GRAINS RESEARCH AND DEVELOPMENT CORPORATION

RESEARCH, DEVELOPMENT
AND EXTENSION PLAN 2018–23
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This plan is the key planning document that guides the GRDC’s investments in grains research, development and extension priorities for the period 2018–2023. This Plan specifically targets profitability for Australian grain growers, recognising the challenges ahead in the Australian grains industry to improve rates of return, through increased yields and reduced costs. The priorities were determined through extensive consultation involving a broad spectrum of industry participants, government and the GRDC’s representative organisations. During consultation the GRDC considered and sought feedback on the strengths, weaknesses, opportunities, threats and long-term trends in the Australian grains industry. That analysis is contained in this plan, and those factors have helped to identify the key investment areas in which GRDC investments can deliver a quantifiable impact.

The investment portfolio is structured around the key drivers of profitability, which have been defined as: Profit = (Yield x Price – Costs) x Risk. This plan prioritises investments against each of the key drivers and defines investment objectives, performance measures and targets. Detailed information on each of the priorities is provided in the two-page RD&E plan on pages 29–30.

Priorities and key investment targets will be reviewed each year against the needs of the grains industry and will inform the development of the GRDC’s annual operational plans. Each annual operational plan will set out the annual budgets, key investment targets and performance indicators.

Each year’s annual report will examine the GRDC’s success in achieving its investment targets and delivering on its purpose: To invest in research, development and extension to create enduring profitability for Australian grain growers.
INTRODUCTION

Over the past 15 years the Australian grains industry has seen an increase in gross value of production from approximately $6 billion to approximately $15 billion. Most of this additional value has come from Australian grain growers adopting new technology. The GRDC and its research partners have been major contributors to the creation of canola, chickpea and lentil industries that now drive grain grower profitability in large parts of the Australian cropping area. The water use efficiency of wheat has almost doubled over the same timeframe. The GRDC has worked with research partners to protect grain growers from losing potential profitability, through a wide range of investments in areas such as managing the quality of export grain, preventing and managing disease, and managing herbicide-resistant weeds.

Whilst gains have been made, grain grower terms of trade have declined dramatically, climate variability has added further challenges, and growers are now required to invest higher levels of capital up front in each new season cropping program, exposing them to unprecedented financial risk. There is evidence to suggest that the overall profitability of grain growing in some areas of Australia is now plateauing or even in decline.

The GRDC has responded, changing its approach to drive enhanced levels of grain grower profitability. This has been the primary driver for the GRDC’s undergoing a significant period of transformation.

The GRDC has introduced new management and business structures and continues to expand its regional presence. The GRDC’s footprint of engagement in the grains industry is now the greatest it has ever been. Through our regionalised structure, our Regional Cropping Solutions Networks and regional panels, Grower Solutions Groups, and other forums, grain growers have more opportunities than ever before to have input into the GRDC’s RD&E priorities. Increased responsiveness and grower engagement will also provide greater transparency of the GRDC’s investments and ensure that our investment portfolio balance matches grower priorities.

A very important component of this ongoing transformation is a new five-year research, development and extension (RD&E) plan. This five-year RD&E plan is part of a 10–20 year strategy to deliver on the GRDC’s purpose: To invest in research, development and extension to create enduring profitability for Australian grain growers. On every grain farm in Australia, growers are focused on the bottom line. Consequently, the GRDC has shifted its focus to maximise growers’ long-term profitability with RD&E investment strategies focused on profit drivers: improving yield, maintaining or improving price, optimising costs, and managing risk.

This plan will focus on identifying the key investment targets that can deliver transformational gains to the profit drivers. Australian grain growers’ competitive advantage relies on innovation and access to new technologies at a pace that is at least as fast as those of our international competitors. The world is now a global marketplace and the business of RD&E is more international than it has ever been before. The GRDC is positioning itself to attract and actively seek opportunities to bring innovation and technology to Australia and is committed to delivering tools and information to growers to have the greatest possible impact on their bottom line. This purpose-driven five-year RD&E plan is a living document; it will continually evolve through the adoption of an agile approach to RD&E portfolio management that is responsive to grower needs, industry challenges and market opportunities.

The GRDC team is very excited about the road ahead—working with all industry stakeholders to deliver the greatest possible benefit to Australian grain growers.

John Woods
Chair

Steve Jefferies
Managing Director
THE GRDC’S PURPOSE

The GRDC’s purpose is:

To invest in research, development and extension to create enduring profitability for Australian grain growers.

The purpose is carefully crafted around core terms:

- **Invest**—the GRDC will invest to deliver a return on investment to its core stakeholders; it will not provide grants
- **Research, development and extension**—the GRDC will make investments in research, development and extension (RD&E) activities in line with the objectives of the *Primary Industries Research and Development Act 1989* (PIRD Act)
- **Create**—the GRDC will invest to develop innovative approaches to constraints and opportunities and facilitate their adoption
- **Enduring**—the GRDC will invest to drive long-term, sustainable impact on grain-growing businesses and their profitability
- **Profitability**—the GRDC will focus on grower profitability, not just productivity
- **Australian grain growers**—the GRDC will invest to deliver value to its primary stakeholders, Australian grain growers. While not all growers will benefit from every investment, the GRDC will aim to deliver impact to all growers commensurate with the levies they contribute.

The purpose of the GRDC is unashamedly focused on the profitability of growers and aligns with the Australian Government’s policy to ‘improve the net farm-gate returns for agriculture, fisheries, forestry, food and fibre industries’.

Benefits associated with this investment are realised more broadly through:

- improved economic and social outcomes in rural and regional communities
- improved environmental management underpinned by sound RD&E
- enhanced contribution to the broader Australian economy from the agriculture industry

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INVESTORS

The resources available to the GRDC for investment in RD&E predominantly arise from levies paid by grain growers and contributions made by the Australian Government. Total GRDC income, including grower and government contributions as well as revenue from interest and returns from the protection and commercialisation of intellectual property, averaged $214 million per annum over the past three years (from 2014–15 to 2016–17).

**Growers**

Grower contributions to the GRDC are made via levies based on the net farm gate value of 25 crops:

- wheat
- coarse grains—barley, oats, sorghum, maize, triticale, millets/panicums, cereal rye and canary seed
- pulses—lupins, field peas, chickpeas, faba beans, vetch, peanuts, mungbeans, navy beans, pigeon peas, soybeans, cowpeas and lentils
- oilseeds—canola, sunflower, safflower and linseed.

Grower contributions to the GRDC increased from $51 million in 2006–07 to $139 million in 2016–17, commensurate with an increase in the gross value of production (GVP) of the grains sector from $5.1 billion to $18.1 billion (Figure 1). Grower contributions over the past three years have averaged $122 million per annum.
The Australian Government’s contribution is determined annually, based on the three-year rolling average of the GVP of the 25 leviable crops. Government contributions are capped at 0.5% of GVP and have averaged $68.9 million per annum over the past three years.

**Investment partners**

Effective partnerships with co-investors enable the GRDC to leverage resources and research capability; share market knowledge, technologies and intellectual property; and reduce the risk associated with individual investments.

Most GRDC co-investors are also research collaborators. They include state government departments, CSIRO, universities, cooperative research centres, and private sector bodies. The number of effective linkages between the GRDC and agribusiness participants, including farm advisers and agronomists, is also increasing. Partnerships with agribusiness have tended to focus on the identification of R&D priorities and facilitation of the adoption of R&D outputs by grain growers.

The GRDC co-invests with other rural R&D corporations (RDCs), particularly in addressing cross-sectoral issues defined under the National Primary Industries Research, Development and Extension Framework. This includes collaborations related to the Rural Research and Development for Profit (RRD4P) program and other collaborations where mutual benefit is likely.

In developing approaches to co-investment with other RDCs, the GRDC takes into account that many Australian grain growers are also producers of other agricultural commodities (e.g., cotton, livestock or horticultural produce) and invest in RD&E in those commodities through other RDCs. The GRDC looks for opportunities to partner with relevant RDCs to target R&D outcomes that are returned across the mixed farming system.

The GRDC also recognises that partnering across commodities can generate economies of scale that in turn benefit grains levy payers. Examples of this include biosecurity surveillance with other plant-based industries and investments informed by cross-sectoral strategies on soils and climate research.

These collaborative investment decisions are informed by the identification of common interests through engagement with other RDCs via the Council of Rural RDCs, cross-sectoral collaborations strategies and other forums.

Cross-sectoral partnerships that the GRDC currently leads or is involved in include:

- Cross-sectoral strategies under the National Primary Industries Research and Development and Extension Framework, on plant biosecurity, soils, climate research and water use
- Primary Industries Health and Safety Partnership
- Managing Climate Variability program
- Plant Biosecurity Research Initiative
- AgVet Collaborative Forum.

The GRDC also builds strong relationships with international partners, both to broaden the resources available to the Australian grains industry and to access international RD&E expertise and/or capacity not available in Australia.

**INDUSTRY REPRESENTATION**

The GRDC works closely with Australian grain growers and their advisers to ensure that identified priorities are effectively addressed through appropriate investment in RD&E.

The GRDC engages with Australian grain growers through several mechanisms, including but not limited to:

- representative organisations as declared under the PIRD Act
- the GRDC’s advisory panels
- a range of GRDC-supported delivery and communication channels, such as Regional Cropping Solutions networks, Grower Solutions Groups, grower and adviser updates, and technical workshops on specific issues.

Grain Growers Limited and Grain Producers Australia Limited are the industry representative organisations declared by the Minister for Agriculture and Water Resources. The GRDC meets with its representative organisations at least once every six months and provides a formal opportunity for them to review the GRDC’s performance and direction annually.

The representative organisations were involved in the development of this RD&E plan.

Broader industry interests are captured through the GRDC’s participation in and interaction with a range of industry bodies, such as:

- Australian Grains Industry Discussion Group
- Wheat Quality Australia and the Wheat Quality Classification Council
- Barley Australia
- Pulse Australia
STAKEHOLDER PRIORITIES

Growers

Growers’ investment priorities for this RD&E plan were identified through a number of mechanisms, including workshops with GRDC advisory panels and representative organisations as well as feedback from the industry-wide consultation undertaken at the beginning of 2018. Ongoing interaction with panels and representative organisations will be an important aspect of the GRDC’s approach to maintaining the alignment of R&D investments with grower priorities.

The GRDC’s regional advisory panels—comprising growers, advisers and researchers, as well as GRDC executives—are particularly important. The panels have been an integral part of the RD&E investment process for almost two decades. Their key functions include:

- identifying and monitoring regional grains industry issues and national issues that are relevant to the region
- interacting and exchanging information with grower groups, Regional Cropping Solutions networks and other interested parties
- identifying and developing priorities for RD&E investment
- keeping growers and advisers informed about the GRDC’s strategic direction, investment portfolio and research projects
- assisting the GRDC to monitor the effectiveness of the investment portfolio.

Government

The national Science and Research Priorities were established by the Commonwealth Science Council in 2015, to support research excellence that builds on comparative advantages and maximises the benefits of RD&E to Australia. The priorities relevant to the grains industry are:

- Food—optimising production and processing, enhancing food safety and minimising waste
- Soil and Water—making better decisions in the context of potentially conflicting demands between development, the environment and landscape management
- Transport—developing low cost, reliable, resilient and efficient transport systems that meet the needs of businesses and enable sustainable mobility, while lowering carbon emissions and other pollution
- Environmental change—building Australia’s capacity to respond to environmental change.

The Science and Research Priorities are consistent with the Australian Government’s Rural RD&E Priorities, which were adopted in 2016. The Rural RD&E Priorities are:

- advanced technology, to enhance innovation of products, processes and practices across the food and fibre supply chains through technologies such as robotics, digitisation, big data, genetics and precision agriculture
- biosecurity, to improve understanding and evidence of pest and disease pathways to help direct biosecurity resources to their best uses, minimising biosecurity threats and improving market access for primary producers
- soil, water and managing natural resources, to manage soil health, improve water use efficiency and certainty of supply, sustainably develop new production areas and improve resilience to climate events and impacts
- adoption of R&D, focusing on flexible delivery of extension services that meet primary producers’ needs and recognising the growing role of private service delivery.
Research community
The research community is not simply a provider of research expertise to the GRDC—it is an integral part of the innovation system. Understanding the importance of RD&E expertise and communication capability in achieving its purpose, the GRDC maintains strong connections with research partners, including state government departments, CSIRO, universities, cooperative research centres, other rural RDCs, and investment partners from the private sector. Effective partnerships enable the GRDC to remain aware of new ideas and technologies; leverage resources and research capability; share knowledge and intellectual property; and reduce the risk associated with individual, sole-funder investments.

The GRDC is informed by the Grains Industry National RD&E Strategy, which was developed by research providers and the GRDC in 2011 and updated in 2017. The strategy aims to deliver greater efficiencies in the management and delivery of RD&E resources, and identifies agencies’ core RD&E strengths as well as regional centres of applied RD&E capability. This RD&E plan draws on the Grains Industry National RD&E Strategy to identify future R&D capacity requirements as part of an overall capacity-building focus, as well as identifying potential key collaborators for each RD&E priority or KIT.

Industry supply chain
Grains ‘industry good’ functions deliver benefits across the grains industry, including the entire supply chain—input suppliers, producers, transport operators, marketers and processors. Industry good activities or functions often create valuable information (e.g. wheat classification) and require some form of collective funding by the entire supply chain to ensure that value is both created and captured.

Industry good priorities are currently funded by different combinations of cash and in-kind support, and include:
- wheat classification
- malt accreditation
- grains market access management
- international market intelligence.
Most of these functions are associated with maintaining the international competitiveness of Australian grain and are important functions that underpin market access and grain grower profit as well as delivering wider benefits across the Australian grains industry.

CORPORATE GOVERNANCE
The GRDC is a Commonwealth statutory authority under the PIRD Act. It was established in 1990, to plan and invest in RD&E that assists the Australian grains industry to:
- increase economic, environmental and social benefits to members of primary industries and to the community in general by improving the production, processing, storage, transport or marketing of grain
- achieve sustainable use and management of natural resources
- make more effective use of the resources and skills of the community in general and the scientific community in particular
- improve accountability for expenditure on R&D activities.

The GRDC does not undertake RD&E in its own right; rather, it partners with other organisations that have the necessary capabilities. The GRDC is not an industry representative body and does not participate in agripolitical activities.

Board
The GRDC Board, headed by the Chair, oversees corporate governance, sets strategic direction and monitors the ongoing performance of the corporation and the Managing Director.

The GRDC Board operates in accordance with the requirements set out in the PIRD Act and the Public Governance, Performance and Accountability Act 2013. The Board is accountable to the Australian Parliament through the Minister for Agriculture and Water Resources, and to Australian grain growers through the representative organisations.

The GRDC Board has between seven and nine directors, who are appointed by the Minister for Agriculture and Water Resources on the recommendations of an independent selection committee, as specified in the PIRD Act.

Organisation
The GRDC has five business groups with subgroups as follows:
- Managing Director’s Office—Legal; Human Resources; and Corporate Affairs
- Deputy Chief Executive Officer’s Office—Finance; Information Technology; Economics; Governance and Reporting; Business Operations; and Business Development
- Genetics and Enabling Technologies—Pre-breeding; Data Analytics; and Bioinformatics, Modelling and Data
- Applied Research and Development—Agronomy; Farming Systems; Soils; Nutrition; and Crop Protection
- Grower Communications and Extension—Extension; and Communication.

Investment planning and assessment is performed by cross-functional teams involving input from relevant business groups across the GRDC, while individual investment contracts are negotiated and monitored by managers within relevant groups.
Regional focus

The GRDC manages RD&E investments and delivers services to meet the needs of each region and the industry, through a network of four offices: a national office in Canberra and regional offices in Adelaide, Perth, and Toowoomba (Queensland). Contact details for each office are on the back cover of this publication.

To strengthen alignment between GRDC staff and grower stakeholders, the GRDC has accelerated the recruitment of staff to its regional hubs in Perth, Adelaide and Toowoomba. Regional hubs are important in providing greater interaction with growers, improved transparency of decision-making and more effective collaboration with co-investors. They provide a regional point of communication for all stakeholders.

Other regional staff are also being recruited, particularly to provide extension activities where close association with grain growers, grower groups and advisers is essential to effective adoption of innovative technologies and practices.

Governance framework

GRDC operations, planning and reporting are governed by a series of requirements set out in legislation and contracts. The following have an important influence on GRDC strategy and investment activities:

- the PIRD Act
- the Public Governance, Performance and Accountability Act 2013, which applies a common scheme of governance and accountability to all Commonwealth entities
- the statutory funding agreement between the GRDC and the Department of Agriculture, which is the contractual arrangement with the Commonwealth under which the GRDC receives funds (both government- and grower-derived).

The key elements in the GRDC’s planning and reporting framework are shown in Figure 2. These documents are available for download from the GRDC’s website.

RD&E = research, development and extension
Australian grain production is characterised by the predominance of winter cereals, produced across a wide area in a number of distinct agroecological zones with differing climate, soil characteristics and farming systems. Recently, strong export market demand together with access to improved varieties and farming systems has driven the expansion of pulse production, particularly chickpeas in northern Australia and lentils in southern Australia.

Gross value of production
Agriculture has a minor but important impact on Australian gross domestic product (GDP). Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) statistics show that agriculture contributed 2.2% of total GDP in 2016–17.

Within the agriculture sector, livestock (for slaughter) and grains production contribute the most in terms of GVP (Figure 3). In 2016–17, the GVP of grains was $18.1 billion and constituted 28% of the total gross value of agricultural production.

Wheat still dominates Australian grains production, followed by barley, canola, sorghum and pulses (figures 4 and 5).

More recently, greater demand and improved prices, as well as price stability, have driven greater production and gross returns for pulses (mostly chickpeas and lentils).

This change in focus of production brings many opportunities for diversification of farm businesses but is also accompanied by the challenges of adjusting farming systems.
Location

Australian grains production occurs across three regions—comprising 13 different agroecological zones—with distinct climate, cropping and market characteristics, as described in Figure 6.

Figure 6: Grain-growing regions

<table>
<thead>
<tr>
<th>NORTHERN REGION</th>
<th>SOUTHERN REGION</th>
<th>WESTERN REGION</th>
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<tr>
<td>Soil fertility is generally high, although there is increasing evidence that this has been run down over time. The region has relatively high seasonal rainfall and production variability compared with the other two regions. Yield depends, to a significant degree, on conservation of soil moisture from summer rainfall. The region has the highest diversity of crop production, including maize, sorghum and tropical pulses as well as wheat, barley, winter-growing pulses and oilseeds. It is the largest source of Australia's premium hard high-protein wheat. Demand for feed grains from the region's livestock industries is a key driver of production.</td>
<td>The region has a diverse suite of soils with generally low fertility and many subsoil constraints, such as salinity, sodicity and toxic levels of some elements. However, some areas have very productive soils. Yield potential depends on seasonal rainfall, especially in autumn and spring, and is less dependent on stored soil moisture than in the Northern Region. Crop production systems are varied and include many mixed farming enterprises with significant livestock and cropping activities.</td>
<td>Soil fertility is generally low to very low, and yield depends on winter and spring rainfall. In many areas, low yields are compensated for by the large scale and degree of mechanisation of cropping enterprises. Long-term variability in seasonal rainfall and production is lower in the coastal areas than in the Northern and Southern regions. Wheat, barley, canola and lupins are the dominant crops. Mixed farming systems with livestock are generally less important. The region has a relatively small domestic market and exports more than 85 percent of its grain production.</td>
</tr>
<tr>
<td>Key characteristics: • high proportion of vertosol clay soils • tropical, sub-tropical and temperate environments • summer dominant cropping in Queensland, winter dominant cropping in New South Wales • high proportion of mixed farming, including sugarcane, cotton and pastures • large and diverse domestic and export markets.</td>
<td>Key characteristics: • relatively infertile soils • temperate climate • yield depends on reliable spring rainfall • smaller enterprise size and diverse production patterns and opportunities • innovative phase farming with perennials • shift toward intensive livestock production and demand for feed grains • large and diverse domestic market.</td>
<td>Key characteristics: • low soil fertility • Mediterranean climate • dependence on winter rainfall as spring rainfall is unreliable • large enterprise size • leading grain storage practices • narrow range of crop options • dominant export market, and transport advantage to South-East Asia.</td>
</tr>
</tbody>
</table>
MAJOR MARKETS

Although Australia is a relatively small producer of grains in a global context, Australia exports a significant volume of grains each year, as shown in tables 1 and 2. Demand from new and existing markets is increasing.

Table 1: Top grain export commodities by volume (tonnes)

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>5-year average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>17,761,439</td>
<td>18,015,586</td>
<td>16,936,210</td>
<td>15,939,870</td>
<td>20,205,690</td>
<td>17,771,759</td>
</tr>
<tr>
<td>Canola</td>
<td>3,070,253</td>
<td>2,447,050</td>
<td>1,965,788</td>
<td>3,599,318</td>
<td>172,024</td>
<td>2,250,887</td>
</tr>
<tr>
<td>Barley</td>
<td>3,759,375</td>
<td>3,614,328</td>
<td>3,212,395</td>
<td>4,624,085</td>
<td>5,826,475</td>
<td>4,207,332</td>
</tr>
<tr>
<td>Sorghum</td>
<td>1,216,126</td>
<td>367,123</td>
<td>1,659,034</td>
<td>883,718</td>
<td>325,905</td>
<td>890,381</td>
</tr>
<tr>
<td>Chickpeas</td>
<td>541,897</td>
<td>595,305</td>
<td>1,253,046</td>
<td>1,236,929</td>
<td>1,734,273</td>
<td>1,072,290</td>
</tr>
<tr>
<td>Lentils</td>
<td>315,339</td>
<td>286,460</td>
<td>229,051</td>
<td>274,645</td>
<td>795,977</td>
<td>380,294</td>
</tr>
<tr>
<td>Lupins</td>
<td>162,820</td>
<td>338,276</td>
<td>209,884</td>
<td>276,988</td>
<td>181,230</td>
<td>233,840</td>
</tr>
</tbody>
</table>

Source: Australian Bureau of Statistics

Table 2: Top grain export commodities by value ($m)

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>5-year average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>6,285,527,448</td>
<td>6,129,142,999</td>
<td>6,062,395,808</td>
<td>5,092,176,308</td>
<td>5,790,802,208</td>
<td>5,872,008,954</td>
</tr>
<tr>
<td>Canola</td>
<td>2,332,760,196</td>
<td>1,465,203,944</td>
<td>1,523,239,764</td>
<td>1,281,285,290</td>
<td>1,548,789,515</td>
<td>1,630,255,742</td>
</tr>
<tr>
<td>Barley</td>
<td>1,065,508,861</td>
<td>991,363,541</td>
<td>1,019,455,241</td>
<td>1,157,579,783</td>
<td>1,325,065,584</td>
<td>1,111,794,602</td>
</tr>
<tr>
<td>Sorghum</td>
<td>394,867,525</td>
<td>124,914,373</td>
<td>587,255,194</td>
<td>234,811,484</td>
<td>90,921,900</td>
<td>286,553,966</td>
</tr>
<tr>
<td>Chickpeas</td>
<td>303,466,434</td>
<td>324,658,888</td>
<td>1,002,431,862</td>
<td>1,209,483,296</td>
<td>1,683,235,256</td>
<td>904,653,737</td>
</tr>
<tr>
<td>Lentils</td>
<td>205,686,723</td>
<td>216,847,953</td>
<td>244,338,351</td>
<td>289,624,487</td>
<td>620,047,903</td>
<td>315,309,083</td>
</tr>
<tr>
<td>Lupins</td>
<td>76,112,172</td>
<td>137,923,170</td>
<td>99,249,717</td>
<td>106,646,823</td>
<td>65,224,570</td>
<td>97,031,290</td>
</tr>
</tbody>
</table>

Source: Australian Bureau of Statistics
Wheat

ABARES statistics show that, from 2013–14 to 2017–18, an average of 12.3 million hectares of wheat was planted per annum, resulting in average annual production of 25.3 million tonnes with a value of $71 billion. Exports over the same period averaged 17.9 million tonnes and $5.6 billion.

South-East Asia and the Middle East are the major markets for Australian wheat (Figure 7).

In international markets, the main uses of Australian wheat are:

- Asian noodles, including udon, ramen and instant noodles
- Asian steamed products
- Bread products (Asian, Western, Middle Eastern and Indian styles)
- Pasta
- Sweet cakes, pastries and confectionary.

Source: Australian Bureau of Statistics
Barley and other coarse grains

Barley
From 2013–14 to 2017–18, an average of 3.9 million hectares of barley was planted per annum, resulting in average annual production of 9.6 million tonnes with a gross value of $2.3 billion. Exports over the same period averaged 6.7 million tonnes with a value of $2 billion.

Figure 8 highlights the strong demand for barley from North Asia, led by China and Japan. Other major markets for barley include the Middle East, led by Saudi Arabia.

In addition to the use of barley in stock feed, Australian barley is used in many malt products, including:
- beer
- distilled spirits
- malt extract
- confectionary
- flavoured drinks
- breakfast cereals.

Sorghum
From 2013–14 to 2017–18, an average of 0.66 million hectares of sorghum was planted per annum, resulting in average annual production of 1.66 million tonnes with a value of $445 million. Exports over the same period averaged 0.9 million tonnes and $300 million.

Sorghum’s main use has been as a stock feed. Recent growth in demand, however, has been driven by sorghum’s use in producing biofuel and the Chinese spirit baijiu.

Figure 8: Five year average value and volume of Australian barley exports

Major markets for Australian barley
Five-year average to 2017
Total $1.1 billion 4,207,332 tonnes

Source: Australian Bureau of Statistics
Note: values do not include malt barley
Canola
From 2013–14 to 2017–18, an average of 2.5 million hectares of canola was planted per annum, resulting in annual average production of 3.4 million tonnes with a value of $1.68 billion. Exports over the same period averaged 2.6 million tonnes and $1.5 billion.

Europe has emerged as a major importer of Australian canola, with demand driven particularly by biofuel production (Figure 9).

The main uses of Australian canola are:
- food-grade oil
- biofuel
- stock feed, including protein meals.

Source: Australian Bureau of Statistics
Pulses

From 2013–14 to 2017–18, an average 1.9 million hectares of pulse crops were planted per annum, resulting in annual average production of 2.8 million tonnes with a value of $1.77 billion.

Key pulses grown in Australia are lupins (30%–40% of total pulse production), chickpeas (20%–35%), lentils (10%–15%), field peas (10%–15%), and faba beans and broad beans (10%–15%).

India is the major market for Australia’s key pulse exports, lupins, chickpeas and lentils (Figure 10).

Australian pulses are varied and have specific uses, but are mainly used for:

• foods for human consumption
• stock feed.

Figure 10: Five year average value and volume of Australian pulses exports

Major markets for Australian pulses
Five-year average to 2017
Total $1.32 billion 1,686,424 tonnes

Source: Australian Bureau of Statistics
GLOBAL TRENDS—SUPPLY AND DEMAND

The GRDC has undertaken several global grain supply and demand studies to inform strategy and investment decisions. Those studies provided valuable context for the development of this RD&E plan.

Cereals

For almost a decade, extending from 2005 to 2015, there was a strong relationship between the prices of cereals (predominately wheat) and the demand for ethanol for fuel. While the demand for ethanol was largely met by maize production, the diversion of maize for ethanol production had the effect of increasing demand for wheat to fill the production gap. More recently, the demand for maize for ethanol has slowed. In response, wheat demand has contracted, and prices have declined. Overall real wheat prices have largely been declining since 1960 and the recovery driven by ethanol during the mid-2000s appears to have ended (Figure 11).

This may seem to portray a gloomy outlook for wheat, Australia’s most important crop. There are many positive trends, however, regarding wheat demand and prices. Firstly, in regions with rapid income growth consumers are switching from traditional sources of carbohydrate, such as rice, to more differentiated products, such as noodles and bread, contributing to an ongoing increase in demand for wheat in those regions.

Another notable trend is the continuing growth in demand for wheat from India and South-East Asia, where income growth is driving a shift away from rice to wheat products. India and South-East Asia are markets that Australia has historically supplied, in which Australian grain has a good reputation for cleanliness and functionality and Australia enjoys a freight advantage. Maintaining and growing these markets in the face of increasing competition from emerging exporters will require ongoing efforts to ensure that specific customer demands are met.

In addition, it is anticipated that growth in beer consumption in several developing countries will continue to drive an increase in demand for malt barley. The increased demand for malt barley is, however, expected to be relatively small and to be comfortably met by current growth in yield from existing areas of production.

Another important global trend is the increasing importance, in many demographics, of using diet to prevent health issues. Oats, which are high in beta glucans, are an important health ingredient in Western diets and are increasingly being favoured in many Eastern diets. There is potential for Australia to become an important supplier of premium quality and/or further differentiated oats in global markets.

4 The reports of these studies include Global agriculture and the role of Australia—Guiding the allocation of GRDC’s research budget (March 2015) and Update on the drivers of global agriculture and the role of Australia (December 2017).

5 While care has been taken to try to ensure accuracy, the forward-looking trends and estimates described may be subject to change.
Oilseeds
Global demand for oilseeds is expected to continue to increase. Soybeans will continue to be the preferred oilseed, supporting vegetable oil consumption as well as providing high-protein animal feed.

However, the growing global demand for protein meal and vegetable oil will also support increasing demand for canola. The potential for expansion of canola production in North America remains relatively low and presents an opportunity for Australia to capture a greater share of any growth in canola demand. Ongoing demand for canola, particularly in Europe, will require greater demonstration of production sustainability and provenance as the continent moves away from palm oil. These requirements are likely to feature heavily in customer demand in the future.

Pulses
The increasing trend in demand for cool season pulses (chickpeas, lentils and field peas) from the Indian subcontinent appears unlikely to diminish in the near term, although short-term shocks, such as the recent application of tariffs by the Indian Government, are likely to remain a feature of this market. Vegetarians comprise a large proportion of the population in India and much of the subcontinent. While in many other countries the greater demand for protein will be met by meat, in nations with a high proportion of vegetarians the increasing demand for protein will be largely met by pulses.

Another trend likely to impact on the demand for pulses is an increase in health concerns associated with red meat consumption, particularly in developed countries. A counter to this trend is the fact that the preparation of most pulse dishes is relatively time-consuming, which could limit the desirability of pulses in some countries. Further development of easy-to-prepare pulse dishes and snack foods will be a significant factor in determining future demand for pulses.

GLOBAL TRENDS—OTHER DRIVERS OF CHANGE
An assessment of the potential future operating environment reveals widespread agreement on at least some significant drivers of change. Potential future environmental impacts can be classified as political, economic, social and technological, although there is considerable overlap between these classes.

Political
- Global instability will continue with a likely power shift from West to East.
- Grain importers will continue to use trade barriers to protect domestic industries.
- Public sector investment in RD&E is likely to decline.
- Regulation of new crop protection chemistries and gene technologies is likely to become increasingly proscriptive, particularly in Europe, with flow-on effects on market access constraints and higher costs.
- Water scarcity is likely to lead to further regulation and monitoring. Declining access to clean water for irrigation in many countries, including China and India, is likely to impact on the global crop supply and demand.
- The future for managing health will focus more on prevention than cure, and diet will continue to be an important part of prevention measures.

Economic
- Continuing economic development in Asia will drive further demand for higher value grains as well as feed grains.
- Food standards and safety will continue to grow in importance, with concomitant requirements for traceability of production and identity preservation.
- Closed-loop marketing will be adopted more often to meet growing consumer demand for traceability and food safety.
- Farm consolidation will continue to be a driver of ongoing economies of scale and profitability.
- Renewables will drive disruption in energy markets, with implications for rural energy supply.

Social
- Declining rural populations will impact on social cohesion and are likely to drive higher labour costs.
- Growing environmental demands of predominately urban voters will drive the push for ‘a licence to farm’. Carbon dioxide emissions from farming and agriculture’s carbon footprint will become increasingly important.
- Social debate will be heavily influenced by pseudoscience and ‘alternative facts’ that support preconceived beliefs.
- Ethical preferences (e.g. local, organic, non-GM or non-meat) will have a greater impact on global food consumption trends.
Technological

- Large data sets will require ongoing management and curation to support ongoing analysis.
- Data analysis will be driven by improvements in artificial intelligence, modelling and forecasting.
- Greater use of data in decision-making will drive required improvements in connectivity and a change in grower education.
- Labour shortages will drive automation of farm practices.
- Demonstrated intellectual property management will drive the exchange of knowledge.
- Australian scientific expertise will continue to leak overseas as international institutions provide greater stability and pay.
- Existing supply chains and incumbent business models will be disrupted by digital innovations, including applications of artificial intelligence, machine learning, blockchain and ‘the internet of things’.

AUSTRALIAN GRAINS INDUSTRY SWOT ANALYSIS

The following Australian grains industry SWOT analysis (Figure 12) has been developed considering the likely global supply and demand trends presented above, other drivers of change, and current knowledge of Australian grain production and transport logistics. The analysis is an important contribution to the GRDC’s investment priorities and portfolio balance.

Figure 12: Grains industry SWOT analysis

<table>
<thead>
<tr>
<th>STRENGTHS</th>
<th>WEAKNESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mostly well-informed growers that accept and welcome the need for change and recognise the need to innovate</td>
<td>Demanding environment that limits grain yield and continuity of supply to important markets</td>
</tr>
<tr>
<td>Rapid uptake of new innovation where viable</td>
<td>Relatively high cost of production and higher proportion of that cost invested by grain growers up front</td>
</tr>
<tr>
<td>International reputation for producing high-quality, safe grain</td>
<td>High labour and transport costs</td>
</tr>
<tr>
<td>Geographic proximity to major markets</td>
<td>High environmental production risk</td>
</tr>
<tr>
<td>Broad production base—varied geographical and agroecological conditions and crop types</td>
<td>Relatively small production levels that are unattractive for technology investment (e.g. in specialised crop protection machinery products)</td>
</tr>
<tr>
<td>Well-established R&amp;D system that is envied by the world</td>
<td>Decline in field-based applied R&amp;D capacity (e.g. pathology and research agronomy)</td>
</tr>
<tr>
<td>International reputation of researchers</td>
<td>Variable status of approval across jurisdictions regarding the commercial cultivation of crops incorporating GM technologies</td>
</tr>
<tr>
<td>Robust agricultural chemical and gene technology regulatory systems based on effectively managing risk</td>
<td>Declining public sector investment in grains R&amp;D</td>
</tr>
<tr>
<td>Well-established and novel value capture mechanisms (plant breeder’s rights) that effectively support private plant breeding</td>
<td>Poor regional telecommunications connectivity</td>
</tr>
<tr>
<td>Well-established and highly skilled private consultancy networks (on-farm agronomy and financial advice)</td>
<td>Relatively poor interaction of public sector and private sector R&amp;D efforts</td>
</tr>
<tr>
<td>Larger farms providing economies of scale</td>
<td>Expansion of production, relatively low costs and improvements in quality in emerging grain suppliers (e.g. Black Sea countries)</td>
</tr>
<tr>
<td>Relative ease of access to capital</td>
<td>Ongoing international adoption of hazard-based regulation of technologies (e.g. chemistry, genetics and robotics), limiting the discovery and availability of new technologies</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OPPORTUNITIES</th>
<th>THREATS</th>
</tr>
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<tbody>
<tr>
<td>Increasing influence in key markets that will continue to support demand</td>
<td>Changing weather and/or climate that increases yield variability and production risk</td>
</tr>
<tr>
<td>Product differentiation tailored to current consumer demands and novel products for broader consumer demand</td>
<td>Biosecurity, GM or residue breaches negatively affecting the Australian reputation for clean, quality product</td>
</tr>
<tr>
<td>Good position to capture advantage from increasing demand for food safety, quality-secured products, traceability, and greater demand for healthy foods and demonstrated environmental sustainability</td>
<td>Ongoing demand for greater food integrity that will increase costs but not necessarily price</td>
</tr>
<tr>
<td>Size of farms that provides opportunities to link consumer to producer at scale (e.g. direct sales to processors)</td>
<td>Decline in public sector contributions to R&amp;D</td>
</tr>
<tr>
<td>Use of the R&amp;D base to leverage international technology better</td>
<td>Decline in rural population and impact on government policy and local service provision</td>
</tr>
<tr>
<td>Use of new technologies to mine historic RD&amp;E data for new findings</td>
<td>Potential for negative disruption to the successful Australian R&amp;D model</td>
</tr>
<tr>
<td>Technology to connect growers to each other and to consumers</td>
<td></td>
</tr>
<tr>
<td>R&amp;D and regulatory base that suits the development of Australia as an R&amp;D test hub for international technologies</td>
<td></td>
</tr>
<tr>
<td>Good position to meet some of the increasing global demand for pulses</td>
<td></td>
</tr>
<tr>
<td>Expansion of grain production into non-traditional areas (e.g. northern Australia)</td>
<td></td>
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</table>
AGILITY

Grain growers strategically plan crop rotations over an extended period (five to seven years) but maintain a degree of flexibility to manage constraints and capture opportunities that impact on overall profitability and sustainability. Similarly, growers will often adjust farming practices within a season to manage risks to optimise profit. Simply put, growers continually adjust both long-term and short-term activities to achieve the ultimate objective of maximising profit and sustainability. The GRDC will administer the RD&E portfolio in the same manner, maintaining a focus on delivering its purpose while adopting flexibility in the scope and management of investments to meet unforeseen challenges and/or capture new opportunities.

The GRDC will implement RD&E programs and individual investments that embrace the principles of agility through:

• collaboration with growers (as key beneficiaries) and other stakeholders, to identify the objectives and key investment targets that best deliver on the GRDC’s purpose
• the deployment of cross-functional teams (that include external experts) for each investment target, to undertake gap analysis and identify the desired outcome aligned with the purpose, utilising a program logic approach
• a focus on the delivery of clear outcomes based on Specific, Measurable, Actionable, Realistic and Time-bound (SMART) principles rather than rigid planning of activities
• the establishment of close working relationships with partners, to facilitate a flexible approach to delivering the activities required to achieve a desired outcome
• active management of investments that promotes responsiveness to change
• continual improvement of investment planning and management as the GRDC and its partners identify areas of relative strength and weakness.

As part of agile investment management, detailed individual investment plans for each KIT will be developed. In a changing operating environment, these plans will be continually monitored and adjusted to ensure that they deliver the outcomes desired and to accelerate the delivery of transformational outcomes where they are identified. Growers and other stakeholders will be encouraged to interact with the GRDC on an ongoing basis during the life of each investment plan, to identify new investment targets as they arise. Where new targets provide a compelling case for action, the investment portfolio will be adjusted to accommodate the required RD&E programs.

FOCUS ON PROFIT

This five-year RD&E plan is part of a 10-year to 20-year strategy to deliver on the GRDC’s purpose: To invest in research, development and extension to create enduring profitability for Australian grain growers.

The key drivers of grain grower profitability are yield, price, costs (on farm and post farm gate) and risk. The relationships between these drivers can be expressed as follows:

Profit = (Yield x Price – Costs) x Risk.

It is important to note that the importance of different drivers varies across grain-growing businesses and environments. This will have a significant impact on the shape and scope of the GRDC’s RD&E investment portfolio at the national level, and on the activities and approaches required to support adoption of RD&E outputs at the regional and local levels.
Yield

Closing the yield gap

Analysis of the current gap between actual grain yield and potential grain yield across Australia (modelled on wheat yields) highlights the considerable scope that exists for improvement.

Table 3 shows the estimated gap between actual average wheat yield and the modelled potential wheat yield for each of Australia’s three grain-growing regions, based on 80% of maximum water-limited yield in the region. Yield gaps range from 0.7 tonnes per hectare in the Southern Region to 0.9 tonnes per hectare in the Northern Region. Exploitation of the yield gap has the potential to deliver more than $3.8 billion of increased value annually to Australian wheat production. Yield gaps of similar proportions are likely for other crops; research is underway to determine their values.

Table 3: Relative differences in actual and potential yields of wheat in GRDC regions

<table>
<thead>
<tr>
<th></th>
<th>Western Region</th>
<th>Southern Region</th>
<th>Northern Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average yield (tonnes/hectare)—A</td>
<td>1.6</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Yield potential (modelled) (tonnes/hectare)—B</td>
<td>3.0</td>
<td>3.2</td>
<td>3.3</td>
</tr>
<tr>
<td>Targeting 80% of water-limited yield to account for production risk—C</td>
<td>2.4</td>
<td>2.5</td>
<td>2.6</td>
</tr>
<tr>
<td>Exploitable yield (tonnes/hectare)—C – A</td>
<td>0.8</td>
<td>0.7</td>
<td>0.9</td>
</tr>
<tr>
<td>Value gap ($/hectare/year at $220/tonne)</td>
<td>176</td>
<td>154</td>
<td>198</td>
</tr>
<tr>
<td>Five-year average crop area ('000 hectares)</td>
<td>8,221</td>
<td>6,829</td>
<td>6,696</td>
</tr>
<tr>
<td>Annual value lost ($'000)</td>
<td>1,446</td>
<td>1,052</td>
<td>1,326</td>
</tr>
</tbody>
</table>

Source: Yield Gap Australia

A significant proportion of the current yield gap could be filled through adoption of outcomes from previous grains R&D investments and/or the conduct of additional proof-of-concept R&D. In most production systems, the adoption of many innovations is complex and affected by a range of business constraints and grower motivations. Gaining a better understanding of key influences on successful grower adoption of technical innovations will assist greatly in the design of strategies to improve rates of adoption of new innovation.

Increasing yield potential

A goal to close the gap between actual and potential yields for all crops is clearly a worthwhile objective. However, delivering enduring profitability to grain growers will also require investments aimed at further extending the yield potential and yield stability of Australian grain crops. Extending yield potential can be achieved by increasing the genetic yield potential and by limiting the impact of yield constraints (e.g. frost, hostile soils and heat).

Maintaining yield stability under the impacts of various environmental factors is an important consideration in limiting exposure to production risk and underpins stability of supply. Investments in this area may involve relatively high risks and long timeframes to delivery.

Price

Supporting and enhancing current products

Most Australian grain is exported as bulk commodities. Therefore, prices can be volatile and strongly impacted by many interacting supply and demand variables in global trade. Maintaining current market positions will depend on maintaining the premium quality of Australian grain.

Important functions driving the maintenance of premium quality include Australia’s grain classification systems as well as the effective and prompt management of trade and market access issues as they arise.

Enhancing the value of Australia’s current grain products will require efforts to further differentiate bulk commodities, with a particular emphasis on functionality. The aim is to capture a greater proportion of premium-paying global markets by identifying, segregating and delivering specific functionalities that address specific end-user needs.

Traceability and demonstrated food safety are also likely to remain key customer requirements and are expected to increase in importance in the short-to-medium term. Australia appears to be well placed to capture greater value from being able to create identity-preserved supply chains with assured food safety.

Global trends in relation to food safety and sustainability of production are likely to drive much greater demand for quality-assured products and traceability.

Exploring new products

While the export of bulk commodities will remain a significant part of future Australian grain trading, opportunities to change the functionality and/or composition of traditional commodities will underpin future increases in demand and prices. Opportunities to attract premium prices from novel functionality have been exploited in the past—examples include omega-3 canola, ultra-low-gluten barley and high-amylose wheat developed jointly by CSIRO and the GRDC.

A global population that is more conscious of health and the environment and has a greater proportion of disposable income creates the opportunity to capture value from novel functionalities related to health and wellbeing.
Costs

A wide range of opportunities exist that can lead to incremental and transformational reductions in input costs while optimising production. The challenge is to identify and prioritise the incremental opportunities to match costs with production at a regional scale while also identifying transformational opportunities on a national scale.

The relatively small size of the input market in Australia (compared with global markets) presents challenges for external investment in new crop protection products and innovations in farm machinery. The GRDC will need to collaborate more widely, including internationally, to ensure that the Australian grain industry’s needs are met.

The costs of identifying, developing and commercialising new crop protection chemistries have almost doubled, from US$152 million per chemistry in 1995 to US$286 million in 2014 (Figure 13).

The increase is mostly attributed to activities necessary to meet increased regulatory requirements. Such increases in discovery and development costs are likely to be reflected in increased cost of chemical inputs to grain growers.

Likewise, current fertiliser costs reflect the cost of raw inputs—most notably, the cost of natural gas is reflected in the cost of nitrogen fertilisers. Given the trend toward higher raw input costs, the price of fertilisers is likely to increase in the future.

Changes to Australian domestic freight and supply chain logistics are complex and largely beyond the purview of the GRDC. However, continued R&D into understanding the variables that drive supply chain costs, to inform policy, remains valuable.

Risk

The long-term increase in variable input costs, coupled with modest increases in farm income, has contributed to Australian grain grower profit margins remaining very tight in most years. Importantly, the increase in input costs significantly increases the financial risk to which farm businesses are exposed. This trend is consistent across regions.

Risk is an important part of the profit equation. Risk management practices that are overly conservative can limit profit in above-average production years, while approaches that are overly aggressive can expose growers to large losses that in turn could contribute to business equity issues that ultimately impact profit and future operations. In addition, grower attitude to risk is a key determinant of the speed and scale of uptake of new technology.

A key aspect of this RD&E plan is better understanding growers’ decision-making and attitude to risk. This will be fundamental not only in developing investment strategies to
assist in the management of production and business risk but also in tailoring RD&E to develop and maximise the adoption of new technologies that will underpin profitability.

CORE FRAMEWORKS

This RD&E plan is a strategic framework to deliver grower profitability through investment in RD&E that addresses the primary drivers of profitability. In addition, there are four core frameworks that underpin all RD&E investments: data management and analytics; biosecurity; grower communication and extension; and capacity and skills.

Data management and analytics

Data-driven agriculture is set to deliver transformational change across the grains industry. Growers, researchers, governments and industry are increasingly looking to capture and exploit data relevant to the grains industry, including:

- within paddock, whole-paddock and whole-farm performance data
- regional, national and global production data, including yields and inputs
- data from R&D experimentation
- environment characterisation data (e.g. soil maps, high-resolution imagery and climate and weather data)
- economic data (e.g. market supply and demand data).

Combining these rapidly expanding data resources with state-of-the-art analytics and the power of artificial intelligence will enable a step change for the grains industry. For instance, precision agriculture technology and analytics will enable a step change for the grains industry. Growers, researchers, governments and industry are increasingly looking to capture and exploit data relevant to the grains industry, including:

- within paddock, whole-paddock and whole-farm performance data
- regional, national and global production data, including yields and inputs
- data from R&D experimentation
- environment characterisation data (e.g. soil maps, high-resolution imagery and climate and weather data)
- economic data (e.g. market supply and demand data).

The desired outcome of every GRDC RD&E investment is the adoption of new technologies or innovations that maintain or enhance grain grower profitability. Communication (raising awareness) and extension (influencing behavioural change) are essential to effecting that adoption.

For each KIT, the GRDC will identify requirements for addressing gaps in grain growers’ Motivation, Ability to change, access to appropriate Knowledge, Attitudinal barriers, and Technology constraints (MAKAT). Through this process, the GRDC will develop a balanced RD&E portfolio to effectively address the constraints or capture the opportunities.

Because extension is delivered at the local level, GRDC staff with skills in communication and extension are being placed in offices in all three GRDC regions. Having communication and extension staff side by side with GRDC research staff and key collaborators ensures that the most appropriate path to adoption is being considered as a critical component of every R&D investment, from design to delivery.

To ensure that its communication and extension activities have the greatest impact, the GRDC will continue to strive to understand as much as possible about growers’ learning preferences, attitudes to information channels, decision drivers and barriers to adoption. These understandings will be central in tailoring development and extension packages to meet the needs of different grain grower segments.

With around 80% of growers using adviser services to inform their decision-making on farm, the GRDC will work closely with key influencers—including farming systems groups and other grower groups, farm advisers and agribusiness stakeholders—to ensure that all appropriate communication channels are being leveraged to get the right information to growers in a timely way and in the best format to help increase adoption and, ultimately, profitability.

While still providing information in hard copy, the GRDC will continue to transition to existing and emerging digital platforms, in recognition that different growers prefer to receive information in different ways and that growers and their influencers will be increasingly able to access information via digital channels as technology and bandwidth improve.

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**Capacity and ability**

**Growers and industry**
The Australian grains industry requires grain grower leaders who can contribute innovative ideas, facilitate industry discussion on the RD&E portfolio, and be role models for the adoption of innovation into profitable farming systems and business models. The GRDC will continue to contribute to enhancing the leadership competencies of Australian grain growers in these critical areas.

Grower health, mental and physical, will remain a priority across all agricultural industries, and the GRDC will continue to contribute to cross-industry initiatives that target healthy and safe grower communities.

While profitable grain growers are a fundamental building block of a healthy grains industry, grain growers need to operate within a functional, effective and innovative grains industry value chain. The GRDC is well placed to facilitate collaboration and cooperation across the grains industry and to assist in leveraging positive, precompetitive outcomes for the value chain. To that end, the GRDC will participate in industry good functions, including beyond the farm gate, where those functions align with the GRDC’s purpose.

**Researchers**
The GRDC must collaborate with RD&E providers to ensure the ongoing provision of appropriate experience and ability to deliver key outputs and understanding of often complex issues. The GRDC will continue to contribute to broad RD&E capacities and abilities, but will focus more on establishing critical mass of expertise and delivery pathways in the most important investment areas.

**PORTFOLIO BALANCE**
The planning and delivery of a portfolio that delivers a balanced mix of investments is a key function of the GRDC and the focus of this R&DE plan.

**Maintenance, incremental and transformational impacts**
Investment in RD&E can have a different quantum of impact (either directly or indirectly) on each profit driver, ranging from maintenance of current profit, through incremental improvements in profit of 1% to 2%, to transformational changes of 10% to 20%.

The GRDC will continue to invest in RD&E to maintain grain grower profitability, including investments in aspects of biosecurity, pest and disease management; weed management; grain quality and grain classification; and access to and competitiveness in international markets.

RD&E investments to support incremental improvements in profit generally deliver on-farm changes in the short-to-medium term (up to eight years), and are characterised by having lower levels of technical, commercial and/or adoption risk than those aimed at transformational impact.

Transformational impact is required for the Australian grains industry to remain competitive in the long term and potentially provides opportunities for Australian grain growers to establish dominant positions in some markets. RD&E to support transformational change is generally characterised as being high risk and often requires relatively long periods for delivery.

Following consultation with growers and researchers, a target for investment in transformational RD&E of at least 50% has been established, reflecting the general agreement that, over the longer term, the cost–price squeeze currently experienced by most growers will not be sustainable and transformational change will be needed to support future profitability. Adjustments to the investment portfolio to transfer the focus to higher levels of integrated transformational approaches will take some time to implement, given current investments with out-year commitments. However, it is expected that the target level of transformational investments should be met by the end of the second year of this plan.

**Geography**
The GRDC’s focus is on maximising the impact of RD&E investment on the profitability of the growers that contribute the majority of funds, rather than on the locations where the funds are invested. While investment on a regional and local basis is a critical component of any program seeking to influence grower attitude, motivation or ability to adopt new innovations, the physical locations of the RD&E activities to support the development of new innovations will be determined only by their capability and capacity to deliver. This investment posture is important if the GRDC is to target transformational outcomes for Australia’s grain growers in every region.

Therefore, for the provision of strategic and applied research at least, the GRDC will continue to identify the most suitable providers based on merit regardless of location or other political and/or social factors. This includes partnering in investment with international entities where appropriate.
FINANCIAL FORECASTS

The GRDC is entering this RD&E strategic investment period in a strong financial position. Over the life of this plan, the GRDC will continue to make consistent and significant investments in RD&E to deliver on its purpose.

Income and expenses

While financial modelling cannot take into consideration any unforeseen environmental or legislative change impacts, it is expected that RD&E expenditures and operational costs will be relatively stable across the period. Any short-term revenue variability and the forecasted annual deficits will be managed by using cash reserves.

The GRDC expects to invest in the order of $1 billion in meeting its purpose over the five years of this plan (Table 4).

<table>
<thead>
<tr>
<th>Table 4: GRDC budget, 2018–19 to 2022–23</th>
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<tbody>
<tr>
<td>Income</td>
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<tr>
<td>Levises</td>
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<tr>
<td>Commonwealth matching</td>
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<tr>
<td>Other</td>
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<tr>
<td>Total Income</td>
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<tr>
<td>Expenses</td>
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<tr>
<td>RD&amp;E investments</td>
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<tr>
<td>Employees</td>
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<tr>
<td>Suppliers</td>
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<tr>
<td>Total Expenses</td>
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<tr>
<td>Operating surplus/deficit</td>
</tr>
</tbody>
</table>

Allocation to research and development

Figure 14 indicates how the GRDC’s RD&E investment budget will be allocated to priorities in relation to the key drivers of grower profit and the core frameworks that underpin the delivery of RD&E outcomes.

These proportions will change over the life of the RD&E plan as strategies are developed and the portfolio is adjusted to reflect changes in the priorities of growers and other stakeholders. Changes to investment allocations will be reflected in the annual operational plan and annual report.

Figure 14: Allocation of RD&E investment
**IMPACT ASSESSMENT**

The ultimate way to assess the GRDC’s performance in delivering on its purpose is to measure the impact of the GRDC’s RD&E investments on Australian grain growers’ profitability.

However, this is complicated by factors such as the following:

- The grains industry is very complex and varies greatly across location, farming system, farm type, enterprise mix and the specific financial circumstances of individual grain-growing businesses (e.g. equity). Measures of profitability vary widely between farms and even across seasons within a single farm. Arriving at performance indicators that have relevance at a national level is therefore difficult.

- There is no single collection of profit data across the grains industry to support measurement. Some private sector advisers, however, do currently collect some financial performance data to assist their clients, particularly in business benchmarking exercises.

- The long lag times between the conduct of R&D, the adoption of R&D outcomes on farm, and the impact of those outcomes on profit, as well as the number of interacting variables that can affect profit, make it difficult to directly link R&D investments to impacts.

The GRDC will aim to develop new impact assessment tools during the life of this five-year plan. Of major importance will be the establishment of farm performance data sets that allow the collection of data from like farms (e.g. based on region, enterprise mix or size) for analysis of trends in yield, price, input costs and management of risk that will inform future RD&E priorities. Aggregation of the data will also allow for more accurate assessment of the impact of GRDC RD&E investments.

The GRDC’s performance measurement framework will be dynamic, and will be continually reviewed and updated as new information is generated and new learnings on best practice are adopted. The GRDC aims to work with industry to develop performance measures that are relevant locally, regionally and nationally.

The performance framework is split into three broad sections: KITs, objectives and purpose (Figure 15).

**Figure 15: GRDC performance framework**

The performance framework is split into three broad sections: KITs, objectives and purpose (Figure 15).
Key investment targets

Consultation with growers, researchers and the wider grains industry has identified 30 KITs that underpin the delivery of the GRDC’s purpose. A full strategy for the delivery of each KIT will be developed over the period of this RD&E plan. The GRDC has worked with a range of stakeholders to determine the relative urgency of developing and implementing each KIT strategy.

Utilising a program logic framework, each strategy will clearly outline:

1. outcome—the desired impact of the investment on meeting a priority objective and purpose. The outcome clearly outlines the practice change expected and the target(s) for impact assessment.

2. gap analysis—identification of gaps in MAKAT that must be addressed to deliver the outcome. This includes the use of external expertise to inform analysis, develop business cases to support the expected return on investment, and assess technical feasibility and adoption risk.

3. outputs—investments developed to generate the tangible deliverables required to achieve the outcome.

4. impact assessment—the measures and methods that will be utilised to determine the effectiveness of the investment, as outlined in the outcome.

Overviews of KIT strategies will be communicated widely and reviewed regularly to assess performance and adjust focus in line with agile investment processes.

Objectives

Objectives will be monitored over a longer timeframe, as the cumulative impacts of KITs. The GRDC will utilise a combination of data from the Australian Bureau of Statistics and ABARES, information from industry and other survey data to track improvements and/or declines in achieving objectives, but will need to make assumptions to attribute effects to RD&E outputs and outcomes.

Measures will make wide use of case studies to describe the links between RD&E and practice change at the farm or industry levels. For example, it is well established that planting at the optimum time has a major impact on grain yield potential but the time of planting is constrained by the need to manage the risk of frost (in sowing earlier) and the risk of heat and terminal drought (in sowing later). RD&E investments to expand the frost and heat tolerances of crops could deliver crop varieties that can facilitate both earlier and later plantings, to manage risk and maximise yield. However, it is difficult to accurately quantify the exact improvement that investment in tolerance of extreme heat has had on yield, given that a range of other factors also influence yield. Case studies provide an important tool for inferring or estimating the impact of such RD&E and demonstrating its adoption.

Purpose

Current data from ABARES surveys provides valuable insights into the performance of grain growers at a national scale but does not allow for more localised assessments and comparisons of performance. The GRDC is working with a range of stakeholders to determine the level of support and most appropriate methodology required for the collation of more localised farm performance data. Ultimately, analysis of more localised data over multiple years would allow not only a more informed assessment of farm performance but also the identification of new investments required to create enduring profitability and the exposure of gaps in adoption of new knowledge.

KEY PERFORMANCE INDICATORS

Purpose

Direct measurement of profit on a national basis as a performance indicator is complicated by the fact that performance varies with region, business type, business size, and a range of factors (such as capital gains and losses) that are not directly influenced by RD&E outputs.

ABARES recently calculated the rate of return (ROR) across farm businesses from 2000–01 to 2015–16. ROR is described as profit at full equity expressed as a percentage of total opening capital, excluding capital appreciation. The exclusion of capital appreciation is important, as capital appreciation is generally not influenced by RD&E investment.

Comparison of RORs from 2000–01 to 2016–17 demonstrates that in general grain producers maintain a positive ROR, averaging approximately 2.1% but with large variations across years. It is not sufficient for the GRDC to support the maintenance of average 2.1% ROR over the next five years. Analysis of the trend in ROR since its most recent low (in 2006–07) suggests that the GRDC should be targeting RD&E investment to support a national average RORs of at least 6% by 2023 (Figure 16), taking into consideration that the RORs of individual farm businesses will vary widely around this.
In addition, the GRDC will work with industry to collect farm performance data at a more localised level to allow for the development of performance indicators that better reflect farm scale, enterprise mix and region.

**Figure 16: Rate of return for Australian grain farms**

The impact of RD&E investment in genetic technologies on grain yield potential and stability can be assessed through improvements in the performance of crop varieties as measured in National Variety Trials (NVT). The NVT data set now comprises one of the most comprehensive measures of variety performance in the world.

Measurements of actual grain yield compared with current potential grain yield (the yield gap) will require more complex assessment. CSIRO, supported by the GRDC, has been undertaking regional assessments of the current yield gap. While the approaches to closing the yield gap will differ across regions and farm types, and especially need to take into account risk, a 20% closure of the current gap would generate in excess of $3.8 billion per annum across the grains industry.

The impact of RD&E investment in meeting the objective of improving yield will be measured in terms of:

- minimum yield increases equivalent to 1% per annum for cereals, 2% per annum for pulses and 1.5% per annum for oilseeds, achieved while identifying and investing in technology for transformational improvement in yield potential and yield stability
- minimum 20% closure of the gap between potential and actual yields over five years.

**Objectives**

**Improve yield and yield stability**

Improvements in grain yield can be generated by increasing yield potential and stability through several options, including genetics of new varieties, and by implementing improved practices that allow more of that yield potential to be realised (closing the yield gap).

The impact of RD&E investment in genetic technologies on grain yield potential and stability can be assessed through improvements in the performance of crop varieties as measured in National Variety Trials (NVT). The NVT data set now comprises one of the most comprehensive measures of variety performance in the world.

Measurements of actual grain yield compared with current potential grain yield (the yield gap) will require more complex assessment. CSIRO, supported by the GRDC, has been undertaking regional assessments of the current yield gap. While the approaches to closing the yield gap will differ across regions and farm types, and especially need to take into account risk, a 20% closure of the current gap would generate in excess of $3.8 billion per annum across the grains industry.

**Maintain and improve price**

The link between bulk commodity grain prices and international supply and demand provides relatively little opportunity for GRDC RD&E investment to impact on bulk commodity grain prices. Grain prices are also affected by external factors completely isolated from GRDC influence, such as exchange rates, tariffs and non-tariff trade barriers. Therefore, measuring the direct impact of RD&E investment on grain prices is difficult. However, a range of RD&E activities are known to either support current commodity prices or promote further differentiation and, therefore, the opportunity to extract higher grain prices.

The GRDC will determine the impact of RD&E investments on grain prices through:

- identification of potential new products and investments where a supportive business case can be established
- support for and enhancement of current products through identification of opportunities for differentiation and maintenance of current market access programs.

**Optimise input costs**

Input costs are composed predominately of crop protection chemicals, fertiliser and machinery and labour. Growers expect to maximise their long-term profit by making profits through short-term decisions around crop choices and their allocation of inputs to produce grain. The GRDC aims to assist growers to reduce their input costs relative to outputs over the next five years.

The Australian grain production environment is diverse geographically and environmentally. Growers in various regions produce different crops, use different input mixes, and employ management techniques focused on their local conditions. Growers across all regions face different costs and challenges, so it is difficult to identify a single measure for performance that is relevant for all growers at a national scale.

The GRDC’s efforts to work with growers and their advisers to establish benchmark farm performance data will be critical in allowing the grouping of like farms to compare input cost trends that not only indicate the impact of previous and current RD&E but also highlight the areas of focus where future RD&E might have greatest benefit to profitability. A farm performance database will take at least three years to establish and provide useful trend information. In the meantime, the GRDC will use two measures to monitor costs over time: input costs per hectare, and the ratio of costs to
crop revenue. Input costs measured by dollars per hectare are a good measure of inputs relative to farm size and type while the ratio of costs to crop revenue takes greater account of changes in cropping mix that demand different inputs. Taken together, the two measures help to explain costs at the whole-of-farm level.

In the first instance, the trends in the costs of fertiliser and chemicals will be monitored. The other major operating cost relates to machinery (including annual costs of contracting, fuel and oil, leasing etc.). However, overall trends in machinery operating costs are largely unaffected by R&D as are machinery capital costs. Therefore, while individual investments around machinery operating costs may be made, impact assessment at the more holistic scale will be limited to active monitoring of operating and capital machinery costs and how these may affect delivery on purpose.

All input costs will vary annually around a long-term trend, as shown in Figure 17. In wetter seasons growers are expected to use more inputs to combat pests and diseases and take advantage of the opportunity to increase yields by applying more fertiliser. The effectiveness of inputs (i.e. the impact they have on yield and profit) will also vary. The impact figures below, do not account for input effectiveness directly but such differences are likely to be reflected in improved annual rates of return.

Comparison of the long-term trend (Figure 17) with the shorter trend (Figure 18) allows an estimation of a range of predicted input costs as shown Table 5.

**Table 5: Comparison of actual and predicted input costs ($/ha)**

<table>
<thead>
<tr>
<th>Input</th>
<th>Cost in 2017 cropping season</th>
<th>Predicted cost in 2023 based on five-year trend</th>
<th>Predicted cost in 2023 based on long-term trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals</td>
<td>76.50</td>
<td>85.51</td>
<td>72.22</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>81.00</td>
<td>84.32</td>
<td>79.21</td>
</tr>
</tbody>
</table>

The GRDC’s RD&E investments will aim to maintain input costs below the five-year trend and reduce them below the long-term trend.

Growers may use more inputs if they are producing higher yields over time, i.e. to replace nutrients. Therefore, measuring trends in input use relative to output production can be an informative measure of input efficiency. Growers located in wetter regions will typically use more inputs relative to growers in dryer regions. However, growers in wetter regions will also typically produce more tonnes of crop per hectare relative to growers in dryer regions.

The GRDC’s second measure is therefore the trend in the ratio of input costs for machinery, chemicals and fertilisers relative to the output value (crop revenue). The actual ratios and trend estimates over the long term are shown in Figure 19 and over the shorter term in Figure 20.
Comparison of the long-term trend (Figure 19) with the trend since 2012 (Figure 20) allows an estimation of a range of predicted input to output ratios as shown in Table 6.

### Table 6: Comparisons of actual and predicted ratios of input costs: crop revenue

<table>
<thead>
<tr>
<th>Input</th>
<th>Predicted input costs: crop revenue in 2023 based on five-year trend</th>
<th>Predicted input costs: crop revenue in 2023 based on long-term trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals</td>
<td>0.148</td>
<td>0.166</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>0.156</td>
<td>0.164</td>
</tr>
</tbody>
</table>

Reduce post-farm-gate costs

Post-farm-gate costs associated with freight and supply chain logistics are complex and largely beyond the direct influence of the GRDC. However, the GRDC will continue to support R&D into understanding variables that drive supply chain costs, to inform policy.

Impact on lowering post-farm-gate costs will be measured in terms of timely RD&E-based submissions to government to support policy decision-making.

Manage risk to maximise profit and minimise losses

In developing RD&E investments to deliver on its purpose, the GRDC undertakes assessment of the risks associated with technical failure and level of adoption. Likewise, growers adjust farming and business practices to account for production and business risks.

The variable nature of production and business risks makes it difficult to identify impact indicators that encompass all growers on a national scale. However, several activities are known to support grower management of risk. Support for growers to undertake business training enhances their capability to appropriately deal with risk. In addition, behavioural economics is a fertile field of study that provides insights into growers’ decision-making and attitude to risk.

Impact on managing risk will be measured in terms of:

- proportion of growers undertaking business training
- establishment of a behavioural economics initiative to research grower decision-making
## TWO-PAGE RD&E PLAN

Workshops with members of the GRDC’s Board, advisory panels and representative organisations identified 36 KITs that contribute to the GRDC’s purpose and related objectives. The 36 KITs were rationalised to 30, after consultation with researchers, growers and industry. GRDC staff and advisory panels categorised those KITs in terms of primary (green), secondary (yellow) and tertiary (grey) emphasis. Primary KITs will be targeted for development of business cases and strategies based on program logic techniques. Secondary and tertiary KITs will be targeted as primary KIT strategies are completed. This will not preclude ongoing investment aligned to KITs during the development of strategies.

### Purpose: To invest in research, development and extension to create enduring profitability for Australian grain growers

### Key performance indicator: Minimum 6.0% rate of return by 2023

<table>
<thead>
<tr>
<th>Objective and key performance indicators</th>
<th>Key investment targets</th>
<th>Objective and key performance indicators</th>
<th>Key investment targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Improve yield and yield stability</td>
<td></td>
<td>2 Maintain and improve price</td>
<td></td>
</tr>
<tr>
<td>Minimum yield increases equivalent to 1% per annum for cereals, 2% per annum for pulses and 1.5% per annum for oilseeds, achieved while identifying and investing in technology for transformational improvement in yield potential and yield stability.</td>
<td>Minimise the impact of high temperature at flowering and grain fill on grain yield and stability.</td>
<td>Expand the area of high-value crops to boost average prices and profitability of farming systems, specifically:</td>
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<tr>
<td></td>
<td>1.1</td>
<td></td>
<td>• pulses</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• oats for food or industrial uses</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td></td>
<td>• linseed for industrial uses</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• sorghum for food</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td></td>
<td>• soybeans for food and/or animal feed.</td>
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<td></td>
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<td></td>
<td>1.4 Improve the potential and actual grain yields of high-value pulses, oilseeds (other than canola) and oats in profitable farming systems.</td>
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<td>1.5 Reduce the gap between actual and potential grain yield through more informed and timely decision-making on:</td>
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<td>1.6</td>
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<td>• planting time</td>
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<td></td>
<td>• crop/variety choice</td>
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<td></td>
<td></td>
<td></td>
<td>• weed management</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• pest and disease control</td>
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<td></td>
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<td>• crop nutrition</td>
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<td></td>
<td>1.7</td>
<td></td>
<td>1.6 Reduce the impacts of water repellence, compaction, hard-pan’s and other barriers to the capture and storage of water in soils.</td>
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<td></td>
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<td>1.8 Reduce the impacts of low pH, aluminium toxicity and other nutrient toxicities on plant water uptake to improve grain yield and stability.</td>
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<td></td>
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<td></td>
<td>1.9 Reduce the impact of waterlogging to improve grain yield and stability.</td>
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<tr>
<td></td>
<td>1.9</td>
<td></td>
<td>2.1 Expand the area of high-value crops to boost average prices and profitability of farming systems, specifically:</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• pulses</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• soybeans for food and/or animal feed.</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>Maintain and/or improve the price of Australian grain through differentiation based on:</td>
<td>Improve wheat grain protein through increased availability of nitrogen and better nitrogen use efficiency.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• functionality</td>
<td>Develop new, novel, high-value uses of products and by-products targeted at:</td>
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<tr>
<td></td>
<td></td>
<td>• food safety and traceability</td>
<td>• human health, nutrition and allergenicity</td>
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<td></td>
<td></td>
<td>• sustainability of production</td>
<td>• high-value feed uses</td>
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<td>• reduced downgrading</td>
<td>• new industrial uses</td>
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<td></td>
<td></td>
<td>• new and/or enhanced grain classification processes</td>
<td>• biofuels.</td>
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<td></td>
<td></td>
<td>• optimal management of biosecurity issues.</td>
<td>2.3 Improve processing efficiencies through a better understanding of current and novel grain functionality aligned with innovative processing technology.</td>
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<tr>
<td></td>
<td></td>
<td>2.4 Improve processing efficiencies through a better understanding of current and novel grain functionality aligned with innovative processing technology.</td>
<td>Improve processing efficiency by developing novel grain functionality aligned with innovations in processing technologies.</td>
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<td></td>
<td></td>
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<td>2.6 Improve processing efficiency by developing novel grain functionality aligned with innovations in processing technologies.</td>
</tr>
</tbody>
</table>
## Objective and key performance indicators

### 3 Optimise input costs
- Maintenance of chemicals costs below the forecast trend for 2018–23, equivalent to $85.50/ha or a ratio of input costs:crop revenue of 0.166.
- Maintenance of fertiliser costs below the forecast trend for 2018–23, equivalent to $84.30/ha or a ratio of input costs:crop revenue of 0.164.

### Key investment targets

<table>
<thead>
<tr>
<th>Key investment targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Develop and implement management options to minimise the cost of effectively and sustainably managing weeds.</td>
</tr>
<tr>
<td>3.2 Generate more informed, accurate and timely input for decision-making (e.g. sensor/monitoring technology or decision support models).</td>
</tr>
<tr>
<td>3.3 Develop and implement management options to minimise the cost of effectively and sustainably managing diseases.</td>
</tr>
<tr>
<td>3.4 Develop and implement management options to minimise the cost of effectively and sustainably managing vertebrate and invertebrate pests.</td>
</tr>
<tr>
<td>3.5 Develop technology to reduce fertiliser manufacture and/or application costs and improve fertiliser use efficiency.</td>
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<tr>
<td>3.6 Improve nitrogen and phosphorus availability by:</td>
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<tr>
<td>- greater capture of value from soil biota</td>
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<tr>
<td>- optimisation of nitrogen-fixing legumes in rotations</td>
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<tr>
<td>- soil amelioration to improve nutrient availability</td>
</tr>
<tr>
<td>3.7 Identify engineering solutions to reduce labour costs and/or improve the efficiency of repetitive tasks (including automation and robotics).</td>
</tr>
<tr>
<td>3.8 Identify engineering and novel business model solutions to reduce capital costs and running costs.</td>
</tr>
</tbody>
</table>

### 4 Reduce post-farm-gate costs
- Timely RD&E-based submissions to government to support policy decision-making.
- Timely addressing of technical barriers to trade issues.

### Key investment targets

<table>
<thead>
<tr>
<th>Key investment targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Support research to advise policy and investment decisions that lead to reduced post-farm-gate costs.</td>
</tr>
<tr>
<td>4.2 Invest in R&amp;D that informs industry and government approaches to trade and market access for Australian grain into export markets.</td>
</tr>
<tr>
<td>4.3 Improve the reliability and cost effectiveness of on-farm grain storage to reduce handling costs and capture market opportunities.</td>
</tr>
<tr>
<td>4.4 Improve automation of transport and handling activities and/or alternative logistics and distribution models to realise greater value capture by growers.</td>
</tr>
</tbody>
</table>

### 5 Manage risk to maximise profit and minimise losses
- The number of growers undertaking business training.
- Establishment of a behavioural economics initiative to research grower decision-making.

### Key investment targets

<table>
<thead>
<tr>
<th>Key investment targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Improve the accuracy of short-range and medium-range weather forecasting.</td>
</tr>
<tr>
<td>5.2 Understand grain grower decision-making and the drivers for adoption of new technology.</td>
</tr>
<tr>
<td>5.3 Support grain growers to acquire business management skills.</td>
</tr>
</tbody>
</table>