Climate Science and GIS team, additional workflow diagrams and additional regional maps for each component is available on request.

11.2 Drought Exposure Map

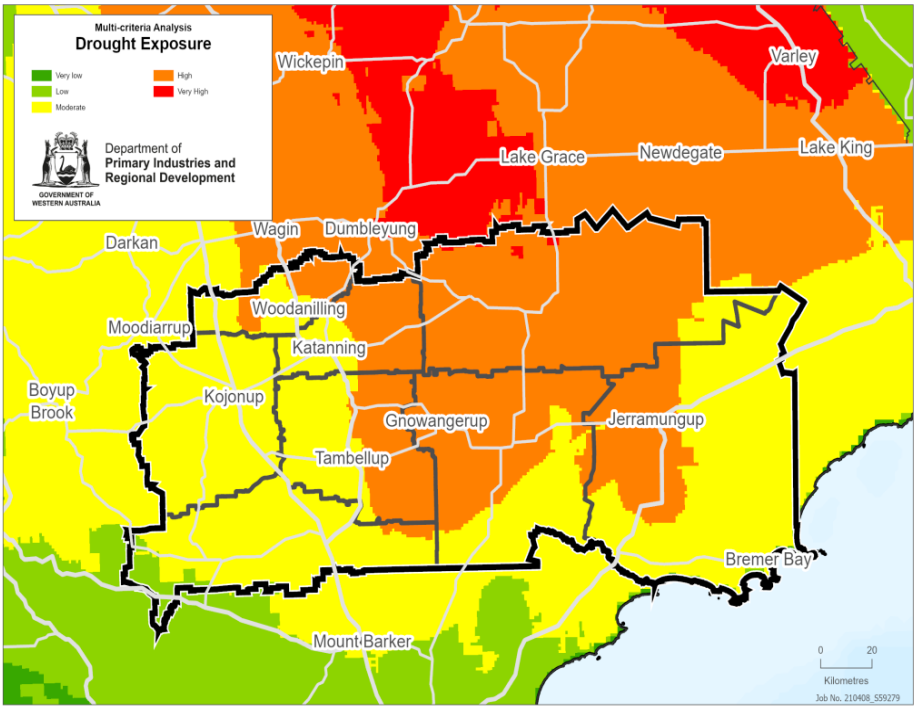


Figure 21 Inland Great Southern Exposure Map

In the Inland Great Southern, exposure to drought ranges from moderate in the far west of the region to high in the north/east region.

This result was influenced by the low incidence of rainfall events over 10mm and 25mm, the percentage change in the autumn break from 1975-1999 to 2000-2020 and decline in average yield potential from 1975-1999 to 2000-2020, number of hot days and decline in growing season rainfall.

11.3 Drought Sensitivity Map

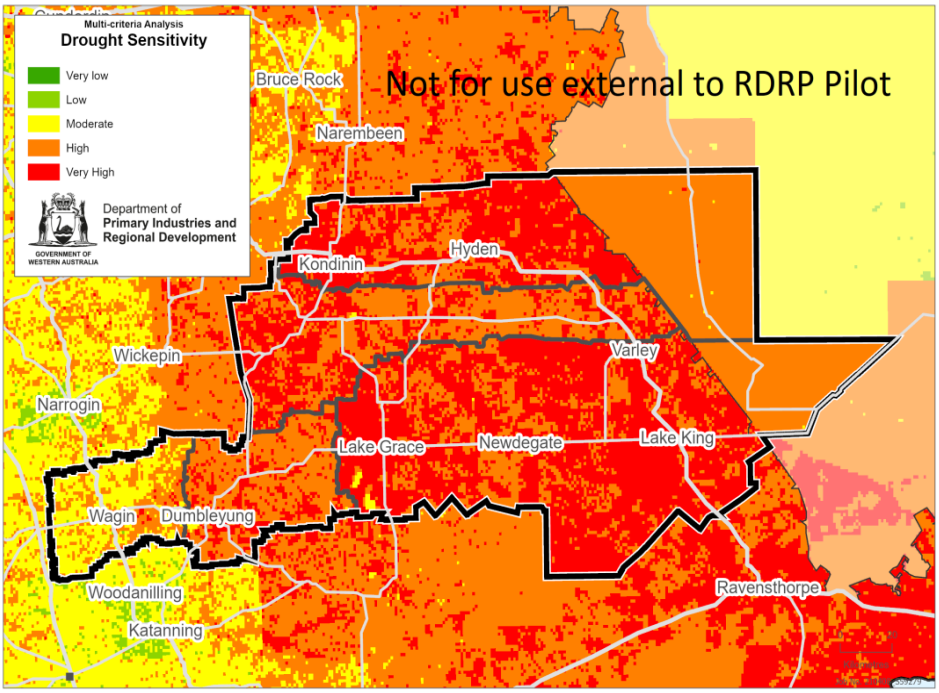


Figure 22 Inland Great Southern Drought Sensitivity Map

In the Great Southern, sensitivity to drought ranges from moderate in the far west of the region and high to very high across Shires of Jerramungup and Kent.

Investigation of the datasets identify accessibility and remoteness, percentage of Drought Risk by farm profit, higher numbers of livestock in some Shires, areas declared water deficient (Jerramungup and Kent) and low counts of water assets (bores and dams), and the high percentage of workers reliant on agriculture, may have contributed to the result.

11.4 Drought Impact Map

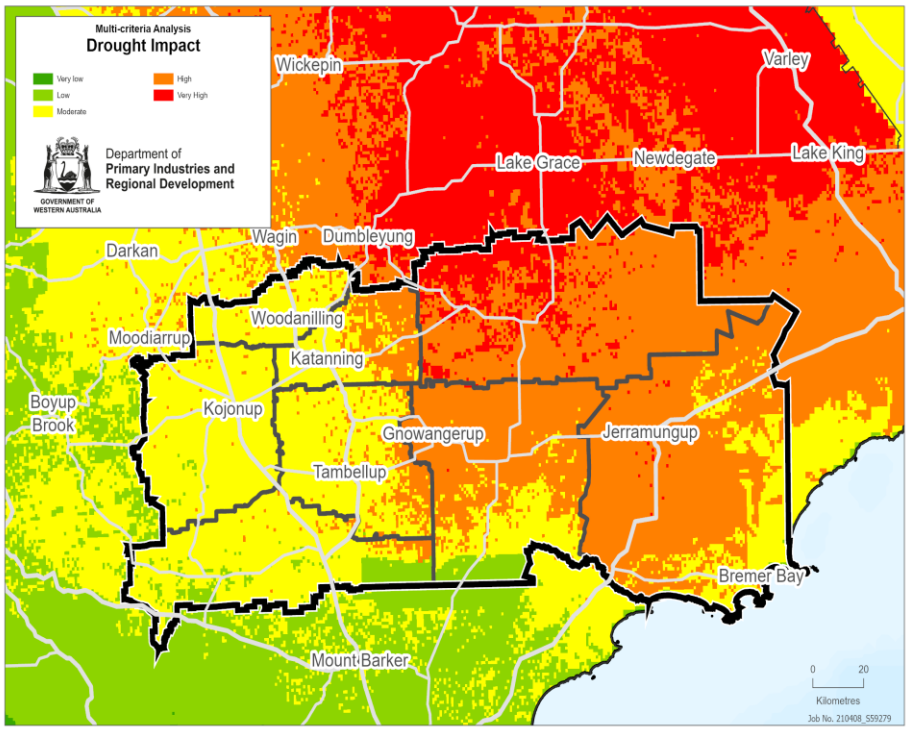


Figure 23 Inland Great Southern Drought Impact Map

The drought impact map is a composite of the Drought Exposure and Drought Sensitivity maps. The Western Shires including Kojonup, Katanning, Tambellup, Woodanilling Cranbrook and Broomehill-Tambellup have moderate risk of being impacted adversely by drought. The eastern half of the Great Southern region has high and very high likelihood of being impacted adversely by drought. Areas of most concern are the northern areas in the Shire of Kent.

Actions that are targeted at improving the reliable harvesting and storage of water, support drought resilient farming systems, and diversification of economic activity across the region will support the ability of the region to lessen adverse impacts of drought.

11.5 Drought Adaptive Capacity Map

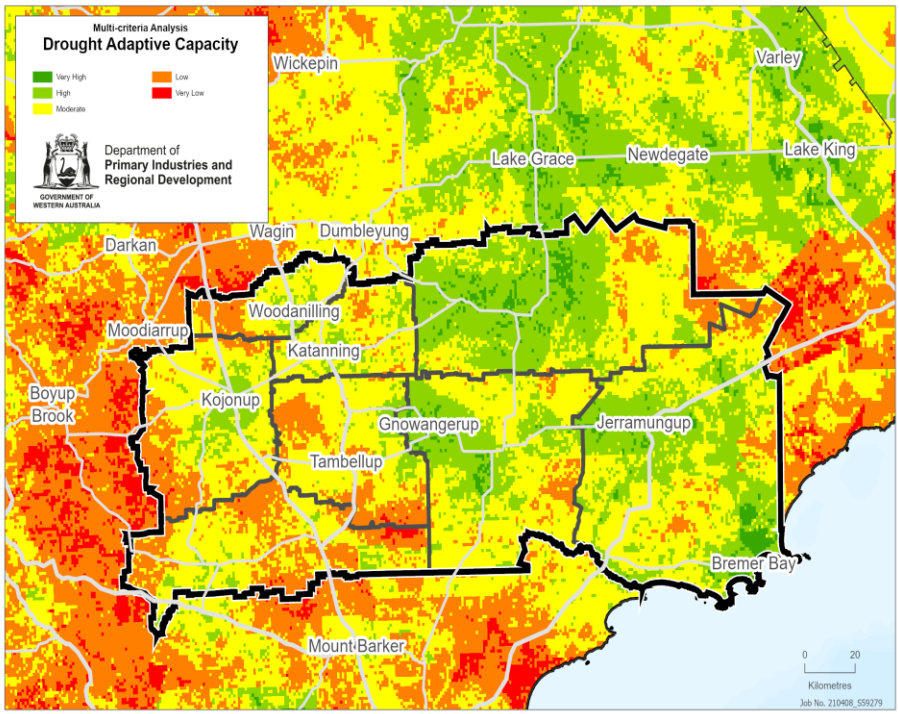


Figure 24 Inland Great Southern Adaptive Capacity Map

The adaptive capacity map is made up of three composite maps for human capital, natural capital and physical capital. This map is based primarily on the natural and physical capital of the region and limited in its depiction of human and social capital. Though through community consultation, and the outcomes of the social impact study, a strong link was identified between natural and physical capital and economic prosperity, which impacts on individual wellbeing and ultimately social and community resilience.

In the Great Southern, the areas that had the highest impact of drought, showed the highest capacity to adapt. The lower levels of capacity around Kojonup and Katanning would need further investigating but could be due to an aging population.

The very low unemployment rate across the region relates to better adaptive capacity, though this does not reflect the issues with attracting labour due to lack of housing options for workers. More exploration is needed of these factors to ascertain true adaptive capacity to drought.

11.6 Drought Vulnerability Map

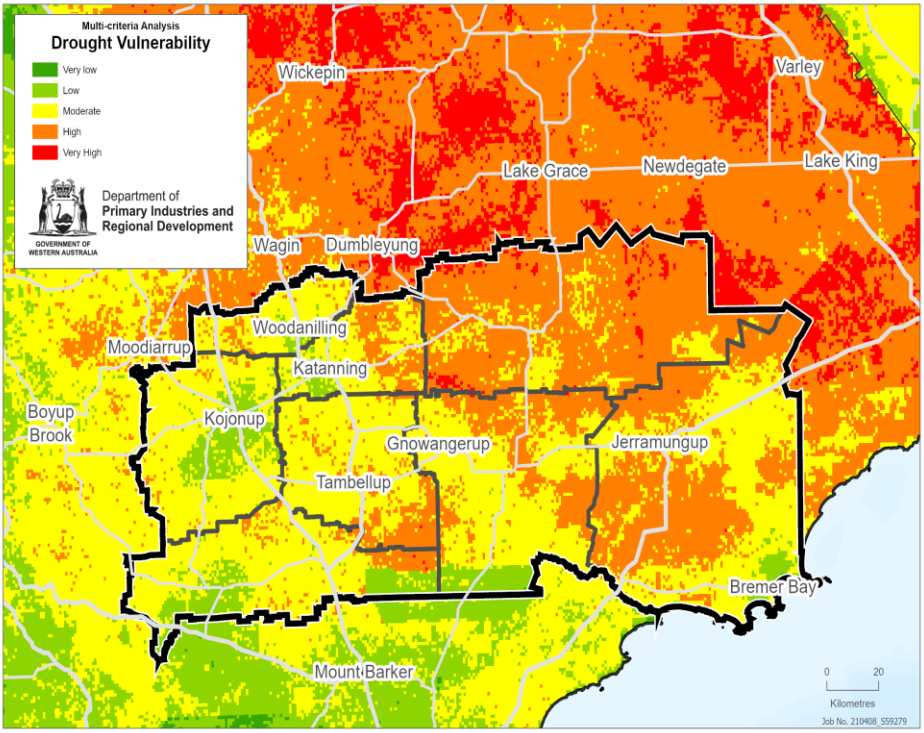


Figure 25 Great Southern Drought Vulnerability Map

The drought vulnerability map is a composite map of Adaptive Capacity and Drought Impact. There is variability in drought vulnerability across the Inland Great Southern. A copy of the MCAS methodology and results can be provided on request.

12. Impacts of Drought in the Inland Great Southern

Drought impacts can be significant and wide ranging, and impact regions, industries and communities economic, social and environmental functioning. Several studies rank drought first amongst natural hazards in terms of the seriousness of impacts, including loss of life and livelihoods, economic losses and adverse social, economic and ecological effects[79].

Reduction in household income, financial hardship and a drop in financial position are three major economic impacts experienced by those in drought across Australia[80]. Broader economic impacts on regional communities include job losses, worker relocation and a reduction in income for small local businesses, particularly in small towns with economies highly dependent on farm expenditure[22].

Environmental impacts of drought include irreversible damage to soil and vegetation, leading to dust storms and a loss of top soil, soil nutrients, organic matter and soil carbon[81,82]. Social impacts of drought can be devastating and include permanent loss of services in regional areas, loss of employment opportunities, negative physical and mental health impacts and financial hardship [22,83,84].

Drought amplifies existing personal and professional burdens of regional communities such as poor health, isolation and limited access to services and infrastructure[85,86]. Drought resilience is strongly influenced by regional characteristics including wealth, infrastructure,

policies and plans, the level of community cohesion and the extent to which regional economies depend directly on agriculture and/or water[87,88,89].

12.1 Regional Level Impacts

It is evident from the literature that climate change is having significant and ongoing impacts on the agricultural regions of WA. Australian average temperatures have increased by about 1º Celsius since 1950 and the South West and southeast of Australia are seeing a trend towards lower average winter rainfall. This includes a forecast increase in hotter weather patterns across WA and a reduction in wet years, with drought becoming a more common occurrence[90].

The South West land division are seeing ongoing declines in rainfall which are forecast to continue. Many areas of the state are experiencing the early impacts of drought and ongoing drying conditions including the Northern Agricultural Region, inland areas of the Great Southern, parts of the Wheatbelt and Southern Rangelands[91].

Decreased water availability is one of the biggest identified concerns across all regions. Forage production may be reduced by up to 10% over the agricultural areas, and by 10–20% over the rest of the state. Broadacre crops are the most vulnerable to rainfall variations with an expected decline in yields in the drier eastern and northern areas of the Great Southern.

Additional potential impacts of climate to consider at a regional level include:

- economic pressures
- increased input costs and energy prices
- competing land-use pressures
- policy-related economic pressures, such as measures to mitigate greenhouse gas emissions.

In their report 'Climate Change: Impacts and Adaptation for Agriculture in WA', commissioned by the Department of Agriculture and Food (now DPIRD), Sudmeyer et al[92] identify common climate related research and development themes in WA:

- climate projections at a local scale
- systems-based research to continue delivering incremental adaptations for short to medium-term climate variability and change
- climate change and agriculture in WA
- improved weather forecasting
- better understanding of the potential long-term impacts of climate projections on farming systems and related industries.

12.2 Environmental Impacts

The challenge for agriculture is to feed a population of 10 billion people by 2050, sustainably with a drying and more variable climate. Globally the industry will need to produce 30% more food in the same land area, while stopping deforestation, cutting greenhouse gas emissions, reducing poverty and loss of vegetation, preventing freshwater depletion, and cutting pollution. This problem will be made worse with more frequent and severe droughts. The environmental risks of drought were captured in the report by L.A One, and the following information has been summarized from this report.

It is widely accepted by science that the future of South Western, Western Australia (WA), will see a drying climate with more variability and extremes. In addition, drought conditions have a significant impact on our natural resources.

Droughts exacerbate impacts on already fragile environments. In the context of broader degradation, drought conditions can have a significant impact on natural resources, including irreversible damage to water quality, soil and vegetation, leading in turn to dust storms and a loss of topsoil, soil nutrients, organic matter and soil carbon[93].

Unlike other natural hazards such as floods, earthquakes, cyclones and fires which occur over a finite period of time and result in visually obvious damage, drought develops slowly and quietly, lacking highly visible and structural impacts.

By assessing the impacts of previous droughts on the environment, we can build a picture of how things will look with more frequent and severe droughts. Four years - 2002, 2006, 2010 and 2019 – were identified as previous drought years for our pilot regions. Condition scores from ANU's environmental condition scorecard reports showed a significant decline in environmental condition during and following years after these periods

Landscapes also provide a range of ecosystem goods and services, including biodiversity and public amenity[94]. Ecosystems provide important services to agricultural production, for example through soil structure and fertility, nutrient cycling, soil retention, crop pollination, food sources, water provision and purification[95,96,97].

Environmental impacts can be widespread and long-lasting, contributing to land degradation processes, and are among the most noticeable effects of drought. During the consultation process, Inland Great Southern stakeholders stated that drought negatively affected soil health, water resources (natural and scheme) and biodiversity.

The impact of drought on soil erosion is one of the greatest risks to soil health, as it strips away the fertile top layers of soil and organic matter, taking with it most of the fertility and organic matter of the soil. [98]

12.3 Drought Events & Increased Fire Risk

The Mediterranean-type climate in the South West of WA is characterised by conditions that are conducive to ignition and spread over a 4–8-month period.[99] There are various weather factors that influence the fire environment including coastal sea-breezes, strong easterly winds, abrupt wind changes, and regular lightning storms during the dry months.[160] The traditional fire season has been prolonged, sometimes by several months as a result of the sustained decrease in rainfall during the past three decades.[160]

The timing, intensity, and frequency of drought events have divergent impacts on fuel flammability and fire behaviour.[100] Droughts after a wet spring can result in an abundance of rapidly drying fuels in bushland and forest understories, but prolonged droughts can limit fire occurrence due to a reduced availability of fuels from a lack of rainfall stimulating vegetation growth.[161]

Fire has devastating effects on the environment. 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.[101] Farmland is scorched, destroying pastures crops, and infrastructure, and killing livestock.[162] Ash can pollute both the air and waterways, causing issues to human health, and depositing unwanted nutrients that can stimulate HABs.[162]

It is important to note that bushfires can play an important role in Australia's environmental ecology.[102] Fire can trigger natural processes like stimulating seed germination and can benefit biodiversity. By clearing out thick undergrowth germination and regrowth of native vegetation is encouraged, while freeing them from competition with weeds, and eliminating diseases and damaging insects.[163] Recurrent fires however potentially threaten regeneration by killing seedlings and impoverishing the seed bank, therefore reducing forest postfire recovery ability.[103]

Figure 26 shows the area of land burnt (%) in 2019 derived from MODIS satellite imagery by the National Aeronautics and Space Administration (NASA). [104] The LGA for the pilot regions are identified using a dot.

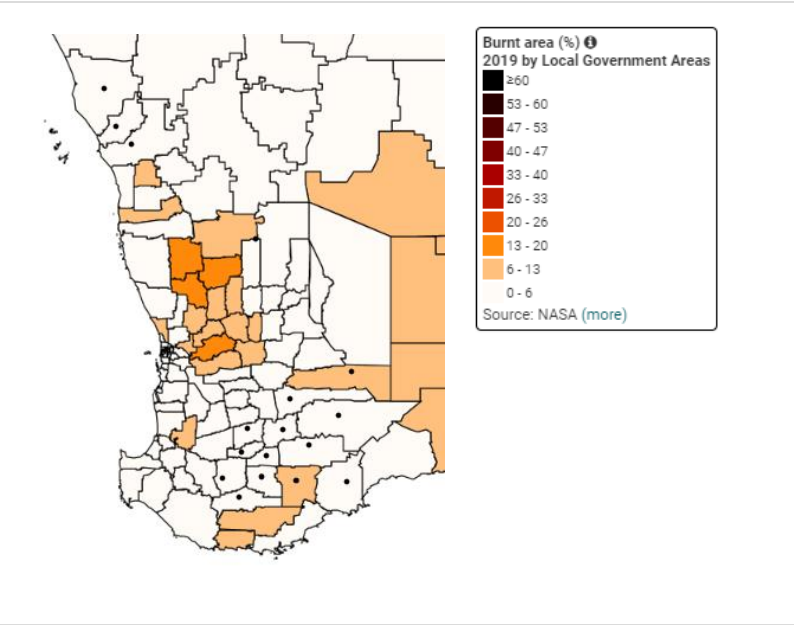


Figure 26 Area of land burnt (%) in 2019 for the pilot regions

12.4 Social Impacts

Mental health pressures are amplified in rural communities in successive dry or damaging event seasons due to the additional burden individuals and the community reported experiencing. This manifests itself through people withdrawing from social interaction, impacting on volunteering and philanthropy which often form the fabric of many communities.

The challenges to maintain green spaces in towns and desertification and decline in natural resource condition (soil erosion, water erosion, vegetation decline) adds to the mental health burden associated with drought and directly impacts social cohesion.

- The financial impact resulted in people giving up farming and selling their properties, around 50% of the community was lost as people relocated seeking financial survival and security;
- Increasing debt loads;
- A significant reduction in livestock numbers, as they were either sold, agisted or destroyed;
- Work off-farm work became normal to financially support families and farm debt;
- A significant negative effect on mental health as stress levels increased to extremes, with 'suicidal' tendencies and suicide incidents;
- Social impacts included marriage breakdowns;

- Small businesses supported by farm businesses struggled or disappeared reducing services, skilled workers and long-term employment opportunities;
- Communities' fragility increased;
- Bores ran out of water. Long-term residual anxiety about the certainty of rainfall, when and if it will rain enough and at the right time;
- The younger generation were negatively impacted and did not return to rural and regional communities to farming businesses;
- Dust everywhere and significant soil erosion.

During the consultation process, Great Southern stakeholders stated that drought negatively affects mental health, led to business closures, causing people to move away from the region, reducing population sizes and access to skills and services. Drought strained community services and support networks. Stakeholders highlighted the need for stronger support to community groups and networks during drought.

12.4.1 A Model for Understanding Community & Individual Resilience

Given the importance of social impacts of drought to regional stakeholders, the University of Western Australia's Centre for Social Impact was commissioned to conduct a review of the evidence around the social impacts of drought, factors which may mitigate those impacts, and what can make communities more resilient and/or more vulnerable to drought. Drought is a meteorological phenomenon that is recognised as a natural disaster when it results in severe socio-economic impacts for affected communities.

The focus of this section is on the social impacts that low rainfall can have on individuals, households and communities. The immediate and medium-term, direct and indirect social impacts of drought are diverse, related to employment, education, migration, family relationships, mistrust of government, uncertainty over the future and over community resources and support systems[105]. All of these factors have the potential to directly or indirectly impact on physical, mental, social and emotional health and wellbeing[106,107,108,109,110,111,112,113,114].

The primary driver of social impacts of drought is the effect that drought has on financial security[115]. Economic factors include direct effects on income and employment[116,117,118] as well as indirect effects of hardship, stress[119], accumulating debt[120], lost productivity, declining populations, disruption of social connections, loss of services, missed schooling[121,], depletion of resources and trauma associated with witnessing damage to livestock, crops, soil and native vegetation[122].

Building resilience to the impacts of drought involves acting at both the individual and community level. Individual resilience refers to the capacity to recover quickly from difficulties and negative experiences such as trauma, tragedy, threats, or significant sources of stress[123,124].

Resilience is impacted by personal (e.g. gender, attitude, perspective), community (e.g. social and community support, service access) and business (e.g. role diversification, succession planning) factors. [125,126].

Community resilience refers to the ability of a community to undertake collective action to deal with adversity[127,128,129,130,131,132,133]. It can be described through a set of adaptive capacities, including economic development, social capital, community competence, information and communication [134].

There is a need for the whole community to be supported during drought, with many non-farming people and businesses also impacted by the loss of income and regional outmigration associated with drought[135].

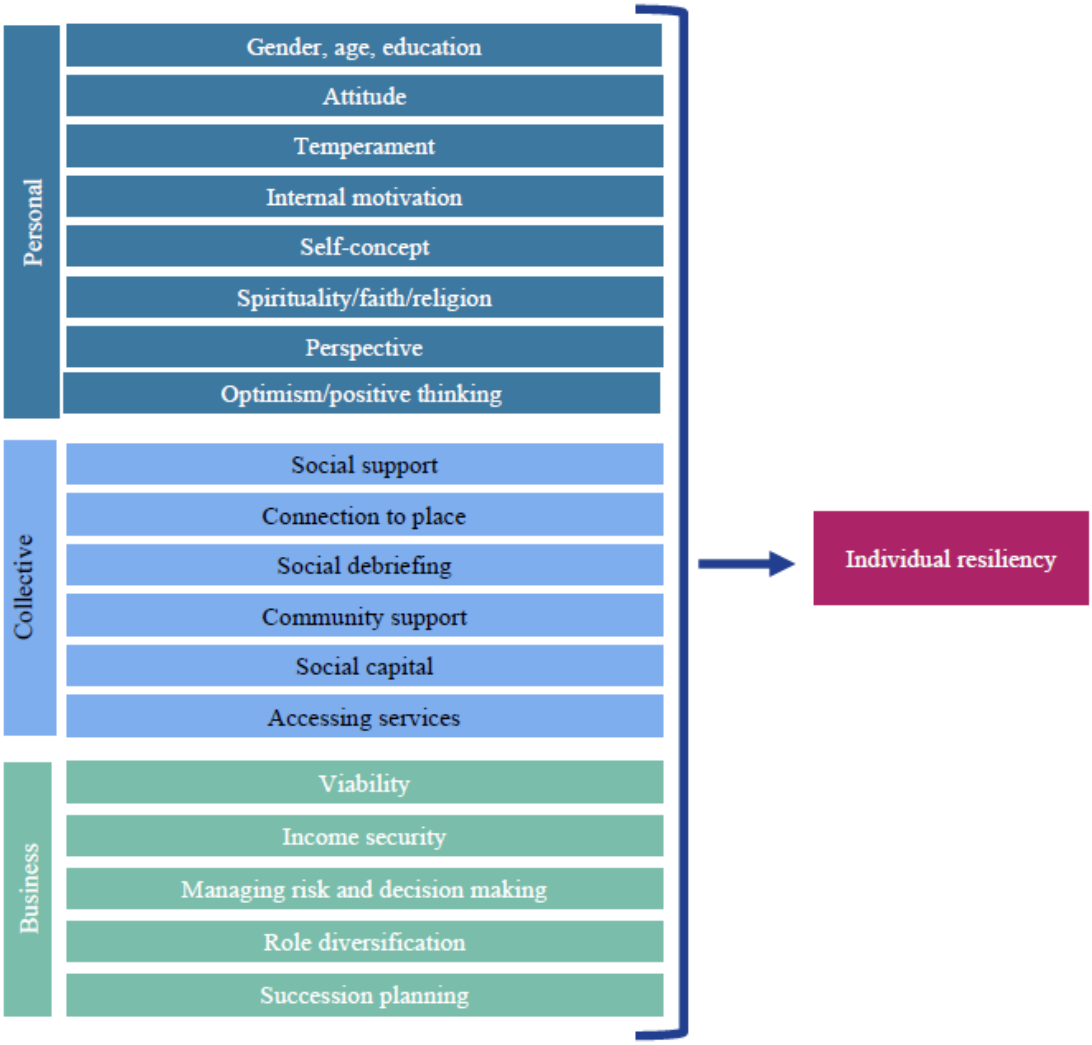


Figure 27 Factors impacting on individual resilience in the face of adversity

Figure 28 The adaptive capacities that make up community resilience

12.5 Economic Impacts

There has been an observation of a decline in permanent worker populations, partly due to changing business practices (farmers and businesses employing seasonal or casual workers). In dry seasons, this can be amplified as agricultural businesses liquidate and discretionary off-farm spending reduces impacting the cash flow and viability of businesses in the region[136].

The economic impacts of drought extend beyond the farm gate, due to the inter-relatedness of farming businesses, agricultural supply chain businesses and support services, non-agricultural businesses in agriculturally dependent communities.

The dominance of agriculture and exposure of agriculture to drought, could mean that droughts impact negatively on the economic and social well-being of the Inland Great Southern communities. Due to the seriousness of economic impacts of drought, the project team commissioned LA One Economics & Consulting Pty Ltd to conduct a review the available literature.

The region is exposed to drought due to the high level of reliance on agriculture in the region and the type, number and size of regional businesses across all Shires. Unexpectedly, farm business with higher incomes are generally considered less vulnerable to drought. Anderton[137] suggests that turnover of more than $600,000 is required to be viable, with $1 million turnover preferred. In this region, the majority of agricultural businesses turnover less than $2m per year.

The most obvious economic impact of drought is on the volume of agriculture production, particularly crops, which typically fall sharply during a drought[4]. Figure 29 illustrates how WA wheat production fluctuates between years from 2002 to 2021 showing significant impacts on wheat production in the drought years of 2002, 2006, 2010 and 2019.

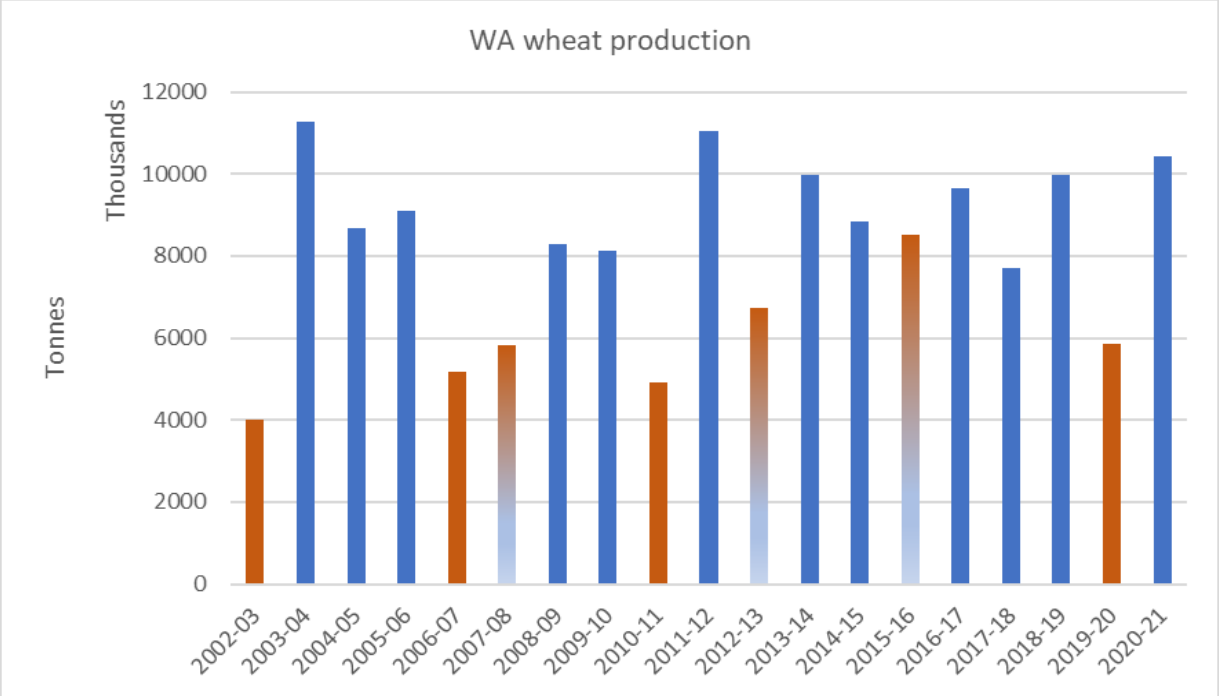


Figure 29 WA What production (tonnes) from 2002 to 2020

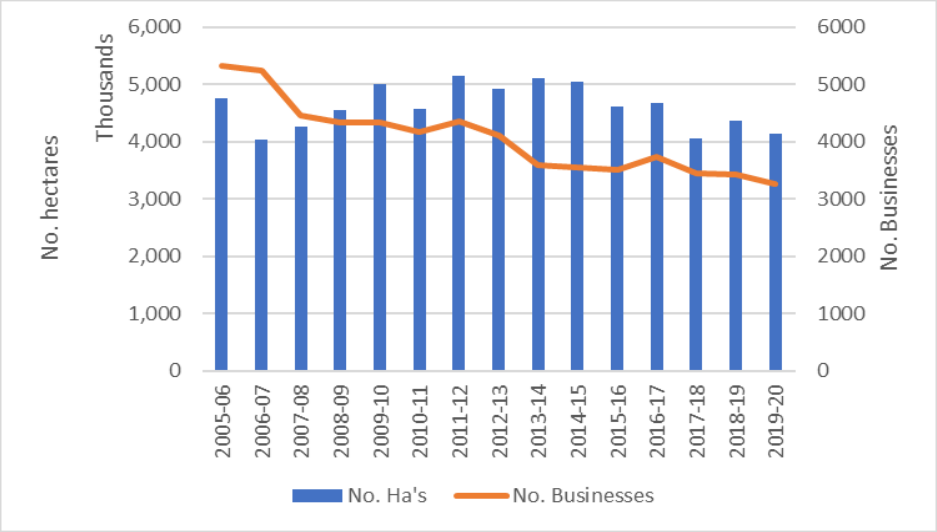


Figure 30 Area of wheat (ha) and number of businesses (Source: ABS)

The impact of drought on livestock products (meat and wool) is a little more complicated. Once drought conditions have become sufficiently established, livestock producers will seek to reduce their herds or flocks, resulting in a temporary increase in the recorded volume of meat production. When the drought breaks, recorded meat production typically falls as graziers focus on rebuilding their herds.[138]

The livestock movements in Figure 31 show the dramatic impact of the 2019 drought in Australia where livestock numbers were at their lowest. The increase in the forecasts predicted by MLA shown in Figure 32 are a combination of herd and flock rebuild and supply chain issues with slaughtering and abattoirs trying to cope with staff shortages due to COVID-19.

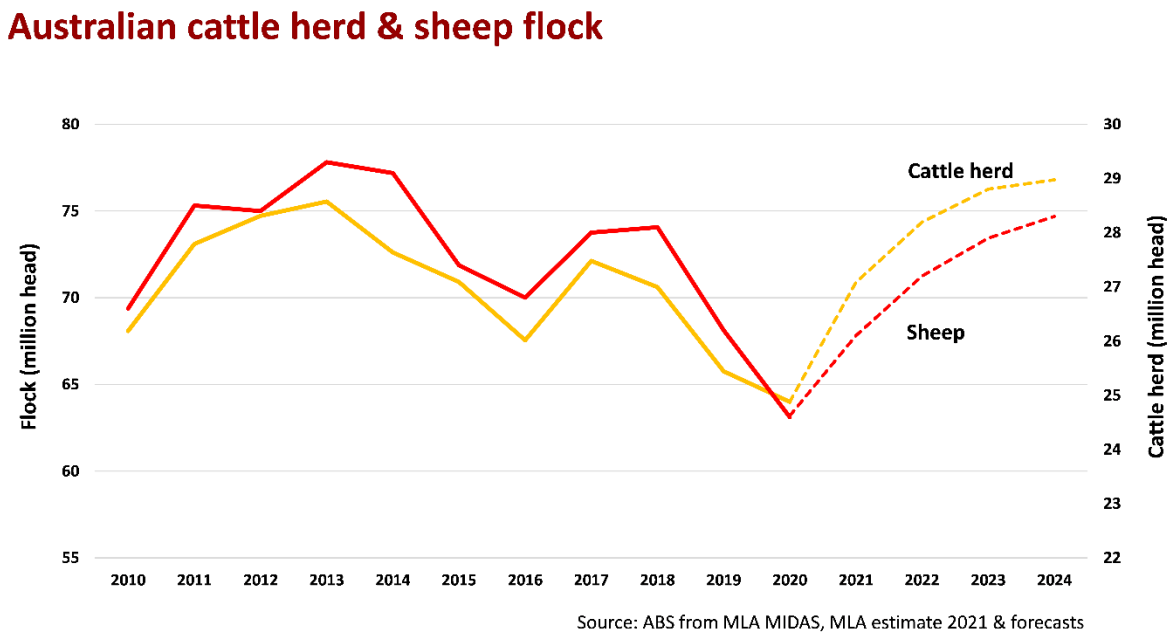


Figure 31 Livestock Movements 2010 to 2024

In WA the impact of the 2011 and 2019 drought meant flock size decreased significantly, The number of sheep decreased from 15.7 million in 2008-09 to 14 million in 2010-11, numbers increased again but decreased to less than 14 million in 2015-16. The decrease in numbers is not all about drought but it is a significant factor.

Due to high demand and good prices in the Eastern States more sheep than usual were transported across the Nullarbor for flock rebuilding and slaughter as shown in Figure 32. In total 1.36 million sheep were transported interstate 2019-2020.

Seasonal variability and risk of drought resulting in scarcity of water and feed for optimum sheep production were identified as critical limiting factors impacting farmers decisions to increase sheep numbers in 2010 and 2020.[139]

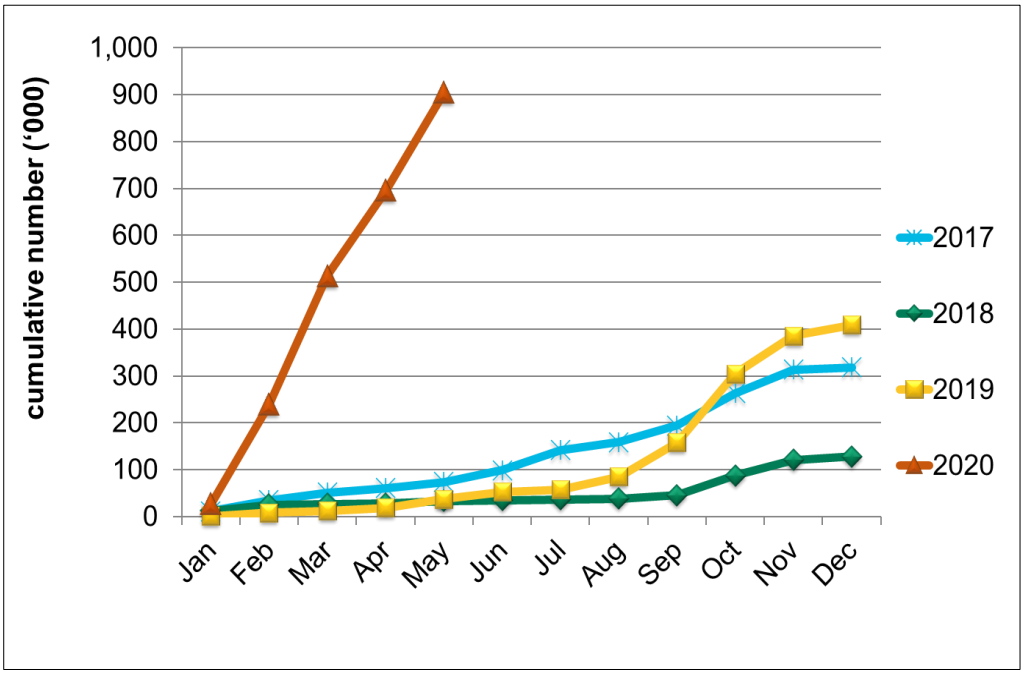


Figure 32 Cumulative Number of Sheep Leaving WA through Ceduna (Source: PIRSA DATA, DPIRD analysis)

The economic impact of drought reaches beyond the farm gate and the impact on the supply chain can be significant, particularly for small processors with limited capital reserves and less ability to diversify.

Processors are vital for sheep meat value chain sustainability. Processing margins are tight which is evident by small processors like Hillside, Shark Lake and Beaufort River Meats struggling to consistently remain open (ABC, 2012). Hermann et al., (2017) sum up the processing game as "cents and pennies game" number of through-put is the key economic driver and economies of scale are vital for efficiency so the variability in seasonal supply of lamb for small processors with intermittent supply can create difficulties, especially maintaining or accessing a workforce. Most processors in WA have a winter break, when supply is low for maintenance shut-down.[123]

WA is reliant on three main processors, Fletcher's at Narrikup, Western Australian Meat Marketing Co-Operative (WAMMCO) in Katanning and V & V Walsh in Bunbury. If any one of these processors were to close the reduction in buyers competing in the marketplace will create a downward pressure on prices. Already, WA saleyard prices lag Eastern State saleyard prices, mostly because there is less competition between buyers, sometimes the difference can be as high as 200 cents per kg. During these periods trade flows from WA to South Australia increase, usually when the price gap is more than 50 cents per kg or greater, and when the price difference is greater than the cost of freight.[140]

If the processing sector in WA were to contract, farm gate sheep enterprise profitability will be negatively impacted, potentially decreasing sheep numbers further so creating more pressure

on processors. Droughts are intermittent and most processors have the flexibility to manage the decrease in supply. The have several strategies to manage short-term shortages of supply, these are, winter shutdowns, reducing number of shifts in a week and improving technology to reduce labour shortages. On the flip side they are able to increase operations quite quickly subject to availability of labour.

12.5.1 Farm Profitability

The financial impact of drought on the farm sector is evident in the Planfarm benchmark data in Figure 33. This time series for the operating surplus (Gross farm income minus total operating expenses (variable + fixed costs) also known as earnings before interest and tax (EBIT) shows how the impact of drought affects the farm business. The operating surplus is required to pay for interest, tax and personal expenses as well as any business expansion, machinery replacement or capital improvements. When it is impacted by drought it becomes difficult for farm businesses to meet all their financial commitments and they often rely on using equity or find an off-farm income.

There are several observations that can be made 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.

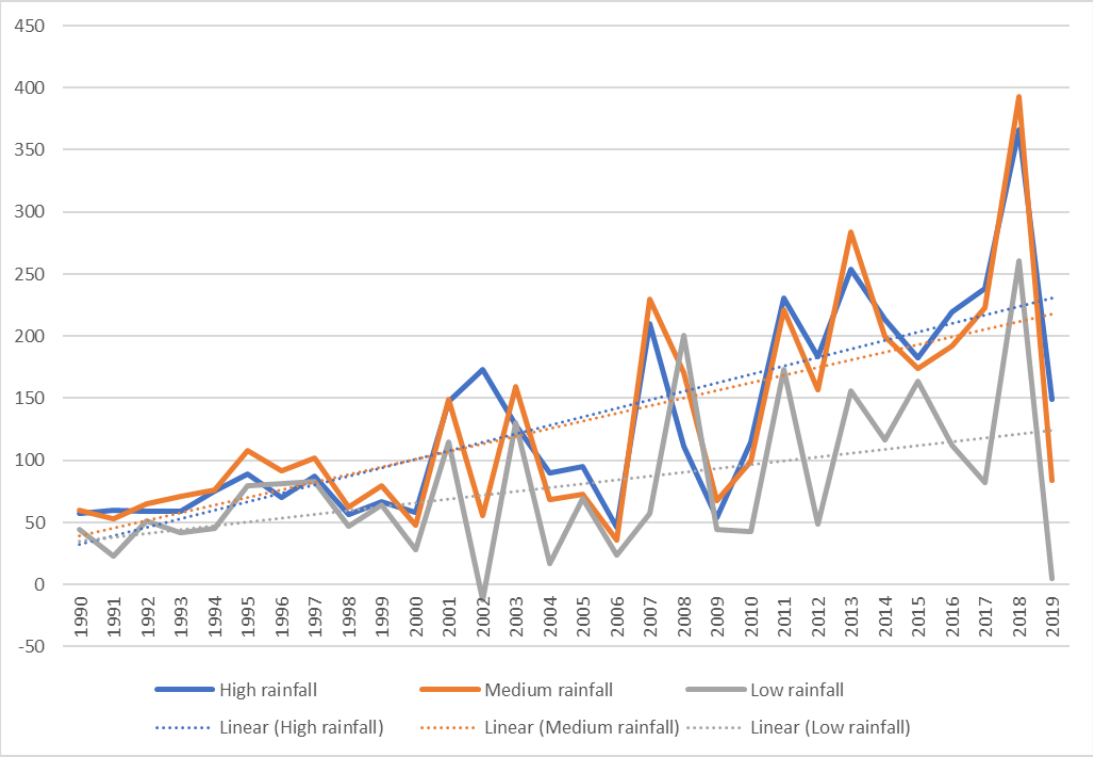


Figure 33 Operating surplus for WA farms 1990-2019

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 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. (R. Grima, personal communication, June 13, 2022).

ABARES research uses *farmpredict* controls for non-climate factors and farm business profit to show that changes in climate conditions over the last 20 years have had 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.

During workshops held with communities in the Northern Agriculture Region to discuss the impacts of drought, many of the issues identified are supported by the literature and analysis.[141]

12.5.2 Impacts On Food Supply Chain

Food reaches consumers by many different routes, typically involving some or all of processors, manufacturers, warehouse operators, retailers and the companies or individuals who transport food between them. These networks are comprised of Australia's food supply chains. There are different types of chains for different products, such as dry goods, fresh fruit and vegetables, meat, frozen food, dairy and bread.[142]

Sometimes these supply chains are referred to as a "value chain" where each link adds value to a product, for further discussion on this concept refer to Bartos (2022)[143].

For several weeks in January and February 2020, food supply shortages were experienced by Australians probably for the first time since the end of World War II. The COVID-19 pandemic has exposed vulnerabilities in Australia's food supply chain, exacerbated by climatic events like the floods in South Australia causing disruptions in the rail freight into WA. Supplies normally readily available were disrupted. Empty supermarket shelves required purchasing restrictions for the second time in two years.

The level of dependency within a supply chain is high and disruptions caused by climatic events can create issues along supply chains. Sometimes critical dependencies are not well understood and "a broader view of climate change beyond disasters and food production, has yet to be fully integrated into food security policy – and supply chain governance and practice – in Australia."[128.]

12.5.3 Economic Impact Measurement

Understanding the economic impacts of drought is critical to informing policy to provide appropriate support in drought affected regions.[144] Yet, the economic impacts of drought are complicated, not only is the start date difficult to determine, but also the duration and drought creates winners. For example, drought-induced higher prices attract goods from other regions to flow into the local market. For farmers in Western Australia, the price of grain was supported in 2018 (wheat price was at historic levels for the first time at $360/tonne) by reduced supply in the Eastern states caused by drought conditions.[145]

In drought years, Australian grain and hay prices tend to increase above world market prices increasing the profits of some farms (grain producers) and decreasing the profit of others (livestock farmers). These farmers could be considered drought affected even if their local rainfall levels would indicate otherwise.

Another important issue is that drought causes long-term impacts. The negative impacts might linger for multiple years with the depletion of farm capital, usually through two mechanisms - reduced farm income which depresses investment during drought years and a depletion in livestock numbers and quality of pastures. Consequently, drought depletes the income earning capacity of farms in recovery relative to no drought. Analysis by Anderton, L. (2016) identified that farmers who made a loss in years of drought were less able to invest in new or existing innovations to improve productivity.

Secondary impacts of drought occur for inter-sectoral businesses relying on the agriculture sector due to interactions and transactions between industries and sectors. Outputs from one industry/sector become inputs into other industries/sectors are affected.

The direct economic impacts on an individual industry spread through upstream or downstream linkages to other industries, causing secondary impacts. An example of this is when grain production is impacted, and supplies are limited to downstream food processors like flour mills who must bid a higher price to obtain wheat. The alternative is to reduce their production. Ultimately the additional costs get passed on to the end consumer.

Another example is livestock. As they are sold to cope with drought, the abattoirs benefit from additional supplies of livestock, but the medium to long-term impacts mean less livestock in the farming system due to reduced numbers and reduced livestock slaughterings.

ABARES broadacre farm survey data uses total family income, defined as the family share of farm cash income less family share of depreciation, plus all off-farm income of the owner/manager and spouse. This is national data used to help guide policy decisions for the sector.

These results aggregate observations across regions, environments, farm size and product mix which masks the actual volatility of income of individual farms. This is national data used to help guide policy decisions for the sector. These results aggregate observations across regions, environments, farm size and product mix which masks the actual volatility of income of individual farms.

Despite experiencing highly variable seasonal conditions, including dry seasons and droughts and reduced government investment in research, development and extension over the last 20 years[146,147,148], Australian farmers have maintained profitability. Adoption and implementation of farming systems technology, new varieties and increasing sophistication in business and financial management, have increased efficiencies, productivity and profitability.

The agriculture sector is well-adapted to highly variable conditions, with WA a world leader in dryland grain production area. Returns are being achieved from seasons that would have been loss-makers a decade ago. Australian farmers are managing inputs and costs more effectively than ever before and achieve returns on both good and marginal land.

The drive for continued efficiencies to maintain and enhance profitability will remain as dependence on export markets, climate change trends, rising rural debt and the increasing costs of doing business[149] increases the vulnerability of the agriculture sector.

Innovations and farming practices that are helping farmers to adapt to climate change:[150]

- General sound management such as weed control, appropriate varieties and stock husbandry. Practices such as new varieties are readily adopted, but other issues such as weed management needs to be integrated into a complex system;
- Non-wetting management, such as clay spreading, mouldboard ploughing or application of wetting agents;
- Seeking methods for improving soil biology to improve efficiency of inputs such as fertiliser;
- Application of lime to improve soil pH and deep ripping for improvement in subsoil pH;
- Precision Agriculture tools such as GPS monitoring of operations allow for better targeted application of inputs;
- Alternative crops and pastures, chickpeas, long coleoptile wheat varieties;
- Lick feeders and increased storage facilities for grain and fodder;
- Labour-saving technology for stock; and
- Re-greening farms to benefit biodiversity in a changing climate.

12.6 Landscape Impacts

12.6.1 Soil Degradation Risk

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,[151] taking with it most of the fertility and organic matter of the soil.[152]

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, affecting the activity of soil organic matter and reducing soil particle cohesion. 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.[147] Major dust storms can sandblast vegetation and crops, and deposit unwanted nutrients threatening plants and animals and causing harmful algal blooms.[147] They also pose a risk to human health by polluting the air causing asthma and other health problems.[147]

12.6.2 Water Holding Capacity

Increasing climate variability indicates that rainfall events will become more extreme and intense.[153] This, combined with drought affected soils that have a lower water holding capacity, leads to greater surface water movement, resulting in water soil erosion.[149] Erosion from drought breaking rainfall has the potential to make up 90% of total soil loss in a 20–30-year cycle.[154] The cost of water erosion to dryland faming in WA is estimated to be approximately $10 million annually.[155]

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.[149]

12.6.3 Vegetation and Biodiversity

Biodiversity underpins a range of ecosystem services including:[156]

- 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.

Western Australia has eight of the 12 biodiversity hotspots in Australia, with the South West being one of the world's top 34 hotspots.[157] Drying trends and drought threaten the biodiversity of these ecosystems through reduced access to water for vegetation growth and animal survival.[158]

Decreased ecosystem productivity and increased mortality of plants and animals are characteristic of these conditions.[159] Competitive species, species adapted to the cold and wet, and species with low reproductive rates and limited mobility are most affected by drought.[158] Most species numbers will decrease during drought. The long-term consequences of drought on biodiversity depend on species abilities to resist, and to recover after drought, and on competitive interactions between species.[158]

Drought-induced vegetation declines have been widely reported across the globe, and Australia. The decline in vegetation productivity and increase of plant mortality due to drought has been identified as having the potential to trigger abrupt and irreversible changes in ecosystem structure and function, with profound implications for biodiversity, ecosystem services, and carbon storage.[160]

A study by Jiao, T (2020) et al., examined the effects of drought on the Australian vegetation. They analysed the magnitude and sensitivity of vegetation responses to the Millennium drought (MD), with satellite-derived information including the fraction of photosynthetically absorbed radiation (FPAR), photosynthetic vegetation cover, canopy density derived from vegetation optical depth, and aboveground biomass carbon.

Results show how South-Eastern Australia experienced the largest impact of the drought, as would be expected because it impacted the east side of Australia more than the west. The negative values indicate drought impacts while positive indicate no drought impacts and grey indicates burn fraction more than ten per cent.[159]

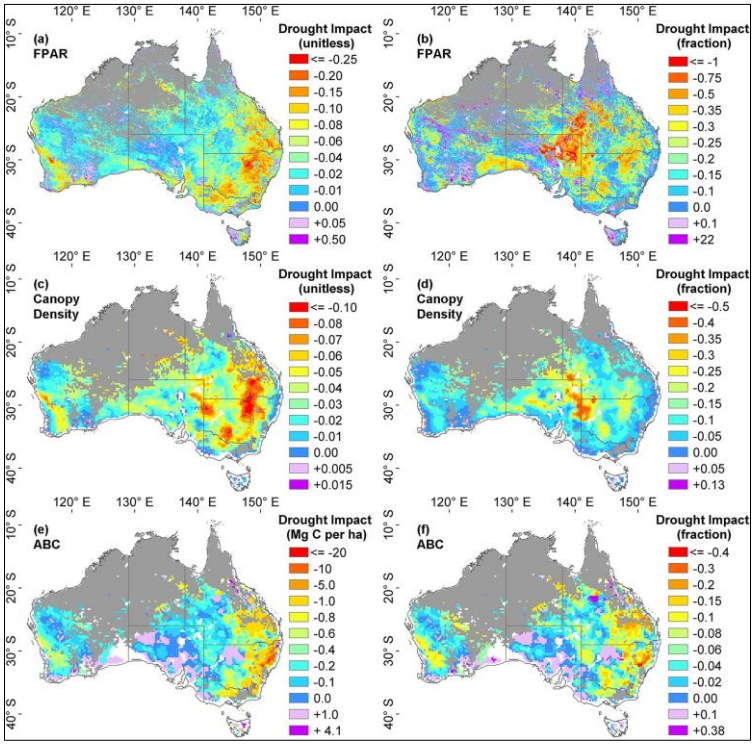


Figure 34 Mean monthly absolute (left panels) and relative (right panels) drought impacts on fraction of photosynthetically absorbed radiation (FPAR), canopy density and above ground biomass carbon (ABC)

In the last twenty years, four were significantly dry years. These were 2002, 2006, 2010 and 2019. They are widely recognised as drought years in Western Australia, where dry conditions were experienced by most regions across the State.

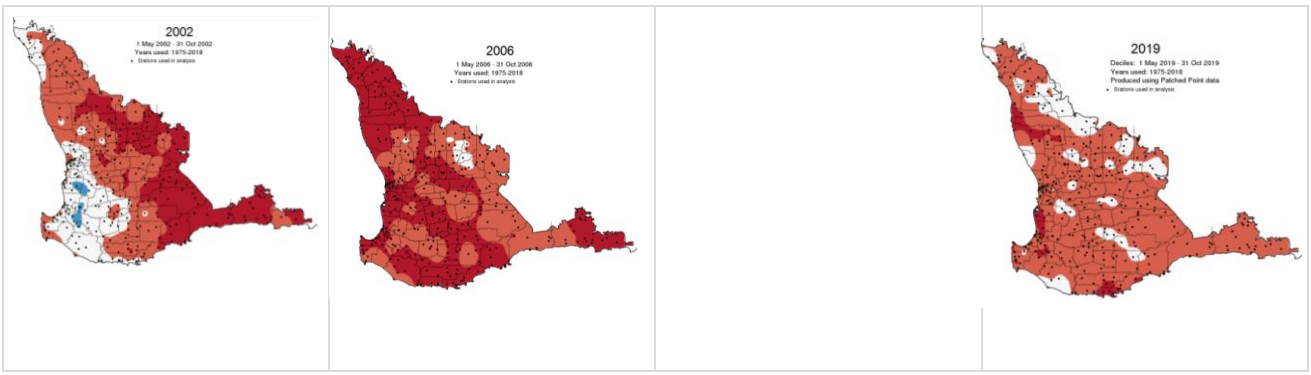


Figure 35 Rainfall decile maps showing drought years for WA between 2002 and 2022, source DPIRD

Elements of data which contribute to the annual environmental condition reports generated by Australian National University (ANU) are used to identify the impact the drought years had on the natural resources for each LGA in the pilot regions.[165]

The environmental condition scorecard summarises a large number of observations on the trajectory of 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 measures of the condition of natural resources and ecosystems are summarised from several spatial data sources. Land cover, inundation, fire occurrence, burnt extent, exposed soil and vegetation leaf area are derived by automated analysis of satellite imagery. The other indicators, tree cover, soil moisture and vegetation growth are estimated by integrating ground

and satellite data with environmental prediction models. Further details about the method and collection of data are in the appendices of this DVA.

The summary score for Western Australia displaying the environmental health of Western Australia for 2021 is presented in Figure 35.

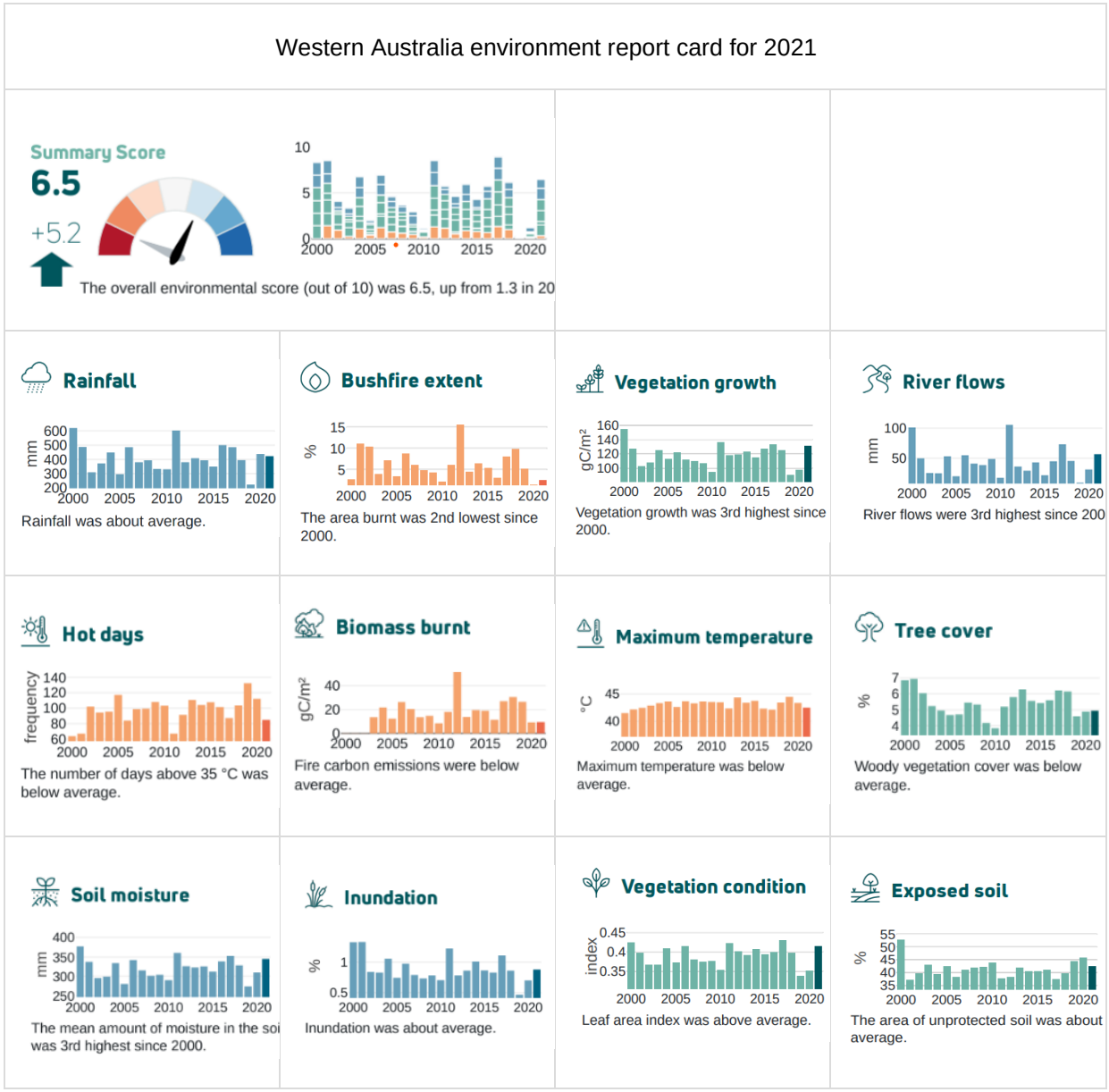


Figure 36 Environmental Score Card for Western Australia 2021

By using this data, we can see the impact of drought on our environment by LGA. The indicators used show the impacts are exposed soil (soil protection), leaf area, plant growth and river flows. Exposed soil is measured using 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. The severity and area of exposed soil was highest in 2020 suggesting that the impact of drought is increasing.

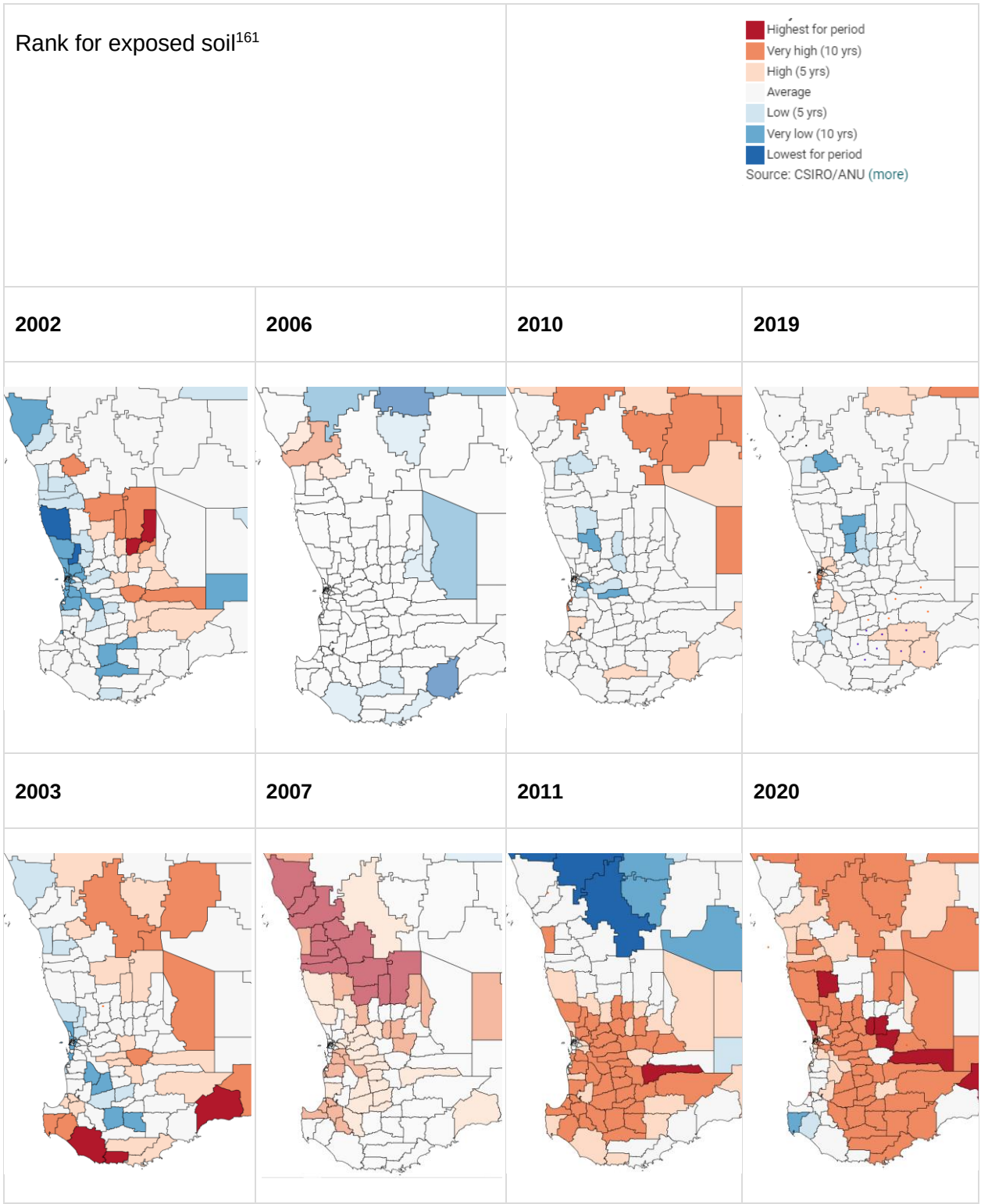


Figure 37 Exposed soil for Local Government Associations in Western Australia for specific drought years identified

Annual environmental condition scores[162,163] for the Inland Great Southern shows the impact of drought on the environment. Scores report on inundation, streamflow, vegetation growth, leaf area, ground cover (exposed soil), tree cover, and number of hot days experienced. Environmental scores were lowest in 2002, 2010, 2019 and 2020, reflecting poor seasons.

Effects of drought on the environment persist and are detectable in environmental condition scores in following years.

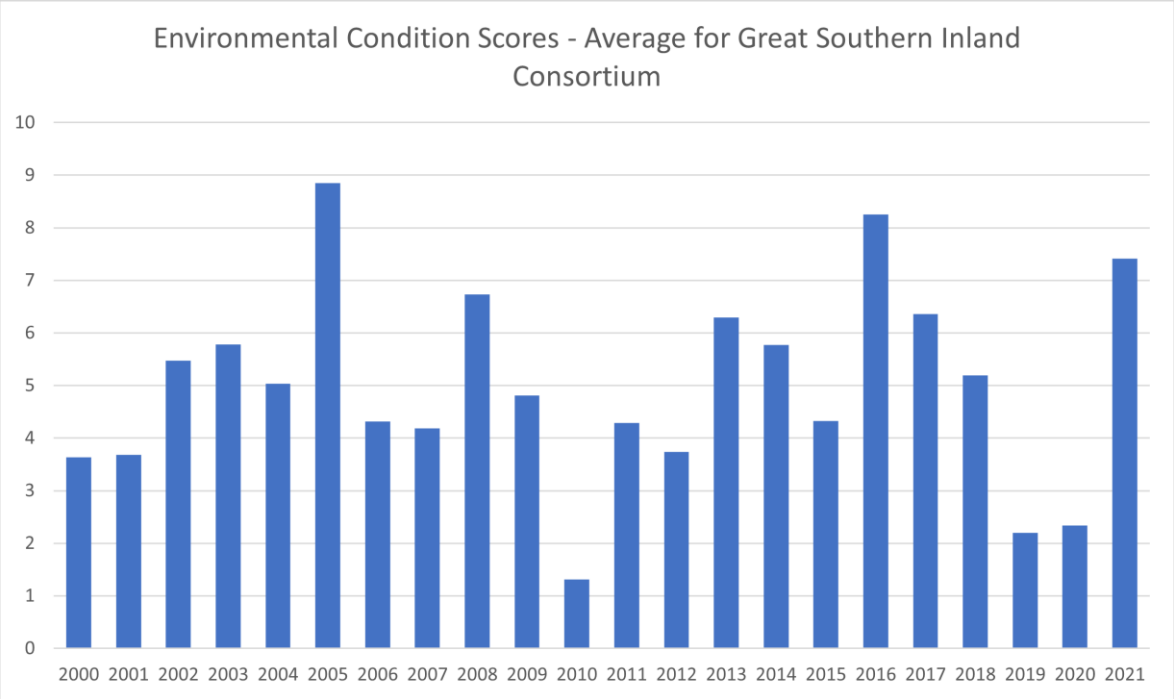


Figure 38 Annual environmental condition scores averaged across the Inland Great Southern Shires

This data appears to indicate recovery from drought can occur quite quickly in years following drought especially when rainfall is above average. However, considering the exposed soil the year after drought, the risk of water erosion is high with intense rainfall events.

The data provided by the four indicators selected show the historical impacts of drought. The risks associated with drought are the impact on soil with increased exposure -especially in the year after drought. This reinforces the need for careful management to prevent wind erosion in these years. The risk to vegetation and its growth is high which is supported by the literature and is exacerbated by extensive clearing of land in the Great Southern. This has exposed the soil and the remaining vegetation to further stress.

12.7 Impacts on Aboriginal Communities

Aboriginal Australians are likely to be disproportionately affected by drought on the basis of pre-existing health and social disadvantage[164]. Adaptive capacity and resilience to drought may be impacted by inadequate infrastructure and health services, and also by social disadvantage[165]. The health status of Aboriginal Australians is lower than that of the general Australian population. Specifically, Aboriginal Australians are more likely to have a disability or a chronic disease and have a significantly lower life expectancy than non-Aboriginal Australians[166,167]. Remote and very remote communities are particularly vulnerable.

Extreme weather events such as drought can impact on physical and social wellbeing, trigger feelings of loss and trauma during and immediately after the events, exacerbate existing stress and mental health issues, impact on livelihoods, affect financial security and cause significant uncertainty and concern for the future[107]. Prolonged drought impacts on rural and regional employment opportunities and degrades the environment.

This can affect Aboriginal peoples' ability to carry out cultural roles that support cultural identity. Barriers to Caring for Country impact on mental, emotional and physical wellbeing in Aboriginal communities[168,169]. During prolonged drought, Aboriginal Australians can experience solastalgia, a feeling of psychological desolation caused by the recognition that one's home is under physical threat and eroding one's sense of belonging[170,171]. The loss of identity associated with the inability to carry out cultural roles is highly correlated with increased rates of substance use and dependency, violence and suicide[103,106,172,173].

12.8 Impacts on Water Infrastructure & Resources

Water is an underpinning resource supporting economic, social and environmental functions across WA, with agriculture accounting for three quarters of total water use in WA.

Despite having relatively good access to piped water from the scheme, and proximity to community water supplies, water deficiencies are still being experienced. The cost to cart water to impacted locations cost the State government $11 million to June 2020[174].

Low storage levels in local town dams seen water carted to top up town supplies in recent years. Regions within the Shire of Jerramungup and Kent had water carted in for emergency livestock use 2020[175].

The lack of adequate on farm water supplies was cited as a key issue to be addressed to support farm business production into the future. Reliable, cost effective and accessible water supplies – both potable and non-potable sources, are believed to support improved drought resilience in agriculture and allied industries in the region.

Great Southern stakeholders stated that having confidence in water supplies to get through dry seasons or periods of drought (2 or more decile 1 rainfall years) is the number one priority to build drought resilience. The agricultural industry is at risk after 2 dry winters, with no significant runoff events.

Improvements to water infrastructure were among the most mentioned responses to help manage past dry seasons at both the farm and community level. Installation of more reliable and appropriate water capture, treatment and storage options, generally incentivised through government rebate schemes, were considered pivotal.

Recognising the importance of the water, Aurora was contracted to review the issues and concerns related to the supply and use of non-potable water in the Great Southern and Wheatbelt[176]. This included surveys with 13 LGS's within the region and consultation with a range of stakeholders involved in water resource management. The survey, consultation and review of policy identified key concepts for water supply during periods of drought. These are in the areas of:

- governance and framework
- partnerships and alliances
- knowledge and understanding
- resources and funding.

The report examines opportunities and constraints related to building resilience to drought and providing confidence in regional areas that there will be sufficient water for agriculture (e.g. stock drinking and crop spraying), community (e.g. firefighting, watering ovals and landscaped areas) and local government authorities (LGAs; road works and water for community uses).

The South West of Australia is experiencing a more drying climate, with greater climate variability and extremes. In the past 60 years, the average rainfall has declined by 20% while temperatures have increased, and these trends are predicted to continue (DPIRD, 2022).

These changes will overlay WA's already naturally large climate variability. It is predicted that the intensity and duration of hot spells is to increase across WA, with wet years becoming less frequent. Dry years, including drought, are likely to become more frequent (DPIRD, 2022). Impacts of drought on water resources will influence water security for these communities. This is due to:

- droughts becoming more severe due to drier hotter conditions;
- declines in soil moisture;
- hotter conditions and reduced rainfall have led to less runoff into streams, rivers lakes and dams;
- long term declines in rainfall;
- water infrastructure such as water supply reservoirs, dams etc have been designed for historic rainfall patterns;
- upgrading infrastructure to ensure supply of water is maintained is expensive; and
- changes in land cover whether it be due to fire, lack of plant coverage through lack of water can adversely affect catchment water supplies.

A range of impacts were identified during consultation. Key among these was the impact to on farm and community water supplies, with pressure applied to scheme water supplies provided by the Water Corporation.

Several localities in the region experienced water deficiencies, with deficiency declarations triggering State Government assistance to cart water for emergency use.

In this region, it is observed that water infrastructure is unable to keep up with demand. Farm practices and enterprise mix changes occurred during drought periods, with livestock being sold or agisted due to lack of feed and water. This correlates with increases in cropping area, that requires different quality water. There is inadequate water to maintain community infrastructure and green spaces. There is insufficient water to fight fires during drought events.

For communities in regional areas water resources are becoming an increasingly problematic issue because the South West of WA has experienced a fifteen percent decline in average annual rainfall since 1975. This has reduced recharge to groundwater aquifers from Geraldton to Esperance.

Across much of the South West corner of the state, groundwater is an important part of the water supply mix and is used for town drinking water supplies, to irrigate public open space, and for irrigated horticulture. Perth's groundwater resources provide more than 40 percent of scheme supplies to households and businesses; almost all the water supply used for parks, sports grounds, and agriculture; and one in four domestic gardens.

Waterways and wetlands in catchments are important for nature conservation and local ecology health water ways and local drainage for floodwater discharge. Drought severely impacts natural aquatic ecosystems, with the major impacts being the loss of water and habitat availability, and the reduction, if not severing, of connectivity.[151]

In times of drought where water resources can already be scarce, the degradation and pollution of freshwater systems with harmful algae blooms creates a significant risk to aquatic ecosystems and the animals and humans that rely on them. Cyanobacteria, or blue greens, produce potent toxins that can be a risk to livestock and other animals that drink or swim in

contaminated water.[177] They can kill native birds and can pose a threat to human health by direct skin contact and consumption of shellfish that have lived in contaminated water.[153]

Information about the condition of the water ways and wetlands in the pilot regions is limited. This review was unable find recent studies or evaluations of the health of water ways. The State of the Environment report in 2007 reports on the condition of major Western Australian rivers indicating the rivers in the study regions were either significantly impacted or impacted, measured by key macro-invertebrates as an indicator of the river ecosystems.

Jatlin et al (2021) more recently reports on the impact of a drying climate and how many rivers and lakes are now dry through summer and autumn causing major problems for freshwater biodiversity. They state the number of invertebrates in 17 lakes in WA fell from over 300 to just over 100 from 1998 to 2011, and that the impact on freshwater fish unable to migrate to spawn means they are near to extinction.[178]

12.9 Impacts on Horticulture & Viticulture

Grape vines are reasonably 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, thus impacting on productivity and cost of producing wine.[179] The wine growing region for the pilot regions is in the Cranbrook shire mostly west of the Albany Highway in a high rainfall environment.

12.10 Impacts on Non-Farming Businesses

Small and medium sized enterprises (SMEs) are considered critically important in the local communities, especially in regional areas and their viability is considered a prerequisite to the future vitality of regional areas. Despite this, little is known about the impact of drought on the operation and viability of SMEs.

A Queensland study identified businesses experience cash flow problems, increased prices, reduction in staffing, costs, stock and spending. These issues were compounded through lack of entrepreneurial and managerial skills, declining populations, skills shortages, business discontinuance, lack of infrastructure and lack of access to government assistance or incentives.

SMEs considered most vulnerable to drought are those with short term planning and narrow focus; less skills in management; fewer resources; limited market share and a conservative approach to risk management. Those with direct links to rainfall, such as those servicing the agricultural industry are particularly exposed.

This study found that SMEs able to access diverse income streams reduced the financial impact of drought, including government, non-agricultural industries and tourism markets[180].

13. Drought Interventions and Adaptation Strategies

13.1 Western Australian Adaptation Strategies

Technological, behavioural, managerial and policy adaptation strategies are identified as important factors in mitigating the effects of drought and improve productivity into the future. In particular:

- on farm diversification
- debt management practices
- accessing farm management and business support
- undertaking measures for improved crop varieties and technologies.[181]

Findings from the Natural Resource Management Drought Resilience survey, conducted by ABARES in 2021[182], reveal the types of farm management practices currently being undertaken by WA farmers and by what percentage, summarised in Table 9. With over half of survey respondents stating that they had adopted new land management practices, it is evident that farmers are employing best practice in land and business management and this is becoming an essential part of most farming businesses.

De-stocking early, improving soil acidity levels and minimising tillage are the three measures most frequently used, while less than 30% of respondents were involved in planting or maintaining deep-rooted perennial pastures and only 14% were undertaking carbon farming/sequestration.

Table 9: Summary of drought mitigation practices in WA

Farm Management Practices – WA (2021)	Used Practice
De-stocking early in low rainfall periods to preserve groundcover	74%
Improving soil acidity levels	73%
Minimising tillage or cultivation	72%
Increasing on–farm water storage	65%
Optimising pesticide or fertiliser use and reduce reliance	60%
Improving soil water retention	59%
Increasing fodder and grain storage	53%
Regrowth of native vegetation	52%
Setting a long-term minimum ground cover requirement	49%
Cell, strip or rotational grazing	47%

Farm Management Practices – WA (2021)	Used Practice
Incorporation of organic matter	43%
Use of cover crops, mulching or matting, or other ground cover	43%
Reducing long term stocking rates	40%
Using technologies/tools to support climate related land management decisions	39%
Fallow	37%
Controlled trafficking	34%
Using more water efficient crop or pasture varieties	34%
Planting or maintaining deep-rooted perennial pastures including fodder shrubs	31%
Carbon-farming/sequestration	14%

Additional findings from this survey highlighted:

- 75% of respondents believed that increasing drought resilience was considered a very important motivator for adopting various farm management practices
- 83% of dairy farms were motivated by financial considerations
- 76% of sugar and other livestock farms were more motivated by environmental factors.

Barriers to changing practices included:

- time (78% of all farms)
- lack of funds (73% of all farms)
- legislation or laws (73% of sugar and livestock farms).

At the sub-regional level, management of landscapes to reduce impact of erosion events (e.g., increased levels of vegetation, permanent plantings) and improve biodiversity are a gap worth noting.

Additionally, regional communities are concerned with maintaining reliable water and power supplies, arresting declining populations, and building economic diversification to help with building resilience to drought events.

13.2 Natural Resource Management

The WA Landcare Network (WALN) which is a not-for-profit peak body providing support to a range of groups works to improve the natural environment. Table 10 outlines some of the organisations working toward this in the pilot regions and provides a snapshot of their current programs and projects.

Table 10 Example organisations and current projects in the pilot regions

Organisation	Current Project
SCNRM Inc	1. Land a. Farmers helping farmers to Maximise soil moisture and producing in prolonged drought areas 2. Biodiversity a. Black Cockatoo survey b. Land for wildlife c. Managing dieback d. Protecting biodiversity restoring Gondwana e. Drone technology 3. Water a. Ramsar Wetlands b. Yakamia Creek c. Fish Friendly Farms 4. Coastal & marine a. Coastscapes coastal corridor b. Bringing oysters back to oyster harbour c. Protecting our shorebirds 5. Culture & community a. Restoring Noongar Boodja – by respecting, recording, applying and sharing Noongar knowledge in NRM b. Merinj Kaartdijin – Aboriginal food knowledge fourm c. Aboriginal Engagement: Strong and proud program https://southcoastnrm.com.au/what-we-do/
Fitzgerald Biosphere Group	● WaterSmart Dams – making dams work again ● Meet our shore birds: Protecting the Wellstead Estuary's Birdlife ● Understanding trends in falling numbers in the medium to high rainfall zones in WA ● Locally relevant Spring & or summer grown cropping opportunities for grain growers suffering excessive winter water logging ● Increasing ground cover to build resilient soils in the Wester Biosphere ● Regenerating saline land: a new approach to an old problem ● Reclaiming the margins – turning unproductive land into sustainable grazing assets using the Enrich Project Model ● Regional land partnerships https://www.fbg.org.au/news
Gillamii Centre Inc	● Connecting and protecting the Kent-Frankland region ● Producer demonstration site: Productive salt land pastures for southern WA ● Farmers helping farmers to Maximise soil moisture and producing in prolonged drought areas ● Flora, Fauna and farming: Connecting kids to country ● Community carbon & conservation ● Productive salt land pastures in southern WA ● RLPGIL climate and SSS trial ● Kent shire fox baiting ● Environment Protection and Biodiversity Conservation Posters ● Bieber Trials https://www.gillamii.org.au/current-projects
Katanning Land Care District Committee (LCDC)	1. Creating and maintaining health farms 2. Improving and protecting Biodiversity and Habitat 3. Creating Sustainable Living programs 4. Improving water security – both on and off farm https://katanninglandcare.org.au/partners/projects/
North Stirling's Pallinup	● Restoring an Ancient Landscape ● Strategic fox baiting ● Regional Land Partnerships ● Waterways Restoration – connecting the Pallinup River its people and culture https://www.nspnr.com.au/current-projects
Gondwana Link Ltd	The Gondwana Link project is a biodiversity and cultural conservation strategy for the Great Western Woodlands in recognition of Ngadju's people who have exclusive Native Title over 4.4 million hectares ● Reconnecting country, from the Karri forests of the far South West to the woodland and Mallee bordering the Nullarbor, in which ecosystem function and biodiversity are restored and maintained. ● Nowanup Restoration

Organisation	Current Project
	• Nullaki feral control and fauna monitoring • Fencing the Oyster harbour catchment • Large-scale restoration at Peniup • Restoring wetlands and hooded plovers

13.3 Agri-Environmental Practices & Technologies

As outlined at the start of this document the environment provides significant eco-system services to agricultural production. It is in the interest of the managers of agricultural landscapes to have a healthy ecosystem and also to manage land to prevent offsite impacts.

Agri-environment activities are typically designed to achieve positive environmental and/or land management outcomes. In addition to these intended benefits, these activities are widely acknowledged as often having co-benefits, particularly social or economic benefits that may not be the intended objective but emerge as people engage in managing these activities.

A survey funded by the Department of Agriculture, Water and the Environment was conducted by ABARES. The purpose was to identify NRM practices producers were undertaking, including finding out what motivated them and identifying barriers to adoption with the aim of providing data to support the monitoring of long-term drought resilience indicators alongside the implementation of Future Drought Fund (FDF) activities.

The producers surveyed (n=2,355) accessed information about drought preparedness practices mostly from their peers, neighbours or friends, the internet was a source of information for 32% of respondents and a small percentage (24%) used private consultants. Only 10% used government extension officers. Although, there was a relatively high awareness of the National Landcare Program (NLP) (79%) and the Future Drought Fund (60%).[183]

The survey revealed that farmers are aware of the importance of maintaining groundcover as 84% of farms surveyed were retaining stubbles, most reporting they adopted this practice more than 3 years ago.

This strategy had the highest uptake. Increasing drought resilience was most commonly considered a very important motivator for adopting various farm management practices on broadacre farms. 68% of farms surveyed were de-stocking early in low rainfall periods to preserve groundcover and 27% were implementing a strategy of reducing long-term stocking rates and 22% increasing fodder and grain storage.

A lack of funds or lack of time were the main barriers to changing practices. Management practices identified by ABARES as key strategies for improving drought resilience that were included and asked about in the survey are:

1. Minimising tillage or cultivation (e.g., permanent beds, direct planting);
2. Periods of fallow in crop rotation;
3. Retained stubble;
4. Controlled trafficking (e.g., constant wheel spacing, traffic lanes);
5. Incorporation of organic matter (e.g., mulch, green manure);
6. Use of cover crops, inter-row crops, mulching or matting, or other ground cover;
7. Management practices to optimise pesticide or fertiliser use and reduce reliance;
8. Planting or encouraging regrowth of native vegetation;
9. Cell, strip or rotational grazing;
10. Setting a long-term minimum ground cover requirement;

11. Planting or maintaining deep-rooted perennial pastures including fodder shrubs;
12. Using technologies/tools to support climate related land management decisions (e.g., APSIM, Climate Kelpie, Yield Prophet);
13. Increasing on-farm water storage;
14. Improving soil water retention;
15. Improving soil acidity levels (e.g., lime application);
16. Using more water efficient crop or pasture varieties;
17. Increasing fodder and grain storage;
18. Reducing long-term stocking rates;
19. De-stocking early in low rainfall periods to preserve groundcover;
20. Carbon-farming/sequestration.

The data is only available at State level and identifying nuances for the pilot regions is not possible. Interestingly the motivation for implementing measures were strongly influenced by building drought resilience and environmental.

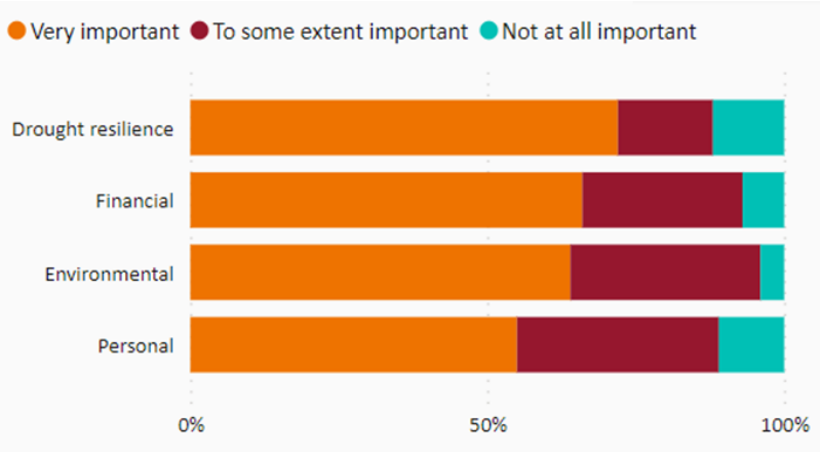


Figure 39 Motivation for Implementing Agri-Environment Practices

Agri-environment activities in the agricultural landscape are diverse, and it is likely that some have no effect on resilience to drought while others may have a positive effect for some types of farmers[184]. Results from Brown and Schimmer (2018) analysis of the Regional Wellbeing Survey (RWS) suggest that targeted investment in agri-environment strategies can help farmers build resilience to drought by designing programs that assist farmers to:

- forward plan for a range of risks including drought: the results showed that risk planning, rather than drought planning, was the stronger predictor of drought resilience;
- maintaining groundcover;
- feral animal control;
- increasing water use efficiency;
- increasing feed reserves and financial reserves (not exactly agri-environment practices but they were associated with improved resilience to drought).

13.4 Transformational Interventions

13.4.1 Non-agricultural Landscapes

Technology is providing some solutions for managing and building resilience in the environment, technologies such as:

- real time data on health of habitats, biota and biological processes allowing us to mitigate the threats;
- imaging techniques such as those used to generate the data to understand the impacts of drought;
- remote sensing with aerial and aquatic drones;
- robotics - robots wondering around collecting data do little to disturb the biodiversity and can enter places that either cannot or should not be entered by humans;
- cyborg animals - remotely controlled by humans using microchips linked to the animals' brain;
- camera trapping and the deployment of motion detection cameras.

Two contemporary systems being developed are the Australian Ecosystems Models Framework[185] and the Habitat Condition Assessment System[186] . The Australian Ecosystem Models Framework project is collating, synthesising and summarising scientific knowledge of ecosystem dynamics and will capture this knowledge in a set of dynamic ecosystem models. These models will describe the dynamic characteristics and drivers of Australian ecosystems in unmodified and modified states.

The Habitat Condition Assessment System project is aiming to provide Australia with its first consistent, repeatable and cost-efficient national biodiversity habitat condition assessment and reporting capability—Habitat Condition Assessment System (HCAS). It is expected that this new system will enhance our capacity to:

- identify priority areas for management interventions
- undertake national environmental reporting
- identify natural and non-natural influences on habitat condition.

The HCAS approach breaks new ground through its use of remote sensing, spatial ecological modelling and sparse data from on ground condition assessments to generate a national view of condition.

13.4.2 Agricultural Landscapes

In Western Australia and Australia generally adaptation to climate change and finding solutions to reduce emissions in agriculture has included questioning current farming practices considered best practice but with a high level of dependency on manufactured fertiliser and use of chemicals to manage weeds and pests. The cost of these inputs has recently increased and resistance of some pests and weeds has also facilitated discussion about alternative farming systems. Regenerative agriculture is potentially an opportunity to improve agri-environment outcomes and is discussed further.

13.4.3 Regenerative Agriculture

Regenerative agriculture is widely considered an alternative means of food production with lower, or net positive environment and social impact.[187] The report on Climate Change & Land for IPCC defined RA as sustainable land management practices focused on ecological functions that can be effective in building resilience of agro-ecosystems.[188]

DPIRD have defined it as an approach to farming that uses natural systems to increase biological activity, sequester carbon, rejuvenate soil health, improve nutrient cycling, restore landscape function, and produce food and fibre while aiming to maintain or improve farm productivity.[189]

Regenerative agricultural systems are often defined by the inclusion of practices, such as cover crops, crop rotations, and the integration of livestock into the system.[175] There are also several practices where their exclusion is definitional of RA, including no- or low-tillage, and reducing synthetic inputs such as fertiliser and pesticides.[175]

Outcomes and goals of regenerative agriculture revolve around improving soil health and structure of agricultural land, aiming to increase carbon sequestration into the soil, increase biodiversity and improve water resources.[175]

The Food and Agriculture Organisation of the United Nations (FAO) estimated in their report that at the current rate of soil destruction through conventional agricultural (CnvA) practices, the world will run out of topsoil in 60 years.[190] CnvA currently destroys soil structure, significantly reducing its ability to perform in climate friendly, sustainable ways, and reduces its resilience to climatic events through reduced water retention and increased susceptibility to erosion and nutrient leaching.

Transitioning to regenerative agriculture practices has been identified as fundamentally important to meet climate change targets, food security needs, protect farmland and build healthier food systems.[178] They can build resilience in farming systems by reducing or even reversing the effects of climate change by sequestering carbon into the soil, increasing ground cover with cover crops, improving biodiversity to reduce soil erosion and nutrient leaching, and improving soil structure to enable greater water retention and water use efficiency.[177]

There are multiple practices that farmers have already implemented in their farming systems, including moving to low- or no-till operations, and implementing crop rotations. However, there are also many barriers preventing producers from moving more towards regenerative agriculture systems, particularly in broad acre farms in WA.

Yields of crops from regenerative agriculture are lower than those achieved with CnvA.[177] This loss of productivity equated to a decline in profitability, particularly in the first two or three years after switching to an regenerative agriculture system where yields are reduced due to the time for soil biomes to establish equilibrium, and when the farm is yet to be eligible for any price premiums that are available for more sustainable products.[177] This loss in profit can be particularly difficult for businesses with a high level of debt.

The transformation cost of changing to regenerative agriculture practices can also be a significant barrier to producers moving to this system of farming. These costs can be both financial and opportunity costs. There is a significant time cost to changing on-farm practices, including the time to research and learn the practices to enable implementation.[177] There are always financial costs associated with implementing a new way of doing things, whether it be an investment into the infrastructure for regenerative agriculture, or the opportunity cost from reduced yields.

Regenerative agriculture adoption faces a major barrier in Western Australian broadacre farms through the Southern Wheatbelt and Great Southern pilot regions. There has been a change in the structure of these farming systems over the past two decades, with many producers significantly decreasing the percentage of their farm allocated to livestock, and many farms getting out of livestock production all together.

Livestock can play an important role as it allows for more cover crops to be planted, crop rotations to include pastures and for land to put to permanent pasture while remaining productive. These practices all have positive impacts on improving soil structure, sequestering carbon, and reducing erosion. These outcomes can be vital in building resilience to drought in agricultural systems.

13.5 Farmers' Response to Drought

Resilient farming systems which have the capacity to adapt to changing environments are key to the future success of farm businesses facing uncertain conditions. Farmers mitigate risk with their management practices. Through active management, farmers limit the effects of climate and price risk. For example, in the cropping sector farmers make use of weather and commodity price forecasts, reduce crop area planted and inputs applied (like fertiliser) when drought conditions or poor output prices are more likely.

In the livestock industry farmers monitor pasture growth rates, store adequate quantities of grain and hay, and generally run lower stocking rates. The importance of organisational skills and timely management decisions cannot be underestimated for managing risk and farm performance.

Decision making processes for the farm business can be improved. The literature shows that, although farmers make many of their decisions based on 'gut feel' or rules of thumb, that their decision making (and that of their advisors) can be improved by encouraging them to access more information, reflect more on their experiences and get a better understanding of the relationship between the many variables of their business

Farm business management is about converting resources, skills and competencies into a financial outcome to meet business and family lifestyle goals. Decisions are made on physical inputs and outputs, which are determined by climatic, technical, and economic environment, it is about responding to a complex set of variables and risks. Like most walks of life, risk and uncertainty are inescapable.

The complexity associated with understanding these risks and the many variables and their interactions is time consuming, therefore, many farmers outsource their most basic financial analyses to a third-party which is costly. The advantage to this strategy is having a third party with expertise to discuss options. The disadvantage is the third party usually has control of the economic model and numbers. The farmer has to rely on the firm to "crunch-the-numbers."

13.6 Regenerative Agriculture – Case Study

A farming group WHAGS operates across the agricultural zone with members having participated in a holistic farming course and/or practice regenerative agriculture. A field trip by the WHAG's members in April 2022 to Lyn and David Mathwin's farm southeast of Kojonup, provided an opportunity to hear about strategies implemented by the Mathwins to increase drought resilience. A summary of these strategies is discussed below.

Lyn and David run 1300 Merino breeding ewes on 880 hectares. During the 2018/2019 dry years, the Mathwin's invested in additional water infrastructure including a new, 375000 litre tank and polypipe. This extended water supplies from two key dams to 90% of paddocks and reduced evaporation loss by using tank storage. The tank fills from existing roof catchment in subsequent wetter years.

In 2019, both key dams went dry after three years of severely reduced rainfall. The Mathwin's were able to purchase water from a neighbour who had installed a desalination unit. This was noted as cheaper than the standpipe in Kojonup and closer to travel. Without access to this supply, the cost of water and carting distances would have further impacted the farming operation during the dry seasons.

The Mathwins established perennial pastures as part of their normal farming operation. These were used as drought resources to help them get through the dry seasons.The Mathwin's noted that, with consecutive dry seasons, the perennials were not able to be rested

adequately. Hence there was an impact on the survival of some species, so they aimed to replant some of the perennials. They noted the advancement in perennial species since they were planted over 20 years before. Due to the perennial pastures, Lyn and David fed out less grain and hay during the dry season and were able to maintain a higher-than-expected number of stock during the drought.

The Mathwin's did however reduce livestock numbers, reducing older ewes and replacement ewes. This flexibility in managing the livestock numbers was seen as a good strategy to reduce the economic and ecological risk of drought.

Cell grazing has been implemented on the Mathwin's farm for over 20 years. This is where the paddock is grazed with higher stocking rates and then rested for extended periods for pasture recovery. This enables farmers to plan for the season, as the farmer knows exactly at any point the capacity of the feed supply to maintain livestock for a certain period.

These critical decision points can then be implemented based on the season, good planning and with less reactivity. This helps with mental health in knowing you are adequately prepared for dry seasons.

Maintaining soil cover and soil health is seen as critical by Lyn and David, hence they ensured there is no overgrazing or erosion during dry seasons.

Lambing is undertaken in June to ensure that the ewes have maximum plant growth during the highest time of lactation. This also reduces the risk of soil erosion during the autumn feed break. The farm also runs cattle which calve in August to capture the highest period of grass growth coinciding with highest requirements for lactation. Their ambition is to 'kick the hay habit'.

The Mathwin's use the holistic management framework for decision making which includes ensuring the farm business planning is in place prior to the drought. An example of this framework includes:

1. Drought proofing (preparation for the next drought, while we don't have one);
2. Managing effectively while in a drought; and
3. Recovering as fast as possible.

Drought goal: To maintain the land and productivity with a view to long term soil health, sustained pasture stability, sustained profit and happy homes (source RCS).

Photo 1 WHAG members discussing drought resilient strategies, April 2022

13.7 Carbon Farming

Carbon farming is the term used to define agricultural practices and land-uses aimed at either sequestering carbon from the atmosphere or avoiding the release of more greenhouse gases.[191] Agriculture is responsible for 14% of Australia's GHG emissions, meaning finding ways to reduce these is important for meeting climate change objectives. Producers can benefit from these practices through increased productivity and profitability, and by meeting national objectives with funding and special market opportunities.[179]

Atmospheric carbon dioxide can be sequestered into soils, vegetation, and the ocean. Increasing the proportion of the year a soil is actively growing a crop or pasture, and the amount of organic matter that is returned to the soil through stubbles and reducing loss from erosion can have a positive effect on soil organic carbon levels.[192] Increasing carbon levels in soil is beneficial to soil function and fertility, resulting in an increase in productivity.[180]

Reforestation and revegetation of land has the potential to sequester the most carbon per hectare.[179] Undergoing these projects can also result in co-benefits both ecologically and financially. Revegetation can provide ecosystem services, including ameliorating saline soils, preventing wind and water erosion, and improving biodiversity.[193] Return on investment may come from forest plantations or from carbon credits through the emissions reduction fund.[181]

Sequestration practices may include:

- increasing soil organic carbon through application of biochar, claying, green and brown manuring
- liming to increase sequestration
- permanent environmental plantings & revegetation.

Reducing the emissions of greenhouse gases is also typical of carbon farming. Agriculture emits GHGs through several activities, including burning biomass, livestock management,

adding nitrogen and animal manure to soils and returning crop residues to soils.[179] Better management of fertiliser use and manure, reducing livestock emissions, and strategically managing fire are all ways that landowners can reduce their on-farm emissions.[179] Avoidance practices may include:

- reducing nitrous oxide emissions by using less nitrogen fertilizer
- managing manure to reduce methane emissions through composting or manure stockpile aeration, use of urease inhibitors to stockpiles, biogas systems
- managing livestock to reduce methane emissions using feed additives that reduce methane production, breeding for methane reducing genetics and/or managing pastures.

Carbon farming activities are considered to create positive environmental outcomes, and there is believed to be a link between carbon farming and drought resilience.[194] While there is still a lot of research to do in this area, there is significant anecdotal and data-based evidence to support this.[195]The common carbon farming activities that enhance biophysical resilience to drought include:

- regenerative grazing practices to maximize pasture productivity;
- increasing soil carbon to create healthier soils;
- planting shelter belts to reduce water evaporation in pastures - improve water holding capacity;
- providing shade and shelter to livestock for more severe weather conditions.

A project identified during stakeholder engagement, included the option to integrate carbon farming to low value agricultural land across a number of properties. This is an example of a project that would have significant benefits to the environment, in addition to a potential economic benefit to landholders in the region.

13.8 Social Capital

In the Great Southern region, community events and projects support ongoing connection and opportunities to volunteer during periods of drought.

While communities came together to support each other, the burden of organising events and coordinating groups often falls to the same people, who are also struggling to get their businesses through drought. It was recognised that the lack of local capacity to stage and manage events to meet regulatory requirements meant large events may be more difficult to offer in the future in regional areas. This is inside and outside of drought situations. The financial and emotional stress of drought may result in a decline in the frequency of local events and gatherings.

Community focused projects and participation in sport or recreational pursuits provided much needed relief during dry periods. Stakeholders value maintenance of green spaces – both at the community and individual level – in supporting sporting participation and sense of escape in a droughted landscape.

Aboriginal people have strong interactions and connections with natural resources and landscapes in the region. Traditional owners in the Great Southern region identify the decline in conditions of vegetation and waterways across the region as emotionally damaging.

Active efforts to rehabilitate and regenerate landscapes are restoring connection to land, while supporting the economic participation of Aboriginal people through business opportunities including seed collection and seedling raising and revegetation efforts. The demand for seedlings for carbon offset plantings are providing a driver for this activity in the region[196].

The UWA team used the resilience literature[197,198,199,200,201,202] to develop a transition roadmap for building resilience to the social impacts of drought. The roadmap includes four stages: infrastructure; governance; population retention; and social capital.

Stage 1 Infrastructure: development of quality water, road and support services infrastructure forms the essential basis for building resilience in drought-exposed communities[203].

Stage 2 Good governance: establishes drought risk reduction and preparedness measures through drought planning, secure and continuous government funding for drought resilience and the ongoing involvement of community leaders and local government in the dissemination of relevant information.

Stage 3 Population retention: in rural and regional areas experiencing drought is achieved through financial support, employment opportunities and stimulus packages.

Stage 4 Social capital: is built by supporting community social networks and social cohesion[204,205]. Both social and task-focused community groups positively impact community well-being. Social cohesion can be encouraged by developing and implementing programs that strengthen intercultural initiatives, celebrate diversity and address social justice and equity issues.

Recommendations for building social resilience to drought include:

- ensuring communities have sufficient water, energy, transport and support services infrastructure to support the needs of the whole community, including local health[206,207,208] and financial services
- ensuring good governance, including the development of drought plans and strategies, water management planning and investment in disaster management, risk reduction and preparedness
- ensuring population retention in rural and regional areas through government financial support during drought, providing income security to both farming and non-farming populations, decreasing out-migration and helping to retain employment within rural communities
- increasing local support service networks, including access to rural financial counsellors, education and health care services, recreational facilities and work opportunities
- strengthening community social networks and social capital and supporting community events
- ensuring early recognition of and effective response to poor mental health, including employment of drought support workers, programs to support youth and the elderly, after-hours access, home visits and telephone / online services for counselling and advice[209,210]
- mapping government funding for drought resilience against outcomes frameworks which are in line with resilience and vulnerability frameworks.

A detailed report on the social impacts of drought can be provided on request.

13.9 Cultural Interventions

13.9.1 Integration of Traditional Knowledge

Traditional ecological knowledge (TEK) can offer effective solutions for land management and adaptation strategies. Operationalising TEK can provide opportunities for local empowerment and employment that can, in turn, address health and wellbeing, cultural and social needs[211].

Nyoongar people highly value *kallip* – the amassing and preservation of knowledge about people, their environment and its systems. There is a desire to share this knowledge with government and industry, though there is a lack of a suitable framework to do so in agricultural regions.

Developing and sharing Noongar "science" to support the improved condition and potential restoration of significant gathering places such as the water pools, was an expressed desire of Nyoongar Elders.

Barriers to participation and integration of Noongar cultural land management to support drought resilience include:

- lack of appropriate access to country, limited Noongar owned country;
- inappropriate Noongar engagement being considered an afterthought or add on, not genuine in its intent including lack of appropriate compensation when mobs are engaged;
- lack of respect, awareness or value of Noongar knowledge and cultural heritage, including incorrect use of cultural protocols;
- misalignment of government boundaries with Noongar Boodjar and Noongar clan groups;
- funded projects that do not weight Noongar led initiatives adequately, limiting collaboration and projects that require Noongar engagement, but do not consider the costs of this, with an expectation this is done voluntarily;
- Noongar people feel over consulted and under-represented in strategies and projects.

13.9.2 Aboriginal Economic Development Opportunities

There are opportunities for Aboriginal businesses to participate and benefit from initiatives to support drought resilience. Noongar Land Enterprise Group (NLE) is a grower group - Noongar owned and operated, active in its pursuit of a range of business ventures including beef, honey, sheep, sandalwood, cultural tourism, bush foods and youth training programs[212].

Looking after country, cultural connectivity and rejuvenation are core elements of the management of NLE land assets in the Wheatbelt and Great Southern region. NLE are well placed to tap into opportunities to build drought resilience across the landscape, while achieving economic and cultural outcomes. NLE are small in size compared to other farming enterprises and diverse, with objectives to drive genuine change for Aboriginal people.

Three case studies were showcased by NLE as part of their research for this project. The case studies demonstrate how degraded *boodjar* (land) can be regenerated through traditional land management knowledge and practices, while still generating a profit.

Climate and drought resilience initiatives would be important to include as part of the economic framework being developed to sit alongside the Indigenous Land Use Agreements that form part of the South West Settlement.

13.9.3 NLE Framework for Action

NLE propose the need for a Framework for Action to facilitate genuine coordinated engagement of Noongar people in initiatives across the regions. They recommend the framework should be Noongar led and that this approach would improve coordination of consultation efforts across agencies – often working in isolation, though consulting with the same people and organisations.

It is proposed this approach would facilitate and indicate a commitment from government and industry to genuinely incorporate Noongar knowledge and practices. It would encourage:

- cross agency collaboration and alignment to regional and organisational priorities
- a focus on healthy country and work from a strength-based approach
- Noongar participation in the restoration economy
- community engagement and collaboration on industry priorities, markets and outputs.

The Djarlma Plan developed for the WA forestry industry is referenced as a model to work towards[213]. Detailed reports on the impact of drought on Aboriginal people and communities are available on request.

13.9.4 Noongar Land Management – Case Studies

Although the economic and environmental impacts of drought have been widely studied, few studies have examined the broader impacts of drought and how Noongar peoples land care have developed and implemented drought resilience practices. NLE captured this in three case studies as described below.

Dowrene Farm Aboriginal Corporation

This case study documents the culturally based land management practices on Dowrene Farm between Franklin River and Cranbrook in Western Australia. The 720- hectare property is managed by the Dowrene Farm Aboriginal Corporation and was an inaugural member of the NLE Group.

Dowrene Farm was bought by the Indigenous Land Corporation in 1999 and divested to the Dowrene Farm Aboriginal Corporation in 2009. The name Dowrene is a combination of Chairperson, Director, and elder Maude Bonshore's parents' names - Dowey and Irene. Maude's son Rhys Bonshore manages the farm.

The commercially successful farming business started initially as a sheep enterprise and has since investigated diversification for its income stream and conducted land rehabilitation. The property also holds cultural significance with 9 burial sites around the farm.

Data was collected by NLE staff through personal contact, written information including photos, reports, and stories provided by the Directors of the Dowrene Farm Aboriginal Corporation and desktop research. Video recorded interviews were also done on country, showcasing collective local knowledge and cultural land management practices.

Dowrene Farm Aboriginal Corporation has invested a large portion of income to:

- rehabilitation of three creek lines by fencing and replanting native species;
- rehabilitation of five areas of remaining trees by fencing and replanting native species;
- rehabilitation of two gullies caused heavy rains, by fencing and replanting with trees;
- cleaning out 15 Dams of silt/sediment caused by run off;
- fencing run off areas into 13 Dams and planting trees to reduce future slitting and sediment;
- construction of four new Dams with an area of 3,000 square meters each;
- maintaining the two original water tanks consisting of 20,000 litres of potable water.

The Directors have increased potable water substantially to 333,000 litres by installing 8 x 22,000 Litre Water Tanks, 3 x 33,000 Litre Water Tanks, and a 42,000 Litre Water Tank. In the future, Dowrene Farm aspires to have a fresh water bore drilled. Initial surveys for fresh water have been conducted and areas of interest noted.

Image: Aerial view of the boundaries and fenced rehabilitation areas of Dowrene Farm.

Photo 2 Aerial view of the boundaries and fenced rehabilitation areas of Dowrene Farm

13.9.5 Beemurra Aboriginal Corporation

This case study documents the Beemurra Aboriginal Corporation's thriving business in sustainable cattle agistment and backgrounding. The freehold property is owned and operated by the Beemurra Aboriginal Corporation (Beemurra). Beemurra was established in 1998 out of the interest of developing a family farming business to support local enterprise development in the Yued community.

The Corporation's property is Yallalie Downs, a 1242-hectare property on Yued country in Dandaragan. It is run and managed by a multi-generational family, led by Kevin Barron and Director Madeline Anderson, who manages the only Aboriginal-run backgrounding business in Western Australia.

Backgrounding is a process of accustoming cattle to more intensive intermingling and feeding and watering them until they reach a goal weight. Backgrounding requires careful management, including stress-free stock handling techniques, which allows the animals to graze calmly and to increase body fat. The management system also requires an effective rotational grazing system so the pastures can recover, and sturdy fencing to keep the paddocks separate. Beemurra has extensively planted perennial native grasses as the primary feed for the cattle.

The Yallalie meteorite crater is a feature of the property, which Beemurra have started using as a key feature in cultural youth camps, sharing Aboriginal stories of the night sky. Each camp event is aligned with a Noongar season. Camping with the seasons on Yallalie Downs youth camps offers a cultural healing space, drawing on cultural astronomy and science to deliver leadership skills and social benefit.

Beemurra Aboriginal Corporation exists to:

- work with the land and support social and economic development for Aboriginal people;
- develop regenerative agricultural practices;
- build a financial base for community development activities;
- promote community development in the areas of education, health, employment, and welfare;
- provide assistance to achieve better educational outcomes, training, and employment opportunities;

- support promotion of language and culture; and
- hold land title in its own right and use the land for the benefit of the community.

Photo 3 Establishing first perennials

13.9.6 Yaraguia Enterprises Incorporated

This case study documents the regenerative farming practices on Yaraguia Farm in the Shire of Beverley located 122 km East of Perth. The Yaraguia Property (Avondale Park) is 832 hectares and was acquired by the McGuire family in 2008 under the environmental stream of the Land Acquisition Program of Indigenous Land Corporation. The name 'Yaraguia' is derived from the combining of two Noongar family groups – the McGuire's and the Yarran's.

The Yaraguia Property is noted as a great example of traditional custodians and 'European farmers' coming together to share learnings on regenerative farming practices. The property also has several sacred sites previously undiscovered, and carvings made by Noongar ancestors.

Yaraguia Farm's key focus is:

- demonstrating regenerative farming practices in the hope that it will be widely accepted as being integral to the future of Western Australian agriculture and biodiversity;
- 'healing the country' in partnership with Greening Australia and the Avon Catchment Council by developing a fully structured re-vegetation and conservation program as a process of regenerating the property back to its more natural state and biodiversity;
- developing contemporary and culturally appropriate processes to fight salinity and soil erosion and to contribute to the reduction of greenhouse effects;
- incorporating European traditional farming practices such as crop growing and grazing sheep as part of its lease-back agreements and farm forestry (Native Sandalwood) while developing 'non-traditional' farming options such as native rehabilitation and revegetation, with the aims of producing bush foods, medicine, and possible carbon sequestration for securing environmentally, culturally and economically sustainable land management practices.

14. Key Water Issues for the Inland Great Southern

14.1 Water Supply

The Great Southern towns water supply scheme (GSTWSS) is the main scheme supply for inland towns in the region. The scheme provides potable water to nine towns in the Great Southern region: Broomehill, Tambellup, Gnowangerup, Katanning, Nyabing, Pingrup, Kojonup, Woodanilling and Muradup. It also supplies water to towns within the Wheatbelt and Goldfields regions. Water is sourced from the Harris dam near Collie. An average of 7.8 GL/year has been supplied to the scheme during the past three years.

Supply to some towns including Cranbrook, Borden, Ongerup, and Jerramungup is supplemented by small local dams with roaded or bitumen catchments. Water demand is not expected to increase in these towns however, water quality and the cost of maintaining local catchments are challenges for ongoing supply. The Water Corporation carted water to many of these smaller regional towns during 2018-2020.

The *Great Southern Regional Strategic Water Supply Strategy* [214] reinforces there is insufficient water to meet future demand on the GSTWSS. The report notes the Water Corporation is investigating in several options to improve water security for the scheme. A number of these schemes will require new water sources or upgraded infrastructure to meet future water demand. Supply capacity has been reached for several towns and infrastructure costs associated with new development exceed the market value of new lots. The reliance on small, individual surface water catchments also makes these sources vulnerable to climate change into the future.

The report reinforced ways to increase the amount of water collected including improving the condition of roaded catchments, bituminising or resealing catchments and using liners. Covers could reduce the amount of water lost to evaporation. This project would be a high priority for the region and could be funded through the National Water Grid and/or Future Drought Fund.

In addition to supplying urban water needs, some schemes also supply water for agricultural purposes, either through ‘agreements for water supply’ and use of reticulated supply, or through standpipes connected to scheme supplies (used as emergency farmland supplies).

Improved on-farm water supplies and emergency agricultural supplies can also reduce pressure on scheme supplies. Current water demand for agriculture is estimated at 24 GL/year. Agricultural land uses in the Great Southern include broadacre farming, livestock, horticulture, plantations and nurseries.

Declining rainfall and greater seasonal variability present challenges for agricultural water supply now and in the future. With less rainfall, there is less water available in dams, lower levels in natural soaks, increased depth to fresh groundwater resources and decreased streamflow. Agricultural water demand fluctuates from year to year, with market conditions and seasonal variability influencing production. Agriculture in the region is forecast to grow in line with historical trends, with water use expected to increase to about 31 GL/year under a medium growth scenario.

During dry seasons, on-farm supplies are often not sufficient (quantity and/or quality) to meet water needs for stock watering and chemical spraying. Fewer wet winters means there is an increased need to store water so that it lasts longer. A range of emergency farmland supplies are available across the Great Southern when on-farm supplies are unavailable.

These include standpipes connected to scheme water supplies, agricultural area (AA) dams constructed during the development of agriculture in the South West, and community dams and bores built more recently. DWER's emergency farmland water response plans give farmers a process to follow in the event that water is sought from off-farm sources, as well as details on local emergency supplies. In the Great Southern, plans have been prepared for the shires of Jerramungup, Gnowangerup and Kent.

The reliability of supply for firefighting purposes is a major issue that needs to be considered and planned for.

Considerable work has been undertaken in the Great Southern to address rising saline groundwater beneath farming land and rural towns. This water could supplement farm and emergency community water supplies and alleviate the pressure on schemes (such as the GSTWSS) that supply potable water.

Katanning is supplied from the GSTWSS, with current water use is 0.4 GL/year. Water demand is projected to increase to 1 GL/year by 2043 if the population of Katanning increases to the extent outlined in the plan.

At present, mining water demand in the Great Southern region is estimated to be 0.6 GL/year. Companies exploring gold reserves near Katanning indicate that water use is estimated to be 2 GL/year at full production. Local groundwater may be sufficient to meet the project's water demand, although groundwater investigations are needed to confirm yields, quality and reliability.

The Great Southern region has several other known mineral deposits. These are generally located outside of proclaimed groundwater and surface water areas, where our knowledge of water availability is limited. Abstraction of water from these areas is subject to the proponent/s investigations and case-by-case assessment by DWER.

The Water Corporation initiated the Waterwise towns program, which aims to reduce water use in targeted towns by 10 per cent over the next year. In the Great Southern region the program is being adopted in Gnowangerup, Katanning, Kojonup, Tambellup and Pingrup.

Groundwater is an important water source both for town water supply schemes and self-supplied water. Most groundwater resources in the region are not proclaimed under the Rights in Water and Irrigation Act 1914.

Unproclaimed resources are usually those with low levels of use with minimal risk to the environment. There is limited information on sustainable yields or water use from these resources. In other parts of the region groundwater is more saline so use is limited. Groundwater salinity increases to the north and east across the region as rainfall decreases.

Rivers in the Great Southern Region are intermittent and naturally saline. The northern part of the region has several intermittent salt-dominated systems that drain to salt lakes and eventually to the Avon and Blackwood rivers under flooding conditions.

Alternative water supplies such as wastewater, greywater, stormwater and rainwater tanks are important supplies for fit-for-purpose use that can help reduce the pressure on the region's potable water supply schemes or high-quality groundwater or surface water resources.

The Great Southern region has the highest level of wastewater recycling across the state, with 94 per cent of wastewater reused for irrigating public open space, tree plantations and agriculture.

Some local governments have implemented or are developing stormwater recycling schemes for irrigating public open space and/or providing emergency agriculture supplies. The shires of Jerramungup, Plantagenet and Denmark have also prepared local planning policies that encourage decentralised water supplies such as plumbed-in rainwater tanks, greywater recycling and water efficient appliances for new residential developments.

Table 11 Options for reducing scheme water demand

Option	Example
Targeted efficiency programs with households and businesses	Water Corporation's Waterwise towns program, which provides personalised water use advice to households and businesses and retrofits with Waterwise products for targeted towns.
Water conservation measures and policies	Various local government policies and strategies such as replacing high-water-use gardens with Waterwise plants, waterless parks, water efficient appliances.
Reuse of wastewater for fit-for-purpose use	Irrigation of public open space and golf course in Katanning; Shire of Jerramungup and Kojonup reuse wastewater combined with stormwater for public open space irrigation
Capture and reuse of stormwater for fit-for-purpose	Projects in the shires of Woodanilling, Broomehill-Tambellup, Cranbrook, Kojonup and Plantagenet for irrigation of public open space.
Use of redundant local catchment dams for non-potable use where towns have been connected to a regional scheme	Proposed transfer of Nieve dam and Nyabing dam to the Shire of Kent for non-potable purposes.
Desalination of groundwater as an alternative supply	Opportunities throughout the Great Southern Region.
Plumbed-in rainwater tanks in viable locations	Shires of Jerramungup, Plantagenet and Denmark local planning policies encourage plumbed-in tanks and greywater systems for new residential developments
Reuse of greywater for fit-for-purpose use	
Improved agricultural water supplies to reduce demand on the scheme	Development of a new dam and soak in the Shire of Cranbrook, upgrades to Quartermaines, Mindarabin and Kwobrup dams in the Shire of Kent and proposed new dam in Jacup.

14.2 On-Farm Water Resources

Most farms in the pilot region are reliant on rainfed water supplies to meet their water demand, which means they require adequate storage using dams and tanks to supply both their domestic and farm business requirements. Water use is changing with a growing need for clean good quality water for spraying crops, caused by large and expanding cropping programs whilst there is reduced demand for livestock water in some areas.

In 2019, many farmers and communities had extremely low water reserves, especially after two consecutive years of low rainfall. Consequently, twelve water deficiency declarations were announced by State Government from May 2019 to June 2020 and water was carted to replenish community supplies and the needs for farmers. A declaration requires the government to provide water for livestock needs at a central storage point within a 40-kilometre radius of the farms concerned. Farmers carting livestock water were encouraged to cart to closed storages or tanks rather than into dams where water losses are high because of evaporation. LGA's Great Southern and Wheatbelt pilot regions requiring water were Lake Grace, Jerramungup, Kent and Dumbleyung.[215] The total cost for carting water to the water deficiency areas was $3.7 million.[251]

The State Government also invested $915,902 through the Community Water Supply Program in 2020–21, helping nine local governments deliver 10 projects to improve their emergency community water capacity and reduce their future use of scheme water grants to undertake works, including improving the stormwater reuse network, fitting new pump, pipe and tank facilities, and realigning catchment channels.

This builds on works the government has previously undertaken on community water supplies, bringing the total to nearly $1.5 million for 17 projects. The Rural Water Planning works program also invested $741,890 to upgrade 32 agriculture area dams vested with the Department of Water and in priority areas to continue to build on the strategic water supply network across the dryland agricultural area.[216]

In response to the 2019 drought, a water infrastructure rebate scheme was introduced for farmers for a period of time by the Federal government with State government making a co-contribution. This has now closed.

Key water supply issues that have been experiences in the past across the region include:

- regional communities ran out of water during the drought of 2019-2020;
- rainfall dependent supplies - community and water supplies dried up and were not available;
- Shires were declared Water Deficient;
- emergency water was carted to communities to provide scheme water;
- 80% of the water demand in dryland agriculture is derived from self-supply, therefore periods of drought pose a significant risk to the dryland agriculture industry (DPIRD, 2021);
- households ran out of rainwater;
- changes in agricultural practices (increased cropping) areas increasing demand for water of a high quality;
- increased water demands on the Scheme;
- community conflict in the use of water within drought affected communities;
- local government authorities lack knowledge of current and future supply and demand needs;
- lack of coordination at the regional level to support planning for water into the future;

- use of potable water supplies where non-potable water supplies would be more appropriate;
- inability to maintain green spaces in town, including town ovals, limiting use of recreational facilities to support social connection;
- standpipes being used for agriculture due to on-farm supplies not adequate and strategic community water supplies not keeping up with demand (and a drying climate);
- a need to build relationships with Water Corporation to ensure understanding of local and regional needs;
- lack of coordinated, regional scale water supply planning – approach is often ad hoc or reactive;
- farm water requirements demand increasing (quantity, quality, reliability);
- areas with no scheme supplies are exposed to greater risk than those able to draw water directly from the government reticulation scheme;
- rain-water tanks not supporting demands for domestic use during dry periods;
- slow standpipes unable to keep up with demand during dry periods;
- on-farm water supply planning - the need to increase supply based on a drying climate and an increased demand due to changes in agriculture, particularly an increase in the demand for good quality spray water;
- groundwater in most areas is saline, rivers are also saline hence limited alternate sources available;
- farmers expressed a real need for assistance to find new water sources.

The following were noted as key to improving planning and implementation of non-potable water projects to support drought resilience:

- updating of key regional and State strategies relating to provision of water to the region;
- coordination across agencies is required, particularly in ensuring joined up approaches to planning, implementation, finalising licences and leases for use of Crown land;
- creating a forum to share water resource issues across the region;
- improve knowledge on current water supply and demand, and future needs;
- investigate streamlining clearing legislation on catchments to enable quicker restoration of their function;
- implementing a rebate scheme for water storage and water supply improvement on farms and in towns;
- share responsibility of water resources with traditional owners, taking into account heritage values;
- include objectives for drought resilience in local government Community Strategic Plans;
- demonstration sites for water efficiency and water harvesting and storage innovation;
- better coordination of water supplies for firefighting purposes.

14.3 Risks Identified by the LGAs (survey results)

Survey results from the Great Southern LGA's are summaries below:

- some LGA's rely on external funding to construct additional non-potable water infrastructure;
- where there has been a shortage of non-potable water, or a Water Deficiency Declaration is in effect;
- the Shires have noted increased costs to maintain LGA assets, roads, green spaces, labour costs in the transportation of water between areas;
- at times during drought, there is a negative community perception toward the LGA as lawn/plants die due to lack of water;

- conflict between different user groups as to which use has water use priority;
- user pay system implemented to recoup costs of infrastructure – not all local governments do this or have done so in the past;
- people travel to neighbouring LGA's to get free water;
- identification of non-potable water sources near LG boundaries can cause issues for use - farmers not in the LGA access community water supplies in another LGA which can cause conflict;
- LGA's have not conducted a risk assessment or know of their own water demands;
- resourcing, staff turnover, staff knowledge, and staff background have impacted on the continuity of projects where research and studies have previously been conducted that relate to current programs;
- condition of catchment areas when AA dams being transferred through to LGA requiring significant works;
- process to transfer of AA dams from Water Corporation to LGA's convoluted; and
- DWER Native Vegetation Clearing - dam catchments may clearing of native vegetation, and the process to obtain a clearing permit is not straight forward and can take time.

The LGAs noted the risks to their reputation if the Shire is not seen to be doing 'something' to assist. Water supply to the community is not a core function of the Council however, in recent years, a significant investment has been made to ensure the community has access to multiple sources of non-potable water, and new works have been undertaken to increase harvesting of stormwater off Council buildings for emergency (fire) purposes.

14.3.1 Shire of Gnowangerup Water Strategy – Improving Drought Resilience

The Shire of Gnowangerup completed a water strategy[217] in 2021 to address the harvesting, storage, and supply of water for potable, industrial, commercial and agricultural use. In 2019, it was reported very low water levels in most dams across the Shire. Also, the Strategic Community Water Supplies, including Gnowangerup # 1 Dam was critically low. A bushfire in the Stirling Ranges further exacerbated the serious water situation for the Shire.

DWER assisted the Shire of Gnowangerup by bolstering facilities at two bore sites, allowing faster fill time for farmers. This provides a suite of drought proofing benefits for the regional community. Water Corporation also augmented water into the Gnowangerup #1 Dam to compensate for water used for firefighting. Both agencies provided a critical role in helping increase drought resilience for the town.

Further funding was obtained through the Drought Communities Fund and DWER's Community Water Supply Grants to complete major water projects. The outcome of the works included 5 connected dams in Gnowangerup creating a high level of flexibility and storage capacity in a new 32.5 million litre dam. The dam is a significant resource for agricultural use and emergency firefighting.

Photo 4: Gnowangerup Airport Dam funded through DWER's Community Water Supply Program in partnership with the Shire of Gnowangerup. Completed in 2021.

14.3.2 System Vulnerability – Summary

The water system of the Inland Great Southern draws from a range of potable and non-potable water sources including:

- potable Water Corporation managed piped scheme water from the Great Southern Towns Water Supply Scheme (GSTWSS). The pipeline is 3000 km;
- farmland customers – 1290 farmers rely on the scheme supply for their farm water;
- non-potable localised farm water supplies – surface and groundwater derived are not keeping up with demand for agricultural use;
- non-potable community supplies – surface water derived, ground water, mixed management, Water Corporation, DWER, Local government;
- non-potable residential and commercial building rainwater harvesting;
- localised use of small-scale desalination (trials at community scale to be implemented in 2022);
- Water Corporation managed wastewater re-use from waste water treatment plants (in some communities); and
- capture of rainwater from town infrastructure including sporting sheds.

14.4 Water Planning, Program, & Policy Response

The Great Southern Regional Water Supply Strategy[218] (GSRWSS) estimates the water demand in the region to increase by more than 20 giga litres a year by 2040 under a medium-growth scenario. This is driven by population growth, mining developments, expansion of industry and irrigated agriculture. At the same time, the report notes a decline in surface and groundwater availability as the region's climate becomes drier.

In 2013, the total licensed and unlicensed water use in the Great Southern region was 31 GL/year. Town water supply schemes support 19 per cent of this demand. The schemes primarily support urban water demand, but also meet some industry and stock watering needs. The remaining 81 per cent of water used in the region is self-supplied. This is primarily for agriculture, including irrigated agriculture and stock water. The GSRWSS has six strategies including:

1. Plan and develop new water sources for the Lower Great Southern towns.
2. Where practical, maximise use of climate-resilient and cost-effective water sources for independent town water supplies.
3. Promote alternative water sources and efficient use of water to reduce use of potable town water supplies.
4. Investigate groundwater and surface water resources to support regional development.
5. Ensure emergency livestock water sources are available for areas with less than 600 mm rainfall.
6. Promote community and inter-agency involvement in water planning and management.

Local government level strategies exist that cover emergency rural water supplies and ground and surface water management in towns, completed under programs such as the Rural Towns-Liquid Assets program[219] [220] [221]. DWER Emergency Rural Water Plans are currently under review for all the study region local governments.

The high costs of maintaining the piped water scheme and reducing populations in eastern parts of the region may limit future government investment in this critical infrastructure. Water planning assumptions based on population growth may lead to perverse outcomes for regional economic and ultimately, drought resilience in the Inland Great Southern.

Interventions to address localised and acute water needs are delivered through the Water Corporation and DWER. DWER are very active in supporting upgrades to on farm and community water supplies under State and Federal government programs, including the National Water Grid and Farm Water Rebates scheme and Community Water Supply program. Oversubscription to these programs indicates the strong demand and desire to proactively improve water supplies.

A range of actors are responsible for planning and managing water supplies in Western Australia, including DWER, Water Corporation and Local government. Improved coordination and transparency; and application of a regional lens would be welcome by all Shires in the study region.

A reimagination of State led programs such as the Rural Towns-Liquid Assets program may provide an opportunity to address holistic total water management planning considerate of climate change, growing industry demand and advances in water systems technology.

An updated supply and demand analysis will be complete for the study region in 2022 and aims to quantify supply and demand and future scenarios under business as usual, RCP 4.5 and 8.5 climate predictions. Gaps in supply will be identified to support investment planning.

14.5 WaterSmart Farms – supporting drought resilience

WaterSmart Farms is a project to research sustainable groundwater supply options using on-farm desalinisation technology. Successful use of this technology using brackish groundwater will increase the ability of farms to weather dry seasons.

The project has three components:

1. Understanding adoption of existing desalinisation plants that process brackish groundwater into a suitable resource for livestock, crop agronomy and other agribusiness activities.
2. Optimise desalinisation technology and its application in the Wheatbelt and Great Southern regions, including assessing the technology, economics and options for the disposal of RO reject water.
3. Undertake a targeted groundwater exploration program and where suitable, locate desalinisation trials.

The project was initiated in response to growing industry requests to develop more climate resilient on-farm water supply options. The urgency for this work was highlighted by the number of water deficiency declarations over the last 3 years and a record 12 water deficiency declarations in 2020.

Dry conditions over the last 3 years meant that on-farm dams and more traditional water supplies were not meeting needs, resulting in an unsustainable demand on scheme water, and more than $3.3 million spent on carting emergency water supplies for livestock.

The WaterSmart Farms project builds on work over the past 3 years by the DPIRD, Water Corporation, Murdoch University and the Wheatbelt Development Commission to assess on-farm desalinisation infrastructure and the implications to businesses, regional economies and the environment.

The project involves relevant agencies, local government, farmers, grower groups and technology providers.

Consultation with stakeholders across the Inland Great Southern supported the need for the continuation of the Smart Farm projects, and extension into vulnerable areas (such as Woodanilling, Kent, Jerramungup). Fitzgerald Biosphere Group in the Shire of Jerramungup recently received funding through the Future Drought Fund and DPIRD for their project “WaterSmart dams – making dams work again”.

This two-year project aims to develop knowledge and water planning tools for farmers who need their dams to work in all years, and be able to make water investment decisions with confidence. The project will involve 12 core demonstration sites, building farm-based water planning tools, workshops, field days and industry training. The project will investigate solutions including renovating existing dams, building new dams, and implementing evaporation suppression and runoff technologies.

The GGA through the South West WA Drought Resilience Adoption and Innovation Hub, will collaborate with the DPIRD and the UWA, leveraging their existing work and prior investment in this field as well as four grower group project partners including Compass Agricultural Alliance, Southern Dirt (Kojonup), Merredin and Districts Farm Improvement Group and the Fitzgerald Biosphere Group (Jerramungup).

Photo 5: Example of a farm demonstrating a dam, capturing rainwater to support their livestock industry. These supplies became critically low in 2019.2020 threatening the livestock industry in Kojonup.

15. Identified Gaps and Future Directions

Despite variability of impacts, trigger mechanism and definition of drought between regions, researchers in the drought field agree that climate change is a key factor in dry weather events and that this will continue into the future – creating widespread economic, social and environmental impacts.

This is significant because it reinforces the importance of agribusinesses being well informed and supported in the use of adaptation measures to be viable and sustainable in the long term. This adaptation is not only vital for business success and profitability, but also for ensuring the viability of regional communities.

15.1 Adaptation and Risk Management

Issues of most concern shared amongst the three consortia regions and its land management groups include water availability and management, effective soil management and alternative crops/pastures. This is particularly relevant as drought severity in WA is projected to increase over time in conjunction with ever increasing demands on water supplies.

However, it is worth noting that research into WA farm practices shows use of water efficient crops or pasture varieties, planting or maintaining deep-rooted perennial pastures, and carbon-farming/sequestration are the least used practices. This suggests the need for more support in the way of training and education around these practices as well as additional research.

Additional recurring themes at a regional level include dealing with feral animals, better technical support and advice, consistent and accessible information, debt reduction strategies,

and effective practices for maximising ground cover. Although there is strong interest in the use of farm planning tools which is promising, the barriers of time and available funds need to be addressed when considering support for farming adaptation.

At the sub-regional level, management of landscapes to reduce impact of erosion events (e.g. increased levels of vegetation, permanent plantings) and improve biodiversity are areas that need further investigation and support. Regional communities are also concerned with maintaining reliable water and power supplies, arresting declining populations, and building economic diversification to support resilience to drought events. Most recently, the South West WA Drought Resilience Adoption and Innovation Hub has undertaken a survey to identify key gaps and needs for agribusinesses to manage and adapt to climate change.

15.2 Data Management

Key messages emerging is the inadequacy of information and knowledge sharing. There appears to be a distinct lack of accessible and reliable climate information globally and nationally, pointing to the need for quality and reliable data that is aggregated into one place.

A common theme is the importance of quality forecasting and monitoring systems in preparing for drought. There was a consensus that, to support farmers in making well informed decisions, they need access to timely, relevant and reliable information, which is not always the case. At present, there are too many different channels and unclear coordination of drought communication. This area needs to be addressed to support program managers, policy makers and farmers in improving drought preparedness. Strong leadership is needed in the drought data management and dissemination space[222].

Recommendations include access to agreed data sets and shared models that can be meaningfully compared amongst regions, a more consistent approach, as well as support for in-house capability in terms of interpreting and applying climate data. There is also an additional need for more climate change information and data in terms of temperature, rainfall, evapotranspiration, relative humidity, soil moisture, drought and fire danger[223].

This review also reveals a need for greater understanding around the causes of reduced precipitation as key to effective policy development and decision making to mitigate drought impacts. The literature emphasises the importance of evaluating precipitation changes, but this can be difficult due to deficiencies in the length and quality of data and lack of metadata in many cases. Although data sourced from radar and satellite-based sources are proving useful in understanding precipitation extremes, new research into new metrics or indices that define precipitation extremes is needed[224].

Additionally, a better understanding is needed around the human impacts on the water cycle and, although this is a growing area of interest, the amount of research available is limited. Improvements are also needed in terms of improving water management efficiencies including irrigation systems, sewage systems for rainwater wastewater usage and cultivating crops with low water demand[225].

15.3 Research

Whilst Australia has a strong reputation in terms of drought research and development, the system for managing this information is complicated and includes many players, as noted by ACIL Allen Consulting in its Stocktake Report on drought resilience (2020), with no central repository, due to the number of different systems involved[226].

In particular, the body of research on drought resilience is limited. Many of the key research organisations do not include resilience as their primary research objective. In their report on

drought resilience research ACIL Allen Consulting highlights the university sector as an important source of research and development of drought resilience and recommend accessing this sector and leveraging off its diverse body of knowledge. This is worth noting, given the Australian government's drought policy identifies resilience as a key priority. There also appears to be a need for more research into the social impacts of drought, as most of the current research is primarily focused on economic and environmental impacts.

"There is no clear broker to partner with for drought resilience social research. The most likely candidates are state and local governments."[227]

More also needs to be done in the way of understanding, monitoring and predicting drought in the regions. Specifically, a better understanding of:

- vegetation feedbacks
- dynamics of the regional storm track
- mechanisms related to drought
- regional coherence of drought
- relationship between synoptic-scale mechanisms and drought
- predictability of vegetation and crop yields
- stability of remote influences
- data uncertainty, and the role of temperature.

15.4 Policy Development

In 2020, the National Drought and North Queensland Flood Response and Recovery Agency (the Agency) completed a review of the Australian Government Drought Response which identified areas for improvement, including: [228]

- monitoring and evaluation approach: inconsistent evaluation of drought support programs
- streamlining communications: unclear communication about drought support and how to access it
- data standardisation and rationalisation: limited consistent and accessible drought related data on drought and drought related programs
- drought indicators and eligibility: complexity and inconsistencies around eligibility for Government drought programs
- rationalisation of programs: fiscal inefficiencies, confusion and inconsistent delivery as a result of numerous (25) drought measures being delivered across many (11) Australian Government agencies in a range of different ways
- strategic framework for proactive support: A more proactive and holistic approach is need in the delivery of drought support.

Additional gaps identified in this review include a need for monitoring and evaluating farm practices to ensure value for money and supporting communities in being well prepared. Furthermore, additional work needs to be done around developing a universal definition of drought and classifying severity to better support preparedness and policy development.

15.5 Insurance

Insurance is an area that requires further investigation and development due its potential to mitigate the economic impacts of drought for agribusinesses. Insurance options for drought are limited in Australia and internationally due to limited products and high premiums. New options are needed and the ABARES is currently working with the Australia Bureau of

Statistics to develop better data sets and tools that support drought insurance and this will be an area of ongoing research [229].

In conclusion, this review has revealed that Australian agriculture has a track record of capacity to adapt and respond to risks. With access to more innovative technologies and a sound knowledge base, Australian agriculture is well positioned to respond to risks in the future[230]. The success of this will depend on adoption of viable alternatives, social capital, willingness to change, and a commitment to innovation.

15.6 Future Recommendations

Research from the Australian Institute of Family Studies (2012) shows that community resilience relies on an understanding of its strengths and vulnerabilities, its physical characteristics (local infrastructure), policies and plans, and its level of community cohesion. The National Climate Resilience and Adaption Strategy 2021-2025 defines adaptation as:

"…*the capacity of communities, environments and economies to cope with a hazardous event or disturbance, while maintaining their essential functions and structure.*"[231]

Diversification of industries can increase the social and employment resilience of communities by providing a buffer to shocks. On-farm adaptation strategies have been well documented in the literature[232] [233] [234] .

Broadacre sector adaptations include:

- diversification of crop varieties
- species change
- shifting planting seasons
- changing crop management practices
- weather and commodity price forecast
- reduce crop area planted and inputs applied.

Livestock adaptations include:

- increasing soil fertility
- ongoing genetic improvement
- using perennials
- confinement feeding
- holding stocks of grain and hay and reducing livestock herd size
- improvements in technology and management practices.

Longer term adaptations include:

- changing the enterprise mix
- diversifying into off farm employment
- investing in off farm assets
- migrating to new industries and regions.

The agriculture sector across the region have made major changes to their farm management practices to minimise the impacts of drought on their businesses[235,236.] These include managing their debt, accessing farm management and business support, de-stocking early and / or permanently, improving soil acidity and water retention capability, increasing on-farm water storage, optimising pesticide and fertiliser use and exit planning.

They have a good history in terms of capacity to adapt and respond to risks, with increasing levels of grain production occurring despite reduced growing season rainfall. There are still areas for further investigation to enable continued productive capacity and profitability in the face of a drying climate.

The targeting and extension of research and development of climate resilient farming systems is considered essential. The South West Western Australia Drought Hub (the Hub) is actively working with Grower Groups and their consortia partners to develop and enhance to uptake of farmer-centred drought innovation and adoption practices in the region[237]. A draft situational analysis has identified a drop in growing season rainfall, a later traditional "break of season", and increased warming during grain filling since the year 2000. The reduced frequency of intense rainfall events (10mm to 20mm) mean many of the Great Southern dams are not as reliable at capturing runoff as they previously were.

Great Southern stakeholders identified gaps in past drought responses that could be addressed through future drought resilience building activities. The number one priority for these communities is increasing their confidence in available water systems to ride out at least two successive drought years. This would ensure agricultural businesses can continue to function, through direct access to water and to enable critical road maintenance to be undertaken. It would also maintain amenity of community spaces to support social wellbeing.

Supporting the diversification of the economy through encouraging business development in the region was also considered important in enhancing economic and community resilience.

Gaps in past drought responses were identified, including a need for drought relief systems (financial assistance to drought affected families and businesses) that are more understandable, easier to access and quicker to mobilise during drought. Opportunities to enhance drought response included well-informed farm business planning, earlier identification of drought impacts and interventions to support community groups and local governments, and continued investment in research and development into farming practices to maximise drought resilience. Stakeholders called for an improved definition of drought, more relevant to regional farming systems and the local climate, as well as for improvements in long-range weather forecasting to support decision-making.

Australia is an ancient landscape with highly weathered and largely infertile soils, particularly in WA. Combined with a dry and variable climate that is drying and experiencing increasing frequency of droughts the challenge is for positive environmental outcomes for future generations.

At the outset we outlined the impact agriculture has on our landscape, that increasing world populations and demand for food has created competition for space that is almost an insurmountable challenge for biological conservation.

We also identified how ecosystem services flows from farmers to the environment and society, and the need for healthy ecosystems to meet the needs of agriculture, an agriculture sector which is made up of many individual farms and embedded within society. Farmers focus on generating wealth to meet family and lifestyle objectives. Most see the importance of the environment to their well-being, but as we identified at the start classical conservation philosophy and production focus do not always align.

A 'super sizing' of agriculture with the constant need to improve productivity has led to structural adjustment in the pilot regions, where landscapes continue to be modified to create large scale broad-acre farms. Land clearing albeit in small areas on farms in WA continues to make way for large scale agriculture.

Ecosystems services thinking allows for conservation goals within agricultural landscapes and is an opportunity for the uptake of conservation actions. The challenge is to convince time-poor individuals and communities suffering with burnout and exhaustion to see the urgent need of an ecosystems approach. The developing Environmental Social Governance frameworks are gathering momentum and consumer and investors' expectations will demand more from producers of goods and services, including farmers.

In conclusion from reviewing the literature the following recommendations apply to the LGA pilot regions:

1. Improve collection of real time data for environmental health on agricultural land and non-agricultural land including waterways and wetlands
2. Use data to identify the priority areas for stabilisation & restoration of ecosystems on agricultural land and non-agricultural land
3. Review and update the state of the environment report for WA
4. Continue to improve agriculture production systems that reduce the impacts on the environment by using technology and education
5. Supporting networks of grower groups and NRM groups
6. Protecting soil health
7. Identify opportunities to improve sustainability of resource use and supply chains e.g., Fertiliser from fossil fuels
8. Support policy with outcomes to improve conservation
9. Review land clearing
10. Work on strategies for reducing carbon footprint to net-zero.

Building resilience into the environment to enable it to withstand severe climatic events is more important than ever. Resilience comes from healthy ecosystems, which are created through healthy soils, freshwater security, and abundant vegetation and biodiversity. Managing these fundamentals should be the priority of the region to ensure we have a healthy and resilient environment, able to meet the challenges of food security and sustainability for future generations.

16. Consultation Key Findings & Discussion

South Coast NRM were contracted support the development of the drought resilience plan for the inland Great Southern through provision of community consultation and stakeholder engagement. The key focus of this report is to summarise the findings and outcomes of the stakeholder engagement process and provide insights including:

- stakeholders identified risks related to drought
- summary of stakeholder responses that have been effective in the past and gaps in these responses that could be improved on in future
- input/comments on the vulnerability assessment framework
- stakeholders understanding and knowledge of the historical and likely future impacts of drought on the Shire and local communities
- stakeholder comments on appropriate drought indicators for Western Australia
- suggestions for a vision for a resilient drought region
- summary of regional needs and priorities that may inform future investments under the Future Drought Fund
- opportunities to enhance community and industry resilience
- a summary of projects that could be further developed into business case studies that support drought resilience.

Consultation included a survey, targeted one-on-one interviews, a community workshops and three participatory workshops with South Coast NRM Reference Groups. Information collated in the report *Regional Drought Resilience: Community Consultation Report for the Inland Great Southern*[238] is presented below.

Discussion of information generated through consultation is presented around the key themes of understanding drought impact, drought risks, regional needs and priorities, and enhancing resilience.

Farmers noted the definition of drought is very Eastern States focussed and not relevant to Western Australia, suggesting developing a State specific drought definition is necessary. This could then assist with supporting appropriate drought responses by providing a framework to assess impacts. There is a need to ensure the criteria takes into consideration regional differences, in particular growing season rainfall. It would help to validate how difficult some seasons are locally, without having to compare to other regions with different rainfall patterns and land uses.

Farmers were asked how they would define the difference between drought and dry seasons and five responses defined drought as receiving exceptionally lower than average rainfall for more than one season of which three respondents quantified this as lower than 20% of average rainfall. The remaining two responded that they had not experienced drought.

Farmer interview responses indicate a strong level of resilience within these farmer champions and their businesses along with regional climate differences. The responses indicate they:

- recognise adverse seasonal conditions and fully understand the impacts of dry seasons on their business
- business planning was seen as helping to limit the stress, with the need to be adaptable and flexible seen as invaluable
- the need to read the season early and make early decisions was seen as important
- changing climate trends and overall impacts on agriculture were also noted.

16.1 Recommendations for Increasing Drought Resilience

A summary of recommendations to increase drought resilience based on the outcome of stakeholder consultation include:

Water access: Enabling sustainable access to water, both in considering the environmental and off farm needs, as well as ensuring consistency of supply

Innovation: Continue to support and celebrate farmer innovation with extension and additional information such as cost benefit analysis to assist decision making of innovative project uptake.

Planning: Drought response needs to be holistic and recognise that the impacts of drought and a changing climate do not stop at the farm boundary. In delivering drought planning and mitigation actions, communications consistency is critical and relevant to all actions. Building recognition of the impacts of drought and what's needed for resilience should be an ongoing conversation - set the groundwork in the good times to prepare for the bad times.

Diversification and value adding: The extension so information on a yearly basis is useful for preparing for drought and a changing climate, and could include seasonal outlook, recommended tools, support available and assist with ensuring the risks of drought and dry season remains at the forefront. For example an online portal specific for Western Australia

and communications need to be strategic and support the desired outcomes of building resilience.

Monitoring of environmental condition: Timely access to information at the right times is required to ensure that any management decisions are made with the best available information.

Improving and maintaining natural capital: Building and restoring natural resources is essential to supporting landscape scale resilience to drought. Consideration needs to be given to pre and post drought natural resource needs.

Rehydrating landscapes: Promote the principles of rehydration and support the process through education and funding for on ground trials and demonstrations.

Strong and healthy communities: Individual mental health and social wellbeing needs to be supported by a range of initiatives from access to counselling and support from mental health professionals. At the community level supporting health and wellbeing can be through community gatherings and include supporting town centre revitalisation projects, landscaping activities, as well as improving facilities and support access.

Information generated through the workshops and interviews was then collated into a project list grouped into themes around three strategic priorities. Within each theme, actions are grouped around key action areas which are supported by knowledge, innovation and extension; collaboration and capacity; and related policy and planning needs. These have been integrated into the final RDRP Plan for the Inland Great Southern.

16.2 Key Findings & Discussion

Farmers noted the definition of drought is very Eastern States focussed and not relevant to Western Australia, suggesting developing a state specific drought definition is necessary. This could then assist with supporting appropriate drought responses by providing a framework to assess impacts. There is a need to ensure the criteria takes into consideration regional differences, in particular growing season rainfall. It would help to validate how difficult some seasons are locally, without having to compare to other regions with different rainfall patterns and land uses.

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- business planning was seen as helping to limit the stress, with the need to be adaptable and flexible seen as invaluable
- the need to read the season early and make early decisions was seen as important

16.3 Drought Impacts

The following impacts are a summary of those from stakeholder engagement.

Financial impacts

Financial and enterprise impacts including the decrease in income and increase in expenditure on items such as stock feed and water. It was noted that reduced production in dry seasons leads to financial impacts throughout rural towns and communities, described as slowing everything down and reducing community spending.

Farm business planning

There are additional labour demands with the need to carry out activities such as confinement feeding and water carting for some businesses identified.

Staff retention was also seen an issue, with less staff on a farm during dry seasons, leading to an increase workload for those that remain. Impacts on farm enterprise were also noted such stocking, spraying, affecting decision-making with risk aversion and reducing progressive measures.

Agronomists noted that drought or dry seasons have encouraged better farming practices and planning, bringing farmers attention to improvement required. Some farmers have worked harder to increase drought resilience although there is room for some enterprises to improve their cost structuring and farm planning.

Recovery time

Recovery times from drought are not immediate, especially for stock related enterprises and rebuilding natural capital. It can take considerable time to restock to pre-drought levels. Time between droughts: 2018-2019 two years in a row has far greater impact than one year event.

Social and mental health

Increased stress and mental health impacts were identified and seen as something that affects both the individual, the family unit and the community as a whole. Mental health was also seen as a community wide issue, with the stress of drought impacting the broader community

Other impacts noted included:

- reduced amenity, and quality of life, such as dying gardens, lack of water for recreation (e.g. swimming, need for shade)
- mental health impacts
- lack of recreational opportunities (e.g. fishing)
- lack of bush foods - leads to less family gathering opportunities on country
- opportunities to bond over a shared stress were also expressed.

> "It's mentally draining during tough times, we need to be proactive in making decisions. Other issues can make it overwhelming and it affects family. Drought has a big financial impact and we have to make hard decisions such as destocking and cropping decisions."

Communities

Farmers noted the broader impacts of drought or dry seasons on the broader community and regional businesses

Volunteering

Increased on farm workload during contributes to less volunteering, less time and the perception of a reduced commitment to the community.

Natural Resources

Natural resource management was noted as one of the first things that are cut in a dry season, with no extra time or money for activities like revegetation. The impact on natural resources were identified, with associated decreases in ground cover and the need for increased soil cover and care.

Farmer champions interviewed identified that investment in natural resource management and natural capital protection activities were the first to be cut. It can be assumed that they are also the last activities to be reinstated post drought. Loss of native vegetation exacerbates the desertification of the area.

Vegetation

Impacts on vegetation noted by stakeholders included:

- decline in vegetation condition, which can lead to an increase in pests (weeds and animals)
- increase in fire loads
- implications for cultural burning and fire management into the future
- risk of drought on shallow rooted bushfood species
- lack of bushfoods - reducing family gathering times
- changing vegetation - some species may be expanding range
- fire impacts due to drought may impact seed set of key species which could lead to a loss of ecological niches (e.g. montane heath).

Water

Impacts on waterways, rivers and estuaries were noted by stakeholders as a key issue due the decreased rainfall, leading to decreased flushing and even increased duration of estuary mouth closures, which has an impact on aquatic diversity. The amount of salt in rivers increases in drought events with a flow on effect on aquatic biota.

Water allocation is an issue with competing demands - balancing of water access between economic and environmental needs, as well as allowing for groundwater recharge may be contentious.

Landscape

Impacts noted by stakeholders focused specifically on soil erosion due to drought event, or water erosion when the rains finally come. The increased risk of bushfires from dry vegetation. Also, long-term impacts on natural systems such a peat swamps, increased salinity, changing vegetation communities and ultimately changing whole ecosystems.

Climate

Increased variability in weather conditions and slightly more intense events (e.g. droughts followed by floods). Important to recognise that impacts span a spectrum and may be cumulative. For example, a drought may not be seen as severe, but impacts might be greater due to a lack of recovery between stress events.

Aboriginal Community

In cooperation with South Coast NRM and Keogh Bay Consulting, we consulted with:

- Senior Elders in the Noongar community to provide decades long perspectives on climate and the impacts of changing climate on Noongar people, culture and Country
- Noongar people whose livelihoods depend on the land and reliable rainfall
- Noongar people whose work gives them special insights into potential impacts of drought
- Tambellup Strong and Proud Participants; a program which engages with Noongar Youth aged 11-17.

During stakeholder consultation, Aboriginal community members were extremely concerned about the degradation of the natural environment, through land clearing, and salinisation, worsened by global warming, higher temperatures and more frequent droughts. Noongar cultural values connect substantially with the natural landscape, the disappearance of which is being hastened by drought and drying.

Drought resilience planning needs to recognise that for Noongar people, drought is one of several linked factors that have damaged the foundation of Noongar identify and well-being. That foundation being a natural environment. All respondents had clear and consistent views on the impact of environmental changes, including drought and drying on Noongar people and Noongar culture. These views are founded in the deep conviction that a healthy native ecology is essential for Noongar health and wellbeing; the recreation and communication of Noongar culture and healing.

> *Definitely noticed the effects of clearing on drought. Clearing increases drought, they are all connected. I did a painting many years ago of mother earth. And I actually drawed tears on it...and if you take your tears even when we cry, they are salty, and mother earth is very much the same.*
>
> *We have gone from scarifier seeding to broadacre, so all the trees that used to be in the paddock have just been knocked away. It's just opened vast space. It's just crops, crops, crops. You don't get rain, you get wind and the top soil is gone, blown away into the creeks (Noongar Stakeholder 2).*
>
> *Land clearing really affects the environment and its ability to retain water. Water runs off the land very fast and poisons creeks with the fertilizer or chemicals and silt. And it brings up the salt. You see algal blooms in a lot of creeks because of this. All the land clearing creates heat. It becomes too hot for condensation to happen and the soil dries out. These days I see a lot of trees dying because it is too dry (Ken Kelly).*

Tambellup Strong and Proud Youth expressed their views of drought and drying through art. The Youth expressed big picture thinking with many identifying climate change and global warming. They expressed solutions of 'reduce, reuse and recycle'. With calls for no more fossil fuels. They artistically represented the Country with trees and landscapes and highlighted the importance of trees to address global challenges. Solar power, wind power and a move to adopt innovation were highlighted by the Youth. The consultation process included in-person interviews, meetings and workshops.

Figure 40 Pictures of drought solutions drawn by Tambellup Young and Proud Youth, 2022

To build drought resilience, recommendations from First Nations people included:

1. Revegetation: restoring the landscape with original species.
2. Noongar land management: re-establish Noongar land management where-ever possible, especially traditional burning. Noongar people must be central participants or owners of this restoration process, because they believe it is their responsibility to care for and heal the land. In doing so, it will help provide for personal healing, cultural maintenance, and employment
3. Expanded restoration projects: restoration projects led, managed or involving Noongar people. A number of models are available like Ranger programs, Ballogup, Gondwana Link, Nowangup, Badgebup and Mindaribin Reserve.
4. Education and information sharing: Restoration projects to incorporate information sharing and on-going engagement between Noongar people and researchers
5. Youth education: support for Noongar youth to undertake school-based traineeships in environmental management, school curriculum teaching children about Country
6. Building Collaboration: increase collaboration between Noongar organisations, native title holders, farmers and natural resource management or Landcare groups, especially in the planning and conduct of land restoration projects
7. Ownership and business: expanding and supporting Noongar land ownership and businesses in consultation with organisations such as the South West Land and Sea Centre (SWALSC) and Noongar Land Enterprises
8. Rangers and environmental services: support and expand existing Noongar organisations including Ranger programs, nurseries, seed collection and rehabilitation

businesses, among others, to increase their capacity to offer environmental services and employ Noongar people.

Drought resilience planning should include expanded and on-going support for native landscape restoration projects, led, managed, or involving Noongar people. A number of positive existing models are available, such as Ballogup, Gondwanalink, Nowanup, Badgebup and Mindaribin Reserve.

> *But we have also seen, sometimes our little birds, our Chida, they have two or three lots of babies in one season, like our Jirrijirri [Willy wagtail] and our mudlark, even the kulbardis [magpie] have two lots of babies in the one season. They have been making the most of the hot summer and having their babies way later in the year than they should be. I don't know if it is a good thing if they go from hot weather to cold weather and these little babies aren't quite ready (Noongar Stakeholder 4).*
>
> *You go looking around for payin, the little pigface, and the kurok and they are all changing because the seasons are getting warmer (Robbie Miniter).*

To further capture Noongar knowledge and practices for integration into drought resilience strategies, Noongar Landcare Enterprises (NLE) were contracted May to June, 2022. NLE undertook to review literature on high level impacts of drought (Nationwide) and First Nation land management practices with a focus on Noongar country and the impacts of drought on the Noongar region[239].

Case studies documented Noongar land management on country with Noongar knowledge to capture their stories. Case studies were recorded using videography. Online facilitated workshops were held with Noongar business, Noongar land management practitioners and Noongar knowledge holders with the view to inform the development of the next steps consultation and engagement process.

This review found there is less written about the impact of drought on Indigenous communities in Australia and even less on the Aboriginal communities of Western Australia. However, the literature that does focus on Indigenous communities, is very clear in its conclusions.

In 2020 the CSIRO in partnership with the North Australian Indigenous Land and Sea Management Alliance, with support from the Australian Committee of the International Union for Conservation of Nature and an Indigenous-majority Project Steering Group of key agencies, published 'Our Knowledge, Our Way in Caring for Country'.

Over 100 First Nations individuals and organisations, including partners, co-authors, case-study providers, and reviewers, contributed to the development of the Best Practice Guidelines for working with First Nations knowledge in land and sea management. The Guidelines are based on 23 Australian case studies, submitted by First Nations People and their representative bodies, that show how Our Knowledge Our Way in caring for Country can be supported through:

1. Strengthening Indigenous knowledge - including creating and maintaining access to land and sea Country, ensuring strong cultural government of Indigenous knowledge; and keeping and revitalising knowledge, language and culture through programs and practice.

2. Strong partnerships that enable the building of respect and appreciation for Indigenous knowledge, development of protocols to guide knowledge sharing, engaging with the principles of free, prior, and informed consent.
3. Sharing and weaving knowledge: Indigenous managers often weave knowledge to manage new and complex land and sea management issues, Indigenous-led and co-developed tools are most appropriate, and those that promote intergenerational transfer of knowledge are highly valued.
4. Indigenous networks – national and global networks that promote Indigenous knowledge practices are important as they offer peer-to-peer learning opportunities for Indigenous land and sea management practitioners. They support:
    - learning about good partners, projects, and approaches to keep knowledge strong
    - learning from others about best-practice protocols and processes for managing partnerships
    - building strength and inspiration through solidarity
5. Empowering Indigenous people to look after Country 'our way'
6. Improving environmental conditions and recognising the multiple social, cultural, and economic benefits that come from effective Indigenous adaptive management of 'Country'.[240]

First Nations People intrinsic knowledge and connection to all things living give them a holistic view; with an understanding of the relationships between all things and the causal effects should there be a change. The effects of drought are felt most strongly in First Nations communities as people feel country hurting. This is also felt by the youth who feel a disconnection from country when it is hurting. For First Nations People, it is the struggle to retain identity, connection and culture when the heart of their existence is not working as it should.

16.4 Drought Risks Identified through Stakeholder Consultation

The risks of drought can be understood from the impacts of drought. This section focusses on the risks identified through the stakeholder consultation; it does not include all risks of drought.

Water availability

Access to water and competition for access during periods of drought was seen as a key risk, especially competition with other industries

Economic risks

On farm, an economic risk of drought includes destocking and restocking. Access to appropriate stock and within a necessary timeframe and within budget when a whole area is attempting to restock can be difficult.

Bushfire risks

The drier than average conditions can lead to vegetation drying and death, leading to a potential increase in fuel load. Bushfire frequency and ferocity is a risk to natural capital, with impacts on vegetation health, condition and recruitment. Disturbance to these ecosystems by fire can also lead to increased weed incursions and the lack of groundcover post fire can increase the risk of erosion. Drought can also increase the probability of ignition and the rate at which fire spreads.

Mental health

The long-term mental health risks need to be considered. It is important to recognise and consider the impact on children growing up in stressful environments that can be caused from the impacts of drought. Family stress can deprive children of crucial developmental input and put them at higher risk of stress related diseases and problems in later life. https://parentingscience.com/family-stress/). Mental health support needs to be a big consideration.

Voice of the youth

One information gap identified during the community workshop is the voice of the younger generation. Grower groups provide a format for younger farmers to connect with older farmers, however there is a need to include beyond the farmer community.

16.5 Regional Priorities

SCNRM in cooperation with the community and their stakeholders, identified key priority projects based on the regional needs and priorities. A summary of their projects is available upon request. These regional needs and priority projects underpin the Inland Great Southern Drought Plan.

Access to water

Water is critical during drought. Consideration needs to be given to reducing distances between off farm water sources and increasing the capacity of community water sources. Investigating alternative water sources, e.g. desalination.

Peer to peer learning

Opportunity to learn from other regions about their experiences e.g. learning from inland (WA eastern wheatbelt) experience. This needs to include opportunities for intergenerational transfer of knowledge and experience.

Communication and education

Broad and diverse methods of communication methods need to be considered. This needs to include timely information around topics like accessing water in the local area. It is noted that further knowledge building and innovation to manage drought impacts is needed. Recognise the role that government and independent community groups (such as grower groups) have in extending this type of information.

Innovation

Projects to include components like a cost benefit analysis. For example, extending information around desalination and how it works would be well supported by additional information provided by a cost benefit analysis. This would help to improve decision making and possible uptake.

Access to mental health support in regional areas

The need to begin planning for support early to build trust and increase likelihood of service access when in times of drought.

Protection of marginal and fragile landscapes

Protection of natural capita and protection of marginal agricultural land to maintain productivity values were noted as key needs to increase drought resilience in the region.

17. Drought Risk Priority Areas

17.1 The Mapping Process

Using GIS-based multi-criteria analysis (MCA) [241,242,243,244,245], DPIRD's GIS team have spatially integrated relevant economic, environmental and social data at a scale appropriate to inform local level political, administrative and operational decision-making (LGA boundaries).

A set of maps were produced identifying high priority drought risk areas, taking into consideration farm water supply, agricultural production, soil health and erosion potential along with a range of socio-economic and landscape features that contribute to drought resilience or exacerbate drought risk in the Great Southern region. These features include water-related ecological infrastructure, high value agricultural land and areas of higher socio-economic vulnerability.

The approach consolidates complex information into user-friendly spatial products designed to enable fine-scale, local-level decision making on drought resilience. The maps will be included in the Regional Drought Resilience Planning Program (RDRP) DVAs, forming part of the evidence base for RDR Plans.

Inputs into the MCA follow the RDRP conceptual framework, investigating aspects of exposure, sensitivity, impact and adaptive capacity. Our understanding of the ways in which each of these components relate to and inform vulnerability and resilience to drought in the regions was guided by a comprehensive regional stakeholder engagement process.

Drought resilience priority areas maps are made up of a set of composite maps for i) exposure, ii) sensitivity, iii) impact (combining exposure and sensitivity and iv) adaptive capacity. Forty-four variables and 10 composite maps were weighted according to their likely influence on drought resilience, based on literature review, expert opinion and feedback from regional stakeholders, and combined to create the final drought priority map.

The analysis was performed using the Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S) tool developed by ABARES[246]. Drought resilience priority areas lie at the intersection of all categories, where exposure, sensitivity and adaptive capacity overlap. The overlapping areas highlight where droughts are likely to occur most frequently and have the largest impact on water resources and agricultural production. They also identify locations where regional communities may be more vulnerable to the impacts of drought due to socio-economic factors including relative remoteness, access to infrastructure and income.

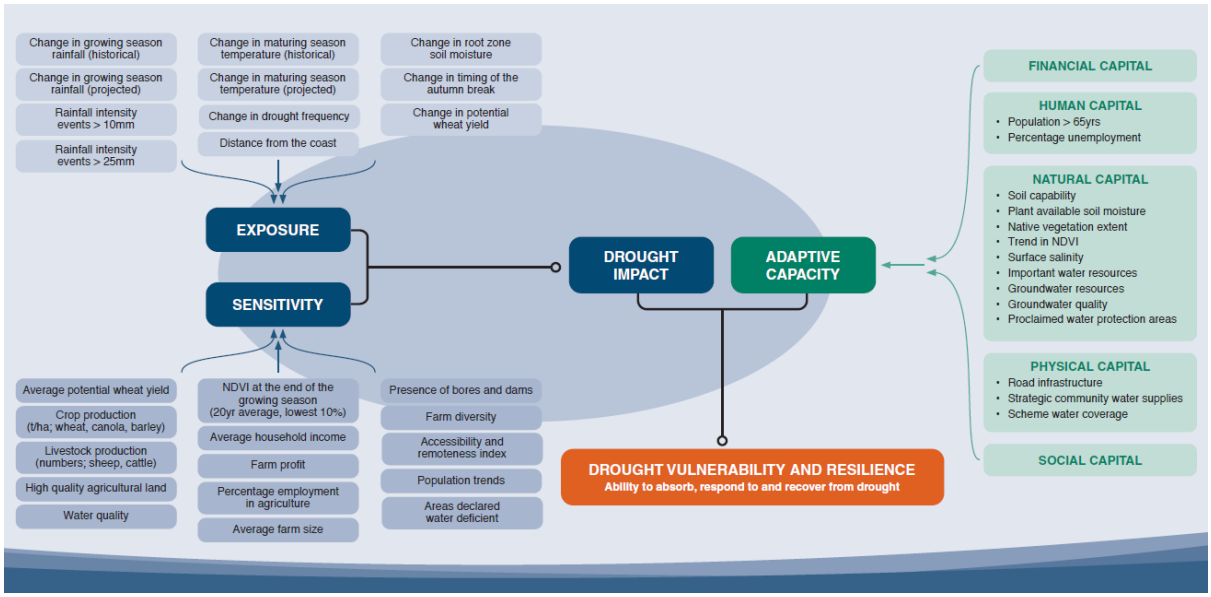

Figure 41 Data sets included in the analysis, showing how each data set fits within the over-arching program conceptual framework.

The maps were ground-truthed with the community and the technical working group and feedback was incorporated into the final products. The composite drought priority areas map has the potential to be a powerful decision-support tool for the South West of WA). There is a high level of confidence in the analysis as many of the included datasets are robust, regularly collected and available at high spatial and temporal resolution across South West WA, including the participating Shires in the Inland Great Southern.

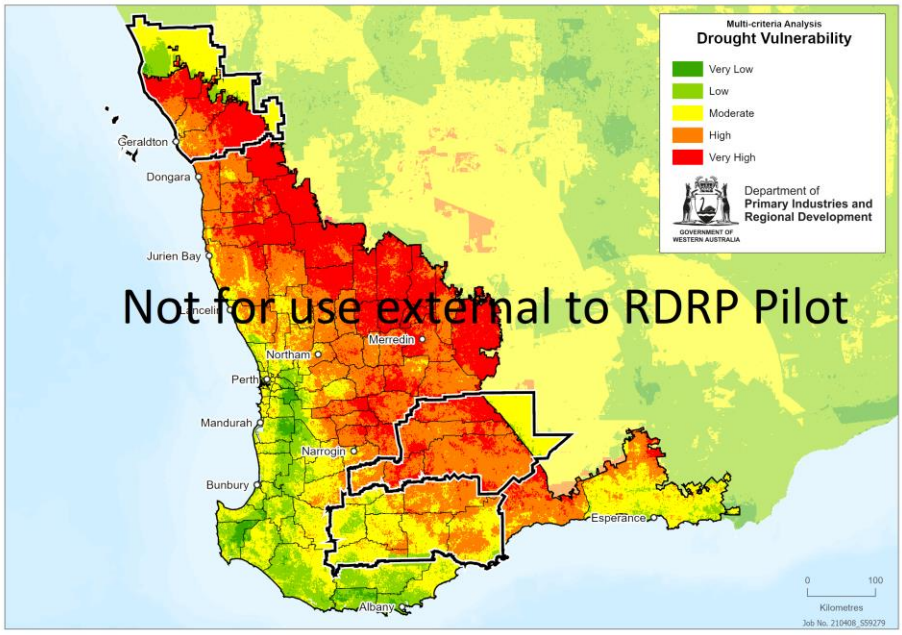

Figure 42 Final drought vulnerability map showing that the areas in Western Australia most vulnerable to drought are in the north and east of the region.

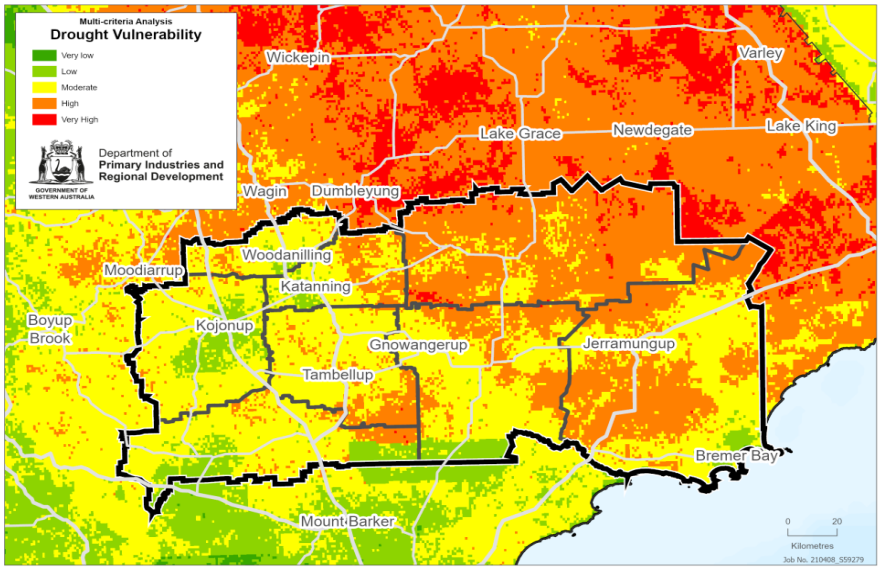

Figure 43 Final drought vulnerability map zoomed in to the Great Southern region showing high to very high vulnerability across the region

The links between the component datasets and impacts of drought well understood, for example low rainfall exacerbates drought risk, as does a shorter or warmer growing season; drought is associated with reduced production and farm income; problems with water quality or infrastructure can leave regional communities more vulnerable to the effects of drought.

The included datasets align well with regional communities' perceptions of how they are affected by drought, specifically low rainfall, high temperatures, compromised agricultural production, financial stress and shrinking regional communities. Those datasets in which we have lower confidence, either in terms of data quality and resolution or the link between the indicator and impacts of drought, are accounted for through the weighting structure applied throughout the analysis. There is a high level of agreement between the priority areas highlighted in the final map and those identified through participatory mapping with regional stakeholders.

Presenting information at the scale of the sub-national administrative unit enables direct embedding of the priority areas identified into wider government and institutional processes[247]. Spatial products such as the drought risk and resilience priority areas maps can provide significant support to decision-makers by collating complex climate, ecological, and socio-economic information into a single powerful image. These maps, developed together with regional stakeholders, are widely replicable.

As a next step, spatially defined priority areas need to be linked explicitly with clear, site-specific implementation activities, through participatory and stakeholder-engaged engaged planning and implementation.

A reporting detailing the analysis conducted by the DPIRD Climate Science and GIS team, additional workflow diagrams and additional regional maps for each component is available on request.

17.2 Drought Exposure Map

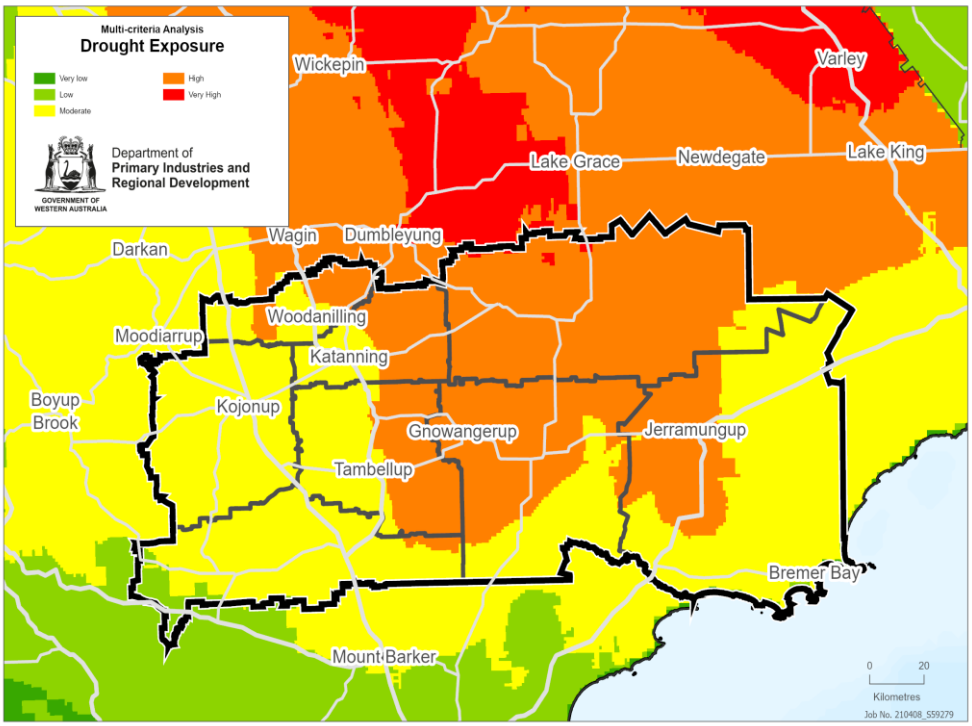

Figure 44 Inland Great Southern Exposure Map

In the Inland Great Southern, exposure to drought ranges from moderate in the far west of the region to high in the north/east region. This result was influenced by the low incidence of rainfall events over 10mm and 25mm, the percentage change in the autumn break from 1975-1999 to 2000-2020 and decline in average yield potential from 1975-1999 to 2000-2020, number of hot days and decline in growing season rainfall.

17.3 Drought Sensitivity Map

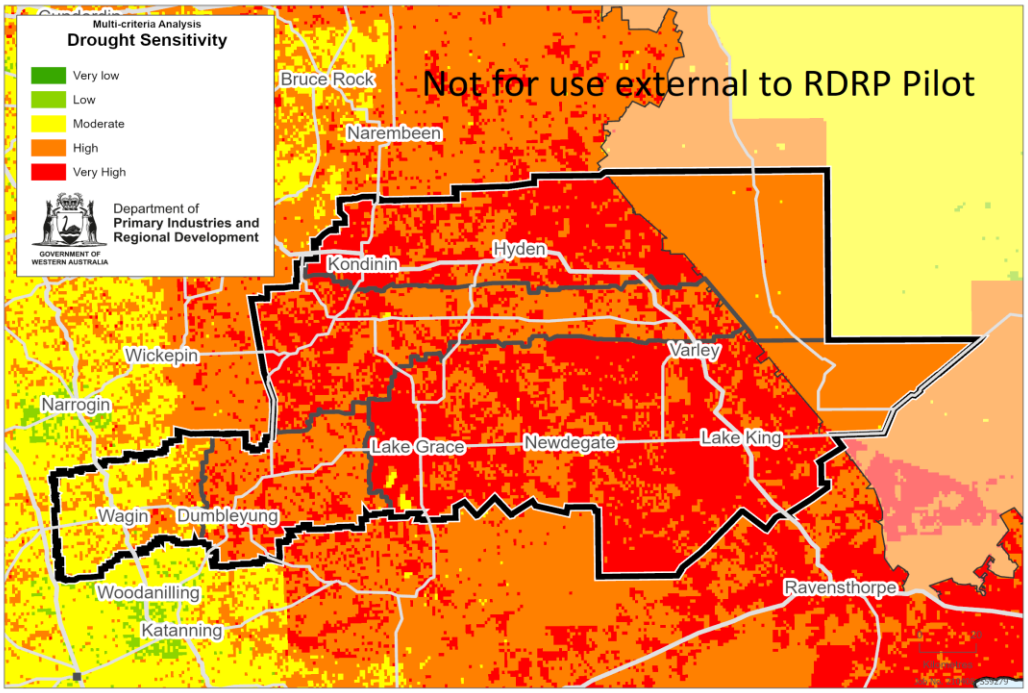

Figure 45 Inland Great Southern Drought Sensitivity map

In the Great Southern, sensitivity to drought ranges from moderate in the far west of the region and high to very high across Shires of Jerramungup and Kent. Investigation of the datasets identify accessibility and remoteness, percentage of Drought Risk by farm profit, higher numbers of livestock in some Shires, areas declared water deficient (Jerramungup and Kent) and low counts of water assets (bores and dams), and the high percentage of workers reliant on agriculture, may have contributed to the result.

17.4 Drought Impact Map

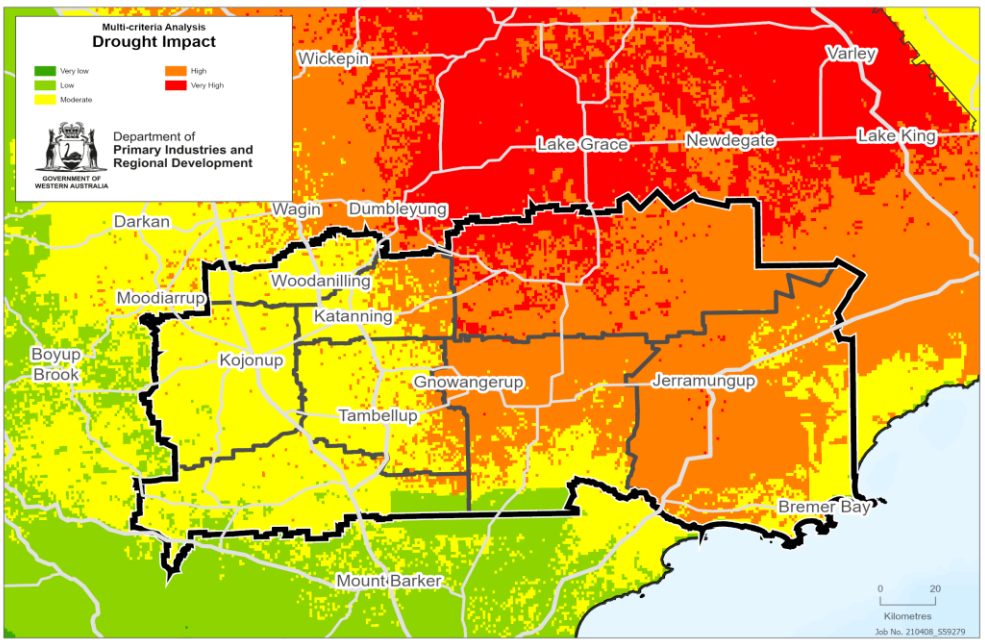

Figure 46 Inland Great Southern Drought Impact map

The drought impact map is a composite of the Drought Exposure and Drought Sensitivity maps. The Western Shires including Kojonup, Katanning, Tambellup, Woodanilling Cranbrook and Broomehill-Tambellup have moderate risk of being impacted adversely by drought. The eastern half of the Great Southern region has high and very high likelihood of being impacted adversely by drought. Areas of most concern are the northern areas in the Shire of Kent.

Actions that are targeted at improving the reliable harvesting and storage of water, support drought resilient farming systems, and diversification of economic activity across the region will support the ability of the region to lessen adverse impacts of drought.

17.5 Drought Adaptive Capacity Map

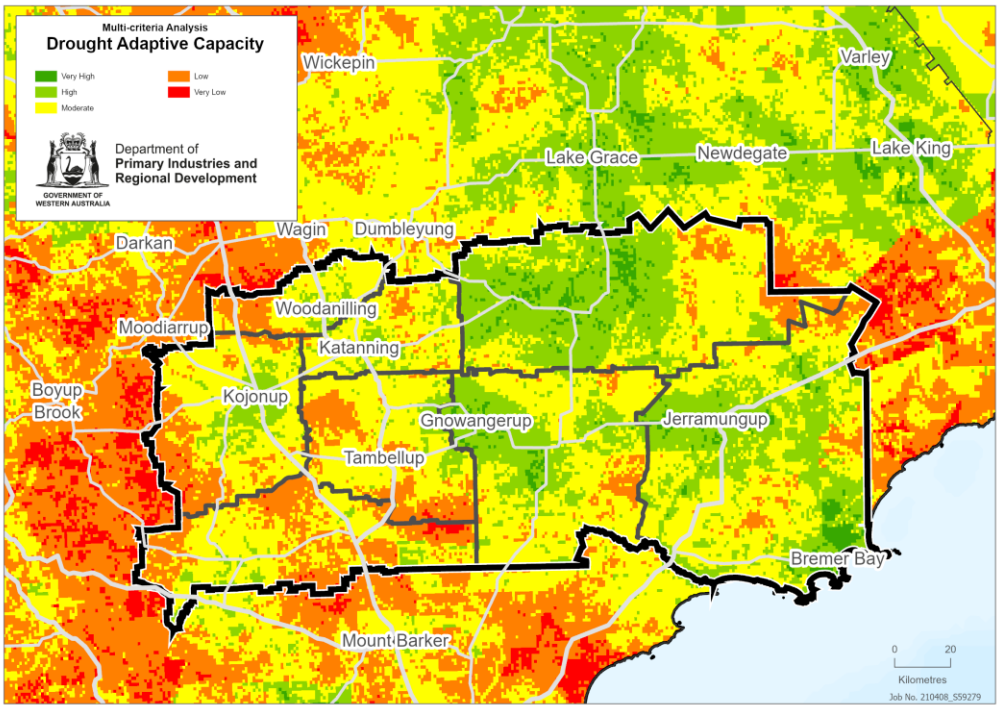

Figure 47 Inland Great Southern Drought Adaptive capacity map

The adaptive capacity map is made up of three composite maps for human capital, natural capital and physical capital. This map is based primarily on the natural and physical capital of the region and limited in its depiction of human and social capital. Though through community consultation, and the outcomes of the social impact study, a strong link was identified between natural and physical capital and economic prosperity, which impacts on individual wellbeing and ultimately social and community resilience.

In the Great Southern, the areas that had the highest impact of drought, showed the highest capacity to adapt. The lower levels of capacity around Kojonup and Katanning would need further investigating but could be due to an aging population.

The very low unemployment rate across the region relates to better adaptive capacity, though this does not reflect the issues with attracting labour due to lack of housing options for workers. More exploration is needed of these factors to ascertain true adaptive capacity to drought.

17.6 Drought Vulnerability Map

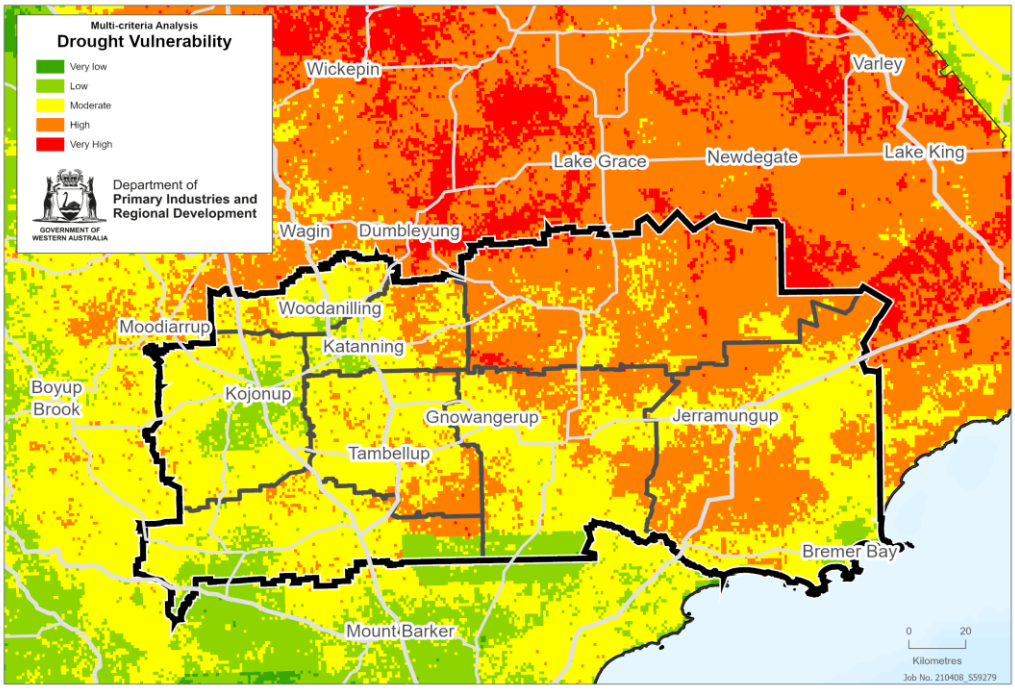

Figure 48 Great Southern Drought Vulnerability map

The drought vulnerability map is a composite map of Adaptive Capacity and Drought Impact. There is variability in drought vulnerability across the Inland Great Southern Further assessment of the region's drought vulnerability is provided in Section 6. A copy of the MCAS methodology and results can be provided on request.

18. Drought Vulnerability Assessment

The reports presented in this section summarise several different possible approaches to assessing drought vulnerability focusing primarily on measurable biophysical and economic indicators (Indicators of Drought) or primarily on socio-economic factors (Measuring Drought Resilience, Assessing Vulnerability to Drought). These contributions were considered and incorporated into the overarching conceptual framework for the vulnerability assessment.

Further work is needed to consolidate the different approaches and agree on a final vulnerability assessment framework for regional drought resilience planning in Western Australia. While the current drought vulnerability assessment for the Inland Great Southern is best represented by the regional drought priority areas maps in Section 0 of this report, the spatial analysis is limited in its ability to include social and economic data. These limitations are addressed in the approaches either tested or outlined below.

A final framework, which could be used for future years of the project, will be informed by the approaches outlined below and the lessons learned during the development and implementation of the draft framework during the foundational year 2021-22.

18.1 Indicators of Drought

Understanding the social and economic impacts of drought is critical for informing policies and initiatives to adequately prepare regions for drought and support them during and post drought. Drought indicators are generally described using observable changes in rainfall, temperature, soil moisture and other factors, though it was not clearly understood if these parameters can used to reliably predict social and economic impacts.

The project team commissioned CSIRO to conduct an analysis of social, economic and environmental data recently compiled by the Nous Group[248] to test whether social and economic impacts of drought (indicators) can be predicted from more readily measurable environmental and economic variables. Recently, machine learning models have been used successfully in predicting remote-sensed drought indices around the world, including the southern United States[249], Iran[250], Ethiopia[251] and the UK[252]. Noting this, the team used two machine learning methods, random forests[253] and regression trees[254], to model three social and five economic indicators as a function of environmental and economic variables for the broadacre cropping regions of South West WA.

Table 12: The social and economic indicators used in the analysis conducted by CSIRO, along with the associated code used to refer to the indicator in the figures below, frequency at which data were collected and years for which data are available.

Type	Indicator	Frequency	Years
Social[a]	Mental health-related presentations to emergency departments per 10,000 population	Annual	2015–2019
Social[a]	Episodes of residential mental health-related care per 10,000 population	Annual	2013–2019
Social[a]	Mental health-related community contacts per 10,000 population	Annual	2014–2018
Economic[b]	Number of debtors in the past quarter per 100,000 population	Quarterly	2007–2019
Economic[c]	Farm-based profit percentile rank score	Annual	2000–2019
Economic[d]	Internet Vacancies Index, all occupations	Monthly	2010–2020
Economic[e]	Social Security payments per person	Quarterly	2015–2019
Economic[f]	Unemployment rate	Quarterly	2010–2020

[a] Australian Institute of Health and Welfare[255], [b] Australian Financial Security Authority[256], [c] Australian Bureau of Agricultural and Resource Economics and Sciences[257], [d,f] Labour Market Information Portal[258,259], [e] Australian Department of Social Services[260].

Table 13: Environmental and economic variables

Type	Indicator	Frequency	Years
Environmental[a]	Daily average rainfall in past 12 months	Monthly	2000-2020
Environmental[b]	Mean maximum temperature over last 12 months	Monthly	2000-2020
Environmental[c]	Average Forest Fire Danger Index over past 12 months	Monthly	2000-2020
Environmental[d]	Root zone soil moisture for the past 12 months as an absolute value	Monthly	2000-2020
Terrestrial[e]	Growth in proportion of land that is vegetated as a percentile in overall distribution of growth over the years	Monthly	2002-2020
Terrestrial[f]	Relative proportion of land that is vegetated in past 12 months as a percentile in overall distribution of years	Monthly	2001-2020
Terrestrial[g]	Monthly snapshot of proportion of land that is bare soil	Monthly	2001-2020
Economic[h]	Hours of agricultural-related employment (including downstream manufacturing) as a proportion of all employment	Quarterly	2001-2020
Economic[i]	Index of Relative Socio-Economic Disadvantage	Every 4 years	2001-2016
Economic[j]	Economic Diversity Index (Hachman index based on employment by industry division)	Assumed constant	2016

[a,b,c,d] Australian Government Bureau of Meteorology[261,262,263,264], [e,f,g] National Computational Infrastructure Australia[265], [h,i] Australian Bureau of Statistics[266,267], [j] Nous Group[268]

Temperature, rainfall and FFDI were related to social and economic indicators and the predictive models fit well, returning sensible predictions for known relationships (e.g. between rainfall, vegetation cover and farm profits[269]). The team 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. For example, regression trees for social indicators related to mental health included some branches with expected relationships if drought conditions were related to mental health impacts, but also many branches that were not related to drought conditions. This inconclusive result highlights that there are many factors influencing mental health in addition to drought.

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.

It is difficult for this analysis to definitively attribute driving conditions of drought (such as low rainfall, high temperature and low soil moisture) to social and economic impacts becoming more severe. While this work did determine a strong predictive model using the selected variables, the non-linear nature and complexity made it difficult to effectively attribute the relationship to drought. Several of the predictive pathways were not consistent with drought as the main driver of the measured social and economic impacts.

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. This may include the application of a working definition of drought, or better-defined environmental predictors such as relative temperature and rainfall changes that account for spatial variation over the broadacre cropping regions of South West WA. Initial exploration accounting for geographical influences has shown promise. A copy of the full CSIRO Drought Indicators report is available on request.

18.2 Measuring Drought Resilience

Drought resilience can be difficult to measure. It is, however, important to attempt measurement to assist regional communities with assessing and prioritising their needs and goals, establish baselines for monitoring progress and recognising success and to raise awareness of the costs and benefits of resilience building activities[270].

As resilience can rarely be measured directly, assessment is commonly made via indices (containing indicators which represent a selected characteristic of resilience), scorecards (an evaluation of performance or progress toward a goal) and tools (models, frameworks or toolkits developed to measure resilience), all of which rely on a suite of proxy variables to represent likely resilience[271]. Currently, resilience is typically measured based on characteristics of a community as it now exists, not as the potential for transformations that will / could happen within and to that community after a crisis such as drought. This makes it challenging to measure transformational capabilities using indices.

Common elements in measures for assessing community resilience include attributes and assets (economic, social, environmental, infrastructure) and capacities (social capital, community functions, connectivity, planning, governance).

Assessing resilience consists of measuring a core set of attributes and assets, capacities and proxy measures including:

- economic capacities or indicators such as education, education equality, annual income, wealth of retirees, household income;
- social capacities or indicators such as the number of civic organisations and registered non-profit organisations, health access, faith-based networks;
- community capacities and indicators such as physical assets, infrastructure and community services;
- environmental indicators such as impervious surfaces that prevent or hinder absorption of water into the soil; and
- institutional or governance indicators such as plans, support programs, insurance policies.

Table 14 Existing Disaster Resilience Assessment Measures Used in the United States[195]

Measure	Type
Communities Advancing Resilience Toolkit[272]	Tool
Conjoint Community Resiliency Assessment Measure (CCRAM)[273]	Tool
Coastal Resilience Index[274]	Scorecard
Community Based Resilience Analysis[275]	Tool
Community Resilience System[276]	Tool
Community Resilience Index[277]	Index
Food and Agriculture Organisation Livelihoods[278]	Index
Oxfam Great Britain[279]	Index
Population and Demographics, Environmental/Ecosystem, Organized Governmental Services, Physical Infrastructure, Lifestyle and Community Competence, Economic Development, and Social-Cultural Capital (PEOPLES)[280]	Tool
Rockefeller 100 Resilient Cities[281]	Tool
Rural Resilience Index[282]	Index
San Francisco Bay Area Planning and Urban Research Association[283]	Scorecard

An inclusive and adaptive social-focused drought resilience framework could consist of five sub-dimensions of social resilience: social structure, social capital, social mechanisms, social equity and social belief[284]. Such a framework includes a set of 16 characteristics and 46 corresponding indicators for measuring social resilience based on the most used and important resilience characteristics in the global literature. This framework can be adapted to any geographical area, hazard or community context and many of the indicators are available in the public domain. The full report from the UWA Centre for Social Impact is available on request.

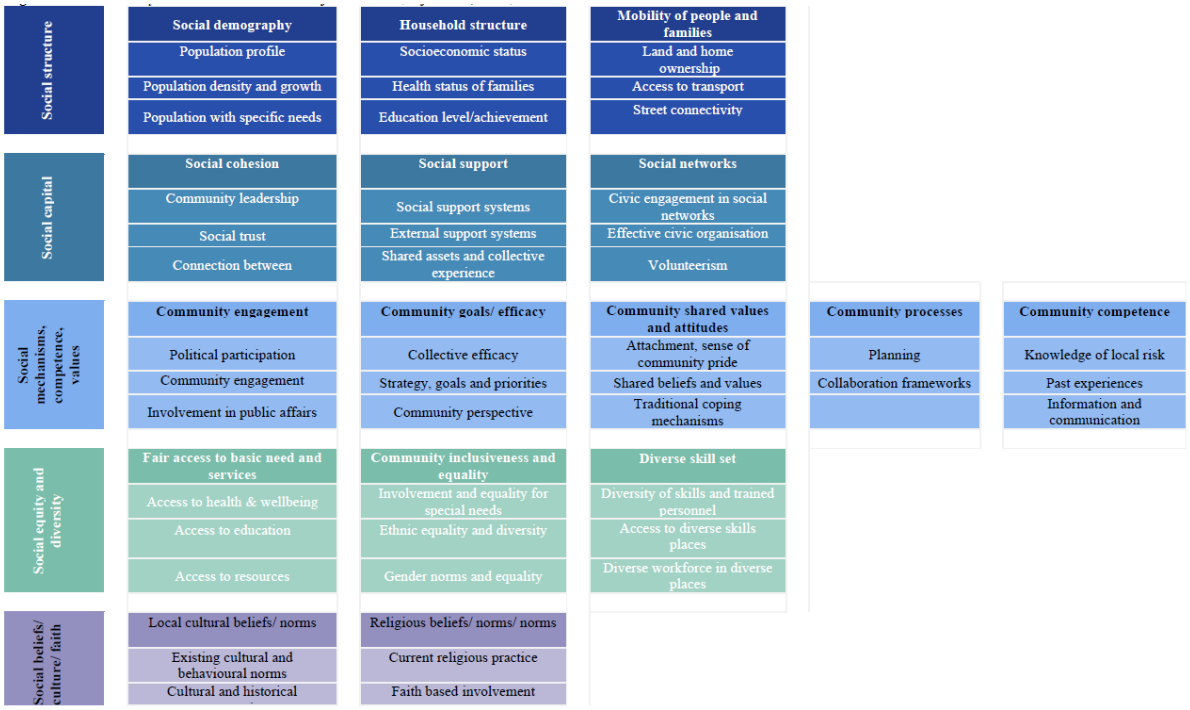

Figure 49 Framework for measuring community resilience.

18.3 Assessing Vulnerability to Drought

Drought vulnerability is the degree of susceptibility within society to, and the capacity to cope with, the adverse impacts of drought[285]. It is a function of three major drivers: exposure to drought, the sensitivity of the community to the impacts of drought and the capacity of the community to adapt to drought (see Introduction to this report).

Vulnerability assessments aim to identify vulnerable places and populations and determine ways to make the affected place or population more resilient. This is achieved through identifying underlying causes of risk such as inadequate infrastructure, management or technology, or economic, environmental and social factors. A review of the literature shows that social, economic, physical, crime and conflict, governance, environment and farming practice risk factors are among the important metrics to include in a vulnerability assessment[211,286,287,288].

The framework in Figure 50 suggests the dimensions, factors and possible indicators that could be included when measuring drought vulnerability. Many of the listed indicators are available as publicly held datasets.

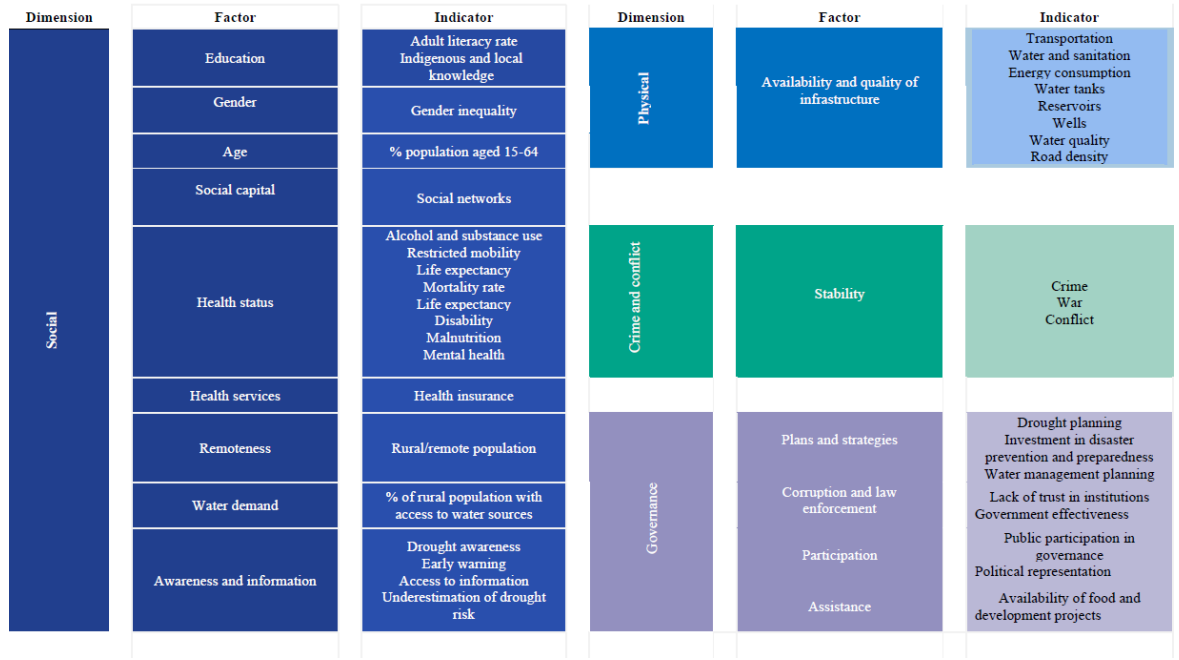

Figure 50 Suggested framework for a risk assessment component of Drought Vulnerability Assessment.

Crisis management is the basis of much drought response activity the world over. Studies have shown, however, that effective drought management strategies are based on proactive risk assessment and risk management[213]. Drought risk management involves risk reduction (prevention, mitigation, preparation), disaster management (alert, response) and recovery and adaptation (rehabilitation)[289].

Prevention involves the ongoing involvement of the community and local government in the dissemination of information, promotion of water conservation and sustainable water practices, monitoring of health in vulnerable groups and capacity building of local health services.

Mitigation involves working with local stakeholders in the local community to identify, measure and reduce risk and vulnerability in the community, promoting participation in public policy programs for water resource infrastructure and participating in efforts to address drought impacts.

Preparation involves assessing response capacity, identifying local resources, establishing partnerships for action, participating in vulnerability and risk assessments, establishing an action plan, and working with community leaders and local government to inform and create awareness within the community.

Alert involves the active identification of vulnerable groups and the issue of timely and clear warnings to affected groups and communities.

Response involves identifying the direct and indirect impacts of drought and the providing an integrated, thorough and timely response.

Rehabilitation involves the evaluation of community vulnerabilities, risks, impacts and resilience in order to develop interventions. A coordinated and supportive government response is needed to empower the community, improve adaptive capacity and enhance community resilience in the long term.

A list of drought risk reduction and adaptation strategies is included in Figure 51, based on a review of more than 40 studies[221]. These strategies include structural (engineering-based or technical) solutions and non-structural solutions at the individual, government and ecosystem level.

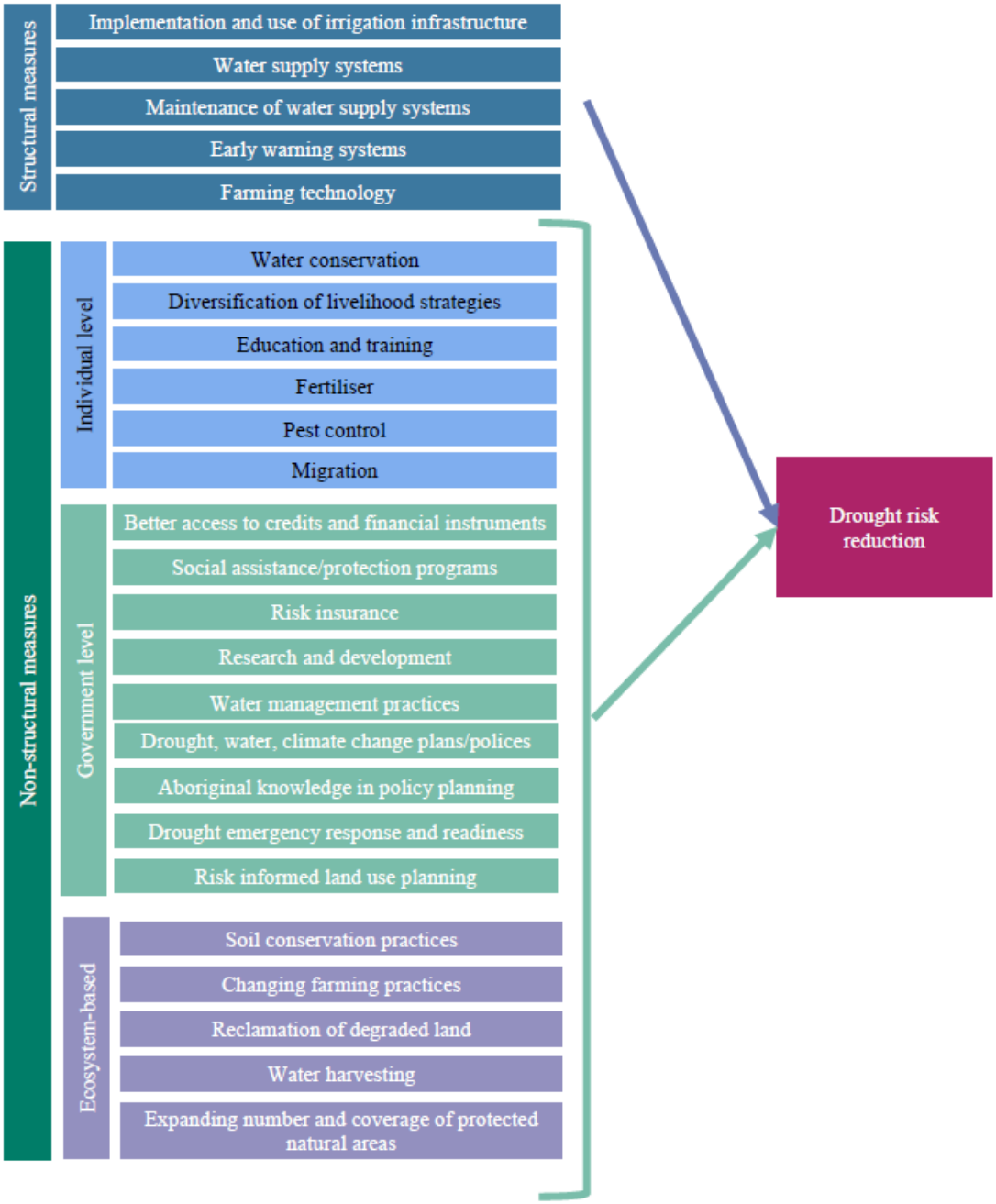

Figure 51: Drought risk reduction and adaptation options based on literature review

19. Vulnerability Index for the Inland Great Southern

This chapter presents a Vulnerability Index for the Inland Great Southern region, which aims to assist local decision makers and managers in the rapid evaluation of drought risk in the region. The index has been specifically designed to track change over time for the study, although it could be adapted for any region across WA and is primarily based on the regional and national datasets used throughout this report. The index can be seen as a repeatable exercise providing a snapshot of vulnerability to drought that can be tracked over time.

The analysis utilizes the overarching DVA conceptual framework understanding overall vulnerability as the outcome of interacting exposure, sensitivity and adaptive capacity parameters. We have used a number of indicators within each category to serve as proxies for **exposure, sensitivity** and **adaptive capacity**.

Each sub-indicator was scored using a 1-5 sliding scale where 1 represents the most desirable condition (low vulnerability) and 5 represents the least desirable state (high vulnerability) in terms of drought risk. The data used for determining scores for each indicator were drawn from the same (largely) publicly available datasets used to create the drought risk priority areas map in Section 0 of this report. Scores represent the average for the region.

Table 14 List of the indicators used as proxies for exposure, sensitivity and adaptive capacity to calculate an index of vulnerability for the Great Southern region.

Component	Data Set	Score
Exposure	Projected change in growing season rainfall and maturing season temperature	2
	Change in timing of the autumn break to date	4
	Change in drought frequency to date	4.5
Sensitivity	Production risk (crop and livestock combined)	2.5
	Trend in NDVI (lowest 10%)	3.5
	Percentage employment in agriculture	5
Adaptive capacity	Percentage unemployment	2
	Access to infrastructure	1.5
	Soil capability	3
	Ground water	5
	Average score	**3.3**

19.1 Exposure

Indicator 1 - Projected change in temperature and rainfall

Temperature change is measured as the change in number of days above 34ºC August to November by 2050 based on data from Climate Services for Agriculture.

Rainfall change is measured as the percentage change in rainfall April to October by 2050 based on data from Climate Services for Agriculture.

Sliding scale 1-5

- 1 No increase in number of hot days, no change or an increase in rainfall
- 2 Moderate increase in number of hot days (<2.5), moderate decrease in rainfall (<15%)
- High increase in number of hot days (<2.5 more hot days), moderate decrease in rainfall (<15%)
- Moderate increase in number of hot days (<2.5), large decrease in rainfall (≥15%)
- High increase in number of hot days (≥2.5 more hot days), large decrease in rainfall (≥15%).

Given that Australia is a water stressed country overall, it is assumed here that significant projected reductions in annual average rainfall will have stronger negative consequences than projected increases, which we take to represent opportunities.

Inland Great Southern score: The Inland Great Southern region scores a 2 for drought risk in terms of projected temperature and rainfall change, showing moderate increases in temperature and moderate drying.

Description: Growing season rainfall is projected to decline by 10-15% across the entire region by 2050. The number of hots days during the maturing season is not expected to increase significantly across region see below.

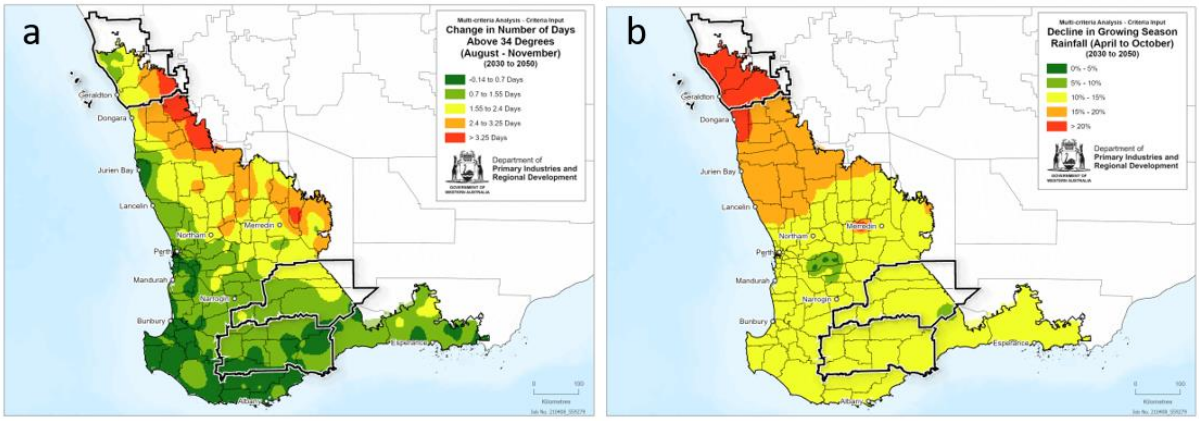

Figure 52 Maps showing (a) projected change in the number of hot days during the wheat maturing season by 2050 and (b) projected change in growing season rainfall shown as percentage change by 2050.

Indicator 2 - Change in timing of the autumn break

The data show the percentage difference between the median break of season for the period of 1975-1999 and 2000-2020, interpolated using DPIRD and BOM automatic weather stations. Autumn break is defined as at least 25 mm of rainfall over three consecutive days prior to the commencement of sowing.

Sliding scale 1-5

- 1 Percentage decrease in timing of the autumn break – break occurs earlier

- 2 Autumn break occurs later (0-2%)
- Autumn break occurs later (3-5%)
- Autumn break occurs later (6-8%)
- Autumn break occurs later (≥9%)

Given that temperatures in region are too high to support wheat production in the late spring and summer months, a later autumn break shortens the available growing season.

Inland Great Southern score: The Inland Great Southern region scores a 4 for drought risk in terms of change in timing of the autumn break experienced to date.

Description: Change in timing of the autumn break is variable in the Inland Great Southern, though has tended towards a later break of between 3 and 6% to some areas more than 9%.

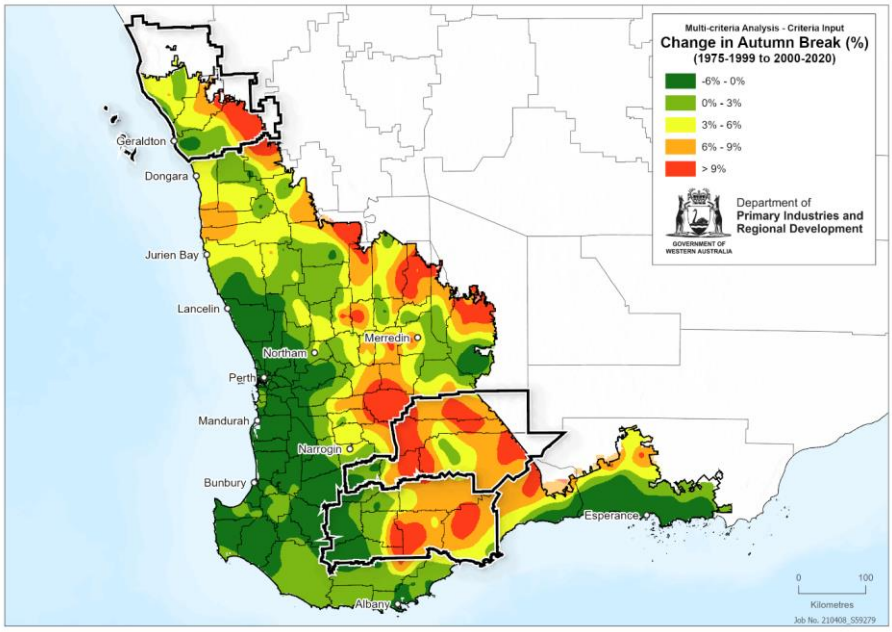

Figure 53 Change in timing of the autumn break.

Indicator 3 - Change in drought frequency

The data show different in the number of droughts that occurred during 1980-1999 compared to 2000-2020. Drought is defined as rainfall during the growing season in the 10th percentile. It is calculated for each year against the average rainfall over the preceding 40 years.

Sliding scale 1-5

- 1 Three or four fewer droughts
- 2 One or two fewer drought
- Equal number of droughts
- One or two more droughts
- Three or four more droughts

An increasing number of droughts is undesirable because droughts are associated with failed crop and livestock production.

Inland Great Southern score: The Inland Great Southern region scores a 4.5 for drought risk in terms of increasing drought frequency.

Description: Half the Inland Great Southern region has experienced 1 or 2 more droughts in the last 20 years, and half 3 or more compared to the preceding 20 years.

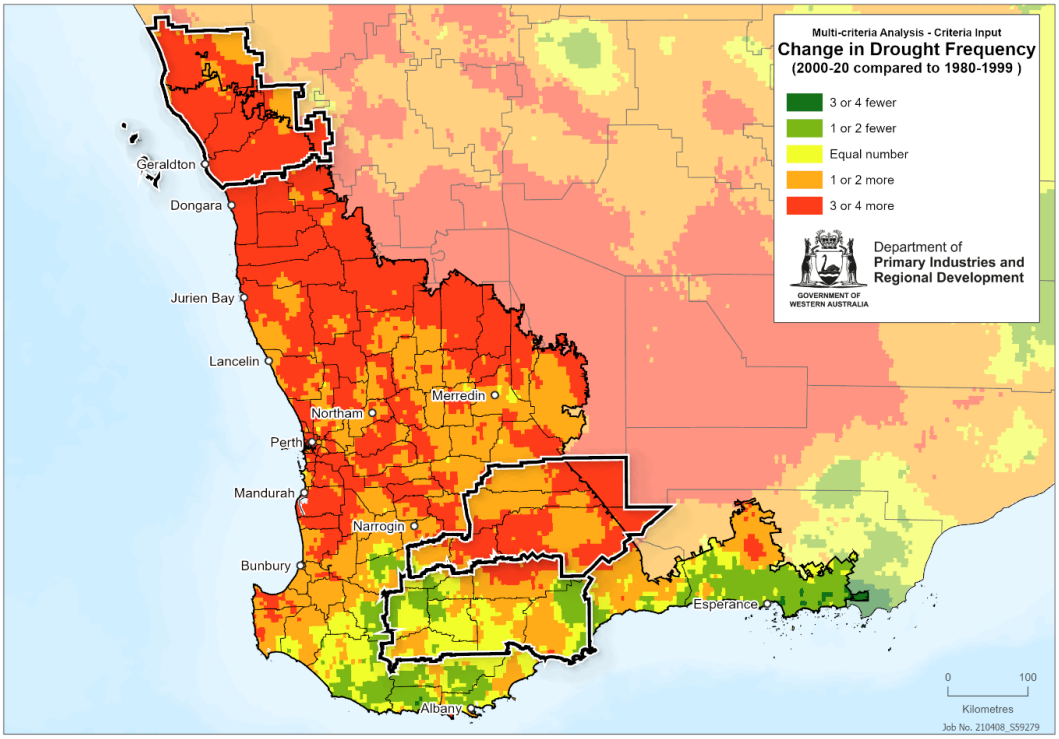

Figure 54 Change in drought frequency

19.2 Sensitivity

Indicator 1 - Production risk

The assessment of production risk incorporates measures of average production in the region for wheat, barley, canola, sheep and cattle, high quality agricultural land, wheat yield potential and 20-yr average NDVI.

Sliding scale 1-5

- 1 Very low risk – good production, good soils and high average NDVI
- 2 Low risk
- Moderate risk
- High risk
- Very high risk – marginal production, poor soils and low average NDVI

This indicator operates on the assumption that higher levels of production and ground cover are desirable and promote resilience.

Inland Great Southern score: The Inland Great Southern region scores a 2.5 for drought risk in terms of production risk.

Description: While there are some more marginal areas in terms of average production, soil quality and/or average NDVI in the eastern parts of the region, the majority of the region is classified as having low to moderate production risk.

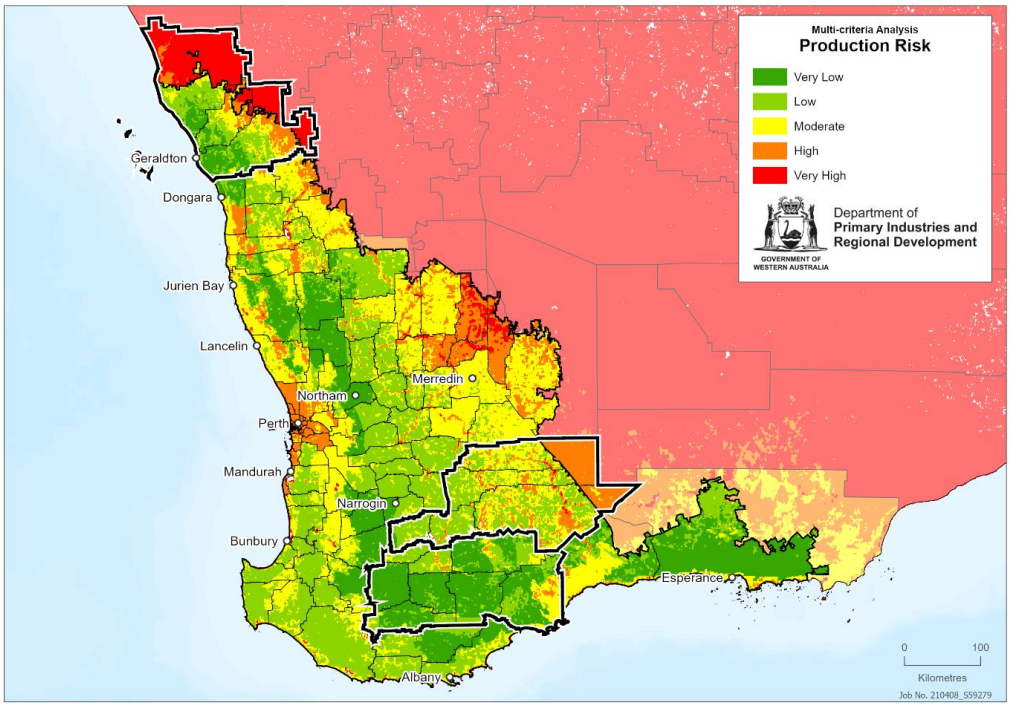

Figure 55 Production risk

Indicator 2 (trend in NDVI – lowest 10%)

The data show values for the lowest 10% of MODIS vegetation indices (NDVI) between 2002 and 2021. MODIS indices are produced on 16-day intervals and at multiple spatial resolutions and provide spatial and temporal comparisons of vegetation canopy greenness, a composite property of leaf area, chlorophyll and canopy structure.

Sliding scale 1-5

- 1 NDVI 181-200
- 2 NDVI 161-180
- NDVI 141-160
- NDVI 121-140
- NDVI 100-120

Low NDVI values indicate low levels of ground cover. Given that ground cover reduces the risk of soil erosion and improves soil health, low NDVI values are considered undesirable and likely to increase risk.

Inland Great Southern score: The Inland Great Southern region scores a 3.5 for drought risk in terms of the lowest 10% of NDVI values recorded between 2002 and 2021.

Description: NDVI values across most of the region are in the 141-160 range, with a more area in the east in the 121-140 range and tending towards the 161-180 range in Wagin.

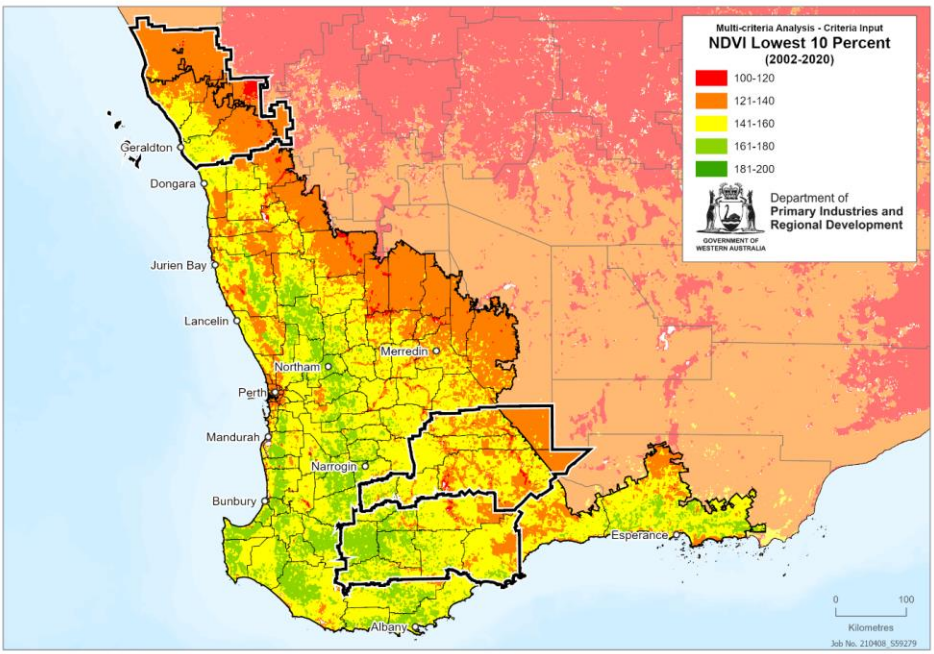

Figure 56 NDVI lowest 10%

Indicator 3 - Percentage employment in agriculture

The data show the percentage of people who are employed in farming and allied industries according to the Australian Census 2016 records of characteristics of employed persons.

Sliding scale 1-5

- 1 Very few people employed in agriculture (<10%)
- 2 Few people employed in agriculture (10-20%)
- Some people employed in agriculture (20-30%)
- Many people employed in agriculture (30-40%)
- Very many people employed in agriculture (>40%)

Livelihoods that depend directly on dryland agriculture are at higher risk of negative impacts from drought.

Inland Great Southern score: The Inland Great Southern region scores a 5 for drought risk in terms of the percentage of the population that is employed in agriculture.

Description: More than 40% of the population are employed in agriculture across the whole region, meaning potentially high exposure to the impacts of drought.

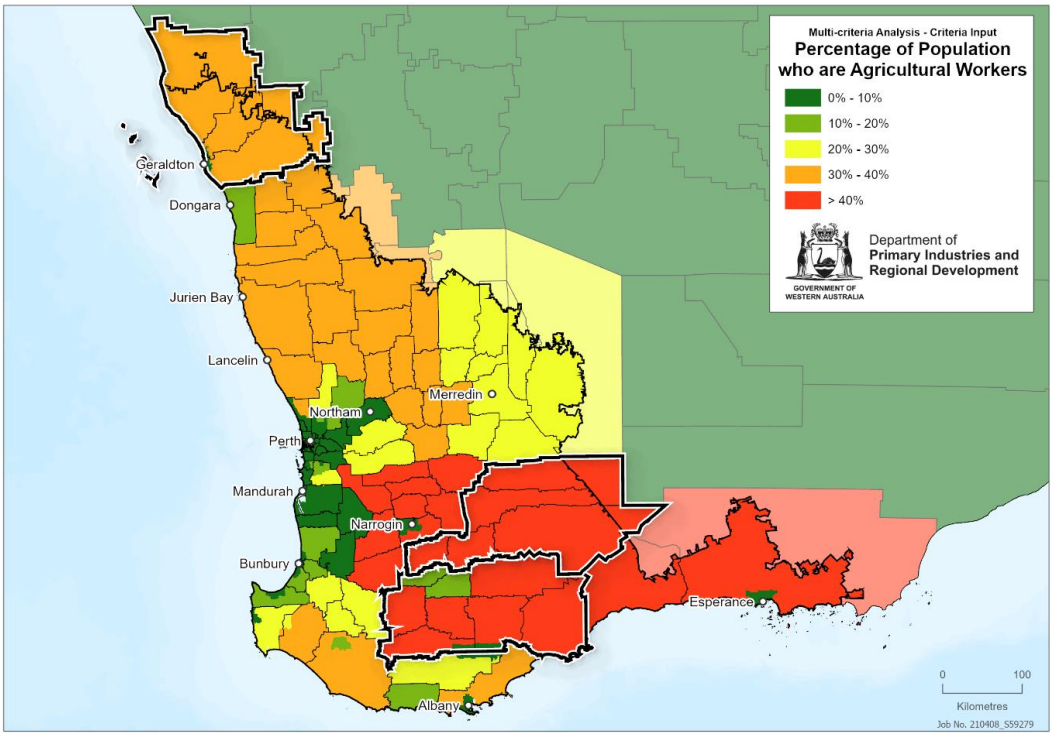

Figure 57 Percentage of the population employed in agriculture

19.3 Adaptive Capacity

Indicator 1 - Percentage unemployment

The data show the percentage of people who are unemployed according to the Australian Census 2016 records of total labour force status.

Sliding scale 1-5

- 1 Very low unemployment (0-2%)
- 2 Low unemployment (2-3%)
- Moderate unemployment (3-4%)
- High unemployment (4-5%)
- Very high unemployment (>5%)

Unemployment is an indicator for financial stress and dependency. Existing unemployment can increase the risk of adverse impacts from drought; economic consequences will exacerbate pre-existing social or economic disadvantage.

Inland Great Southern score: The Inland Great Southern region scores a 2 for drought risk in terms of levels of existing unemployment in the region.

Description: Levels of unemployment are very low across eastern areas, with Dumbleyung and Wagin having slightly higher unemployment. Low unemployment across the region is also indicative of the difficulty in attracting people to the region due to competitive labour markets and low housing availability. This can impede on population and economic growth, impacting on drought resilience.

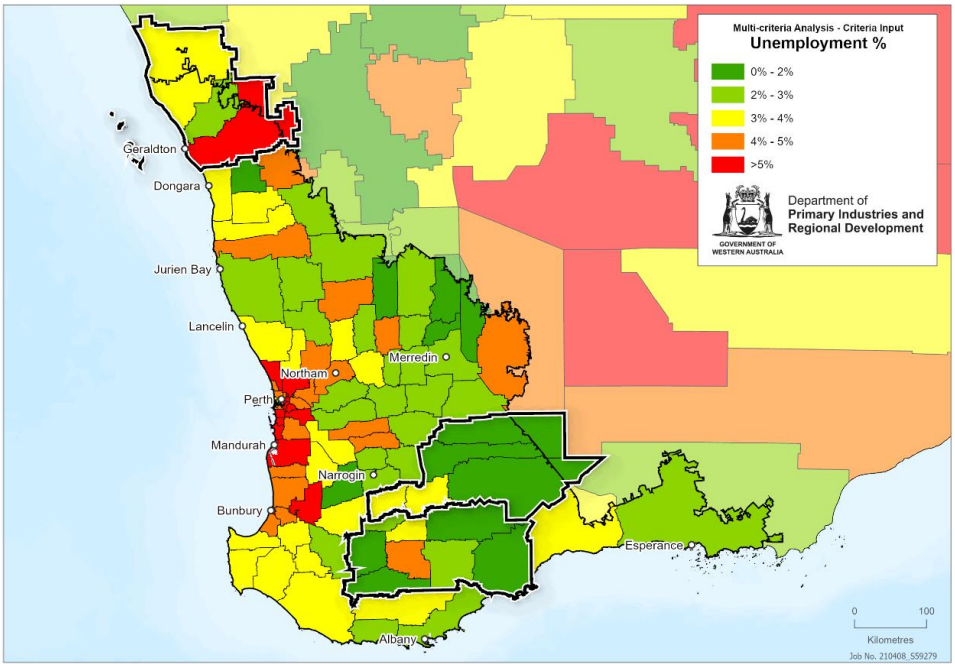

Figure 58 Unemployment as a percentage of the total working age population

Indicator 2 - Access to infrastructure

The data show scheme water coverage and proximity to main road infrastructure and strategic community water supplies.

Sliding scale 1-5

- 1 Critical road and/or water infrastructure within 10km (very high)
- 2 Critical road and/or water infrastructure 10-25km away
- Critical road and water infrastructure 25-50km away
- Critical road and water infrastructure 50-100km away
- Critical road and water infrastructure more than 100km away (very low)

Relative remoteness can affect drought resilience as people located further from infrastructure and services may find it more difficult to access emergency water supplies or transport services when these are needed during drought.

Inland Great Southern: The Inland Great Southern region scores a 1.5 for drought risk in terms of access to water services and transport infrastructure.

Description: Critical water services and road infrastructure are accessible across the Inland Great Southern region, with less accessibility noted in parts of Lake Grace. Note this map does not consider the limitations and constraints of the water system under drought conditions and periods of high water demand. Despite this high accessibility, parts of the region have experienced water deficiencies and restrictions applied to piped water infrastructure.

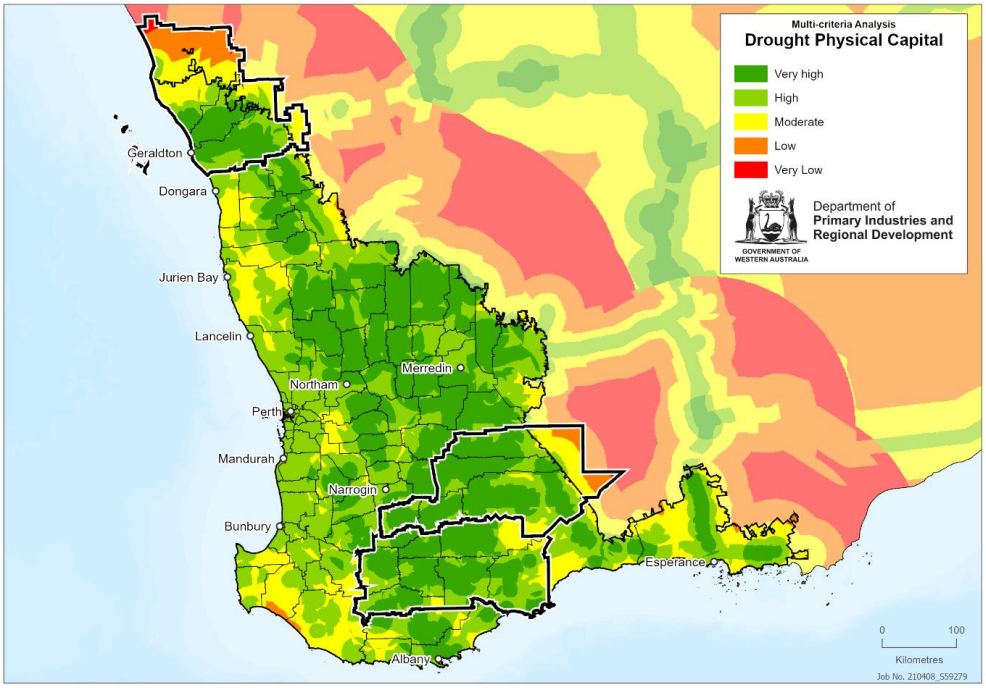

Figure 59 Proximity to water and road infrastructure

Indicator 3 - Groundwater quality

The data show likely groundwater salinity.

Sliding scale 1-5

- 1 ≤500mg/L Total Dissolved Solids
- 2 500-999mg/L Total Dissolved Solids
- 1000-2999mg/L Total Dissolved Solids
- 3000-6999mg/L Total Dissolved Solids
- ≥7000mg/L Total Dissolved Solids

Access to groundwater to augment water supplies may assist in building drought resilience, though it is noted that in the Inland Great Southern, the sourcing of quality groundwater is challenging.

Inland Great Southern score: The Inland Great Southern region scores a 5 for drought risk in terms of groundwater quality.

Description: Groundwater quality is highly saline across the region. Desalination is an opportunity, and would address the impacts of rising saline water tables on infrastructure and production, as well as providing an alternative water resource, though research is required to ascertain best fit technologies for extremely saline water environments.

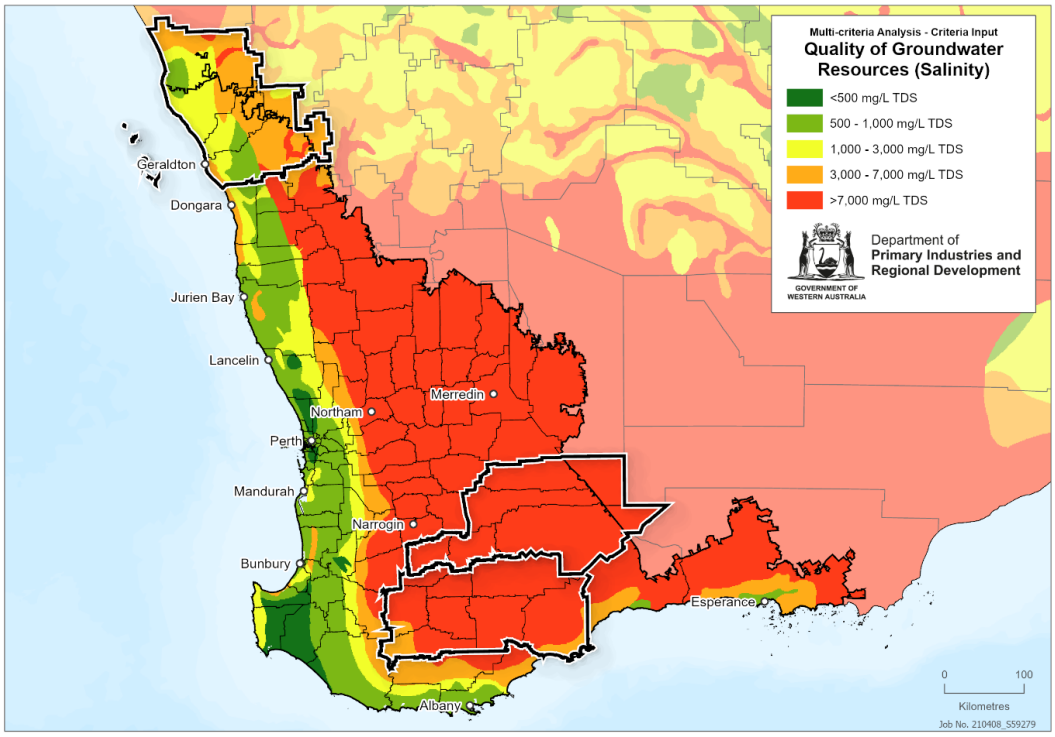

Figure 60 Groundwater quality

Indicator 4 - Soil capability

The data show land capability for cropping in the south west of Western Australia based on analysis and interpretation of the best available soil-landscape mapping dataset provided by DPIRD. The assessment covers dryland production of field crops under a cropping system that incorporates minimal tillage practices and stubble retention.

Sliding scale 1-5

- 1 High to very high capability 50-70%
- 2 Moderate to very high capability >70%
- Moderate to very high capability 50-70%
- Low to very low capability 50-70%
- Low to very low capability >70%

Good soil capability contributes to drought resilience by ensuring the crops can be reliably produced in subsequent years, under better conditions, to make up for losses incurred due to failed production during drought.

Inland Great Southern: The Inland Great Southern region scores a 3 for drought risk in terms of soil capability.

Description: Soil capability for dryland cropping is variable across the region, with patches of very low to low soil capability in western areas, with high soil capability in eastern and northern areas of the region.

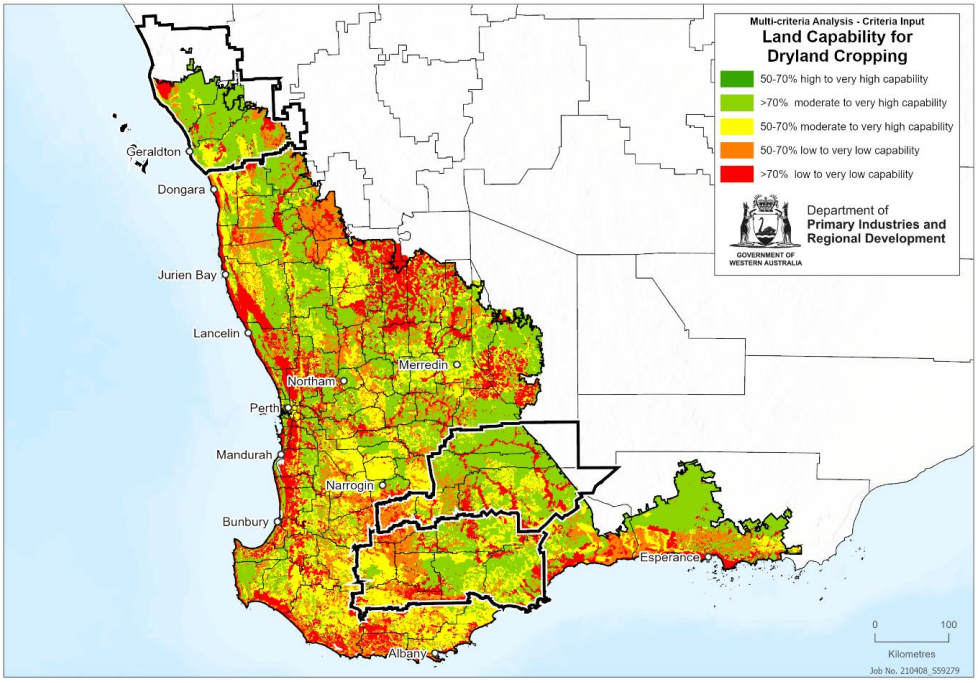

Figure 61 Land capability for dryland cropping.

19.4 Summary of Drought Vulnerability

Averaging the scores from each individual indicator returns an overall vulnerability index of 3.3, indicating moderate vulnerability to drought. A radar chart is useful for seeing which components of vulnerability need to be addressed most urgently as risk is not evenly spread across the selected indicators and therefore poorly represented by the average score. Given that each indicator has been scored on a 1-5 sliding scale where 1 represents the most desirable state and 5 the least desirable, it is most desirable for the indicators to cluster towards the centre of the radar chart.

Areas of strength in terms of drought resilience in the Inland Great Southern region lie in soil and production capability, access to critical infrastructure and limited exposure to production risk. These are areas to maintain and build on for a successful response to future drought in the region. These are shown on the radar chart as points closer to the centre of the chart.

Weaker areas in terms of drought resilience are shown on the radar chart as those points further from the centre of the chart. These are the expected impacts of climate change on temperature and rainfall patterns, increasing drought frequency, NDVI trends and the level of direct dependence of local economies and livelihoods on agriculture. These are the aspects of vulnerability to drought in the region that need to be prioritised to improve resilience. If these can be improved, or better understood, planned for and dealt with, the region will be in a better position to respond effectively to drought. Improving levels of economic diversity are a desired outcome for the region to build drought resilience.

Factors with moderate scores are change in timing of the autumn break, levels of unemployment, groundwater quality and access to water and road infrastructure.

Improving understanding of the impact of changing weather patterns on agricultural production is required. Measures to improve access to water and road infrastructure, as well as other services, increase and diversify employment opportunities and adapt agricultural practices in the region to accommodate shorter or later growing seasons will improve resilience to drought.

Current climate projections suggest that the situation is likely to worsen over time and steps should be taken now to ensure proactive adaptation to expected impacts.

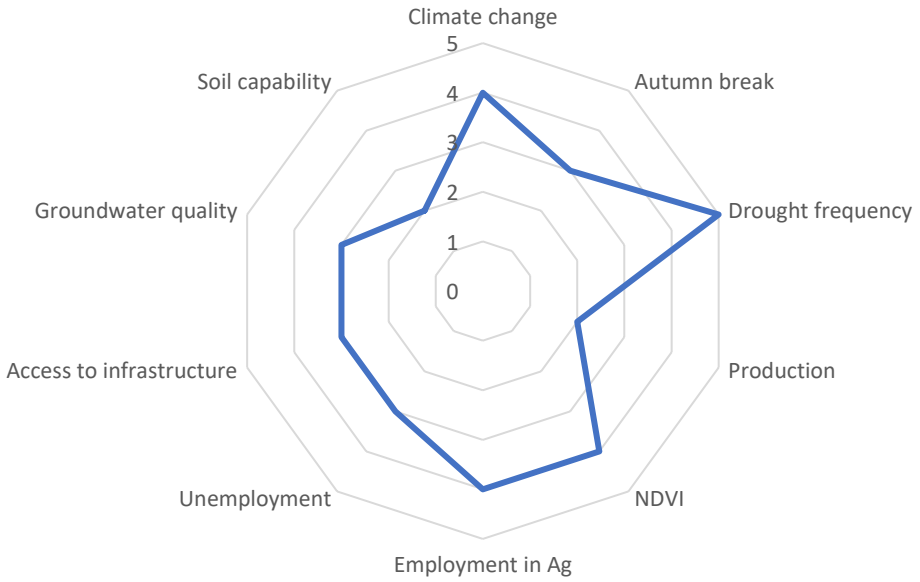

Figure 62 Radar chart of vulnerability index scores

20. Transformative Drought Solutions

To review transformative solutions to build drought resilience of the community, regional businesses, and agriculture, AgDots consulting was contracted to conduct a global literature review. This is a multiscale search for innovation and ideas that will support increased resilience to drought at three scales: community, business or regional scale.

Consultation with the Steering Committee project team members highlighted the purpose for the outcomes from the review. The review was tasked to develop a project pipeline of transformative ideas that reduce community and regional business vulnerability or build their resilience. The ideas need to be:

- scalable
- suitable to be incorporated into an investment framework that will speak to the Federal, State and Local Governments
- able to be commercialised for regional investors (if not at proof-of-concept stage, define what would get the idea to proof of concept stage).

The project pipeline would inform the three Regional Drought Resilience Plans to provide drought resilience projects nested within the plans. The overarching objective is that when implemented, the transformative projects need to build the resilience of the communities and regional businesses. Farming systems ideas were to be included, but the level of transformation is important. The scope was not to include incremental adaptive management ideas in this project, as they would be identified through the Drought Hub nodes.

The research areas were identified by mega trends and short-range trends, their impact on the regions and what type of change they would drive. The areas to research were developed

from the drivers and then workshopped with the regional areas to identify priorities. The seven categories were then identified: Water, Digital, Farm Business, Farming Systems, Natural Capital, Community Resilience and Regional Economy resilience. As many areas were researched under these areas as could be achieved with the project resources.

20.1 Definition of Transformation

The project team developed a working definition of transformation to assist the research to determine if an idea was to be included or not prioritised for research. The idea needed to meet one of several of the following criteria:

- challenges business as usual (BAU)
- not incremental change (5 or 10% improvement = incremental)
- growth not consolidation (yardstick minimum x 2 – turnover)
- creates new value
- changes the market/system
- reframes a problem to an opportunity.

Using this definition eliminated some of the areas that were discovered in the community consultation process. Those ideas could still emerge through the Regional Planning community engagement processes and become prioritised in the Regional Plans, but they weren't included in this project unless they met the transformation hurdle.

20.2 Identifying the Drivers & Areas of Transformation

The search for transformative options occurred at multiple scales. This included online searches, online interviews, and targeted local, regional, state and national contacts in each of the areas identified. Interviews with key networks and contacts within the regions. The level of innovation being so high within the regions, provided the opportunity to leverage existing projects to support increasing resilience. The review identified the problems at this level in each subject area, the review then conducted national or in some cases global online searches to supplement what the home-grown innovation was telling us about useful interventions or solutions in each area.

An online search was conducted on mega trends which would potentially impact the three areas. Four sources have been referenced in this report:

1. CSIRO Megatrends Shaping Australian Agriculture 2020
2. Project Management Institute
3. Batterman Consulting
4. Gro 2022 Watchlist

Table 15 demonstrates how these megatrends were transformed into transformative research areas.

Table 15 Mega trends and transformative research areas for drought resilience

Mega Trend	Relevance/ impact	Driver	Opportunity or threat	Impacts	Transformative Ideas
Supply and demand shocks	Inflationary pressure food, tight supply commodities,	Higher commodity prices and low interest rates driving up land values	Opportunity	Supply chain disruptions	1. Low input cropping options

Mega Trend	Relevance/ impact	Driver	Opportunity or threat	Impacts	Transformative Ideas
	countries restricting exports (quotas), high input costs (fertiliser also about high energy costs), Machinery costs	Confidence in ag industry and capital growth resulting in increase in sectoral wealth Input price impact – look for greater efficiencies and precision, substitution effect of inputs			2. Agtech – precision technology to improve yields from lower inputs 3. Localisation of supply chain eg. Fert production 4. Capital in farming – will it create more investment up and down supply chain? Flow through to regional economy? 5. Regional manufacture machinery
Food trends	Vegetable oil demand (pressure to decrease palm oil usage) Food for fuel – biofuel production globally Health trends – plant protein demand Localisation of food supply chains Growth in Aquaculture production (fish stocks worldwide under pressure) Intensification of horticulture	Support for canola in rotation Other crop options Plant protein crop options Demand for farmers markets and localised food chains Onshoring meat production Aquaculture industry growth	Opportunity	Vegetable oil demand Plant protein demand Food security and resilience of supply chain Aquaculture Product demand	6. Crop options for this region – vegetable oil or plant protein 7. Local food or beverage manufacturing or marketing to build food supply chain resilience 8. Onshoring of meat value adding and processing 9. Aquaculture industry supply chain development examples (processing and input production) 10. Horticulture industry major innovations and future opportunities
Global demographic shifts	Growth 60+ cohort Return to the regions trend (holiday locations) Ongoing eastern orientation economy – rising middle class	Connected cyber seniors, available pool of talent Housing market entry strategies for urban/coastal communities – Geraldton and Dongara, Kalbarri? Export market development opportunities,	Opportunity	Aging population Move to the regions Rise and rise of the eastern economy	11. Where and why is the return to the regions trend strongest and how can this be enhanced – lifestyle x connectivity 12. Research community efforts or

Mega Trend	Relevance/ impact	Driver	Opportunity or threat	Impacts	Transformative Ideas
		including education and tourism			campaigns to engage 60+ cohort as key talent to build labour market resilience 13. Housing market entry strategies to build housing market resilience 14. Tourism strategies that support building resilience
Climate crisis	Change in weather patterns Shift or increase in vulnerability of farming systems or communities Growth Blue Economy	Need for increasing adaptive responses Eco-system services, natural capital market, carbon market opportunities	Opportunity and threat	Net zero transition + decarbonising economy Growth Blue Economy	15. Carbon market opportunities that build regional resilience 16. Market for eco-system services or natural capital market opportunities that support increasing resilience 17. Carbon accounting and systems for small businesses to support decarbonisation 18. Blue economy opportunities that support increase in ocean system resilience 19. Farming systems options to build resilience (link to Drought Hub work) 20. Native vege cover, cover over summer in cropping systems
Resource scarcity	Resource Scarcity – oil, gas, water, labour	Underpinning inputs for the regions economy Workforce availability is a key constraint	Opportunities and threats	Water and energy key drivers of quality of future	21. Mid west Green hydrogen industry 22. Other renewable energy development opportunities that build

Mega Trend	Relevance/ impact	Driver	Opportunity or threat	Impacts	Transformative Ideas
					resilience eg. Hydro project Great Southern 23. Solar or wind farm project opportunities and on farm renewable energy project ideas 24. Water source, efficiencies (treatment, capture, reuse – including desal), storage/distribution and new technology ideas
Digital transformation	Acceleration of level of digital applications	Connectivity - the new highway and data is the new currency	Opportunity and threat	Connectivity Digitisation of regional industries and business Digital divide	25. Better use of data to drive decision making and efficiencies in industry and blockchain applications – how will this support building resilience 26. Fit for purpose connectivity options and infrastructure opportunities 27. Automation and EV's in ag – ideas for acceleration 28. #Agtech and #Foodtech
Neo-ecology	Sustainability evolving to be a major econ factor (from social movement)	Regen will evolve from a movement to an efficiency driver	Opportunity	Sustainability credentials for trade + market access Regen ag	29. Sustainable use of resources in ag industry 30. Sustainability credentialling - opportunities
Rise of the entrepreneur	Pollinators and Harvest agristart program	Opportunity to support start up culture and build great regional culture (optimistic, outward looking, opportunity focussed)	Opportunity	Innovation	31. Innovation economy and start up community ideas
Equality and justice movements	South West Native Title settlement Gender equity and changing role of women	Opportunity to harness all talent	Opportunity	Aboriginal Economic Development Rise of women in leadership roles	32. Growth of Indigenous businesses to support growth industries e.g.

Mega Trend	Relevance/ impact	Driver	Opportunity or threat	Impacts	Transformative Ideas
					Seedling businesses 33. Role of women leading change in family farms
Pandemics and biosecurity	n			A less safe world more impacted by cataclysmic events	34. Biosecurity – disease impact on production – how would you do biosecurity in areas more vulnerable to drought – how could you build resilience?
Wellbeing		Wellbeing of impacted communities			35. Social capacity and capital as a buffering factor - community events and services critical for resilience

The 35 transformative areas identified from this process were then socialised with each region and priorities identified. 20 key areas of research were identified by the 3 regions as being priorities and were grouped into 13 overall areas.

Table 16 Research Groupings for Transformative Research areas

Improving on farm water and feed options	
Resilient farming Systems	Improving on farm water and feed options
	Building soil health
	Catchment management, rehydration, revegetation
	Drought tolerant crops and breeds + alternate crops
	Low input cropping options
Managing natural capital	Carbon Farming (low rainfall) and Natural capital market opportunities
	Other crop opportunities and associated products e.g. bush tucker, honey bee production
Improved risk management	Farm Financial and Business planning

	Improving on farm water and feed options
	Improving long range weather forecasting
	Access to financial mechanisms during drought
Capturing more value from supply chain	Aquaculture supply chain development and opportunities
	Increase level of value adding of commodities
	On farm feed lotting
Digital resilience	Improving telecommunications infrastructure
	Improving digital skills, connectivity skills and data utilisation
	Improving tech capacity
Water resilience	Water source, capture and storage
	Water technologies
	Water system efficiencies – treatment, capture, re-use, water linked to energy
Sustainability	Sustainability credentialling as an opportunity
Renewable energy	Micro-grid capacity and EV's on farm
Workforce and housing Shortages	Labour or housing supply opportunities/innovation
Community resilience	Retaining people in the regions
	Supporting community networks and mental health
	Innovation and the start-up economy
Mining and agriculture industry linkages	Mining industry growth acceleration and potential linkages

Improving on farm water and feed options	
Diversification opportunities	Horticulture
	Tourism
Biosecurity	Innovative options for managing pests, weeds, diseases that will build resilience or reduce vulnerability

20.3 Transformative Research Areas Identified to Build Resilience

To research the transformative areas, the criteria to search for opportunities are described in the following table.

Table 17 Search criteria to identify drought resilience opportunities

Opportunity	Describe the opportunity	Example
Is the option:		Cropping Wildflowers to build natural capital
Novel	Idea is untested but conceptually feasible	Idea is novel (NB Great Southern business commercially producing one variety)
Feasible	Developed idea, prototype in place, but not implemented commercially, no viability assessment	
Viable	Examples of commercial application exist + can be reviewed	
What type of option is it? These categories are linked to the initiatives able to be funded under the Drought Plan This would send project to other funders	Policy R+D Adoption or Innovation Improving NRM (better soil, vegetation, water or soil health) Tool/technology Community on-ground action Infrastructure initiative (enabler) Commercial options (may not be funded by drought funds, but could consider other funders)	R+D and Adoption
Scale of idea	Local ● Sub $1M ● $1 - $5M Sub Regional ● $5 to $20M Regional ● $20 to $50M State-wide ● >$50M	Local $1 - 5M
Dependencies/ Intervention required	All the things that have to be in place for this idea to work, or barriers, e.g.: ● Funding required and matching funds ● Approvals/compliance ● Barriers to commercialisation ● Skills/capacity ● Enablers (infrastructure/labour supply) ● Market opportunity	Pilot prototype project to test seed harvesting capacity Identify size of product market. Identify cost/benefit of investment. Identify which stream of funding is most applicable.

Impact + how does it build resilience or reduce vulnerability	• Reduce costs • Increases income • Creates economic diversification • Decreases or manages risk • +ve on impact social resilience factors (UWA eg. connection, trusted information, increases sense of community, promotes equity) • Builds skills or knowledge • Creates a positive narrative	Economic diversification Manages landholder financial risk during drought Builds natural capital and resilience in natural environment (public benefit) Builds seed supply chain capacity in region
Where and how the project would be implemented	Project Plan Costings	Insert if known

The results from the research areas were then used throughout the project to inform regional and community stakeholder consultation and to develop project ideas within each regional cluster. These are summarised in table 18.

Table 18 Transformative research areas to build transformative drought resilience priority projects

Water Resilience	Digital Resilience	Farm Business Resilience	Farming Systems Resilience
• Water Supply and Risk Assessments (Regional Water Security and Investment Plans) • Conduct water source investigations for all new water sources • Support and expand desalination pilots in communities and on-farm • Support development of on farm planning tools to accelerate water resource planning at local scale (eg. Farm Cat project acceleration) • Incentivise on farm water infrastructure investment	• Improve connectivity through co-investment in digital infrastructure (includes backhaul + wireless networks to farms) • Build tech skill and support in ag (connectivity literacy, data management capability, farm tech capability of industry) • Regional tech support built withing regions (CRC flying squads) and develop long term plan to build tech capacity in regions	• Build capability for useage of on-farm data for insurance index products • Support grower education and training for risk management tools to support financial risk management • Advocate FMD maximum cap to be relative to the size of the business • Evaluate impact of drought support programs on farm businesses to inform future strategies	• Support R&D and industry development for alternative drought tolerant crops (legume, GM + long coleoptile wheat, alternative oil seed crop, bushfoods + cultivate endemic species) • Support R&D and industry development for livestock feeding options (carbon positive feed supply eg asparagopis) • Support R&D and adoption in low input cropping options (VRT, alternative fuels, electric vehicles, regen farming) • Support R&D and industry development for building soil health (greater depth soil amelioration, hostile soil management, biochar) • Support R&D and catchment management initiatives and build soil and water systems health (eg landscape ecology and rehydration)
Presented as an overarching framework to suggest no hierarchy in research options, and the areas of transformation are linked and impact each other			

Natural Capital Resilience	Community Resilience	Regional Economy Resilience
• Support national natural capital framework development in WA Ag to enable natural capital on balance sheets • Evaluate and expand biodiversity stewardship program and trials in WA • Pilot participation in national biodiversity trading platform • Improve carbon and climate literacy and understanding of the carbon market • Support projects to test market to develop smaller more integrated projects (pollination, soil conditions, biodiversity) + create a model to provide co-benefits and support local communities and businesses	• Build workforce capability through workforce planning, digital activation, recruit and train young people for high demand industries, active employer engagement + provide childcare • Build housing supply through innovation – encourage start up activity, support communities to build housing companies NFP's, provide incentives for building or renovating in rural communities (loans, grants or services), and create a seasonal accommodation matching platform • Support well being measures that build resilience including network strengthening activities and programs that increase physical well being and support positive health outcomes	• Support Tourism planning processes (destination management plans) and invest in regional and local tourism projects • Support higher level of integration and planning for major mining resource projects and develop community structures to capture benefit from investment • Develop more intensive farming opportunities eg. horticulture through water security assessments and identification of land/water/workforce/infrastructure packages for investors • Create a revolving loan fund to encourage regional entrepreneurship and innovation and support innovation/resilience training for regional businesses eg. WBN program for regional resilience
Presented as an overarching framework to suggest no hierarchy in research options, and the areas of transformation are linked and impact each other		

13.4 Farm Business Resilience – Research Example

Farming Systems Topics – Research

ALTERNATIVE / DROUGHT TOLERANT CROPS AND BREEDS

OPPORTUNITY	NOVEL, FEASIBLE OR VIABLE	TYPE OF OPTION	SCALE OF IDEA	KEY DEPENDENCIES / INTERVENTION REQUIRED			HOW DOES IT BUILD RESILIENCE	HOW DOES IT REDUCE VULNERABILITY	WHERE AND HOW (LINK TO PROJECT PLANNING)
Alternative / drought tolerant crops and breeds	Feasible	Advocacy R&D	State	Regulatory	Market acceptance	Funding for R&D and field testing	Crop that has proven drought tolerance	Reduce risk of crop failure	Drought hub
Drought tolerant wheat (GM)	***Description of Option and why is it transformative*** Climatic conditions including delays in autumn rainfall, drought and spring heat stress conditions are occurring in the low-medium rainfall areas of the WA grainbelt. Wheat breeding traditionally has been focussed on yield maximisation, as a result environmental resilience of many modern varieties is low. With wheat being the dominant crop in the low rainfall area of the WA grainbelt this leaves farmers highly exposed to crop failure or uneconomical yields in drought seasons where crops are exposed to prolonged periods of moisture stress and heat stress events. ***Examples, including existing projects*** **HB4® Wheat (GMO)** The HB4® variety of wheat is the world's first genetically modified wheat variety with drought tolerance. Its drought tolerance is conferred by the expression of the novel transcription factor HaHB4 from sunflower. HB4® decreases ethylene synthesis which plays an important role in the determining yields of crops grown under abiotic stress conditions such as drought, salinity, low or high temperatures. HB4® causes plants to be more insensitive to its effects resulting in a variety that displays higher yield in low productivity potential environments. The main criticism of other 'resilient' conventionally bred wheat varieties, is that they have 'yield drag' which is a consistent yield penalty when compared to other varieties in low or no moisture stress environments. This adds to their risk profile as farmers are unable to 'make the most' of a good seasons. Bioceres Crop Solutions (the developers), state that HB4® wheat is substantially equivalent to its conventional counterparts and is the first of its kind with data indicating: · no yield penalty in good years when yields are greater (no yield drag) · improved yields in soybean-wheat systems by between 10-20 %, in adverse years when yields are generally low. Due to the highly regulated research and cultivation frameworks and market sensitivity surrounding GM currently most of the research and data has been carried out in South America and there is very little data for HB4 trait wheats outside of this region. But overall, the research evidence is strong and agronomically there is a potential fit for this variety in low-medium rainfall areas of the WA grainbelt. Global status: · In 2020 Argentina granted regulatory approval to HB4® wheat. · In late 2021 Brazil announced it will accept the importation of genetically modified wheat flour from Argentina. · There are only five countries in the world that allow imports of GM wheat, Australia is one of them. · HB4® variety of soybean is approved for unrestricted cultivation and commercialization in China, United States, Canada, Brazil, Argentina, and Paraguay (represent 85% of the global soybean trade).							

ALTERNATIVE / DROUGHT TOLERANT CROPS AND BREEDS (CONT.)

OPPORTUNITY	NOVEL, FEASIBLE OR VIABLE	TYPE OF OPTION	SCALE OF IDEA	KEY DEPENDENCIES / INTERVENTION REQUIRED			HOW DOES IT BUILD RESILIENCE	HOW DOES IT REDUCE VULNERABILITY	WHERE AND HOW (LINK TO PROJECT PLANNING)
Alternative / drought tolerant crops and breeds	Feasible	Advocacy R&D	State	Regulatory	Market acceptance	Funding for R&D and field testing	Crop that has proven drought tolerance	Reduce risk of crop failure	Drought hub

Drought tolerant wheat (GM)	Australian status:
	• GMO's are strictly regulated through a nationally consistent framework via the Commonwealth Gene Technology Act 2000, the Gene Technology Regulations 2001 and corresponding state laws. The Office of the Gene Technology Regulator (OGTR) is responsible for carrying out the legislated process for GMO's. There are two current dealings involving an intentional release (DIR) licenses which pertain to 'drought tolerant' wheat and barley:
	  • DIR 186 was granted in February of 2022 authorising The University of Adelaide to conduct a field trial of GM wheat and barley. The five-year license period will enable field condition research to be undertaken in South Australia (Light Regional Council) under strict conditions. Interestingly, the *Summary of Risk Assessment* notes that The University of Adelaide amended their original application removing the Shire of Merredin (WA) as one of the trial sites.
	  • DIR 151 approved in 2017 to CSIRO detailed in section below.
	  • It should be noted that there are other current DIR licenses relating to GM wheat and barley these include frost tolerance and disease resistance.
	• On 6 May 2022 Food Standards Australia and New Zealand (FSANZ) approved the sale of imported food made from GM wheat, making them two of just five countries in the world to declared GM wheat safe for consumers. The FSANZ safety assessment for the application concluded that food derived from HB4® wheat (IND00412-7) is considered to be as safe for human consumption as food derived from non-GM wheat cultivars. Important to note that this does NOT cover the cultivation of GM wheat or importation of GM wheat seed, this is a separate regulatory assessment process through the Gene Technology Regulator.
	CSIRO Drought Tolerant GM Wheat research
	There is CSIRO work (funded by GRDC) into traits/ genes which allow plant to adapt to adverse environmental conditions identified genetic variants that protect pollen development (specifically stoma response) from drought stress (OGTR license no. DIR 151). The work is complex but findings have identified the interplay of two opposing hormone systems that control stoma response in water stress. CSIRO found that:
	• 'tolerant' wheat lines the auxin hormones dominate allowing stomata to remain open during 10-day reproductive window
	• in sensitive wheat lines the ABA (abscisic acid) hormone is induced by drought stress which closes the stomata.
	Possible drought tolerance is determine by the level of water stress which will then see the ABA hormone takeover. This finding opens the potential of screening for variants that have a higher threshold (before ABA takes over). Two genetic wheat populations have been mapped, and one was trailed in three locations in ACT and NSW in 2019. This leads the way for variety development which can take over 10 years for a new variety to reach the market.								

ALTERNATIVE / DROUGHT TOLERANT CROPS AND BREEDS (CONT.)

OPPORTUNITY	NOVEL, FEASIBLE OR VIABLE	TYPE OF OPTION	SCALE OF IDEA	KEY DEPENDENCIES / INTERVENTION REQUIRED			HOW DOES IT BUILD RESILIENCE	HOW DOES IT REDUCE VULNERABILITY	WHERE AND HOW (LINK TO PROJECT PLANNING)
Alternative / drought tolerant crops and breeds	Feasible	Advocacy R&D	State	Regulatory	Market acceptance	Funding for R&D and field testing	Crop that has proven drought tolerance	Reduce risk of crop failure	Drought hub
Drought tolerant wheat (GM)	***What is the gap preventing commercialisation or widescale application?*** There are many farmers in the low-medium rainfall zone of the WA grainbelt that would like to see drought tolerant varieties field tested in the region to assess their fit for WA conditions and start the learning journey in regard to agronomy and farming systems. However, both the GM commercially released variety HB4® and the CSIRO drought tolerant GM wheat research do seem quite a way-off getting to this stage. The timeframes from GMO regulation are significant. If a GM variety of wheat is approved by OGTR for cultivation there is still an additional process of Wheat Classification by Wheat Quality Australia which assesses new wheat varieties to determine the inherent quality characteristics of a new variety, focusing on processing and end use performance. This process takes approximately three years but it is unclear whether this could be done at the same time as the OGTR process. ***Opportunities for Investment: Advocate for extended field testing of GM drought tolerant wheat (and barley) varieties in WA's low-medium rainfall grainbelt.*** ***Investment challenges or barriers:*** • Timeliness- this is completely guided by regulatory timeframes • Market risk- In addition to regulation challenges, the consumer and market exposure risks associated with GM food varieties is tricky to navigate. GM consumption by humans is very new and there are key market acceptance challenges. Much of the world's livestock corn and soy feed is GMO's and has been for a long time. Although WA has a proven segregation system with GM canola wheat differentiates in that it is a directly consumed product (milled flour) as opposed to canola which is consulted as oil and has a large non-human consumption market. • Field testing and adoption- South American research is considered credible however any new variety would need to be field tested in local/ regional conditions before widespread adoption can be expected. • The highly competitive of genetics and breeding mean that there is little willingness of seed companies to share information. However recent news reports indicate that Trigall Genetics (joint venture between Bioceres Crop Solutions and Groupe Florimond Desprez) will be setting up a base in Australia. • Strong and consistent advocacy is required across the agricultural spectrum ***Additional information and good contacts:*** • Dr Felicity Harris, Crop Physiologist, NSW DPI, M: 0458 243 350 E: *felicity.harris@dpi.nsw.gov.au* • Dr Rudy Dolferus, CSIRO (recently retired) E: *rudy.dolferus@csiro.au* • Associate Professor Matthew Tucker, School of Agriculture, Food and Wine, The University of Adelaide, M:0403 314 740 E: *matthew.tucker@adelaide.edu.au*								

ALTERNATIVE / DROUGHT TOLERANT CROPS AND BREEDS (CONT.)

OPPORTUNITY	NOVEL, FEASIBLE OR VIABLE	TYPE OF OPTION	SCALE OF IDEA	KEY DEPENDENCIES / INTERVENTION REQUIRED			HOW DOES IT BUILD RESILIENCE	HOW DOES IT REDUCE VULNERABILITY	WHERE AND HOW (LINK TO PROJECT PLANNING)
Alternative / drought tolerant crops and breeds	Feasible	Advocacy R&D	State	Regulatory	Market acceptance	Funding for R&D and field testing	Crop that has proven drought tolerance	Reduce risk of crop failure	Drought hub
Drought tolerant wheat (GM)	*Supporting literature:*								

GM Wheat	Drought tolerant wheat genetic imminent	GRDC	*https://groundcover.grdc.com.au/innovation/plant-breeding/drought-tolerant-wheat-genetics-imminent*
GM Wheat	DIR 151 - Limited and controlled release of wheat genetically modified for disease resistance, drought tolerance, altered oil content and altered grain composition	Office of the Gene Technology Regulator (OGTR)	*https://www.ogtr.gov.au/gmo-dealings/dealings-involving-intentional-release/dir-151*
GM Wheat	Safety assessment – Application A1232 Food derived from drought-tolerant and herbicide-tolerant wheat line IND-00412-7	FSANZ	*https://www.foodstandards.gov.au/code/applications/Documents/01_A1232_SD1.pdf*
GM Wheat	Genetically Modified Wheat Gets a Boost With Brazil Approval	Blomberg	*https://www.bloomberg.com/news/articles/2021-11-11/brazil-clears-genetically-modified-wheat-developed-by-bioceres*
GM Wheat	DIR 186- License details- Limited and controlled release of wheat and barley genetically modified for yield enhancement and improved abiotic stress tolerance	OGTR	*https://www.ogtr.gov.au/gmo-dealings/dealings-involving-intentional-release/dir-186*
GM Wheat	HB4 White Paper	Geronimo Watson, Lucas Paultroni, Sergio Simonsini, Enrique Lopez Lecube	*https://s26.q4cdn.com/783252186/files/doc_presentations/2020/08/White-Paper-Aug-2020.pdf*
GM Wheat	Fact sheet - How are genetically modified organisms (GMOs) regulated in Australia?	OGTR	*https://www.ogtr.gov.au/sites/default/files/files/2021-06/18_-_how_are_genetically_modified_organisms_gmos_regulated_in_australia.pdf*
GM Wheat	GMO wheat approved for consumption in Australia and New Zealand	Successful Farming Website (9 May 2022)	*https://www.agriculture.com/news/business/gmo-wheat-approved-for-consumption-in-australia-and-new-zealand*

21. Conclusion

21.1 Summary

The goal of a Drought Vulnerability Assessment is to identify key areas of vulnerability to inform priorities and actions and reduce susceptibility to the impacts of drought. The Inland Great Southern region, defined in this study as the Shires of Kojonup, Woodanilling, Katanning, Broomehill-Tambellup, Kent, Jerramungup, Gnowangerup and Cranbrook, is a region at medium - high risk of the impacts of drought - particularly those Shires on the eastern edge.

This vulnerability assessment provides localised analysis, guidance and recommendations to local decision makers and managers in the region regarding the possible impacts of drought and priority areas in which resilience-building efforts should be concentrated.

The impacts of drought are cross-cutting and require a joined-up approach to ensure regional communities can adapt to future drought. The patterns of climate change to date, high levels of direct dependency on agriculture and a demonstrated ability for the agricultural industry, regional businesses and communities to adapt to changing conditions make the region an excellent candidate for drought resilience action.

Efforts should be made to reduce socio-economic vulnerabilities and increase institutional capacities. This is important as enhanced capacities will result in an improvement in people's wellbeing, as well as an improved understanding of the importance of ecosystem services and natural resources for the region.

Although the current assessment represents a major step forward in our -understanding of the drought-related vulnerabilities in the region, and our ability to represent these spatially, a

number of the analyses require further refinement in order for them to integrate well into regional planning processes. As climate science advances and new economic, social and environmental data comes online, it may be necessary to update this analysis.

21.2 Actionable Results

The actionable results of this report are as follows:

From Section 3 - Demographics and Institutional Arrangements

Economic dependence on agriculture in the region is very high, with broadacre cropping the primary land use in eastern areas, with livestock production prevalent in western areas. Resilience building activities should focus on strengthening the ability of the agriculture sector and allied industries to prepare for and respond effectively to drought.

Drought response planning around the world is moving from reactive crisis management to proactive risk management. Measures that promote self-reliance and preparedness are generally preferred by farmers, industry and government agencies alike. This includes appropriate use of financial instruments, business planning and access to professional advice to manage in intra and inter-season variability.

Under the Future Drought Fund, Australia has a very comprehensive program in place to build resilience in regional areas. The Western Australian government is shifting its focus to climate resilience, with agencies such as DPIRD and DWER, and government trading enterprises Western Power and Water Corporation addressing climate adaptation in their strategy and operations. There is opportunity to better connect links across international, national and local agencies involved in drought research, preparedness, response and recovery and in delivering drought resilience programs. Improved communication around the support available to regional communities, and how to access that support, is required.

From Section 4 - Climate Data

Meteorological definitions of drought need to focus on growing season rainfall. Defining drought based on annual rainfall totals can be misleading for regions that do receive some summer rainfall, but rely fundamentally on autumn and winter rainfall to produce a crop.

An expanded definition of drought is also useful because drought is defined in terms of its impact on primary production, surface and groundwater levels, and regional communities. Drought could be defined as a prolonged period of abnormally dry conditions that impacts negatively on water availability and agricultural production in a region and, consequently, impacts negatively on the economy and environment of the region and the health and well-being of its residents.

Average temperatures have increased by 1.4°C since 1910 leading to an increase in the frequency and severity of extreme heat events and heat waves in the region. There has been a prolonged period of extensive drying in the region since the 1970s, and the autumn break now occurs up to a month later than it used to.

Droughts have increased in frequency and, alarmingly, hot droughts, which can be devastating for the environment. Appropriate steps must be taken to anticipate and mitigate the potentially devastating effects of hot droughts.

Temperatures will continue to increase as climate change progresses and growing season rainfall will very likely to continue to decrease across the region. The time spent in

meteorological drought, where conditions are significantly drier than the average over the preceding 30 years, will increase over the course of the century and across the region.

Drought is expected to impact adversely on crop and livestock production in the region, as well as on the amount of water available other agricultural activities via impacts on surface water flows and aquifer recharge.

From Section 5 - Drought Impacts

Economic: Agriculture is the primary land use in the region and Inland Great Southern stakeholders report experiencing financial stress because of failed production during drought. Farming families sell livestock, liquidise assets or increase their debt to survive, and non-farming families in regional areas suffer from reduced employment opportunities and cash flows.

Environmental: Drought can have serious, long-term consequences for soil health, vegetation cover and biodiversity. Reduced vegetation cover and drier soils increase the risk of erosion and invasion by weeds, pests and diseases. This also impacts on the functioning of the landscape for economic and social purposes.

Impact on Aboriginal Communities: Aboriginal communities are likely to be disproportionately affected by drought based on pre-existing health and social disadvantage. Aboriginal community members expressed concern about the impact of drought on vegetation, water and fire regimes in the region, as well as the impact of land transformation and climate change on the region's vulnerability to drought.

Social: The uncertainty and financial stress associated with drought negatively affects mental health in regional areas. Drought contributes to failed businesses, causing people to move away and, in turn, reducing population sizes, access to skills and services and the availability of community services and support networks in the region.

Water: The Inland Great Southern is dependent on piped potable scheme water located in distant geographical areas, and a mix of locally sourced supplies for non-potable use. Groundwater is limited due to geology and requires desalination for productive use. To reduce reliance on scheme supplies, and enhance ability to cope with consecutive dry seasons, continued on farm water supply improvement, and local and regional scale water supply planning and investment is required to address supply constraints and future demand under climate change scenarios.

From Section 6 - Drought Risk Priority Areas

High priority areas for drought resilience action occur at the intersection of high exposure to drought, high sensitivity to drought and low adaptive capacity. In the Inland Great Southern, areas most at risk from drought are located in the Shire of Kent and Jerramungup.

Exposed areas are characterised by long-term increases in temperature and decreases in rainfall, measurable increases in drought frequency and measurable declines in potential wheat yield and root zone soil moisture.

Sensitive areas are characterised by marginal crop and livestock production, low vegetation cover, high levels of economic dependence on agriculture and demographic factors such as relative remoteness, population size and economic diversity.

Areas with low adaptive capacity are characterised by relatively poor access to infrastructure and resources, high unemployment and reliance on degraded and/or poor-quality natural resources, including water and soils.

From Section 7 - Assessing Vulnerability to Drought

There are many good quality, publicly available data sets in Australia that can be used to assess vulnerability to drought and could serve as indicators to predict the impacts of drought.

Several approaches are presented using publicly available data to assess vulnerability. These approaches all need further refinement and testing before they can be more generally applied in other regions.

The region displays moderate vulnerability to drought with an overall index score of 3.3 out of 5. Areas of strength and resilience, which should be maintained and built upon, lie in the region's soil and production capability.

The index highlights a number of areas of high vulnerability to drought:

- projected increases in temperature and decreases in rainfall
- changes in the timing of rainfall
- increases in the frequency of drought
- trends in groundcover during dry years
- unemployment
- access to infrastructure and services
- the level of direct dependence of local economies and livelihoods on agriculture

These are the aspects of vulnerability to drought in the region that need to be prioritised to improve resilience. If these can be improved, or better understood, planned for and dealt with, the region will be in a better position to respond effectively to drought.

21.3 A Way Forward

The Inland Great Southern Drought Vulnerability Assessment is intended to provide the evidence base for the Inland Drought Resilience Plan and investment into drought resilience actions.

There are limitations to some of the datasets used in the assessment process, due to the granularity, frequency of data capture, and scale of the data. It is recommended that the DVA is reviewed on a regular basis to integrate updated or new datasets of relevance. This would not only inform future planning and investment but enable longitudinal monitoring of drought resilience.

The agricultural regions of South West Western Australia are a success story in terms of climate adaptation to date. While regions like the Inland Great Southern are exposed to the impacts of climate change and have demonstrated good capacity to adapt to drought, there is a continual need to adapt, innovate and potentially transform to enable this success to be maintained or built upon. The region is also well placed to capitalise on opportunities to support the decarbonisation of the economy, further supporting drought resilience.

Future applications of the Vulnerability Assessment methodology should consider resilience to the broader impacts of climate change, not just drought impact, and the vulnerability and adaptive capacity of the broader regional economy, not just the agricultural and allied sectors. The rationale for this is, in part, because drought cannot be considered in isolation of climate change and regional communities, while at the surface are dependent on agriculture, are

made up of a complex mix of businesses and services. Some of these are highly dependent on agriculture, though many are increasingly diversifying their own markets. These businesses and services are likely to be the drivers of population and economic growth, building community, and playing an important role in supporting the retention of people, the region's most important resource.

22. Supporting Technical Reports

A panel of technical experts were contracted to provide their expertise that is included in this drought vulnerability assessment. This scientific rigour underpins the development of the final *Inland Great Southern Drought Resilience Plan*

Anna Dixon Consulting 2022. *Regional Drought Vulnerability Assessment: Background Research and Analysis.* Report prepared for DPIRD's Regional Drought Resilience Planning Program

Bruce, J., Bourne, A., Guthrie, M., Veljanoski, I. Koh, L. and Parker, K. 2022. *Drought Priority Areas Map for South West Western Australia.* DPIRD

Clifton, P. and Price, M. 2022. *Water Issues and Policy Analysis for the Regional Drought Resilience Planning Program.* Report prepared for DPIRD's Regional Drought Resilience Planning Program. Aroura Consulting

Flatau, P. and Lester, L., Kyron, M. 2022. *Understanding the Social Impact of Drought.* Report prepared for DPIRD's Regional Drought Resilience Planning Program. Centre for Social Impact, University of Western Australia

Gladish, D.W. and Hochman, Zvi 2022. *Investigating the Application of Drought Indices to Western Australia*. Report prepared for DPIRD's Regional Drought Resilience Planning Program. CSIRO

Grima, R. 2022. *Drought Viability Report*. Planfarm

Mastrantonis, S 2022. *Defining Drought in Western Australia*. Report prepared for DPIRD's Regional Drought Resilience Planning Program. Centre or Crop and Disease Management, Curtin University

Noongar Land Enterprise Group 2022. *Valuing Noongar People and Practices in Drought Resilience*. Report prepared for DPIRD's Regional Drought Resilience Planning Program

South Coast NRM 2022. *WA Regional Drought Resilience Planning, Community Consultation Report for the Inland Great Southern.* Report prepared for DPIRD's Regional Drought Resilience Planning Program

South Coast NRM 2022. WA Regional Drought Resilience Planning. *WA Regional Drought Resilience Planning, Report on Aboriginal Community Consultations. Inland Great Southern.* Report prepared for DPIRD's Regional Drought Resilience Planning Program

Please contact gsdc@gsdc.wa.gov.au to request a copy of these reports

23. Appendices

Appendix 1 Stakeholder Engagement Record

Record of drought resilience plan stakeholder engagement record: A total of 323 people across 150 organisations were engaged during the RDRP Pilot process. This included local government, community and grower groups, regional businesses and technical experts and traditional owners. People participated in a range of opportunities, from surveys, one on one interviews, facilitated workshops and technical, steering or advisory meetings. The below table is the timeline record of engagements. Consultation reports are available on request.

Date	Organisation	Engagement Type	Location
Aug 2021-August 2022	GSDC	Presentation, briefing notes (monthly updates)	Great Southern
August 2021 - Aug 2022	WALGA	Presentation, updates x 3	Cross regional
August	National Recovery and Resilience Agency project officer	One-on-One meeting x 2	Albany
Sept 2021	Shire of Kojonup, Katanning, Broome-hill Tambellup, Jerramungup, Gnowangerup, Cranbrook, Woodanilling and Kent.	Inception meeting CEO's, Shire presidents, face to face, or via phone	Kojonup, Katanning, Broome-hill Tambellup, Jerramungup, Gnowangerup, Cranbrook, Woodanilling,
Sept 2021	WALGA (representative and Shire President Kojonup)	One-on-one meeting	Mt Barker
Sept 2021	South Coast NRM (CEO and Operations Manager)	One-on-one meeting	Albany
Oct – Dec 2021	CSIRO	Technical advice	Cross regional
Nov 2021	WA Producers Co-op (Chairman)	One-on-one meeting	Albany
September 2021 to August 2022	Steering Committee: Including representatives DPIRD, WDC, GSDC, MWDC, South West WA Drought Resilience Adoption and Innovation Hub, NACC	Steering Committee meetings x 6 weekly	Cross regional, online/face to face
Nov 21, Apr 2022	Technical Working Group: Including representatives DPIRD (Policy, GIS, Farming Systems, Climate, Water Science), WDC, GSDC, MWDC, Drought Hub, NACC, DWER, Murdoch, UWA, Curtin, CSIRO, Water Corporation, Mental Health Commission, Regional Mens Health, Ruralwest, WALGA, GGA, Wheatbelt NRM, SCNRM, RRR Network, AgDots, LGA Reps	Workshops (x3), 20 plus attendees each workshop	Cross regional, Perth, on-line
November 2021 to June 2022	Shire of Kojonup, Katanning, Broome-hill Tambellup, Jerramungup, Gnowangerup, Cranbrook, Woodanilling	Workshop – drought risk, DVA input	Kojonup, Katanning, Broome-hill Tambellup, Jerramungup, Gnowangerup, Cranbrook, Woodanilling
Nov 2021	Treasury	Presentation	Cross regional

Date	Organisation	Engagement Type	Location
Dec 2021 – April 2022	Ag Consultant Lucy Anderton	One-on-one meeting, consultation with regional businesses, DPIRD, presentations to Steering Committee, Technical Working Group, Community forums	Cross regional
Nov 2021 - Feb 2022	UWA Centre for Social Research	One-on-one meetings, presentations to Steering Committee, Community Forums and Technical Working Group	Cross regional
Feb 2022 – August 2022	Aurora: Consultation undertaken with DWER (Rural Water Planning, Allocation), Water Corporation, WALGA, LGA's Inland Great Southern	One-on-one meetings, survey LGA's interviews	Great Southern and Wheatbelt
Feb – March 2022	Community Survey	Survey (on-line) targeting regional community members, LGA's. 16 respondents	Great Southern
Feb 2022 – May 2022	South Coast NRM – consultation undertaken with six champion farmers, 4 grower groups, 2 farm consultations. 3 workshops undertaken with South Coast NRM Reference Groups. Membership includes 36 community organisations, community members, agencies and internal staff	Targeted interviews, Reference Group workshops	Great Southern
March 2022	WHAGs (Regenerative Agriculture Group), 10 attendees	Workshop	Kojonup
April – May 2022	Community Forum (26 attendees)	Presentation and field day (10 attendees)	Great Southern
Nov 2021 – Feb 2022	Curtin University	Presentation to Technical Working Group, Steering Committee	Cross regional
Feb 2022 – June 2022	AgDots (consultant)	Targeted interviews with State Agencies, regional businesses, grower groups. Presentations to Steering Committee, Technical Working Group, Community Forums.	Cross regional
April – June 2022	Noongar Landcare Enterprises	Case studies on country with Noongar knowledge holder, business and/or elder. Videography – 3 films produced. 1-2 online facilitated workshops with Noongar business, Noongar land management practitioners and Noongar knowledge holders	Great Southern and Wheatbelt
April – May 2022	South Coast NRM in cooperation with Gillamii Centre and Keogh Bay Consulting: Consultation with 20 indigenous community members, land owners, elders	Consultation with a selection of Aboriginal community members and representatives from across the Great southern (including Elders, Noongar people whose livelihood depends on land, Noongar people whose	Great Southern

Date	Organisation	Engagement Type	Location
		work provides an insight into drought, Tambellup Strong and Proud Participants 2022 (Noongar Youth 11-17). 18 interviews, 60 pages of transcribed interviews	
Apr-2022	Grower Group Alliance	Consultation	Online
August 2021-2022	South West WA Drought Resilience Adoption and Innovation Hub	Consultation, membership on Steering Committee	On-line, Perth
April-June 2022	Survey	Consultation	Online
Apr-2022	Rural Water Council	Update	On-line
Feb 2022 – August 2022	Murdoch University	Consultation with DWER, Water Corporation, DPIRD, LGA's in Wheatbelt and Great Southern	Great Southern and Wheatbelt

Appendix 2 Record of Engagement with Stakeholders

Below is the record of the unique organisations engaged and the method of engagement over the RDRP Pilot.

	Organisations represented	Number of people engaged	Stakeholder Meetings	One on one consultation or interview	Community Workshop	Video interview	Contracted to undertake work
Great Southern Development Commission	9	9	x		x		
Shire of Kojonup	1	2	x	x			
Shire of Katanning	1	2	x	x			
Shire of Cranbrook	1	2	x	x			
Shire of Woodanilling	1	2	x	x			
Shire of Kent	1	2	x	x			
Shire of Broomehill-Tambellup	1	2	x	x			
Shire of Gnowangerup	1	2	x	x			
Shire of Jerramungup	1	2	x	x			
Shire of Kojonup Councillors	9	11			x		
Shire of Katanning - Councillors	9	11			x		
Shire of Cranbrook - Councillors	9	11			x		
Shire of Woodanilling – Councillors	9	11			x		

	Organisations represented	Number of people engaged	Stakeholder Meetings	One on one consultation or interview	Community Workshop	Video interview	Contracted to undertake work
Shire of Gnowangerup - Councillors	9	11	x		x		
Noongar Land Enterprise Group	1	6	x	x	x	x	x
South Coast NRM	1	2	x	x			x
South Coast NRM Reference Groups	1	30			x		
Grower Group Alliance	1	1	x		x		
South West WA Drought Innovation and Adoption Hub	1	4	x	x	x		
Survey participants	16	16		x			
Gillamii Centre	1	2	x	x	x		x
Fitzgerald biosphere Group				x			
Southern Dirt Grower Group	1	5		x			
North Stirlings Pallinup Natural Resources	1	2		x			
Farm Advisors	2	2		x			
Farming champions	6	6		x			
Katanning Landcare Centre	1	1		x			
Department of Water and Environmental Regulation	1	4	x	x	x		
Great Southern Development Commission	1	6	x		x		
Noongar Interviews	21	21	x	x		x	
Water Corporation	1	2	x	x			
Great Eastern Country WALGA Zone	1	40	x				
Central Country WALGA Zone	1	40	x				
Rural Water Council	1	20	x				
DPIRD (GIS, Farming Systems, Climate, Water Science, Soils)	1	10	x		x		x

	Organisations represented	Number of people engaged	Stakeholder Meetings	One on one consultation or interview	Community Workshop	Video interview	Contracted to undertake work
Centre for Crop Disease Management - Curtin	1	1	x		x		x
Harry Butler Institute - Murdoch	1	3	x				x
CSIRO	1	3	x		x		x
UWA (Centre for Social Impact, Agriculture, Economics)	1	6	x		x		x
Mental Health Commission	1	1	x				
RuralWest	1	2	x	x			
Western Australia Local Government Association	1	1	x	x			
Rural, Remote and Regional Women's Network	1	1	x				
AgDots	1	1	x				x
Northern Agricultural Catchments Council	1	2	x				x
Wheatbelt NRM	1	2					
Mid West and Wheatbelt Development Commission	1	2	x				
Regional Men's Health	1	1	x				
Aurora	1	2					
Total	**150**	**323**					x

Appendix 3 Snapshot of International Drought Programs and Resources

Program	Description
Agricultural Meteorology Programme (WMO)	Provides weather and climate services to farmers, herders and fishermen in order to support agricultural sustainability, increase productivity and contribute to food security.
Climate-Smart Agriculture (CSA)	Food and Agriculture Organisation of the United Nations which helps support the agricultural sector move towards green and climate resilient practices. Three key goals: ● Sustainably increasing agricultural productivity and incomes ● Adapting and building resilience to climate change ● Reducing and/or removing greenhouse gas emissions where possible.
Global Climate Observing System (WMO)	Assesses the status of global climate observations and produces guidance for its improvement.

Program	Description
Global Drought Information System (GDIS)	International resource that for non-prescriptive drought information and comparison information on drought conditions and resources from around the globe.
Integrated Drought Management Programme (IDMP) – launched by the World Meteorological Organisation and the Global Water Partnership	Addresses multiple components of drought management, including disaster risk reduction, climate adaptation strategies and national water policies. Provides advice and guidelines to communities, countries and regions affected by drought through the Integrated Drought Management Helpdesk.
NASA Precipitation Education/Drought	A wide range of educational resources and programs related to NASA Earth data (precipitation).
National Drought Mitigation Centre (USA) (NDMC)	Drought related educational, planning, and monitoring resources at an international level.
The Drought Initiative (United Nations Convention to Combat Desertification)	Focuses on drought preparedness systems, regional efforts to reduce drought vulnerability and risk and a toolbox to boost the resilience of people and ecosystems to drought.
The SPEI Global Drought Monitor	Provides real-time information on global drought conditions.
UN Environmental Programme – DHI Centre on Water and Environment	Works with countries to improve their water management for sustainable development.
World Meteorological Organisation (WMO) Global Data-processing and Forecasting System (GDPFS)	International resource offering members access to meteorological analyses and forecasts products – organised as a network of global, regional and national Centres.
WMO Met-eLearning Site	Available to WMO members offering access to online resources for training in meteorology, hydrology and associated sciences.
World Climate Research Program (WMO)	Coordinates and guides international climate research to develop, share and apply the climate knowledge that contributes to wellbeing.
World Climate Services Program (WMO)	Improving the availability of and access to reliable climate data, monitoring and forecasts.
World Weather Research Program (WMO)	Advancing and promoting research in weather, its prediction, and its impact on society.

** *Not an exhaustive list*

Appendix 4 Universities Involved in Drought-Related Research

University Institution	Drought Related Focus	Base
Australian National University (ANU)	Centre for Climate and Energy Policy (CCEP): an organised research unit comprised of a network of experts on climate change economics and policy, and analysis of related topics.	Canberra, Australian Capital Territory
University of Canberra	Climate Change Adaptation and Resilience Research Network: contributing and advancing solutions for sustainability and resilience.	Canberra, Australian Capital Territory
Monash University	Climate Works Australia; Monash Sustainable Development Institute; Monash Climate Change Communication Research Hub	Melbourne, Victoria
University of Melbourne	Climate Energy College: international team of researchers on climate and energy systems collaborating with leading Australian and German research institutions, with a focus on climate change and energy transitions.	Melbourne, Victoria
University of New South Wales	Climate Change Research Centre: one of the largest in Australia with focus areas on key areas of Earth's climate, including atmospheric, oceanic and terrestrial processes.	Sydney, New South Wales
University of Newcastle	Centre for Water Climate and Land: understanding how to deal with the impacts of climate variability including hydroclimatic extremes, hydroclimate forecasting, extreme event risk	Newcastle, New South Wales

University Institution	Drought Related Focus	Base
	analysis, hydrological modelling, water resources management and climate-smart agriculture.	
University of New England	Animal Genetics and Breeding Unit (AGBU): genetics of livestock and plants; R&D of genetic evaluation systems for cattle and sheep. The Australian Centre for Agriculture and Law: includes research on climate change, agriculture and the law with issues including food security and climate resilient development. Centre for Agribusiness: international network the see agribusiness as part of the solution to the planet's future, undertaking projects in the industry based on real-world problems.	Armidale, New South Wales
University of Adelaide	Environment Institute: involved in addressing complex environmental problems.	Adelaide, South Australia
University of Tasmania	Climate Futures Research Group: expertise in local planning and adaption – bridging the gap between fundamental climate science and local adaptation needs of Australian industries, government agencies and communities.	Hobart, Tasmania
University of Southern Queensland	Centre for Applied Climate Sciences: climate change research including climate risk-related insurance and reinsurance, agricultural and water resource applications and disaster risk reduction.	Toowoomba, Queensland
University of the Sunshine Coast	Sustainability Research Centre: research into economic, social and environmental sustainability.	Sunshine Coast, Queensland
Griffith Climate Change Response Program (GCCRP)	Coordinates climate change research across the university and seeks external funding for projects. Works with national and international partners in developing collaborative research projects.	Gold Coast, Queensland
Charles Darwin University	The Australasian Centre for Resilience Implementation for Sustainable Communities: research and consultancy collective to develop evidence-based strategies for building more resilient communities in the face of natural, health and human-made disasters.	Darwin, Northern Territory
Murdoch University	Research focus across three streams of food security, health futures and sustainable development. Food Futures Institute: focus area on meeting the emerging challenges of global food production. Research areas include soil and water, breeding and genomics, animal welfare, pest control and post-harvest technologies, food quality and provenance.	Perth, Western Australia
Curtin University	Centre for Crop and Disease Management (CCDM): Industry research centre to reduce the impact of crop disease in the Australian grains industry. Food Agility Cooperative Research Centre: data-driven technology for the agrifood industry, using AI, robotics, blockchain, sensors, advanced data analytics and more. Includes a focus on carbon.	Perth, Western Australia
University of Western Australia	Institute of Agriculture: providing research-based solutions to food and nutritional security, environmental sustainability and agribusiness. International Centre for Plant Breeding: provides advanced education and research in plant breeding. Centre for Legumes in Mediterranean Agriculture (CLIMA): investigates problems and priorities identified by the WA grain and pasture legume industries. Centre for Environmental Economics and Policy: optimisation, statistics, social surveys, benefit/cost analysis, project evaluation, bio-economic models, non-market valuation, and decision support tools. Western Australian Centre for Rural Health: inter-related health factors for regional communities in WA.	Perth, Western Australia

University Institution	Drought Related Focus	Base
	Centre for Social Impact: inter-related research on regional communities including those who are drought-affected.	

Appendix 5 Australian Government Drought Support Measures

Program/measure	Summary
Farm Household Allowance	Not a drought measure *per se* as is always available to provide recipients with time-limited income support, supplements and case management resources. This package gives people breathing space to develop strategies for self-reliance, and to create an incentive to make significant business decisions where the farm business is unsustainable.
Rural Financial Counselling Service Program	The RFCS is available to Australian farmers, fishers, foresters and related small businesses experiencing, or at risk of, financial hardship, no matter the cause (not a drought measure *per se*). Rural financial counsellors help eligible clients to understand their financial position, identify options and implement plans to improve their financial situation.
Drought Community Support Initiative	Provides up to $3,000 per household to support farmers, farm workers and suppliers/contractors who are facing hardship due to drought.
Drought Community Outreach Program	Australian Government agencies, in partnership with state government agencies and non-government organisations, organise events in drought-affected communities. The events provide face-to-face confidential conversations to farmers and community members suffering the impacts of drought. The program also includes the provision of $500 household vouchers.
Country Women's Association of Australia (June 2019 grant)	The program funds the CWA of Australia to provide $3,000 payments to farmers and farming families experiencing hardship due to drought.
Regional Investment Corporation loans	Concessional drought loans provided through the RIC help farmers improve their long-term resilience and profitability, through refinancing existing debt or accessing new debt. AgBiz Drought Loans assist small businesses that directly provide primary production related goods and services to farm businesses in drought affected communities.
Taxation Measures	The Australian Government has made a number of taxation concessions available to help farmers better manage their cash flows and invest in the profitability and resilience of their farms. Key amongst these are: The Farm Management Deposits Scheme (FMDs) assists farmers to deal more effectively with fluctuations in cash flows. It is designed to increase the self-reliance of Australian primary producers by helping them manage their financial risk and meet their business costs in low-income years by building up cash reserves in good years. Accelerated depreciation arrangements are available to allow farmers to immediately deduct the purchase cost of new water facilities, fodder infrastructure and fencing. There are also a number of other taxation concessions more broadly available to small businesses that primary producers can access.
Communities Combating Pests and Weed Impacts During Drought Program	Provides grants to help to manage wild dogs and other established pests and weeds at a time when drought-affected communities and farmers are least able to.

Program/measure	Summary
On-farm Emergency Water Infrastructure Rebate Scheme	Provides rebates of up to $25,000 to assist farmers with purchase and installation of on-farm infrastructure for stock and permanent plant watering.
Water for Fodder	Water available to irrigators in the southern connected Murray–Darling Basin at reduced price to increase fodder and pasture production.
Improving Great Artesian Basin Drought Resilience	Funding to improve drought resilience in the Great Artesian Basin (GAB) is delivered in partnership with state and territory jurisdictions.
Mental and Community Health - Empowering our Communities, Trusted Advocates Network Trial, Telehealth, ReachOut	Funding to nine Primary Health Networks to plan and commission community-led initiatives to address the immediate support needs of rural and regional communities and foster longer-term recovery and resilience. Connecting the Youth Awareness-raising Initiative (ReachOut) delivers a targeted education campaign to promote available mental health support to youth and their families in drought affected areas. The program aims to raise awareness of a range of digital mental health services available to youth, through focused advertising, activities and school events. Empowering Our Communities program aims to increase access to mental health support initiatives to help farmers and communities deal with the anxiety, stress and uncertainty of drought conditions. Telehealth provides access to Better Access Telehealth for people living in rural and remote regions, including drought affected areas, who face barriers to access to mental health treatment and services. The Trusted Advocates program provides funding for people in drought affected communities to undertake Mental Health First Aid or Accidental Counsellor training so they can help others in their communities.
National Drought Map	The National Drought Map is an online interactive tool aimed at increasing the level of information and data available to improve farm business and government policy decision making.
FarmHub	FarmHub is a single, online one-stop shop for farmers seeking information on the support available from all levels of government, industry groups and not-for-profits concerning risk management, farmer assistance and drought.
Weather radars	The Australian Government has funded four new radars in Queensland. New weather radars will fill significant coverage gaps and provide the agriculture and related industries with improved access to real-time weather information.
Regional weather and climate guides to help with on-farm decision making	The Bureau of Meteorology has developed Climate Guides for each of Australia's 56 Natural Resource Management regions, which helps farmers understand and manage their climate risk.
Support for the wider community affected by drought	
Drought Communities Programme Extension	Provides economic stimulus in drought-affected communities by funding targeted local infrastructure projects and drought-relief activities to provide employment opportunities for people in communities experiencing hardship.
Drought Communities Program Extension – Roads to Recovery	DCP Extension communities receive funding for road infrastructure, providing additional economic stimulus in drought-affected communities.

Program/measure	Summary
Building Better Regions Fund – Drought Round	The BBRF supports the Australian Government's commitment to create jobs, drive economic growth and build stronger regional communities into the future. BBRF Round Four prioritises projects supporting drought-affected communities.
Foundation for Rural and Regional Renewal	Funds provided to the Foundation's Tackling Tough Times Together program for community groups and non-profit groups in drought-affected regions. Grants are available for grassroots, community-led initiatives aimed at economic renewal, reducing volunteer fatigue, bolstering local leadership and funding community infrastructure.
Drought Communities Small Business Support Program	The program assists eligible small regional businesses impacted by drought, bushfire, and COVID-19 to understand their financial position, identify options and implement plans to improve the viability of their enterprise.
Education Special Circumstances	Supporting non-government schools facing financial hardship as a result of ongoing drought conditions, including fee concessions for schools, boarding schools and additional counselling services.
Community Child Care Fund	The Community Child Care Fund is designed to support continuity of child care, particularly in disadvantaged or vulnerable communities, where service viability is affected by an unforeseen or extreme weather event, or another event or circumstance, which would result in market failure for the community.
Support for long-term resilience and preparedness	
Future Drought Fund	The $5 billion Fund provides a secure, continuous source of long-term funding for drought resilience initiatives. The FDF will deliver a range of programs and projects, promote the adoption of new technology and help improve environmental and natural resource management on farms. It will help Australian farmers and communities prepare and respond to the impacts of drought. The current FDF programs are: ● Drought Resilience Self-Assessment Tool ● Climate Services for Agriculture Program ● Natural Resource Management Drought Resilience Program ● Drought Resilience Research and Adoption ● Networks to Build Drought Resilience ● Drought Resilience Leaders ● Farm Business Resilience Program ● Regional Drought Resilience Planning
National Water Grid Authority	Funding for National Water Grid Authority comprises $41.185m in administered funds, $23.815m in departmental funds, and $35m that forms part of the National Water Infrastructure Development Fund. Funding for construction of more than 20 projects and more than 50 infrastructure projects feasibility studies has been committed under the Fund.

Appendix 6 Other National Drought-Related Programs

Program	Description
Australian Combined Drought Indicator (CDI) (NSW Government – Department of Primary Industries)	Drought early warning system based on the US Drought Monitor concept focused on four drought indicators (rainfall, soil moisture, evapotranspiration, and Normalised Difference vegetation Index (NDVI).
Climate Systems Hub (Australian Government – Department of Agriculture, Water and the Environment)	Provides research to advance the understanding of Australia's climate, its extremes, and associated drivers. This research will directly inform climate adaptation.
Drought Communities Programme -Extension (Australian Government)	Funding for councils for drought relief projects.
farmpredict model (ABARES)	The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) is the research arm of the Australian Government's Department of Agriculture, Water and the Environment (DAWE). It is involved in drought and climate research projects including the *farmpredict* model. ABARES is examining this model's potential to explore and assess long term climate projection scenarios for Australian broadacre farms which are most susceptible to the negative impacts of drought. It's also using the *farmpredict* model to measure broadacre farm sensitivity to drought and changes over time which will help guide farm drought resilience initiatives in the future.
National Strategy for Disaster Resilience	Acknowledges the increasing severity and regularity of natural disasters in Australia and the need for a coordinated and cooperative national effort to enhance Australia's capacity to withstand and recover from emergencies and disasters.
Natural Resource Management Regions Australia	Natural Resource Management Regions Australia (NRMRA) is a national group of representatives of the NRM Chairs' Forum. NRMRA is involved in a number of drought resilience measures and interventions including: ● Increasing groundcover ● Increasing water use efficiency ● Reducing loss of pasture during dry times ● Increase planning for risks associated with drought. Across Australia, NRMRA is improving drought resilience in the following ways: ● Providing grants and facilitator support for drought planning ● Maintaining groundcover – more analysis is needed incorporating soil health, water quality and livestock wellbeing and productivity to identify which aspects are most useful ● Controlling weeds and feral animals (2018 Pest and Weed Drought Funding Program) - reducing grazing pressure and spread of weeds ● Increasing water use efficiency (e.g. on farm irrigation efficiency program in the SA Murray-Darling Basin); ● Building networks ● Retained stubble ● Reduced reliance on pesticide ● Optimisation of fertiliser use ● Minimising tillage or cultivation ● Destocking early in low rainfall periods to preserve ground cover and improve water retention.
New Insurance Markets (ABARES)	ABARES has conducted research into the benefits of parametric insurance where 'payouts are based on weather data rather than actual farm damages.' Parametric weather insurance would allow for self-managing climate risks.
Northern Australia Climate Program (Australian Government/BoM)	Collaboration between the Queensland government (through their drought and Climate Adaptation Program) and Meat and Livestock Australia Donor Company. Funded the University of Southern Queensland and program partners to

Program	Description
	undertake research development and extension projects. Funded from 2018-2021.
The Drought and Climate Adaptation Program (Queensland Government)	Aims to help producers better manage drought and climate impacts. Collaboration of climate scientists, government and non-government agencies, producers and industry leaders. Partners include the Dept of Ag and Fisheries, the Dept of Env and Science, the USQ, BoM and MLA.

Appendix 7 WA Drought Response Actors and Involvement

Actor	Involvement
Australian Association of Agricultural Consultants WA (AAAC)	Responsibilities include managing Aboriginal lands and heritage, administering Western Australia's crown land, and land use planning in Western Australia.
Pastoralists and Graziers Association (PGA)	WA based not for profit organisation representing primary producers of wool, grain, meat and livestock.
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Drought resilience research: ● Environmental resilience ● Farm resilience ● Forecasting and monitoring ● Smart agriculture ● Social and urban resilience
Kondinin Group	Provides research findings and agricultural information on best farming practices.
Curtin University of Technology (CUT)	Focus areas: ● Centre for Crop and Disease Management ● Curtin Earth Dynamics Research Group ● Remote Sensing and Geospatial Sciences Group ● Centre for Digital Agriculture ● Remote Sensing and Satellite Research Group
Department of Primary Industries and Regional Development (DPIRD)	Committed to growing and protecting WA's agriculture and food sector. Focus areas related to drought: ● Climate change ● Dry seasons and drought ● Land use planning ● High rainfall pastures ● Carbon farming ● Water management ● Assessment for agricultural expansion ● Report card on conditions and trends ● Managing soils
Department of Water and Environmental Regulation (DWER)	Supports Western Australia's community, economy and environment by managing and regulating the state's environment and water resource. Key roles: ● EPA conducting environmental impact assessments and developing policies to protect the environment. ● Environmental Regulation responsibility for all environment and water regulation. ● Managing the availability and quality of water.
Department of Planning, Lands and Heritage (DPLH)	Focus areas (relevant to this report): ● Aboriginal heritage and lands management. ● Integrated land and infrastructure policy development. ● Land use planning and policy development.
Edith Cowan University (ECU)	Climate Initiative Taskforce Report: includes recommendations and projections based on climate change research and trends and annual carbon footprint auditing. Centre for Ecosystem Management.
Facey Group	Not for profit grower led group facilitating local research, information and networking. This group covers the Top of the Avon and Blackwood River Catchments, servicing members from the regions of Kulin in the east to Wandering in the West, from Pingelly and Yealering in the North down to Williams, Wagin, Dumbleyung and Katanning in the South.

Actor	Involvement
Grain Industry Association of WA (GIWA)	Facilitates an effective and efficient WA grain industry, focusing on communication, capacity building and grain supply chain solutions.
Grower Group Alliance (GGA)	Capacity building for grower groups and connecting WA grower groups, researchers, funding bodies and industry.
Industry Groups	There are a number of industry groups established at the level including (but not limited to): ● Southern Dirt ● Evergreen ● Stirlings to Coast ● South East Premium Wheat Growers Association ● Western Australia No-Till Farmers Association ● WA Farmers Federation ● Oil Mallee Association and private agricultural consultants.
Murdoch University	Food Futures Institute: consolidates research to sustainably improve food production.
Noongar Land Enterprises (Grower Group)	Made up of 8 Indigenous land management groups that manage agricultural land across the South West, with the aim of developing and expanding businesses managed on Aboriginal land.
Northern Agricultural Catchment Council (NACC)	Sustainable Agriculture Program: helps farmers tackle environmental issues and support sustainable natural resources and offers funding opportunities, capacity building, workshops and events.
Regional Development Commissions	Common goal of long-term social and economic growth.
Rural Business Development Corporation (RBDC)	Administers assistance schemes and other services for the rural industry on behalf of the State and other services for the rural industry.
Sheep Alliance of WA	Involved in providing strategy and leadership for the sheep industry.
South Coast NRM	Examines the impacts of climate on farm businesses, feral animal control, water quality and food innovation.
South Regional TAFE	Provides important training and education in natural management issues.
South West WA Drought Hub	One of 8 hubs across Australia, this project is led by the Grower Group Alliance and forms part of the Australian Drought Resilience Adoption and innovation Hub. Running to June 2024, its focus is on drought and agricultural innovation, with a particular focus on drought resilience.
The Western Australian Biodiversity Science Institute (WABSI)	Facilitates partnerships across industry, government, community and researcher to address science knowledge gaps, support decision making and improve biodiversity outcomes. With restoration of biodiversity in agricultural lands one of its key focus areas.
University of Western Australia (UWA)	UWA's Centre of Excellence in Natural Resource Management (CENRM): Based in Albany CENRM maintains networks in national natural resource management activities and has worked with regional organisations and communities on matters where evidence-based science is important to their policy and operation. Further details of its drought related programs are provided in Table in Section 2.62. Key Drought Actors Nationally. At a snapshot, UWA also lead or are involved in: ● Institute of Agriculture ● International Centre for Plant Breeding ● Centre for Legumes in Mediterranean Agriculture (CLIMA) ● Centre for Environmental Economics and Policy ● Inter-related regional health focus through the Western Australian Centre for Rural Health
WA Farmers Federation	Works towards a more viable, profitable and sustainable future for the agricultural industry.
WA No-Tillage Farmers Association (WANTFA)	The largest agronomic grower in Western Australia, WANTFA supports the adoption of sustainable and profitable broad acre cropping systems through shared experiences and innovative research. It is the only WA group focused on precision agriculture, endorsing the following principles: ● Limited soil disturbance; ● Precision agriculture; ● Permanent ground cover; ● Diverse rotations; and ● Reduced compaction.

Actor	Involvement
Water Corporation	Key priorities: ● Waterwise Business Program; ● Waterwise Towns Program; ● Waterwise Councils Program; ● Undertaking large water integrated schemes to ensure a climate-resilient water supply.
Western Australian Landcare Network	Not-for-profit organisation with a foundation membership of 10 community groups. It operates with an Executive Committee who work with part time staff to provide benefits to members and raise the profile of land care in WA.
Wheatbelt NRM (WNRM)	Focussed on Innovations in Regenerative Agriculture – methods for sustainably managing soil to improve soil carbon retain soil moisture.
Northern Agri Group	Representing farmers in Binnu, Ajana, Ogilvie and Northampton. Interests include sustainability, improving yields, farming in a changing climate.
Mullewa Dryland Farmers Initiative (MDFI)	MDFI serves as a hub to disseminate information to growers in the area on a variety of trials & workshops available. An annual field walk is the primary activity, with other events coordinated as required.

Appendix 8 Drought Related Initiatives in WA

Note, this is not an exhaustive list.

Initiative	Description
Beyond Reasonable Drought (NACC)	Drought-focused, sustainable agriculture initiative in the Mid West region funded through the Future Drought Fund.
Chapman Catchment Collaborative Landscape Scale Regeneration Program (NACC)	From a cohort of champion landholders in the catchment, six sites will be developed as demonstration sites for innovative practices to prepare and respond to drought. The lessons learnt will be shared more broadly.
EPBC Species, Climate Action and Aboriginal Farms (Gillamii)	Introductory project involving scoping of activities which will then form the basis in developing the future of this project (years 2-5) around the key topics addressing: Climate Action and EPBC Species in the Gillamii sub region, and also scoping Aboriginal Farming relationships/building NRM knowledge, in the South Coast NRM region from Denmark to Esperance.
Farm Water and Rural Community grant scheme	Targets dryland agricultural regions of the State which receive less than 600 millimetres of annual average rainfall and are without access to a reticulated water service. Objective: to increase self-sufficiency and optimise the efficient use of all available non-potable water supplies through improved water resource planning and the provision of rebates and grants to develop both on and off farm water supplies.
Farmers Helping Farmers to Maximise Soil-moisture and Production in Prolonged Drought Areas (Gillamii)	A project focused on drought mitigation and planning through shared experiences and farmer networking.
Future Drought Fund programs	Regional Drought Resilience Planning Program: key program in the Future Drought Fund in 2021-22. Drought Resilience Adoption and Innovation Hubs (South West, Northern WA): foster connections that stimulate new research and innovation in agriculture. WA Farm Business Resilience Program 2021-June 2022: Connecting pastoralists and farmers with each other and business professionals, with the aim of improving farm business resilience skills, tools for risk management.
Innovations in Regenerative Agriculture (Wheatbelt NRM)	Increasing awareness and ability of growers to adopt methods of sustainably managing soil.
NRM Planning for Climate Change	SCNRM – provided analysis of climate change impacts and adaptation approaches.

Initiative	Description
Pilot of Drought Reform Measures	The Australian Government, in partnership with the WA Government began a pilot of drought reform measures across 67 local government areas in July 2010. Included the Gascoyne, Midwest, Wheatbelt, Great Southern and Goldfields-Esperance regions. Extended in 2011 to include the South West region of WA, adding another 62 LGAs. Range of pilot measures were trialled: ● Farm planning: workshops to develop strategic plans to support drought resilience. Priority activities to improve management and preparedness. ● Building farm Businesses: provided Business Adaptation Grants and Landcare Adaptation for eligible farm businesses. ● Stronger rural communities: a number of measures to assist farm communities prepare for and manage hardship. ● Beyond farming: putting farmers in touch with former farmers to discuss alternative opportunities outside of farming.
Productive Saltland Pastures in Southern WA (Gillamii)	Supports and equips farmers with knowledge and tools across the Southern WA agricultural regions to regenerate saline and marginal production lands
RLPGIL Climate and SSS Trial (Gillamii)	Includes a climate action element resulting in the delivery of Greenhouse Gas farm surveys, Community and Stakeholder engagement events to support the region to adapt, innovate and address market demands for sustainable food production and, surveying of knowledge on climate change and adoption of new tools and strategies.
South West WA Drought Resilience Adoption and Innovation Hub	Part of the Future Drought Fund, led by Growers Group Alliance.
State Natural Resource Management Program	Designed to conserve and sustainably manage the State's natural resources by supporting community groups to undertake stewardship of natural resources in their local area. Guided by the WA Natural Resource Management Framework.
Stormwater Reuse Project	Better management, harvesting and reuse of stormwater.
Supporting Smarter Farms (NACC)	Offering innovative opportunities to address soil acidity, wind erosion, increase soil organic carbon and improve native vegetation and on-farm biodiversity.
The WA Climate Science Initiative (WACSI)	$3.1 million government commitment under the Western Australian Climate Policy to better equip Western Australians with the latest climate science and knowledge needed to respond to our changing climate. Four-year initiative from 2021 to 2025. Aims: ● To make high resolution climate data and information for Western Australia available and accessible to decision makers and the community; ● To engage and empower Western Australians to use climate data in planning and decision making; ● To identify and plan for future sector and regionally specific climate data and knowledge needs; Committed Outcomes: ● Climate Risk Framework ● Climate Resilience Strategy ● Sectoral Adaptation Plans
Water Smart Farms	Three year project to research sustainable groundwater options to supply water for primary production and other agribusiness activities. Delivered in the Grain belt and Great Southern regions of WA by DPRID and the Great Southern Development Commission.

24. Endnotes

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