KIT 3.2

Generate more informed, accurate and timely input for decision-making (e.g. sensor/monitoring technology or decision support models)

Impact	**Growers are able to optimise input costs and profitability through data-informed decision-making.**
Summary	• Growers know what to collect, how to collect it and how to use it to inform decision-making on farm. • Growers have access to the tools and knowledge required to make more data-informed decisions. • Growers can accurately quantify the effects of crop input decisions on their whole-of-farm business profitability.

OVERVIEW

The KIT 3.2 strategy will involve investing in science that underpins tools and technologies which enable Australian grain growers to make profitable, data-driven decisions. There is a growing body of on-farm, off-farm data and knowledge that can be combined with new analytical methods to improve data-driven decision making. Recognising there is an increasing number of AgTech solutions being offered to Australian and international grain producers, a prevailing bottleneck is the availability of foundational science and R&D at the pre-competitive stage that can enable new data-driven solutions for the key decision points faced by growers. KIT 3.2 will exploit this opportunity by complementing existing grower knowledge and experience with tools that enable the biological and financial impacts of tactical and strategic decisions to be predicted and quantified, empowering growers to make decisions that align with their own preferences, business positions and risk appetites.

Grain growers face many important decisions that often need to be made without complete information and with large levels of uncertainty. The importance of each decision depends on the associated costs, benefits, risks and effects on other variables in the farming system. In addition to the unique biophysical aspects of their farming system, all grain growers have different preferences, risk appetites and opinions which in turn affect how they make farm business decisions[1]. Technology or tools that aim to prescribe a single 'optimal' decision often fail to address the biological complexity within a farming system, the business conditions of the grower and their individual risk appetite. In order to optimise input costs, an improved understanding is required of the specific important variable input costs. An improved understanding of the impact on yield and price of each important input variable is a priority. Reducing the uncertainty associated with different decisions faced by growers is important. Key decisions affecting farm management and input cost optimisation include (but are not limited to):

- Farm and resource management decisions related to input cost categories such as machinery, fuel, labour and grain handling.
- Strategic decisions (e.g. pre-planting and at sowing) such as soil amelioration, crop establishment method, crop and variety choice, rotation sequence, summer fallow management (especially in the GRDC Northern region) as well as nutrition and crop protection decisions at sowing.
- In-crop decisions regarding nutrition and crop protection, grain yield and quality forecasting and responses to other system stresses and shocks such as frost, heat and price drops.
- Pre and post-harvest decisions related to grain harvesting strategies, quality assessments and segregation and selling strategies.

As can be seen in Figure 1, fertiliser and crop protection chemicals are the two largest expenses for the average broad-acre farm in Australia, however these vary considerably from region to region and from one business to the next. In reference to nitrogen fertiliser alone the average annual expenditure in broadacre cropping approximates $135,000 per annum (Figure 1)[2], but it's estimated in most cases that approximately 40-60per cent of the applied N fertiliser isn't taken up by the crop[3,4,5]. This is partly due to an inability to accurately predict the economically optimum N rate, form of fertiliser, application method and timing for a given situation. Growers are faced with similar complexity at many another decision points throughout a cropping calendar where the 'optimum' decision requires knowledge of the predicted impacts on not just a primary response variable but other important variables in the farming system and their overall business.

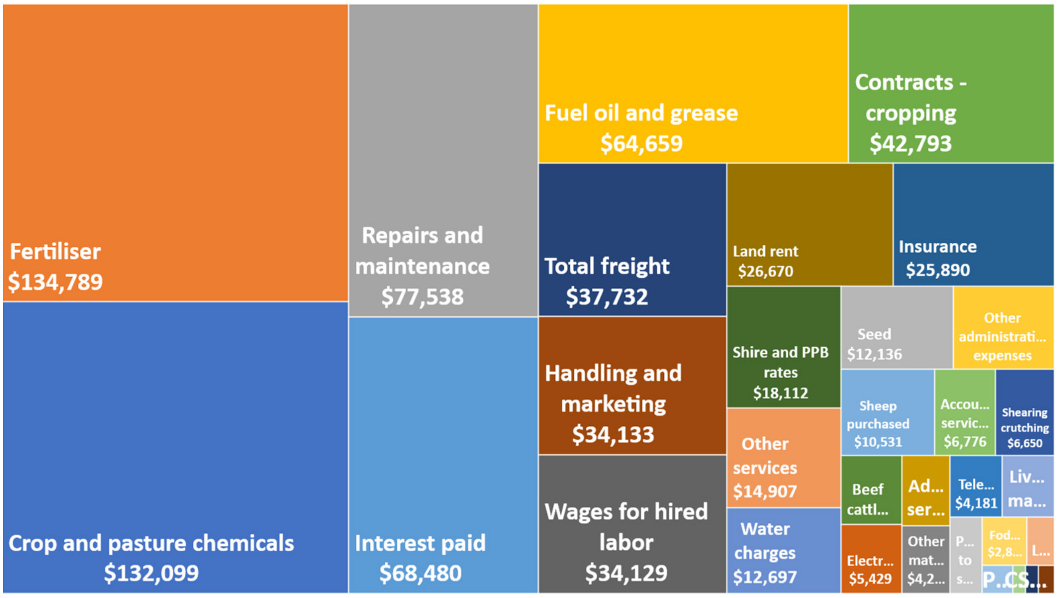


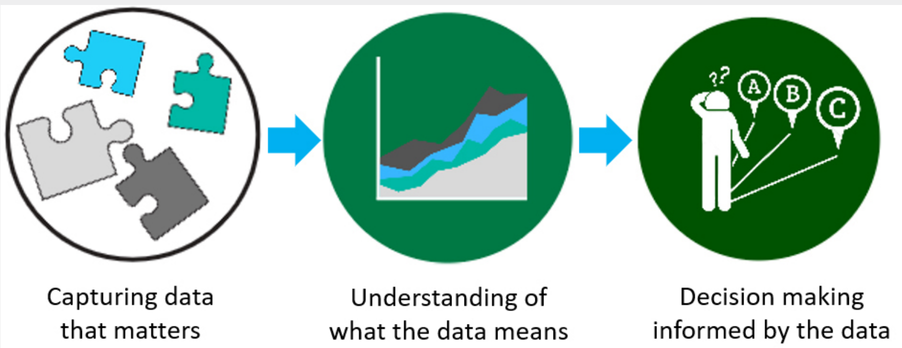
Figure 1. Average broad-acre costs for wheat and other crop businesses – average 5-year proportions. Data sources from ABARES AgSurf data[2]. NB: this is only including variable costs.

FUTURE RD&E FOCUS

The development of a data-driven solution for a key decision generally requires three inter-related enablers:

1. capturing the data that matters,
2. understanding what the data means *via* analysis, and
3. using the results to enhance insights that enable an optimal decision.

R&D is required at the pre-competitive stage that assist growers in making more accurate, timely and informed decisions at key points during the cropping cycle. The three components of KIT 3.2 are displayed schematically below.



Investment and path to market principles

GRDC will invest in pre-competitive R&D that enables commercial third parties to develop new and novel tools and technologies to support grower decision making but will generally seek to avoid investing in 'front-end' solutions that directly interface to growers. These R&D outputs will generally take the form of detailed methodologies, derivative datasets, project results and the soft-ware source code and documentation that provides access to modules of newly developed analytical frameworks and algorithms. These assets can then be exploited (i.e. operationalised, iterated, combined) for the benefit of Australian grain growers via researchers as well as the product managers and engineering teams within digital ag companies, start-ups and any other market intermediary willing to invest in developing front-end solutions for growers.

While reviews of commercial tools, technologies or services are outside the scope of KIT 3.2, as are regulatory issues related to data sharing, ownership and standards for collection/metadata, research into the methods and approaches that underpin data capture and analytics is well within the scope of this strategy.

SCOPE – Capture the data that matters

Tools, technologies and methods are developed to identify and cost-effectively capture the data that matters.

With most decision points there are a multitude of approaches that can be taken to capturing relevant data. Each approach will have inherent trade-offs in reference to accuracy, precision, cost, scale-ability and use-ability. Idenityfing a near optimal approach for a given use case based on comparitive assessments of cost, accuracy, precision and use-ability requires strong engagement with growers, advisors, domain experts and measurement/sensing experts[6,7,8].

From an R&D perspective, each approach will also necessitate different considerations in reference to the path to market. A direct measurement or proximal sensing approach may deliver relative advantages in accuracy and precision but have a high relative cost and limited scale-ability across time and space in the hands of a grower or advisor compared to satellite imagery[9,10], the latter of which can be delivered to growers through software analytics products. For example, research and development in proximal sensing approaches on-farm would need to consider the potential value generated from specific applications on-farm and how the value generated would be partitioned amongst equipment manufacturers and other necessary intermediaries involved in supporting a path to market to growers. Similarly, a measurement approach that's contigent on UAV imagery may be limited in reference to Civil Aviation Safety Authority regulations and workflow processes associated with flight planning and image processing but provide greater accuracy and precision than satellite imagery. Increasingly so, R&D that's focussed on quanitfying the cost:benefit of collecting different layers of data to aid with specific decision points will be necessary to meet the needs of growers and advisors and enable answers to key questions such as:

- What are the foundational data layers to capture for a given decision point in a cropping calendar and subsequent analysis?
- What's the additive benefit (and cost) of collecting other specific data layers?
- What is the optimum spatial and temporal resolution to capture different data layers for a given decision point given a constrained budget, and how can/should spatial sampling data be interpolated?
- Which layers are readily re-useable in mutiple analyses and thus of greater relative value?
- How can key data layers be captured more accurately, precisely and cost-effectively with less human input in the process and greater automation?

The aligned investment oucomes within KIT 3.2 that relate to the capture of data that matters are:

Investment Outcome 3.2.1 – Growers have the knowledge and skills required to quantify the value proposition of collecting new and existing data to aid with decision-making.

Investment Outcome 3.2.2 – Growers have access to the tools and technologies required to collect key data accurately and cost effectively.

SCOPE – Understanding of what the data means

Data is used to understand current constraints to production and forecast likely outcomes of associated crop input decisions.

In this strategy analytics is used to refer to the discovery of quantitative relationships between input decisions (e.g. fertiliser rates) and response variables (e.g. yield and protein/oil levels), as well as the processing and transformation of raw data into a format ready for analysis. The value of capturing different data layers is inherently linked to their explanatory and/or predictive power within analytics tools, which in turn is often driven by the quality and quantity of data made available for analyses. For example, there is evidently key gains to be made through the increased production and availability of good quality (i.e. cleaned, trimmed, normalised and kriged) yield data from growers who currently have access to yield monitoring technology[2]. A supplementary consideration is the suite of analyses that could then potentially be undertaken when hisotorical yield data is made available alongside information on historical paddock rotations, seeding rates, sowing dates, variety selections, crop protection inputs, nutrition history, weather information, a combination of these and/or other explanatory variables[11,12,13]. However, in few circumstances are the full range of on-farm data layers captured and readibly available for analyses. As such, the pragmatism and innovativeness with which different analytical methods can deal with the variable quality and availability of on-farm and off-farm data during an R&D phase, and when the final analytical tools are deployed to support growers is a key factor affecting investment planning in analytics.

A supplementary yet key component of this KIT strategy relates to the development of easily accessible, modular components of agro-economic and farming systems models which can be widely leveraged both for further R&D, and in turn for the production of new and improved digital agriculture tools to support grower decision making[14,15]. The aligned investment outcomes within KIT 3.2 related to the understanding of what the data means are:

Investment Outcome 3.2.3 – Growers and industry have access to tools enabling automated processing of raw data into analysis-ready formats to improve the timeliness and accuracy of crop input decision-making.

Investment Outcome 3.2.4 – Growers have the knowledge and tools to extract greater value from existing on-farm data sources in forecasting the likely production outcomes of crop input decisions.

Investment Outcome 3.2.5 – Growers have access to tools enabling the timely detection, mapping and forecasting of different production constraints on-farm.

SCOPE – Decision making informed by the data

Knowledge and tools are developed to enable growers to identify the optimal decisions throughout and across cropping cycles.

Growers are often weighing up a range of priorities based on the relative importance of different outcomes. They need to be able to quantify the impact of different decisions on a number of biophysical and financial response variables to make the best decisions for their individual business given their unique circumstances and competing priorities. Upon having the capacity to access the tools and technologies required to effectively capture key data layers and understand what it all means (i.e. predict biophsycial responses), growers need to be able to apply predictive analytics tools in a manner that's tailored to their business. For example, the decision to adjust a crop rotation in response to a dry start is affected by biophsycial concerns regarding weed and disease control, as well as financial considerations related to seasonal profitability and cash flow. The integration of biophsyical prediction tools with on-farm financial data can ensure that individual growers can make important decisions such as crop type with a clear, quantiative understanding of the likely impacts of different decisions on a number of biophysical and financial response variables. GRDC and co-investors are well positioned to invest in the creation of easily accessible biophsycial prediction tools that could be integrated/calibrated with on-farm data via other commerical third parties who act as a conduit to growers, advising them in relation to their own biological and financial data (e.g. digital agriculture companies, agronomists and farm businss consultants).

The KIT 3.2 strategy will drive the development of tools, technologies and enablers required to collect and use data to predict the biophysical outcomes of different decisions which can then be leveraged by commercial intermediaries such as agronomists, consultants and software as a service businesses (as well as growers) to deliver optimised recommendations for individual farming businesses. The aligned investment outcomes within KIT 3.2 related to the understanding of what the data means are:

Investment Outcome 3.2.6 – Growers have access to the prediction tools required to quantify the seasonal and farming systems impacts of strategic agronomic decisions.

Investment Outcome 3.2.7 – Growers have access to the tools and knowledge required to more accurately predict the return on investment and optimise the whole-of-farm business implications from key seasonal crop input decisions.

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