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Final Case Study Report

Prospective Economic Analysis of Graincast

Prepared for

Planning, Performance and Impact
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Executive Summary

Graincast™ is a digital agriculture tool that provides real-time and early-season crop monitoring and identification, and crop-yield forecasts. It does so via machine learning, satellite remote sensing, climate forecasts, time series data, and in-season training data collected from farmers via a smartphone app.

The technology has the potential to benefit every segment of the Australian agricultural supply chain, although the use cases and willingness to pay for these capabilities likely vary by stakeholder perspective. End users could possibly span farm input producers and suppliers, farmers, transportation and logistics companies, wholesalers, and those providing financial and insurance products to agricultural producers. Examples of the benefits of its use would be:

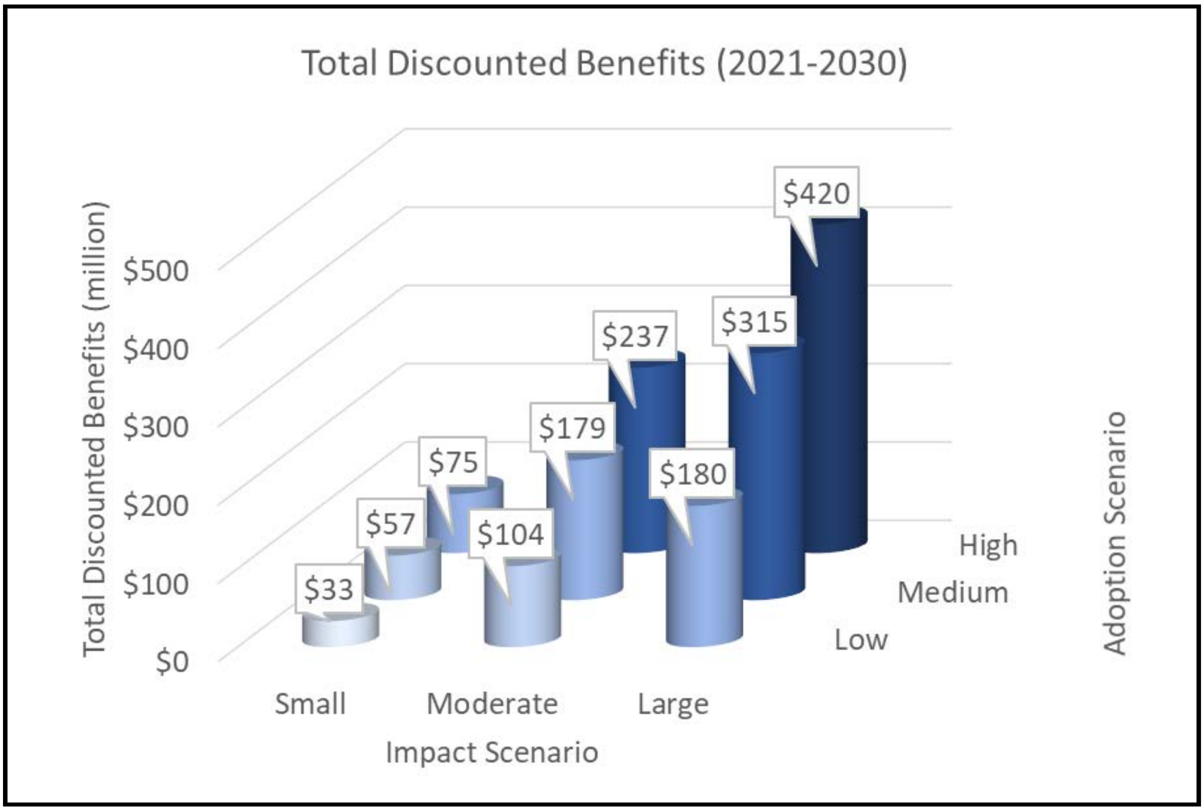
- Companies supplying inputs to farms (e.g., fertiliser, herbicide) may better project regional demand for their products.
- Farmers may more efficiently apply inputs to those crops which will most benefit, reducing overall costs and increasing yields.
- Transportation, handling, and storage companies may better predict the volume of grain production by region, which can result in reduced vehicle miles travelled and optimise logistics networks.
- Grain wholesalers, processing facilities and livestock feeding operations would have improved projections of seasonal domestic supply, allowing them to better balance their purchases of international grain.
- Financial institutions and insurance providers can better measure farm-level risk based on projected yield, which can reduce costs and facilitate access for farmers to financial products.

The concept, approaches, and platform for Graincast were funded by the Digiscape Future Science Platform. Graincast's budget was $3.5 million over a 4-year period from FY2016/17 through FY2019/20. CSIRO's development team was led by Roger Lawes, PhD. The technology was licensed to Melbourne-based start-up, Digital Agriculture Services (DAS), in which CSIRO is also an equity partner.

Graincast is currently in commercial development. As such, this case study proposes multiple adoption scenarios that may characterise the range of socioeconomic outcomes from Graincast's future use. Each scenario postulates impact potential based on the scientific and economic literature related to the use of information, and consequent adjustments in behaviour in the agriculture value chain.

In brief, our team found that Graincast has the potential to provide between $33 million and $420 million in economic impacts (present value terms, 2020, 7% discount rate) across the Australian agriculture supply chain between 2021 and 2030 (Figure ES.1).[1] From a social perspective, the largest proportion of benefits are expected to come from on-farm use, which would likely result in improved input application efficiency, and therefore improved yields.

Figure ES.1. Estimated Total Present Value of Benefits from Graincast Between 2021-2030 Across a Range of Adoption and Impact Scenarios



Note: Dollar values are in millions of 2020 dollars.

[1] Each scenario result is the present value of future benefits from 2021 to 2030, assuming that Graincast is deployed commercially in 2021. We employ a 7% real social discount rate, per CSIRO conventions. The dollar year and the base year for discounting are both 2020.

1. Introduction and Background

Graincast is a digital agriculture application that enables users to monitor and forecast grain yields after entering a series of inputs into a smartphone app, including:

- the paddock to be analysed,
- the crop that was grown in the previous season, and
- the crop growing or to be grown in the current season.

The app relies on a powerful computing platform that combines machine learning, predictive modelling, and real-time data with user inputs to generate results. The data generated through the app is then used to inform machine learning models to determine what crops are grown where.

The development of the app started as a response to feedback from farmers about the type of data needed for crop production and the format in which they wanted to receive the information. Specifically, farmers wanted to be able to learn or verify key details about land conditions via a system that was mobile, timely, and easy to use. Rather than be prescribed on-farm activities to maximise yield, farmers stressed the need for additional data that they could analyse themselves to make production decisions.

Grain production is a large industry. In 2016, Australia produced a record grain and oilseed crop of 63 million metric tonnes (mmt) (see Figure 1.1). This was a 40% increase over the five-year average from 2012 to 2016 for winter crops (AegicBARES, 2018). Domestic grain consumption has remained steady at about 14 mmt over the ten-year period from 2006 to 2016 (White and Carter, 2018). The 2016 grain surplus was approximately 49 mmt, or approximately 77% of total domestic production. Surplus has historically been exported to international markets, including the Middle East and Asia.

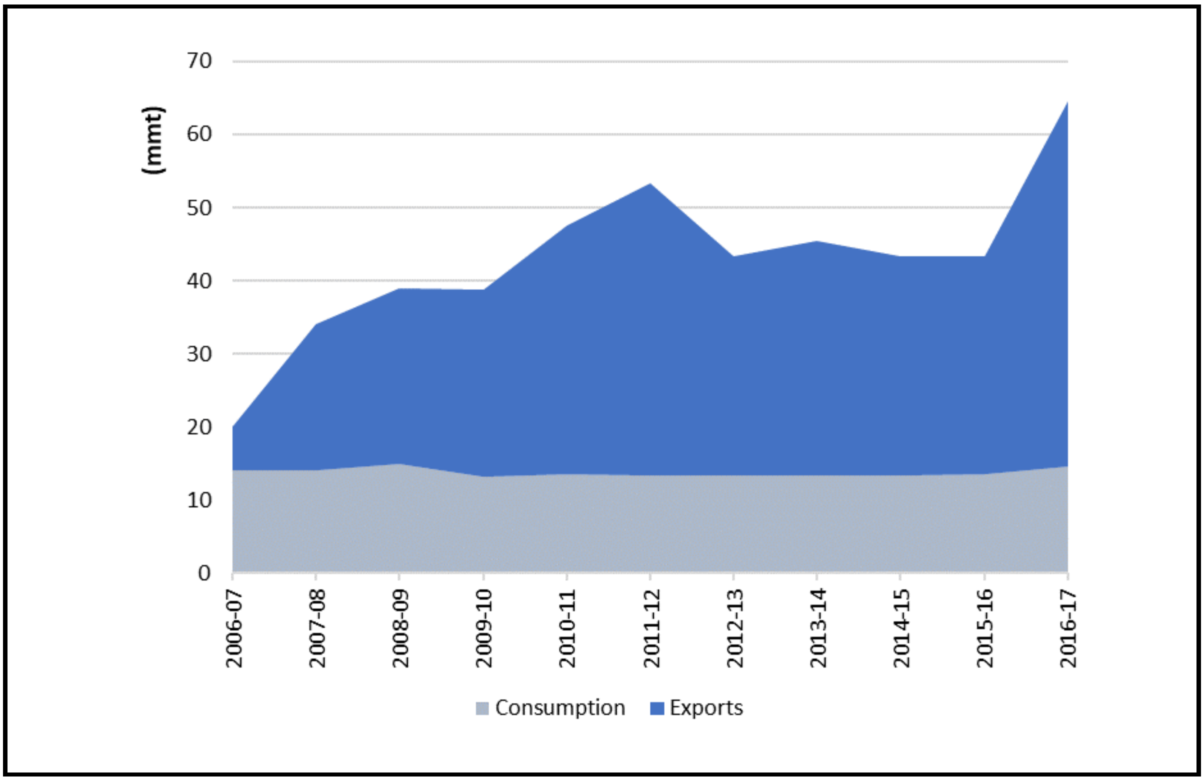
Grain production is challenging and hard-to-predict, due to Australia's drought-prone climate. Figure 1.1 illustrates this pattern. Besides increasing the risk of asset degradation, temporal volatility in grain production stemming from prolonged drought periods hinders planning and management activities for grain farmers and handlers (Stretch et al., 2014).

This reality has contributed to Australia's high overall cost of grain handling, storage, marketing, and transport. Transportation costs across the entire agricultural supply chain total more than $2.6 billion annually (Higgins et al., 2017). Given the pervasive need for in-season data and projections, Graincast's capabilities have the potential to have applications across the agricultural value chain.

This report quantifies the potential impacts stemming from Graincast. It describes the technology; leverages learnings from the scientific and economic literatures; and describes the potential economic benefits from various use cases at varying degrees of adoption and impact. The overall goal is to provide a reasonable assessment of how

Graincast may generate social value for Australians over the 10-year period from 2021 to 2030.

Figure 1.1. Australian Grain and Oilseed Production Delineated by Consumption and Exports (mmt)



Adopted from AEGIC (2018).

1.1 Digiscape Future Science Platform

Graincast's development was supported by the **Future Science Platform** initiative. Future Science Platforms (FSPs) are investments in science that underpin innovation and that have the potential to help reinvent and create new industries for Australia. FSPs are designed to grow the capability of a new generation of researchers and allow Australia to attract the best students and experts.

The Digiscape refers specifically to the digital agriculture FSP. According to CSIRO, Digiscape is about harnessing the digital revolution for Australian farmers and land managers. It endeavours to solve multiple real-life knowledge shortfalls in the land sector simultaneously by building a common big data infrastructure to support next generation decision-making and transform agricultural industries and environmental action.

1.2 The Science behind Graincast

Yield forecasts and the capability to collect and deliver timely and useful data are inherently complex processes. In addition to climate data, forecasts about crop area and yield require reliable information about soils, crop growth, and crop type (CSIRO, n.d.).

These complexities are some of the reasons why Australia lacks a comprehensive national system able to accurately quantify yield and geo-locate crop areas at a locally relevant scale (CSIRO, 2020). The absence of such a system complicates farmers' ability to leverage trustworthy data that could help them better inform their decisions.

To address farmers' needs and fill this technological gap, CSIRO developed the technology underlying Graincast with the primary purpose of demonstrating that collecting data efficiently and inexpensively to calibrate forecasting models was feasible. Information from satellite remote sensing, climate forecasts, and in-season training data are collected from a variety of sources and brought together in CSIRO's servers. By leveraging CSIRO's agricultural modelling capabilities and machine learning techniques, CSIRO's computer server enables the Graincast app to produce two sets of outputs, namely:

- Crop monitoring and identification (Crop ID), and
- Crop yield forecasting.

The crop identification component - Crop ID - applies machine learning techniques to a combination of satellite imagery and large amounts of training data to identify and map different types of grain planted across a specific area.

Yield forecasting applies the C-Crop Algorithm to satellite data, a modelling approach tuned to a crop species from the training data. This estimates in-season yields for a variety of grain crops, including wheat, barley and canola (DAS, 2019).

While Graincast's outputs resemble others in the marketplace such as Yield Prophet Lite and The Soilwater App, there are crucial differences (CSIRO, 2018). For instance, the app does not require large amounts of user data, other than crop type and paddock. Other inputs such as soil type are selected automatically from the CSIRO-developed soil landscape grid, while data on climate is extracted directly from the Australian Bureau of Meteorology. In addition to farmers conceivably marketing their crop with more confidence through increased accuracy of in-season yield estimates, these outputs could enable a variety of users to optimise their supply chain and minimise risk, through increased certainty of seasonal grain supply (CSIRO, n.d.).

Another advantage of Graincast over other alternatives is its capacity to provide real time estimates and seasonal forecasts of dryland crop area plantings and crop yields across the entire country (CSIRO, 2018). This advantage stems from the technology's capacity to analyse large geographical areas using satellite imagery, which has the potential to enable outputs to be scaled up from the local to the national level.

To date, CSIRO has invested $3.5 million in Graincast's development. Since its inception, the app has undergone continued development to improve the accuracy and quality of its outputs. It now has over 1,000 registered users (DAS, 2019).

1.3 Digital Agricultural Sciences (DAS) Ltd.

As technology development progressed, CSIRO undertook an internal review of potential commercialisation pathways. CSIRO partnered with Digital Agricultural Services (DAS), a Melbourne-based start-up, to transition Graincast into the market under an exclusive license.

DAS was established in 2017 with a mission to deliver reliable rural intelligence using rural data and machine learning techniques. The commercialisation partnership associated with Graincast was motivated by previous successful collaborations between the two institutions, and DAS's capability of applying artificial intelligence (AI) and machine learning techniques to rural data across its services. CSIRO holds equity in DAS.

Graincast has been integrated into the DAS Rural Intelligence Platform, which provides an array of data services, under the name Commodity Hub. The app and its two main components, Crop ID and C-Crop yield forecasting, are each offered as a standalone data product within this Hub (DAS, 2019).

DAS is working with at least one company within the Australian grain value chain to further develop Graincast prior to broad commercial availability. Through this collaboration, the companies are focusing on five key business components. These are:

- use case development,
- crop production monitoring,
- estimating what customers are growing and their sell-to-production ratio,
- forecasting grain production early in the growing season, and
- making the data available to customers to facilitate their decision-making process.

1.4 Case Study Purpose

Case studies of the outcomes and impacts of CSIRO activities are a central component of CSIRO's evaluation and performance measurement program. They describe the rationale for CSIRO action; the investment made and research conducted towards national goals; and the resulting or expected outcomes and impacts. Cost-Benefit Analysis (CBA) is one of the core methods used to evaluate results.

CSIRO commissioned RTI International, an independent nonprofit research institute, to evaluate the potential social, environmental, and economic impact stemming from Graincast. This evaluation aims to provide a more holistic picture of the potential impact on the agriculture industry.

As stated above, there is not yet a commercial product offering of Graincast. However, it is being used by farmers in Western Australia to help inform yield projections. Graincast is also being piloted by a few companies within the larger agricultural supply chain to test its capabilities for informing purchasing, logistics and planning decisions.

As such, this case study undertakes a prospective CBA to quantify the net benefits arising from the development, adoption, and use of Graincast over a future 10-year period with varying rate of adoption and impacts to reflect uncertainty. The findings from this study are intended to be used for the purposes of performance management, accountability, communications, and continual improvement.

2. Graincast's Potential Economic Benefits

The potential benefits for Australia from the development and adoption of Graincast are broad. Our CBA approach uses historical market data, existing research on the impact of improved yield projections, and interviews with Graincast's developers.

We implemented a Benefits Transfer approach. This is an approach in which one leverages insights and results from other studies that are topically, regionally, contextually, or methodologically relevant to the research questions or case studies at hand. Following best practices in economics, we transferred values from the literature to support our modelling work for each case study.

Our analysis is prospective because the technology remains in commercial development. As such, all estimates presented herein are to be interpreted as probable, should adoption, impact, and use cases emerge as hypothesised. Overall, we recommend interpretation focus on the direction and magnitude of benefits rather than the specific quantitative value.

We developed projections of potential impacts for 2021-2030. We present the net present value of benefits using a 7% annual discount rate (2020 base year and in 2020 dollar terms).

2.1 Adoption and Impact Scenarios

Given its pre-market status and the limited historical data on usage and impact, this case study offers estimates of potential value based on ranges of estimated uptake and user benefits. We designed future scenarios which cover potential outcomes based on an overall assessment of where Graincast could generate impact. Three adoption scenarios (low, medium, and high) and three impact scenarios (small, moderate, and large) are combined to present nine total impact scenarios. (Scenarios are described in greater depth in each impact segment.)

In brief, adoption scenarios represent the potential uptake of Graincast across each value chain segment. These scenarios are based on historical adoption rates for similar products, where available (Table 2.1). Conservative estimates are used where there are limited historical data.

Our impact scenarios are designed to capture the uncertainty around the potential direct impacts of Graincast on each segment. As with the adoption scenarios, these have been designed using historical data or previous literature, and use conservative estimates where data are limited (Table 2.2). Details on the development of these scenarios are presented below.

Table 2.1. Projected Annual Adoption Rates for Each Adoption Scenario by Industry with Percentages Representing the Proportion of Each User Group Using Graincast (2021-2030)

Use Case	Adoption Scenario	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agrichemical	Low	0%	0%	0%	0%	0%	50%	50%	50%	50%	50%
	Medium	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
	High	50%	50%	50%	50%	50%	100%	100%	100%	100%	100%
Farmer - on farm use	Low	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
	Medium	3%	3%	4%	4%	5%	5%	6%	6%	7%	7%
	High	3%	4%	5%	5%	6%	7%	8%	8%	9%	10%
Farmer - reduction in fertiliser shortage	Low	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%
	Medium	0%	0%	1%	1%	1%	2%	2%	2%	3%	3%
	High	0%	1%	1%	2%	2%	3%	3%	4%	4%	5%
Transportation and Logistics	Low	0%	1%	1%	2%	2%	3%	3%	4%	4%	5%
	Medium	0%	1%	2%	3%	4%	6%	7%	8%	9%	10%
	High	0%	2%	3%	5%	7%	8%	10%	12%	13%	15%
Wholesaler	Low	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
	Medium	1%	1%	1%	2%	2%	2%	2%	3%	3%	3%
	High	1%	1%	2%	2%	3%	3%	4%	4%	5%	5%

Table 2.2. Projected Annual Impact Rates for Each Impact Scenario

Industry	Impact Scenario	TOTAL
Agrichemical - reduction in cost	Small	0.1%
	Moderate	0.5%
	Large	1.0%
Farmer - on farm use	Small	1.0%
	Moderate	3.0%
	Large	5.0%
Farmer - indirect use through fertiliser supply	Small	10.0%
	Moderate	25.0%
	Large	50.0%
Transportation and Logistics	Small	0.5%
	Moderate	1.0%
	Large	1.5%
Wholesaler	Small	0.01%
	Moderate	0.10%
	Large	0.50%

2.2 Farm Input Suppliers

The fertiliser industry has the potential to greatly benefit from Graincast's ability to accurately predict grain yields across space prior to crops being planted. Fertiliser has a large impact on the productivity of Australian agriculture. It has been found that without access to fertiliser, Australian agricultural production would fall by $12.7 billion annually, with a larger indirect impact of over $40 billion loss to the Australian economy (Ryan, 2010).

About 50% of fertiliser consumed in Australia is supplied through international markets; this creates logistical hurdles (Ryan, 2010). Long shipping times (between 18-45 days according to Ryan, 2010) and contract agreements made three or more months prior to receiving goods limits companies' ability to respond to weather and climatic events that can have a direct impact on crop yields, and thus, demand for fertiliser products. Better information around seasonal yields will allow fertiliser suppliers to improve logistics required to accurately supply customers with needed inputs. This will reduce overall cost for companies which use Graincast.

Our impact scenarios seek to reflect the proportion of total costs to farm input suppliers dictated by the planning and acquisition of foreign materials used in the production of agrichemicals. With many of the costs associated with production and distribution of agricultural inputs being fixed (e.g., production costs, storage costs, etc.,) we believe that the direct impact of improved yield estimates from Graincast will be relatively small compared with total annual cost. For example, from 2010-2016 the relative price of fertiliser paid by Australian farmers fluctuated by only about 8% (ABARES, 2017). This leads us to believe that the potential cost savings within this industry are relatively small. Descriptions of the adoption and impact scenarios are presented in Table 2.3.

To estimate the economic benefits from reduced costs to farm input suppliers we use the following formula:

$$Impact_{InputSuppliers} = AvgAnnualCosts * Adopt * Impact$$

Where:

$AvgAnnualCosts$ = average annual total cost of the farm input industry (CSIRO, n.d.)
$Adopt$ = percentage of firms adopting Graincast
$Impact$ = decrease in annual costs from utilising Graincast (%)

CSIRO (n.d.) found that average annual costs across the industry were around $1.76 billion. Assuming this cost remains constant, we find that potential annual discounted benefits range from <$1 million to $8 million, with total benefits from 2021 to 2030 of $2 million to $82 million. For a full breakdown of case study results, see Tables 3.1 and 3.2.

Table 2.3. Descriptions of Adoption and Impact Scenarios for Farm Inputs Sector

Adoption Scenario	
Low	This scenario recognises that the fertiliser and on-farm chemical supply industry is controlled by two major companies and there is potential to miss a large portion of the sector if one company decides not to incorporate Graincast. Here we assume that one company adopts the tool in 2026 only.
Medium	The medium scenario assumes that one of the two major companies in this industry begins using Graincast in 2021 and remains the only user through 2030.
High	The high scenario assume that one of the two major agrichemical companies adopts the tool in 2021, while the second party adopts the tool in 2026.
Impact Scenario	
Small	0.1% reduction in overall cost[a]
Moderate	0.5% reduction in overall cost
Large	1.0% reduction in overall cost

[a] Historical costs for this industry are around $1.76 billion (CSIRO, n.d.).

2.3 Grain and Oilseed Farmers

2.3.1 Direct Use

Through the development of Graincast, it was shown that when farmers have more reliable information on paddock and field level projections of yields, they can more efficiently apply inputs such as nitrogen, phosphorus, and potassium (CSIRO, n.d.). Farms utilising the tool *Yield Prophet*, which provides similar analytical outputs, realised about 3% increases in yields relative to those not using the software. Graincast has developed the concepts pioneered with Yield Prophet; while reducing the data input needs required from users, it still results in accurate yield projections. Internal CSIRO documents showed that about 3% of grain and oilseed producers adopted Yield Prophet with a target rate of 10% (CSIRO, n.d.).

All three adoption scenarios presented here begin with a 3% uptake level in 2021, based on adoption rate of Yield Prophet. This remains at 3% through 2030 in the low scenario; grows linearly to 7% by 2030 in the medium scenario; and grows to 10% linearly by 2030 in the high scenario.

The impact scenarios are designed around the yield growth impacts found by farmers using *Crop Prophet*, where the 3% increase in yield found in CSIRO (n.d.) is used as the moderate impact. We decrease this impact to 1% for the small Impact scenario and raise it to 5% for the large impact scenario. Impact scenarios range from 1%, 3%, and 5% increases in yield for the small, moderate, and large impact scenarios respectively (further details on the adoption and impact scenarios are presented in Table 2.4).

Table 2.4. Descriptions of Adoption and Impact Scenarios for Direct Usage of Graincast on Grain and Oilseed Farms

Adoption Scenario	
Low	This scenario represents no growth in the adoption of Graincast. Yield Prophet was found to be adopted by 3% of grain and oilseed farmers. We assume that these same farmers would be willing to adopt Graincast and no more over time.
Medium	In this scenario we use 3% as the initial adoption rate, with 7% adoption rate achieved by 2030 at a linear rate.
High	In the high adoption scenario, we us a 3% initial uptake rate, with overall adoption reaching the target rate of 10% by 2030 (with a linear annual growth rate)
Impact Scenario	
Small	1% annual increase in yield is realised by farmers utilising the tool. This recognises the potential that some users may have apprehensions towards adjusting their on-farm practices based on Graincast results.
Moderate	3% annual increase in yield is realised by farmers using the tool, this is based on the impact that farmers saw from using Crop Prophet, which provides similar yield estimates
Large	5% annual increase in yield is realised by farmers using the tool. This reflects the potential that that small changes in farming practices could result in a relatively large impact in yields on farms with a low marginal cost of improving yields.

To estimate the impact of improved input application efficiency we use the following formula:

$$Impact_{FarmInput} = AvgProd * Adopt * AvgPrice * Impact$$

Where:

$AvgProd$ = average production of grain and oilseed crops by farm 2010-2016 (tonne)

$Adopt$ = percentage of farmers adopting Graincast

$AvgPrice$ = average price per tonne of grain from 2010-2016 ($/t)

$Impact$ = increase in annual yield from using Graincast (%)

Between 2010 and 2016 there were, on average, 122,886 farms in Australia, and 6.3% of these focused on growing grains (ABARES, 2017). Historically, the average grain farm produced $1.85 million worth of grain (ABARES, 2017). Under our range of impact and adoption scenarios, we find that improved yields resulting from improved on-farm efficiency ranges from $28 million to $285 million from 2021 to 2030 across all grain farms, with annual impacts ranging from $3 to $29 million.

2.3.2 Indirect Use

In addition to assisting farmers target and ultimately realise higher yields, Graincast can increase the probability that farmers have access to a stable supply of inputs from agrichemical companies. As about half of the fertiliser consumed in Australia is imported, the potential impacts from unmet demand are sizeable (Fertilizer Australia, 2020).

Relying on historical data, we estimate that over $6 billion of agricultural production annually is reliant on the supply of international fertiliser.[2] During years of high demand for fertiliser, suppliers are unable to receive additional supply quicker than 21 days (it usually takes 3-5 days to load a ship and the shortest transit time is 18 days) (Ryan, 2010). This delay can result in mis-timed application of inputs, leading to reduction in potential yields. Ryan (2010) found that grain and oilseed production is reduced by 4% to 27% without fertiliser across Australia.

Adoption rates in this case study represent the percentage of farmers potentially impacted from unmet demand for fertiliser. Impact scenarios account for the fact that if there is a shortage of fertiliser during a growing season, most fields will receive inputs at some point in the season, as opposed to reducing some paddocks to zero inputs while others receive full applications. Descriptions of the adoption and impact scenarios are presented in Table 2.5.

Table 2.5. Descriptions of Adoption and Impact Scenarios for Indirect Impacts on Grain and Oilseed Farming Sector via More Resilient Farm Input Supply

Adoption Scenario	
Low	In this scenario adoption rates are 0% in 2021 growing to 1% in 2030.
Medium	In this scenario adoption rates are 0% in 2021 growing to 3% in 2030.
High	In this scenario adoption rates are 0% in 2021 growing to 5% in 2030.
Impact Scenario	
Small	The low impact scenario assumes that under limited input availability farmers are relatively flexible in spreading out the available resources across their fields, thus reducing the impact of unmet demand. Here we assume that the impact is 10% of expected yield reduction rates.
Moderate	The moderate impact scenario represents the potential impact of avoiding a shortage in key growth stages of crops which could result in 25% of expected yield reduction rates.
Large	The large impact scenario represents 50% of expected yield reductions occurring due to limited access to fertiliser.

To estimate the benefit from reducing the likelihood that farmers will not have access to necessary on-farm inputs we use the following function:

$$Impact_{FarmFert} = TotalProd * \sum(\%prod_S * \%loss_S * Impact_s) * Adopt * Import\%$$

Where:

$TotalProd$ = average total production of grain and oilseed crops 2010-2016 ($)
$\%prod_S$ = percent of total production produced within each state, S

[2] Ryan (2010) found that, without access to fertiliser, Australian agricultural production would fall by $12.7 billion annually. Assuming half of fertiliser consumed in Australia comes from overseas supplies (Fertilizer Australia, 2020), we estimates more than $6 billion in annual agriculture production can be attributed to imported fertiliser use.

$\%loss_S$ = average reduction of production without fertiliser access within each state, S

$Impact_s$ = parameter representing the range of actual impacts to yield reduction from limited fertiliser use, for each scenario, s

$Adopt$ = percentage of farmers impacted by shortage

$Import\%$ = percentage of fertiliser imported to Australia

The total production values used are the same as those presented in the previous section (2.2.1 Direct Use). Table 2.6 presents the percent of production of grain by state ($\%prod_S$), and the average production loss without fertiliser use by state ($\%loss_S$). Multiplying the average production by state with the average production loss by state, we estimate that the potential loss in yields nationally without access to fertiliser is 18.8%. Using this value, the percentage of fertiliser imported and the proportion of production loss potentially experienced by a shortage ($Impact$), we estimate that the average annual discounted benefits from improved supply of fertiliser to farmers to be $0 to $2 million, with total benefits from 2021 – 2030 to be $1 to $19 million.

Table 2.6. State-Level Averages of Percentage of Total Australian Grain Production (2000-2018) and Average Production Loss Without the Use of Fertiliser by State

State	Average Percentage of National Grain Production 2000-2018 (ABARES, 2017)	Average Production Loss Without Fertiliser Usage (Ryan, 2010)
New South Wales	24.1%	4.3%
Victoria	17.5%	19.0%
Queensland	13.2%	25.1%
South Australia	18.1%	11.5%
Western Australia	26.8%	26.6%
Tasmania	0.3%	18.8%[a]
Australia	**100.0%**	**18.8%**

[a] Ryan (2010) did not have observations for Tasmania, so we assumed the national average.

2.4 Transportation and Logistics

The transportation of grains and oilseeds in Australia is a major cost borne by famers - over 30% of total supply chain costs arise from transportation of grains, which results in a direct cost of about $24 per tonne to farmers (AgriFutures Australia, 2019). Total transportation cost for grains in Australia, across the entire agriculture supply chain, has been found to be over $2.6 billion annually (AgriFutures Australia, 2019).

There are two main drivers of this relatively high transportation cost, namely:

1. the low density of grain production in Australia, driven by a low number of farms that solely produce wheat; and
2. the volatility and uncertainty in wheat yields (Stretch et al. 2014).

Improved pre-season and during-season estimates of crop yields will not reduce overall volatility of yields. However, it will reduce uncertainty for transportation and logistics companies, which can optimise trucking and train routes, while minimising empty or partially filled trailers and train cars. This can improve efficiencies throughout the entire agricultural supply chain, not only for farmers.

Overall, projected impact scenarios are relatively low for this industry. This reflects the improvements made by the industry over the past 30 years. Wheat supply chain costs were 33% of wheat FOB price in 1987 but have fallen to between 18%-23% in 2013-14, or about a 0.4% decrease in cost annually (Stretch et al., 2014). Adoption scenarios and impact scenarios are presented in Table 2.7.

Table 2.7. Descriptions of Adoption and Impact Scenarios for Transportation and Logistics Sector

Adoption Scenario	
Low	In this scenario adoption rates are 0% in 2021 growing to 5% in 2030.
Medium	In this scenario adoption rates are 0% in 2021 growing to 10% in 2030.
High	In this scenario adoption rates are 0% in 2021 growing to 15% in 2030.
Impact Scenario	
Moderate	This scenario assumes that there are a moderate amount of benefits that can arise from using Graincast, and those companies that adopt the technology see a 1% reduction in costs.
Large	This scenario represents a 1.5% annual reduction in cost to companies and represents a relatively large impact to a highly developed industry.

To estimate the impact that improved logistics management can have from the adoption of Graincast we use the following formula:

$$Impact_{FarmFert} = (CostRoad + CostRail) * Adopt * Impact$$

Where:

$CostRoad$ = annual average total cost of road transportation for grains across the supply chain ($) (from Higgins et al. 2017)

$CostRail$ = annual average total cost of rail transportation for grains across the supply chain

($) (from Higgins et al. 2017)

$Impact$ = reduction of transportation costs (%)

$Adopt$ = transportation and logistics companies using Graincast (%)

The average total cost of road transportation for grains is estimated to be $2.27 billion, while the total cost of rail transportation for grains is estimated to be $0.51 billion (Higgins et al. 2017). Using these values, together with our impact and adoption assumptions, we find that the total benefits from improved efficiency of the transportation of grain products across the agricultural supply chain to be $2 to $18 million from 2021-2030, with annual benefits ranging from <$1 to $2 million.

2.5 Grain Wholesalers

Wholesalers of grain to both food processing facilities and livestock feeding operations can improve planning activities with information provided by Graincast. Contracts between wholesalers and processers are agreed upon months in advance of delivery; this limits wholesalers' abilities to respond to shortages in grain production in low yield years. The cereal and grain wholesaler industry is comprised of nearly 500 individual businesses with an industry revenue of $17.3 billion in 2019-2020 (IBISWorld, 2020). The industry profitability has fluctuated over the past five years and is directly impacted by the volatility of grain production.

Graincast can impact this industry in two distinct ways. The first is through farmers utilising the tool to maximise input application efficiency, which could result in a slight reduction in production variability. The second is through direct use of the tool by wholesalers to better project the upcoming supply of grain prior to arranging or finalising purchasing agreements. It is not expected that either of these impacts will have drastic impacts on the profitability of this industry, but they will provide marginal cost reductions to the industry as a whole, with slightly higher reductions to companies which decide to utilise Graincast to help inform purchasing decisions. Overall, the impact scenarios are smaller for this industry relative to others included in the case study (see Table 2.8).

Table 2.8. Descriptions of Adoption and Impact Scenarios for Grain Wholesale Sector

	Adoption Scenario
Low	The low scenario is modelled to represent the impact to wholesalers if the only impact from Graincast is related to small reductions in the variability of annual grain production. We represent this by using an adoption rate of 1% in 2021 which remains constant through 2030.
Medium	The medium scenario assumes that some wholesale industry partners begin using Graincast to help inform decisions around purchasing decisions. Adoption begins at 1% in 2021 and grows linearly to 3% by 2030.
High	The high scenario assumes that a larger number of companies within the industry adopt the tool to inform purchasing decisions. Uptake is 1% in 2021 growing linearly to 5% in 2030.
	Impact Scenario
Small	0.01% reduction in overall cost
Moderate	0.10% reduction in overall cost
Large	0.50% reduction in overall cost

To estimate the impact to wholesalers we use the following formula:

$$Impact_{Wholesalers} = AvgRevenue * Adopt * Impact$$

Where:

$AvgRevenu$ = average annual revenue for the industry ($)

$Impact$ = reduction of costs through improved efficiency (%)

$Adopt$ = Wholesale companies using Graincast (%)

Using the average industry revenue between 2016-2020 ($17.3 billion -IBISWorld, 2020), and our assumed impact and adoption scenarios, we project an annual impact of $0 million to $2 million, with a total impact from 2021 to 2030 of <$1 to $16 million.

3. Summary

Table 3.1 presents the total net present value of impacts (in millions of 2020 dollars) across each impact and adoption scenario. (Table A.1 and Table A.2 in Appendix A: Supplemental Results present the average annual benefits across each use area, and total net present value of benefits across each use area, respectively).

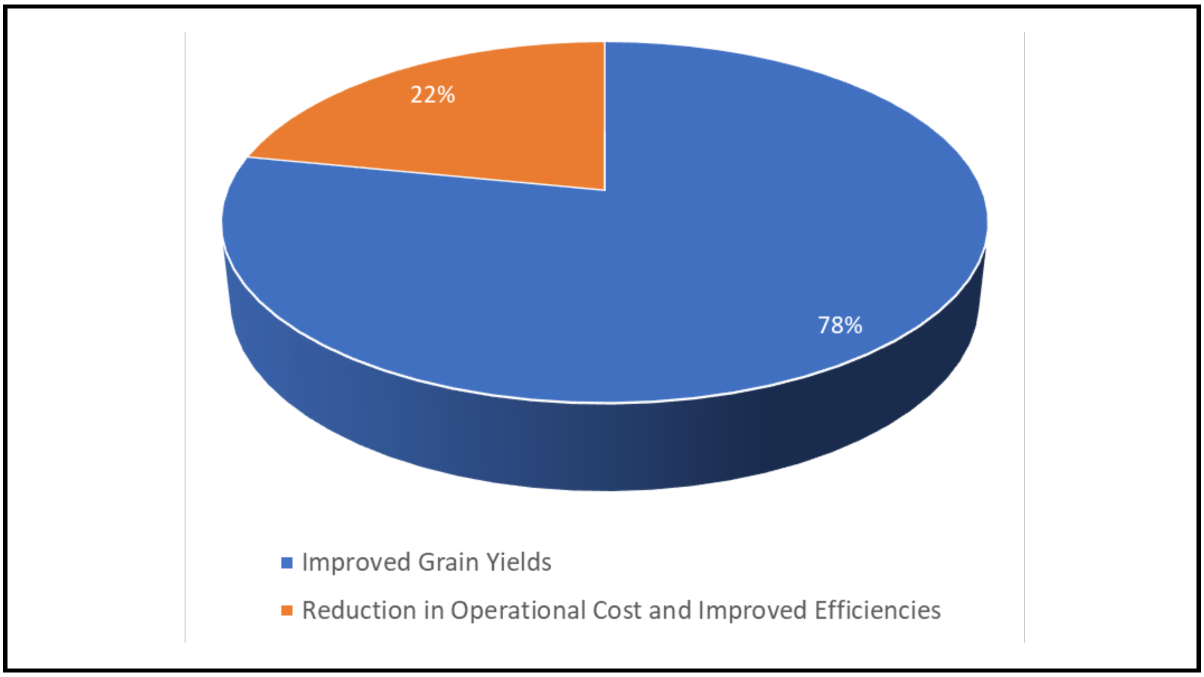
Table 3.1. Net Present Value of Total Benefits (million $, 2020)

Adoption Scenario	Impact Scenario		
	Small	Moderate	Large
Low	$33.4	$103.6	$180.4
Medium	$56.9	$178.7	$315.1
High	$75.3	$236.6	$419.6

Notes: NPV calculated using a 7% real social discount rate for the period from 2021 through 2030.

The marginal impact from moving from lower to higher **impact** scenarios is much greater than moving from lower to higher **adoption** scenarios. Additionally, the largest source of benefits comes from improvement in grain yields (78% of total in the Medium Adoption – Moderate Impact scenarios), followed by improvements in operational efficiencies (16% of total), with the rest made up through reduction in operational costs (6%) (Figure 3.1).

Figure 3.1. Distribution of Benefits in the Medium Adoption - Moderate Impact Scenario



If adoption is medium, but the overall impact is small, one would anticipate approximately $59.4 million in social value creation over the period 2021 to 2030.

However, if impact were greater, the same level of adoption could generate social value of $186.4 million. Note that additional results are presented in Appendix A: Supplemental Results, including average annual discounted benefits for each sector and scenario (Table A.1); net present value of total benefits to each sector across scenarios (Table A.2); and the range of average annual discounted benefits by sector (Figure A.1).

There are additional social benefits, which have not been included in this study. Through reduced vehicle miles travelled, the transportation and logistics industry not only becomes more efficient, but also reduces greenhouse gas emissions, and limits the wear and tear on infrastructure. An increased efficiency of application or reduction of fertiliser inputs can have direct environmental improvements. These include reduced runoff of nitrogen into local water supplies which can cause harmful algae blooms; limiting the number of pathogens and nitrates entering drinking water supplies; and reduced emissions of greenhouse gases (Berg et al. 2017). Additionally, increased yield on food production systems, whether through grains directly or through processes that use grains as an input, such as livestock feeding operations, increases food security within Australia. Finally, improvements in information on grain yield can allow insurers and financial institutions to better value farms and project seasonal yields, which will allow them to better estimate risk. This in turn could potentially reduce the cost of insurance or capital and expand access to these resources to a wider audience (CSIRO, n.d.).

In addition to PV estimates, we also calculated internal rate of return, and benefit costs ratios (BCR) for each scenario. Between 2015 and 2018, $3.5 million was invested in Graincast, which we split evenly over each of these years ($875,000 annually). Our estimates resulted in internal rate of return ranging from 49% to 117% across all scenarios. Additionally, we find the BCR ranges between 9.1 to 114.6 across the lowest and highest scenarios (see Table 3.2 for full range of results).

Grain yield improvements (either through production decisions or input application decisions) are significant and thus the largest proportion of benefits. There are also potential reductions in operational costs for the transportation, logistics and wholesale industries. We also expect that improvements in efficiencies can be achieved by the agrichemical companies through better balancing the supply of farm inputs (i.e., fertiliser) with the local demand.

The marginal value which each non-farm entity receives (given the small number of them) may be sufficient to create a willingness to pay for access to the intelligence stemming from the aggregation of information about farm production decisions and behaviour. From a social impact perspective, more value could be generated for Australian society by encouraging usage and adoption by ag producers as a production decision support tool. From a financial perspective, it is more likely that input suppliers and downstream services would be willing to pay for information, once a certain threshold number of farms are using Graincast.

Table 3.2. Economic Performance Measures for Each Impact and Adoption Scenario Pair

Scenario	Benefit-cost Ratio	IRR
Low-Small	9.1	49%
Medium-Small	15.6	58%
High-Small	20.6	62%
Low-Moderate	28.3	80%
Medium-Moderate	48.8	93%
High-Moderate	64.6	96%
Low-Large	49.3	98%
Medium-Large	86.1	114%
High-Large	114.6	117%

Ultimately, the actual impact will be identifiable once there is more user experience with Graincast. Greater per user impact will likely help drive adoption. This suggests that, from a social perspective, providing training or workshops to Graincast users on how to best analyse and apply the results of the tool could be more impactful than focusing on growing the user base.

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Appendix A: Supplemental Results

Table A.1. Average Annual Benefits Across Industry and Scenarios from 2021-2030 (million $)

	Average Annual Benefits 2021-2030 (million $)								
	Small			Moderate			Large		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
Agrichemical	0.2	0.6	0.8	1.2	2.9	4.1	2.4	5.8	8.2
Farmers - on farm use	2.8	4.5	5.7	8.4	13.4	9.2	14.1	22.3	28.5
Farmers - indirect	0.1	0.2	0.4	0.2	0.6	0.5	0.4	1.2	1.9
Transportation and Logistics	0.2	0.4	0.6	0.4	0.8	0.7	0.6	1.2	1.8
Wholesalers	0.01	0.0	0.0	0.1	0.2	0.2	0.6	1.1	1.6
TOTAL	3.3	5.7	7.5	10.4	17.9	14.6	18.0	31.5	42.0

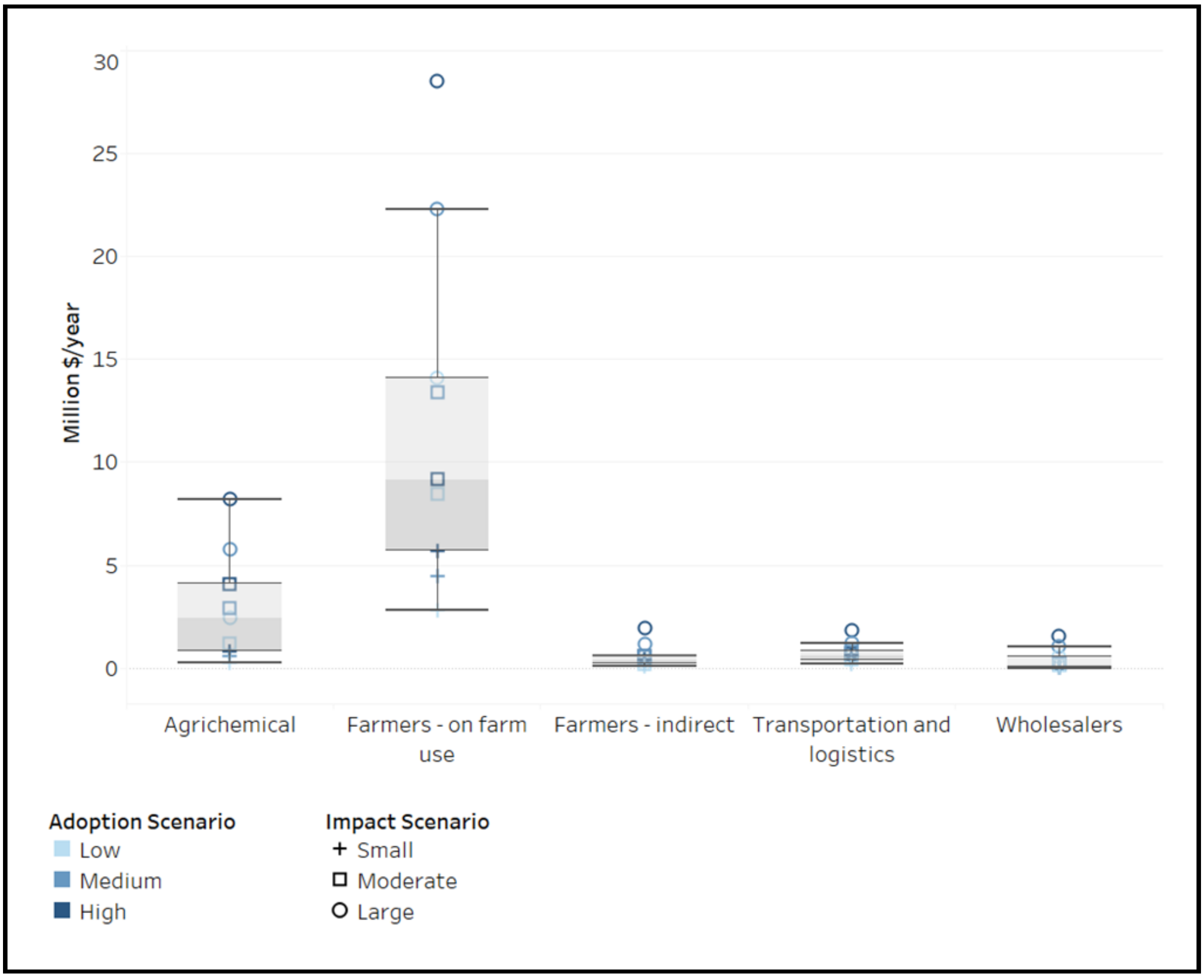
Notes: NPV calculated using a 7% real social discount rate for the period from 2021 through 2030.

Table A.2. Net Present Value of Total Benefits Across Industry and Scenarios from 2021-2030 (million $)

	Total Discounted Benefits 2021-2030 (million $)								
	Small			Moderate			Large		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
Agrichemical	2.4	5.8	8.2	12.0	28.9	40.9	24.1	57.8	81.8
Farmers - on farm use	28.1	44.6	56.9	84.4	133.8	170.8	140.7	223.0	284.7
Farmers - indirect	0.8	2.3	3.9	1.9	5.8	9.7	3.9	11.6	19.4
Transportation and Logistics	2.0	4.0	6.0	4.0	8.0	12.0	6.0	12.0	18.0
Wholesalers	0.1	0.2	0.3	1.1	2.1	3.1	5.7	10.7	15.6
Insurance/Financial									
TOTAL	33.4	56.9	75.3	103.6	178.7	236.6	180.4	315.1	419.6

Notes: NPV calculated using a 7% real social discount rate for the period from 2021 through 2030.

Figure A.1. Range of Average Annual Benefits by Sector for Each Adoption and Impact Scenario Pair



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