ACIL ALLEN CONSULTING

REPORT TO DEPARTMENT OF AGRICULTURE, WATER AND THE ENVIRONMENT

SEPTEMBER 2020

Drought Resilience Research Development Extension and Adoption Stocktake

GAPS AND OPPORTUNITIES FOR INVESTMENT

FINAL REPORT

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EXECUTIVE SUMMARY

The Future Drought Fund (Fund) is a long-term investment fund established by the Commonwealth Government in 2019. The Fund provides a sustainable source of funding to help Australian farmers and communities become more resilient to the impacts of drought, economically, environmentally and socially. The Fund will have a program to deliver drought resilience Research, Development Extension and Adoption (RDE&A) for public good across the triple bottom line.

The Fund commissioned ACIL Allen to undertake a stocktake to:

- understand the drought resilience RDE&A ecosystem
- provide a picture of the current level and focus of drought resilience RDE&A knowledge
- provide insights into opportunities for investment by the Fund.

The stocktake involved developing a drought resilience RDE&A framework. This was populated with data from a survey of 17 RDE&A organisations and an international search of academic literature and outputs.

The framework was refined following preliminary analysis of results and by input from 30 stakeholders through a series of focus groups and interviews (refer Appendix B).

Key observations

Drought resilience – a complicated construct within a complicated RDE&A system

Variability in drought and farm performance has significant implications for the demand of drought resilience RDE&A, this is because:

- there is no agreed definition for drought resilience
- drought is not a constant adversity and the need for drought resilience RDE&A varies over time and space depending on the frequency, severity and duration of drought
- resilience means different things to different people and therefore specific locations, industries or groups' drought resilience RDE&A needs will vary over time and some will be more prepared than others.
- This creates challenges in supplying timely RDE&A given significant lead times in R&D and E&A is less effective when it is not aligned to users current needs.

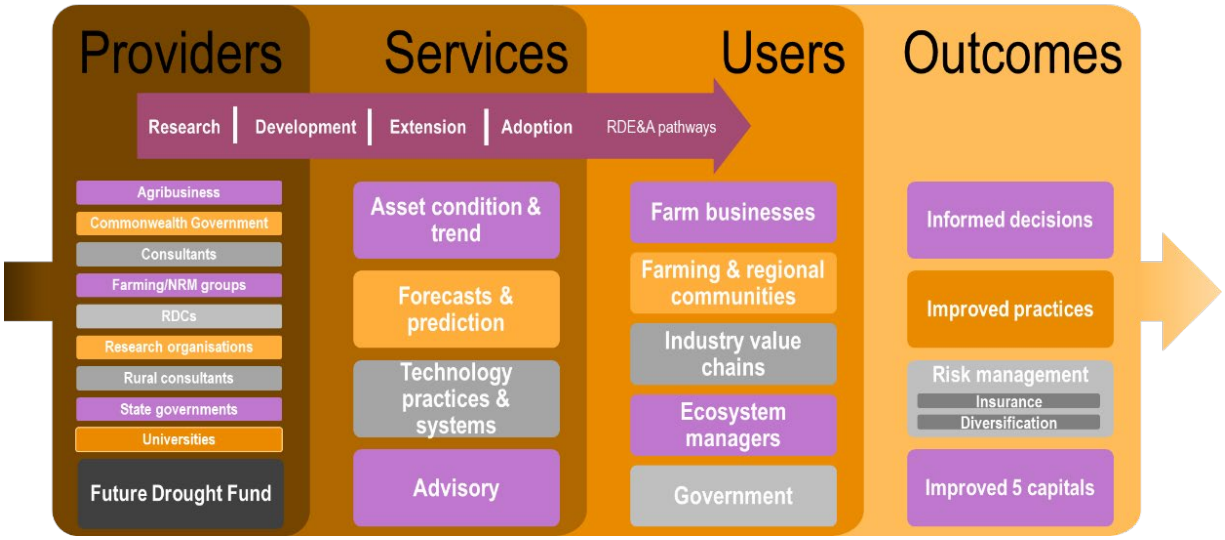
On top of this drought is not the only risk faced by farm businesses and their communities and is often linked to climate change. The net result is drought on its own is not enough to incentivise RDE&A service providers across the system to focus primarily on drought resilience.

Although, Australia has a good reputation for R&D the complexity and structure of Australia's agricultural innovation system makes coordination and setting drought resilience R&D priorities and direction difficult.

Drought resilience – a stocktake of current RDE&A

Drought resilience RDE&A operates as an innovation system (within a broader innovation system) providing knowledge as a service to a wide range of users to support realisation of multiple outcomes (Figure ES 1).

FIGURE ES 1 DROUGHT RESILIENCE ECOSYSTEM



SOURCE: ACIL ALLEN

From a representative sample of 17 organisations the stocktake identified:

- 286 funders/providers
- 832 program activities[1]
- investment of more than $1.5 billion for current programs.

Drought resilience is rarely a primary research objective, with the majority of surveyed programs reported to have drought resilience as a secondary objective (91 per cent) which accounts for 83 per cent of reported investment (Table ES 1).

TABLE ES 1 PROGRAMS AND FUNDING BY DROUGHT RESILIENCE FOCUS

	Primary	Secondary
Programs (%)	9%	91%
Funding ($ million)	$251	$1,244
Funding (%)	17%	83%

SOURCE: ACIL ALLEN CONSULTING

[1] These activities are mainly R&D activities, it was difficult to capture E&A activities through the survey – and where investment in E&A was reported it was not done so consistently across respondents.

Nearly all programs (97 per cent) and investment (99 per cent) have an economic resilience objective, this means that they focus mainly on enhancing economic outcomes such as productivity, reducing costs or increasing efficiency of a farming system or an industry.

Environmental resilience objectives (with focus on securing better outcomes for the environment) are secondary, while social resilience (which looks to improve social outcomes for individuals and communities) only account for a small proportion of programs and funding (Table ES 2).

TABLE ES 2 FOCUS OF DROUGHT RESILIENCE RDE&A PROGRAMS IDENTIFIED

	Economic	Environment	Social
Programs (#)	807	187	89
Programs (%)	97%	22%	11%
Funding ($M)	$1,480	$450	$90
Funding (%)	99%	30%	6%

SOURCE: ACIL ALLEN CONSULTING

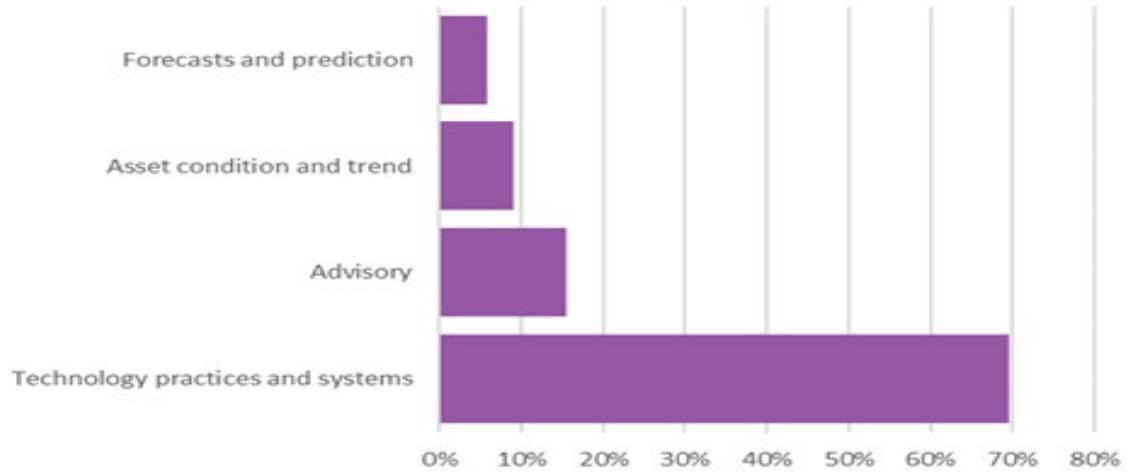
The program activities clearly target farm businesses above other users (Table ES 3) and focus on providing technology and practices above other services (Figure ES 2).

TABLE ES 3 USER GROUPS OF DROUGHT RESILIENCE ACTIVITIES

	All	Communities	Ecosystem managers	Farm businesses	Government	Industry value chain
Programs (#)	3	23	41	778	22	96
Programs (%)	0%	3%	5%	93%	3%	12%
Funding ($M)	<$1	$40	$60	$1,464	$110	$64
Funding (%)	<1%	2%	4%	84%	6%	4%

SOURCE: ACIL ALLEN CONSULTING

FIGURE ES 2 DROUGHT RESILIENCE SERVICES



SOURCE: ACIL ALLEN CONSULTING

Drought resilience – a review of completed research

The literature review surveyed drought resilience research conducted over the last century and indicates that the number of documents produced has been increasing over time. Further, there has been a substantial increase in the number of publications per year since 2008.

The USA dominates the international research system in drought resilience producing 25 per cent of all research. Second is China with 15 per cent and then Australia at 8 per cent.

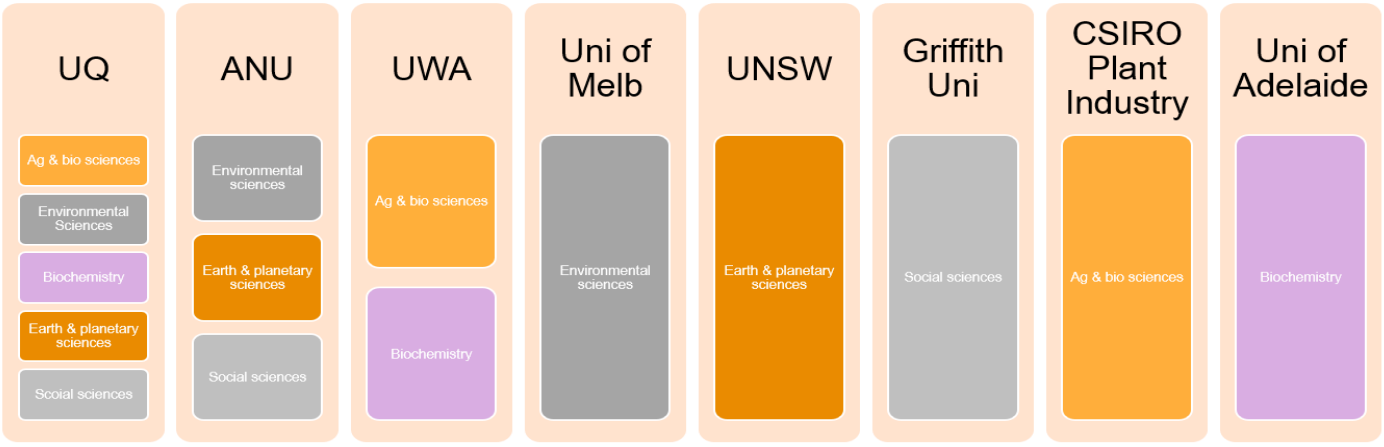
International research is dominated by agricultural and biological science research accounting for 64 per cent of all research. This is followed by 34 per cent in environmental science space, 26 per cent in biochemistry, genetics and molecular biology, 13 per cent in earth sciences and 12 percent categorised as social sciences research (including economics, econometrics and finance and business management). These trends are similar nationally.

The top ten institutions globally are:

- Chinese Academy of Sciences, China
- Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia
- United States Department of Agriculture (USDA), United States
- French National Research Institute for Agriculture (INRA) [combined], France
- Spanish National Research Council (CSIC), Spain
- University of Chinese Academy of Sciences, China
- National Centre for Scientific Research (CNRS), France
- Ministry of Education China, China
- Wageningen University and Research Centre, Netherlands
- Chinese Academy of Agricultural Sciences, China

In Australia the leading institutions by subject area are presented in Figure ES 3. This provides an indication of capability across Australia for drought resilience research.

FIGURE ES 3 MAJOR AUSTRALIAN UNIVERSITY DROUGHT RESILIENCE RESEARCH CAPABILITY BY SUBJECT AREA



SOURCE: SCOPUS

Opportunities and gaps

The stocktake has identified there is a sophisticated innovation system operating in Australia which does consider drought resilience in its RDE&A however much of it has drought resilience as a secondary rather than a primary research objective.

There are six strategic opportunities for the Fund, detailed below.

Leverage the existing innovation system

The rural innovation system is predominantly focused on the economic and environmental resilience of agricultural industries and landscapes, particularly farming systems. Given the diversity of pathways, the number and often specialised focus of the providers, drought resilience RDE&A lacks an 'owned' strategy or a community of practice. The diversity limits transparency, especially to those not deeply engaged in the rural innovation system.

The academic-university sector is engaged in but extends beyond the rural innovation system. The academic sector produces large and growing research and development of drought resilience related knowledge. While the drivers and operations of the academic sector vary from those of the broader ecosystem, it is an important provider of drought resilience knowledge. Given the volume and diversity of research coming out of domestic and international institutions, the Fund should seek to tap into the academic sector to utilise its productive power.

Three logical partnership points for the Fund to pursue opportunities are: the 15 RDCs (individually and through the Council of Rural RDCs Climate Change sub-committee), Commonwealth and State Governments and national research organisations such as CSIRO, ACIAR, and BoM.

The key opportunity for the Fund is to engage with the rural innovation system to improve the transformational focus and impact of its RDE&A by:

- improving the coordination of strategies and programs (i.e. the programs listed in Appendix A)
- bundling of services to strengthen extension and adoption.

Further discussion is needed around how best to invest in drought resilience RDE&A within and across sectors.

Develop a roadmap for farming systems

There is a need for a roadmap to examine the role of farming systems, development of potential climatic scenarios for these farming systems, an assessment of the available knowledge and RDE&A underway, and assessment about whether the uptake of the knowledge produced will be sufficient, and whether the RDE&A underway will achieve the $100 billion desired by the industry.

The outcome from this analysis will be an assessment about whether the current drought resilience RDE&A investment levels are sufficient and appropriately focused. While this analysis may be best done by individual RDCs, the work will have similarities across all RDCs and should be undertaken collaboratively and with the FDF.

Get more from information products and platforms

There is no single and shared repository for drought resilience RDE&A outputs/knowledge/data. The outputs from research often needs to be synthesised with other research outputs to allow end-users to optimise farming or social and environmental systems. This stocktake assists with identifying a significant breadth of activity completed and underway, but more needs to be done to maximise the value from the significant investment already made into drought resilience RDE&A.

Focus more on social and environmental drought resilience

There is a trend towards increased drought resilience-related R&D, often associated with climate change, extreme events, sustainable farming systems and novel innovations. However, there is a clear opportunity to develop research focused on social and environmental outcomes relative to research with an economic outcome. The existing ecosystem is predominantly focused on the agricultural sector, and few providers have responsibility for social or environmental outcomes. Smaller proportions of funding are allocated across environment and social drought resilience programs relative to programs focused on economic outcomes. There is no clear broker to partner with for drought resilience social research. The most likely candidates are state and local governments. The FDF will need to negotiate collaborative agreements with State and Territory Government to coordinate and leverage activity and maximise benefits. In the environmental space, the FDF should work with National Environmental Science Program and NRM groups.

Improve risk management activity

Development of insurance markets has the potential to significantly increase the drought resilience of agricultural businesses. While RDE&A on insurance has been underway for decades and not yet delivered broad markets, the limited RDE&A activity on agricultural insurance and diversification was a surprise. There may be value in evaluating previous RDE&A and identifying further opportunities to undertake RDE&A that has the potential to deliver economic value.

Conduct research to better understand and further connect users

The stocktake and focus groups show there is not a single- or one-time solution to improve drought resilience. There is also considerable variation in drought resilience within user groups. Some are more resilient than others at a given point in time. The focus groups also highlighted that the demand for drought resilience extension and adoption is inconsistent. As is the case with much adoption, a trigger is needed to increase motivation to utilise available knowledge, technologies, practices and systems.

We have identified four knowledge services that are integral to drought resilience and form part of the drought resilience RDE&A ecosystems map. Each of these services would benefit from additional investment and development to address the specific needs and adoption barriers of user segments.

The FDF can assist to clarify the priorities for drought resilience with partners across economic, environmental and social RDE&A, including the relevant meaning of drought resilience. The FDF can also facilitate more cooperation and connection between researchers and end-users through the design of its programs and partnerships.

Gaps and challenges

The question whether there are gaps in drought resilience RDE&A is a matter of perspective.

- The fact that farmers, industries and communities continue to be impacted by drought is seen by many as the need for greater adoption of knowledge generated by R&D to improve resilience.
- The fact that not all R&D is currently adopted is seen by many as the need for more extension, R&D or both.
- The expectation that droughts will have a greater impact in the future amplifies this need and signals that reorganisation/ transformation will be required.

While these propositions can be justified, they do not hold true in all cases.

Further work

There has been and will continue to be investment in drought resilience RDE&A. To maximise the benefit, transparency and visibility of completed drought resilience research and RDE&A activity underway, RDE&A outputs could be stored in a centralised, searchable manner.

Building on the stocktake done, and database developed as part of this project would assist the FDF and others in the development of drought resilience RDE&A investment strategy.

1 INTRODUCTION

The Department of Agriculture, Water and the Environment (the Department) commissioned ACIL Allen Consulting (ACIL Allen) to undertake a stocktake of drought resilience research, development, extension and adoption (RDE&A) knowledge for the Future Drought Fund (the Fund) to inform its future strategic investment in drought resilience RDE&A. The stocktake was conducted between April and July 2020.

1.1 The Future Drought Fund

The Fund is a long-term investment fund that provides a sustainable source of funding to help Australian farmers and communities become more prepared for, and resilient to, the impacts of drought. Established under the *Future Drought Fund Act 2019* in September 2019, the Fund began with a $3.9 billion investment, with earnings to be reinvested by the Future Fund Board until the balance reaches $5 billion.

From July 2020, $100 million will be available from the Fund to invest in drought resilience programs. The programs will support farm businesses to be better informed, more productive, profitable and adaptable, and to adopt more resilient land and natural resource management practices. The programs will also build capacity in rural and regional communities to be less vulnerable to the socio-economic impacts of drought. Through grants or other arrangements, the Fund will support a range of initiatives including research and adoption of new and existing knowledge and technology; improved farm business planning and decision-making; improved environmental and natural resource management; and a range of community resilience initiatives.

Drought Resilience Funding Plan

The Drought Resilience Funding Plan 2020-2024[2] (the Funding Plan) sets out an approach for making arrangements or grants in relation to drought resilience or entering into agreements in relation to such grants. The Funding Plan serves as a framework for all expenditure from the Fund.

The Funding Plan has three interconnected strategic priorities:

- economic resilience for an innovative and profitable agricultural sector
- environmental resilience for sustainable and improved functioning of farming landscapes,
- social resilience for resourceful and adaptable communities.

[2] See https://haveyoursay.awe.gov.au/48071/widgets/284939/documents/144176 Accessed 5 August 2020

Any research funded under the Future Drought Fund must enhance the public good (see Section 3 of the *Future Drought Fund Act 2019*). Examples of research which enhance the public good, as listed in the Explanatory Memorandum for the Act, include research into improved availability of data and information on drought-related risks to agriculture which may enable the insurance sector to target more affordable and relevant insurance products to meet specific needs within the farming sector. Furthermore, the Explanatory Memorandum notes effective communication of research findings to the farming sector will accelerate the adoption of new knowledge and technologies that build drought resilience through more efficient and effective farming practices and more sustainable management of natural resources. The public good would not be enhanced by measures that solely benefit individual farm entities.

There may also be a need for research directed at making communities more drought resilient and the provision of associated extension services to community bodies and leaders.

Drought Resilience Research, Development, Extension and Adoption Program

The Fund's Drought Resilience Research, Development, Extension and Adoption (RDE&A) Program is one element of the Fund's investment portfolio.

On 1 July 2020, the Minister for Agriculture, Drought and Emergency Management announced the first year of the Fund's eight programs including the Drought Resilience Research and Adoption Program. This program has been allocated $20.3 million to:

- establish two regionally located Drought Resilience Adoption and Innovation Hubs
- provide Innovation Grants for research organisations, private sector, industry, not-for-profit organisations and community groups.[3]

The Fund is part of the Government's Drought Response, Resilience and Preparedness Plan (refer Box 1.1) and the National Drought Agreement[4] (NDA).

[3] See https://minister.awe.gov.au/littleproud/media-releases/building-drought-resilient-australia-future-drought-fund Accessed 5 August 2020
[4] See https://www.agriculture.gov.au/ag-farm-food/drought/drought-policy/national-drought-agreement Accessed 5 August 2020

BOX 1.1 DROUGHT RESPONSE, RESILIENCE AND PREPAREDNESS PLAN

The Drought Response, Resilience and Preparedness Plan (the Plan) was developed in 2019 and is supported by the findings of the Coordinator-General for Drought's report to government in 2018. The Plan is comprised of three components and is underpinned by a vision and foundations for successful drought management.

1. Immediate action for those farmers and communities in drought
2. Support for rural and regional communities affected by drought
3. Developing long term approaches to building resilience and preparedness.

The vision is:

To have farm businesses and rural communities that are prepared for, and capable of managing, drought in pursuit of a prosperous and sustainable future.

This vision is based on successful drought management foundations which include:

- Drought is a feature of the Australian landscape and is not a natural disaster
- Drought conditions are likely to increase in frequency, severity and duration as a result of climate change
- Drought is one of several business risks that needs to be managed
- Drought must be prepared for even when there is no drought
- Drought policies and programs need to focus on planning and preparation and should be done so in conjunction with communities and industry
- Data about drought and its effects on the local society, economy and environment needs to be collected to inform the development of preparation, plans and responses.

SOURCE: HTTPS://WWW.AGRICULTURE.GOV.AU/AG-FARM-FOOD/DROUGHT/DROUGHT-POLICY

On 1 September 2020, the Australian Government announced that the Drought Resilience Research and Adoption Program would be allocated $86 million over four years. The Program will include eight Drought Resilience Adoption and Innovation Hubs. The hubs will be established in major climatic and agricultural zones across regional Australia. Hubs will be networks of researchers, primary producers, industry groups, community groups and others.

The Drought Resilience Adoption and Innovation Hubs will support the development of extension and adoption activities, and opportunities to commercialise new knowledge. Hubs will harness research, development and innovation to build drought resilience. They will translate research into practical on-ground action through support for extension, adoption, testing, scaling up and commercialisation support.

1.2 Purpose

Information and RDE&A are crucial for building drought resilience. When focused on farming and community needs, these activities can guide technological advances and support good decision-making and risk management. Example focus areas could include:

- more efficient water use
- better natural resource management (NRM)
- adaptation to climate change
- sustainable business models.

Australia has a good reputation for R&D. The complexity of Australia's R&D system makes coordination and setting drought resilience R&D priorities and direction difficult. This complexity also makes it difficult to identify gaps in drought resilience R&D. There are many players providing information, investing in and conducting R&D and providing extension, including federal and state government departments, universities, industry bodies and the private sector.

Accordingly, this report has the objective of informing the Fund on the drought resilience knowledge, the RDE&A ecosystem and pathways to adoption. Specifically, the terms of reference include the objectives of:

- documenting the global and national trends and drivers relevant to drought resilience knowledge and R&D
- identifying drought resilience related existing knowledge, knowledge that needs adapting to promote uptake, or R&D that is underway
- mapping the national drought resilience ecosystem by identifying key organisations investing in, undertaking or reliant upon drought related RDE&A across the entire R&D value chain from fundamental research through to commercialisation
- public[5] and private good drought related RDE&A investment and activity and identifying strategic opportunities to leverage existing investment.

Request for Quote

1.3 This report

ACIL Allen has undertaken a data-driven approach to cataloguing and analysing drought resilience RDE&A and the ecosystem. The analysis has been taken from an unprescriptive basis that is with the data and evidence leading the conclusions. The study includes analysis of:

— the body of drought resilience knowledge

— the drought resilience ecosystem: RDE&A pathways that link knowledge generation (research and development) and use (extension, adoption and potential commercialisation).

Data and insights into the drought resilience RDE&A ecosystem were collected through three approaches. These were:

1. **Drought resilience ecosystem database** – a database was developed of RDE&A providers, their focus, funding and activity. The database is a sample[6] of all providers and activities but provides insights into the ecosystem and activities in Australian drought resilience knowledge RDE&A. The database focuses on a number of key institutions including the Research Development Corporations (RDCs), state governments and government research organisations. The database includes approximately 832 activities involving 286 organisations from 17 institutions with drought resilience RDE&A relevance.

2. **Literature survey** – a survey of drought knowledge literature and outputs was gathered to provide insights into the academic sector. This includes an analysis of the fields of study involved in drought resilience research, the trends in their focus, the affiliations of the research organisations, and the linkages between them. Approximately 36,500 research outputs have been included in the analysis.

[5] "For this proposal, public goods deliver significant benefits that can be accessed or shared by many (rather than be captured solely by individual businesses or industries solely for commercial gain)" (footnote # 2 from the Request for Quote).
[6] A sample is defined as: a small part or quantity intended to show what the whole is like.

3. **Stakeholder focus groups** – a series of stakeholder focus groups, run over two weeks, with representatives from academia, RDCs, government agencies, research organisations, farming systems groups and government departments. The focus groups informed on the drivers of drought resilience RDE&A and the opportunities for future investment.

The structure of this report

The rest of this report is structured as follows:

- Chapter 2 presents the drought resilience RDE&A ecosystem based on the Australian innovation system's characteristics and outlines the structure of the stocktake used in subsequent chapters.
- Chapter 3 presents the entities within the drought resilience RDE&A ecosystem, its providers, their drivers, linkages and partnerships. It introduces the database that has been used to provide a picture of the ecosystem.
- Chapter 4 outlines the activities undertaken within the drought resilience ecosystem. It characterises the fields within which drought resilience knowledge is generated, the users targeted by activities, drought resilience services and the objectives of drought resilience activity.
- Chapter 5 outlines the relationship of the academic sector to the broader drought resilience RDE&A ecosystem. It looks at the institutions, their collaborations, drivers, capabilities, and focus of R&D efforts.
- Chapter 6 provides recommendations and principles for the Fund's drought resilience RDE&A investment.
- Appendix A lists the drought RDE&A programs/activities identified by the stocktake.
- Appendix B summarises the focus group discussions.

2 DROUGHT RESILIENCE AND RESEARCH DEVELOPMENT EXTENSION AND ADOPTION

This chapter defines drought resilience and explains the key attributes of drought and resilience. It also describes the Australian RDE&A system, describes how drought resilience can be improved through a process of RDE&A, and how the pathways of RDE&A work across the drought resilience RDE&A ecosystem to realise outcomes.

2.1 Drought resilience

The Fund defines drought resilience as:

> the ability to adapt, reorganise or transform in response to changing temperatures and increasing variability and scarcity of rainfall, for improved economic, environmental and social wellbeing.
>
> The Future Drought Fund (2019)[7]

Taking this definition, there are two key constructs to unpack: first, the construct of drought and its attributes, and second, the construct of resilience.

The attributes of drought

Drought is part of life

No matter how it is defined, we know that drought will occur. What we do not know is when, how often, how long or how bad it will be (that is drought is uncertain in terms of frequency, duration and severity). Recent experience evidences drought frequency, duration and severity have been increasing over time. This means that overtime drought has increased in relevance.

[7] The Future Drought Fund, (2019), The Drought Resilience Funding Plan 2020-2024. Australian Government. Available at: https://haveyoursay.agriculture.gov.au/future-drought-fund Accessed 5 August 2020

Drought, on its own, is not enough

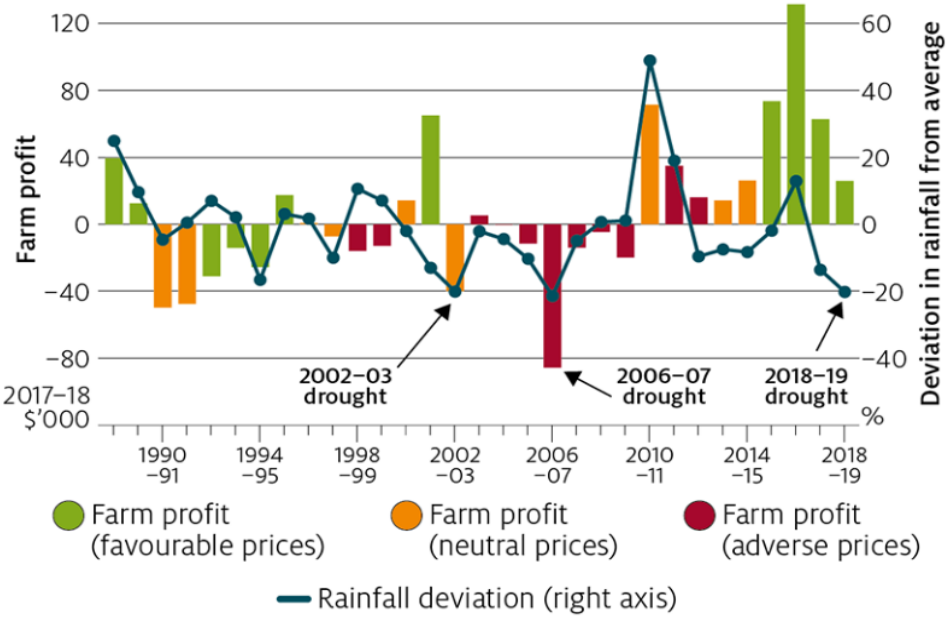
Drought is not the only adversity facing agriculture in Australia, and nor is it adversity that is stand-alone. The NDA acknowledges that drought is just one of many risks faced by farming businesses.[8] ABARES recent report from December 2019, corroborates this noting:

> Australian farmers face a wide range of risks, but they are particularly exposed to variability in climate and commodity prices.
>
> Hughes et al., 2019[9]

Figure 2.1 shows broadacre farm profits relative to drought since the late 1980s, highlighting that even in times of extreme drought (2018-19) well-prepared farmers can be faced with favourable prices and have the ability to turn a profit.

The variability in drought and farm performance has significant implications for drought resilience RDE&A which were raised in the focus groups. Firstly demand for drought resilience will vary over time depending on the frequency and severity of drought. Similarly demand within specific locations, industries or groups will also vary given some will be more prepared than others. This creates challenges in supplying timely RDE&A given R&D can have significant lead times and extension is effective when aligned to users current needs. On top of this drought is not the only risk and often linked to climate change. The net result is drought on its own is not enough to incentivise service provision enterprises across the RDE&A system to focus solely on drought resilience. It can also lead to stop-start programs of RDE&A.

FIGURE 2.1 ANNUAL AVERAGE BROADACRE FARM PROFIT RELATIVE TO RAINFALL AND COMMODITY PRICES (FARM TERMS OF TRADE) OVER TIME



Note: Farm business profit is calculated at market prices for all inputs and outputs, including unpaid family labour, as well as changes in the value of stocks (including inventory and livestock). Years classified as 'favourable prices' (100–65 percentile), 'neutral prices' (65–35 percentile) and 'unfavourable prices' (35–0 percentile) based on ABARES farmers terms-of-trade index. Rainfall is average for broadacre farms for the financial year.

SOURCE: HUGHES ET AL, 2019

[8] See: https://www.agriculture.gov.au/ag-farm-food/drought/drought-policy/national-drought-agreement#attachment-a-principles-for-reform

[9] Hughes, N., Galeano, D. and Hatfield-Dobbs, S. (2019), The Effects of Drought and Climate Variability on Australian Farms, ABARES Report, available: https://www.agriculture.gov.au/abares/publications/insights/effects-of-drought-and-climate-variability-on-Australian-farms Accessed 5 August 2020

The construct of resilience

In terms of human behaviour (although equally relevant in describing the behaviour of a system), the term resilience describes an ability to deal with or prepare for adversity. The concept is often overly simplified.

In most human-centric disciplines, resilience is framed as a dynamic process (the capacity to rebound). In the case of ecological disciplines, it is described as a trait or outcome (the state of being resilient despite and to deal with adversity).[10]

A third dimension, commonly overlooked, is the adversity itself, [11] in this case, drought. Adversity is critical and required context to build resilience. Without adversity, there is no reason to undertake the process of becoming resilient. Resilience is, therefore, a dynamic process that is undertaken in the context of adversity – drought is a common occurrence but is not a constant adversity.

Resilience is also a variable construct – that is, some people or systems may be more resilient than others, and that degree of resilience depends on many other variables within the broader environment. With respect to drought resilience RDE&A investment, this means that there are some communities and industries that may be more or less resilient than others.

Both the reality that drought is not a constant adversity and the variability of resilience across the population/systems may go some way to answering the question why preparing for drought is not at the foremost of people's minds.

Systemic resilience

The aim of this project to examine what drought resilience-related RDE&A exists and what drought resilience RDE&A is needed to help to adapt, reorganise or transform in the face of drought (as adversity) across multiple domains (economic, environmental and social).

The complexity of the agricultural production system and the rural innovation system (which are inter-related) create a need to consider drought resilience in terms of multiple systems (systemic resilience) or in terms of resilience thinking.

Walker and Salt (2006) consider the concept of "resilience thinking" and propose a framework for considering multiple systems as one system spanning many scales and linked across time and space. Walker and Salt describe their singular "system" as being comprised of many variables with each representing a dimension. For example, the drought resilience RDE&A system has, at a minimum, a relationship to the variables of drought, agriculture, and RDE&A. That is a three-dimensional system.[12]

[10] Ungar, M. (2018) Systemic resilience: principles and processes for a science of change in the contexts of adversity, ecology and society, 23(4)34. See: https://www.psychologytoday.com/sites/default/files/ungar-systemic_resilience-ecology_society_2018.pdf Accessed 5 August 2020

[11] This is an important dimension because by challenging the adversity itself, rather than accommodating it, may lead to actual transformation. See: http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0037-80542018000100002 Accessed 5 August 2020

[12] Walker, B and Salt, D. (2006) Resilience Thinking, Sustaining Ecosystems and People in a changing world, Island Press, Washington D.C., USA. Accessed 5 August 2020.

FIGURE 2.2 DROUGHT RESILIENCE RDE&A IS RELATED TO MULTIPLE-CONNECTED SYSTEMS

Note: This is purely illustrative and is not a comprehensive or an exhaustive list of systems related to drought resilience RDE&A.
SOURCE: ACIL ALLEN CONSULTING

An alternative approach, taken by Ungar (2018) is that instead of considering many systems as one, the relationships are best described as a "sequence of systemic interdependent interactions".[13]

Regardless of the terminology used, the construct of resilience, whether described in terms of a process or an outcome, is not easily achievable across multiple systems or multiple dimensions in either time or space.

In relation to drought resilience RDE&A, the ecosystem is very complex, and drought resilience RDE&A is just one very small part of the broader innovation system. It spans multiple and co-occurring systems: ecological, biophysical, climate, agricultural, E&A, economic, psychological, sociological, political, rural innovation and the broader R&D system to name a few. These systems are not aligned or incentivised to produce drought resilience RDE&A specifically.[14]

2.2 Research, Development, Extension and Adoption

In the context of Australian agriculture, we use the term RDE&A to define:

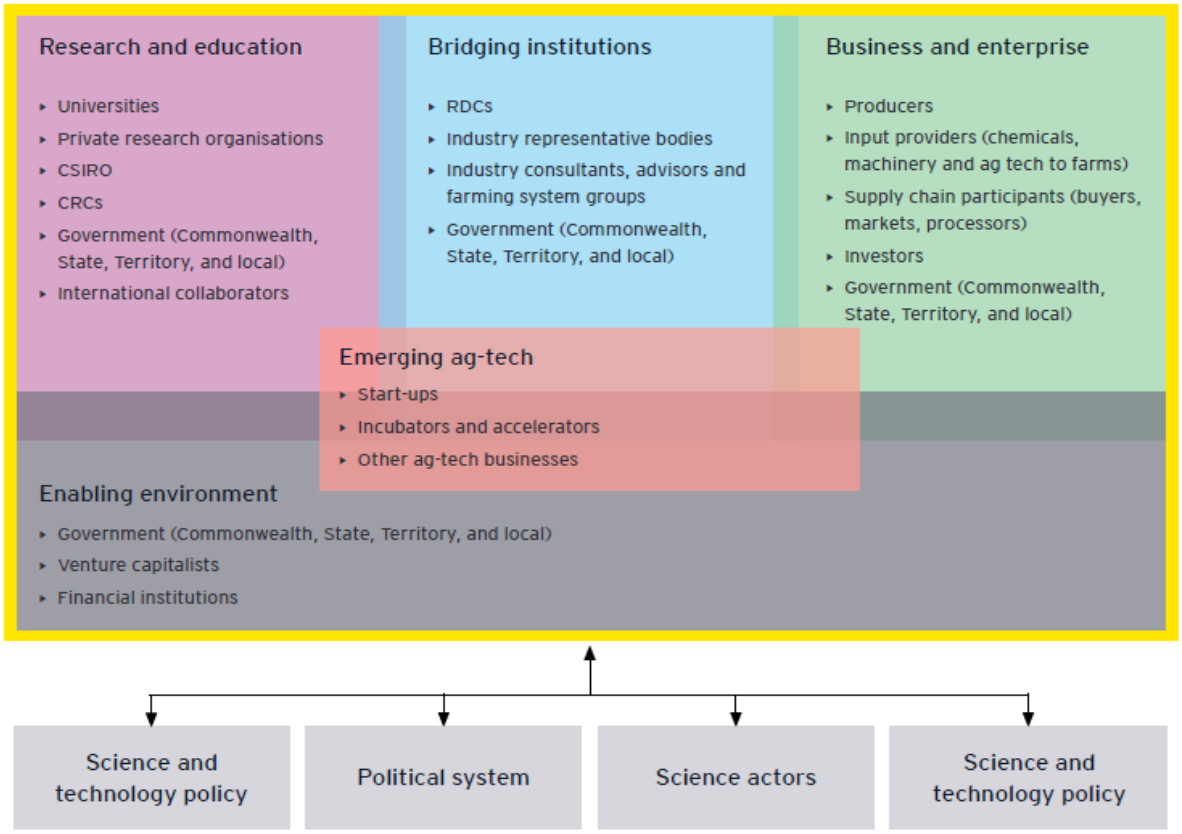
- a linear combination of the Frascati definition of R&D and technology transfer
- the rural innovation system.

[13] Ungar, M. (2018) Systemic resilience: principles and processes for a science of change in the contexts of adversity, ecology and society, 23(4)34. See: https://www.psychologytoday.com/sites/default/files/ungar-systemic_resilience-ecology_society_2018.pdf Accessed 5 August 2020.
[14] The majority of RDE&A identified in this report is indirect research that may go some way to developing drought resilience but is not designed with the aim to produce drought resilience.

For this stocktake, the latter definition is used. This allows the full potential of RDE&A to be considered rather than it be limited to technology transfer. At the same time, it recognises that the Fund will invest in a dynamic RDE&A system rather than in independent contributors.

The drought resilience RDE&A ecosystem is a composite of existing innovation systems. The agriculture innovation system is directly relevant and summarised in Figure 2.3.

FIGURE 2.3 THE AGRICULTURE INNOVATION LANDSCAPE



SOURCE: AGRICULTURAL INNOVATION – A NATIONAL APPROACH TO GROW AUSTRALIA'S FUTURE (EY, 2019)

The presence of multiple systems and independent actors working across them in various roles means the overall system is fragmented which reduces transparency. This is particularly the case when considering cross-cutting national priorities such as drought resilience. The coordination challenge associated with fragmentation and structural rigidity in the innovation system is well known and been subject to numerous reviews.[15]

The challenge is noted in the NDA, in which the parties have agreed to work collaboratively on drought preparedness RDE&A. It is important to note that governments and their stakeholders (including the independent RDCs who operate under government mandate) are constrained by their constitution/legal obligations to their levy payers.

[15] For example, see: https://www.aph.gov.au/DocumentStore.ashx?id=3fb371c8-17d8-4a9c-91f0-a6e1b28f59f1&subId=612462 and https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/agriculture-food/innovation/full-report-agricultural-innovation.PDF
and https://haveyoursay.awe.gov.au/modernising-rdc and https://www.pc.gov.au/inquiries/completed/rural-research/report and https://www.innovationaus.com/rural-innovation-is-a-hot-mess/ Accessed 5 August 2020

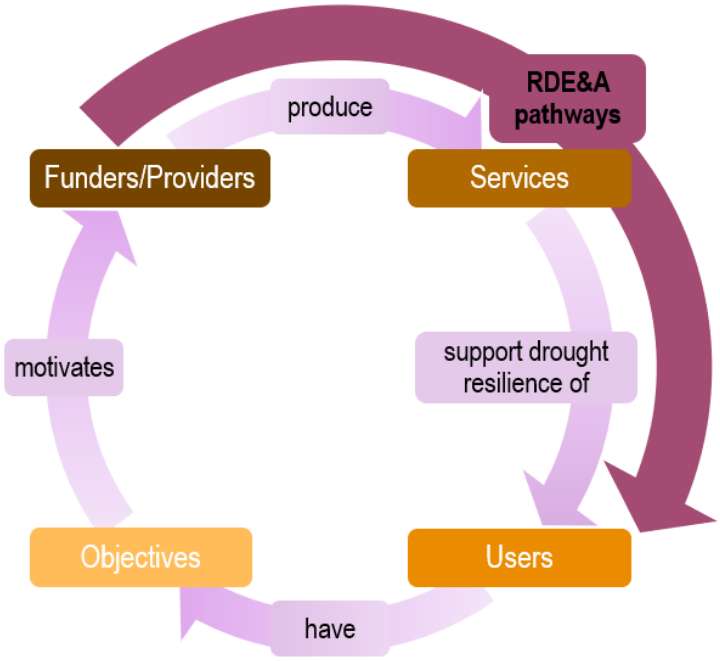
2.3 Improving drought resilience RDE&A - a process map

The process of improving drought resilience is presented as a circular flow and an adaptive process (see Figure 2.4) where providers invest in or undertake activities (of which RDE&A is one) to offer a suite of services (including the provision of knowledge) related to drought resilience for various users, which contribute to outcomes known to assist with drought resilience (if adopted) and ultimately helps to motivate provider activities.

Drought resilience RDE&A knowledge, as noted above, is an aspect of this process. The RDE&A value chain can be defined as a supporting process which is directed by funders and providers, improves services, and ultimately benefits users. It is a layered process where often multiple cooperating funders and providers offer various services along the value chain.

The overall drought resilience improvement process and supporting drought resilience RDE&A value chain is illustrated in Figure 2.4.

FIGURE 2.4 THE PROCESS FOR IMPROVING DROUGHT RESILIENCE AND THE ROLE OF RDE&A



SOURCE: ACIL ALLEN CONSULTING

Knowledge as a service supporting the realisation of outcomes

The findings of this stocktake (see Chapter 4) show that while there is a significant amount of drought resilience-related research published and underway, there is no clear widely agreed definition of drought resilience research or a readily accessible repository of knowledge for users. This is not surprising given the multiple systems that drought resilience RDE&A spans.[16]

[16] This point was noted in all focus groups.

In the focus groups conducted as part of this project, participants were able to identify how RDE&A generates knowledge and how it contributes to drought-related outcomes in specific areas, but not as a complete body of knowledge. The major reasons raised as to why there is not a complete body of knowledge readily accessible for adoption relate to:

- the diversity of users, by industry, location, business characteristics and drought risk limits the ability to fully codify a specific and relevant body of knowledge
- the degree to which users can access RDE&A due to (public and private) service availability and individual motivation/capability to do so
- the motivation and ability to realise expected outcomes in the short and longer term.

An alternative view is to present RDE&A knowledge as a portfolio of services that act as or contributes to one or more services which result in outcomes that can improve drought resilience.

This is consistent with the principles of resilience as a systematic and enduring process where users can draw on a pool of services to implement improvements that build drought resilience.

Looking at the span of RDE&A, there are four categories of RDE&A services identified in the stocktake that provide knowledge and support users to develop knowledge outcomes based on the stocktake data and focus groups:

- **Asset status and trend**
  Provides information on the environment at various scales and frequencies. These services are fundamental datasets to inform decision making. The services also extend to human, physical, financial and social capitals.
- **Forecasts and predictions**
  Provides information on the likelihood and severity of drought and other risks/events. They can be extended to include predictions or scenarios on the impact of drought and other risks on farming systems, businesses, industries and communities.
- **Technologies, practices and systems**
  Provides a combination of technologies, practices and systems to improve drought resilience. Predominantly focused at improving farming systems (including environmental management).
- **Advisory**
  A mixture of private and public organisations provide advice to farm businesses, industries and communities on drought resilience and other matters. Can be linked to an R&D or RDE&A program but also operate separately/independently.

There are four knowledge outcomes which can improve drought resilience based on the stocktake data and focus groups. These outcomes apply to all users and other forms of resilience:

- **Informed decisions** – combines the ability of users to access relevant information and have a suitable process to apply it to decision making.
- **Improved practices** – applying technologies and practices to improve existing systems or establish replacement systems (from farming systems to communities/industries).
- **Risk management includes:**
  - **Insurance** – use of specific and widely investigated financial risk management practices applied to businesses to secure insurance against drought.

    - **Diversification** – production across agro-ecological locations and generation of income from non-drought affected assets and enterprises.

— **Improved 5 capitals**[17] – farm businesses, communities and industries rely on five sources of capital: manufactured, financial, human, social and environmental. Each capital is dynamic in that its condition changes with use and as it is shocked (e.g. drought) or replenished (e.g. rain). Building sources of capital builds capacity and improves drought resilience.

These outcomes and services can and have been broken down/combined in many ways to meet the diverse needs of users.

The pool of existing drought resilience knowledge is distributed across a range of RDE&A providers and users. As a result there is a limited understanding of what the outcome pathways are, or the adoption level is, when drought resilience is considered holistically across the system or the value chain.

Each of these services would benefit from additional investment and development to address the specific needs and adoption barriers of user segments. In practice, this will be challenging due to the fragmented nature of the mature and sophisticated Australian RDE&A system. This has been present in the system for a considerable period and creates both demand and supply-side challenges (Box 2.1).

BOX 2.1 A GAP – THE ADOPTION OF R&D

Andrews (2012) notes that there are multiple impediments and a lack of incentives on the R&D supply side. These include:

— The culture and practice of research, i.e. the 'publish or perish' focus and the difficulty of creating relationships, power struggles and 'language'.

— The lack of opportunities (and incentives) to build capacity in extension and/or adoption.

— The boundaries of sectors and disciplines. This is particularly prevalent across the social and biophysical sciences.

On the demand side, there are also barriers. These include:

— Complexity of systems beyond the development of knowledge and information (specifically those related to behavioural change). These systems include the political, socio-economic, biophysical, pyscho-cultural systems as well as the knowledge infrastructures of both the R&D provider and the recipient.

— The nature of the knowledge and how that fits with the 'values' of those it intends to influence.

The timing of the knowledge and the context in which it is received.

SOURCE: ANDREWS, K., (2012) KNOWLEDGE FOR PURPOSE: MANAGING RESEARCH FOR UPTAKE—A GUIDE TO A KNOWLEDGE AND ADOPTION PROGRAM, DEPARTMENT OF SUSTAINABILITY, ENVIRONMENT, WATER, POPULATION AND COMMUNITIES, CANBERRA

[17] An understanding of how to improve your capital structures can lead to drought resilience. For example, knowledge of ways to diversify your capital sources or knowledge of how to build your social or environmental stocks will enable improvement.

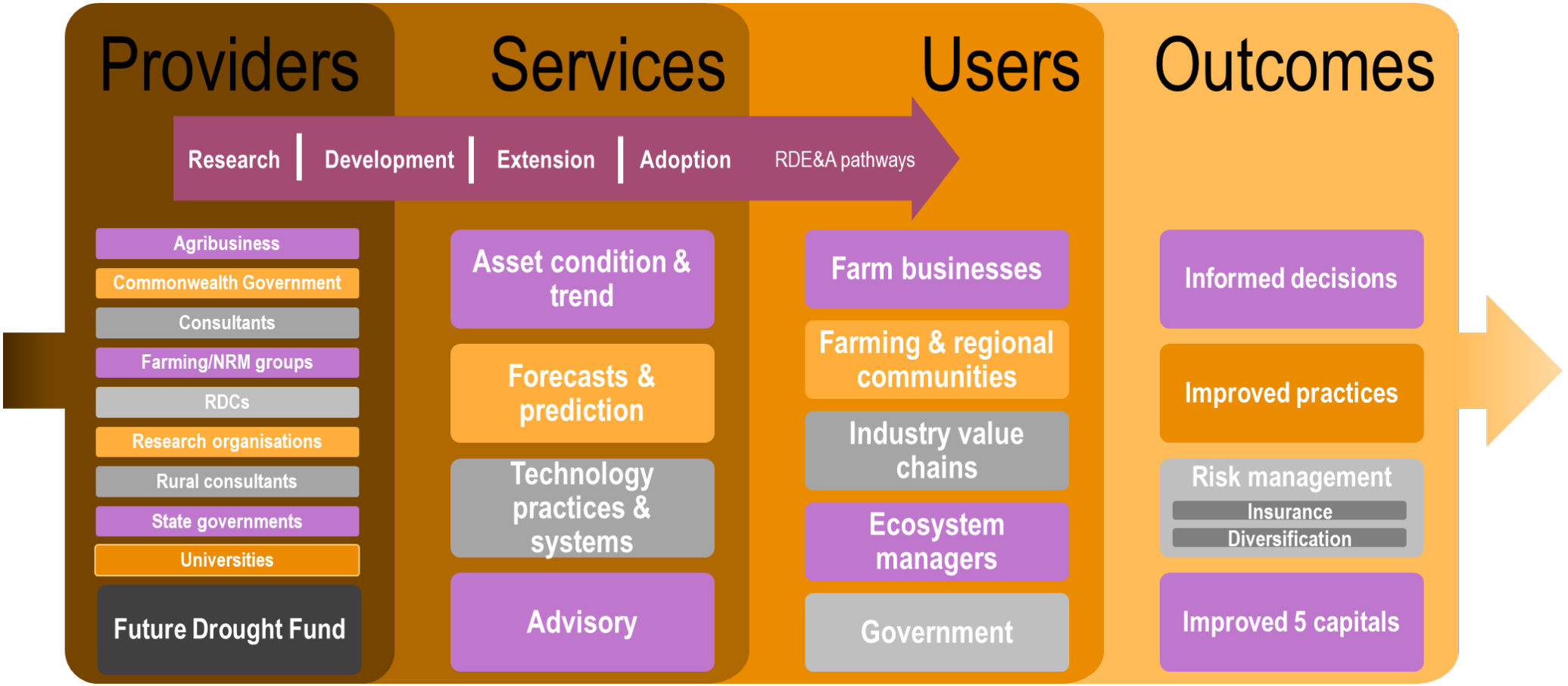
2.4 The drought resilience RDE&A ecosystem

The drought resilience RDE&A ecosystem refers to the entities who focus on the RDE&A aspect of the drought resilience process, their interactions, and their services (or activities). It is a dynamic combination of multiple and interconnected providers and multiple and interconnected services which are aimed at multiple and interconnected users to achieve direct or indirect outcomes. This system is linked to various RDE&A pathways that lead to various outcomes designed to improve the process of drought resilience.

A linear illustration[18] is presented in Figure 2.5, overleaf.

[18] In reality, this system is unlikely to be linear but has been presented as such for purposes of simplification.

FIGURE 2.5 DROUGHT RESILIENCE IMPROVEMENT ECOSYSTEM AND RDE&A PATHWAYS



SOURCE: ACIL ALLEN CONSULTING

2.5 Key findings

The Fund defines drought resilience as “the ability to adapt, reorganise or transform in response to changing temperatures and increasing variability and scarcity of rainfall, for improved economic, environmental and social wellbeing”.

Importantly drought resilience is the result of a systematic and enduring process that will include adaptive and transformational responses.

This process is dynamic and is composed of many interrelated systems which all influence drought resilience RDE&A. For simplicity and the purposes of this project and the stocktake, they are limited to:

- the agricultural innovation system (providers and funders of RDE&A)
- farms and associated communities/industry systems (users).

The process of improving drought resilience can be directly influenced through RDE&A pathways which provide knowledge as a service to deliver outcomes to users—noting that these provider systems do not operate solely as a linear transfer of technology model and use varying definitions when they do. This limits the degree to which knowledge and adoption can be defined.

Although some providers produce knowledge specifically related to drought resilience, the innovation system in Australia is driven by other priorities as well. That is drought is not the only risk faced by farms and farming communities and it is not a constant adversity). The innovation system is complex involving multiple providers offering a range of services to a range of users for multiple outcomes.

The Fund can influence the innovation system through clarifying drought resilience outcomes and how to achieve them through its investments.

At any point in time, users (different farms, communities and industries) have differing levels of drought resilience. Drought is also variable, so the degree to which an industry or a community are motivated to adopt drought resilience improvements varies. This creates challenges for:

- drought resilience RDE&A in terms of matching supply with demand
- this stocktake in its ability to precisely identify what specific knowledge creation/adoption should be prioritised going forward.

3 DROUGHT RESILIENCE RESEARCH DEVELOPMENT EXTENSION AND ADOPTION PATHWAYS

This chapter outlines how the ecosystem operates to create drought resilience RDE&A pathways based on a current RDE&A identified through a survey. It discusses the entities within the broader drought resilience ecosystem which provide drought resilience RDE&A activities. It also maps their relationships and structure of the pathways.

3.1 The RDE&A pathway

At the national level, there are two key funders of drought resilience RDE&A:

- Rural RDCs – structured by industry they independently invest industry levies and matching R&D funds to progress both industry and the national interest. They play a key bridging role and liaise with industry to target RDE&A.
- Australian Research Council (ARC) – national research funding body for universities in the national interest.

At the national and state-level, public organisations involved in drought resilience RDE&A include:

- State agencies – provide R&D and E&A to primary industries and the environment in various combinations as well as in-drought support, community services and (regional) development.
- Commonwealth Scientific and Industrial Research Organisation (CSIRO) – national science organisation focused on R&D and some extension.
- Bureau of Meteorology (BOM) – national weather service and weather and climate researcher.
- Universities – provide fundamental and applied R&D with limited extension.

In the private sector, numerous companies are providing RDE&A services such as:

- Weather and market service providers offering tailored services based on national, and their own, research.
- Financial advisory – a range of independent and institutional organisations providing advice/finance.
- Input advisory services – rural resellers who also offer advice to farming businesses.
- (Farm) consultants – providing technical and business advice to farm businesses.

There is also a mixture of not for profit and government organisations formed as:

- Farming groups – such as farming systems groups focused on a regional location, industry and special interest groups covering a range of different farming systems and special interests.

— Natural Resource Management (NRM) groups – there are 56 NRM regions across Australia operating as not for profit or under state legislation to develop and implement landscape plans collaboratively. There are also NRM groups operating and at a finer scale.

There are also local technology companies and international universities and technology companies in the system who work in partnership with one or more of the above.

3.2 Mapping the ecosystem

ACIL Allen has characterised the academic literature to describe knowledge that has been produced and undertaken for agriculture and developed a database of current drought resilience RDE&A activity. The database is based upon a representative sample (n=17) of Australian providers' RDE&A programs.

This approach was taken because while many providers have drought (resilience) as a priority, capturing data on actual work underway is a better representation of where RDE&A is currently focused. The database provides evidence on the structure of the ecosystem, the entities within, and their relationships. It provides a snapshot of the major providers, activities and their linkages. The database has been gathered from providers responsible for investment and/or conducting research directed at a national level, more often than not funding R&D activity.

There is a high degree of co-investment and delivery in Australia's innovation system. The sampling approach was to target organisations who play a key role in co-investment and delivery related to drought resilience. Thirty organisations were targeted and 17 provided data within the timeframe of this stocktake. The stocktake identified over $1.5 billion in total program funding over a 3-5 year timeframe.[19] This is a high number given the rural RD&E system was estimated to have an annual of $3.3 billion in 2014-15.[20]

This database includes 832 RDE&A programs related to drought resilience involving 286 providers. The organisations where the data was drawn from are:

— AgriFutures Australia
— Agriculture Victoria (AgVic)
— Australian Plant Phenomics Facility (APPF)
— Australian Research Council (ARC)
— Bureau of Meteorology (BoM)
— Climate Research Strategy for Primary Industries (CRSPI)
— Cotton Research and Development Corporation (CRDC)
— CSIRO
— Dairy Australia (DA)
— Grains Research and Development Corporation (GRDC)
— Horticulture Innovation Australia (Hort Innovation)
— Meat and Livestock Australia (MLA)
— NSW Department of Primary Industries (NSW DPI)
— Primary Industries and Regions South Australia (PIRSA)

[19] The stocktake data received was not sufficient to estimate an annual investment total.
[20] Refer: https://www.agriculture.gov.au/abares/research-topics/productivity/related-research/rural-rde-investment#:~:text=A%20%243.3%20billion%20investment%20in%20innovation&text=Funding%20for%20rural%20R%26D%20increased,inputs%20and%20the%20processing%20sector.

- Queensland Department of Agriculture and Fisheries (QDAF)
- Queensland Department of Environment and Science (QDES)
- South Australian Research and Development Institute (SARDI)
- WA Department of Primary Industries and Regional Development (DPIRD)
- University of Southern Queensland (USQ)

The database collected information on the provider characteristics, the span (or focus) of the activities, and the influences on the programs (Figure 3.1).

The database has been analysed in terms of the fields of research, activity funding, focus on drought resilience, triple-bottom-line outcome, industry, geography, and provider. The database is a picture of current drought resilience RDE&A activity and is not a comprehensive stocktake of all activity.

FIGURE 3.1 DATABASE FRAMEWORK

SOURCE: ACIL ALLEN CONSULTING

3.3 The structure of the ecosystem

Drought resilience services and users in the RDE&A system

To understand where the priorities and the RDE&A linkage challenges lie, a typology of providers was used to rate each on the degree to which they prioritise services relative to each other using a two-point scale ('lower' priority and 'higher' priority) (Table 3.1). This rating was based on information from the database and from focus group discussions.

TABLE 3.1 DROUGHT RESILIENCE RDE&A PROVIDERS AND SERVICES

Provider type	Role	Asset condition and trend	Forecasts and predictions	Technology and practices	Advisory
Agribusiness	Provider	Lower	Lower	Higher	Higher
Commonwealth government	Provider/funder	Higher	Higher	Higher	Lower
Consultants	Provider	Lower	Lower	Higher	Higher

Provider type	Role	Asset condition and trend	Forecasts and predictions	Technology and practices	Advisory
Farming/NRM Groups	Provider	Lower	Lower	Higher	Higher
RDCs	Provider/funder	Lower	Lower	Higher	Higher
Research organisations	Provider	Higher	Higher	Higher	Higher
Rural consultants	Provider	Lower	Lower	Higher	Higher
State and territory governments	Provider/funder	Higher	Higher	Higher	Lower
Universities	Provider/funder	High	Higher	Higher	Lower

Note: This map represents the partnerships and entities in the stocktake database and does not capture all entities or relationships in the system.

SOURCE: ACIL ALLEN CONSULTING

The asset condition/trend and forecast/predictions services are a higher priority for Governments with research organisations and universities are extensively involved. This is consistent with the public good associated with providing information to farm businesses, communities, and industries. The other provider categories are users of these services of this knowledge helping end users use it to inform decisions.

All provider categories are involved in technology and practices R&D. Their involvement ranges from fundamental applied research to local adaption. This does not extend to advisory services. The emergence of private providers means the rationale for government extension services is not universal. A key priority for the Fund will be partnering with the full range of advisory service providers.

The focus groups noted that improving adoption of drought resilience RD&E is reliant on understanding the end users. There are several reasons why end users may not be interested in adopting drought resilience RD&E, as noted in the focus groups:

- Resilience is a relative construct for both regions, communities and individuals, because both ‘drought’ and ‘resilience’ have different meanings to different people. This may mean that some people do not believe they need to build resilience or adopt RD&E, or that they do not see their RD&E needs to be specific to drought.
- There are other issues that interact with concepts like drought on the farm enterprises in multiple ways such as a user’s financial position, their family or the broader community. Most RD&E is not integrated to consider multiple issues and may therefore be underutilised.
- The capability of end users is variable as is their capacity to change. Those with options and/or are at scale may have less of a need to build resilience or adopt RD&E.

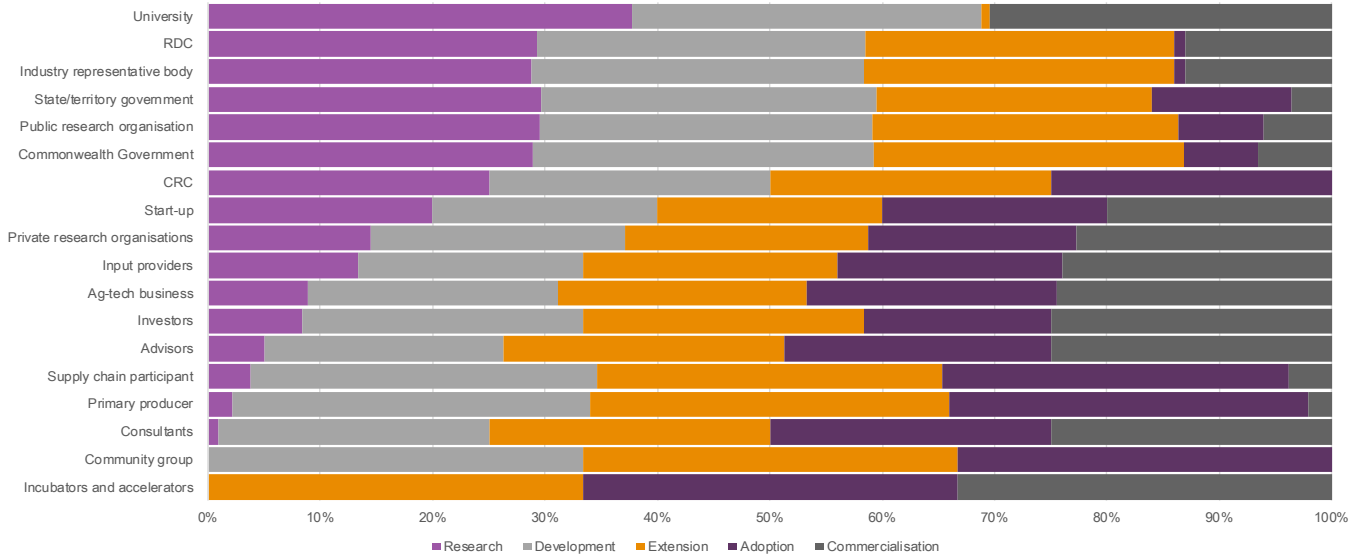
Bundling of asset condition/trend and forecasts/prediction services with technology/practices services is seen as integral. This was evidenced in the focus groups and is based on the assumption that an improved understanding of drought resilience risk will motivate adoption of suitable technologies and practices. There are challenges in identifying shared segmentations of user groups between providers to allow coordinated service delivery. There are also questions around the degree to which the advisory services can remove constraints to user adoption that extend beyond motivation and knowledge.

The database, complement these findings and also highlights that many providers focus on a broader area rather than drought resilience in its entirety even if it is a primary objective of the research. This is discussed further in the following sections.

Roles in the RDE&A value chain

Entities within the drought resilience ecosystem can, and do, perform multiple roles within the value chain. For instance, an RDC can be responsible for organising research and development in one area, while acting in the extension and adoption role in another. Given the highly heterogeneous nature of the drought resilience knowledge and RDE&A, some degree of overlap is expected—with entities taking adaptive roles to match complex conditions. Figure 3.2 shows the overlapping roles across RDE&A.

FIGURE 3.2 ROLES OF ENTITIES WITHIN THE DROUGHT RESILIENCE RDE&A VALUE CHAIN



Note: Role describes the incidence of entities within the database being described by a place on a point on the value chain. It does not describe the degree of effort to which each type of entity applies to each part of the value chain.

SOURCE: ACIL ALLEN CONSULTING

Primary and secondary focus on drought resilience

Each program has been rapidly assessed by its relative relatedness to drought resilience as either primary or secondary (Table 3.2). This is based on each provider's assessment of its programs and where data was not entered a subjective assessment was made based on the program details provided.[21] Approximately 17 per cent of funding identified relates to programs where drought resilience RDE&A is identified as the primary objective.

TABLE 3.2 PROGRAMS AND FUNDING BY DROUGHT RESILIENCE FOCUS

	Primary	Secondary
Programs (%)	9%	91%
Funding ($ million)	$251	$1,244
Funding (%)	17%	83%

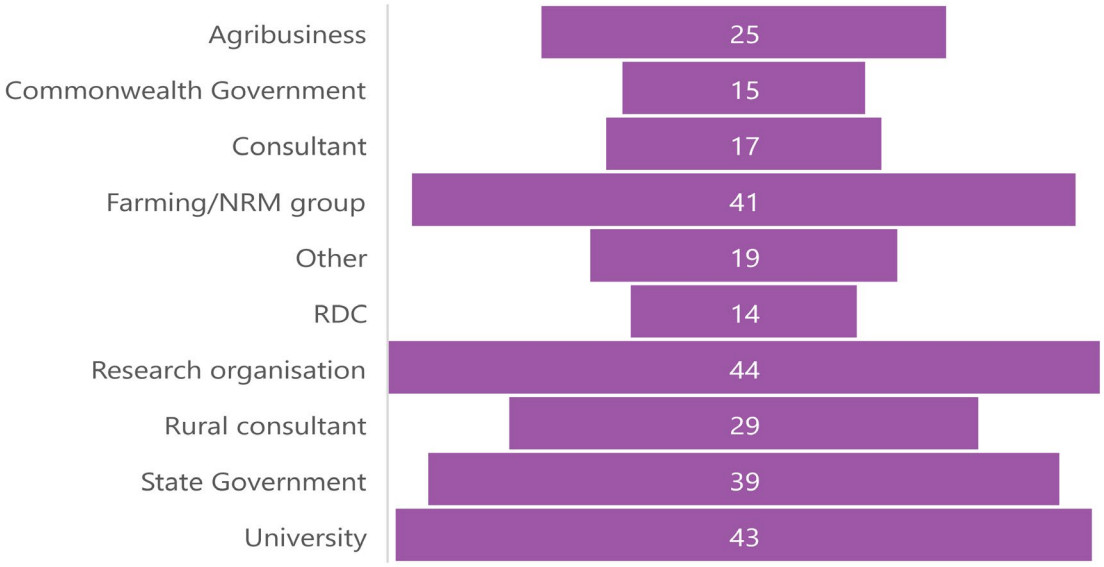
SOURCE: ACIL ALLEN CONSULTING

[21] The program description text was read, understood and assessed as to how it related to the Fund's definition of drought resilience. If it was not clear from the text, further research was conducted to see if any further information could assist with the assessment.

3.4 Provider profiles

The section below presents profiles on each of the major provider categories as identified through the data collection and stocktake. In total 286 providers were identified as being involved in current drought resilience RDE&A across 10 categories (Figure 3.3).

FIGURE 3.3 NUMBER OF DROUGHT RESILIENCE RDE&A ORGANISATIONS BY CATEGORY



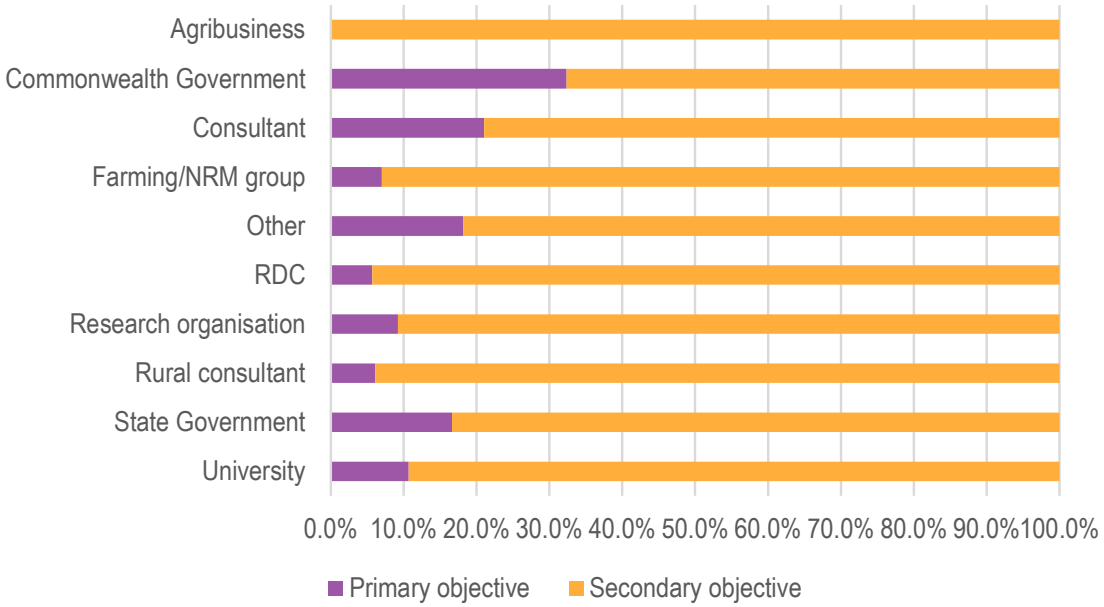
SOURCE: ACIL ALLEN CONSULTING

The results show that a wide range of providers are involved in drought resilience RDE&A that extends beyond public organisations. The large number of universities, private research organisations, specialist consultants and agribusiness companies highlight the breadth of capabilities utilised. There are also numerous farming groups, NRM groups and rural consultants[22] involved which bring further capabilities and local connections to rural businesses and communities.

As part of the stocktake the program activities were analysed to determine what proportion of providers in each category involved in a program where drought resilience is the primary, rather than the secondary, research objective (Figure 3.4).

[22] Rural consultants differ from specialist consultants in that they specialise in the rural sector and/or provide advisory services to farmers.

FIGURE 3.4 PROPORTION OF PROGRAMS WITH DROUGHT RESILIENCE RDE&A AS A PRIMARY AND SECONDARY OBJECTIVE BY PROVIDER CATEGORY



SOURCE: ACIL ALLEN CONSULTING

The most noticeable feature across all stakeholder categories is that drought resilience is predominantly addressed as a secondary objective. This highlights drought resilience RDE&A is integrated into addressing a broader set of outcomes than just drought resilience.

The results from the database show that the Commonwealth and State/Territory Governments play a critical role in RDE&A programs where drought resilience RDE&A is the primary objective. The Consultants and Other categories are higher than the State/Territory for the primary objective of drought resilience research. These organisations have specific capabilities needed for drought resilience RDE&A.

It is important to remember the database is relational and each program commonly involves two or more organisations contracting to align funds and capabilities against specific objectives. The objectives align with the strategies of each partner but it is often challenging to determine how this relates to a larger shared objective such as drought resilience. This issue was raised repeatedly in the focus groups – how to align individual activities in the presence of multiple strategies?

Research and Development Corporations (RDCs)

RDCs are unique to Australia. They invest industry levies and matching Commonwealth funds in RDE&A. While often referred to as a collective, each RDC has its own strategy. They are individually accountable to the industries they serve as well as the Commonwealth Government.

Enduring mechanisms to align RDC strategies include the Commonwealth's National Rural R&D Priorities, the inter-governmental Research and Innovation (R&I) Committee, which includes RDC representation, and the Council of Rural RDCs. In practice RDCs collaborate to co-invest with each other and others on specific policies, issues or where interests lie on a case by case basis. The RDCs are currently scoping a special purpose vehicle to create an enduring co-investment mechanism with climate change as the first priority under consideration.

For the purposes of the stocktake, data was provided by six RDCs[23] giving a representative sample of RDC investment in drought resilience RDE&A. These RDCs account for approximately two thirds of total RDC investment.

The stocktake identified 14 of the 15 RDCs[24] are currently investing in drought resilience RDE&A (Table 3.3) often in collaboration with each other.[25] The majority of their investments have economic objectives (97.4 per cent) while 18.9 per cent and 8.2 per cent focus on environmental and social objectives respectively. This is consistent with their strategies and remit to work closely with industries. The ephemeral nature of drought means demand for drought resilience RDE&A waxes and wanes compared to other more enduring priorities such as productivity.

TABLE 3.3 RESEARCH AND DEVELOPMENT CORPORATION PROFILE (% OF PROGRAMS WITH PRIMARY, SECONDARY, ECONOMIC, ENVIRONMENTAL OR SOCIAL OBJECTIVES)

Organisations	Primary	Secondary	Economic	Environmental	Social
14	5.7%	94.3%	97.4%	18.9%	8.2%

- Agrifutures Australia [a]
- Australian Eggs
- Australian Meat Processor Corporation
- Australian Pork
- Australian Wool Innovation
- Cotton Research and Development Corporation [a]
- Dairy Australia [a]
- Fisheries Research and Development Corporation
- Forest & Wood Products Australia
- Grains Research and Development Corporation [a]
- Hort Innovation [a]
- Meat and Livestock Australia [a]
- Sugar Research Australia
- Wine Australia

[a] Data provided directly to the stocktake

SOURCE: ACIL ALLEN CONSULTING

RDCs have the lowest proportion of programs where drought resilience is the primary objective (5.7 per cent). This highlights that RDCs integrate drought resilience with other objectives.

The focus groups noted that much, if not most, of the RDE&A conducted by RDCs and others is (perceived) to be incremental in nature. This reflects a number of influences on their strategies:

— mature farming systems are amenable to adaptive gains

— a steady flow of cumulative adaptive gains can provide transformational impacts

— stakeholders have a preference for adaptive gains and managing RDC investment portfolio risk.

The RDCs provide information on industry state/trend to varying degrees.

The key opportunity for the Fund's drought resilience RDE&A investment lies in harnessing the RDCs significant capabilities. This extends beyond leverage of financial resources to their knowledge of the industries they serve and the considerable capabilities they hold to search out suitable RDE&A programs.

[23] GRDC, MLA, Dairy Australia, CRDC, Hort Innovation and AgriFutures Australia.

[24] Although data was only provided by 5 RDCs – programs related to the other 9 RDCs were captured indirectly through the data provided by the 5 RDCs and other contributors to the stocktake.

[25] While the stocktake did not identify any current drought resilience RDE&A for LIVECORP the result does not indicate it is not a priority or an active areas for LIVECORP. LiveCorp, along with AMPC and MLA operate under the Red Meat Industry Strategic Plan which includes drought and climate change.

A gap identified through the focus groups is that there is no clear national picture of farming systems and the degree to which they may need to transform in response to drought, what RDE&A is in train and what is required to improve.

State and Territory Governments

In terms of drought resilience RDE&A the State and Territory Governments are critical to setting the policy/strategy agenda as well as being funders and providers of RDE&A.

The National Drought Agreement includes agreement to collaborate on drought resilience RDE&A. There are several national forums which the State, Territory, and Commonwealth, Governments are members relevant to drought resilience RDE&A such as Agriculture Ministers Forum (AGMIN), Agriculture Senior Officers Committee (AGSOC) and the Research and Innovation (R&I) Committee. The later oversees the National Primary Industry RD&E Framework that includes sectoral and cross sectoral RD&E strategies. There is a cross-sectoral RD&E climate change strategy under the framework and a Climate Research Strategy for Primary Industries (CRSPI) which the Commonwealth and RDCs and some research organisations are involved in. The focus group highlighted renewing or replacing these strategies provide an opportunity to improve the coordination and impact of RDE&A. There is not a single national RDE&A strategy for drought (resilience) to inform and coordinate collaboration.

The stocktake identified 39 State or Territory organisations currently involved in drought resilience RDE&A (Table 3.4). The range extends beyond primary industries and natural/ water resource departments reflecting the breadth of policies and services drought resilience covers.

TABLE 3.4 STATE AND TERRITORY GOVERNMENT PROFILE (% OF PROGRAMS WITH PRIMARY, SECONDARY, ECONOMIC, ENVIRONMENTAL OR SOCIAL OBJECTIVES)

Organisations	Primary	Secondary	Economic	Environmental	Social
39	16.6%	83.4%	97.2%	28.3%	20.0%

- Agriculture Victoria
- Arthur Rylah Institute for Environmental Research
- Department of Environment, Land, Water and Planning
- Department of Jobs, Precincts and Regions
- Energy Safe Victoria
- Environment Protection Authority Victoria
- Government of South Australia
- Hermitage Research Station
- NSW Department of Primary Industries
- NSW DPI Agriculture
- NSW DPI Biosecurity
- NSW DPI Fisheries
- NSW DPI Forestry
- NT Department of Primary Industries and Resources
- NT Government
- Office of the Director of Gas Safety Tasmania
- Primary Industries Research South Australia
- QLD Department of Natural Resources and Mines
- Queensland Department of Agriculture and Fisheries
- Queensland Department of Environment and Science
- Queensland Department of Science, Information Technology and Innovation
- Queensland Government
- SA Environment Protection Authority
- SA Office of the Technical Regulator
- Safe Work SA
- South Australia Department of Energy and Water
- South Australia Department of Planning, Transport and Infrastructure
- South Australian Research and Development Institute
- State water agencies
- Tasmania DPIPWE
- Tasmanian Climate Change Office
- Tasmanian Institute of Agriculture
- WA Department of Commerce-Energy Safety
- WA Department of Environment and Regulation
- WA Department of Fisheries
- WA Department of Primary Industries and Regional Development
- Western Australian Agriculture Authority
- Western Australian Government
- Work Safe Vic

Note: The organisations are listed based on a limited desktop analysis and data provided by stocktake contributors. The actual number of involved will be higher.

SOURCE: ACIL ALLEN CONSULTING

State and Territory Governments play a significant role in prioritising drought resilience RDE&A. This is reflected in 16.6 per cent of their programs having drought resilience as a primary objective. States and Territories have environmental and social objectives for 28.3 per cent and 20.0 per cent of programs respectively. These proportions are higher if farming systems RDE&A programs delivered in partnership with RDCs are not considered. None the less the majority of their programs have an economic objective (97.2 per cent).

The State and Territory Governments play an important role in extension. They all provide information portals related to drought, climate, industry conditions/trends as well as practices to varying degrees. Incentives to develop plans and undertake works to improve (drought) resilience are also provided by some States and Territories at various times. The States and Territories also employ Extension Officers and fund NRM/farming groups to varying degrees.

They are also leading a range of town, regional/local government and industry planning and development programs related to drought, climate change and natural disasters (such as bushfires and floods). Planning and development programs were not included in the stocktake.

Commonwealth Government

In terms of drought resilience Commonwealth funds and provides RDE&A as well as being involved in leading policy through the National Drought Agreement (discussed above in State and Territory Governments section).

In terms of drought resilience RDE&A the stocktake identified 15 Commonwealth organisations (Table 3.5). This category has the highest proportion of programs with drought resilience as primary objective (32.4 per cent) and mainly with an economic objective (94.1 per cent). The proportion of programs with environmental objectives (79.4 per cent) is the highest relative to the other provider categories. Social objectives (35.5 per cent) are the second highest relative to the other provider categories. The profile represents the important role the Commonwealth plays in setting the drought resilience RDE&A agenda.

ABARES and the Bureau of Meteorology are important drought resilience information service providers relevant to farm businesses, industries, and communities as well other government users.

These results also highlight the importance of departments outside primary industries and natural resources to fund and create the linkages across all aspects of drought resilience RDE&A.

TABLE 3.5 COMMONWEALTH GOVERNMENT PROFILE (% OF PROGRAMS WITH PRIMARY, SECONDARY, ECONOMIC, ENVIRONMENTAL OR SOCIAL OBJECTIVES)

Organisations	Primary	Secondary	Economic	Environmental	Social
15	32.4%	67.6%	94.1%	79.4%	35.3%

- ABARES [a]
- Australian Centre for International Agricultural Research
- Australian Research Council [a]
- Bureau of Meteorology [a]
- Clean Energy Finance Corporation
- Commonwealth Department of Infrastructure
- Commonwealth Environmental Water Office
- Commonwealth Government (unspecified)[b]
- Department of Agriculture, Water & the Environment
- Department of Home Affairs
- Department of Industry and Science
- Murray-Darling Basin Authority
- National Water Grid Authority
- Natural Environment Research Council
- Office of Science

[a] Profiled by desktop review and data contributions to the stocktake

[b] The Commonwealth Government was identified as a partner in a program but the specific Department for some contributions to the stocktake.

Note: The organisations are listed based on a limited desktop analysis and data provided by stocktake contributors. The actual number of involved will be higher.

SOURCE: ACIL ALLEN CONSULTING

Universities

Universities are integral to the rural innovation system as both a funder and a provider of RDE&A.

The stocktake identified 44 universities that are currently involved in drought resilience RDE&A (Table 3.6). Universities are 15 per cent of all providers identified. This includes 39 Australian universities and 5 international universities.

Like the Commonwealth and State/Territory provider categories their focus and capability extends beyond agriculture and drought resilience. Only 10.7 per cent of the programs universities are involved in have drought resilience as a primary objective. The majority of programs Universities are involved in have an economic objective (95.0 per cent) while 26.0 per cent have an environmental objective. Universities have the lowest proportion of programs with social objectives (5.7 per cent).

The profile represents a number of influences which were raised and discussed during the focus groups. First universities are a key source of research that is then developed into technologies, practices and systems. This is important and accounts for a large proportion of the programs identified by the stocktake and many are (co)funded with RDCs and others.

TABLE 3.6 UNIVERSITY CORPORATION PROFILE (% OF PROGRAMS WITH PRIMARY, SECONDARY, ECONOMIC, ENVIRONMENTAL OR SOCIAL OBJECTIVES)

Organisations	Primary	Secondary	Economic	Environmental	Social
44	10.7%	89.3%	95.0%	26.0%	5.7%

- Australia National University
- Australian Catholic University
- Australian National University
- Central Queensland University
- Charles Darwin University
- Charles Sturt University
- Curtin University
- Deakin University
- Edith Cowan University
- Federation University of Australia
- Flinders University
- Griffith University
- James Cook University
- La Trobe University
- Lanzhou University
- Macquarie University
- Monash University
- Murdoch University
- Queensland University of Technology
- RMIT
- Southern Cross University
- Swinburne University
- Universität Ulm
- University of Adelaide
- University of Agriculture, Faisalabad
- University of California, Davis
- University of Canberra
- University of Edinburgh
- University of Melbourne
- University of Minnesota
- University of New England
- University of New South Wales
- University of Newcastle
- University of Queensland
- University of South Australia
- University of Southern Queensland **a**
- University of Sunshine Coast
- University of Sydney
- University of Tasmania
- University of Technology Sydney
- University of Western Australia
- University of Western Sydney
- University of Wollongong
- Victoria University

Note: The organisations are listed as provided by stocktake contributors. The actual number of universities involved will be higher.

SOURCE: ACIL ALLEN CONSULTING

A second issue is the degree to which universities are involved in and capable of driving adoption? Where there are clear pathways (e.g. commercialisation of varieties) then it is well established as to how the universities partner with other research providers. Although this is subject to competitive pressures. The universities' role in extension is less clear. An individual university does not necessarily have a platform to engage directly with regionally based businesses and communities.

Research organisations

The stocktake identified 44 research organisations (Table 3.7). Research organisations that have been identified in the survey have strong focus on economic objectives (97.1 per cent). Drought resilience as the primary objective was only a small proportion of programs (9.2 per cent).

TABLE 3.7 RESEARCH ORGANISATIONS PROFILE (% OF PROGRAMS WITH PRIMARY, SECONDARY, ECONOMIC, ENVIRONMENTAL OR SOCIAL OBJECTIVES)

Organisations	Primary	Secondary	Economic	Environmental	Social
44	9.2%	90.8%	97.1%	28.9%	7.5%

- ADI Systems Asia Pacific
- Agronomy Solutions Pty Ltd
- AgVivo pty Ltd
- Animal Genetics and Breeding Unit
- Antarctic Climate Ecosystems CRC
- Aus Export Grains Innovation Centre
- Australian Centre for Plant Functional Genomics
- Australian Plant Phenomics Facility **a**
- Australian Wine Research Institute
- B+LNZ Genetics Limited
- Barenberg Group
- Barton Vale Technologies
- BASF AUSTRALIA LIMITED
- Bayer CropScience Pty Ltd
- Biomedia
- Cambridge Environmental Research Consultants
- CESAR Pty. Ltd
- Cooperative Research Centre for Polymers
- Cooperative Research Centre for Water Sensitive Cities
- Crown Analytical Services Pty Ltd
- CSIRO **a**
- Datagene
- Eurofins Agroscience Services
- Fight Food Waste CRC Program
- Industry Capability Network
- Intergrain
- International Centre for Agriculture Research in Dry Areas (ICARDA)
- International Crops Research Institute for the Semi-Arid Tropics
- Invetus Pty Ltd
- ISK Biosciences Oceania Pty Ltd
- Lifecycles
- Marcroft Grains Pathology Pty Ltd
- Micrometeorlogical Research and Educational Services (MR&ES)
- National Environmental Science Program's Earth Systems and Climate Change (ESCC) Hub
- National Eye Research Centre
- National Managing Variability Program of Agrifutures
- National Natural Science Foundation of China
- National Science Foundation
- NCCARF
- NDF Ag Design
- Peracto Pty Ltd
- Pork CRC
- Trialco Pty Ltd
- UK Research and Innovation

[a] Provided data to the stocktake

Note: The organisations are listed as provided by stocktake contributors. The actual number of departments involved will be higher. For example Soils CRC.

SOURCE: ACIL ALLEN CONSULTING

This the most diverse category in the stocktake. A major sub-category is Australian public research organisations and facilities. The focus varies considerably from national institutions (e.g. CSIRO) to individual research facilities (e.g. Australian Plant Phenomics Facility) to industry wide organisations (e.g. Australian Wine Research Institute) as well as a number of Cooperative Research Centres. Private research organisations relate to multinationals (e.g. Bayer) and Australian applied research organisations (e.g. Trialco). Overseas organisations include foundations (e.g. Natural Science Foundation of China) and research facilities (e.g. International Centre for Agriculture Research in Dry Areas).

The diversity of research organisations identified in the database illustrates the sophistication. This indicates the innovation system is utilising a range of capabilities and partnerships across Australia and overseas. This clearly extends beyond the domain of public research capability alone.

The opportunity for the Fund is to harness these capabilities. The challenge is determining what mechanism the Fund can use to do so, given these capabilities are driven by other strategies and not always with a focus on (Australian) public good drought resilience outcomes.

Consultants

The stocktake identified 17 consultants involved in drought resilience RDE&A (Table 3.8). These consultants are contracted by RDCs, government or research organisations to provide specialist skills. Most programs focus on economic objectives (94.1 per cent) as is the case with all provider categories. Drought resilience is the primary objective for 21.1 per cent of the programs they work on. 26.3 per cent of programs have a social objective. This is relatively high compared to other provider categories, reflecting their specialist skills.

TABLE 3.8 CONSULTANT PROFILE (% OF PROGRAMS WITH PRIMARY, SECONDARY, ECONOMIC, ENVIRONMENTAL OR SOCIAL OBJECTIVES)

Organisations	Primary	Secondary	Economic	Environmental	Social
17	21.1%	78.9%	94.7%	10.5%	26.3%

- AgCommunicators Pty Ltd
- All Energy Pty Ltd
- Arinex
- Arq Group Enterprises Pty Ltd
- Conference Design Pty Ltd
- Corteva
- FPA Patent Attorneys Pty Ltd
- Gas Advisory Services Pty Ltd
- Lastek Pty Ltd
- Smart Business Hub Pty Ltd
- Sol Energy
- Private individuals (6)

Note: The organisations are listed as provided by stocktake contributors. The actual number of consultants involved will be higher.

SOURCE: ACIL ALLEN CONSULTING

Rural Consultants

A key finding of the stocktake is that extensive use is being made of rural consultants. The stocktake identified 29 rural consultants (Table 3.9). The distinguishing feature of this category is that they all have agribusiness clients who they provide advice to on a fee for service base. The list is not exhaustive and there are many other similar rural consultants across Australia.

These rural consultants are a key part of the RDE&A pathway, providing extension and access to programs through their own network of end users. This extends beyond just economic objectives. The stocktake found that 26.5 per cent and 16.3 per cent of the programs they are involved in relate to environmental and social objective, respectively.

Overall the rural consultants represent an important component of social capital in regional Australia. The opportunity for the Fund is to ensure they are engaged as part of its RDE&A program.

TABLE 3.9 RURAL CONSULTANT PROFILE

Organisations	Primary	Secondary	Economic	Environmental	Social
29	6.1%	93.9%	95.9%	26.5%	16.3%

- AgEcon
- AgPro Management
- Agrimix Pastures Pty Ltd
- AKC Consulting Pty Ltd
- Betzner Consulting Pty Ltd
- Bill Campbell Consulting Pty Ltd
- Bill Gordon Consulting Pty Ltd
- Crop Circle Consulting
- Crop Consultants Australia Incorporated
- CropTraits Pty Ltd
- Data Farmer
- Dung Beetle Solutions International
- Farmacist
- Farmanco Management Consultants Pty Ltd
- Field Systems Australia Pty Ltd
- FMC Australasia Pty Ltd
- FSA
- Goanna Ag
- Grasslanz Technology Limited
- Heuston Agronomy Services Pty Ltd
- Independent Consultants Australia Network
- Kalyx Australia Pty Ltd
- Living Farm Pty Ltd
- Planfarm Pty Ltd
- PulseAg Consulting
- Rural Consulting Group
- Rural Directions
- Sefton & Associates
- Private individual

Note: The organisations are listed as provided by stocktake contributors. The actual number of rural consultants involved will be higher.

SOURCE: ACIL ALLEN CONSULTING

Farming and NRM Groups

Farming and NRM groups are another important regionally based provider group. The stocktake identified 41 such groups (Table 3.10). This is a representative sample of these types of groups (there are over a thousand NRM and farming groups distributed around Australia).

TABLE 3.10 FARMING AND NRM GROUP PROFILE (% OF PROGRAMS WITH PRIMARY, SECONDARY, ECONOMIC, ENVIRONMENTAL OR SOCIAL OBJECTIVES)

Organisations	Primary	Secondary	Economic	Environmental	Social
41	7.0%	93.0%	95.0%	28.0%	15.0%

- Angus Society of Australia
- Aus Oilseed Federation
- Australian Brahman Breeders Assoc
- Australian Wagyu Association
- Birchip Cropping Group
- CarbonLink
- Central West Farming Systems
- CORRIGIN Farm Improvement Group
- DA Regional Teams
- Eyre Peninsula Agricultural Research Foundation
- Facey Group Inc.
- FarmLink Research Limited
- FLO Australia Pty Ltd t/a Kaiuroo
- Foundation for Arable Research (FAR)
- Gipps Dairy
- Herefords Australia Limited
- Invasive Animals Ltd
- Irrigated Cropping Council Inc
- Irrigation Research Extension Committee
- Landcare
- Local Land Services [a]
- Lower Eyre Agricultural Development Association
- Mackillop Farm Management Group
- Mallee Catchment Authority
- Mallee Sustainable Farming Inc
- Mingenew-Irwin Group Inc
- Murray Dairy
- Northern Grower Alliance Incorporated
- Pasture Trial Network
- Pulse Australia Limited
- Ravensthorpe Agricultural Initiative Network Inc
- RRDP Grant
- South Coast Natural Resource Management Inc.
- South East Premium Wheat Growers Association
- Southern Dirt
- Southern Farming Systems
- Soy Australia Ltd
- Stirlings to Coast Farmers
- The Liebe Group Incorporated
- Victorian No Till Farmers Association
- West Midlands Group

[a] Local Land Services are a NSW Government organisation and regional NRM group.
Note: The organisations are listed as provided by stocktake contributors. The actual number of groups involved will be higher.
SOURCE: ACIL ALLEN CONSULTING

There are a number of distinct sub-categories. Farm improvements groups (e.g. Mallee Sustainable Farming Inc) are based in specific locations. They focus on local RDE&A. Many have broadened to address wider local issues. There are also farming groups who focus on specific issues, commodities or species (e.g.Pasture Trial Network). NRM groups include the 56 Regional NRM organisations and various landcare, local and issues-based groups. Regional NRM organisations and some state government agencies develop regional NRM plans.

The farming and NRM groups vary considerably in form and capability as well. Overall there is a predominance of associations and many are highly reliant on securing grants to remain viable.

Their diversity, stakeholder base and reliance on external program funding drives their drought resilience RDE&A profile. Some have local endowments and levying capabilities. They collaborate and compete with rural consultants for program funding. Like the consultants, they are an important regional social capability.

Agribusiness providers

The agribusiness category includes organisations involved in the production and processing of agricultural goods. The stocktake identified 25 agribusiness organisations (Table 3.11).

They are the only provider category where none of the programs have drought as a primary objective. On the other hand, they have the second highest proportion of programs with an environmental objective (42.9 per cent). They also have the lowest proportion of programs with an economic or social objective (88.6 per cent and 5.7 per cent). Many are large organisations who have their own R&D as well as extension capabilities.

TABLE 3.11 AGRIBUSINESS PROVIDERS PROFILE (% OF PROGRAMS WITH PRIMARY, SECONDARY, ECONOMIC, ENVIRONMENTAL OR SOCIAL OBJECTIVES)

Organisations	Primary	Secondary	Economic	Environmental	Social
25	0.0%	100.0%	88.6%	42.9%	5.7%

- AMIA Accolade Wines
- ADAMA Australia
- AGRONOMO
- AQ ARQUA
- Cotton Seed Distributors
- DAVREN Global Pty Ltd
- de bruin Engineering
- Elders Rural Services Australia Ltd
- Hardwick Meatworks Pty Ltd
- Integrity Ag Services Pty Ltd
- JBS Australia
- Macquarie Infrastructure and Real Assets
- National Australia Bank
- NORCO
- Northern Co-Operative Meat Company
- Nufarm Limited
- Oakey Beef Exports Pty Ltd
- Organic Force
- Organic Nutrients Pty Ltd
- Peanut Company of Australia
- Pernod Ricard Winemakers: Treasury Wine Estates
- Retail Ready Operations Australia
- Teys Australia Pty Ltd
- Tolpuddle Vineyard
- Western Meat Packers Group

SOURCE: ACIL ALLEN CONSULTING

Other providers

The stocktake identified 19 additional providers which do not readily fit into the other provider categories.

TABLE 3.12 OTHER PROVIDERS PROFILE (% OF PROGRAMS WITH PRIMARY, SECONDARY, ECONOMIC, ENVIRONMENTAL OR SOCIAL OBJECTIVES)

Organisations	Primary	Secondary	Economic	Environmental	Social
19	18.2%	81.8%	100.0%	27.3%	36.4%

- Australian Meat Industry Association
- Appalachian Regional Commission
- Australian Alliance for Energy Productivity
- Australian Biogas Group
- AW Howard Memorial Trust
- Barossa Grape and Wine Association
- China Scholarship Council Office
- Council of Australasian Weed Societies
- D-Arm
- Fraunhofer Institute
- Gardiner Foundation
- GO Resources
- Indigenous Land Corporation
- NT Farmers Association.
- Plant Health Australia
- Quantum Power Ltd
- Sunraysia TAFE
- United Kingdom Met Office
- Wine Victoria

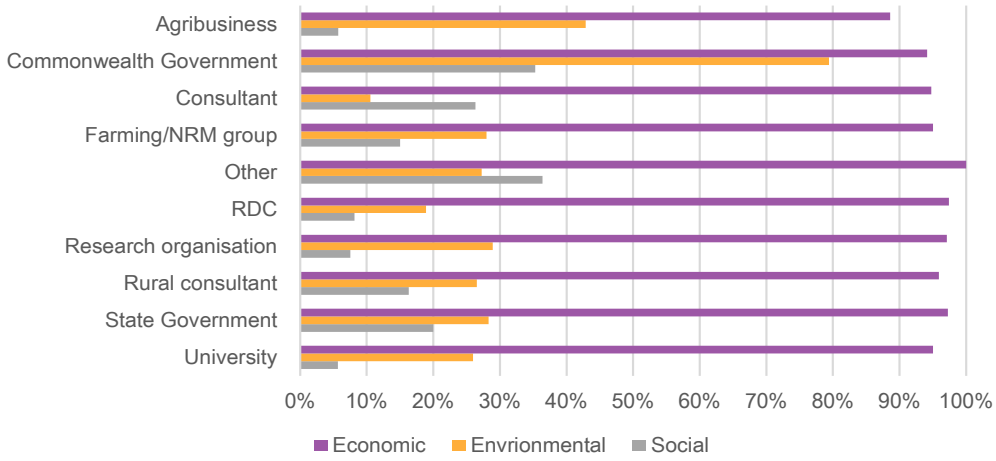
SOURCE: ACIL ALLEN CONSULTING

3.5 Implications

Drought resilience RDE&A is highly distributed. The stocktake identified 286 organisations that are undertaking drought resilience RDE&A. Their roles across the RDE&A pathways are not discrete and are often overlapping. Strategically, the drought resilience RDE&A ecosystem relies on various priorities, plans and committees established for indirectly related purposes. As a net result drought resilience is addressed as a secondary rather than primary objective of most providers and programs.

There is a strong focus on economic resilience in these programs across the stakeholder groups (Figure 3.5). This is consistent with a long and successful focus on developing farming systems technologies and practices which take economic and environmental considerations into account. This focus shapes the existing RDE&A pathways.

FIGURE 3.5 DROUGHT RESILIENCE FOCUS BY PROVIDER CATEGORY (PROPORTION OF PROGRAMS)



SOURCE: ACIL ALLEN CONSULTING

Large public R&D organisations collaborate with each other and private research organisations to develop knowledge, practices and technologies. These practices and technologies are commercialised and extended to end users through a large number and array of public organisations, associations and private organisations. Many are located in regional Australia and are highly reliant on RDE&A program funding to remain viable. There is pathway to provide environmental (and market) information alongside the economic technologies and practices to users.

The RDE&A pathway for environmental (drought) resilience, however, does have additional components. Environmental RDE&A pathways (e.g. natural resource (water) allocation) are highly related to the economic pathway. Water allocation is not within the scope of this stocktake. The other environmental pathway relates to (regional) NRM and RDE&A on environmental market (formation). Much of this focuses on participatory approaches and is presently dominated by climate change adaptation research.

The RDE&A pathway for social (drought) resilience is the least developed. In part this is due to the dominance of the farm focused economic-environmental (drought) resilience RDE&A pathway. The pathway is also very different. Social resilience RDE&A is less amenable to technology/practice solutions that can be readily extended, commercialised and adopted. Informing government and industry policy at various scales is an important part of building social resilience. Focus groups, which supported the stocktake, suggested that there is considerable variability in (social) resilience across and between various end users. As a result participatory approaches are important, as is integrating multiple risks/opportunities and economic-environmental resilience. The net result is while there is social resilience R&D capability there is no enduring social resilience R&D or Extension and Adoption pathway.

Establishment of the Future Drought Fund and its drought resilience RDE&A program is an important development. The program will provide focus and need to harness the considerable but highly distributed RDE&A pathways and providers' capability.

4 CURRENT DROUGHT RESILIENCE RESEARCH DEVELOPMENT EXTENSION AND ADOPTION ACTIVITIES

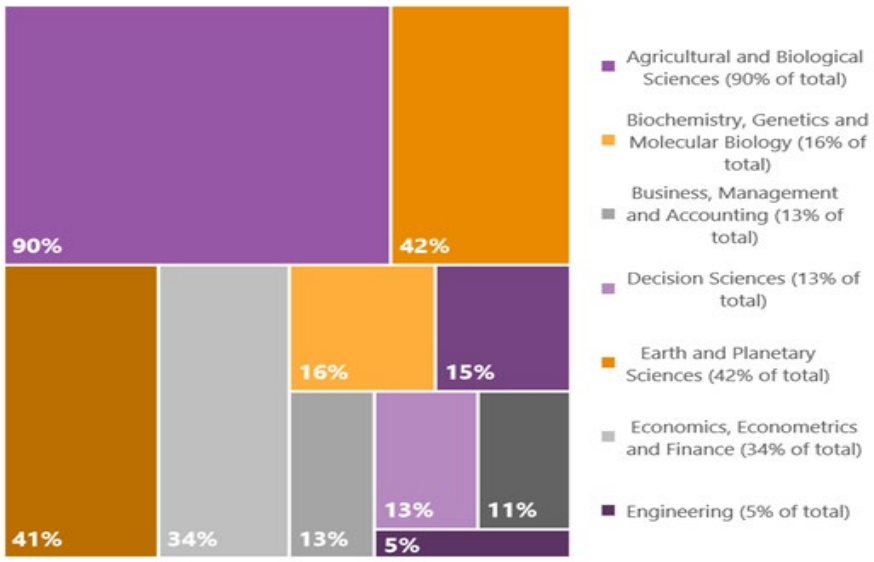
This chapter outlines the activities undertaken within the drought resilience ecosystem based on the database. It characterises the research fields where drought resilience knowledge is generated, the users targeted by activities, drought resilience services and the objectives of drought resilience activity.

4.1 Drought resilience RDE&A activity

Fields of RDE&A activity

Drought resilience RDE&A activity underway, as captured by the database, is overwhelmingly related to agricultural and biological sciences. Agricultural and biological sciences naturally support much drought-based research given the rainfall-dependence in agricultural and biological systems (Figure 4.1) and the agriculture-focus of many providers captured in the database. Significant portions of the drought resilience related RDE&A activity also combines expertise from earth and planetary sciences (for example planning or prediction tools), environmental sciences (for example water management or sustainable agriculture programs), and economics, econometrics and finance (for example farm planning).

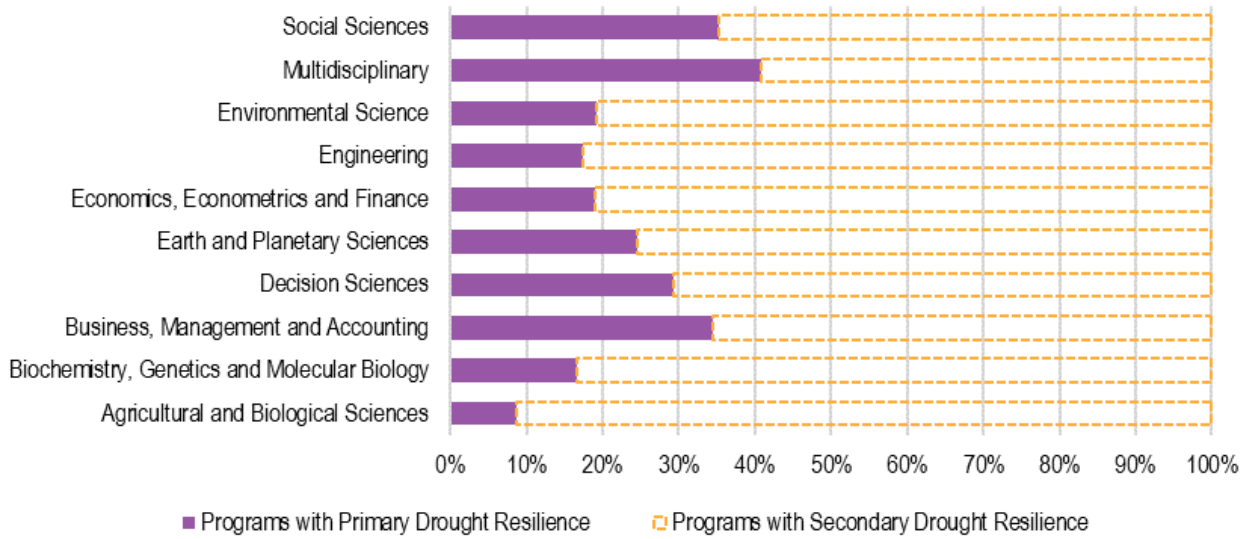
FIGURE 4.1 RESEARCH FIELD IN PRIMARY DROUGHT RESILIENCE RELATED ACTIVITY



SOURCE: ACIL ALLEN CONSULTING

The majority of the activities and programs captured have an agriculture focus, and drought resilience is a secondary feature. Of those programs for which drought resilience is a primary feature, a significantly higher proportion relate to multiple research fields and are more likely to incorporate elements of business, management and accounting, decisions sciences, earth and planetary science, environmental sciences and social sciences (Figure 4.2).

FIGURE 4.2 DROUGHT RESILIENCE RELATEDNESS BY RESEARCH FIELD



SOURCE: ACIL ALLEN CONSULTING

The database captures approximately $1.5 billion of funding within the RDE&A ecosystem. However, not all financing or activity has a primary drought resilience focus.

Drought is inseparable from rural (and urban) economies, communities and environments. Accordingly, many programs and research are intended to improve farm outcomes generally, which may improve outcomes during drought without having a specific drought focus.

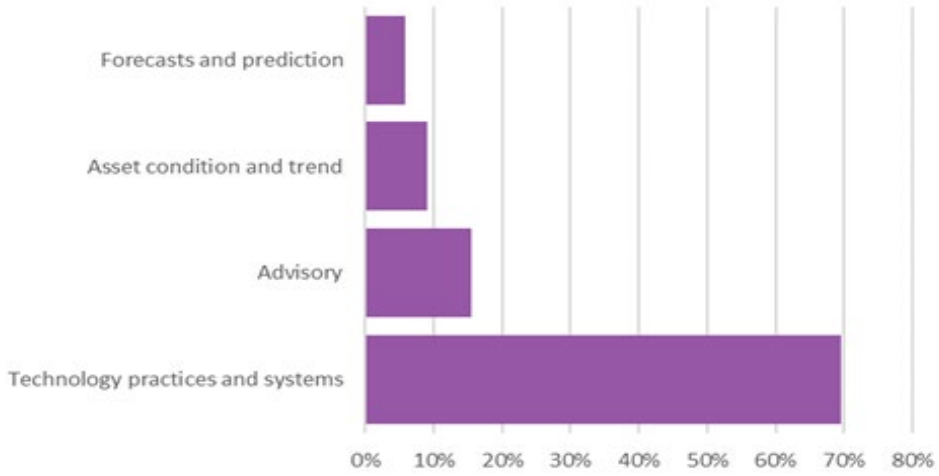
4.2 Drought resilience services

The activity captured in the database shows that the most common service area for drought resilience is in improvements in technology practices and systems. A typical program is the development of improved crop varieties or improvements in management practices using the latest science and knowledge. This service line accounts for approximately 70 per cent of all activities within the database, and 76 per cent of all funding (Figure 4.3).

The other services are:

- **advisory services**, which account for 16 per cent of activity and 25 per cent of funding. A typical program in this service is education and training for farmers or capacity building.
- **asset condition and trend**, which accounts for 10 per cent of the programs and 4 per cent of funding. A typical program in this service area is RDE&A on environmental and agrological function.
- **forecasts and prediction** (e.g. weather services), which accounts for 7 per cent of activities and 4 per cent of funding. A typical program in this service area is weather or climate information improvement or dissemination.

FIGURE 4.3 PROPORTION OF DROUGHT RESILIENCE ACTIVITIES BY SERVICE AREA



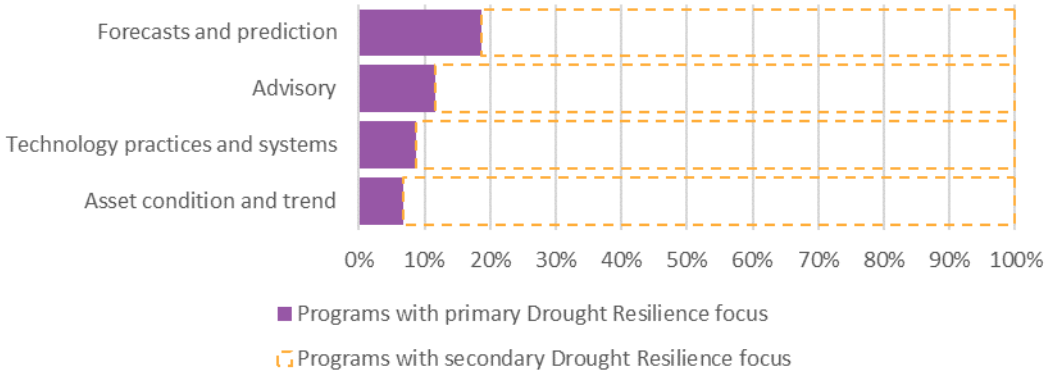
SOURCE: ACIL ALLEN CONSULTING

In contrast to absolute levels of activity, forecast and prediction services are more likely to be primarily focused on drought resilience than the other service areas. Activities which focus on improving forecasting and prediction are often focused on improving information on drought prediction, climate change, or at improving localised weather information.[26] Approximately 46 per cent of drought resilience-focused activities are forecasts and prediction.

Asset condition and trend services are the least likely to be primarily drought resilience focused. Only 7 per cent of activities are related principally to drought resilience, and they make up only 11 per cent of primarily drought resilience-related programs overall.

The technology practices and systems service area also has less than 10 per cent of programs with primary drought reliance focus. Technology practices and systems services is however a much broader are relative to other service areas and cover a wide range of issues, beyond drought resilience (Figure 4.4).

FIGURE 4.4 DROUGHT RESILIENCE FOCUS BY SERVICE AREA



SOURCE: ACIL ALLEN CONSULTING

[26] Forecast and prediction activities are not just weather related and can be applied to yield, volumes, demand or markets.

4.3 User focus

In line with the agricultural focus of much of the drought resilience activity, farm businesses are the main target user of drought resilience activities (approximately 92 per cent of activities, at 83 per cent of funding). The next largest user group is industry value chain participants, such as abattoirs, farm input vendors, and processors.

Communities and ecosystems make up only three and five per cent of activities respectively, an even lower proportion than the programs which target social and environmental outcomes — 11 per cent and 22 per cent respectively (Table 4.3). This may suggest that many of the environmental and social programs are focused on farm businesses and industry value chain participants (as there are proportionally less programs focused on communities and ecosystem managers that there are programs that are focused on social and environmental objectives). Examples of these types of programs may include efforts to improve soil and ecosystem quality on farms.

TABLE 4.1 USER GROUPS OF DROUGHT RESILIENCE ACTIVITIES

	All	Communities	Ecosystem managers	Farm businesses	Government	Industry value chain
Programs (#)	3	23	41	778	22	96
Programs (%)	<1%	3%	5%	93%	3%	12%
Funding ($M)	<$1	$40	$60	$1,464	$110	$64
Funding (%)	<1%	2%	4%	84%	6%	4%

SOURCE: ACIL ALLEN CONSULTING

Regional focus

Most activities are not regionally focused and could apply across Australia. Approximately 21 per cent of programs and 23 per cent of funding is regionally focused (Table 4.2). Regionally focused programs broadly fall into three categories:

— State-based activities, which are run but state governments and have a local focus.

— Industry based activities, such as programs focused on the sugar industry, which has a highly regional focus.

— Specific regional programs, which focus on users in particular areas (e.g. the Murray-Darling Basin).

TABLE 4.2 PROGRAMS BY REGIONAL FOCUS

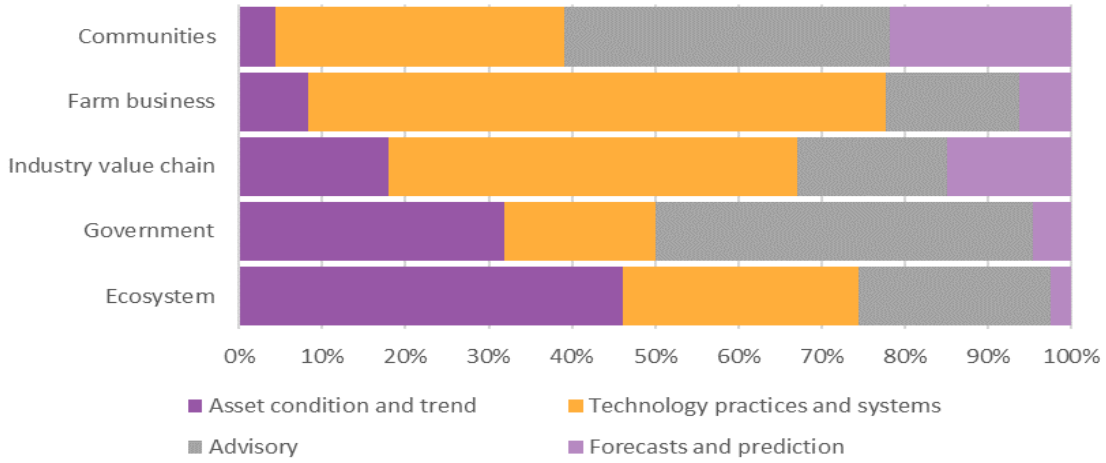
	Australia-wide	Regional focus
Programs	656	177
Programs, proportion of total (%)	79%	21%
Funding ($)	$1,147	$349
Funding, proportion of total (%)	77%	23%

SOURCE: ACIL ALLEN CONSULTING

Services by users

Service areas also vary by users. Technology practices and systems are the most common service provided to farm businesses and industry value chain participants. Services targeted at communities include programs with communities as a secondary user. They are often advisory — about improving aspects of a community (or farmer knowledge) — or about bringing together people together for a discussion through interaction. Programs which target ecosystems as end users typically have an additional user (such as government or farms), and often relate to ecosystem mapping, primary research, or conferences on ecosystem management (Figure 4.5).

FIGURE 4.5 SERVICES BY END USER



SOURCE: ACIL ALLEN CONSULTING

4.4 Objectives of drought resilience RDE&A activities

Triple-bottom line outcomes

Programs have been classified relative to their (social, economic and environmental) outcomes. Table 4.3 shows that the majority of research programs have an economic outcome. It is important to note here that many programs have more than one outcome, and the numbers in the table do not sum. Economic outcomes are synonymous with efficiency and productivity and relate to the overarching objectives of RDCs. Only 4 per cent of programs have a triple bottom line outcome (Table 4.4).

TABLE 4.3 PROGRAMS AND FUNDING BY OUTCOMES

	Economic	Environment	Social
Programs (#)	807	187	89
Programs (%)	97%	22%	11%
Funding ($M)	$1,480	$450	$90
Funding (%)	99%	30%	6%

SOURCE: ACIL ALLEN CONSULTING:

Most RDE&A activity captured in the database is focused predominantly on improving economic outcomes, especially within agriculture. Approximately 20 per cent of programs improve environmental and economic outcomes. Only 39 programs were identified, which provided social and environmental outcomes, these included the same programs which had triple bottom line outcomes as an objective (Table 4.4).

TABLE 4.4 PROGRAMS AND FUNDING BY CROSS-CUTTING OUTCOMES

	Environment and Economic and Social	Environment and Economic	Environment and Social	Economic and Social
Programs (#)	38	164	39	89
Programs (%)	5%	20%	5%	11%
Funding ($M)	$58	$437	$58	$90
Funding (%)	4%	29%	4%	6%

SOURCE: ACIL ALLEN CONSULTING:

Activity by drought resilience outcomes

Most activity is focused on improving practices — in most cases, improved practice is associated with technology practices and services (Table 4.5). Improved decision making is the second most common outcome, which makes up 13 per cent of activities and 11 per cent of funding. These programs are often tied with the forecasts and prediction, and the advisory service areas. Often, this involves improved modelling, weather services or educational programs. Only one program was found which has insurance as an explicit outcome (and none for diversification), however, these topics may be treated in programs which improve farm businesses in general. Risk management is described as a goal of a number of programs, though this is often in the context of managing risks of a single crop type or the farm business.

TABLE 4.5 ACTIVITY BY DROUGHT RESILIENCE OUTCOMES

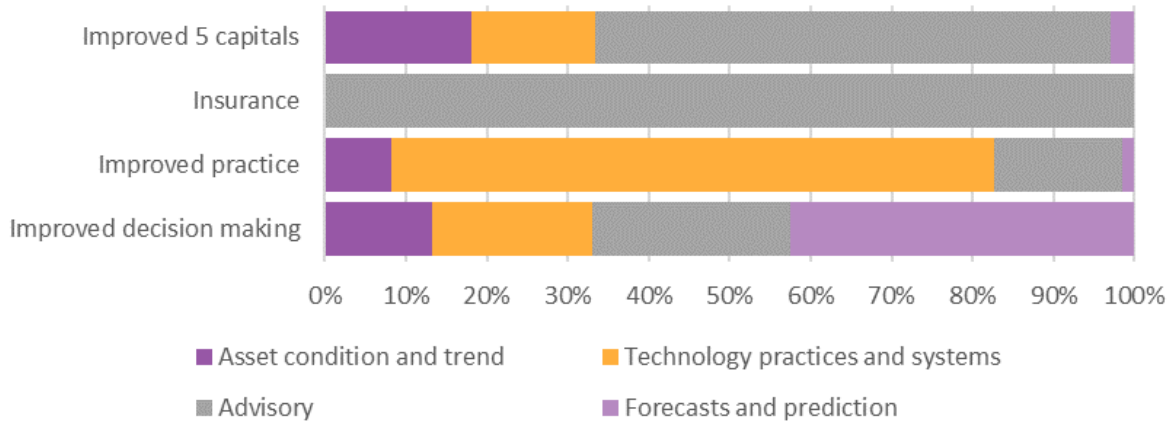
	Improved decision making	Improved practices and technologies	Insurance	Diversification	Improved 5 capitals
Programs (#)	106	752	1	0	33
Programs (%)	13%	90%	<1%	<1%	4%
Funding ($M)	$176	$1,366	$1	<$1	$31
Funding (%)	11%	92%	<1%	<1%	2%

SOURCE: ACIL ALLEN CONSULTING:

Services by drought resilience outcomes

Drought resilience outcomes are highly related to the knowledge services that drive them. Improvements to technologies practices and systems is the largest service in improving practices — most technology practices and systems services are intended to improve practice. In contrast, less forecasts and prediction services are intended to improve decision making (Figure 4.6).

FIGURE 4.6 SERVICES DIRECTED TO DROUGHT RESILIENCE OUTCOMES



Note: Insurance only has one program identified which may not be representative.
SOURCE: ACIL ALLEN CONSULTING

5 DROUGHT RESILIENCE RESEARCH DEVELOPMENT EXTENSION AND ADOPTION AND THE ACADEMIC SECTOR

This chapter uses evidence from published academic literature to examine the universities that produce drought resilience knowledge, their location (within Australia and internationally) and capabilities. The chapter also considers the networks of collaboration between the universities; and examines high-level trends in drought resilience research and development.

5.1 The academic sector as part of the broader ecosystem

There is significant drought resilience research and development capability in the academic sector in Australia and overseas. This includes and extends beyond the RDE&A from the rural innovation system identified by the stocktake and discussed in the previous chapters.

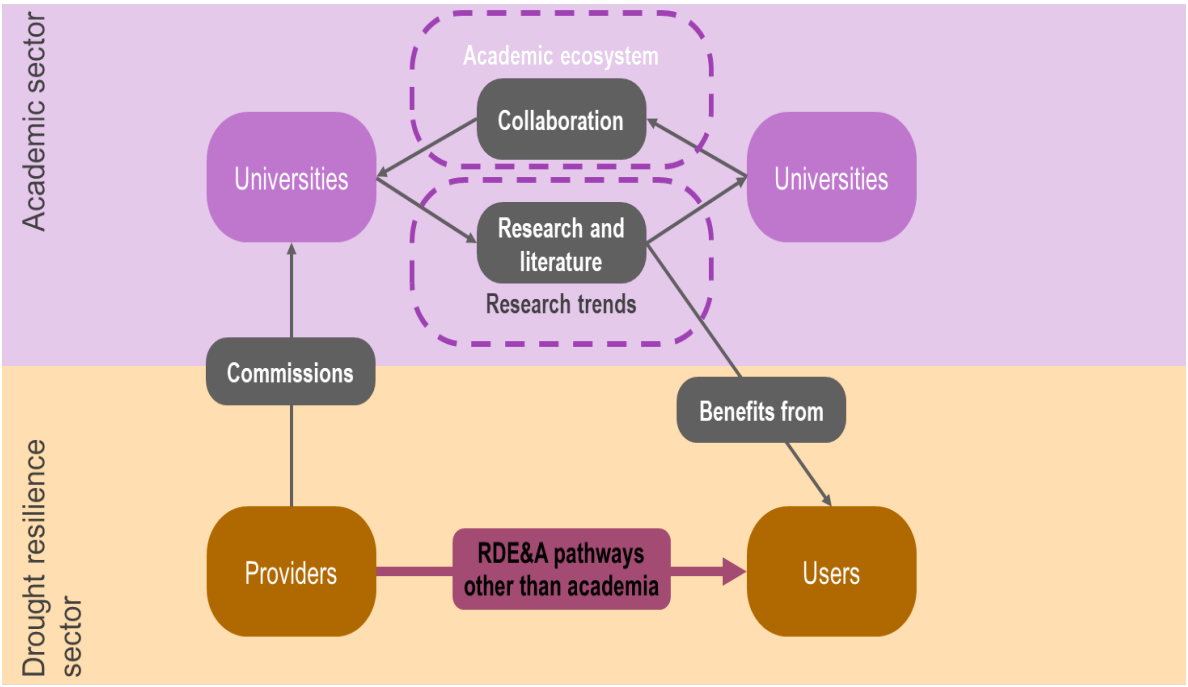
The academic sector is often the primary supplier of new drought resilience R&D,and is often where the research capabilities for the broader ecosystem sit.

In contrast to the rural innovation system, where much of the activity is driven by specific objectives or end user needs, the academic sector is mainly driven by its own goals and inhabits its own system. The academic sector, made up primarily of universities, predominantly interacts with itself:

- producing and consuming research, which is often published in academic journals
- collaborating within and across universities in producing new research.

The academic sector interacts with the broader drought resilience ecosystem through research commissioned by providers, and in the benefits that accrue to users (sometimes via E&A providers). This interaction is stylised in Figure 5.1.

FIGURE 5.1 THE ROLE OF THE ACADEMIC SECTOR IN DROUGHT RESILIENCE KNOWLEDGE



SOURCE: ACIL ALLEN CONSULTING

5.2 Academic research providers

The majority of research providers of drought resilience knowledge are academic institutions or government-based research organisations. Australian researchers produce a sizable portion of the global drought resilience research and are relatively well connected.

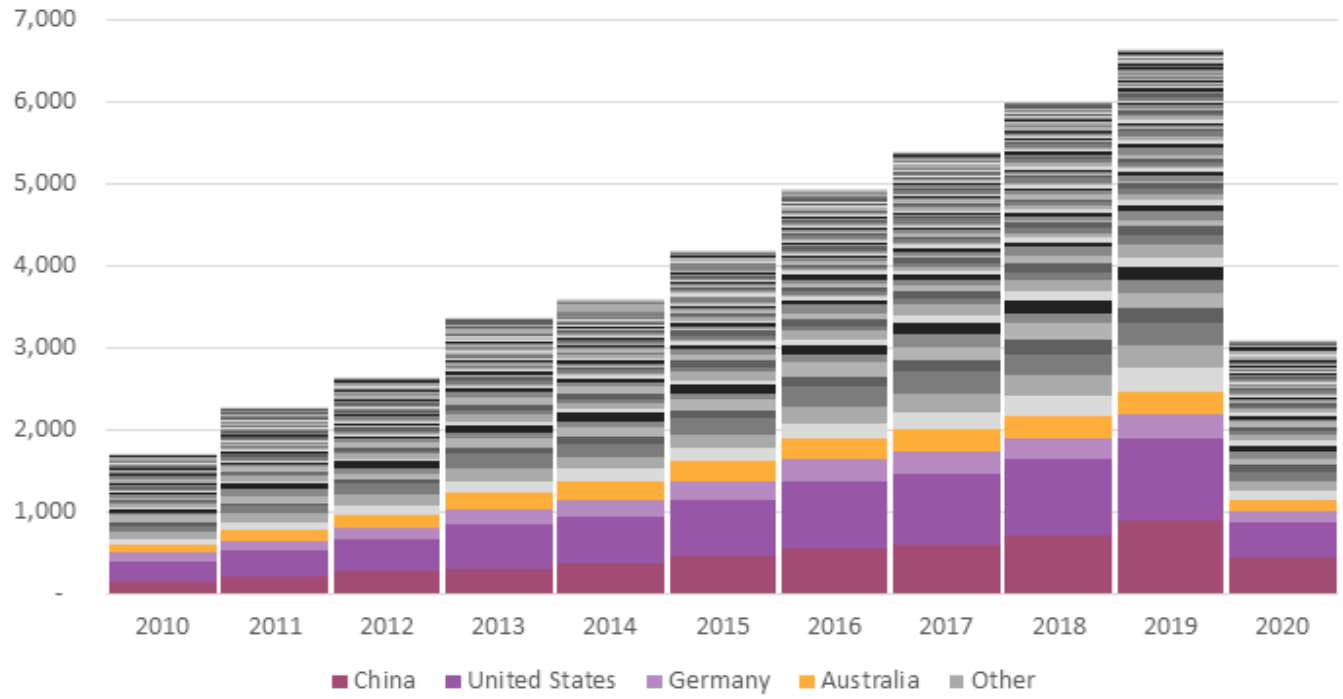
Countries producing drought resilience research

Globally, drought resilience research[27] accounts for about one-third of all drought-related research internationally (approximately 33,500 drought resilience documents have been published over the last century) and the number of documents produced has been increasing over time. There has been a substantial increase in the number of publications per year since 2008.

The USA dominates the international research system in the area producing 25 per cent of all research. Second is China with 15 per cent and then Australia at 8 per cent. Other countries that produce high volumes of research in drought resilience include Germany, India, United Kingdom, Spain, France, Italy and Canada. In total, drought resilience research comes from every continent and region, with approximately 160 countries publishing research in this space (Figure 5.2).

[27] Search term used was: Drought AND resilience OR preparedness OR adaptation.

FIGURE 5.2 DROUGHT RESILIENCE RESEARCH PUBLICATIONS BY COUNTRY OF ORIGIN



SOURCE: ACIL ALLEN CONSULTING

The largest single research funder of drought resilience research is National Natural Science Foundation of China which funds approximately 6 per cent of research. In comparison, the Australian Research Council funds approximately 1 per cent.

International research is dominated by agricultural and biological science research accounting for 64 per cent of all research documents identified. This is followed by 34 per cent in environmental science space, 26 per cent in biochemistry, genetics and molecular biology, 13 per cent in earth sciences and just 8 per cent categorised as social sciences research.

The major institutions with capability in the drought resilience space internationally are:

1. Chinese Academy of Sciences, China
2. Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia
3. United States Department of Agriculture (USDA), United States
4. French National Research Institute for Agriculture (INRA) [combined], France
5. Spanish National Research Council (CSIC), Spain
6. University of Chinese Academy of Sciences, China
7. National Centre for Scientific Research (CNRS), France
8. Ministry of Education China, China
9. Wageningen University and Research Centre, Netherlands
10. Chinese Academy of Agricultural Sciences, China
11. Northwest A&F University, China
12. University of Western Australia, Australia
13. University of Arizona, United States

14. University of Queensland, Australia
15. National Ocean and Atmospheric Administration, United States
16. Colorado State University, United States
17. Beijing Normal University, China
18. University of Florida, United States
19. University of California [system], United States
20. United States Geological Survey, United States

All these institutions have each produced more than 300 research documents related to drought resilience.

Australian research capability

Australia produced about 8 per cent of global drought resilience research documents identified. The Australian trends in terms of the subject area are similar to the international scene with agricultural and biological sciences accounting for 65 per cent of research, environmental science accounting for 34 per cent, 20 per cent in biochemistry, genetics and molecular biology, 12 per cent in earth sciences and just 8 per cent categorised as social sciences research.

Within Australia, the top ten funding sources[28] for 1,601 articles where the funding sources was noted are as follows:

- Australian Research Council (ARC) – 8.1 per cent
- National Science Foundation of China – 5.5 per cent
- Grains Research and Development Corporation (GRDC) – 4 per cent
- Commonwealth Scientific and Industrial Research Organisation (CSIRO) – 2.8 per cent
- Australian Centre for International Agricultural Research (ACIAR) – 1.7 per cent
- University of Western Australia – 1.0 per cent
- China Scholarship Council – 1.0 per cent
- European Commission – 0.9 per cent
- European Research Council – 0.9 per cent
- University of Queensland – 0.9 per cent

Based on the stocktake provider categories used in Chapter 3 the funding proportions are:

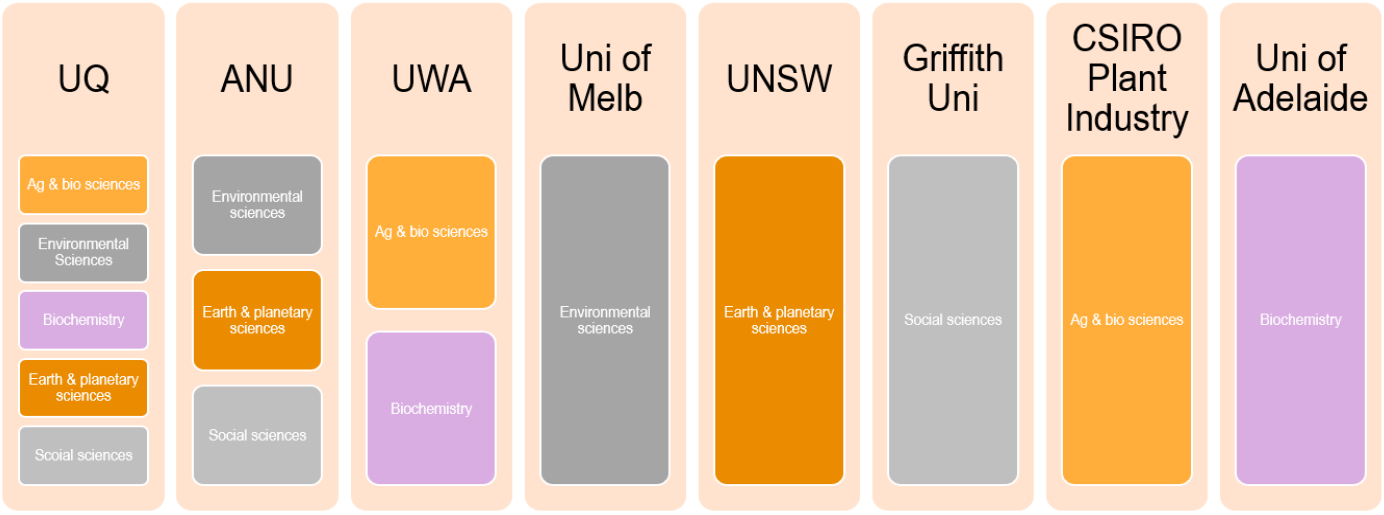
- Research organisations and universities (overseas) – 47.4 per cent
- Commonwealth Government (including ARC, CSIRO, ACIAR and NHMRC)- 25.2 per cent
- Universities (Australian) – 13.2 per cent
- Research and Development Corporations – 7.7 per cent
- State Government – 3.4 per cent
- Research organisations (Australian) – 3.1 per cent.

[28] Based on the search of Scopus abstracts up to 2019 for the key word drought, Australia, and (resilience or adaptation or preparedness)

It is significant that nearly 50 per cent of research in drought resilience is funded by overseas institutions. This compares to 3 per cent of overseas funding for all Australian university research (ABS, 2016). [29] A possible explanation for this is that drought resilience research is not prioritised by Australian funding providers, and researchers working in the drought resilience space are collaborating with international colleagues to secure funds.

Depending on the subject area, there are different institutions identified as having the capability in the drought resilience space (e.g. agricultural and biological sciences research is dominated by different players than the social sciences space). However, some institutions such as the University of Queensland, University of Western Australia, University of Melbourne, University of Adelaide have capabilities across several different subject areas (refer Figure 5.3).

FIGURE 5.3 MAJOR AUSTRALIAN UNIVERSITY DROUGHT RESILIENCE RESEARCH CAPABILITY BY SUBJECT AREA



SOURCE: SCOPUS

Research networks

Between research providers, a significant number of published articles involve researchers affiliated with more than one institution. Co-authorships indicates relationships between research providers. Research networks are highly dependent on the academic area, country of origin, focus of the research, and language. Agricultural and biological sciences has the largest body of research related to drought resilience (approximately 65 per cent of the articles analysed) and has the most well-defined research network (Figure 5.4). Australian institutions feature heavily and are linked to the USA in the Agricultural and Biological Sciences area.

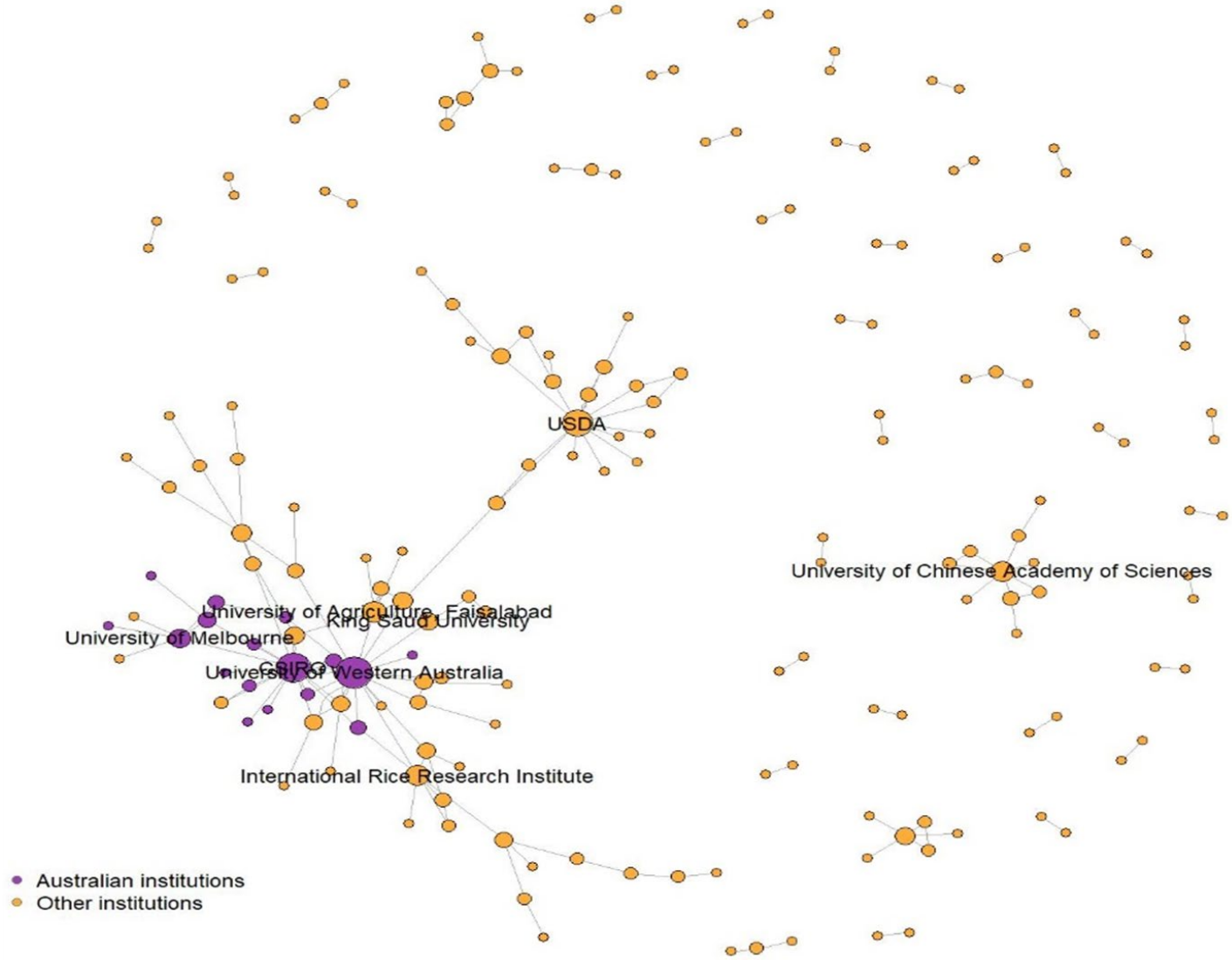
Chinese (centre-right) and US-based (centre) clusters of research providers are also evident. Smaller groupings include European-based providers (slightly above the Australian institutions), Asian-based providers (to the bottom right of Australian providers), and Middle East-based providers (to the upper right of the Australian providers). Smaller linkages (single or only a few identified links) connect many of the institutions shown.

[29] ABS, 2016, Research and Experimental Development, Higher Education Organisations, Australia, #8111. To provide further context, total higher education research funding in 2016 was in the order of $10.9 billion, an order of magnitude greater than all of the drought resilience research identified in the database.

Other subject areas have less well-connected relationships. Environmental sciences feature similar Australia, US and China-based networks but they are not well linked. Earth and planetary sciences feature a very well-connected core of institutions featuring many US, European and Australian institutions (especially meteorological, oceanographic, and geological institutions).

However, laboratory-based research such as medical sciences; and biochemistry, genetics and molecular sciences have more limited partnerships and networks. Other fields, such as chemical engineering, have too few drought resilience related research to map research networks.

FIGURE 5.4 AGRICULTURAL AND BIOLOGICAL SCIENCES RESEARCH PARTNERSHIPS



Note: This stylised network map represents the partnerships and affiliations as self-described in the published literature and does not display all entities or relationships in the system.

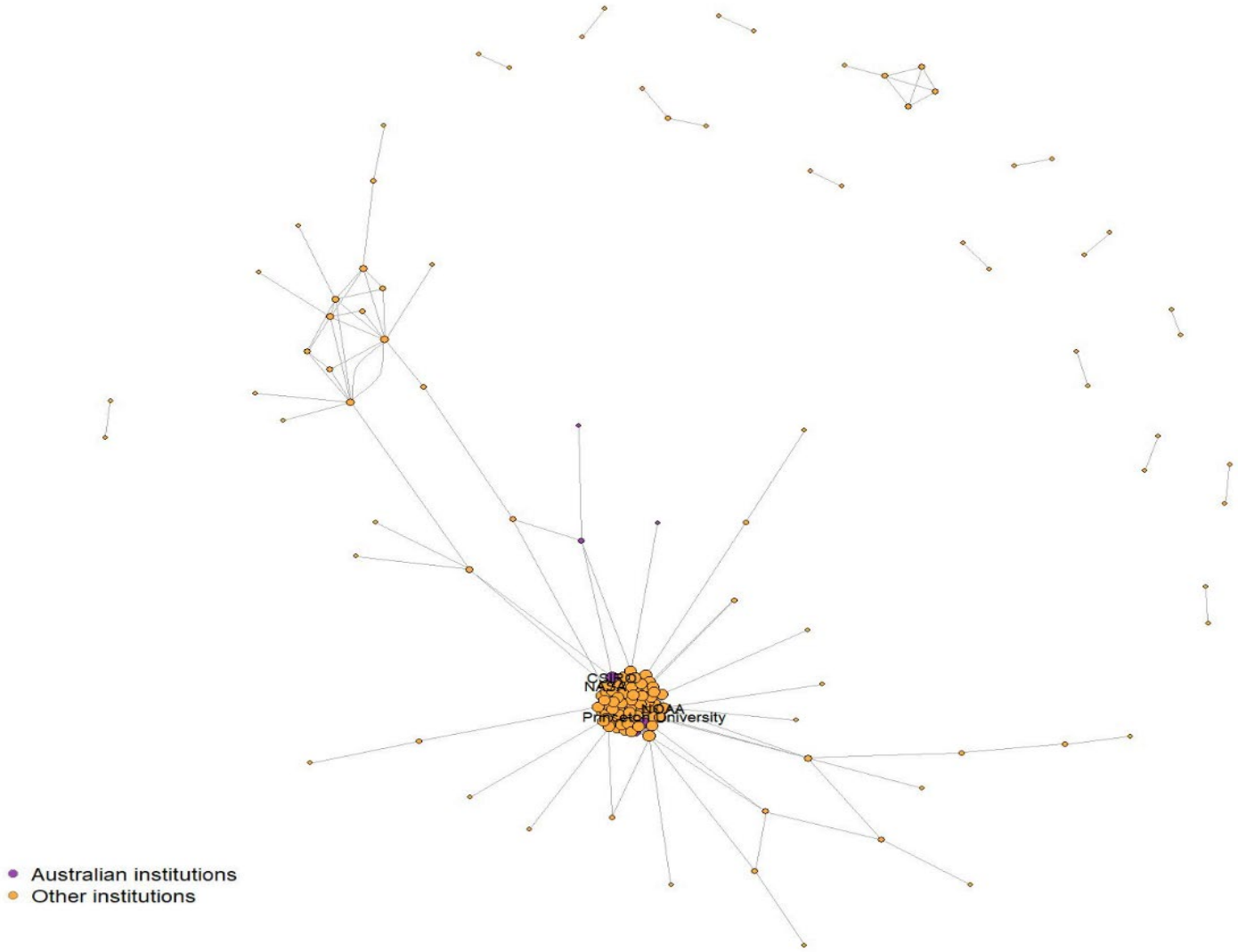
SOURCE: ACIL ALLEN CONSULTING

FIGURE 5.5 ENVIRONMENTAL SCIENCES PARTNERSHIPS

Note: This stylised network map represents the partnerships and affiliations as self-described in the published literature and does not display all entities or relationships in the system.

SOURCE: ACIL ALLEN CONSULTING

FIGURE 5.6 EARTH AND PLANETARY SCIENCES PARTNERSHIPS



Note: This stylised network map represents the partnerships and affiliations as self-described in the published literature and does not display all entities or relationships in the system.

SOURCE: ACIL ALLEN CONSULTING

5.3 Drought resilience knowledge

Trends and drivers in international research have been examined through analysis of drought resilience research reports—from government and research organisation libraries—and academic journal articles captured in Scopus by Elsevier, using title-abstract-keyword searches.[30]

> Scopus is the largest abstract and citation database of peer-reviewed literature: scientific journals, books and conference proceedings. Delivering a comprehensive overview of the world's research output in the fields of science, technology, medicine, social sciences, and arts and humanities, Scopus features smart tools to track, analyze and visualize research.

Each search uses the following search terms:

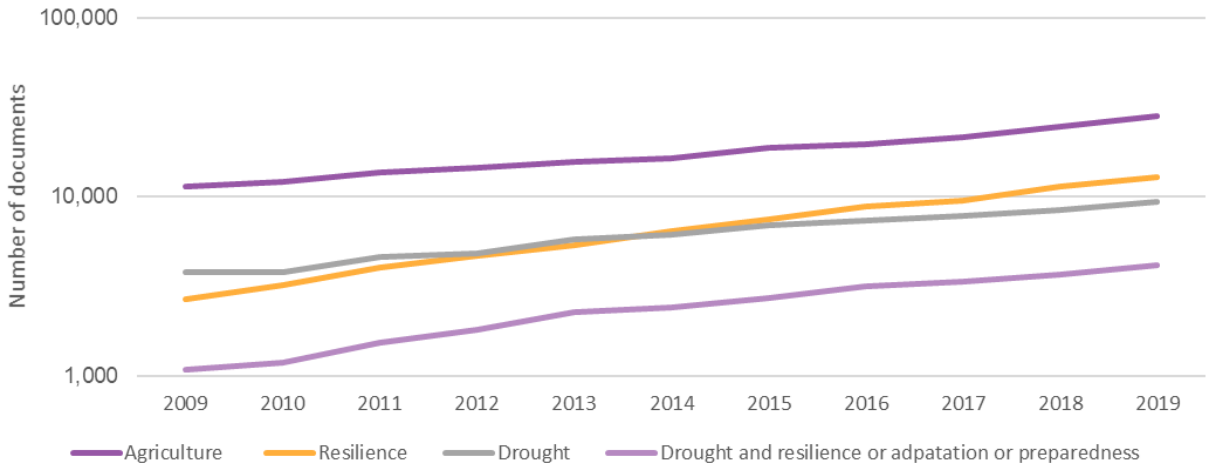
- Resilience = ‘resilience’
- Drought = ‘drought’
- Drought resilience = ‘drought AND resilience OR adaptation OR preparedness’.

The information below presents the results from these search terms focusing on work published before 2020.

Figure 5.7 presents the number of research documents over the last decade using title-abstract-keyword searches. To provide context, ‘agriculture’ was also run as a search term. This suggests that resilience and drought and drought resilience are areas of emerging research relative to agriculture. Interestingly all research areas show an increase in documents over time.[31]

> But just how fast is the mass of scientific output actually growing?... It is impossible to know for sure, but the real rate is closer to 8-9% each year, they argue. That equates to a doubling of global scientific output roughly every nine years.
>
> Van Noorden, 2014.[32]

FIGURE 5.7 NUMBER OF RESEARCH DOCUMENTS PUBLISHED OVERTIME



SOURCE: SCOPUS

[30] See: https://www.scopus.com/home.uri
[31] This is not unique to these research areas, see: http://blogs.nature.com/news/2014/05/global-scientific-output-doubles-every-nine-years.html
[32] Van Noorden, R. (2014), Global Scientific Output Doubles Every Nine Years, see: http://blogs.nature.com/news/2014/05/global-scientific-output-doubles-every-nine-years.html

Examining the rate of increase over the last decade adds context to the trends in global drought resilience research relative to resilience research, drought research and agriculture research. Table 5.1 shows that all of these areas are performing at or above the 'real rate' of 8-9 per cent per year. Drought and agriculture research reflect an annual rate of increase of 8 and 9 per cent, respectively. Resilience research is increasing at the highest rate per year (17 per cent), followed by drought resilience research at a 15 per cent increase year-on-year. Over the last decade, research on resilience has more than tripled and research on drought resilience research has more than doubled.

TABLE 5.1 PERCENTAGE CHANGES FROM A BASE 2009 IN NUMBER OF RESEARCH DOCUMENTS OVER TIME BY KEYWORD

	Resilience	Drought	Drought resilience	Agriculture
Average yearly change	17%	10%	15%	10%
Change from 2009-2019	388%	144%	287%	148%

Possible reasons for this may be:

- Increasing concern about climate change
- the focus on publishing ('publish or perish') at universities
- it is quicker now to publish research than in the past (especially given the advent of the internet).

Trends in research

The volume published each year increases over time, and the total body of knowledge on drought resilience research accumulates. However, the focus of researchers changes over time and within research fields. The changes in focus can reflect:

- The external world, for instance, climate change has affected the prevalence and effect of drought which has changed the focus of research
- Research methods, such as the development of machine learning have allowed previously impossible avenues for investigation across a number of fields
- The natural progression of a research field as knowledge accumulates.

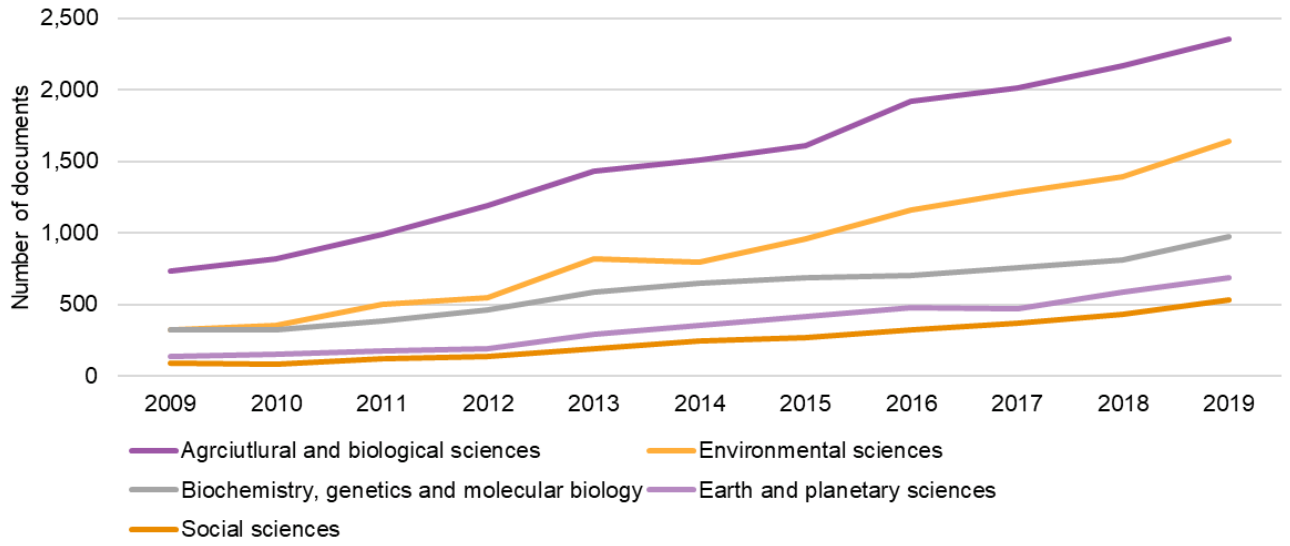
Based on the number of reports and articles on drought resilience, the major fields of research include:

- agricultural and biological sciences
- environmental sciences
- biochemistry, genetics and molecular biology
- earth and planetary sciences
- social sciences

The number of articles related to drought resilience by research field is shown in Figure 5.8.

The following sections present the focus associated with drought resilience research across these fields. The focus is based upon the relative prominence of the major keywords authors use to describe their research.

FIGURE 5.8 ARTICLES ON DROUGHT RESILIENCE RESEARCH PUBLISHED PER YEAR, BY FIELD OF RESEARCH

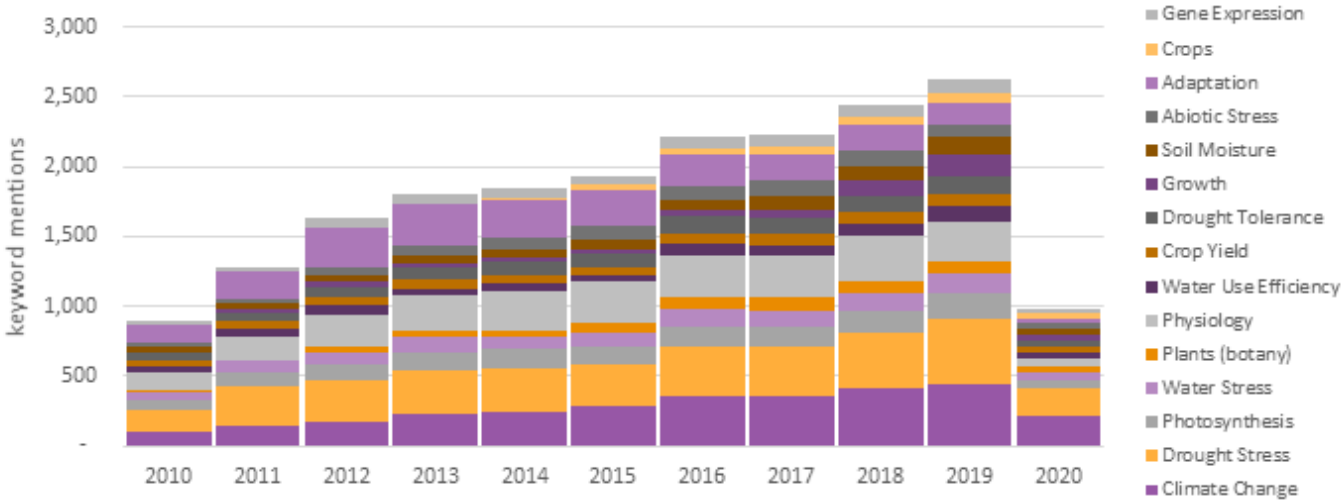


SOURCE: SCOPUS

Agricultural and biological sciences

Climate change is a fast-growing focus for agricultural and biological sciences research in the documents identified. Relative to other areas, it has changed from the fourth most common keyword in 2010 to the most common keyword in 2020, with its absolute use doubling over the period. *Adaptation* and *physiology* have become relatively less prominent as research topics (Figure 5.9).

FIGURE 5.9 LEADING DROUGHT RESILIENCE KEYWORDS – AGRICULTURAL AND BIOLOGICAL SCIENCES



Note: Keywords such as “drought”, “China” (and other geographic labels), “article” (and other non-specific keywords) and the like have been excluded.
Note: 2020 includes keywords in the year-to-date when the analysis was conducted.
SOURCE: SCOPUS

In terms of Australian drought resilience research ten organisations produced 84 per cent of the published articles identified by the stocktake. The three most published organisations produced 44.4 per cent of the articles (Table 5.2).

TABLE 5.2 AUSTRALIAN DROUGHT RESILIENCE RESEARCH PUBLICATIONS BY ORGANISATION - AGRICULTURAL AND BIOLOGICAL SCIENCES

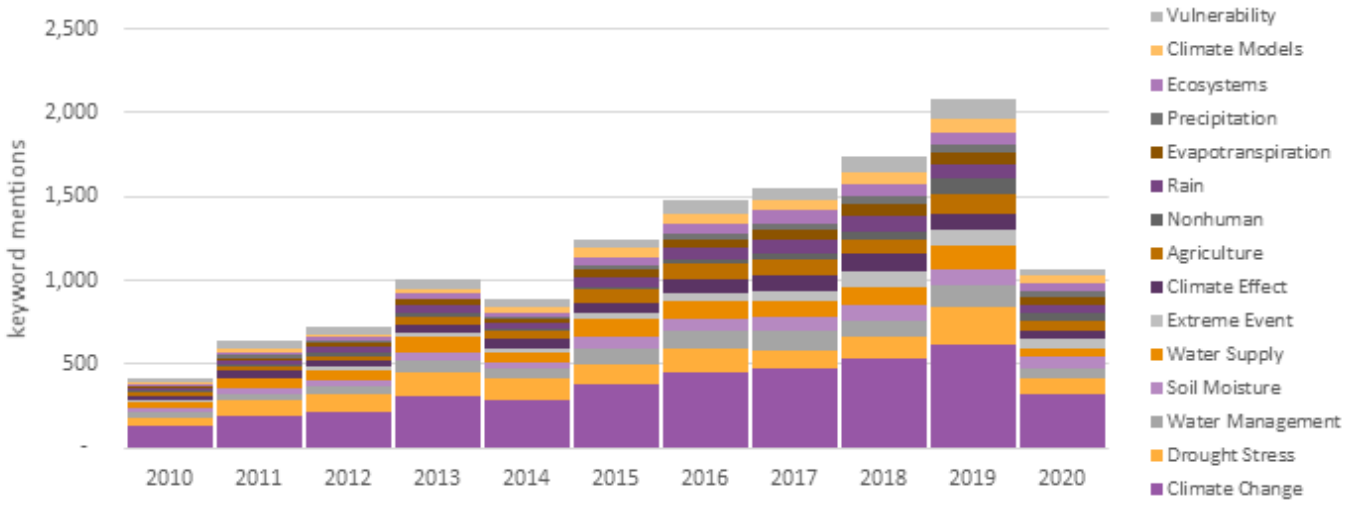
Organisation	Articles	Proportion
University of Western Australia	299	16.3%
Commonwealth Scientific and Industrial Research Organization	272	14.8%
The University of Queensland	243	13.2%
University of Melbourne	145	7.9%
The University of Adelaide	122	6.7%
The University of Sydney	113	6.2%
Western Sydney University	102	5.6%
The Australian National University	101	5.5%
University of Tasmania	77	4.2%
Murdoch University	67	3.7%
Other organisations	293	16.0%
Total	1834	100.0%

Note: Articles published up to and including 2019 based on keyword search (Australian AND drought) AND (resilience OR adaptation or preparedness)
SOURCE: SCOPUS

Environmental sciences

In environmental science, *extreme event* has been growing in relative and absolute prominence. *Climate change* remains the most commonly used keyword by a significant margin, used consistently three or more times more often than other keywords in the documents identified (Figure 5.10).

FIGURE 5.10 LEADING DROUGHT RESILIENCE KEYWORDS – ENVIRONMENTAL SCIENCES



Note: Keywords such as “drought”, “China” (and other geographic labels), “article” (and other non-specific keywords) and the like have been excluded.
Note: 2020 includes keywords in the year-to-date when the analysis was conducted.
SOURCE: SCOPUS

In terms of Australian drought resilience research ten organisations produced 69 per cent of the published articles identified by the stocktake. The three most published organisations produced 30.7 per cent of the articles (Table 5.3).

TABLE 5.3 AUSTRALIAN DROUGHT RESILIENCE RESEARCH PUBLICATIONS BY ORGANISATION – ENVIRONMENTAL SCIENCE

Organisation	Articles	Proportion
Commonwealth Scientific and Industrial Research Organization	120	12.4%
The University of Queensland	91	9.4%
University of Melbourne	86	8.9%
The Australian National University	73	7.5%
Griffith University	64	6.6%
Monash University	58	6.0%
University of Western Australia	50	5.2%
University of New South Wales UNSW Australia	47	4.9%
The University of Adelaide	40	4.1%
Murdoch University	39	4.0%
Other organisations	300	31.0%
Total	968	100.0%

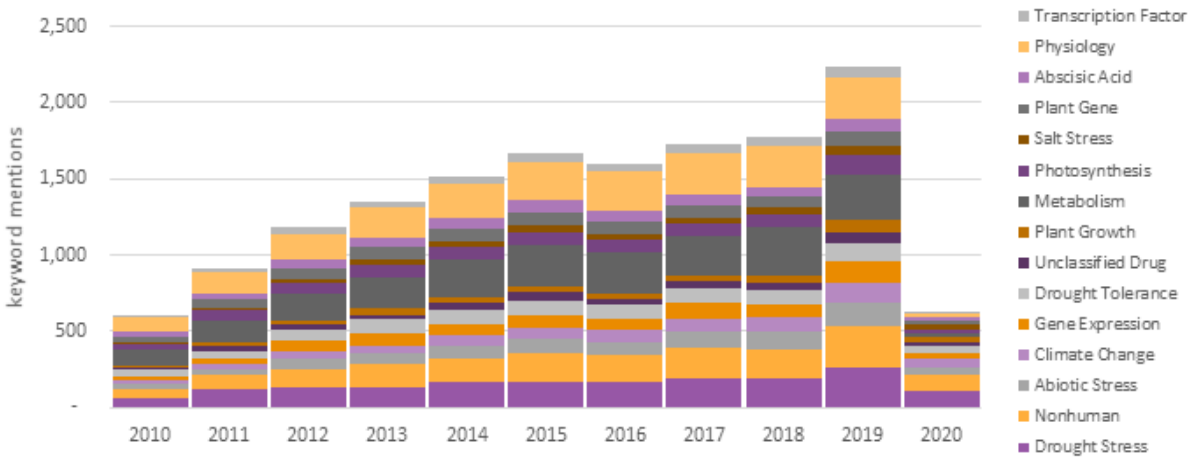
Note: Articles published up to and including 2019 based on keyword search (Australian AND drought) AND (resilience OR adaptation or preparedness)

SOURCE: SCOPUS

Biochemistry, genetics and molecular biology

Drought stress and *climate change* are both keywords which have grown rapidly in the biochemistry, genetics and molecular biology fields in the documents identified. *Climate change* has expanded by approximately five times in the ten years from 2010. Classic biological keywords, such as *metabolism* and *physiology*, have become relatively less important in comparison to genetics-based keywords such as *gene expression* and *transcription factor* (Figure 5.11).

FIGURE 5.11 LEADING DROUGHT RESILIENCE KEYWORDS – BIOCHEMISTRY, GENETICS AND MOLECULAR BIOLOGY



Note: Keywords such as “drought”, “China” (and other geographic labels), “article” (and other non-specific keywords) and the like have been excluded. 2020 includes keywords in the year-to-date when the analysis was conducted.
SOURCE: SCOPUS

In terms of Australian drought resilience research ten organisations produced 93.3 per cent of the published articles identified by the stocktake. The three most published organisations produced 38.1 per cent of the articles (Table 5.4).

TABLE 5.4 AUSTRALIAN DROUGHT RESILIENCE RESEARCH PUBLICATIONS BY ORGANISATION – BIOCHEMISTRY, GENETICS AND MOLECULAR BIOLOGY

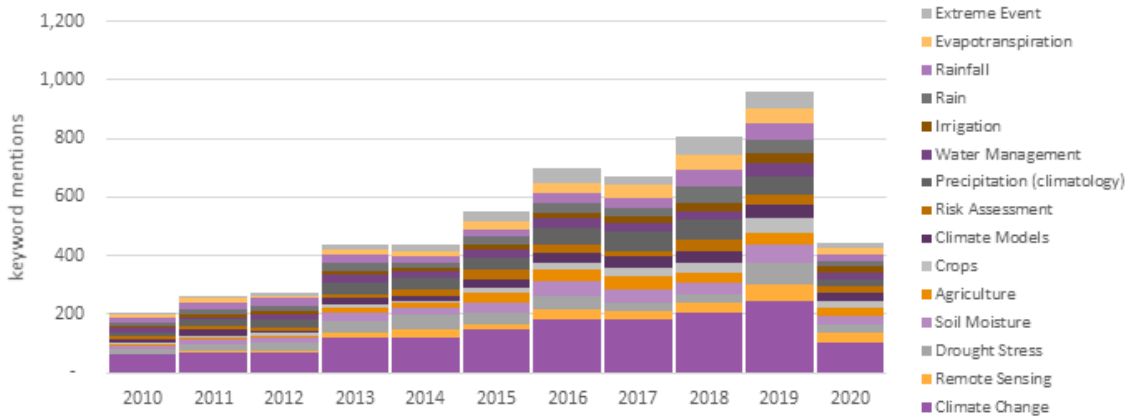
Organisation	Articles	Proportion
The University of Queensland	77	13.9%
University of Western Australia	76	13.7%
The University of Adelaide	58	10.5%
Commonwealth Scientific and Industrial Research Organization	57	10.3%
University of Melbourne	52	9.4%
Western Sydney University	44	7.9%
The University of Sydney	44	7.9%
The Australian National University	39	7.0%
University of Tasmania	37	6.7%
Australian Centre for Plant Functional Genomics	33	6.0%
Other organisations	37	6.7%
Total	554	100.0%

Note: Articles published up to and including 2019 based on keyword search (Australian AND drought) AND (resilience OR adaptation or preparedness)
SOURCE: SCOPUS

Earth and planetary sciences

In contrast to other fields, *climate change* is becoming relatively (although still increasing in absolute terms) less prominent in earth and planetary sciences in the documents identified. However, many of the keywords which are becoming more prominent relate to research into the details of climate change and may reflect the relatively high base. Reflecting improving computing technology, low-cost satellite access, and computational techniques *remote sensing* has grown rapidly in recent years to become the second most commonly used keyword in earth and planetary science research in 2020 (Figure 5.12).

FIGURE 5.12 LEADING DROUGHT RESILIENCE KEYWORDS – EARTH SCIENCES



Note: Keywords such as “drought”, “China” (and other geographic labels), “article” (and other non-specific keywords) and the like have been excluded.Note: 2020 includes keywords in the year-to-date when the analysis was conducted.
SOURCE: SCOPUS

In terms of Australian drought resilience research ten organisations produced 79.3 per of the published articles identified by the stocktake. The three most published organisations produced 32.3 per cent of the articles (Table 5.5**).**

TABLE 5.5 AUSTRALIAN DROUGHT RESILIENCE RESEARCH PUBLICATIONS BY ORGANISATION – EARTH SCIENCES

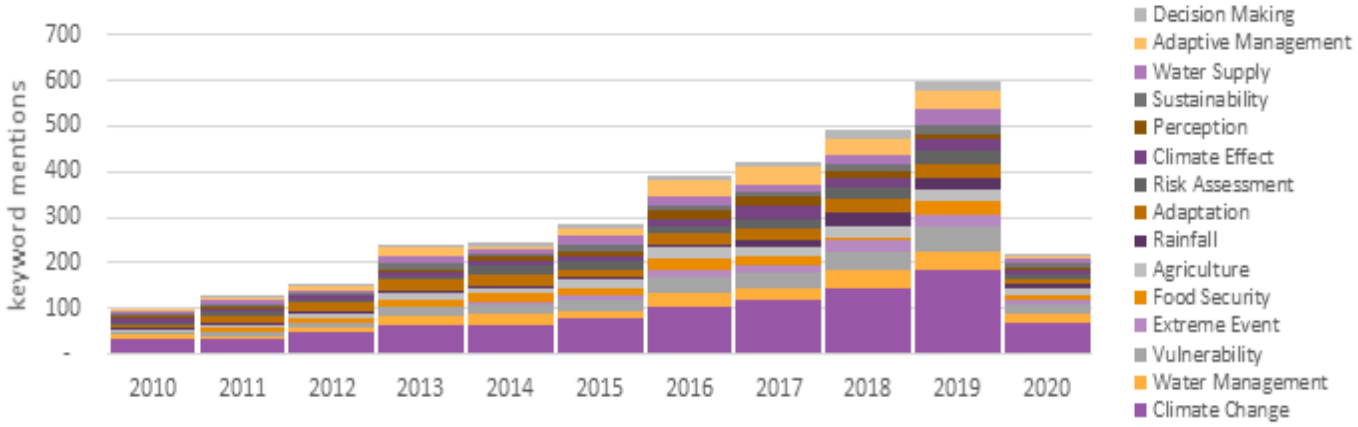
Organisation	Articles	Proportion
Commonwealth Scientific and Industrial Research Organization	51	14.4%
University of New South Wales UNSW Australia	32	9.1%
The Australian National University	31	8.8%
The University of Queensland	29	8.2%
University of Melbourne	27	7.6%
University of Technology Sydney	25	7.1%
University of Western Australia	24	6.8%
Monash University	23	6.5%
University of Southern Queensland	19	5.4%
Macquarie University	19	5.4%
Other organisations	73	20.7%
Total	353	100.0%

Note: Articles published up to and including 2019 based on keyword search (Australian AND drought) AND (resilience OR adaptation or preparedness)
SOURCE: SCOPUS

Social sciences

In social sciences, *decision making*, *risk assessment* and *vulnerability* are the keywords which have grown most rapidly in prominence, replacing more tangible keywords topics like *rainfall and water supply*. Like many fields, *climate change* has increased in prominence year on year (Figure 5.13).

FIGURE 5.13 LEADING DROUGHT RESILIENCE KEYWORDS – SOCIAL SCIENCES



Note: Keywords such as “drought”, “China” (and other geographic labels), “article” (and other non-specific keywords) and the like have been excluded.
Note: 2020 includes keywords in the year-to-date when the analysis was conducted.
SOURCE: SCOPUS

Within Scopus, social science — which includes **economics, econometrics and finance** research and **business, management and accounting** research — research in drought resilience accounts for just 12 per cent of all drought resilience research (of this 8 per cent is categorised as Social Sciences and additional 4 per cent of documents are categorised as Economics, Econometrics and Finance research and Business, Management and Accounting research). So far in 2020, research into drought resilience is approximately 21-times more likely to be **agriculture and biological** than **social sciences**.

In terms of Australian drought resilience research ten organisations produced 64.3 per of the published articles identified by the stocktake. The three most published organisations produced 26.3 per cent of the articles (Table 5.6). It was not until 2009 that Australian researchers produced more than ten documents a year – this peaked in 2017 with 42 documents. Approximately one third of published documents have been cited more than ten times.[33]

TABLE 5.6 AUSTRALIAN DROUGHT RESILIENCE RESEARCH PUBLICATIONS BY ORGANISATION – SOCIAL SCIENCES

Organisation	Articles	Proportion
The Australian National University	33	11%
The University of Queensland	24	8%
Griffith University	24	8%
The University of Adelaide	19	6%
University of Melbourne	19	6%
Monash University	18	6%
University of South Australia	16	5%
University of Newcastle, Australia	15	5%

[33] It would be expected that more recently published research would be less cited.

Organisation	Articles	Proportion
University of Southern Queensland	15	5%
Commonwealth Scientific and Industrial Research Organization	15	5%
Other organisations	110	35.7%
Total	308	100.0%

Note: Articles published up to and including 2019 based on keyword search (Australian AND drought) AND (resilience OR adaptation or preparedness)

SOURCE: SCOPUS

6 DROUGHT RESILIENCE RESEARCH DEVELOPMENT EXTENSION AND ADOPTION GAPS AND OPPORTUNITIES

This chapter summarises the key findings of this report and presents the opportunities and gaps for the Fund to invest as identified in the stocktake of drought resilience knowledge and the analysis of the drought resilience RDE&A ecosystem.

6.1 Key findings

Drought resilience research is increasing. There is no documented work on why drought resilience research has been growing over time. However, there are several plausible reasons (or combination of reasons) as to why resilience and drought research may be on the rise:

- Resilience is an area which lends itself to dealing with human and systemic behaviour under conditions of risk and uncertainty (such as the adversity caused by drought).
- Droughts are becoming a more relevant adversity as there appears to be an increase in duration, frequency and severity as a result of changing climate.
- Drought resilient research related to agro-ecological systems and the accompanying disciplines remains a core driver in the on-going adaptation of farming systems in Australia and overseas.

The construct of drought resilience knowledge as a tangible good that can be readily extended and adopted is challenging, as noted in the literature survey and the focus groups. Reasons as to why include:

- Drought resilience knowledge is embedded/latent in farming systems/businesses, their industries and communities – making it challenging to determine what drought resilience knowledge is specifically.
- Drought resilience knowledge is variable within and between farming businesses, industries and communities as well as locations – making it challenging to establish who has the knowledge, who needs additional knowledge and what knowledge is needed.
- Demand for drought resilience knowledge is variable farming businesses, industries and communities as well as locations. It appears to depend on current drought conditions and the degree to which future drought is prioritised – making it challenging for different actors to develop/promote/adopt knowledge at times.
- Drought resilience is achieved through an enduring, systematic and adaptive response. This implies an on-going process suited to the context rather than targeting discrete outcomes.

None the less the construct of knowledge as a tangible good that simply requires extension and adoption to improve performance remains popular and a core research driver endures. In part this stems from previous success in providing information, practices and technologies that improve (farming) systems, businesses and industries in Australia and overseas.

In Australia drought resilience RDE&A is predominantly in the rural innovation system. The system is a highly capable and proven performer in the areas where it focuses — especially within the agricultural industry. Its RDE&A pathways are diverse and fragmented, with each typically concentrating on a narrow band of subject matter and end-user. The system is sophisticated and mature with a diversity of organisations and capabilities. The stocktake identified 286 organisation and 832 RDE&A program activities related to drought resilience in the rural innovation system.

The stocktake has identified four services which act has pathways for existing and new knowledge to flow from RDE&A providers to farm businesses, their industries and communities:

- Asset status and trend (10 per cent of activities and 4 per cent of funding identified)
- Forecasts and predictions (10 per cent of activities and 4 per cent of funding identified)
- Technologies, practices and systems (70 per cent of activities, 76 per cent funding identified)
- Advisory (16 per cent of activities and 25 per cent of funding identified)

A distinct feature of the system is that drought resilience is mostly addressed as a secondary rather than the primary objective of RDE&A. There is a strong focus on adaptation and economic resilience. The net result is RDE&A is farm (systems) centric and concentrated on economic-environmental resilience outcomes.

6.2 Gaps and opportunities

The question whether there are gaps in drought resilience RDE&A is a matter of perspective.

The fact that farmers, industries and communities continue to be impacted by drought is seen by many as the need for greater adoption of knowledge generated by R&D to improve resilience. The fact that not all R&D is currently adopted is seen by many as the need for more extension, R&D or both. The expectation that droughts will have a greater impact in the future amplifies this need and signals that reorganisation/ transformation will be required. While these propositions can be justified, they do not hold true in all cases.

The stocktake has identified there is a sophisticated innovation system operating in Australia which does consider drought resilience in its RDE&A. While there are many gaps, strategically there are six opportunities for the Fund:

- leveraging the existing innovation system
- developing a roadmap for farming systems
- getting more from information products and platforms
- addressing the social and environmental drought resilience gap
- improving risk management activity
- participatory action research to further connect users.

6.2.1 Leveraging the existing innovation system

The stocktake has identified Australia's innovation systems' drought resilience RDE&A exceeds the Funds' RDE&A investments by an order or magnitude.

Australia's innovation system has significant collective capability. The includes searching for opportunities as well as forging private nationwide and overseas partnerships and investments.

It will be critical for the Fund to harness this capability. Particularly since the system exceeds the Fund's proposed RDE&A investment if all current programs identified are considered. Leverage will extend the Fund's impact and play an important role in improving coordination.

A distinct feature of the innovation system is there is no single strategy, broker or brokerage point to coordinate drought resilience RDE&A. Rather there are a series of overlapping sub-systems covering rural industries, wider technology and industry/regional development, environmental/natural resource management, human/social services and infrastructure/land planning.

The stocktake collected detailed information on two: the rural innovation system and the academic-university sector. There is a great opportunity to align pathways and create entrepreneurial mechanisms to leverage technologies and systems-based approaches with existing and new partners. The Fund should seek to bring providers together and co-design objectives and efforts.

Agricultural innovation system

The rural innovation system is predominantly focused on the economic and environmental resilience of agricultural industries and landscapes, particularly farming systems. Given the diversity of pathways, the number and often specialised focus of the providers, drought resilience RDE&A lacks an 'owned' strategy or a community of practice. The diversity limits transparency, especially to those not deeply engaged in the rural innovation system.

Three logical partnership points for the Fund to pursue opportunities are: the 15 RDCs (individually and through the Council of Rural RDCs Climate Change sub-committee), Commonwealth and State Governments and national research organisations such as CSIRO, ACIAR, and BoM.

The key opportunity for the Fund is to engage with the rural innovation system to improve the transformational focus and impact of its RDE&A by:

- improving the coordination of strategies and programs (i.e. the programs listed in Appendix A)
- bundling of services to strengthen extension and adoption.

Academic sector

The academic-university sector is engaged in but extends beyond the rural innovation system. The academic sector produces large and growing research and development of drought resilience related knowledge. While the drivers and operations of the academic sector vary from those of the broader ecosystem, it is an important provider of drought resilience knowledge. Given the volume and diversity of research coming out of domestic and international institutions, the Fund should seek to tap into the academic sector to utilise its productive power.

The source of drought resilience academic research is becoming increasingly international. Research clusters are particularly evident in the United States. Australia only produces a fraction of the global drought resilience knowledge, and breakthrough knowledge is increasingly likely to be developed overseas.

Fortunately, in many academic fields, Australian universities are highly connected and have developed relationships with academic research clusters around the world. The Fund should look to highly connected Australia universities, in fields with high amounts of connectivity, to tap into cutting-edge international research. It should look to invest in ways of adapting international knowledge to local conditions, and then driving international knowledge through extension and adoption networks within Australia.

So far in 2020, research into drought resilience is approximately 21-times more likely to be **agriculture and biological than social sciences**. This highlight a key opportunity for the Fund is to expand the current RDE&A effort beyond farming systems and to build the platform for improved social resilience extension and adoption.

6.2.2 Developing a roadmap for farming systems

Most farming systems in Australia are well established. The accompanying RDE&A system is sophisticated and focused on continual adaptation. There is an implicit assumption that such research will support transformation through cumulative adaptive gains and periodic high impact solutions.

Farming systems RDE&A is structured around single industries and to a lesser degree geography. A gap identified through the focus groups is that there is no clear shared national picture across farming systems. This includes:

- the R&D pipeline to improve the Genetics, Environment and Management (GxExM) of existing and new farming systems across Australia
- the degree to which they may need to transform in response to drought resilience and other influences.

None the less it is apparent that this knowledge is latent in the innovation system from the focus group discussions.

There is a clear opportunity to articulate a technology roadmap for farming systems in relation to drought resilience and what R&D is in train. Although this is out of scope for this project, a roadmap should be led by the RDCs.

6.2.3 Getting more from information products and platforms

Providing information on the likelihood, severity and impact of drought is an important public good. This helps build resilience by measuring progress/change and informing decision making. It is also seen as an important motivator to farm businesses, industries and communities becoming aware of the need to make significant/transformational changes to improve their resilience.

This extends beyond drought to other risks and includes all five capitals: environment, physical, social, financial and human capital.

The stocktake highlighted many providers offer asset status/trend and forecasts/predictions services. In the focus groups, participants highlighted challenges in resourcing, interoperability and connectivity to provide services that are widely adopted. There are also challenges in balancing the need to provide sufficient information to motivate by a specific individual to improve their overall drought resilience against a more generic drought resilience technology or practice.

There is an opportunity to improve these information services by joining them up into a real-time network to overcome some of these barriers. The foundation of the network should be a data commons (stored in one location) to facilitate the sharing of data between existing and new providers, both public and private. This

will avoid unnecessary duplication of investment and data collection and improve transparency, adoption and coordination as well as facilitate interoperability through standards.

The network should be also be modular so the resulting information products can be bundled and applied nationally and attract partners for localised adaptation. The cost of collecting data and providing information is considerable. Particularly if greater granularity is required. A modular approach allows wider application while providing a framework for those motivated to progressively develop and operate from more cost effectively.

In the first instance this should focus on regions, industries and communities so they can assess their drought resilience needs in an interoperable manner. This will allow consideration of how the supply side shock of drought risk impacts them so they may formulate strategies. There should be alignment between data and platforms and the farming technology systems roadmap to inform the targeting of RDE&A and motivate adoption by end users.

6.2.4 Addressing the social and environmental drought resilience gap

There is a trend towards increased drought resilience-related R&D, often associated with climate change, extreme events, sustainable farming systems and novel innovations. However, there is a clear opportunity to develop research focused on social and environmental outcomes relative to research with an economic outcome. The existing ecosystem is predominantly focused on the agricultural sector, and few providers have responsibility for social or environmental outcomes.

The lower levels of social drought resilience publications and activities are likely to be related to the success of farming-oriented R&D and the challenge of integrating other disciplines. None the less this is a clear gap. Likewise, while there is a role for the agricultural sector in implementing environmental outcomes, not all environmental objectives can be achieved through farming systems and the existing ecosystem.

The Fund is mandated to invest in triple bottom line outcomes of which social and environmental outcomes are not addressed as well as economic outcomes in relation to funding or the number of programs as determined by this stocktake. The Fund should also give serious consideration to commissioning activities centred on social resilience so as to develop better knowledge and build capability in Australia. This is particularly relevant to participatory action research.

6.2.5 Improving risk management activity

Overwhelmingly, the drought resilience knowledge services provided to end-users are technology practices and systems, typically intended to improve practices. Second to this, prediction and forecasting (typically of weather or farm condition) are used to improve decision making. There is a clear gap in activities with a direct intent to improve risk management — through diversification or insurance.

Drought insurance is well studied but has yet to form a widespread viable commercial market. Rapid advances in technology/data science continue to improve the actuarial basis of insurance. A meta-evaluation on what it will take to close the gap between what farm businesses are willing to pay, and insurers are willing to offer will inform what steps could be taken to form the market.

6.2.6 Research to further connect users

In many cases, RDE&A pathways are well developed with clearly defined end-users. For example, RDCs drive drought resilience knowledge which draws from and provides knowledge services to farmers within its industry. However, many RDE&A pathways will have less clear relationships with end-users.

The stocktake and focus groups show there is not a single- or one-time solution to improve drought resilience. There is also considerable variation in drought resilience within user groups. Some are more resilient than others at a given point in time. The focus groups also highlighted that the demand for drought resilience extension and adoption is inconsistent. As is the case with much adoption, a trigger is needed to increase motivation to utilise available knowledge, technologies, practices and systems.

We have identified four knowledge services that are integral to drought resilience and form part of the drought resilience RDE&A ecosystems map. Each of these services would benefit from additional investment and development to address the specific needs and adoption barriers of user segments.

The stocktake identified a large number of private organisations as well as farming/NRM groups who all play an active role in extension that often extends into R&D as well. Their services extend beyond drought resilience and collectively they provide a significant RDE&A capability in regional Australia.

Another opportunity for the Fund is to invest in bundling the four services identified by the stocktake to target a specific user group or outcome. This “bottom-up” approach would also contribute to building or sustaining capabilities in the regions.

The Fund can play a role in commissioning research partnerships to develop the processes. Participatory action research is one method for conducting this research. It can be used to develop and validate a drought resilience process for farming communities and industries that can be scaled and adapted.

These processes need to be developed “in-situ” to ensure validity and build local capacity. Rather than define the groupings upfront, the Fund could consider groups as they self-define. The partnerships must include multi-disciplinary research teams across the triple bottom line and directly involve users in governance and design as well as implementation.

Examples of the types of participatory action research programs that could be funded include:

- Farming systems: within an industry or location including improvements to current systems, new systems and diversification
- Communities: within a industry or location including the towns, non-agricultural industries, services infrastructure, environment and social structures
- Value chains: supply continuity, integrity and stewardship, value adding and cross value chain collaboration
- Landscapes: environmental services and restoration to improve ecological function as well as social and economic resilience.

APPENDICES

DROUGHT RESILIENCE RESEARCH DEVELOPMENT EXTENSION AND ADOPTION ACTIVITIES

A

Program	Provider	Environment	Economic	Social
Economic impacts of climate change and adaptation strategies in agricultural industries in NSW	ABARES		YES	
Heat stress in dairy and livestock	Agriculture Victoria		YES	
Drought tolerant pasture	Agriculture Victoria		YES	
Alternate forage species	Agriculture Victoria		YES	
Australian Grains Genebank	Agriculture Victoria		YES	
Drought tolerant crops	Agriculture Victoria		YES	
Bridging the profitability gap and resilient grain production	Agriculture Victoria		YES	
Combining biophysical and genomic selection models to breed for future environments	Agriculture Victoria		YES	
Land and water resources predictive modelling and monitoring at the catchment and regional scale	Agriculture Victoria		YES	
Digital agriculture (IOT program and Smarter Safer Farms)	Agriculture Victoria	YES	YES	
Water efficient farming systems - Irrigation scheduling/ water availability	Agriculture Victoria		YES	
Energy efficient farming systems - (Agriculture Energy Investment Plan (AEIP))	Agriculture Victoria	YES	YES	
Business Farm Management and Planning Support program	Agriculture Victoria	YES	YES	
AgVic Seasonal Risk Program	Agriculture Victoria	YES	YES	YES
Climate Research Strategy for Primary Industries (CRSPI)	Agrifutures	YES	YES	YES

Program	Provider	Environment	Economic	Social
PRJ-012469: Innovation & Technology to improve natural disaster management	Agrifutures	YES	YES	YES
PRJ-012274: Water security for the chicken meat industry	Agrifutures	YES	YES	YES
PRJ-012310: Carbon and environmental impacts of poultry production: 2020 and beyond	Agrifutures	YES	YES	YES
PRJ-011067: Traits of importancefor aerobic 'Dry Rice' varieties for the Riverina region	Agrifutures	YES	YES	
PRJ-012398: SIP2 - Making the most of water	Agrifutures	YES	YES	YES
PRJ-012384: Smarter irrigation for Profit 2	Agrifutures	YES	YES	YES
PRJ-012401: SIP2 - Smarter irrigation in rice growing system	Agrifutures	YES	YES	YES
Enabling Platforms for Controlled Environment Phenotyping	APPF		YES	
Enabling Platforms for Field phenotyping	APPF	YES	YES	
Data and software- tools and services	APPF		YES	
Quantitative risk anaylsis of the impact of climate variability on the Australian red meat processing industry.	Australian Meat Processor Corporation		YES	
Development of New ERF Methods for the Pork Industry	Australian Pork	YES		
ABBA Biomass Mapping Project	Australian Pork	YES	YES	
National Agricultural Manure Management Program (NAMMP)	Australian Pork	YES	YES	
Quantifying Greenhouse Gas Emissions from Australian Piggeries	Australian Pork		YES	
PigGas - Pork Industry Greenhouse Gas Calculator and Case Studies	Australian Pork		YES	
Trends in environmental impacts from the pork industry	Australian Pork	YES	YES	
Assessment of treatment technologies and strategies to mitigate GHG emissions	Australian Pork	YES	YES	
PigBal v4.099	Australian Pork	YES		
Code of Practice for On-Farm Biogas Production and Use (Piggeries)	Australian Pork		YES	YES
Centre of Excellence for Climate Extremes	Australian Research Council	YES		
Forewarned is Forearmed	BoM	YES	YES	
Northern Australian Climate Program	BoM	YES	YES	
Trusted Private Automatic Weather Stations	BoM	YES		

Program	Provider	Environment	Economic	Social
Near real-time water reporting for MDB	BoM	YES	YES	YES
Soil Moisture Forecasting and Projections	BoM	YES	YES	YES
PhD:Building climate change resilience in cotton through translational physiology	Cotton Research and Development Corporation	YES	YES	
Modern Systems Agronomy for Resilient Cotton Production	Cotton Research and Development Corporation		YES	
PhD: Utilising novel plant growth regulators to develop resilient future cotton systems	Cotton Research and Development Corporation		YES	
PhD: Characterisation of brassinosteroid effects and brassinosteroid -responsive genes in cotton for growth and stress tolerance enhancement	Cotton Research and Development Corporation		YES	
Minimising yield variability to maximise yield	Cotton Research and Development Corporation		YES	
Improving water use efficiency in a changing climate	Cotton Research and Development Corporation	YES	YES	
Quantifying the effectiveness of cover crops as a means of increased water infiltration and reduced evaporation in the northern region	Cotton Research and Development Corporation		YES	
Managing Climate Variability Program - Phase 5	Cotton Research and Development Corporation	YES		
Precise real-time automated cotton irrigation for improved water productivity	Cotton Research and Development Corporation		YES	
Smarter Irrigation 2: Precise real-time automated cotton & dairy irrigation for improved water productivity	Cotton Research and Development Corporation		YES	
Smarter Irrigation 2: New tech cotton irrigation key learning sites	Cotton Research and Development Corporation		YES	
Gwydir Valley demonstration of the application of the latest digital technologies for precise automated irrigation.	Cotton Research and Development Corporation		YES	YES
Smarter Irrigation 2: Plant-based sensing for cotton irrigation	Cotton Research and Development Corporation		YES	
Feasibility study of managed aquifer recharge for improved water productivity for Australian cotton production	Cotton Research and Development Corporation		YES	
Evaporation mitigation solutions for Australian cotton farm water storages	Cotton Research and Development Corporation		YES	
Water use efficiency for irrigated and dry land cotton benchmarked (includes CottonInfo technical lead and myBMP module lead)	Cotton Research and Development Corporation		YES	
Developing novel cotton farming systems	Cotton Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
Developing novel farming systems - CQ	Cotton Research and Development Corporation		YES	
Climate and energy for cotton farming businesses	Cotton Research and Development Corporation	YES	YES	
Forewarned is forearmed	Cotton Research and Development Corporation	YES	YES	
Professor of Soil Biology	Cotton Research and Development Corporation	YES		
Climate, energy and business analysis for cotton growers (including CottonInfo Technical Lead)	Cotton Research and Development Corporation	YES	YES	
PhD: Sustainable water extractions: Low flow regia and critical flow thresholds	Cotton Research and Development Corporation		YES	
Managing riparian corridors on cotton farms for multiple benefits	Cotton Research and Development Corporation		YES	
Managing natural landscapes on Australian cotton farms to increase the provision	Cotton Research and Development Corporation	YES	YES	
Improving the nitrogen use efficiency of cotton crops through better understanding the role of dissolved organic N	Cotton Research and Development Corporation		YES	
Cotton Landcare Tech Innovations: Improved natural capital (biodiversity) on Australian cotton farms	Cotton Research and Development Corporation	YES	YES	
Mitigating irrigation infrastructure impacts on aquatic biodiversity	Cotton Research and Development Corporation	YES		
Increasing profitability through improved NUE and reducing gaseous losses of N	Cotton Research and Development Corporation		YES	
Smarter Irrigation - 2018 CottonInfo Researchers Tour: Optimising Irrigation and Nitrogen	Cotton Research and Development Corporation		YES	YES
PhD: The impact of irrigation methods and management strategies on nitrogen fertiliser recovery in cotton in southern QLD	Cotton Research and Development Corporation		YES	
More profit from nitrogen - enhancing nutrient use efficiency in cotton	Cotton Research and Development Corporation		YES	
The platform for monitoring and analysis of cotton canopy nitrogen status and yield projection using calibrated aerial and satellite imagery	Cotton Research and Development Corporation		YES	
Future Farm Phase 2: Improving farmer confidence in targeted N management through automated sensing and decision support	Cotton Research and Development Corporation		YES	YES
PhD: Alternative energy technologies and policy solutions for the Australian cotton industry	Cotton Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
Towards carbon neutral cotton production	Cotton Research and Development Corporation	YES	YES	
CottonInfo: Measuring nitrogen loss during early season irrigation	Cotton Research and Development Corporation		YES	
CottonInfo: Improving the distribution uniformity of fertiliser spreaders to optimise fertiliser (urea) application	Cotton Research and Development Corporation		YES	
More Profit from Nitrogen	Cotton Research and Development Corporation	YES	YES	
R-91388 Drought Resilience Mission scoping phase	CSIRO	YES	YES	YES
OD-217776, OD-220287, Projects with the National Water Grid Authority	CSIRO	YES	YES	
OD- 219818 Effects of conservative irrigation on salinity	CSIRO	YES	YES	
OD-218878 Third Party Weather Station Evaluation	CSIRO		YES	
R-08236 Northern Water Resources Assessments	CSIRO	YES	YES	YES
R-09241 Natural Capital	CSIRO	YES	YES	
R-09241 Transforming Agriculture in the Pilbera	CSIRO	YES	YES	
OD-213111 Climate Guides	CSIRO		YES	YES
Northern Australian Climate	CSIRO	YES	YES	
Weather together	CSIRO	YES	YES	
National Climate Service Capability	CSIRO	YES	YES	
National Environmental Science Program (NESP) Climate Change in Australia Resource Management Project	CSIRO	YES	YES	
AdaptNRM	CSIRO	YES	YES	
Soil Condition Analyses System	CSIRO	YES	YES	
AGClimate Data Shop	CSIRO	YES	YES	
Life Cycle Assessments, Eco-Accounting	CSIRO	YES	YES	
Adaptive Value Chain Approaches	CSIRO	YES	YES	
Value Chain Analytics Platform	CSIRO	YES	YES	YES
Digiscape	CSIRO	YES	YES	YES
Assessing and managing climate risks on the cropping margins	CSIRO	YES	YES	
Frost modelling	CSIRO	YES	YES	
Forest Climate Risk Tool	CSIRO	YES	YES	
Seasonal climate forecasts for grains	CSIRO		YES	
Pasture API	CSIRO		YES	

Program	Provider	Environment	Economic	Social
Adapting to increased heat stress in dairy systems	CSIRO		YES	
Yield Prophet Lite	CSIRO		YES	
Climate Smart Sugarcane Irrigation Partnerships (CSSIP)	CSIRO	YES	YES	
P2 - Adaptation strategies for Climate change	Dairy Australia	YES	YES	
P290 Forewarned is forearmed	Dairy Australia	YES	YES	YES
P279 NLP Smart Farms	Dairy Australia		YES	
A128 Fertsmart website support	Dairy Australia		YES	
P275 Adapting Dairy Farm Systems	Dairy Australia		YES	
Smarter Irrigation for Profit II	Dairy Australia		YES	
C4 Milk	Dairy Australia		YES	
Dairy Bio Forages and Animals	Dairy Australia		YES	
Dairy Feedbase	Dairy Australia		YES	
Forage Value Index	Dairy Australia		YES	
Our Farm Our Plan	Dairy Australia		YES	YES
Smarter energy use case studies	Dairy Australia		YES	YES
Energy for farms videos	Dairy Australia		YES	YES
Energy resources and tools - printing and finalisation	Dairy Australia		YES	YES
DGAS deployment as a web application	Dairy Australia	YES		
Natural Capital Risk Assessment Pilot	Dairy Australia	YES		
Sustainable Dairy Products - meeting market and investor needs for evidence based metrics	Dairy Australia	YES		
Dairy Forecast Service Cool Cows	Dairy Australia		YES	
Heat stress research UQ	Dairy Australia		YES	
Dairy Forecast Service 2018 - 2020	Dairy Australia		YES	
Review and update Cool Cows program content - Tom Walsh	Dairy Australia		YES	
Cool Cows microsite content	Dairy Australia		YES	
Economic modelling: DBFC Murray Dairy	Dairy Australia		YES	
Biophysical modelling: DBFC Murray Dairy	Dairy Australia		YES	
Profitable Dairying in a Carbon Constrained Future	Dairy Australia	YES	YES	
Regional Management of LWC Activities	Dairy Australia	YES		
Victoria's Climate Change Framework Victorias Climate Change Adaptation Plan 2017-2020	Department of Jobs, Precincts and Regions	YES	YES	YES

Program	Provider	Environment	Economic	Social
Technologies for Reducing Greenhouse Gas Emissions and Providing Offset Options for the Beef and Dairy Industries.	Department of Jobs, Precincts and Regions	YES	YES	
Lifting Farm Gate Profit	Forest & Wood Products Australia		YES	
2018 Harvester Fire Workshops	Grains Research and Development Corporation		YES	
PBA Australian Faba Bean Breeding Program	Grains Research and Development Corporation		YES	
Snails slugs and slaters in Albany and Esperance port zones of Western Australia	Grains Research and Development Corporation		YES	
Optimising Mungbean Yields	Grains Research and Development Corporation		YES	
Making Lupins Profitable Again in the Northern Wheatbelt of the Western Region	Grains Research and Development Corporation		YES	
Cost:Benefit of Irrigation Crops Under Drought Conditions	Grains Research and Development Corporation		YES	
Growing Profitable Irrigated Durum Wheat	Grains Research and Development Corporation		YES	
Understanding how waterlogging affects water and nitrogen use by wheat.	Grains Research and Development Corporation		YES	
Evaluation of wheat germplasm derived from Indian materials for specific traits of importance to the Australian cropping environment	Grains Research and Development Corporation		YES	
Lupin Breeding for Australia	Grains Research and Development Corporation		YES	
Applying Technology Solutions for Improved Frost Detection, Diagnostics and Precision Management Decisions	Grains Research and Development Corporation		YES	
New Chemistry options for Wild Radish Control: Summary for CROSS-RDC Impact Assessment Report	Grains Research and Development Corporation		YES	
UWA00144 - Building National Capacity in Education and Research in Applied Entomology°	Grains Research and Development Corporation		YES	YES
UQ00063 - Regional soil testing guidelines for the northern grains region°	Grains Research and Development Corporation	YES	YES	
DAW00224 - Management of barley and barley cultivars in Western Australia°	Grains Research and Development Corporation		YES	
CSA00041 - Better Irrigated Wheat Germplasm°	Grains Research and Development Corporation		YES	
CUR00020 - Managing on-farm biosecurity risk through pre-emptive breeding: the case of rust°	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
CUR00021 - An international collaborative effort to sequence the genome of field pea (Pisum°	Grains Research and Development Corporation		YES	
ARN00001 - Support of the Australian Glyphosate Sustainability Working Group°	Grains Research and Development Corporation		YES	
CSP00168 - Photosynthesis Traits for Raising Wheat Yield Potential°	Grains Research and Development Corporation		YES	
DAV00127 - Using next-generation genetics to accelerate variety improvement in bread wheat, durum and barley	Grains Research and Development Corporation		YES	
DAW00227 - Tactical break crop agronomy in Western Australia°	Grains Research and Development Corporation		YES	
CRA00004 - Cultivar Crown Rot Tolerance Trials°	Grains Research and Development Corporation		YES	
UM00050 - 'Proof of concept' for approaches designed at increasing disease resistance to fungal pathogens of canola	Grains Research and Development Corporation		YES	
UM00051 - National Canola Pathology Program including new molecular knowledge, pathogen ev°	Grains Research and Development Corporation		YES	
UM00052-UG - Improving grower surveillence, management, epidemiology knowledge and tools to manage	Grains Research and Development Corporation		YES	YES
DAW00229 - Improving grower surveillance, management, epidemiology knowledge and tools to m°	Grains Research and Development Corporation		YES	YES
DAV00129-BA - Improving grower surveillance, management, epidemiology knowledge and tools to m°	Grains Research and Development Corporation		YES	YES
DAQ00187 - National Barley Foliar Pathogen Variety Improvement Program (NBFPVIP)°	Grains Research and Development Corporation		YES	
ANU00020 - The generation of wheat cultivars with improved drought tolerance°	Grains Research and Development Corporation		YES	
UCS00020 - Weed management in the southern region mixed farming systems - strategies to com°	Grains Research and Development Corporation	YES	YES	
CSP00175 - Maintaining wheat grain number under reproductive-stage drought conditions.°	Grains Research and Development Corporation		YES	
ANU00021 - Molecular tools for the modulation of transpiration efficiency in wheat.°	Grains Research and Development Corporation		YES	
DAN00180 - Benchmarking and managing soil herbicide residues for improved crop production	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
UQ00068 - Delivery of wheat root traits that contribute to water limited yield stability°	Grains Research and Development Corporation		YES	
UQ00070 - Sorghum Core Pre-breeding Program°	Grains Research and Development Corporation		YES	
CSP00179 - Raising water productivity: Trait assessment for Australian rainfed wheat°	Grains Research and Development Corporation		YES	
CSP00182 - Genetically improving wheat's ability to outcompete weeds°	Grains Research and Development Corporation		YES	
CUR00022 - Fungicide resistance management strategy and communications°	Grains Research and Development Corporation		YES	
DAW00236 - Soil Acidity is limiting grain yield°	Grains Research and Development Corporation		YES	
DAW00238 - Development of lupin molecular markers tagging yield QTL genes and yield-related°	Grains Research and Development Corporation		YES	
ICA00011 - Pre-emptive chickpea pre-breeding for biotic stresses and germplasm enhancement°	Grains Research and Development Corporation		YES	
ICA00012 - Focused improvement of ICARDA/Australian durum germplasm for abiotic tolerance°	Grains Research and Development Corporation		YES	
UMU00050-DAW00240 - Manipulating barley phenology to maximise yield potential°	Grains Research and Development Corporation		YES	
DAQ00191 - Sorghum Midge Testing Scheme°	Grains Research and Development Corporation		YES	
CSP00185 - Collection, phenotyping and exploitation of wild Cicer genetic resources for chi°	Grains Research and Development Corporation		YES	
UM00054 - PhD project - Predicting insect pest issues in Australian grain crops°	Grains Research and Development Corporation		YES	
DAW00242 - Subsoil constraints - understanding and management°	Grains Research and Development Corporation		YES	
DAW00243 - Minimising the impact of soil compaction on crop yield°	Grains Research and Development Corporation		YES	
DEP00002 - Push Notifications to enable proactive management of pests, weeds and diseases°	Grains Research and Development Corporation	YES	YES	
DAW00244 - Delivering enhanced agronomic strategies for improved crop performance on water°	Grains Research and Development Corporation		YES	
DAW00245 - Yield loss response curves for host resistance to leaf, crown and root diseases°	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
CMA00003 - Linking APSIM-based management tools with POAMA seasonal forecasts°	Grains Research and Development Corporation		YES	
UA00152 - Genomic Selection: Development and utilisation in a commercial wheat breeding program°	Grains Research and Development Corporation		YES	
UMU00044 - Identifying low pH tolerance and effective rhizobia for wild Cicer to improve adaptation to acid sandy soils	Grains Research and Development Corporation		YES	
WCA00004 - Reduced herbicide usage through application technology°	Grains Research and Development Corporation	YES	YES	
USQ00017 - Assessing collections of wild chickpea relatives for resistance to root-lesion nematodes	Grains Research and Development Corporation		YES	
CUR00024 - Genetics of wild germplasm, gene-pool expansion and integrated ASSD approach to°	Grains Research and Development Corporation		YES	
CSP00187-DAN - Optimised canola profitability understanding the relationship between physiolo°	Grains Research and Development Corporation		YES	
DAQ00196 - Delivery of Improved Invertebrate Pest Management in the Northern Grains region.°	Grains Research and Development Corporation		YES	
DAW00247 - Improved genetic solutions for management of yellow spot in wheat°	Grains Research and Development Corporation		YES	
DAW00248 - Effective genetic control of Stagonospora nodorum blotch°	Grains Research and Development Corporation		YES	
DAV00144 - Cereal and Pulse cultivar resistance ratings for the Southern region°	Grains Research and Development Corporation		YES	
DAN00203-BA - Effective genetic control of Septoria tritici blotch (STB)°	Grains Research and Development Corporation		YES	
CES00003 - Aphid and insecticide resistance management in oilseed and pulse crops°	Grains Research and Development Corporation		YES	
CSP00192 - Development of gene deployment strategies: using evolutionary principles to optimise the development of genetic resistance in crops	Grains Research and Development Corporation		YES	
UNE00022 - Evaluating testing methods for phosphorus and potassium soil reserves (2015.04.0°	Grains Research and Development Corporation		YES	
UQ00078 - Deep placement of nutrients°	Grains Research and Development Corporation		YES	
DAN00204 - Conventional insecticide resistance in Helicoverpa – monitoring, management and°	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
RDP00015 - Grain Weeds Advisory Committee°	Grains Research and Development Corporation		YES	YES
UA00156 - Emerging weeds (Seed-bank biology of emerging weeds)°	Grains Research and Development Corporation	YES	YES	
CSE00059 - New knowledge to improve the timing of pest management decisions in grain crops°	Grains Research and Development Corporation		YES	
UQ00080 - New uses for existing chemistry°	Grains Research and Development Corporation		YES	
UA00158 - Mechanisms, evolution and inheritance of resistance°	Grains Research and Development Corporation		YES	
DAN00206 - Innovative approaches to managing subsoil acidity in the southern grain region°	Grains Research and Development Corporation		YES	
UCS00024 - Surveillance of herbicide resistant weeds in Australian grain cropping°	Grains Research and Development Corporation	YES	YES	
DAQ00201 - National Pest Information Service (NPIS)°	Grains Research and Development Corporation	YES	YES	YES
DAW00252 - Innovative approaches to managing subsoil acidity in the Western Region	Grains Research and Development Corporation		YES	
UWA00172 - WeedSmart - Stage Three	Grains Research and Development Corporation	YES	YES	
UA00159 - Improving wheat yields on sodic, magnesic, and dispersive soils°	Grains Research and Development Corporation		YES	
CFF00009 - Molecular markers for root hair traits and enhanced phosphorus use efficiency (PUE) in wheat°	Grains Research and Development Corporation		YES	
UMU00048 - Genetic approaches to reduce the nitrogen dilution effect and increase nitrogen-use efficiency (NUE) in wheat	Grains Research and Development Corporation		YES	
PRB00001 - Improving on-farm grain storage management practices through technical training°	Grains Research and Development Corporation		YES	
DAN00209 - eXtensionAUS Crop Nutrition Learning Network°	Grains Research and Development Corporation		YES	YES
DAV00146 - eXtensionAUS Field Crop Diseases Learning Network°	Grains Research and Development Corporation		YES	YES
ANU00025 - Using next generation approaches to exploit phenotypic variation in photosynthetic efficiency to increase wheat yield°	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
UWA00174 - A LONG-TERM STUDY TO INCREASE WATER USE EFFICIENCY, GRAIN YIELD AND THE PROFIT OF GROWERS IN THE WESTERN REGION IN A NO-TILL SYSTEM	Grains Research and Development Corporation		YES	
MRE00002 - Air inversion modelling to manage spray drift°	Grains Research and Development Corporation		YES	
UM00057 - 2016.03.15A Insecticide resistance management in RLEM and chemical sensitivities°	Grains Research and Development Corporation		YES	
DAS00160-BA - Biology and management of snails and slugs in grain crops°	Grains Research and Development Corporation		YES	
DAW00257 - Locally Important Weeds°	Grains Research and Development Corporation	YES	YES	
MCM00003 - Strategic oversight and coordination of grain protection chemicals°	Grains Research and Development Corporation		YES	
ANU00027 - Improving yield by optimising energy use efficiency°	Grains Research and Development Corporation		YES	
UQ00082 - Updated nutrient response curves in the northern and southern regions°	Grains Research and Development Corporation		YES	
CFF00010 - Genetic solution to crown rot in barley°	Grains Research and Development Corporation		YES	
UA00163 - Pulse Breeding Australia: Faba Bean Breeding°	Grains Research and Development Corporation		YES	
BN00002 - Soil Constraints-West Steering Committee°	Grains Research and Development Corporation		YES	
DAV00149 - 2016.05.07 Understanding the amelioration processes of the subsoil application of amendments in the Southern Region	Grains Research and Development Corporation		YES	
UWA00175 - An integrated platform for rapid genetic gain in pulse crops°	Grains Research and Development Corporation		YES	
DAN00212 - Pulse Breeding Australia (Chickpea)°	Grains Research and Development Corporation		YES	
GRS11003 - Roles of dual water:ion aquaporins in cereal osmotic stress response	Grains Research and Development Corporation		YES	
GRS11006 - Adult plant resistance and pathogen virulence in blackleg disease of canola	Grains Research and Development Corporation		YES	
AVP00003-A - Compaction Mitigation options for growers in the Albany and Kwinana West port zones	Grains Research and Development Corporation		YES	
Economic thresholds for the major pests reducing profitability in the Australian grains industry	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
SFS00032 - Harvest weed seed control for the southern region - 2015.03.06D	Grains Research and Development Corporation	YES	YES	
Cultural management for weed control and maintenance of crop yield	Grains Research and Development Corporation	YES	YES	
DAS00162-A: Validating recent research on break crop options in the low rainfall zone to determine the best options for the different climate, soil type and biotic stress situations	Grains Research and Development Corporation		YES	
DAN00175 - National Crown rot epidemiology and management program	Grains Research and Development Corporation		YES	
DAQ00186-USQ - Improving grower surveillance, management epidemiology knowledge and tools to manage crop disease - DAFFQ	Grains Research and Development Corporation		YES	
DAS00133-BA - Improved Resistance to oat pathogens and abiotic stress management	Grains Research and Development Corporation		YES	
DAN00202 New tools and germplasm for Australian pulse and oil seeds breeding programs to respond to changing virus threats	Grains Research and Development Corporation		YES	
DAV00128 - National nematode epidemiology and management program	Grains Research and Development Corporation		YES	
DAS00165-BA - Assessment of N and water co-limitations by remote sensing as a tool to improve wheat and canola profitability and manage risk	Grains Research and Development Corporation		YES	
DAW00228 - National pathogen management modelling and delivery of decision support	Grains Research and Development Corporation		YES	
DAS00166-BA - Improving profit and reducing risk by managing nitrogen in wheat and extreme temperature in pulses	Grains Research and Development Corporation		YES	
HIP00001 Herbicide Innovation Partnership	Grains Research and Development Corporation	YES	YES	
GRS10780 - Grains Industry Research Scholarship - Adam Taranto (ANU) Components of Immunity to Stagonospora nodorum in Wheat	Grains Research and Development Corporation		YES	
GRS10932 - Grains Industry Research Scholarship - Joseph Barry (USQ) A comparison of the growth patterns of three root pathogens in wheat.	Grains Research and Development Corporation		YES	
GRS10695 - Grains Industry Research Scholarship - Sarah Lorberg (UQ) Novel sources of disease resistance in Brassica	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
DAS00167-BA - Regional Agronomy SA - Improving disease management through improved agronomic practices	Grains Research and Development Corporation		YES	
DAS00168-BA - Regional Agronomy SA - Improving weed management in high break crop intensity farming systems	Grains Research and Development Corporation		YES	
DAS00169-BA - Improving sustainable productivity and profitability of Mallee farming systems with a focus on soil improvements	Grains Research and Development Corporation		YES	
GRS10941 Belinda Worland (UQ) Identification of nitrate transporters and corresponding regulatory and metabolic genes under variable conditions of nitrate supply in diverse Sorghum bicolor genotypes for improved nitrogen use	Grains Research and Development Corporation		YES	
CUR00023-BA-1 - Centre for crop and disease management – 8+ years	Grains Research and Development Corporation		YES	
US00074 - Development of genetic tools for Australian barley crops against leaf rust	Grains Research and Development Corporation		YES	
UA00157 - Development of tools to accelerate nematode resistance gene deployment	Grains Research and Development Corporation		YES	
US00075 - Integrated Genetic Solutions to Crown Rot in Wheat	Grains Research and Development Corporation		YES	
US00083 - ARC Research Hub for Legumes for Sustainable Agriculture	Grains Research and Development Corporation		YES	
US00084 - Innovative crop weed control for northern region cropping systems	Grains Research and Development Corporation		YES	
USQ00019 - Genetic control of nematode species affecting major crops - Germplasm enhancement for nematode control in cereals and pulses	Grains Research and Development Corporation		YES	
UT00030 - Effective control of barley yellow dwarf virus (BYDV) in wheat	Grains Research and Development Corporation		YES	
UWA00170 2015.03.17 ? Emerging foliar diseases of canola	Grains Research and Development Corporation		YES	
DAV00158 -DEPI BA-2- Quantifying the value of pulse grains	Grains Research and Development Corporation		YES	
DAQ00211 - Quantifying the effectiveness of cover crops as a means of increased water infiltration and reduced evaporation in the northern region	Grains Research and Development Corporation		YES	
CSE00061 - PYC106 - CSIRO Snail biocontrol revisited – Phase 2	Grains Research and Development Corporation		YES	
UMU00046 Improved Adaption of Barley to Acid Soils	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
UM00059 - PYC106 - Control of Snails and Slugs - New products for snail and slug control*- Biological control of slugs using ciliate protozoa	Grains Research and Development Corporation		YES	
DAW00258 Overcoming constraints to profitable cropping on forest gravel soils of the Western Region	Grains Research and Development Corporation		YES	
Australian National Vetch Breeding Program	Grains Research and Development Corporation		YES	
National Soybean Breeding Program 2017 to 2019	Grains Research and Development Corporation		YES	
Australian Cereal Rust Control Program - Continued monitoring of cereal rust pathogens in Australia	Grains Research and Development Corporation		YES	
CSP00208 - Optimising whole-farm water use efficiency and risk using whole farm bioeconomics - Postdoctoral Fellow aligned to Northern farming Systems projects	Grains Research and Development Corporation		YES	
Leveraging generic resources and associated data from Chickpea Feed the Future Innovation Lab in the US	Grains Research and Development Corporation		YES	
Improved surveillance and management options for mice in crops	Grains Research and Development Corporation		YES	
Determining the effectiveness of zinc phosphide rodenticide bait in the presence of alternative food supply	Grains Research and Development Corporation		YES	
Commonwealth Grant – Improving Plant Pest Management Through Cross Industry Deployment of Smart Sensor, Diagnostics and Forecasting	Grains Research and Development Corporation		YES	
Intelligent Robotic Non-Chemical Weeding	Grains Research and Development Corporation		YES	
Post-doctoral Fellowship - Managing soil constraints with On-Row Seeding Systems for the Low Rainfall Zone	Grains Research and Development Corporation		YES	
Future Farm Phase 2: Improving farmer confidence in targeted N management through automated sensing and decision support	Grains Research and Development Corporation		YES	YES
Stealth Plow: Mechanical control of hard to kill weeds with minimum soil disturbance.	Grains Research and Development Corporation	YES	YES	
A simple and innovative test for real-time detection of resistance in weeds	Grains Research and Development Corporation		YES	
Increasing the effectiveness of nitrogen fixation in pulse crops through development of improved rhizobial strains, inoculation and crop management practices	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
Tailoring an integrated solution to effectively address subsoil constraints by incorporation of chemically-balanced nano-amendments	Grains Research and Development Corporation		YES	
Non-chemical Weed Control System - Integrated Harrington Seed Destructor Accessibility Expansion - Design for Combine Harvesters Class 5 to 8	Grains Research and Development Corporation		YES	
Russian Wheat Aphid Risk Assessment and Regional Thresholds	Grains Research and Development Corporation		YES	
In field assessment of selected soil properties and plant N contents using IR Spectroscopy	Grains Research and Development Corporation		YES	
Biosolids to overcome subsoils constraints in the Victorian grain growing soils	Grains Research and Development Corporation		YES	
High work rate 'plough and sow' technology for farm-scale sandy soil amelioration	Grains Research and Development Corporation		YES	
Adapted barley germplasm with waterlogging tolerance for the Southern and Western regions	Grains Research and Development Corporation		YES	
More nitrogen from pulse crops for growers in the Southern region	Grains Research and Development Corporation		YES	
Using soil and plant testing data to better inform nutrient management and optimise fertiliser investments for grain growers in the southern region	Grains Research and Development Corporation		YES	
Post-doctoral Fellowship - Crop lower limit: Root water extraction responses to soil properties as key to variability in PAWC - aligned to CSP00210	Grains Research and Development Corporation		YES	
BA - Development, characterisation and incorporation of novel herbicide tolerance traits in pulse crops.	Grains Research and Development Corporation		YES	
Lupin Breeders Toolbox - A Resource for Lupin Genetic Improvement	Grains Research and Development Corporation		YES	
Post-Doctoral Fellowship – Understanding mechanisms of subsoil amelioration	Grains Research and Development Corporation		YES	
Post-Doctoral Fellowship - Improving root growth in dispersive soils	Grains Research and Development Corporation		YES	
GLP residue study - Trifluralin residues in oats	Grains Research and Development Corporation		YES	
Post-Doctoral Fellowship - More profit from lentils through enhanced tolerance of waterlogging and improved canopy management	Grains Research and Development Corporation		YES	
Managing Weeds in the GRDC Northern Grains Region - Development of technical content	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
Licence and Support Contract – Crop Diseases Mobile Application	Grains Research and Development Corporation		YES	
Post-doctoral Fellowship - Interfacing crop improvement and agronomy/ nutrition programs	Grains Research and Development Corporation		YES	
Post-doctoral Fellowship - When are earwigs pests and when are they beneficial?	Grains Research and Development Corporation		YES	
Managing Weeds in the GRDC Northern Grains Region – Co-ordination of workshop material; and establishment and monitoring of regional focus paddocks	Grains Research and Development Corporation		YES	
Managing early season canola pests in New South Wales - Establishment and coordination of grower/ advisor groups	Grains Research and Development Corporation		YES	YES
Post-doctoral Fellowship - An integrative approach towards sustainable management of sorghum stalk rot in the GRDC northern region	Grains Research and Development Corporation		YES	
Agvet R2#006 Grant Agreement - Field peas x Silver grass - Priority Use	Grains Research and Development Corporation		YES	
Agvet R2#007 Grant Agreement - Lentils x grass weeds & Lentils x broadleaf weeds - Priority Use	Grains Research and Development Corporation		YES	
Agvet R2#008 Grant Agreement - Lupins x wild radish & other broadleaf weeds - Priority Use	Grains Research and Development Corporation		YES	
Agvet R2#009 Grant Agreement - Mung beans x grass weeds & Mung beans x broadleaf weeds - Priority Use	Grains Research and Development Corporation		YES	
Agvet R2#010 Grant Agreement -Oats x Grasses and broadleaf weeds - Priority Use	Grains Research and Development Corporation		YES	
BFDC - Making Better Fertiliser Decision for Cropping Systems in Australia, phase 3	Grains Research and Development Corporation		YES	
Understanding mouse biology and ecology in zero- and no-till cropping systems to inform best practice crop production and mouse management practices	Grains Research and Development Corporation		YES	
GRDC Communities - crop nutrition	Grains Research and Development Corporation		YES	
GRDC Communities - field crop diseases	Grains Research and Development Corporation		YES	
Pulse Check - local extension and communication for profitable pulse production in Coast & Tablelands	Grains Research and Development Corporation		YES	YES
Pulse Check – local extension and communication for profitable pulse production in South West NSW	Grains Research and Development Corporation		YES	YES

Program	Provider	Environment	Economic	Social
Pulse Check – local extension and communication for profitable pulse production in Central West NSW	Grains Research and Development Corporation		YES	YES
Pulse Check- local extension and communication for profitable pulse production in North West NSW	Grains Research and Development Corporation		YES	YES
Pulse Check - local extension and communication for profitable pulse production in North East NSW	Grains Research and Development Corporation		YES	YES
Pulse Check – local extension and communication for profitable pulse production in Central QLD	Grains Research and Development Corporation		YES	YES
Pulse Check – local extension and communication for profitable pulse production in Liverpool Plains	Grains Research and Development Corporation		YES	YES
Pulse Check – local extension and communication for profitable pulse production in Central East NSW	Grains Research and Development Corporation		YES	YES
Pulse Check – local extension and communication for profitable pulse production in Eastern Downs QLD	Grains Research and Development Corporation		YES	YES
Pulse Check – local extension and communication for profitable pulse production in Western Downs QLD	Grains Research and Development Corporation		YES	YES
Pulse Check – local extension and communication for profitable pulse production in South East NSW	Grains Research and Development Corporation		YES	YES
Pulse Chemical Stewardship Program	Grains Research and Development Corporation		YES	
DAV00153 - Pulse Breeding Australia: Field Pea Breeding	Grains Research and Development Corporation		YES	
DAV00154 - Pulse Breeding Australia: Lentil Breeding	Grains Research and Development Corporation		YES	
IRE00002 - State-of-the-art Automated Pipe Through the Bank irrigation layout	Grains Research and Development Corporation		YES	
UQ00086 - Fertiliser form and soil interactions when applied in high concentration bands – Post-Doctoral Fellow aligned UQ00063	Grains Research and Development Corporation		YES	
DAQ00210 - National Mung Bean Improvement Program	Grains Research and Development Corporation		YES	
Improved sampling methods to better predict nutrient availability and supply for soils in the Western region	Grains Research and Development Corporation		YES	
UWA00171 - Australian Herbicide Resistance Initiative - Phase 5	Grains Research and Development Corporation	YES	YES	

Program	Provider	Environment	Economic	Social
DAN00213-BA2 - NSW DPI Bilateral Agreement - Winter Pathology	Grains Research and Development Corporation		YES	
Agvet #051 Grant Agreement -Adzuki beans - Thrips- Priority Use-ISK	Grains Research and Development Corporation		YES	
Agvet #046 Grant Agreement -Peanuts - Aphids/Mealybugs - Priority Use -Bayer	Grains Research and Development Corporation		YES	
Agvet #045 Grant Agreement-Mungbeans-powdery mildew-Priority Use-Adama	Grains Research and Development Corporation		YES	
Agvet #052 Grant Agreement- Canola - Aphids - Priority Use -ISK	Grains Research and Development Corporation		YES	
Agvet #044 Grant Agreement -Adzuki beans/Mungbeans -Mites-Priority Use-Adama	Grains Research and Development Corporation		YES	
Agvet #050 Grant Agreement - Maize/popcorn - Northern blight - Priority Use - BASF	Grains Research and Development Corporation		YES	
Agvet #049 Grant Agreement -Chickpeas-Botrytis-Priority Use-BASF	Grains Research and Development Corporation		YES	
Agvet #048 Grant Agreement -Soybeans - Rust/Sclerotinia - Priority Use -Bayer	Grains Research and Development Corporation		YES	
Agvet #047 Grant Agreement - Sunflowers - Powdery mildew - Priority Use-Bayer	Grains Research and Development Corporation		YES	
Increasing profit from N, P and K fertiliser inputs into the evolving cropping sequences in the Western Region	Grains Research and Development Corporation		YES	
Nutrient re-distribution and availability in ameliorated and cultivated soils in the Western Region	Grains Research and Development Corporation		YES	
DAS00174 - Improving chickpea adoption to environmental challenges in Australia and India	Grains Research and Development Corporation		YES	
Positioning the Soil Wetting Agent Technology for Commercial Success	Grains Research and Development Corporation		YES	
IAC00003 - Development of a New Rodenticide	Grains Research and Development Corporation		YES	
DAN9175799 - Future Durum Breeding	Grains Research and Development Corporation		YES	
UWA00173 - Capacity building to understand plant energy efficiency in harsh environments	Grains Research and Development Corporation		YES	
Endophytes for insect management in cereals	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
BWD9175825 - Building capacity, skills and knowledge for the pulse industry in the Southern Region: Supporting expansion of high value pulses into new areas and ensuring sustained profitability of all key pulse crops in existing areas	Grains Research and Development Corporation		YES	YES
Pathways to Registration - Minor Use	Grains Research and Development Corporation		YES	
GRS - Protecting the Australian Pulse Industries from Diamondback Moth infestations.	Grains Research and Development Corporation		YES	
GRS - Evolution and management of Group J resistance in annual ryegrass (Lolium rigidum)	Grains Research and Development Corporation		YES	
Economics of ameliorating soil constraints in the northern region: Economics of adoption	Grains Research and Development Corporation		YES	
GRS - Extent, distribution and management of herbicide resistant common sowthistle and prickly lettuce in lentils	Grains Research and Development Corporation		YES	
GRS Understanding Invasiveness of Wild Oat in - Wheat Production under Drought and Heat Stress in Conservation Agriculture	Grains Research and Development Corporation		YES	
RDC - RnD4Profit-115-02-005 - New biocontrol solutions for sustainable management of weed impacts to agricultural productivity	Grains Research and Development Corporation		YES	
Economics of ameliorating soil constraints in the northern region: Spatial soil constraint diagnoses	Grains Research and Development Corporation		YES	
Economics of ameliorating soil constrains in the northern region: Program co-ordination – communication, extension and evaluation	Grains Research and Development Corporation		YES	
Economics of ameliorating soil constraints in the northern region: Soil constraint management and amelioration	Grains Research and Development Corporation		YES	
GRS - Common rust of maize	Grains Research and Development Corporation		YES	
Australian Cereal Rust Control Program - Wheat and barley breeding support	Grains Research and Development Corporation		YES	
Boosting profit and reducing risk on mixed farms in low and medium rainfall areas with newly discovered legume pastures enabled by innovative management methods – southern region.	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
GRDC Research Scholarship - Genome-wide identification of disease resistance genes in the Brassicaceae and characterisation of their DNA methylation status in Brassica napus	Grains Research and Development Corporation		YES	
Low weed seed bank persistence under sustained integrated weed management	Grains Research and Development Corporation	YES	YES	
Australian Cereal Rust Control Program - Novel sources of stem rust resistance from uncultivated wild relatives of wheat	Grains Research and Development Corporation		YES	
Benefits of foliar micronutrients on cereals in a low rainfall environment	Grains Research and Development Corporation		YES	
Australian Cereal Rust Control Program (ACRCP) - CSIRO: Delivering genetic tools and knowledge required to breed wheat and barley with resistance to leaf rust, stripe rust and stem rust	Grains Research and Development Corporation		YES	
Tactics for improving rooting depth and crop yield on sodic soils	Grains Research and Development Corporation		YES	
Incorporating lime to depth in duplex wheatbelt soils	Grains Research and Development Corporation		YES	
Boosting profit and reducing risk on mixed farms in low and medium rainfall areas with newly discovered legume pastures enabled by innovative management methods – Western region (Dryland pasture legume systems).	Grains Research and Development Corporation		YES	
Optimising timing and rate of Nitrogen application in waterlogging conditions in the Esperance Port Zone	Grains Research and Development Corporation		YES	
Australian Cereal Rust Control Program (ACRCP) - University of Sydney: Delivering genetic tools and knowledge required to breed wheat and barley with resistance to leaf rust, stripe rust and stem rust	Grains Research and Development Corporation		YES	
Development of local strategies to enable the integrated and profitable management of annual ryegrass seed banks in high rainfall zone farming systems of the Southern Region	Grains Research and Development Corporation		YES	
Soil Quality iBook	Grains Research and Development Corporation		YES	
Demonstrations of Legume crops for reliable profitability in the Albany Port Zone	Grains Research and Development Corporation		YES	
Seeding systems to improve cereal crop establishment on heavy textured soils	Grains Research and Development Corporation		YES	
9176093 - PulseBio Project 3: Stable grain yield in pulses through improved stress tolerance (P3)	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
Demonstrating the benefits of soil amelioration and controlled traffic practices across a broad range of soil types in Western Australia.	Grains Research and Development Corporation		YES	
Chafflining in the Geraldton port zone - a new, cost effective harvest weed seed control tool	Grains Research and Development Corporation		YES	
9176121 - PulseBio 4: Biosecure pulse seeds	Grains Research and Development Corporation		YES	
Optimising timing and rate of Nitrogen application in waterlogging conditions in the Western Region	Grains Research and Development Corporation		YES	
Demonstration of Legume crops for profitability in the Western Region	Grains Research and Development Corporation		YES	
Legumes for profitability in the Esperance Port Zone	Grains Research and Development Corporation		YES	
Practical and applied workshops and communications to promote key messages and resources to maximise the effectiveness of spray applications in the southern region	Grains Research and Development Corporation		YES	
Supporting the sustainable use of insecticides and local on-farm implementation of integrated pest management strategies in the GRDC Southern region	Grains Research and Development Corporation		YES	
Mentoring a new scientist to manage soilborne fungal diseases	Grains Research and Development Corporation		YES	
Molecular Diagnostic Centre national disease surveillance	Grains Research and Development Corporation		YES	
Improved disease management in South Australian field crops through surveillance, diagnostics and epidemiology knowledge	Grains Research and Development Corporation		YES	
9176339 - Managing eyespot in intensive cereal, stubble retention farming systems in South Australia	Grains Research and Development Corporation		YES	
Ensuring long-term, applied, field-based cereal pathology and capability for South Australia	Grains Research and Development Corporation		YES	
Ensuring long-term, applied, field-based cereal entomology and capability for South Australia.	Grains Research and Development Corporation		YES	
Monitoring Diamondback Moth for forecasting and adaptive management of outbreak and insecticide resistance risk.	Grains Research and Development Corporation		YES	
Optimising mungbean yield in the northern region - Mungbean Physiology	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
PBRI - Plant Biosecurity Research Initiative Collaboration and Funding Agreement	Grains Research and Development Corporation		YES	
Optimising mungbean yield in the northern region - Mungbean Agronomy	Grains Research and Development Corporation		YES	
Disease epidemiology and management tools for Australian grain growers	Grains Research and Development Corporation		YES	
GRS (Andrew Longmire)- Hyperspectral remote sensing of wheat crops for rapid assessment of effective nutrient status and improved crop growth model performance	Grains Research and Development Corporation		YES	
Herbicide behaviour workshops for the Australian Grains Industry	Grains Research and Development Corporation	YES	YES	
Preserving Australia's Rhizobial Collections to Benefit the Australian Grain Industry	Grains Research and Development Corporation		YES	
Increasing the effectiveness of nitrogen fixation in pulses through improved rhizobial strains in the GRDC Northern region	Grains Research and Development Corporation		YES	
Spray Drift Inversion Hazard System Program Coordination	Grains Research and Development Corporation		YES	
Early and Effective Summer Weed Control: A Workshop Series for the WA Grainbelt	Grains Research and Development Corporation		YES	
Extent of RLN throughout the grain growing regions of WA and options to address	Grains Research and Development Corporation		YES	
National Resistance Monitoring for Insect Pests of Stored Grain.	Grains Research and Development Corporation		YES	
Post Doctoral Fellowship -Maximising crops and minimising weeds with smart phase farming	Grains Research and Development Corporation		YES	
GRANT: A holistic approach to seep management for preventing land degradation in the landscape	Grains Research and Development Corporation		YES	
Updating GRDC spray application resources	Grains Research and Development Corporation		YES	
GRS (Emily Mackie) - Development of herbicide cocktails with a novel mode of action for circumventing resistance mechanisms.	Grains Research and Development Corporation	YES	YES	
GRS (Kaylene Ballard) - The bioactivity and functionality of the molecular and microbial components of snail mucus	Grains Research and Development Corporation		YES	
Demonstrating and validating the implementation of integrated weed management strategies to control barley grass in the low rainfall zone farming systems	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
Updating Spray Application Resources	Grains Research and Development Corporation		YES	
Discussion groups: managing drought conditions and planning for post drought recovery	Grains Research and Development Corporation		YES	YES
Increasing the effectiveness of nitrogen fixation in pulses through improved rhizobial strains in the GRDC Western Region	Grains Research and Development Corporation		YES	
Facilitated discussion groups: Managing Drought Conditions and planning for post drought recovery	Grains Research and Development Corporation		YES	YES
Expanding the sowing window for canola and lupins – what works in WA?	Grains Research and Development Corporation		YES	
Re-engineering soils to improve the access of crop root systems to water and nutrients stored in the subsoil.	Grains Research and Development Corporation		YES	
High Value Pulses – Raising awareness, optimising yield and expanding the area of lentil, chickpea and faba bean in Western Australia	Grains Research and Development Corporation		YES	
Increasing farming system profitability and longevity of benefits following soil amelioration	Grains Research and Development Corporation		YES	
Increased grower profitability on soils with sodicity and transient salinity in the eastern grain belt of the Western Region.	Grains Research and Development Corporation		YES	
Extension of best practice principles for identifying and managing soil limitations in southern and central NSW	Grains Research and Development Corporation		YES	
Development and validation of soil amelioration and agronomic practices to realise the genetic potential of grain crops grown under a high yield potential, irrigated environment in the northern and southern regions.	Grains Research and Development Corporation		YES	
Facilitated action learning groups to support profitable irrigated farming systems in the northern and southern regions.	Grains Research and Development Corporation		YES	YES
Determination of residue of glyphosate in linseed following a single foliar application of glyphosate (as Weedmaster ARGO)	Grains Research and Development Corporation		YES	
Post-doctoral Fellowship - Understanding sorghum root growth and function in cold soils aligned to UOQ1808-001RTX	Grains Research and Development Corporation		YES	
Identification, surveillance and advisory platform for management of grains pests	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
Validation of spray droplet movement under different surface air inversion conditions	Grains Research and Development Corporation		YES	
The adaption of pulses (chickpea and lentil) across the northern grains region.	Grains Research and Development Corporation		YES	
Upskilling Tasmanian growers and advisors to manage annual ryegrass through exposure to external knowledge and peer-to-peer learning	Grains Research and Development Corporation		YES	YES
Survey of vertebrate and invertebrate pests and beneficials harbouring in harvest weed-seed control systems	Grains Research and Development Corporation		YES	
Non-wetting management options for growers in the Albany port zone	Grains Research and Development Corporation		YES	
"Under Cover Downunder - Getting Fair Dinkum About Soil Health"	Grains Research and Development Corporation	YES	YES	
Survey Of The Summer/Autumn Brassica Refuges For Diamondback Moth In The Western Region To Predict Early Season Risk Of Infestation	Grains Research and Development Corporation		YES	
Australian Fungicide Resistance Extension Network (AFREN): fungicide resistance management targeted at regional level	Grains Research and Development Corporation		YES	
Program 2 - Towards Effective Control of Blackleg of Canola: Coordinating international blackleg research and development	Grains Research and Development Corporation		YES	
Optimising farm scale returns from irrigated grains: maximising dollar return per megalitre of water	Grains Research and Development Corporation		YES	
Towards Effective Control of Blackleg of Canola Program 1: Disease Epidemiology And Management	Grains Research and Development Corporation		YES	
Australian Pulse Conference 2019	Grains Research and Development Corporation		YES	YES
Program 4 - Towards Effective Control of Blackleg of Canola: Phenotyping for Adult Plant Resistance (APR - Quantitative Resistance) in canola	Grains Research and Development Corporation		YES	
Program 3: Towards Effective Control of Blackleg of Canola: Identification of novel sources of blackleg resistance genes	Grains Research and Development Corporation		YES	
Surface and sub-surface runoff systems and their relevance to crop management decision-making in southern coastal areas of WA	Grains Research and Development Corporation		YES	
Pilot workshops - why weeds grow where they do and how to control them	Grains Research and Development Corporation	YES	YES	

Program	Provider	Environment	Economic	Social
Novel suppression and resistance management of invertebrate pests	Grains Research and Development Corporation		YES	
Multi-species DNA chip platform - A resource for pulse genetic improvement	Grains Research and Development Corporation		YES	
Program 5 - Towards Effective Control of Blackleg of Canola : Canola infrastructure and FFS	Grains Research and Development Corporation		YES	
Post-Doctoral Fellowship: Unravelling the relationships between soil mixing uniformity by spading and crop response	Grains Research and Development Corporation		YES	
Understanding the value of Delta-T with for ground spray application with VC, XC & UC	Grains Research and Development Corporation		YES	
New knowledge and practices to address topsoil and subsurface acidity under minimum tillage cropping systems of South Australia	Grains Research and Development Corporation		YES	
Post-doctoral Fellowship: A Model for Predicting Chickpea Ascochyta Blight Risk	Grains Research and Development Corporation		YES	
Post-doctoral Fellowship: Understanding gene flow in mouse populations to improve management outcomes	Grains Research and Development Corporation		YES	
Post-Doctoral Fellowship: Exploiting the Potential of a Novel Fungal Biofertiliser	Grains Research and Development Corporation		YES	
Increasing knowledge and profitability of cropping on Ironstone gravel soils	Grains Research and Development Corporation		YES	
New methods of snail control	Grains Research and Development Corporation		YES	
Australian Pulse Opportunity Analysis	Grains Research and Development Corporation		YES	
NVT Pathology Services SARDI	Grains Research and Development Corporation		YES	
NVT Pathology Services Agreement WAAA	Grains Research and Development Corporation		YES	
Integrated weed management of herbicide resistant annual ryegrass at Lake Bolac	Grains Research and Development Corporation	YES	YES	
Herbicide options for the management of emerging summer grass weeds in winter cereals	Grains Research and Development Corporation	YES	YES	
NVT Pathology Services Agreement NSWDPI	Grains Research and Development Corporation		YES	
NVT Pathology Services DPJR	Grains Research and Development Corporation		YES	
NVT pathology services USQ	Grains Research and Development Corporation		YES	
National blackleg ratings	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
NVT Pathology Services Agreement DAFQ	Grains Research and Development Corporation		YES	
Post-Doctoral Fellowship - Predicting weed seed dynamics in farming systems aligned to CFF00011	Grains Research and Development Corporation		YES	
Durum Crown Rot benchmarking for improved grower access to durum varieties with greater Crown Rot resistance	Grains Research and Development Corporation		YES	
Post-doctoral Fellowship: Understanding P dynamics and bioavailability in alkaline clay soils aligned to UQ00082.	Grains Research and Development Corporation		YES	
Virtual fencing for better crop integrated weed management	Grains Research and Development Corporation	YES	YES	
Summer Weed Survey of Western Australian Cropping Districts	Grains Research and Development Corporation	YES	YES	
Integrated disease management strategies for southern region cereal and pulse growers	Grains Research and Development Corporation		YES	
New capability to survey pulse and cereal crops for root pathogens	Grains Research and Development Corporation		YES	
Managing Botrytis diseases in intensive pulse cropping systems	Grains Research and Development Corporation		YES	
Integrated disease management in western region grain crops	Grains Research and Development Corporation		YES	
Hydrogen to Ammonia Research and Development Project	Grains Research and Development Corporation		YES	
Integrated disease management tools to manage summer crop diseases in the northern region	Grains Research and Development Corporation		YES	
Surveys and associated diagnostics of the incidence and severity of diseases of cereals and pulses within the Southern Region (Victoria).	Grains Research and Development Corporation		YES	
Accelerating Post-Entry Quarantine (PEQ) processing and delivery of 1st batch of wild-elite chickpea segregation population	Grains Research and Development Corporation		YES	
Surveys and associated diagnostics of the incidence and severity of diseases of cereals and pulses within the Northern Region	Grains Research and Development Corporation		YES	
Surveys and associated diagnostics of the incidence and severity of diseases of cereals, pulses and oilseeds in the Western Region	Grains Research and Development Corporation		YES	
Post-Doctoral Fellowship: Understanding causes of physical constraints in sandy soils and implications for targeted deep tillage	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
Post-doctoral Fellowship: Integrating yield optimisation in mungbean aligned to UOQ1807-003RTX.	Grains Research and Development Corporation		YES	
Increasing regional capacity in identification of crown root infection of Rhizoctonia in the low rainfall zone of the Southern Region	Grains Research and Development Corporation		YES	
Ripper Gauge - Demonstrating The Impact Of Deep Ripping Timing	Grains Research and Development Corporation		YES	
Glyphosate use in barley, for pre-harvest desiccation and spray topping of weeds.	Grains Research and Development Corporation	YES	YES	
Validation and demonstration of decision-making tools for managing blackleg in Canola in the Western Region	Grains Research and Development Corporation		YES	
Investigating snail rollers to clean small conical snails out of barley and canola	Grains Research and Development Corporation		YES	
Elders Bendigo and Albury Grower Herbicide Resistance Management Study Tour to WA	Grains Research and Development Corporation	YES	YES	
21st and 22nd Australasian Weeds Conference	Grains Research and Development Corporation		YES	YES
Transitioning to the Chickpea Breeding Program 2020-2025	Grains Research and Development Corporation		YES	
Maintain the longevity of soils constraints investments and increase grower adoption through extension - western region	Grains Research and Development Corporation		YES	
Leveraging Existing International Germplasm to Deliver Improved Acid Soil Tolerance Chickpea for Australian Growers (GRDC/USA/Ethiopia Initiative)	Grains Research and Development Corporation		YES	
Development of ‘Nowcasting’ ability for hazardous and non-hazardous atmospheric conditions for agricultural spraying	Grains Research and Development Corporation		YES	
Insecticide resistance in the green peach aphid: national surveillance, preparedness and implications for virus management	Grains Research and Development Corporation		YES	
Commercial-in-Confidence: Development of Davren™ SAS Insect Control for the Grains Industry	Grains Research and Development Corporation		YES	
Manganese (Mn) solutions to understand and manage the incidence of split seed in high yielding lupin varieties	Grains Research and Development Corporation		YES	
Improving The Adaptation And Profitability Of High Value Pulses (Chickpea And Lentil) Across Australian Agroecological Zones	Grains Research and Development Corporation		YES	
UNDERSTANDING SOILS TO ASSESS AMELIORATION POTENTIAL IN THE SOUTHERN WIMMERA	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
National Workshop on Pulse Phenology - 4-5 September 2019	Grains Research and Development Corporation		YES	
Determination of Fipronil residues in Soybean after an in-furrow treatment at planting.	Grains Research and Development Corporation		YES	
Determination of clothianidin residues in mungbeans and navy beans following the application of SHIELD SYSTEMIC INSECTICIDE	Grains Research and Development Corporation		YES	
AGVet R4 - Determination of Clethodim residues in Linseed after a single foliar application (BBCH39)	Grains Research and Development Corporation		YES	
Spray Forum - for improved understanding of safe spray practices to ensure that any negative impacts of spray drift or chemical misuse are minimised on the Darling Downs	Grains Research and Development Corporation		YES	
Sprayer calibration / application workshops to increase spray efficiency and efficacy	Grains Research and Development Corporation		YES	
Demonstrating the effects of reduced lupin seed integrity on crop establishment	Grains Research and Development Corporation		YES	
Most Common Weeds: The Ute Guide - Provision of content and image identification	Grains Research and Development Corporation	YES	YES	
GAPP BLG101: Chickpea root quantification: an applied research tool to understand variety and management effects on root distribution, activity and abiotic resistance/tolerance	Grains Research and Development Corporation		YES	
GAPP BLG103: Pilot study: Effect of plant type on biomass accumulation and water use efficiency (WUE).	Grains Research and Development Corporation		YES	
GAPP BLG107: Determine optimum plant types and canopy management for high yielding environments of southern NSW and establish a relationship between photothermal quotient and grain yield of canola.	Grains Research and Development Corporation		YES	
GAPP BLG111: Does improving chilling tolerance of chickpea increase and stabilize yield and improve farming system ‘fit’	Grains Research and Development Corporation		YES	
GAPP BLG112: The adaptation of profitable pulses in the central and southern zones of the Northern Grains Region.	Grains Research and Development Corporation		YES	
GAPP BLG202: Management and Surveillance of Lupin Anthracnose in NSW	Grains Research and Development Corporation		YES	

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GAPP BLG203: Resistance to Stemphylium blight in faba bean and studies on its epidemiology to assist in the development of a control strategy	Grains Research and Development Corporation		YES	
GAPP BLG204: Monitoring aphid vectors to develop a pulse virus prediction and management program.	Grains Research and Development Corporation		YES	
GAPP BLG205: Improving management of Phytophthora root rot of chickpea	Grains Research and Development Corporation		YES	
GAPP BLG206: IDM for Broadleaf Crops in southern and central NSW	Grains Research and Development Corporation		YES	
GAPP BLG207: Southern NSW winter cereals integrated disease management and surveillance of fungal pathogens	Grains Research and Development Corporation		YES	
UA00143 - Australian Wheat and Barley Molecular Marker Program - Genetic Analysis°	Grains Research and Development Corporation		YES	
DAN00178 - Curation of Mapping Populations - Barley/Wheat°	Grains Research and Development Corporation		YES	
UA00147 - Genetic analysis of heat tolerance in wheat	Grains Research and Development Corporation		YES	
US00081 - 2016.02.01C - Introgression of heat-tolerant genes to broaden genetic variation in current wheat breeding populations	Grains Research and Development Corporation		YES	
UA00148 - Trait dicovery in wild barley using the nested-association mapping population HE°	Grains Research and Development Corporation		YES	
ICA00014 - Application of Focused Identification of Germplasm Strategy (FIGS) in Australian environment°	Grains Research and Development Corporation		YES	
USA00017 - Building capacity in stored grain facilities research at UniSA°	Grains Research and Development Corporation		YES	
PCA00003 - Australian Peanut Breeding Program°	Grains Research and Development Corporation		YES	
CSP00199 - Validation trials for dwarfing genes, vigour x management interactions, and preliminary assessment of rate of grain-filling	Grains Research and Development Corporation		YES	
DAW00256 - Building Crop Protection and Production Agronomy R&D Capacity in regional Wester°	Grains Research and Development Corporation		YES	
PHA00015 - Biosecurity preparedness for the grains industry - Preparation and review of eme°	Grains Research and Development Corporation		YES	

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US00080 - 2016.02.01G A national approach to improving heat tolerance in wheat through more efficient carbon allocation	Grains Research and Development Corporation	YES	YES	
ACP00009 - AVP1, PSTOL1 and NAS - Three high-value genes for higher wheat yield - International Wheat Yield Partnership	Grains Research and Development Corporation		YES	
CSP00202 - Identification of wheat frost tolerance loci using a combination of genetics, biochemistry and molecular approaches	Grains Research and Development Corporation		YES	
CSA00056 - Developing farming systems for the LRZ of Western Australia°	Grains Research and Development Corporation		YES	
ACP00010 - Benchmarking and field validation of transgenic frost tolerance wheat lines°	Grains Research and Development Corporation		YES	
CSP00203 - Increasing production on sandy soils in low and medium rainfall areas of the Sou°	Grains Research and Development Corporation		YES	
GRS11001 - Frost tolerance in wheat: Grain Research Scholarship for field-based phenotyping tools in pre-breeding	Grains Research and Development Corporation		YES	
ULA9175069 - Development of crop management packages for early sown, slow developing wheats in the Southern region	Grains Research and Development Corporation		YES	
CSP00169 - Achieving stable and high canola yield across the rainfall zones of WA	Grains Research and Development Corporation		YES	
UA00160 - Australian Research Council (ARC) Industrial Transformation Research Hubs: Genetic Diversity and molecular breeding for wheat in a hot and dry climate	Grains Research and Development Corporation		YES	
UMU00049 - 2016.02.01F - Maintenance of grain plumpness and transfer of heat tolerance into Australian barley germplasm	Grains Research and Development Corporation		YES	
DAS00148 Australian Pastures Genebank	Grains Research and Development Corporation		YES	
CTR00001 - Heat and Drought Wheat Improvement Consortium (HeDWIC) Proposal for an initial capability study	Grains Research and Development Corporation		YES	
CSP00210 - Methods to predict plant available water capacity (PAWC)	Grains Research and Development Corporation		YES	
MCV5 - Managing Climate Variability (MCV) - Phase V Investment	Grains Research and Development Corporation	YES	YES	
GRS - Adaptation of fast winter wheat genotypes to the Mediterranean semi-arid cropping regions of southern Australia	Grains Research and Development Corporation		YES	

Program	Provider	Environment	Economic	Social
GRS - Optimising crop predicted and produced yield through an intuitive and cost effective decision support tool	Grains Research and Development Corporation		YES	
Ripper Gauge Demonstration sites - Esperance Port Zone	Grains Research and Development Corporation		YES	
Canola pre-breeding investment to continue some activities conducted under DAN00208	Grains Research and Development Corporation		YES	
Improving grower profits through longer season wheat crops	Grains Research and Development Corporation		YES	
Rural R&D for Profit-16-13-007 Forewarned is forearmed: managing the impacts of extreme climate events	Grains Research and Development Corporation	YES	YES	
The provision of NVT Sorghum field trials: North Central QLD and South Central QLD	Grains Research and Development Corporation		YES	
Sorghum NVT	Grains Research and Development Corporation		YES	
National Oat Breeding Program	Grains Research and Development Corporation		YES	
Rooty: A root ideotype toolbox to support improved wheat yields	Grains Research and Development Corporation		YES	
GRS (Calum Watt) - Determining the genetic control of grain size and heat stress tolerance during flowering in barley	Grains Research and Development Corporation		YES	
GRS (Erin Hill) - Extracellular vesicles from Zymoseptoria tritici: investigating the non-classical secretion of pathogenicity factors by a fungal wheat pathogen	Grains Research and Development Corporation		YES	
Investigating phenology diversity in germplasm to optimise profitability from April sown oats	Grains Research and Development Corporation		YES	
7th International Symposium on Soil Organic Matter	Grains Research and Development Corporation		YES	
Post-doctoral Fellowship: Alternative phenotyping for reproductive stage frost tolerance using metabolite markers and identification of frost tolerance QTL in wheat - aligned to CSP00202	Grains Research and Development Corporation		YES	
Post-Doctoral Fellowship: Photosynthetic acclimation to high temperature in wheat aligned with US00080	Grains Research and Development Corporation		YES	
Post-Doctoral Fellowship: Minimising the impact of high temperature at flowering on spikelet fertility aligned to Project UMU00049	Grains Research and Development Corporation		YES	
Improving canola heat tolerance - a coordinated multidisciplinary approach	Grains Research and Development Corporation		YES	

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Using long season wheats for increases in profits and grazing opportunities	Grains Research and Development Corporation		YES	
Agronomic strategies for late breaking seasons	Grains Research and Development Corporation		YES	
Manipulation of stomata to increase yield potential in wheat (IWYP collaboration)	Grains Research and Development Corporation		YES	
GAPP BLG102: Pilot study: The influence of abiotic stresses on wheat sterility	Grains Research and Development Corporation		YES	
GAPP BLG106: Quantifying the effects of abiotic stresses on pulse growth and development - (1) Temperature - effect of stubble type, load and form on the thermal response of winter pulses.	Grains Research and Development Corporation		YES	
GAPP BLG108: Effects of heat stress on canola (pilot project) – Provisional research and protocol and hypothesis development.	Grains Research and Development Corporation		YES	
GAPP BLG306: Pod set at cool temperatures – opportunities for improvement in chickpeas	Grains Research and Development Corporation		YES	
DAW00198 - Managed Environment Facility (MEF) - Merredin°	Grains Research and Development Corporation		YES	
EAS00003 - The Provision of Field Trial Services for the National Variety Trials Program 20°	Grains Research and Development Corporation		YES	
SFS00035 - The Provision of Field Trial Services for the National Variety Trials Program 2015/16 - 2018/19	Grains Research and Development Corporation		YES	
BWD00029 - The Provision of Field Trial Services for the National Variety Trials Program 2015/16 - 2018/19	Grains Research and Development Corporation		YES	
UT00032 - The Provision of Field Trial Services for the National Variety Trials Program 2015/16- 2018/19	Grains Research and Development Corporation		YES	
DAN00211 - NVT Services Agreement°	Grains Research and Development Corporation		YES	
DAS00163 - NVT Services Agreement°	Grains Research and Development Corporation		YES	
LIV00002 - NVT Services Agreement°	Grains Research and Development Corporation		YES	
DAQ00206 - NVT Services Agreement°	Grains Research and Development Corporation		YES	
GRS10929 - Grains Industry Research Scholarship - Tahnee Manning (RMIT) Modification of photosynthesis by gene replacement in crop plants.	Grains Research and Development Corporation		YES	

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KAL00007 - The Provision of Field Trial Services for the National Variety Trials Program 2015/16-2018/19	Grains Research and Development Corporation		YES	
Managing early season canola establishment pests in New South Wales – Development of technical content	Grains Research and Development Corporation		YES	
The provision of NVT Sorghum field trials: Liverpool Plains	Grains Research and Development Corporation		YES	
NVT Services Agreement	Grains Research and Development Corporation		YES	
Partnership for Climate Research Strategy for Primary Industries (CRSPI)	Grains Research and Development Corporation	YES	YES	
Dealing with the Dry Forums	Grains Research and Development Corporation		YES	YES
AL13009 Better tree performance and water use efficiency through root system resilience	Hort Innovation		YES	
AP14023 Improving tree nutrition for the Australian apple industry	Hort Innovation	YES	YES	
VG16078 Soil Wealth and Integrated Crop Protection - Phase 2	Hort Innovation	YES	YES	YES
ST16004 Optimising nutrient management for improved productivity and fruit quality in mangoes	Hort Innovation	YES		
ST16005 Optimising nutrient management for improved productivity and fruit quality in cherries.	Hort Innovation	YES		
MT17016 Coir Waste Management for Hydroponics in Berry	Hort Innovation	YES	YES	
PH15001 Healthy bee populations for sustainable pollination in horticulture	Hort Innovation	YES		
VG16063 The EnviroVeg program 201-2022	Hort Innovation			
HA19001 A Sustainability Framework for Horticulture	Hort Innovation	YES	YES	YES
AL14006 Managing Almond production in a variable and changing climate	Hort Innovation	YES		
MC15007 Still wild about macadamias - conserving a national icon	Hort Innovation	YES	YES	YES
TU16000 An Environmental Assessment of the Australian Turf Industry	Hort Innovation			
PT16001 Impact of groundwater quality on management of centre pivot grown potato crops	Hort Innovation	YES	YES	
VG16068 Optimising cover cropping for the Australian Vegetable Industry	Hort Innovation	YES	YES	

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MU17008 Understanding and managing the impact of climate change on Australian Mushroom Production	Hort Innovation	YES		
TU17008 Conveying the benefits of living turf - mitigation of the urban heat island effect	Hort Innovation	YES		
AL7004 Almond Irrigation Best Practice Management	Hort Innovation	YES	YES	
NY18008 Nursery Industry Natural Disaster Risk Mitigation and Recovery Plan	Hort Innovation	YES	YES	YES
GC15002 Which Plant Where When and Why for Urban Green Space	Hort Innovation	YES	YES	
GC16002 Researching the benefits of demonstration green roofs across Australia	Hort Innovation		YES	YES
VM18002 Risk and crisis management for the melon industry	Hort Innovation	YES	YES	
AP12029 Understanding apple and pear production systems in a changing climate	Hort Innovation	YES	YES	
HG14033 SITplus: Raising Qfly Sterile Insect Technique to World Standard	Hort Innovation	YES	YES	
MC18004 Genetic diversity and population structure of wild and domesticated Macadamia	Hort Innovation	YES	YES	
MC19000 National Macadamia Breeding and Evaluation Program	Hort Innovation		YES	
AS17000 National Tree Genomics Program	Hort Innovation		YES	
BS17000 National Strawberry Varietal Improvement Program	Hort Innovation		YES	
AL17005 National Almond Breeding and Evaluation Program	Hort Innovation		YES	
HG10025 Novel, sustainable and profitable horticultural management systems: soil amendments and carbon sequestration	Hort Innovation	YES	YES	
BA16009 Banana Enterprise Perforamance Comparison	Hort Innovation	YES	YES	
TU17006 Economic, environmental, social and health impacts and benefits of the turfgrass and lawncare industries in Australia	Hort Innovation	YES	YES	YES
Managing Climate Variability Program	Meat and Livestock Australia	YES	YES	YES
P.PSH.0793 Sustainable pasture systems under climate extremes	Meat and Livestock Australia	YES	YES	
B.CCH.2107 Communication Coordinator for the Managing Climate Variability Progr	Meat and Livestock Australia	YES	YES	

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P.PSH.0951 Northern Australian Climate Project (NACP) Phase 2 - Innovative drou	Meat and Livestock Australia	YES	YES	
B.NBP.0749 Evaluating promising stylo lines for southern Queensland	Meat and Livestock Australia		YES	
P.PSH.1185 Trial Electric Two-Wheel Motorbikes on grazing properties.	Meat and Livestock Australia		YES	
V.RMH.0096 Mince Cooling by Liquid Nitrogen- Phase 1 feasibility	Meat and Livestock Australia		YES	
B.PSP.0018 Project Agreement RnD4Profit-15-02-016 P Efficient Pastures	Meat and Livestock Australia		YES	
B.FLT.0396 Long-term total greenhouse gas emissions from beef feedlots	Meat and Livestock Australia	YES	YES	
P.PSH.0823 Key research to assist the development of Emissions Reduction Fund c	Meat and Livestock Australia	YES	YES	
B.TGP.2001 Quantifying spatial and temporal changes in feed supply and demand	Meat and Livestock Australia		YES	
B.GBP.0024 The gateway to selecting for nutrient efficient livestock - Better	Meat and Livestock Australia		YES	
P.PSH.0857 LPP Optimising supplement use in Australia's northern beef industry	Meat and Livestock Australia		YES	
B.GBP.0050 Scoping the development of high value beef production from dairy bul	Meat and Livestock Australia		YES	
B.FLT.5003 Improving Feedlot Water & Energy Use Efficiency	Meat and Livestock Australia	YES	YES	
B.GBP.0026 Feeding Leucaena to manage the rumen for maximum beef profit	Meat and Livestock Australia		YES	
P.PSH.1055 Desmanthus pasture in grazed pastures and its role in methane emissi	Meat and Livestock Australia	YES	YES	
B.CCH.6621 Advancing the agronomy package for tedera to fill feed-gaps	Meat and Livestock Australia		YES	
B.GBP.0032 Fit for purpose biochar to improve effic	Meat and Livestock Australia	YES	YES	
B.ERM.0108 Wambiana - Grazing strategies and tools to improve profitability and	Meat and Livestock Australia		YES	
P.PSH.1016 Nitrogen recycling as determinant for feed efficiency of Bos indicus	Meat and Livestock Australia		YES	
L.LSM.0018 No more gaps with superior shrub systems	Meat and Livestock Australia		YES	
P.PIP.0497 Anaerobic Ammonium Removal (AAR) Waste Water Treatment Facility	Meat and Livestock Australia		YES	
B.CCH.7712 Exploring profitability and resilience through novel livestock and p	Meat and Livestock Australia		YES	

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P.PSH.0884 Development of a sterile Leucaena to enhance red-meat production in	Meat and Livestock Australia		YES	
P.PSH.1044 LPP Improving the use of forage brassicas in mixed farming systems	Meat and Livestock Australia		YES	
P.PSH.1048 LPP Perennial pasture & forage combinations to extend summer feed fo	Meat and Livestock Australia		YES	
P.PSH.1134 RRDfP Dung beetle ecosystem engineers - enduring benefits for livest	Meat and Livestock Australia	YES	YES	
P.PSH.1136 RRDfP Novel Pasture Legumes in Dry Areas	Meat and Livestock Australia		YES	
B.ERM.1103 Rearing of O.Vacca data review	Meat and Livestock Australia		YES	
P.PIP.0398 Oakey Abattoir methane capture storage & re-use	Meat and Livestock Australia		YES	
P.PIP.0566 NCMC energy & wastewater options assessment for energy self-sufficie	Meat and Livestock Australia		YES	
B.FLT.0394 Asparagopsis feedlot feeding trial	Meat and Livestock Australia		YES	
V.SCS.0007 Concentrated Solar Thermal and Concentrated Solar Power - Assessment	Meat and Livestock Australia		YES	
P.PIP.0732 Churchill Abattoir wastewater characterisation	Meat and Livestock Australia		YES	
P.PSH.1219 NEXUS project: exploring profitable sustainable livestock businesse	Meat and Livestock Australia		YES	
V.RDP.3010 RRDfP Wastes to Profits	Meat and Livestock Australia		YES	
B.CCH.8100 RRDfP Bureau of Meterology Forewarned is forearmed: managing the imp	Meat and Livestock Australia		YES	
B.CCH.8110 RRDfP University of Melbourne Forewarned is Forearmed: managing the	Meat and Livestock Australia		YES	
B.CCH.8120 RRDfP University of Southern Queensland Forewarned is Forearmed: ma	Meat and Livestock Australia		YES	
B.CCH.8140 RRDfP Birchip Cropping group Forewarned is Forearmed: managing the	Meat and Livestock Australia		YES	
B.CCH.8300 RRDfP Russell Pattinson (National Coordinator)	Meat and Livestock Australia		YES	
B.FLT.4011 Cattle Heat Load Toolbox 2019 to 2021	Meat and Livestock Australia		YES	

Program	Provider	Environment	Economic	Social
L.FAP.1903 Persistent and Productive Pasture project (P&P Pastures)	Meat and Livestock Australia		YES	
L.FAP.1901 The Less Weeds Better Pasture Package	Meat and Livestock Australia	YES	YES	
L.FAP.1902 The Healthy Soils Project	Meat and Livestock Australia		YES	
L.PDS.1807 Increasing carrying capacity and poor season resilience: Bulking pas	Meat and Livestock Australia		YES	
L.PDS.2001 PDS: Exclusion Feeding for Lambs in Drought	Meat and Livestock Australia		YES	
L.PDS.1907 PDS: Winter Forage Tropical Grass Systems for Cattle	Meat and Livestock Australia		YES	
P.PSH.1000 LPP Improving profit from pasture through increased feed efficiency	Meat and Livestock Australia		YES	
B.GBP.0031 Reducing calf loss due to exposure	Meat and Livestock Australia		YES	
B.NBP.0812 Progressing superior tropical grasses and legumes in seasonally-dry	Meat and Livestock Australia		YES	
P.PSH.1027 LPP - Developing a framework for tactical decision making to address	Meat and Livestock Australia		YES	
P.PSH.1030 LPP Extending the boundaries of legume adaptation through better soi	Meat and Livestock Australia		YES	
P.PSH.1236 NEXUS project: exploring profitable sustainable livestock businesse	Meat and Livestock Australia		YES	
P.PSH.1235 Spatially Resilient Grazing Systems: Measuring and optimising landsc	Meat and Livestock Australia		YES	
B.CCH.8130 RRDfP SARDI Forewarned is Forearmed: managing the impacts of extrem	Meat and Livestock Australia		YES	
B.CCH.2111 MCV5 - Changes in summer rainfall and implications for agriculture	Meat and Livestock Australia		YES	
L.GEN.1713 Improving the Australian Poll Gene Marker Test	Meat and Livestock Australia		YES	
L.GEN.1817 Quantifying the benefits of breeding for immune competence in high d	Meat and Livestock Australia		YES	
P.PSH.0503 Phase 2 - Hereford Information Nucleus & Young Sire progeny Test Pro	Meat and Livestock Australia		YES	
P.PSH.0774 Northern Beef Information Nucleus Stage II	Meat and Livestock Australia		YES	
B.CMM.0153 NLMP Algae Methane	Meat and Livestock Australia		YES	
L.GEN.1704 Advanced genetic evaluation tools and systems enabling faster and mo	Meat and Livestock Australia		YES	
L.GEN.1816 Feed intake measurement of cattle in the Tullimba R&D Feedlot BIN Pr	Meat and Livestock Australia		YES	

Program	Provider	Environment	Economic	Social
P.PSH.0848 Genetics R&D: Wagyu Net Feed Intake data collection and analysis	Meat and Livestock Australia		YES	
P.PSH.0869 Optimizing temperate cow herd efficiency - a Trans-Tasman collaborat	Meat and Livestock Australia		YES	
P.PSH.0528 Angus Australia Progeny Test and Information Nucleus	Meat and Livestock Australia		YES	
P.PSH.0849 Genetics R&D: Crossbred Wagyu Data Capture and Analysis	Meat and Livestock Australia		YES	
P.PSH.0942 Genetics R&D: Phenotypic and genetic relationships between retail be	Meat and Livestock Australia		YES	
L.GEN.1807 Feed intake measurement of cattle in the Tullimba R&D Feedlot BIN Pr	Meat and Livestock Australia		YES	
P.PSH.0559 Brahman Beef Information Nucleus/Progeny Test Project	Meat and Livestock Australia		YES	
P.PSH.0743 Northern Beef Information Nucleus Stage I	Meat and Livestock Australia		YES	
P.PSH.0921 Intensive phenotyping in industry to expand the Brahman reference po	Meat and Livestock Australia		YES	
B.SGN.0142 Resource Flock 2014 -2020	Meat and Livestock Australia		YES	
L.GEN.1814 Further development of a reference population for genomic prediction	Meat and Livestock Australia		YES	
L.SBP.1601 Feed intake measurement of cattle in the Tullimba R&D Feedlot BIN Pr	Meat and Livestock Australia		YES	
B.SBP.0138 Feed intake measurement of cattle in the Tullimba R&D Feedlot BIN Pr	Meat and Livestock Australia		YES	
P.PSH.1172 Australian Angus Reference Population	Meat and Livestock Australia		YES	
P.PSH.1221 Building and delivering effective genomic selection for northern Aus	Meat and Livestock Australia		YES	
V.RDP.3000 Grant Agreement RnD4Profit-16-03-002 Wastes to profits	Meat and Livestock Australia		YES	
B.ERM.1000 Grant Agreement RnD4Profit-16-03-016 Dung beetle ecosystem engineers	Meat and Livestock Australia	YES	YES	
B.PSP.0014 Grant Agreement RnD4Profit-15-02-016 Phosphorus efficient pastures	Meat and Livestock Australia		YES	
B.PSP.0016 Dairy Australia: RnD4Profit 15-02-016 Phosphorus efficient pastures	Meat and Livestock Australia		YES	
B.PSP.0017 AWI: RnD4Profit-15-02-016 P Efficient Pastures	Meat and Livestock Australia		YES	
B.CCH.8000 Grant Agreement RnD4Profit-16-03-007 Forewarned is forearmed: managi	Meat and Livestock Australia		YES	

Program	Provider	Environment	Economic	Social
B.CCH.8200 RRDfP Contributions	Meat and Livestock Australia		YES	
P.PSH.1050 LPP Phosphorus management and requirements of tropical legume pastur	Meat and Livestock Australia		YES	
P.PSH.1036 LPP - Novel dual purpose perennial cereals for grazing	Meat and Livestock Australia		YES	
P.PSH.1045 LPP Dual purpose crops for lamb production in southern QLD and north	Meat and Livestock Australia		YES	
P.PSH.1195 Measuring soil carbon in grazing system s using non-destructive flux	Meat and Livestock Australia	YES	YES	
B.PAS.0354 Legume best management practice in the Brigalow belt bio-region. (St	Meat and Livestock Australia		YES	
P.PSH.1029 LPP - Increasing livestock production by integrating tropical pastur	Meat and Livestock Australia		YES	
B.GBP.0040 Demonstrating the productivity and profitability of cattle grazing	Meat and Livestock Australia		YES	
P.PIP.0745 Demonstration of an industrial microgrid as a means of enabling red	Meat and Livestock Australia		YES	
B.GBP.0039 Paddock Power : increasing reproductive productivity through evidenc	Meat and Livestock Australia		YES	
L.PDS.1909 PDS: Sustainable Long Term Leucaena Grass Producer in Northern Austr	Meat and Livestock Australia		YES	
B.GBP.0029 The Sweet Spot : Improving breeder herd performance through optimal	Meat and Livestock Australia		YES	
P.PSH.1202 LPP - New generation NIRS calibrations to improve feed evaluation an	Meat and Livestock Australia		YES	
P.PIP.0484 Energy awareness monitoring and controls program	Meat and Livestock Australia		YES	
P.PSH.0791 NCAP - Northern Australia Climate Program. Planning phase one. Innov	Meat and Livestock Australia	YES	YES	
P.PIP.0547 General feasibility review of an automated bio-energy and waste wate	Meat and Livestock Australia		YES	
B.ERM.0216 Rearing Onthophagus vacca and Bubas bubalus for release in southern	Meat and Livestock Australia		YES	
P.PIP.0730 Investigation into alternative wastewater treatments options for a l	Meat and Livestock Australia		YES	
B.ERM.1102 The release and monitoring the establishment of Onthophagus vacca	Meat and Livestock Australia		YES	
Emission Reduction Pathways	NSW Department of Primary Industries	YES	YES	
Accessing Carbon Markets	NSW Department of Primary Industries	YES	YES	YES
Vulnerability Assessment	NSW Department of Primary Industries	YES	YES	

Program	Provider	Environment	Economic	Social
Climate Smart Pilots	NSW Department of Primary Industries	YES	YES	
Clean Energy Solutions	NSW Department of Primary Industries	YES	YES	YES
Energy Efficiency Solutions	NSW Department of Primary Industries	YES	YES	YES
Seasonal conditions reporting/Enhanced Drought Information System	NSW Department of Primary Industries		YES	YES
Young Farmer Business Program	NSW Department of Primary Industries		YES	YES
Rural Women's Network	NSW Department of Primary Industries		YES	YES
Rural Resilience Program	NSW Department of Primary Industries	YES	YES	YES
Developing profitable dairy and sheep meat production systems in central Tibet - China	NSW Department of Primary Industries	YES	YES	YES
NSW Climate Change Fund Project 3: Biomass for Energy	NSW Department of Primary Industries		YES	
Reducing calf loss from exposure	NT Department of Primary Industries and Resources		YES	
NT carrying capacity research and advisory service	NT Department of Primary Industries and Resources		YES	
NT Pastoral Feed Outlook	NT Department of Primary Industries and Resources		YES	
Understanding the impact of climate change on mango production in the Northern Territory	NT Department of Primary Industries and Resources		YES	YES
EDGE training workshops – particularly Grazing Land Management and Grazing fundamentals	NT Department of Primary Industries and Resources		YES	YES
Barossa Grape and Wine Improve Soil Health Project	Primary Industries Research South Australia	YES	YES	
State Soil C baseline report and Building Soil Carbon 2020	Primary Industries Research South Australia	YES	YES	
CRC for High Performance Soils (CRC-HPS) Regen Farming Systems Project	Primary Industries Research South Australia	YES	YES	
CRC-HPS Sandy Soils Project	Primary Industries Research South Australia	YES	YES	
EPARF Sandy Soils Impact Project	Primary Industries Research South Australia	YES		
LEADA Soils Demo Trials	Primary Industries Research South Australia	YES		
AMLR NRM Regen Health Soils 19/20 Project	Primary Industries Research South Australia	YES	YES	
CSIRO/GRDC Sandy Soils 16/21 Project	Primary Industries Research South Australia	YES	YES	

Program	Provider	Environment	Economic	Social
New Horizons Program	Primary Industries Research South Australia	YES	YES	
Establishment of regional soil carbon long term reference / monitoring sites	Primary Industries Research South Australia	YES	YES	YES
MFMG Mixed Cover Cropping Project	Primary Industries Research South Australia	YES	YES	YES
Red Meat and Wool Program	Primary Industries Research South Australia		YES	YES
Managing heat in vineyards Project	Primary Industries Research South Australia	YES	YES	
Investigate Abalone Summer Mortality Project	Primary Industries Research South Australia	YES	YES	
Multitrophic Aquaculture Project	Primary Industries Research South Australia	YES	YES	YES
Improve surveillance and emergency disease response to Pacific Oyster Mortality Syndrome (POMS)	Primary Industries Research South Australia	YES	YES	
AS10930 Innovation Project: Strategic Analysis Data – Sheep in South West Qld	Queensland Department of Agriculture and Fisheries		YES	YES
AS10436 Improving drought preparedness	Queensland Department of Agriculture and Fisheries	YES	YES	YES
AS10690 DCAP DAF 6 Delivering integrated production and eco	Queensland Department of Agriculture and Fisheries	YES	YES	YES
RD10936 Drought Support	Queensland Department of Agriculture and Fisheries		YES	
RD10808 USQ4NACP	Queensland Department of Agriculture and Fisheries	YES	YES	YES
RD10719 USQ DCAP Agreement	Queensland Department of Agriculture and Fisheries		YES	
RD10708 DSITI DCAP MOU	Queensland Department of Agriculture and Fisheries	YES	YES	YES
SP10430 DCAP USQ Collaborative Agmnt	Queensland Department of Agriculture and Fisheries	YES	YES	YES
RD10860 NACP Project 3 "Extension Project"	Queensland Department of Agriculture and Fisheries	YES	YES	YES
SP10437 QDMC Tripartite MOU	Queensland Department of Agriculture and Fisheries	YES	YES	

Program	Provider	Environment	Economic	Social
AS10838 ON-00560 Leading Sheep 5 2018-2021	Queensland Department of Agriculture and Fisheries		YES	
The inside edge for graziers to master Qld's drought prone climate	Queensland Department of Environment and Science		YES	
Do we really know our baseline climate? Using palaeoclimate data to plan and prepare for extreme events and floods in Qld	Queensland Department of Environment and Science	YES	YES	
Enabling drought resilience and adaptation: A program of social research and knowledge support	Queensland Department of Environment and Science		YES	YES
Fisheries Science Program	South Australian Research and Development Institute		YES	
Aquaculture Science Program	South Australian Research and Development Institute		YES	
Marine Ecosystems Science Program	South Australian Research and Development Institute	YES		
Inland Waters and Catchment Ecology Science Program	South Australian Research and Development Institute	YES	YES	
Re-evaluating the margin of the South Australian grain belt in a changing climate	South Australian Research and Development Institute		YES	
R&D for biosecurity, pest and disease management	South Australian Research and Development Institute		YES	
RD&E on use of climate information in cropping and livestock industries	South Australian Research and Development Institute	YES	YES	
R&D for productive and resilient field crops.	South Australian Research and Development Institute		YES	
R&D for productive and resilient irrigated crops	South Australian Research and Development Institute	YES	YES	
R&D for new crops and farming systems	South Australian Research and Development Institute		YES	
R&D on livestock performance and welfare	South Australian Research and Development Institute		YES	

Program	Provider	Environment	Economic	Social
R&D on pasture	South Australian Research and Development Institute		YES	
R&D on emissions reduction	South Australian Research and Development Institute	YES	YES	
R&D on food systems	South Australian Research and Development Institute		YES	
Preparing fisheries and aquaculture for climate change	South Australian Research and Development Institute	YES	YES	
Productivity improvements through energy innovation in the Australian sugar industry	Sugar Research Australia		YES	
Sugar from space: improved data access, yield forecasting and targeted nitrogen application for the Australian sugar industry	Sugar Research Australia		YES	
Improved irrigation system selection and operation for increased sugarcane productivity and profitability	Sugar Research Australia		YES	
Greenhouse gas emissions from sugarcane: strategies for improving NUE and reducing environmental pollution	Sugar Research Australia	YES	YES	
Unravelling the impact of climate and harvest time on N fertiliser requirements	Sugar Research Australia		YES	
SIX-EASY STEPS continuing perspectives in space and time.	Sugar Research Australia	YES	YES	
Enterprise Suitability Toolkit	Tasmania DPIPWE		YES	
Water for Profit Program	Tasmania DPIPWE		YES	YES
Northern Australia Climate Program	University of Southern Queensland	YES	YES	
Producing enhanced crop insurance systems and associated financial decision support tools – Phase 2	University of Southern Queensland		YES	
Soil constraints initiative - innovative approaches to managing sub soil acidity	WA Department of Primary Industries and Regional Development	YES	YES	
Increased grower profitability on soils with sodicity and transient salinity in the Easter grain belt of the Western Region	WA Department of Primary Industries and Regional Development	YES	YES	
Re-engineering soils to improve the access of crop root systems to water and nutrients stored in the subsoil	WA Department of Primary Industries and Regional Development	YES	YES	
Maintenance of grain plumpness and transfer of heat tolerance into Australian barley germplasm	WA Department of Primary Industries and Regional Development		YES	

Program	Provider	Environment	Economic	Social
Dry Season Response	WA Department of Primary Industries and Regional Development		YES	YES
Improved use of seasonal forecasting to improve farmer profitability	WA Department of Primary Industries and Regional Development		YES	YES
Decision tools to help growers manage variable and extreme climate.	WA Department of Primary Industries and Regional Development		YES	YES
Provision of seasonal outlooks to assist growers in planning and managing activities	WA Department of Primary Industries and Regional Development	YES	YES	
Plan, Prepare, Prosper (PPP) training workshops	WA Department of Primary Industries and Regional Development		YES	YES
State Carbon Strategy (underway)	WA Department of Primary Industries and Regional Development	YES	YES	
Soil Carbon - Pilot Program (pending)	WA Department of Primary Industries and Regional Development	YES	YES	
Carbon Farming information	WA Department of Primary Industries and Regional Development	YES	YES	YES
Australian Biomass for Bioenergy Assessment	WA Department of Primary Industries and Regional Development		YES	
Tactical agronomy	WA Department of Primary Industries and Regional Development		YES	
Managing soil constraints for cropping	WA Department of Primary Industries and Regional Development		YES	
Crop Genetic Improvement	WA Department of Primary Industries and Regional Development		YES	
e-Connected Grainbelt project -	WA Department of Primary Industries and Regional Development		YES	
Understand the abundance variation of scallops stocks in WA and management options in a changing environment	WA Department of Primary Industries and Regional Development	YES		
Redmap (Range Extension Database and Mapping project)	WA Department of Primary Industries and Regional Development	YES		YES
Determining factors influencing recovery of snapper stocks off west coast	WA Department of Primary Industries and Regional Development	YES		

Program	Provider	Environment	Economic	Social
Digital technologies for more dynamic management of disease, stress and yield	Wine Australia		YES	
Adjusting grape berry ripening to suit a changing climate: plant growth regulator-based solutions	Wine Australia		YES	
Managing wine pH in a changing climate	Wine Australia		YES	
Managing the impact of vintage advancement and compression	Wine Australia		YES	
Australia's wine future: Adapting to short-term climate variability and long-term climate change	Wine Australia	YES	YES	
Mitigation of Climate Change Impacts on the National Wine Industry by Reduction in Losses from Controlled Burns and Wildfires and Improvement in Public Land Management	Wine Australia	YES	YES	
Climate adaptation: developing irrigation strategies to combat dry winters	Wine Australia		YES	
The establishment of Cabernet Sauvignon trials in preparation for the evaluation of clonal response to climate and management	Wine Australia		YES	
Assessing the suitability of indigenous Cypriot grape varieties for Australia's challenging and changing climate	Wine Australia		YES	
Impact of elevated CO2 and its interaction with elevated temperature and physiology of Shiraz	Wine Australia		YES	
Assessing clonal variability in Chardonnay and Shiraz for future climate change	Wine Australia		YES	
Manipulating wine grapes with antitranspirants	Wine Australia		YES	
Field trials - new scion-rootstock combinations and evaluation of new technology for improved water use efficiency and reduced costs	Wine Australia		YES	
Regional evaluation of new germplasm - pathway to adoption	Wine Australia		YES	

SOURCE: ACIL ALLEN CONSULTING

B

FOCUS GROUPS SUMMARY

Focus Groups Summary

This appendix summarises the findings of on-line focus groups held between 17-25 June 2020 based on the following questions:

— Questions regarding users of drought resilience RDE&A:
  - Which users are the least drought-resilient?
  - Who is underutilising drought resilience RDE&A?

— Questions regarding drought resilience RDE&A services:
  - Where is the low hanging fruit for each service?
  - What is the best way to bundle services?
  - What is the social drought resilience E&A channel?

B.1 Attendees

TABLE B.1 FOCUS GROUP ATTENDEES

Name	Organisation
Alister Hawksford	Bureau of Meteorology
Anabelle Bushell	Grower Group Alliance
Andrew Moore	Digiscape, CSIRO
Anthony Clark	NSW DPI
Anwen Lovell	CRISPI
Byron de Kock	Horticulture Innovation Australia
Chris Sounness	Wimmera Development Association
Cindy Cassidy	FarmLink
Eykolina Benny	RALF South East SA
Gavin Ramsay	Charles Sturt University
George Wilson	Australian Wildlife Service/ANU

Name	Organisation
Graham Bonnett	CSIRO
Harvey Millar	ARC Centre of Excellence ANU
Jason Crean	NSW DPI
Juliane Kasiske	RALF Mackay Whitsunday
Lauren Rickards	RMIT
Liz Alexander	Central Highlands Accelerating Agribusiness
Maria Cameron	Hunter LLS
Matthew Gilliham	Waite Research Institute
Michael Crawford	Soils CRC
Michael Stewardson	University of Melbourne
Nyree Stenekes	ABARES
Peter Hayman	SARDI
Rob Vertessy	Global Change Advisory
Russell Pattison	Miracle Dog
Sion Jones	NSW DPI
Susie Robinson	NCRIS
Tim Lester	Council of Rural RDCs
Tony Hegarty	Cattle Council
Yheysis Maru	Land & Water CSIRO

SOURCE: ACIL ALLEN CONSULTING

B.2 Users of drought resilience RDE&A

B.2.1 Which users are the least drought-resilient?

- Drought resilience is more variable within communities and industries than across them
- Depends on the definition of both drought and resilience
  - acknowledge that the term resilience is considered ‘frustrating’
  - acknowledge that drought is not uniform and not a constant occurrence
  - acknowledge aridity as being distinct from drought
  - acknowledge drought as a sub-set of larger ‘disasters’ and broader climate change
- Resilience is a relative construct at the individual level too
- Capability is also varied within and across communities and industries
- Capacity to change is also highly variable
- Regional communities/economies (greater than the farming community)
- Consider the concept of vulnerability – some regions and communities are more vulnerable than others they will be less drought-resilient

- Smaller businesses generally more vulnerable
- Those with fewer options are less resilient – options include location, enterprise type, resources, education, connectivity, age, stage, socio-economic status etc
- Fewer options make you more vulnerable (the further away from the coast and urban areas you are the more isolated you are and therefore more vulnerable)
- Two-way relationships between farm businesses and communities – farm households rely on community
- Possibility of conflict between high performance (high input, high returns) and resilience but high performance does provide a financial buffer which can increase resilience

B.2.2 Who is underutilising drought resilience RDE&A?

- Always some early adopters who do very well by utilising R&D and many more laggards
- Contrast between those that embrace technology and those that do not (age, stage, capability)
- Some (many) farmers are underutilising climate seasonal forecasts
- Those at scale and with options do not have a need
- Acknowledge there are other things that interact with concepts like drought on the farm enterprises in many ways such as what you've sown, your financial position, your family, the broader community – we are not good at utilising RDE&A in an integrated way so that its actually useful – this means that it is often underutilised.
- Hard to utilise it because it is hard to find, hard to integrate and hard to understand.

B.3 Drought resilience RDE&A services

B.3.1 Where is the low hanging fruit?

- Participatory research within communities and regions to first identify RDE&A needs and second deliver outcomes
- Communities need empowering and enabling
- Capability building (foundational skill across a range of areas)
- A consolidated database of existing information could assist the RDE&A (and broader) communities
- Awareness and better interpretation of existing information through different modes and channels co-designed with users
- Provision of information across generations
- System-level thinking
- Multi-disciplinary R&D with a strong social research element
- Understand why existing tools may not be appealing
- Co-developing and co-designing cross-disciplinary programs with and in communities
- Better packaging/understanding/capability building around forecasting products
- Link climate forecasts to on the ground business decision making at a regional level

- Increase capability in scenario planning
- Understanding agility
- Preparedness plans and planning (farm business plans)
- Re-examining insurance
- Building trust and confidence in the system
- Alignment between R&D providers and those on the ground
- Alignment of infrastructure needs across innovation and research with other infrastructure providers e.g. communications infrastructure
- Bundling services
- Supporting the E&A sector so as to overcome 'market failure' – not enough people on the ground and not enough resources
- Better consideration of framing research in terms of potential adoption
- Better understanding of drought and recent drought efforts to learn from and guide future investments
- Trade-off between low hanging fruit and transformation
- Trade-off between short term gains and longer-term systemic and strategic investment (infrastructure, education)
- Dangers of picking winners
- Harness and leverage off unfocused resources
- Better use/resourcing of existing groups such as Land Care, rural support officers etc

B.3.2 What is the best way to bundle services?

- Bundling existing information and knowledge in ways that are relevant and accessible to all communities
- Different bundling needs for different purposes, communities, users etc. – no one size all approach, importance of understanding users and segmenting in useful ways so as to better target
- Not everything can be bundled – work with the competitive fragmentation
- Take a longer-term approach to data collection (monitoring), collation and dissemination (enduring construct)
- Acknowledge trade-offs, e.g. increased productivity may mean fewer people in regional communities
- Acknowledge that drought resilience may be better bundled with other or broader resilience 'services', e.g. climate change, declining rainfall, construct of multiple, cooccurring shocks. This may help with endurance and a decline in episodic (or sporadic) service provision.
- Acknowledge drought is not the only adversity and is often a secondary investment.
- Bundling adds complexity and is not merit-based

B.3.3 What is the social E&A channel?

- Farming systems groups and Land Care groups are one dimension which bridge between social and technical groups for E&A

- Local governments have an SME focus
- Communities can be defined in numerous ways meaning that there may be different channels to reach different communities
- Transformation more likely to occur with a deliberative process set up in a participatory way
- Will be unique for each community
- Trade-offs between top-down and bottom-up approaches especially regarding governance, ownership and accountability
- Traditional 'channels' like catchment management and RDA don't recognise the real relationships between communities (e.g. Narrabri and Moree have a relationship even though they are in separate catchments)
- Place-based partnerships work but are very costly
- Collaboration has benefits which many recognise, but no one is prepared to pay the set-up costs
- Lead locally but recognise the benefit of diverse inputs from outside the community
- Enable existing regional/community 'champions' to empower others (ripple effect)

B.4 Focus group presentation

STOCKTAKE: A FUTURE DROUGHT FUND DESIGN INPUT

Future Drought Fund	• Invests to enhance public good by building the drought resilience of farms, farming communities and value chains
Drought resilience	• Ability to adapt, reorganise or **transform** in response to changing temperatures and increasing variability and scarcity of rainfall for improved economic, environmental and social well-being
Drought resilience RDE&A	• Innovation system providing R&D and E&A on drought resilience and other matters • One Future Drought Fund program to support improved drought resilience
Drought resilience RDE&A stocktake	• Drought resilience RDE&A **ecosystem** map and **catalogue** • Analysis of short, medium and long-term **opportunities, challenges and gaps**

Off-farm water systems, mental health and in-drought support are not included in the stocktake

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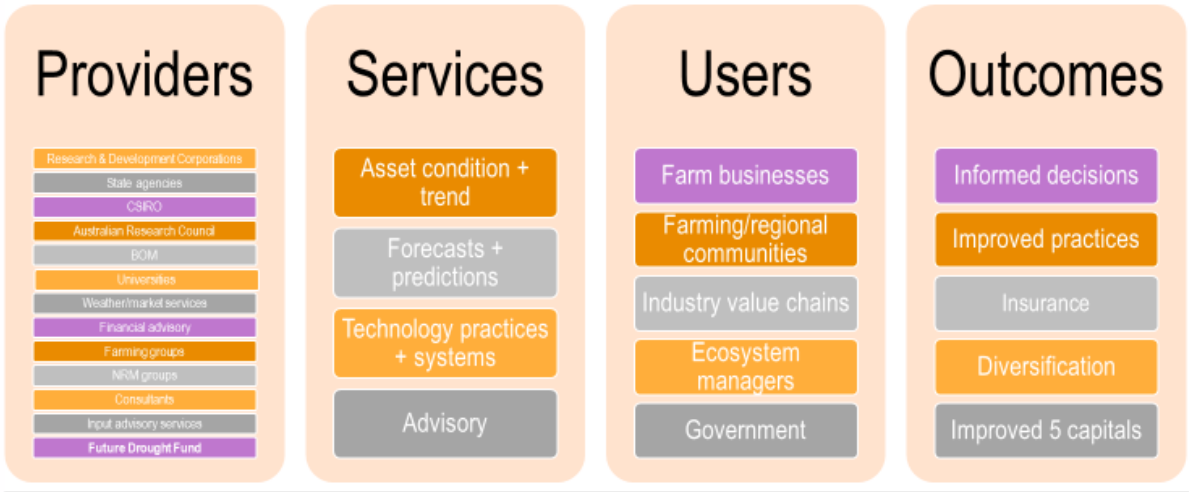
RDE&A ECOSYSTEM MAP



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UNDERUTILISATION OF DROUGHT RESILIENCE (RDE&A)?

Preliminary observations

- Definitions and data limits hinder assessment risk/need
- Trade offs b/t individual/collective responsibility/response
- Highly connected to other (more pressing) drivers

Discussion questions

- Who are least drought resilient?
- Who is underutilising drought resilience RDE&A?
- What are the key improvements they should make?

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HOW TO IMPROVE DROUGHT RESILIENCE RDE&A SERVICES?

Preliminary observations

- Four enduring services identified
- Considerable effort and distributional variation
- Bundling services to achieve an outcome hard

Discussion questions

- Where is the low hanging fruit for each service?
- What is the best way to bundle services?
- What is the social drought resilience E&A channel?

Asset condition and trend information

- Important for baselines and large if all asset classes
- Frequency and granularity

Forecasts and predictions

- Weather and climate significant focus
- Accuracy and granularity

Technologies, practices and systems

- Cumulative incremental farm productivity gains dominates
- Fitting right combination of existing/new heterogeneous

Advisory

- Drought resilience is often ancillary rather than core offering
- Key linking function but highly competitive and fragmented

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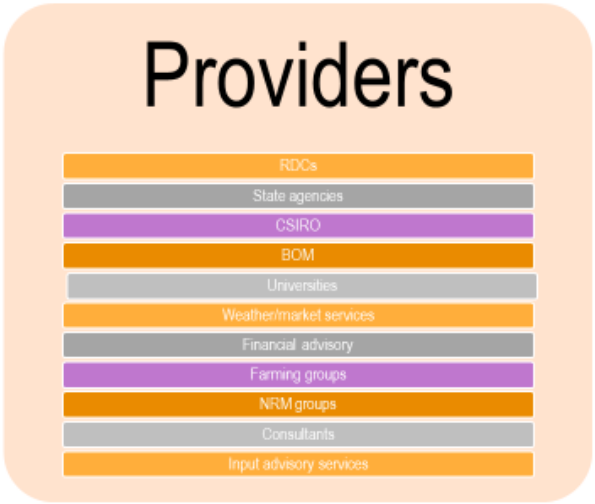
DROUGHT RESILIENCE RDE&A PROVIDER SYSTEMS

Preliminary observations

- There is no drought resilience RDE&A strategy
  - Many actors working to achieve other systems' priorities (industries, NRM + (rural) innovation etc.)
  - Focus/effort patchy and distributed across systems
- Drought resilience RDE&A publications increasing
  - Economics/productivity dominates, social lowest

Discussion questions

- Where is the biggest gap/opportunity in capability?
- What (new) collaborations for transformational impact can be put in place in now and later?



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