



SUBMISSION

2018 Regional Telecommunications Review

4th August 2018

2018 Regional Telecommunications Review Secretariat
Department of Communications and the Arts
GPO Box 2154
CANBERRA ACT 2601

SUBMISSION: 2018 Regional Telecommunications Review

Thank you for the opportunity for AgTechCentric to provide a response to the **2018 Regional Telecommunications Review**. AgTechCentric's mission is to navigate the access of new technology to producers. The company is addressing the need for a facilitated approach to building investment confidence in commercialising these new technologies in an uncertain future landscape while building social license for use. AgTechCentric is all about ironing out the speed humps of regulation and red tape to create a climate of investment confidence to put technologies into producer's pockets.

While currently being a director of AgtechCentric, over a number of years I have been I privileged to be able to support a number of national programs in delivering agricultural technology access to Australian agricultural industry. Recently I was the Project Leader - Accelerating Precision Agriculture to Decision Agriculture (P2D) project, a whole of Australian Agriculture program funded by all 15 Research and Development Corporations with the support of the Federal Governments Rural R&D for Profit Program, led by the Cotton Research and Development Corporation. This project has, based on industry consultation, provided recommendations to deliver a digital agriculture future for Australia. The Accelerating Precision Agriculture to Decision Agriculture - P2D Project¹ has found that a digital agriculture future unconstrained, could potentially deliver a \$20.3 Billion per annum² increase in the gross value of productivity (GVP) to Australian agriculture. There is however a number of issues for industry to consider in using these technologies and the report details findings on current issues and needs plus makes recommendations for next steps including for telecommunications.

Difficulty with regional connectivity and impacts

As part of the P2D project, a CSIRO survey of 1000 producers³ highlighted that the value of changing to digital agriculture is not always clear to producers. Value was not only related to monetary value, but also peace of mind, confidence, social and lifestyle factors. The P2D project survey highlights the difficulties from reliance of the current mobile phone network with 55% of producers using the mobile phone network for internet, yet 43% had patchy or no mobile reception across their property.

Another excellent technical report from the P2D project 'A review of on-farm telecommunications challenges and opportunities in supporting a digital agriculture future for Australia' by Professor David Lamb of the University of New England⁴ found that a lack of access to mobile and internet data telecommunications infrastructure is a major impediment to the adoption of digital agriculture systems. This is costing producers, agribusinesses and the Australian economy billions of dollars each year in terms of lost productivity (and profitability). While connectivity is only one of the five constraints to the progression to digital agriculture identified in the P2D project, it is considered to be the engine. Without connectivity, digital agriculture is not possible. The Rural Telecommunications Review Committee is encouraged to read this detailed technical report by Professor Lamb and also consult further with him on the rapidly moving technical opportunities to deliver practical solutions to rural Australia.

Potential future economic impact of regional connectivity

Australian farmers are ready to adopt new communications technology now, and are proven early adopters of valuable technology. Over 85% of Australian grain producers' farms have adopted GPS-based auto-steer technology, leading the world in adoption of these types of advanced technologies. However only just over 40% of producers have access to effective in-field mobile phone and data coverage. Adoption of further advances in precision

¹ <https://www.crdc.com.au/precision-to-decision>

² P2D summary report - Accelerating precision agriculture to decision agriculture: Enabling digital agriculture in Australia. Cotton Research and Development Corporation. <https://www.crdc.com.au/sites/default/files/CRD18001-001%20CRDC%20P2D%20Report%20low%20res.pdf>

³ Zhang, A, Baker, I, Jakku, E & Llewellyn, R 2017. *Accelerating precision agriculture to decision agriculture: The needs and drivers for the present and future of digital agriculture in Australia. A cross-industries producer survey for the Rural R&D for Profit 'Precision to Decision' (P2D) project*. CSIRO and Cotton Research and Development Corporation. <https://www.crdc.com.au/sites/default/files/P2D%20producer%20survey%20-%20CSIRO%20Final%20Report.pdf>

⁴ Lamb, D 2017. *Accelerating precision agriculture to decision agriculture: A review of on-farm telecommunications challenges and opportunities in supporting a digital agriculture future for Australia*. University of New England and Cotton Research and Development Corporation. <https://www.crdc.com.au/sites/default/files/P2D%20telecommunications%20-%20UNE%20Final%20Report.pdf>

agriculture, big data and automation technologies in agriculture is being stalled by a lack of regional telecommunications. Access to effective on-farm broadband wireless data technology is aligned and likely to be viewed by broadacre producers as delivering similar systems benefits for operational efficiency to farm businesses as experienced with the adoption of autosteer technology.

The P2D report highlights significant opportunity for use of digital agriculture, robotics and automation in delivering labour savings and production efficiencies with potential unconstrained benefit of \$7.4 Billion to the GVP per annum. Most major tractor machinery companies have incubated technologies ready for commercialisation, recognising that Australia is 'market ready' for this technology. This tractor automation technology is predominantly built around a backbone of a cellular mobile data network infrastructure, which is widely available in many competitor countries including the USA and the EU. Much of the in-field data rich sensor technology also uses cellular mobile data. Delivery of the potential benefits to Australian agricultural industry identified in the P2D project will be significantly constrained by the lack of access to in-field data communications.

Frequency – a finite resource

An important consideration for the optimum delivery of rural telecommunications performance with low latency and fast data speed, including the operation of autonomous tractor equipment is the use and availability of the finite resource of radio frequency. The Digital Dividend spectrum (694-820 MHz), previously used for analogue television transmission in Australia is one of the few licenced frequencies that is uncluttered with interference from other sources that is ideal for use in regional areas being able to operate well with the challenges of distance, topography, vegetation, fire and weather. There are however significant policy and competition challenges for access to this frequency spectrum.

The entire Digital Dividend spectrum has now been sold or committed by the Australian Government. It is unfortunate that some of this spectrum was not reserved for strategic delivery in regional areas. There are significant benefits to safety and operation of autonomous equipment and other devices through operating in the 694-820 MHz frequency range, avoiding interference from other sources. The Review Committee is asked to consider the availability and use of radio frequency delivering optimal performance in remote, rural and regional areas in which the telecommunication companies are unlikely to utilise or deliver services.

Summary Comments

A copy of the P2D project summary report is attached to this submission for further consideration. This P2D report recommends a review of policy and investment to improve telecommunications to farms and rural businesses, to establish baseline patterns of data usage, and to compile a national mobile network coverage (data speed and volume) database. For the potential unconstrained benefit of \$20.3 Billion GVP per annum to be realised by Australian agriculture, the issues around telecommunications and in-field data access clearly need to be addressed. It is encouraging that the Australian Government has commissioned this Regional Telecommunications Review. If there are any further questions around the information or issues raised in this submission, please contact me by email rohan.rainbow@agtechcentric.com or mobile [REDACTED]. I look forward to the findings and outcomes of the Regional Telecommunications Review.



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Attachment:

P2D summary report - Accelerating precision agriculture to decision agriculture: Enabling digital agriculture in Australia. Cotton Research and Development Corporation.

SUMMARY REPORT

ACCELERATING PRECISION AGRICULTURE TO DECISION AGRICULTURE

Enabling digital agriculture in Australia

This Project is
supported by funding
from the Rural R&D
for Profit Program



Australian Government
Department of Agriculture
and Water Resources

RDC PARTNERS



RESEARCH PARTNERS



Citation

Leonard, E. (Ed), Rainbow, R. (Ed), Trindall, J. (Ed), Baker, I., Barry, S., Darragh, L., Darnell, R., George, A., Heath, R., Jakku, E., Laurie, A., Lamb, D., Llewellyn, R., Perrett, E., Sanderson, J., Skinner, A., Stollery, T., Wiseman, L., Wood, G. and Zhang, A. (2017). Accelerating precision agriculture to decision agriculture: Enabling digital agriculture in Australia. *Cotton Research and Development Corporation, Australia.*

This report provides a summary of the following six projects commissioned under the Accelerating precision agriculture to decision agriculture project (P2D).

Zhang, A., Baker, I., Jakku, E. and Llewellyn, R. (2017). Accelerating precision agriculture to decision agriculture: The needs and drivers for the present and future of digital agriculture in Australia. A cross-industries producer survey for the Rural R&D for Profit 'Precision to Decision' (P2D) project. *CSIRO and Cotton Research and Development Corporation, Australia.*

Lamb, D. (2017). Accelerating precision agriculture to decision agriculture: A review of on-farm telecommunications challenges and opportunities in supporting a digital agriculture future for Australia. *University of New England and Cotton Research and Development Corporation, Australia.*

Wiseman, L. and Sanderson, J. (2017). The legal dimensions of digital agriculture in Australia: An examination of the current and future state of data rules dealing with ownership, access, privacy and trust. *Griffith University, USC Australia and Cotton Research and Development Corporation, Australia.*

Barry, S., Darnell, R., Grundy, M., Moore, A., Robertson, M., Brown, J., Gaire, R. and George, A. (2017). Precision to Decision – Current and future state of agricultural data for digital agriculture in Australia. *CSIRO and Cotton Research and Development Corporation, Australia.*

Skinner, A., Wood, G., Leonard, E. and Stollery, T. (2017). Advancing precision agriculture to decision agriculture:

A big data reference architecture for digital agriculture in Australia. *Data to Decisions CRC and Cotton Research and Development Corporation, Australia.*

Perrett, E., Heath, R., Laurie, A. and Darragh, L. (2017). Accelerating precision agriculture to decision agriculture – analysis of the economic benefit and strategies for delivery of digital agriculture in Australia. *Australian Farm Institute and Cotton Research and Development Corporation.*

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ISBN: 978-0-9954323-8-3 (Hard copy)
978-0-6482237-0-2 (Electronic)

More information:

www.crdc.com.au/precision-to-decision

Acknowledgement:

Society of Precision Agriculture Australia, Valley Irrigation and Murrumbidgee Irrigation for use of some photos.

Cover image - Australian Farm Institute

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The background image shows a woman in a blue shirt and dark apron, smiling and looking at a tablet in a field of green plants. Overlaid on the image are several circular icons: a smartphone on the left, a computer monitor on the top right, and a network of lines connecting dots across the scene.

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GLOSSARY OF TERMS

TERM	MEANING
AgTech	Commonly used in the investment community to describe digital technologies used in agriculture.
Big data	Any collection of datasets so large and complex that it becomes difficult to store, process and analyse using current technologies. Big data comes from many sources (e.g. text, image, audio, social media etc.) at an alarming velocity, volume and variety, which adds to this challenge.
Decision agriculture	Conclusion or action resulting from the application of knowledge and/or information that may be derived from digital agriculture.
Digital agriculture	Digital agriculture typically involves both the collection and analysis of data to improve both on-farm and off-farm decision making, leading to better business outcomes.
Digital disruption	Digital and associated technologies that 'disrupt the status quo, alter the way people live and work, rearrange value pools, and lead to entirely new products and services', often in a relatively short period of time.
Information and communication technologies (ICT)	ICT is a broad term used to refer to technologies that involve the use of computers, computer networks, telephone networks and internet networks to manage data and information.
Internet of Things (IoT)	Devices such as sensors, machine and other digital instruments which are connected to each other and the internet so that they are able to collect and exchange data with each other.
Open data	Data that is: <ul style="list-style-type: none"> • Freely available to download in a reusable form. Large or complex data may be accessible via a service or facility that enables access in-situ or the compilation of sub-sets. • Licensed with minimal restrictions to reuse. • Well described with provenance and reuse information provided. • Available in convenient, modifiable and open formats; and • Managed by the provider on an ongoing basis.
Precision agriculture (PA)	Farming practices that involve precise spatial management through the use of Global Positioning System (GPS) or machine vision technologies. Involves the observation, impact assessment and timely strategic response to fine-scale variation in causative components of an agricultural production process. ⁱⁱ This can include variable rate seeding and fertiliser application, yield mapping, and animal location and analysis.

ⁱ Manyika, J., Chui, M., Bughin, J., Dobbs, R., Bisson, P., & Marrs, A. (2013). Disruptive technologies: Advances that will transform life, business, and the global economy (Vol. 180). San Francisco, CA: McKinsey Global Institute.

ⁱⁱ Precision Agriculture Laboratory, What is Precision Agriculture? Sydney University available at - https://sydney.edu.au/agriculture/pal/about/what_is_precision_agriculture.shtml



1. INTRODUCTION

DEFINITION :: Digital agriculture typically involves both the collection and analysis of data to improve both on-farm and off-farm decision making, leading to better business outcomes.⁴

Australian agriculture is on the brink of an upgrade. The transition from analogue business and production models to digital is creating challenges and opportunities across all industry sectors, domestically and internationally. Agriculture is not immune.

Economic modelling has shown that digital agriculture could increase the gross value of Australian agriculturalⁱⁱⁱ production by \$20.3 billion (25% increase on 2014-15 levels).

Australia has been a world leading player in the development of precision agricultural tools. For example, the Australian company Beeline released the first navigation system for agriculture more than 20 years ago. Despite our innovative culture, the Australian AgTech market is in its infancy compared to countries such as the United States of America (USA) and Israel. (AFI)

Information and communication technology (ICT) spill over from overseas is occurring in some industries including cropping, dairy and intensive livestock. However, Australian production systems face some unique challenges that require home-grown solutions to enable appropriate data based decision making.

Many Australian producers are finding it difficult to navigate the digital agricultural marketplace and worry about unwise investments without a guarantee of return. Producers lack trust in data management systems, access by third parties and are unclear about the terms that govern their data including who owns their data. Many producers and agricultural stakeholders require improved digital skills and knowledge and are frustrated by the unreliability of telecommunications connectivity and the inadequate services currently supporting the adoption of digital technology.

A lack of producer control and under-utilisation of data to make decisions are putting Australian agriculture at a global disadvantage. **Australia cannot afford to be left behind.**

The value placed on data and technology varies between agricultural industries, but producers are becoming more skilled at deploying precision agriculture (PA) technologies. The volume of data gathered from farm machinery, sensors and digital technologies is increasing exponentially. Increased temporal and spatial information about the status of soil, water, crops, animals and pasture, etc, is of little value

unless it can be used to make and action improved decisions. **How to use this data to improve on-farm profitability often remains the challenge.**

In 2016, the Commonwealth Department of Agriculture and Water Resources funded a Rural R&D for Profit research project, Accelerating precision agriculture to decision agriculture project (P2D). The project was led by the Cotton Research and Development Corporation (CRDC).

The P2D project brought together all 15 Research and Development Corporations (RDCs) for the first time to develop six projects that evaluated the current and desired state of digital agriculture in Australia. Recommendations are provided by the P2D project to ensure Australian primary producers are able to overcome the challenges currently limiting digital agriculture and profit from their data.

Eight regional stakeholder workshops were held in five states and producers were surveyed across the nation to better understand the current perceptions and needs for digital agriculture by producers and other stakeholders (Appendix 6.1).

ⁱⁱⁱ Including forestry, and fisheries and aquaculture



PROJECT LED BY



Australian Government

Cotton Research and Development Corporation

The six reports commissioned to address key areas that are constraining digital agriculture moving towards its promised potential in Australia are as follows*:

1. Producer survey of digital agriculture

The needs and drivers for the present and future of digital agriculture in Australia. A cross-industries producer survey for the Rural R&D for Profit 'Precision to Decision' (P2D) project.

CSIRO and Cotton Research and Development Corporation.

2. Data connectivity for digital agriculture

A review of on-farm telecommunications challenges and opportunities in supporting a digital agriculture future for Australia.

University of New England and Cotton Research and Development Corporation.

3. Legal aspects of digital agriculture and trust

The legal dimensions of digital agriculture in Australia: An examination of the current and future state of data rules dealing with ownership, access, privacy and trust.

Griffith University, USC Australia and Cotton Research and Development Corporation.

4. Data sources for use in digital agriculture

Current and future state of agricultural data for digital agriculture in Australia.

CSIRO and Cotton Research and Development Corporation.

5. A big data reference architecture for agriculture

A big data reference architecture for digital agriculture in Australia.

Data to Decisions CRC and Cotton Research and Development Corporation.

6. Economic benefit and strategies for digital agriculture

Analysis of the economic benefit and strategies for delivery of digital agriculture in Australia.

Australian Farm Institute and Cotton Research and Development Corporation.

* These numbers are used to reference the reports throughout this Summary Report.

Capturing rumen temperature and pH from a reusable sensor bolus and transmitting the data to Cloud storage provides an early alert for heat stress and allows rations to be modified before weight loss occurs.



PHOTO. Emma Leonard, AgriKnowHow

THE PRINCIPLE FINDINGS OF THE P2D PROJECT ARE:



Digital agriculture in Australia is in an immature state in many parts including strategy, culture, governance, technology, data, analytics, and training. This is to the detriment of innovation and producer adoption of digital agriculture in Australia.



With maturity, the economic modelling identified that the implementation of digital agriculture across all Australian production sectors (as represented by the 15 RDCs) could lift the gross value of agricultural (including forestry, and fisheries and aquaculture) production by \$20.3 billion (a 25% increase on 2014-15 levels).



To achieve maturity, cross-industry and cross-sector collaboration is vital as many of the issues impeding maturity are common and this scale of investment is required to implement solutions for Australian conditions and to keep pace with the rest of the world.



PHOTO. Emma Leonard

This historic collaboration of RDCs to jointly fund the P2D project has occurred because many of the issues associated with the transition to digital agriculture are not industry specific. Consequently, the recommendations from this project are focused on benefiting all industries. A cross-industry approach to providing the leadership, governance, connectivity, datasets and platforms and increased digital literacy is required.

Implementing the recommendations from the project will set the stage for increasing the profitability of producers, providing clarity and trust in data ownership and access rights, and stimulating an innovation environment that facilitates the development and adoption of technology.

This Summary Report brings together the key findings and aggregates the 67 detailed recommendations into 13 key recommendations. It also provides direction on the next steps required to implement the recommendations.

The P2D project has detailed a clear value proposition and pathway forward for transformational improvement in Australian farm business management and decision making through digital agriculture (Figure 1.1). For this potential to be realised, it will be essential for industry, RDCs, government and the commercial sector to commit to work together.

The support of all of the Rural Research and Development Corporations and the Australian Government has enabled the P2D project to benefit from a co-ordinated national approach. The thirteen key recommendations provide a clear sight of the way ahead and a next phase of P2D has a compelling case.

It is recommended that all RDCs co-invest in enacting the recommendations at the national scale and seek co-investment from the Australian Government through the Rural R&D for Profit program.

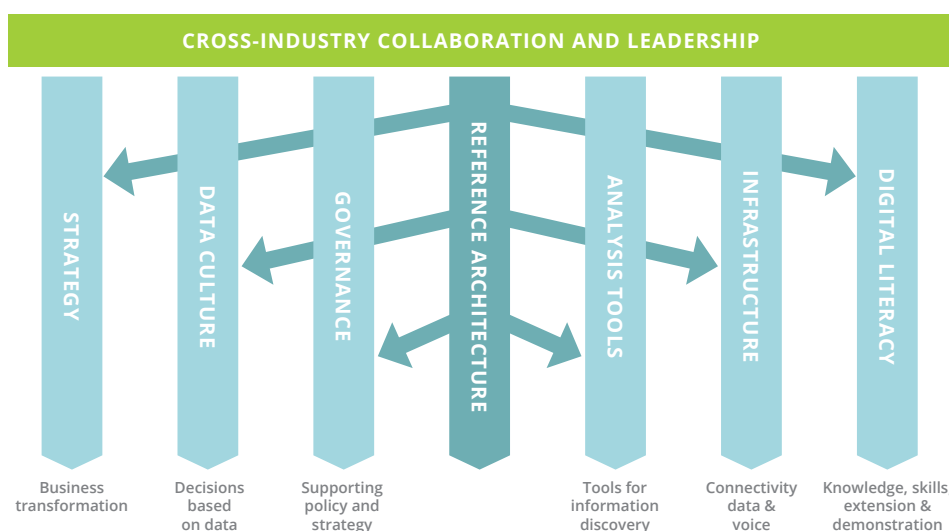


Figure 1.1. A cross-industry approach to achieve the successful implementation and adoption of digital agriculture.

2. POTENTIAL ECONOMIC BENEFIT OF DIGITAL AGRICULTURE

Quantifying the value of digital agriculture to Australia was a fundamental part of the P2D project. Using the Centre for International Economics-Regions Food Processing Model (CIE-Regions FP model), the Australian Farm Institute (AFI) predicted the potential economic benefit of the unconstrained transition to digital agriculture.


















When digital agriculture is fully implemented in Australia, it is estimated that this would boost the value of agricultural production, including forestry, fisheries and aquaculture, by 25% (compared to 2014-15). This is a \$20.3 billion boost to the gross value of agricultural production (GVP) (Table 2.1). The overall potential increase in national gross domestic product (GDP), including the flow-on effect to other parts of the Australian economy, is estimated to be \$24.6 billion.

These estimates are considered to be a conservative best-case situation. They assume a 100% uptake of digital agriculture and exclude any costs associated with the adoption of digital technologies.

The productivity gap between fully-enabled digital agriculture and the current state reflects the size of the opportunity that has yet to be fully captured. The key findings from the six P2D reports (Section 3) identify the factors that need to be addressed in order to achieve the transition to unconstrained digital agriculture in Australia.

Appendix 4 of the AFI report - *Analysis of the economic benefit and strategies for delivery of digital agriculture in Australia* - provides international examples of digital systems already implemented in international agricultural and food value chains. Examples include systems to improve product quality, marketing and automation of compliance. The success of these systems in Australia relies on overcoming all seven constraints to the uptake of digital agriculture that are outlined in Section 3 of this report.

Table 2.1. The impact of unconstrained decision agriculture to the Australian economy.⁶

Sector	Baseline sector value (GVP) 2014-2015 (\$M)	Estimated potential benefit to the sector		Estimated potential benefit to the economy
		GVP ^a Increase (\$M)	GVP Increase (%)	GDP ^b Increase (\$M)
 Rice	260	78	30	46
 Grains ^c	11,522	5,930	51	1,821
 Cotton	1,413	394	28	692
 Sugar	1,257	291	23	660
 Horticulture ^d	1,018	403	40	951
 Beef	10,461	1688	16	4,219
 Sheep meat	2,988	516	17	1,316
 Wool	2,550	452	18	1,128
 Pork	1,084	55	5	429
 Dairy	3,343	497	15	1,298
 Eggs	729	180	25	128
 Chicken meat	2,084	503	24	371
 Wine	5,865	706	12	630
 Forest and wood products	14,864	5,511	37	7,484
 Livestock exports	1,601	72	4	179
 Red meat processing	14,533	2081	14	2,438
 Fisheries and aquaculture	2,132	928	44	855
Total	75,331	20,285	25	24,645

^a Gross Value of Production (GVP) measures the actual production output of an establishment or sector.

^b Gross Domestic Product (GDP) is a summary indicator of economic activity, and measures the sum of the gross value added through the production of goods and services in individual sectors of the economy.

^c Including oilseeds and pulses.

^d Leafy greens, brassicas, and carrots only.



PHOTO. Emma Leonard

Industry specific opportunities

The potential productivity gains vary between industries and by the type of activities that generate the greatest economic benefit from digital technologies.

For example, the use of technologies to achieve automation and labour saving, potentially offer productivity improvements of between 1.6% (Chicken meat and Egg sectors) to 30% (Forestry) (Appendix 6.2).

The AFI report provides a detailed economic assessment of the activities that will provide greatest benefit from implementing digital practices in each of the 17 agricultural industries (Appendix 2 report 6). From these assessments, four fundamental areas that offer substantial potential to improve the GVP across multiple industry sectors were identified and reported as use cases. This report also contains a review of the Australian AgTech sector and the global impact of decision agriculture.

Additional use cases and case studies that illustrate how producers can and are capturing the value of digital agriculture are found in the reports by Data to Decisions CRC, University of New England and CSIRO DATA61.

Paddock to... A QR code on each cotton bale enables traceability back to the production area.

Cross-industry use cases

Increased process automation and labour savings

Labour is one of the most significant costs for most agricultural enterprises. The impact of digital technologies on labour efficiency is likely to be the greatest in sectors that have routine tasks with a high degree of predictability and that need to be performed with a high degree of accuracy.

Process automation can replace subjective human assessment, while automation can also improve workplace health and safety. Digital technologies will also play a role in meeting regulatory and compliance requirements.

For example, digital platforms that collect farm management information can be integrated with compliance requirements for certification that may be required in environmentally sensitive zones such as the Great Barrier Reef catchment. This would save duplication of time and effort from multiple analogue recording systems.

The opportunity estimated by the economic modelling that may be achieved through process automation and labour savings across sectors is a GVP increase of \$7.4 billion. The cotton, horticultural and forestry industries illustrate opportunities for substantial percentage increases in productivity due to automation (Appendix 6.2).

Tailoring inputs to need

Varying inputs, such as nutrients and seed, to better match the unit needs of individual animals, plants or groups of animals and areas of land, offer production and environmental benefits. The application of variable rate technology (VRT) to increase productivity has relevance across most agricultural sectors. VRT is currently at different stages of advancement in different agricultural sectors.

VRT is well advanced in some of the broadacre cropping sectors, such as cotton and grains, however the modelling suggests the scope for significant further improvement is large. In the livestock sectors, there is strong interest in applying the principles of variable rate management to individual animal and pasture management.

While VRT can extend beyond nutrient application to water management, pesticides, fungicides and other inputs, improving nutrient use (in grains and livestock sectors) is still the most common application of this technology.

Economic modelling has estimated that across sectors, better targeting of crop and pasture nutrition as well as feed and water in extensive livestock would improve GVP by \$2.3 billion. Nearly a third of this improvement is anticipated from the beef sector. The sugar industry is estimated to achieve the greatest productivity improvement from the better targeting inputs (Appendix 6.2).



PHOTO. Emma Leonard

Accelerating genetic gains through objective data

Major improvements in plant and animal genetics have been achieved using genetic benchmarking and genomics tools. Data analytics has the potential to accelerate these methods by integrating this information with performance data from other sources such as insights that link genetic, production and processing data.

Even without further genetic gain, decision agriculture provides the capability through the assessment of objective data to select the most appropriate existing genetics or even make fundamental changes to cropping sequences or animal breeds for increased productivity and profitability.

For example, there are potentially significant opportunities to increase the productivity of the livestock industries through integrating genetic and genomic data, with lifetime productivity information (e.g. weight gain, health status) and objective carcase feedback.

By achieving better breeding, genetic selection and rotation decisions through the application of decision agriculture, economic modelling estimated an improvement in GVP of \$2.9 billion. More than half of this was attributed to improving crop rotations in grain production (Appendix 6.2).



PHOTO. USQ NCEA

Improving market access and biosecurity

Traceability, provenance and biosecurity are key areas that producers and industry are looking to digital agriculture for answers.

An immediate economic benefit will be realised from improved management resulting from the data collected as part of broader biosecurity efforts. For example, the monitoring of animal health for disease outbreaks is just as useful for measuring the performance

and efficiency of animals for productivity and profitability gain. Likewise, disease monitoring for biosecurity incursions in horticulture will provide management information required for more efficient production.

Economic modelling estimated an increase in GVP of \$1.0 billion could be achieved through management platforms that form part of broader traceability and biosecurity efforts. Animal health and disease monitoring in the beef industry was estimated to gain significantly from this approach.

Summary

Agriculture of the future will be digitally enhanced at all stages of production, from the primary breeding and production, to processing and logistics and finally to the consumer.⁴ With a cross-industry approach to developing and supporting appropriate governance, infrastructure, datasets and systems and training (Figure 1.1), Australian agricultural sectors can become more productive and sustainable, with a greater capacity to innovate and manage risk, ensuring their competitiveness in the global market and greater profit at the farm gate.⁵



Unconstrained digital agriculture will deliver \$ to producers

Estimated potential increase in gross value of production (GVP) by agriculture^{iv}

\$20.3 billion

(25% increase on 2014-15 levels)



Overall potentially increasing National GDP by

\$24.6 billion
(a 1.5% increase on 2014-15 levels)



ESTIMATED POTENTIAL GVP IMPACTS FROM INDUSTRIES WORKING TOGETHER



Automation and labour savings \$7.4B

e.g. machinery, animal handling & product processing



Genetic gains through objective data \$2.9B

e.g. animal & variety selection



Tailoring inputs to need \$2.3B

e.g. fertiliser seed, & water



Market access and biosecurity \$1B

e.g. pest & disease control

Sector	GVP ^a Increase (\$M)
Rice	78
Grains ^b	5,930
Cotton	394
Sugar	291
Horticulture ^c	403
Beef	1688
Sheep meat	516
Wool	452
Pork	55
Dairy	497
Eggs	180
Chicken meat	503
Wine	706
Forest and wood products	5,511
Livestock exports	72
Red meat processing	2081
Fisheries and aquaculture	928
Total	20,285

^{iv} including forestry, and fisheries and aquaculture

^a Gross Value of Production (GVP) measures the actual production output of an establishment or sector.

^b Including oilseeds and pulses.

^c Leafy greens, brassicas, and carrots only.

3. THE CURRENT STATE OF DIGITAL AGRICULTURE IN AUSTRALIA

The current digital maturity of the agricultural sector has been rated as ‘ad hoc’, meaning it does not systematically and consistently use data to drive decisions. The impact of this is that the sector is missing out on opportunities to improve productivity and realise greater profits.

As part of the P2D project, the Data to Decisions CRC undertook an assessment of the current state of digital maturity of the agricultural sector, with a particular focus on its use of data to drive decisions. This assessment is an important starting point for the findings and recommendations in this report. It also provides a guide to the agricultural industries for the transition to digital agriculture.

The assessment is made against seven key pillars of success for digital maturity, namely strategy, culture, governance, technology, data, analytics and training (Figure 3.1).

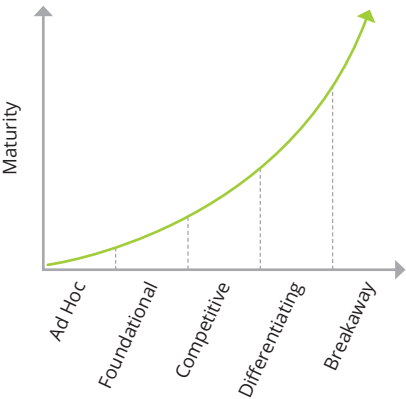


Figure 3.1. Digital maturity levels.⁵

Aggregated mill data indicates regional differences in yield are influenced by row spacing. GPS enables accurate row spacing, and targeted placement of tillage, fertiliser and water, all leading to improved productivity and profitability.

Figure 3.2 indicates that the overall digital maturity of the agricultural sector is ad hoc. This infers that the industry does not systematically and consistently use data to drive decisions and consequently opportunities to improve productivity and profit at the farm gate and through the value chain are being lost.

KEY PILLARS OF SUCCESS FOR DIGITAL MATURITY

STRATEGY (leadership)	Ad hoc
CULTURE (value proposition)	Ad hoc
GOVERNANCE (trust and legal barriers)	Foundational
TECHNOLOGY (connectivity)	Ad hoc
DATA (data sources)	Ad hoc
ANALYTICS (data analytics and support tools)	Foundational to competitive
TRAINING (digital literacy)	Ad hoc

Figure 3.2. The current state of maturity of digital agriculture in Australia as outlined by the Data to Decisions CRC report. Titles in brackets link their structure to the findings across the P2D project⁵.

Through the creation of an actionable cross-industry ‘digitisation roadmap’, many of the maturity challenges identified in this section of the report can be addressed quickly. While this will advance maturity, to grow maturity to become ‘breakaway’ across all categories (if needed) will require focused cross-industry effort and collaboration.



PHOTO. SRDC

Leadership - Ad hoc

A common cross-industry need for greater leadership in digital agriculture was identified. Cross-industry collaboration is required for digital agriculture policy, governance and strategy development and implementation.

The issues and technologies relating to the transition to digital agriculture in Australia generally are not industry specific. These are currently being dealt with at differing levels of detail across the agricultural industry sectors and RDCs. Cross-industry collaboration is required on policy, governance and strategy development and implementation to accelerate and maximise the value of digital agriculture.

- All industries currently lack a clear strategic roadmap for developing big data capability both at an industry and a producer scale. Industries are at different stages in the development of their digital strategies.
- Producers are struggling to know where to start or where to invest to take advantage of the benefits of digital agriculture.
- Governance is in place at a macro level across industries in terms of managing personal information, however deeper governance of data such as privacy, provenance, currency, data quality, foundational data and metadata has not been established in any of the participating industries.
- Data is being collected across industries, however, foundational datasets have yet to be defined, inter-operability is an issue and good data management skills are still to be developed.
- The business outcomes of data required to build a data culture are still to be validated and the time required to do this may in some industries take many years due to crop rotation, etc.
- Technology standards are yet to be developed and cross-industry collaboration to maximise spend is yet to occur. Connectivity and servicing alternative connectivity solutions remain a major limitation.
- A structured approach to building big data and data science expertise is yet to be developed by the participating industries. Capability has been cited as being the leading market failure across industry value chains from the farm gate to processors.^{4, 5}

While there are significant global influences in the digital agricultural marketplace, Australian agriculture has some unique aspects including soil, water, biosecurity and market structure that require locally sourced solutions.

A comprehensive understanding of the current and required maturity (Figure 3.2) of the factors that influence successful implementation of digital agriculture in Australia will support a change management agenda. Delivery of a change management agenda is required to navigate the successful transition from analogue to digital production and development of supporting business systems.

In order to harness the full value of digital processes for Australian agriculture, greater leadership, which includes the development of policy and strategy, is required to enable the inter-related constraints outlined in this section to be overcome.



Cheaper sensors and supporting technologies are enabling improved understanding of environmental conditions and how these may influence product quality. Rapid response to this information can enable superior product assurance supporting greater market access.

PHOTO. Keith Webb

Value proposition - Ad hoc

Producers indicated the value of changing to digital agriculture is not clear. Value was not only related to monetary value, but also peace of mind, confidence, social and lifestyle factors. If digital agriculture is to be adopted, it needs to be sustained by consistency of service and support and the reliability of technology.

For many, the value of changing to digital agriculture is not clear, with many producers expressing frustration at not knowing how to start or where to invest.⁵ Indeed, the level of producer awareness of the potential of digital agriculture is low and development and adoption are at an early stage.¹

There are multiple stakeholders involved in the transition pathway from analogue to digital agriculture in Australia (BREAKOUT). Understanding and engaging with the motivations and requirements of all stakeholders are important in the management of change. The regional stakeholder workshops (Appendix 6.1) provided the opportunity to gather feedback from all stakeholders, while the survey conducted by CSIRO focused only on producers.

The survey interviewed 1,000 producers from 17 agricultural industries at locations across Australia (Appendix 6.1). Its objective was to detail producers' needs, perceived risks and benefits, and expectations associated with digital agriculture and big data.¹

The producer survey highlighted that agriculture is dominated by businesses managed by digital immigrants rather than digital natives. Noting that computers were not introduced to schools until the mid-1980s, the average survey respondent aged 57 would have left school. Indeed, the survey reported that 42% had not completed year 12 schooling and only 10% had a post secondary qualification in agriculture.¹

The challenges and opportunities associated with digital agriculture in

Australia were found to vary by sector, state and farm size. Cotton producers were found to be on a relatively more mature adoption path for digital agriculture (Figure 3.3), as indicated by the collection and use of more data types. Farm businesses with more hectares farmed had greater use of data.¹

Generally, data was valued at some level by all respondents. The overall evaluation of data by respondents who have collected data (87% of cropping industries and 91% of livestock industries) was very positive with 92% of respondents reporting the data they collect is very or extremely useful in helping them make farm management decisions. Responses were less positive for the value of data for farm business profit.¹

It is worth noting that not every producer surveyed reported collecting financial data, which provides an indication of the skills and knowledge challenges that exist.¹



STAKEHOLDERS IN A DATA ECOSYSTEM⁶

Understanding and engaging with the motivations and requirements of all stakeholders are important in managing the change from analogue to digital agriculture in Australia.

- Data suppliers: Individuals/organisations (large and small-to-medium enterprises (SMEs) that create, collect, aggregate and transform data from both public and private sources.
- Technology providers: Typically, organisations (large and SMEs) that provide tools, platforms, services and know-how for data management.
- Data end users: Individuals/organisations from different industrial sectors (private and public) that leverage big data technology and services to their advantage.
- Data marketplace: Individuals/organisations that host data from publishers and offer it to consumers/end users.
- Start-ups and entrepreneurs: Develop innovative data-driven technology, products and services.
- Researchers and academics: Investigate new algorithms, technologies, methodologies, business models and societal aspects needed to advance big data.
- Regulators for data privacy and legal issues.
- Standardisation bodies: Define technology standards to promote the global adoption of big data technology.
- Investors, venture capitalists and incubators: Individuals/organisations that provide resources and services to develop the commercial potential of the ecosystem.

⁶ Curry, E (2016) , The big data value chain: definitions, concepts, and theoretical approaches, Chapter 3 in J Cavanillas et al. (eds), New Horizons for Data-Driven Economy.



Digital innovation will assist with timely decision making through real-time monitoring systems (e.g. remote and proximal sensors), ensuring that product is sustainable and provenance underpinned with sound information.



PHOTO. Julie O'Halloran

Using variable rate irrigation and fertigation based on soil maps, vegetable producers hope to increase carrot yields by 20%.

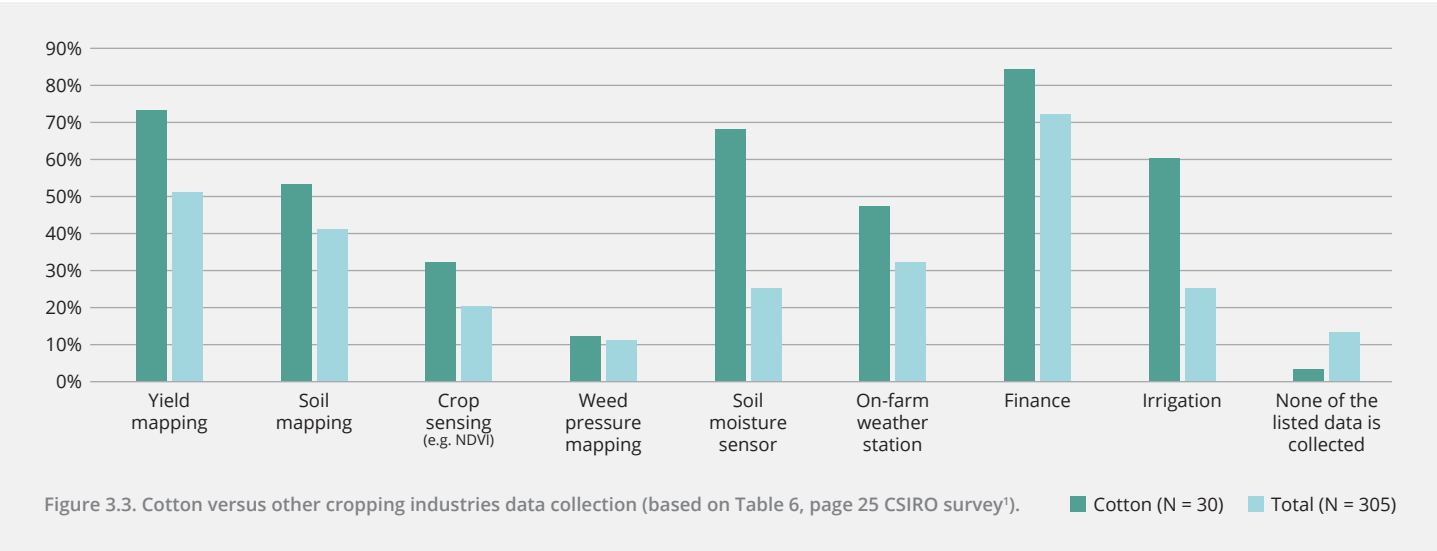
The survey found that users of digital agriculture have to be very self-sufficient, with 53% relying on themselves, family members or employees to sort out their telecommunication needs.¹ This requirement for education and improved service coupled with lack of trust and confidence in the technologies and technology suppliers (see Trust and legal barriers) indicate fundamental market failure and the creation of significant roadblocks to the use of

digital agricultural technologies and approaches to production.

The use cases and case studies found in the reports by AFI, Data to Decisions CRC, University of New England and CSIRO DATA61 highlight the value of changing to digital agriculture. However, producers at stakeholder workshops identified that value can only be widely gained if sustained by consistency of service and support and the reliability of technology.⁵

They also identified that the market for digitisation is not only about digital agriculture, but also fundamental factors including safety, security and peace of mind.

To harness the modelled economics potential, producers need to have a clear value proposition for their industry and business.



Trust and legal barriers – Foundational

Currently, the legal and regulatory frameworks around agricultural data are fragmented, piecemeal and ad hoc for producers. Robust guiding policy at a national scale is required.³

The absence of clear and consistent data management principles, policies and frameworks within Australian rural industries has the potential to expose Australian producers and their businesses to threats to their privacy, security and the safety of their agricultural data. It also means that Australian producers are uncertain, confused and distrustful when it comes to how their data is managed by service providers and third parties. This, in turn, limits the potential benefits that can be derived from digital agriculture and data. In terms of producers' views on data, the P2D survey revealed some alarming trends¹:

The majority of respondents (74%) knew nothing or very little about the terms and conditions for their data collection agreement with service providers.

The lack of trust in service providers maintaining privacy and not sharing data with third parties was high, with 62% not trusting service providers not to share their data with third parties.

49% of respondents were uncomfortable or extremely uncomfortable if service providers had direct access to the data.

With the appropriate legal and regulatory frameworks, producers in all sectors would gain trust and confidence in sharing data with service and technology providers.

Currently, the legal and regulatory frameworks around agricultural data are piecemeal and ad hoc. This means that Australian agricultural policy is lagging behind international law and best practice, and that Australian agriculture is at a competitive disadvantage.³

While there is currently little or no legislation in Australia dealing specifically with data, this may soon change. For instance, the Productivity Commission's final report *Data Availability and Use* (2017) highlighted the importance of data access and availability, and proposed new laws on data rights that may, if implemented, have a fundamental impact on how data, including agricultural data, is managed in Australia.³

Agricultural data contracts are complex and detailed legal agreements are often presented to producers on a 'take it or leave it' basis. There is a general lack of transparency about the terms of these agreements that results in a lack of trust with the way some service and

technology providers manage the data they have acquired. One specific issue that producers highlighted is that they are concerned about third parties gaining access and benefiting from their data without their prior consent.³

Many of the trust and legal barriers identified in the report - *The legal dimensions of digital agriculture in Australia: An examination of the current and future state of data rules dealing with ownership, access, privacy and trust* - can be addressed through the adoption of a national agricultural data management policy, strategy and codes of practice which would directly benefit the Australian agricultural sector as a whole.³

One of the first steps for industry is to implement a national agricultural data management policy. This set of broad, high level principles will form the guiding framework in which data management, including data access, can operate. The policy would include statements on data custodianship and access, data collection and storage, data harmonisation and standardisation, data stewardship, data portability, data security, data lifecycle management and data audits.³



PHOTO. Emma Leonard

Connectivity - Ad hoc

A lack of access to mobile and internet telecommunications infrastructure is a major impediment to the adoption of digital agricultural systems. An improved understanding of producers' data needs and servicing these needs are required.²

Producers are frustrated with the lack of coverage, reliability and speed of telecommunications in Australia. Their frustrations are fed by a perception that these challenges are not being acknowledged, nor responded to, by network operators or at the industry or national strategic level. They feel abandoned and lack local or remote technical support that understands their specific issues.²

The producer survey identified¹:

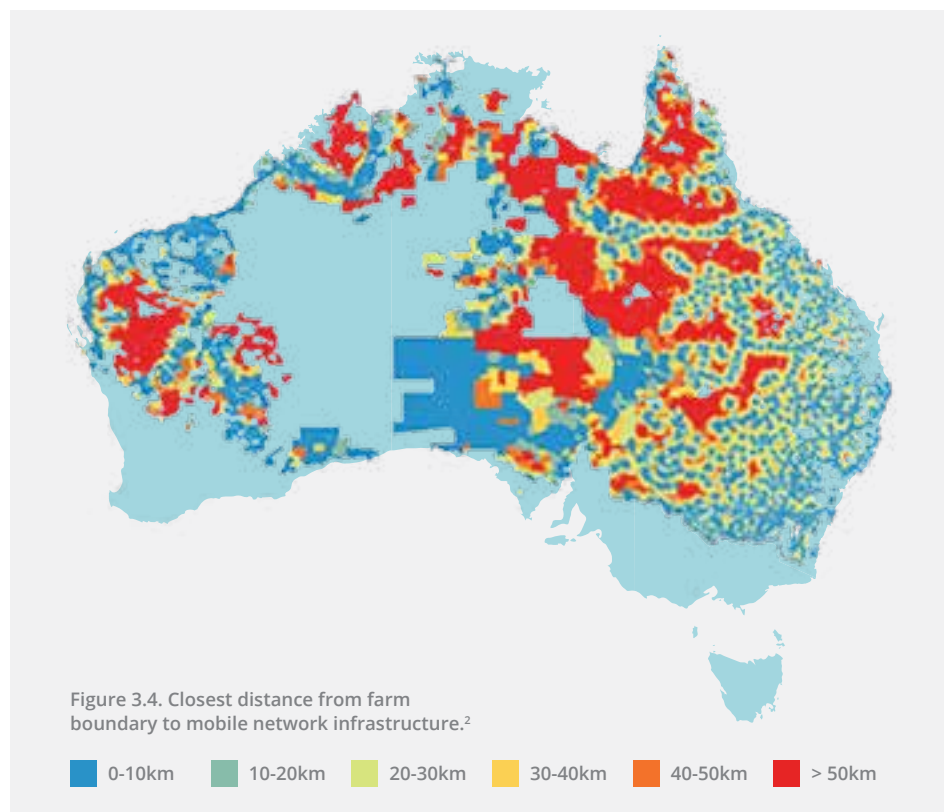
- The vast majority of respondents (94%) had an internet connection for their business, dominated by mobile phone networks (55%).
- Satisfaction with home office internet connectivity was evenly divided, with 30% of respondents being satisfied or extremely satisfied and 40% being not satisfied or not satisfied at all.
- Mobile coverage across the entire farm was commonly reported to be poor, with only 34% of respondents having most or full coverage and 43% having no coverage at all or little coverage.

- Adoption of on-farm telecommunication infrastructure was limited (25%). Such infrastructure would facilitate the 'Internet of Things' (IoT) across the whole farm. Just over a quarter of respondents (26%) thought they might install some on-farm telecommunication infrastructure in the next five years.

An analysis of farm boundaries to mobile network infrastructure found that 66.4% of farms have infrastructure within 10km, 95.8% within 30km and 98.4% within 50km (Figure 3.4).² As urban dwellers are also aware, proximity to telecommunications infrastructure does not guarantee access.



PHOTO. Tamara Modra



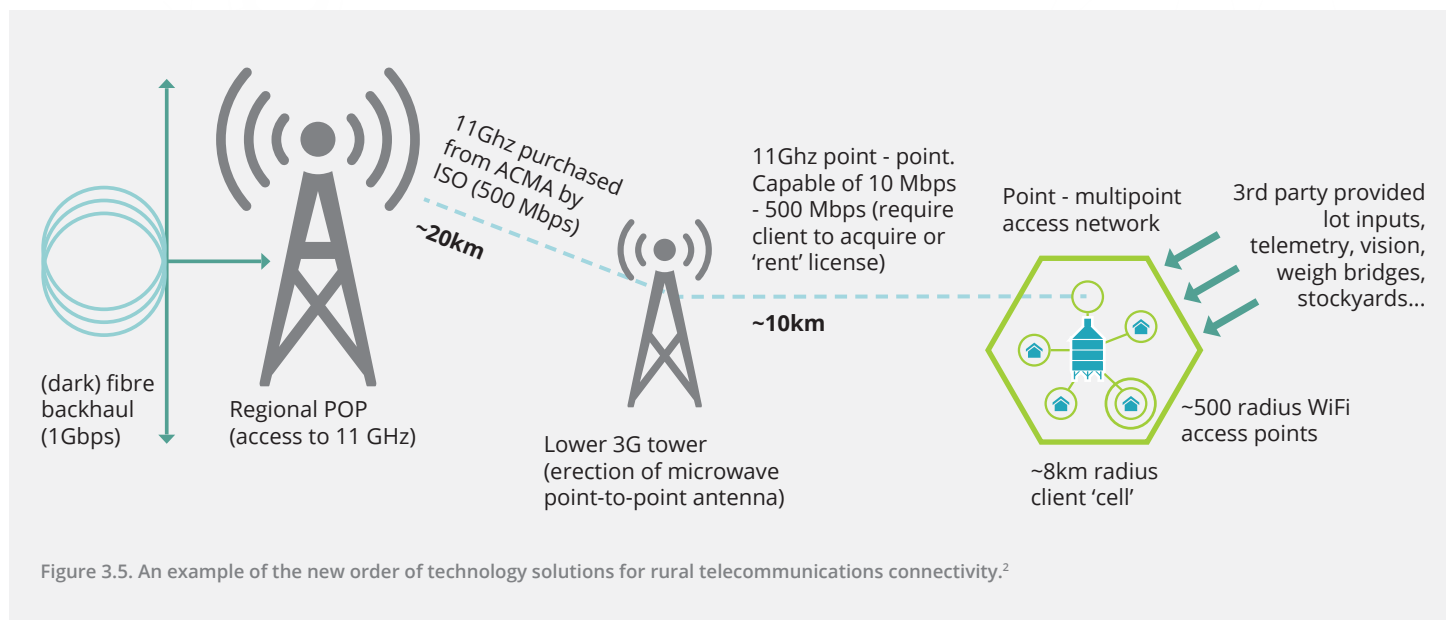
It is considered that the completion of the National Broadband Network (NBN) in 2020 will help reduce, but not overcome the impediment. While the NBN only supplies a single point of access per property and has speed and service limitations, frustration will remain.²

The research highlighted that the role of telecommunications in supporting a digital agriculture future is not necessarily technology constrained as technology

solutions do exist (Figure 3.5). The real constraint is likely to be around who assumes technical risk, service and price.²

The case studies in the report - *A review of on-farm telecommunications challenges and opportunities in supporting a digital agriculture future for Australia* - illustrate how innovative producers are already investing in the type of on-farm infrastructure as outlined in Figure 3.5.2

There is a lack of appropriate quantitative information on data use 'behaviour' of producers and of the capability of existing or planned network infrastructure to cater for that data use. At a national strategic level, there is no centralised knowledge of mobile network data carrying capacity by location. Without such basic information on data use and capacity, how can connectivity for Australian producers be future proofed?²



The ute office. With connectivity, businesses can be run remotely from mobile devices. Reliable data services and technical support that ensure the systems work are essential.

PHOTO. Emma Leonard

Availability of appropriate data sources – Ad hoc

The whole agricultural value chain, irrespective of industry sector, could gain from improved access and inter-operability of stored data that are valuable across the rural sector and that are also widely used in other industries. To achieve this in Australia, alternative private/public business models may be required.^{4,5}

The whole agricultural value chain, irrespective of industry sector, is suffering due to lack or incompleteness of fundamental datasets such as soil, climate and weather, and property boundaries.

The current state of Australian soil data exemplifies this problem. Unlike the USA and some European countries (where farm-scale soil maps have been produced), Australia has not had a long term and detailed soil survey program. As a result, Australian producers do not have access to comparable farm-scale soil information. This makes Australia out of step with the rapid development of on-farm requirements for soil information and limits the compatibility of some internationally developed tools and products.⁴

In addition, access to these institutional soil information systems is developing slowly or deteriorating. The report by CSIRO - *Current and future state of agricultural data for digital agriculture in Australia* - noted that Australian datasets are often not stored and disseminated in findable, accessible, inter-operable and reusable (FAIR) formats, limiting data usefulness and opportunity across industries and stakeholders.⁴

The research found limited availability of internationally developed products in the soil, water and pest management categories that are suited to Australian producers.⁶ Factors that limit the attractiveness of the Australian market both to domestic and international AgTech businesses are summarised in Table 3.1.⁴

The lack of these fundamental datasets at the right scale and in FAIR formats is restricting domestic and international digital product development to support Australian producers. This shortage of commercial investment drives the need for alternative public/private business models to be developed in Australia.^{4,5}

Institutional soil information reform is needed and is the focus of the Australian National Soil Information Facility proposal.⁴

Without a more proactive approach to data management and accessibility, competitors in international markets may leapfrog Australian agricultural industries as they execute more advanced digital strategies.⁵

Table 3.1. Factors that inhibit international investment in digital solutions for Australian agriculture driving the need for alternative public/private business models.⁴

High fixed costs of development caused by diverse populations of potential
Limited context-specificity caused by the coarse spatial resolution of public environmental data compared with other Organisation for Economic Co-operation and Development (OECD) countries
High climatic variability compared with most other developed countries
Need for high-quality user interfaces to support complex systems and time-poor users

Observing variation is of low value without the analytical packages that combine multiple years and sources of data and link the observations to management actions.



⁴ Fair Data Principles, Force 11, sourced from <https://www.force11.org/group/fairgroup/fairprinciple>

PHOTO. Emma Leonard

Data analytics and support tools - Foundational to competitive

While the state of data maturity by industry shows some maturity, the approach to deploying big data solutions across the agricultural sector is uncoordinated and ad hoc. The big data reference architecture provides a common starting point for digital agriculture systems.⁵

Decision support tools continue to be deployed for producer use in many agricultural sectors to a greater or lesser degree of success including Yield Prophet® for grains, ASKBILL for sheep and CottASSIST for cotton. Yet, there is currently no common framework in agriculture for designing big data solutions.

The lack of a common framework inhibits the sharing of data and data insights to maximise profits and improve productivity across agriculture. Moreover, it means that sectors continue to deploy ad hoc digital products and services, which once established, will make it harder for RDCs to collaborate on common platforms to optimise value for their industry and levy payers.⁵

The adoption of the Big Data Reference Architecture (BDRA) developed by the D2D CRC offers a cross-industry solution to these issues.

The BDRA (Figure 3.6) was developed as a common starting point for digital agriculture systems. The BDRA is a framework that describes the common elements required when designing solutions to an organisation's big data needs.

Specifically, it describes aspects such as⁵:

- How to store the data.
- How to process the data.
- How to share this data with others.
- How to analyse this data; and
- How to present (visualise) the results of the analysis.

Fully-enabled digital agriculture requires models and analytics with the ability to transform data into insights applicable to decision making. The BDRA provides a platform for owners and users of agricultural data to exchange, market and value add data for a variety of end purposes.

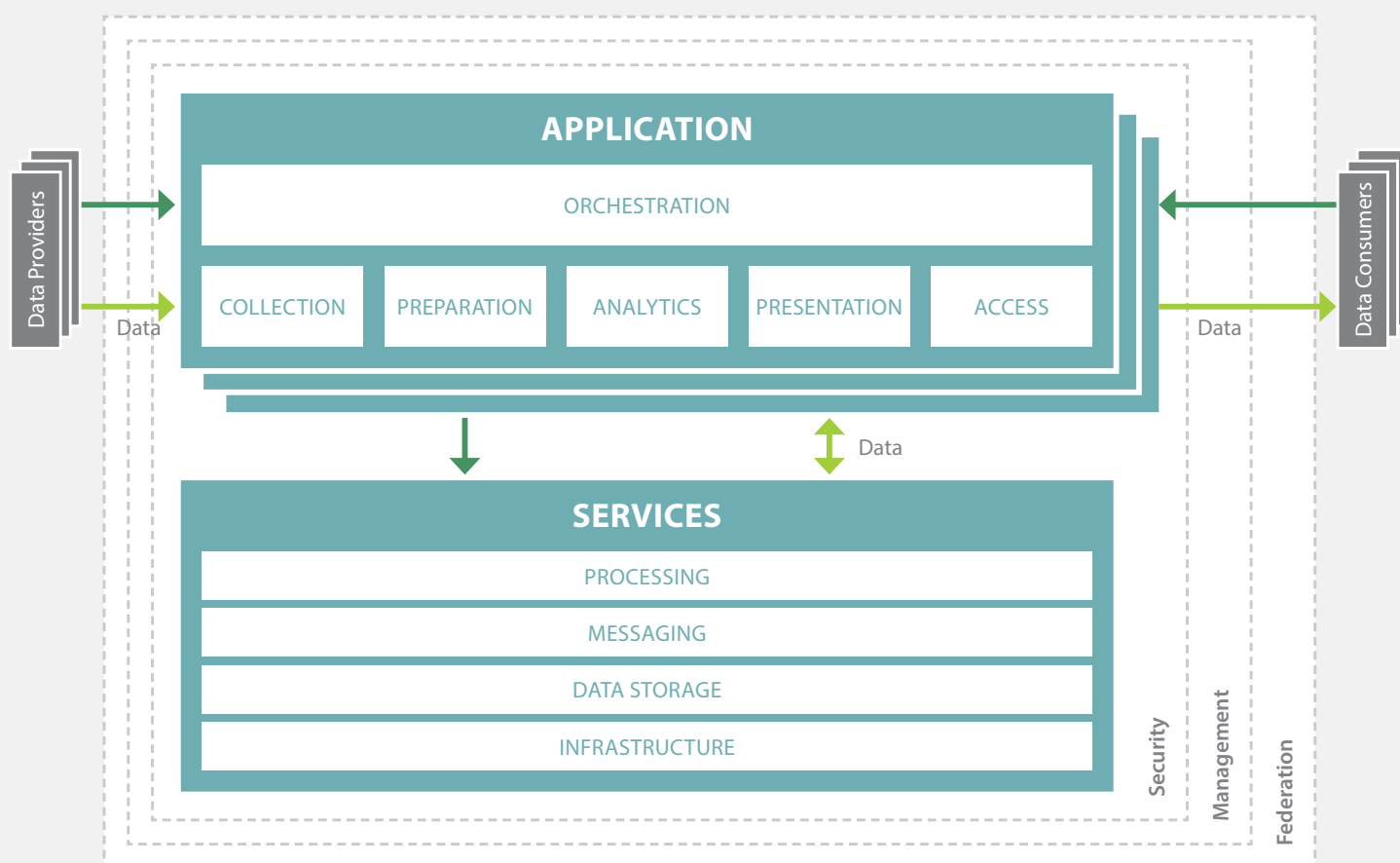


Figure 3.6. Components of a big data reference architecture for digital agriculture.⁵

Digital literacy - Ad hoc

A digital skills and capability gap was identified across the value chain. Equally there is a lack of understanding of agriculture by data scientists. There is a requirement for a review of the skills required for development and adoption of digital agriculture and for the provision of education packages and demonstration sites to be generated for all areas of the value chain.

One of the key findings of the P2D project is that education and skills development are required within the whole agricultural value chain. Industry leaders, government and RDCs need to ensure that agriculture is serviced by a range of providers including technology developers, data analysts and service providers who understand the digital requirements of Australian agriculture.

Knowledge of on-farm communication options was low across all industries, with 61% of survey respondents stating that they knew nothing at all or very little. The survey also identified that when producers have greater knowledge of telecommunication options and data appreciation, their investment in technology increases (Figure 3.7).¹

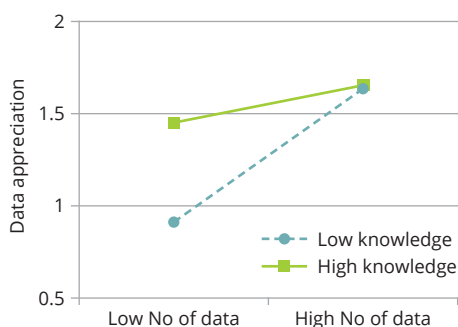


Figure 3.7. Interaction effect between degree of technology/equipment investment and knowledge of telecommunication options on data appreciation for broadacre cropping industries.¹

Knowledge and skills in implementing and capitalising on digital agriculture are lacking across the value chain. Training packages at all levels are required.

During the regional stakeholder workshops, it was found that the Australian university system is not producing sufficient agronomists with the required skills to implement digital solutions, and that the current incentives to change this situation are insufficient.⁴

Skill gaps that were specifically identified in the P2D project are outlined below, but a more comprehensive analysis is required.

On-farm telecommunications - the on-farm telecommunications market is rapidly evolving, but education is one of the biggest challenges faced by those looking for solutions and those offering solutions. The industry needs case studies of current on-farm applications and innovations. Education must target consumers of telecommunications services and technology developers

and service providers. Producers and telecommunications solutions providers identified the need for education about on-farm network and connectivity options. Integral to education about on-farm network options is an understanding of the terms of the services that are being offered. The establishment of demonstrator sites could be considered to enable producers to gain first-hand experience of innovations in a practical environment.²

Data science and data culture - a recurring theme from interviews with value chain participants was concern about the lack of competency in the areas of data science and data culture. This skills gap is seen as a clear market failure that needs to be addressed by the agricultural sector as a whole, as well as participating RDCs.^{2,4,5}

A review of the skills required by producers to maximise the benefits derived from digital agriculture is needed to provide a foundation for the development of educational packages.

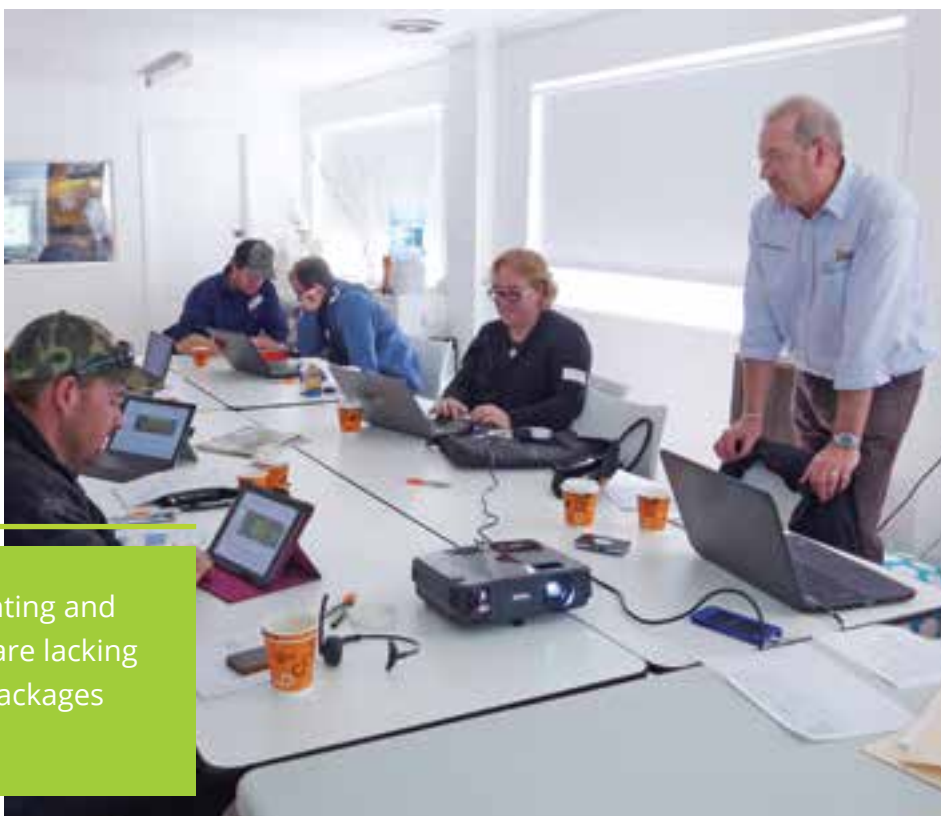


PHOTO. Emma Leonard

KEY FINDINGS



Leadership

A need for greater leadership in digital agriculture was identified, with common issues across industries. There is a need for digital agriculture policy, governance, strategy and cross industry collaboration.



Trust & Legal Barriers

Currently, the legal and regulatory frameworks around agriculture data are piecemeal and ad hoc. 56% of producers indicated having no trust or little trust in service/technology providers maintaining their data privacy.



Value Proposition

Producers indicated the value of changing to digital agriculture is not clear. Value was not only related to monetary value, but also peace of mind, confidence, social and lifestyle factors. If digital agriculture is to be adopted, it needs to be sustained by consistency of service and support and the reliability of technology.



Connectivity

A lack of access to mobile and internet telecommunications infrastructure is a major impediment to the adoption of digital agriculture systems. 55% of producers reported that they relied on the mobile phone network for internet, yet 43% had patchy or no mobile reception across their property.



Availability of Appropriate Data

The whole agriculture value chain irrespective of industry sector could gain from improved access and interoperability of stored data through dissemination of datasets that are valuable across the rural sector that are also widely used in other industries.



Digital Literacy

A digital skills and capability gap was identified across the value chain, including within the RDCs. It was identified that education support was not only required to up-skill the agricultural sectors but also to generate more data scientists and engage them with agriculture.



Data Analysis and Decision Support Tools

There is a need for a platform for owners and users of agricultural data to exchange, market and value add data for a variety of end purposes. Fully-enabled decision agriculture require models and analytics with the ability to transform data into insights applicable to decision-making.

4. KEY RECOMMENDATIONS TO ACHIEVE THE FUTURE STATE OF DIGITAL AGRICULTURE IN AUSTRALIA

Introduction

The P2D project has detailed a value proposition and identified a pathway forward for transformational improvement in Australian farm business management and decision making through digital agriculture. The 67 recommendations from the six P2D technical reports have been aggregated into 13 detailed recommendations.

Delivery of these recommendations could result in a lift in the gross value agricultural production (GVP) of \$20.3 billion. For this potential to be realised, it will be essential for industry, RDCs, government and the commercial sector to commit to work together in each of the following areas:



Policy



Strategy



Leadership



Digital Literacy



Enablers



A. Policy

RECOMMENDATION A1

A Data Management Policy for Australian Digital Agriculture is established to provide governance for the control and use of data to improve the interoperability of datasets and help build trust.

One of the first steps for industry in implementing good data management procedures is to establish a national data management policy. This is a set of broad, high level principles that will form the guiding framework in which data access and management can operate. More specifically, a data management policy for Australian digital agriculture must consider issues such as data custodianship and access, data collection and storage, data harmonisation and standardisation, data stewardship, data security, data portability, data lifecycle management and data audits.

The Australian market for digital agriculture products and services is in its relative infancy compared to the scale and pace of developments occurring in other parts of the world. However, the full economic potential of digital agriculture will struggle to be realised until there is a data management policy that sets out principles on data management. By addressing the constraints identified in the P2D project, this policy will support both the adoption of existing digital agriculture technologies and practices, as well as facilitate the emergence of new business models and their associated products and services.⁶ In addition, a data management policy for Australian agriculture will help ensure that the full economic and social potential of decision agriculture will be achieved.

RECOMMENDATION A2

A voluntary Data Management Code of Practice and a Data Management Certification or Accreditation Scheme are developed in line with the Data Management Policy for Australian Digital Agriculture to provide quality assurance of Australian agricultural data.

Australian producers want to know that their data is adequately protected and used fairly. Currently, many Australian producers do not trust service/technology providers with their data. A lack of trust in the way data is managed was identified during the survey phase of the project, with 56% of respondents having no trust or little trust in service/technology providers not sharing their data with third parties (Figure 4.1).

Implementing a data management code of practice and certification or accreditation provides mechanisms to increase transparency and trust. One way this will be achieved is by developing trust and greater transparency about the terms of use that govern the collection, aggregation, ownership, storage and dissemination of data. This trust and transparency are essential prior to producers entering into commercial relationships with third-party advisers and technology service providers.⁶

Examples of data codes of conduct and certification schemes can be found in other countries including the United States i.e. Ag Data Transparency Evaluator, New Zealand's Farm Data Code of Practice and the United Kingdom's proposed data quality certification mark.³

If the service/technology providers have direct access to your data, how much do you trust them to maintain the privacy of your farm data?
- overall (N = 895)

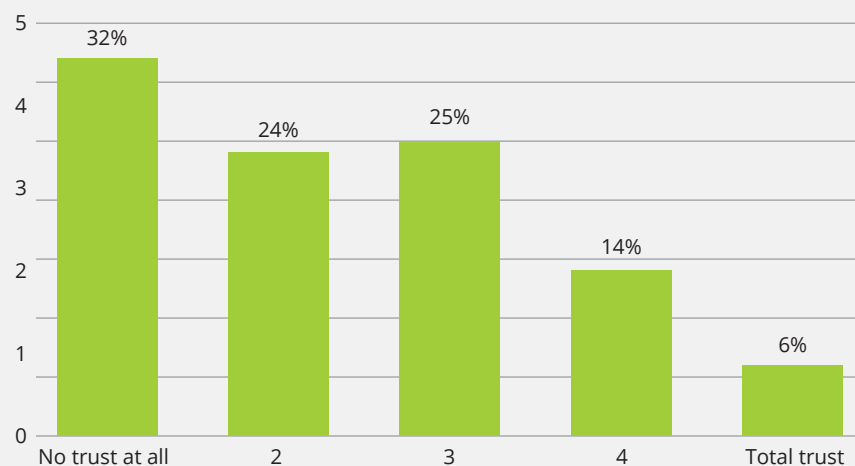


Figure 4.1. Trust in service/technology providers maintaining privacy of producers' data.

RECOMMENDATION A3

That the Federal Government considers policy and investment options to improve telecommunications to farms and rural businesses including the potential for public/private investment models for telecommunications infrastructure.

A lack of access to mobile and internet telecommunications infrastructure is a major impediment to the adoption of digital agricultural systems. Furthermore, it is costing producers, agribusinesses and the Australian economy billions of dollars each year in terms of lost productivity (and profitability)⁶ While connectivity is only one of the five constraints to the progression to digital agriculture, it is considered to be the engine. Without connectivity, digital agriculture is not possible.

Of the 1,000 producers surveyed, 974 respondents reported patchy mobile network coverage across their property (Figure 4.2).¹

Areas of need relating to connectivity that have been highlighted through the P2D project include:²

- Improving wireless backhaul infrastructure.
- Enabling multi-point NBN satellite access to rural properties.
- Improving software providers' understanding of optimising their products/services to work via Sky Muster; and
- Reviewing the Universal Services Obligation (USO) to acknowledge the importance of data 'speed', not just data access.

RECOMMENDATION A4

The potential for new investment models including public/private investment models should be explored, by DATAWG, with the aim of developing policy to support a vibrant data market.

Many of the producers and supply chain organisations that participated in the regional stakeholder workshops commented that they 'struggled to access and integrate data'. The standardisation of data formats introduces inter-operability benefits both for users and developers.

Several approaches have already been tested internationally. Examples include the UK's Open Standards Portal (<https://standards.data.gov.uk>)⁵, Global Open Data for Agriculture and Nutrition (GODAN) and the Consultative Group on International Agricultural Research (CGIAR) Big Data Platform.

Within the international agricultural sector, access to open datasets has been proven to accelerate the availability and adoption of digital agriculture solutions (for example, the US National Soils Datasets). However, much of the data resulting from publicly funded research activities in Australia is not made available for common use.⁵

Public/private investment models would need to support integration of corporate data into foundational datasets and the improved accessibility of data gathered by government bodies to the corporate sector.⁵

The policy needed to enable public/private partnerships for integration of datasets includes:

- The standardisation of data formats.
- An industry wide agricultural data platform for owners and users of agricultural data to exchange, market and value-add data for a variety of end purposes.
- Establishing common cross-industry data security definitions; and
- Standards and dynamic data standards and licensing.

How do you describe your coverage across your entire farm?

By industry (N = 974:1 = no coverage anywhere on the farm, 5 = full coverage)

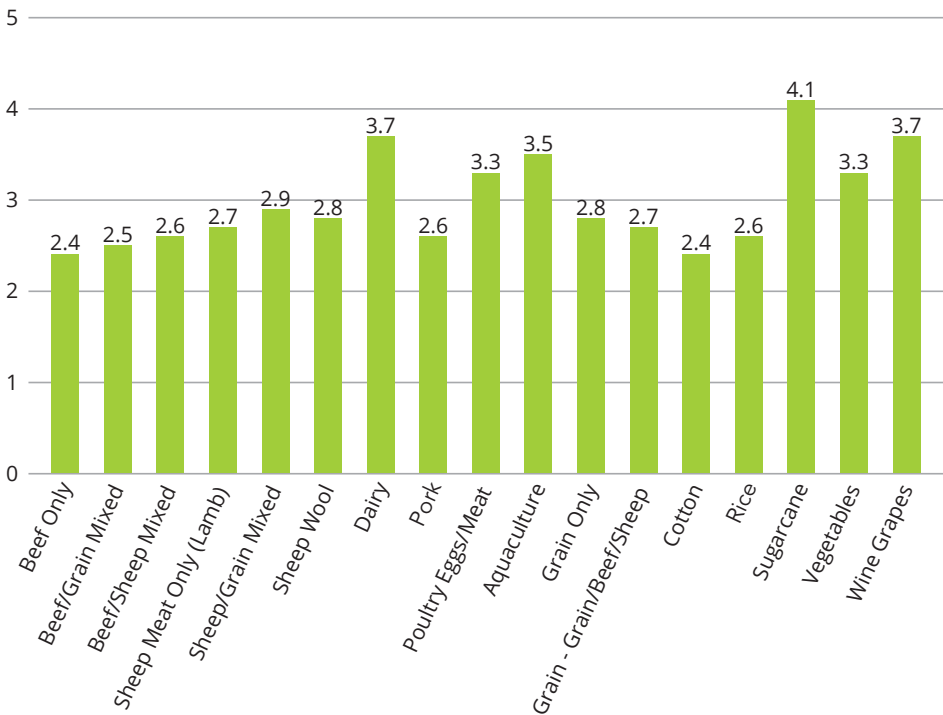


Figure 4.2. Mobile network coverage across entire farm by industry.¹



B. Strategy

RECOMMENDATION B5

Each of the 15 Research and Development Corporations (RDCs) develop a Digital Agriculture Strategy in line with Data Management Policy for Australian Digital Agriculture.

There is an absence of clear digital strategies within the RDCs, as evident from interviews and observations gathered during the P2D project. This indicates that the RDCs lack a clear roadmap for the adoption of digital agriculture.

Example reference architectures (see recommendation B6) and the Architecture Decision Support Tool have been developed in this project to support RDCs in the development of digital strategies and implementation plans.

RECOMMENDATION B6

To instigate a Big Data Reference Architecture for Digital Agriculture and Data Management Implementation Plan that is consistent with the Data Management Policy for Australian Digital Agriculture.

There is an opportunity for RDCs to accelerate the establishment and implementation of industry digital strategies by collaborating on the core components of digital enablement. The reference architecture (Figure 3.6) can facilitate collaboration between RDCs by creating a language and approach when addressing digital agricultural and big data challenges. Without a cross-industry whole-of-agriculture digital strategy it will be difficult for RDCs to clearly communicate the benefits of digital enablement.⁵

For digital enablement to have maximum effect, the outputs of a whole of agriculture digital strategy will need to be deployed at scale.⁵

RECOMMENDATION B7

That Foundational Datasets including soils, climate and market data are reviewed, established and enhanced for use cross-industry.

There are several core or foundational datasets, which form the basis of public and private sector digital agricultural systems including land boundaries, climate, weather, soils, market and biosecurity preparedness and surveillance.⁶ Some of these lack quality and density of information or are on different scales. Farm boundary data is also considered a core dataset needed by industry. While existing for legal (rateable) boundaries by local government, this does not currently exist as a publicly available, up-to-date dataset for cadastral (physical farm) boundaries.⁴

There is a clear need to move from simple data portals that aggregate raw information to information systems that produce data that can be used directly in analysis. Investment is needed to fully leverage the existing data holdings.⁴

Datasets that are missing, incomplete or held in formats not readily accessed for commercial deployment represent a significant barrier to use. There is a clear need to provide quality assured

data that is maintained over time to remain fit for purpose.⁴

The integration of privately collected data into the soil and weather/climate datasets that form an essential foundation for digital agricultural systems should be investigated, such as the establishment of an Australian Soil Information Facility. Inter-operability of datasets is essential to turn data into decisions.^{4,6}

Producer and industry representatives have identified quality and access issues with existing foundational datasets, which support a large number of cross-industry management decisions. The use of data in Australian digital agriculture could be transformed through cross-industry adoption of best data practice, based on the approach described in the Big Data Reference Architecture.⁶

RDCs have a fundamental role in the generation of knowledge to underpin digital agricultural applications, but should not lead the development of software programs or digital agriculture platforms to be used by farm service organisations or producers.⁶

It is the role of the private sector to develop digital agriculture software programs and platforms, however the RDCs should explore new partnership and funding models to support innovation in digital agriculture.⁶

PHOTO. Emma Leonard



Combining individual animal output data such as fleece weight, with other individual animal records including health, fertility and genomics, supports selection of higher performance, healthier and more efficient animals.

PHOTO. Point Farms



Moisture sensors provide an early warning of crop moisture stress and send alerts to mobile devices. This data helps calibrate the satellite based irrigation scheduling tool IrriSAT to match water to crop need.



C. Leadership

RECOMMENDATION C8

The Australian Government, in collaboration with the 15 Research and Development Corporations (RDCs), makes a long-term commitment to digital agriculture by establishing and investing in a **Digital Agriculture Taskforce for Australia (DATA)** headed by the **Chief Digital Agricultural Officer** (separate from the Australian Government Chief Digital Officer).

Interviews with the RDCs identified a lack of technical leadership within industry organisations from a national to a community level.

Staffed by a small cross-industry team of data scientists, technologists and legal experts, DATA would have the broad objectives of:^{2,5}

- Identifying and initiating collaborative data opportunities.
- Building foundational datasets.
- Developing and supporting implementation of a cross-industry digital agricultural strategy.
- Refining and growing the Big Data Reference Architecture (see recommendation B7).
- Monitoring and guiding telecommunications and connectivity; and
- Developing data science capability.

Currently, all 15 RDCs fund projects within their respective industries without cross-industry collaboration or the requirement for leveraging similar research carried out in other industry sectors. This represents a significant cost duplication to levy payers. A consolidated approach to digital agriculture would provide an opportunity for RDCs to collaborate and find new and efficient ways to consolidate, analyse and act upon data at a whole of industry scale.⁵

Instigating the recommendations B6-B7, D10 and E11-13 is considered the responsibility of **Digital Agriculture Taskforce for Australia (DATA)**.

RECOMMENDATION C9

A Digital Agriculture Taskforce for Australia Working Group (DATAWG) is established to drive the policy and investment required to advance digital agriculture in Australia. The group would consist of representatives from the 15 Research and Development Corporations (RDCs), Government and peak industry and commercial representative bodies and relevant industry experts.

Instigating the recommendations A1-A4 and C8 is considered the responsibility of **Digital Agriculture Taskforce for Australia Working Group (DATAWG)**.

At the heart of digital agriculture are telecommunications connectivity and data analysis leading to better informed decision making and implementation. The technologies, enabling functions and many datasets that support digital agriculture are not sector specific.⁶

This commonality of issues reinforces the need for cross-sectoral collaboration to produce uniform policy in areas that will facilitate the unconstrained implementation of digital agriculture.⁶



D. Digital Literacy

RECOMMENDATION D10

That the 15 Research and Development Corporations (RDCs) and the university sector strategically invest in education and capacity building for students, producers, agribusinesses, rural industries and their stakeholders to increase digital literacy and application in the agricultural sector.

There is a need, both in the research and development (R&D) sector and in industry, for people with digital skills who also understand the agricultural sector. Evidence from the regional stakeholder workshops indicates that the Australian university system is not producing sufficient agronomists with the required skills and that current incentives to change this situation are insufficient.⁴

Education and training are required at all levels within the industry to increase knowledge and understanding of connectivity options, best practice in data management and use and data licensing.^{2,3,4,6} New programs should also be developed to provide the relevant skills

to the emerging agricultural workforce that will be required to progress decision agriculture.⁶

A review of the skills required by producers to maximise the benefits derived from digital agriculture is recommended to provide a foundation for the development of educational packages. The establishment of demonstrator sites could be considered to enable producers gain first-hand experience of innovations and best practice in data management in a practical environment.²

Skill gaps have already been identified in the areas of on-farm telecommunications and data science, but a more comprehensive analysis is required.²

The ability to analyse individual animal performance and market data helps achieve better returns for the whole enterprise. Add virtual fencing to the mix and pasture inputs will also be better utilised.



PHOTO. Emma Leonard



E. Enablers

RECOMMENDATION E11

That DATA collaborates with peak industry bodies and the Carriage Service Providers (CSP) to establish baseline patterns of data usage and an on-going national mobile network coverage (data speed and volume) database.

There is no quantitative data available on the diurnal and seasonal demands for data use farming businesses or on data speed requirements for different farming business operations. However, it is known that on-farm demand is growing as was illustrated by the higher than expected demand for NBN in rural and regional Australia.^{2,6}

Quantifying on-farm coverage will help support strategic planning of future national connectivity initiatives.^{2,6}

RECOMMENDATION E12

Options to digitise and automate data collection including for regulatory compliance activities are reviewed.

Currently, there is a burden on producers to collect and submit much of their data for analysis, including regulatory compliance data and information for ABARES surveys. The lack of data culture within agriculture, plus the high level of effort in creating this data, means that it is often produced at a low or inconsistent quality, data may not be calibrated or, often, the data is just not collected at all.⁵

Some implications of decision agriculture will occur beyond the farm gate and will lead to potentially substantial indirect benefits. Issues such as biosecurity monitoring and regulatory compliance for food safety are critical whole of agriculture issues that will require an industry (and government) response to the collection and sharing of data.⁶

RECOMMENDATION E13

A Cross-Industry Survey is executed every three years to identify producers' needs and issues in digital agriculture technologies and the application of big data.

In consultation with P2D project members and participating RDCs, CSIRO designed the survey questionnaire and conducted a survey of 1,000 producers across 17 agricultural industries. The study investigated producers' needs, perceived risks and benefits, and expectations from three aspects - telecommunication infrastructure, the status of current data collection, and data sharing and concerns in the big data context.¹

The results from this study provide a baseline of needs and issues relating to on-farm adoption of digital agriculture. Resurveying every three years will not only identify new needs and issues, but highlight how past needs and issues have been addressed.

More targeted studies focusing on particular aspects for specific industries on a more regular basis will help to inform strategies at the industry level.



SOURCES FOR THE RECOMMENDATIONS

RECOMMENDATION A1

Based on recommendations 1, 2
- Analysis of the economic benefit and strategies for delivery of digital agriculture in Australia, recommendations 2, 3 - A big data reference architecture for digital agriculture in Australia, recommendations 2, 3 - The legal dimensions of digital agriculture in Australia and recommendation 1 - Current and future state of agricultural data for digital agriculture in Australia.

RECOMMENDATION A2

Based on recommendations 6, 9 - The legal dimensions of digital agriculture in Australia, recommendation 2 - Current and future state of agricultural data in Australia and recommendation 10 - Analysis of the economic benefit and strategies for delivery of decision agriculture.

RECOMMENDATION A3

Based on recommendation 9 - Analysis of the economic benefit and strategies for delivery of digital agriculture in Australia.

RECOMMENDATION A4

Based on recommendation 10 - A big data reference architecture for digital agriculture in Australia and recommendations 6, 7, 8, 9 - Current and future state of agricultural data in Australia.

RECOMMENDATION B5

Based on recommendations 3, 14, 15, 16 - Analysis of the economic benefit and strategies for delivery of digital agriculture in Australia and recommendations 3, 14 - A big data reference architecture for digital agriculture in Australia.

RECOMMENDATION B6

Based on recommendations 1, 2, 6 - Analysis of the economic benefit and strategies for delivery of digital agriculture in Australia and recommendations 3, 4, 14 - A big data reference architecture for digital agriculture in Australia.

RECOMMENDATION B7

Based on recommendations 1, 3 - The legal dimensions of digital agriculture in Australia and recommendation 1 - Current and future state of agricultural data for digital agriculture in Australia.

RECOMMENDATION C8

Based on recommendation 5 - A big data reference architecture for digital agriculture in Australia, recommendation 7 - Analysis of the economic benefit and strategies for delivery of digital agriculture in Australia and recommendations 4, 5, 6, 7, 9, 14 - Current and future state of agricultural data for digital agriculture in Australia.

RECOMMENDATION C9

Based on recommendations 1, 2 - A big data reference architecture for digital agriculture in Australia and recommendation 1 - A review of on-farm telecommunications challenges and opportunities in supporting a digital agriculture future for Australia.

RECOMMENDATION D10

Based on recommendation 7 - The legal dimensions of digital agriculture in Australia, recommendation 13 - A review of on-farm telecommunications challenges and opportunities in supporting a big data future for Australian agriculture, recommendation 12 - Analysis of the economic benefit and strategies for delivery of decision agriculture and recommendation 11 - Current and future state of agricultural data in Australia.

RECOMMENDATION E11

Based on recommendations 2, 3, 4 - A review of on-farm telecommunications challenges and opportunities in supporting a digital agriculture future for Australia and recommendation 9 - Analysis of the economic benefit and strategies for delivery of digital agriculture in Australia.

RECOMMENDATION E12

Based on recommendation 12 - A big data reference architecture for digital agriculture in Australia and recommendation 5 - Analysis of the economic benefit and recommendation strategies for delivery of digital agriculture in Australia.

RECOMMENDATION E13

From - The needs and drivers for the present and future of digital agriculture in Australia. A cross-industries producer survey for the Rural R&D for Profit 'Precision to Decision' (P2D) project.



5. NEXT STEPS

For Australian agriculture to realise the potential \$20.3 billion benefit from digital agriculture, the functional engine of digital agriculture needs to be operational.

Recommendations from this report detail the key strategy components of policy, strategy, leadership, digital literacy and enablers that must be addressed for the elements of trust, confidence, functional delivery and operational effectiveness to achieve data driven practice change by producers.

The P2D project has detailed a clear value proposition and pathway forward for transformational improvement in Australian farm business management

and decision making through digital agriculture. For this potential to be realised, it is essential for industry, RDCs, government and the commercial sector to work together. The P2D project has the benefit of being supported by all of the RDCs and the Australian Government, enabling a co-ordinated national approach. The thirteen recommendations provide clear sight of the way ahead and a next phase of P2D has a compelling case.

The next steps in delivery of a successful digital agriculture program will enable Australian agriculture to remain internationally competitive and at the forefront of best practice for production, environment and community benefit.

IT IS RECOMMENDED THAT THE P2D PROJECT MANAGEMENT COMMITTEE AGREES IN PRINCIPLE TO:

1. All RDCs co-invest in enacting the recommendations at the national scale via a Phase 2 P2D project and seek co-investment from the Australian Government through Round 4 of the Rural R&D for Profit program.
2. Nominated RDC representatives on the P2D Project Steering Committee lead the process of developing a detailed joint investment submission to the Australian Government Rural R&D for Profit Program.
3. Support the agricultural, forestry and fisheries industries to convene the Digital Agriculture Taskforce for Australia (DATA) and Working Group (DATAWG) to advise on good data policy for the sector.

P2D SUMMARY REPORT 13 KEY RECOMMENDATIONS, 5 KEY AREAS

To increase gross value of agricultural production by estimated
\$20.3 billion



Policy



Strategy



Leadership



Digital Literacy



Enablers

DELIVERING DIGITAL AGRICULTURE

ACHIEVING THE POTENTIAL CROSS SECTOR INDUSTRY BENEFIT OF \$20.3 BILLION
REQUIRES INVESTMENTS IN ALL OF THESE COMPONENTS



DIGITAL AGRICULTURE ENGINE



CROSS SECTOR INDUSTRY BENEFITS

6. APPENDICES

6.1 P2D Project outline

The six reports commissioned to execute the project, Accelerating precision agriculture to decision agriculture: Enabling digital agriculture in Australia (P2D project), addressed key areas that are constraining digital agriculture moving towards its promised potential in Australia.

Researchers engaged with stakeholders from all sectors with interest in digital agriculture including producers, production and business advisers, researchers, AgTech and agribusiness, data analysts and developers.

All research groups were involved with the regional stakeholder workshops (Table 6.1.1) held across Australia and had input into the questions in the cross industry survey of 1,000 producers (Table 6.1.2).

Led by the Cotton Research and Development Corporation (CRDC), all 15 RDCs and the Department of Agriculture and Water Resources, in conjunction with the research partners, coordinated the P2D project delivery through a Project Management Committee (PMC).

The six reports which addressed key areas that are constraining digital agriculture moving towards its promised potential in Australia are as follows:

Producer survey of digital agriculture

The needs and drivers for the present and future of digital agriculture in Australia. A cross-industries producer survey for the Rural R&D for Profit 'Precision to Decision' (P2D) project. CSIRO and CRDC.

Data connectivity for digital agriculture.

A review of on-farm telecommunications challenges and opportunities in supporting a digital agriculture future for Australia. University of New England and CRDC.

Legal and trust aspects of digital agriculture

The legal dimensions of digital agriculture in Australia: An examination of the current and future state of data rules dealing with

ownership, access, privacy and trust. Griffith University, USC Australia and CRDC.

Data sources for use in digital agriculture

Current and future state of agricultural data for digital agriculture in Australia. CSIRO and CRDC.

A big data reference architecture for digital agriculture.

A big data reference architecture for digital agriculture in Australia. Data to Decisions CRC and CRDC.

Economic benefit and strategies for digital agriculture

Analysis of the economic benefit and strategies for delivery of digital agriculture in Australia.

AFI and CRDC.

Regional stakeholder workshops

Table 6.1.1. Date, location, key industry sectors represented and location of the stakeholder workshops that provided foundational information on issues, attitudes and experiences with digital agriculture.

Agribusiness Forum	18 November 2016	All sectors	Sydney, NSW
Workshop 1	5 December 2016	Horticulture	Gatton, QLD
Workshop 2	1 March 2017	Sugar and horticulture industry focus and other industries	Townsville, QLD
Workshop 3	2 March 2017	Meat, wool, grains and cotton industries	Tamworth, NSW
Workshop 4	16 March 2017	Grains, wool and meat industries	Northam, WA
Workshop 5	28 March 2017	Grains, rice and pork industries	Wagga Wagga, NSW
Workshop 6	29 March 2017	Dairy industry focus and other industries	Tatura, VIC
Workshop 7	30 March 2017	Forestry industry focus and other industries	Launceston, TAS
Workshop 8	27 April 2017	Grape and wine industry focus and other	Tanunda, SA

Table 6.1.2. Number of industries and of respondents per industry across states.

Industry		State							Total
		NSW	QLD	VIC	TAS	SA	WA	NT	
	Beef only	23	63	22	1	7	9	1	126
	Beef/grain mixed	28	21	4	1	5	5	0	64
	Beef/sheep mixed	59	9	17	0	3	6	0	94
	Sheep meat only (lamb)	29	2	19	1	5	3	0	59
	Sheep/grain mixed	45	0	20	1	15	13	0	94
	Sheep wool	37	3	20	2	11	16	0	89
	Dairy	21	9	58	5	1	0	0	94
	Pork	1	6	3	0	4	1	0	15
	Poultry eggs/meat	19	1	9	1	0	0	0	30
	Aquaculture	9	4	5	4	5	1	2	30
	Grain only	19	8	13	0	14	23	0	77
	Grain - grain/beef/sheep	18	4	12	0	12	27	0	73
	Cotton	17	13	0	0	0	0	0	30
	Rice	15	0	0	0	0	0	0	15
	Sugarcane	7	58	0	0	0	0	0	65
	Vegetables	13	8	5	0	3	1	0	30
	Wine grapes	4	1	2	0	6	2	0	15
Total		364	210	209	16	91	107	3	1,000

6.2. Common themes for productivity and profitability improvement from decision agriculture.

Table 6.2.1. Cross-sectoral boost to GVP from process automation and labour saving.






























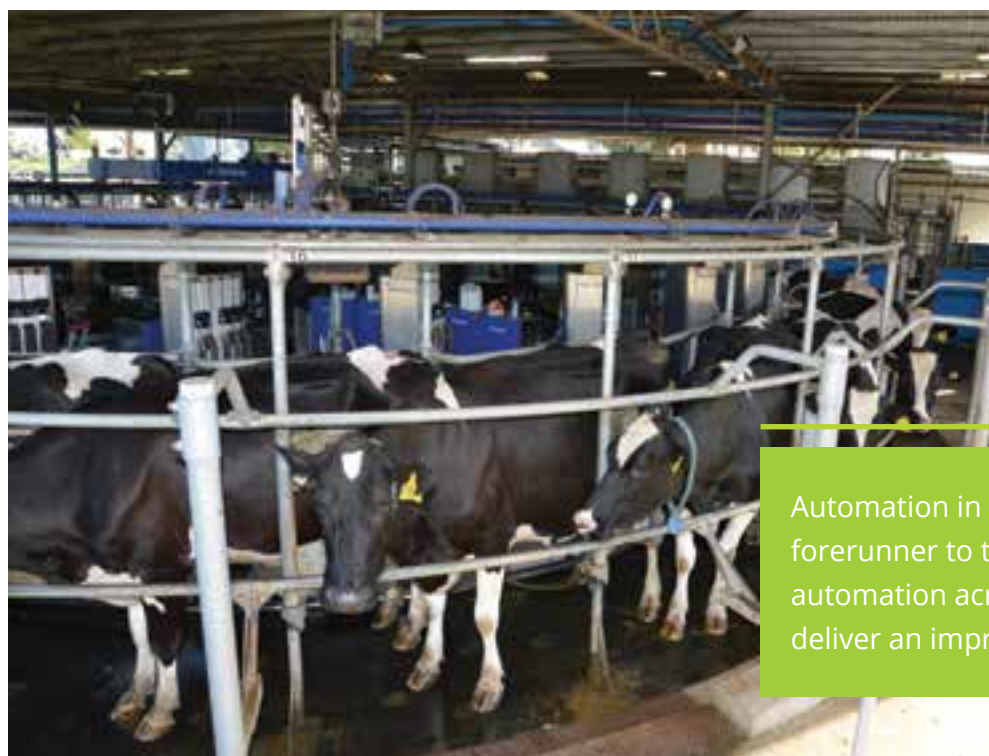
	Sector	Practice	GVP \$ million	Productivity improvement modelled (%)	Increase in GVP (%)
	Rice	Irrigation scheduling and application	38.9	5.32	15
	Rice	Labour saving	17.8	2.44	6.86
	Grains	Labour saving	878.0	2.5	7.62
	Cotton	Irrigation scheduling and application	144.8	17	10.25
	Cotton	Labour saving	33.1	3.88	2.34
	Sugar	Labour saving	23.1	4.2	1.84
	Horticulture	Labour saving	76.3	10.9	7.5
	Beef	Labour saving	161.3	3.17	1.54
	Sheep meat	Labour saving	39.9	2.93	1.33
	Pork	Inefficient feed systems	8.5	5.44	0.78
	Pork	Labour saving	2.8	1.8	0.26
	Wool	Labour saving	35.5	2.99	1.39
	Dairy	Labour saving	102.8	6.64	3.08
	Egg	Shed monitoring	20.7	1.63	0.24
	Egg	Labour saving	24.9	1.96	0.29
	Chicken meat	Shed monitoring	58.9	1.63	0.23
	Chicken meat	Labour saving	69.5	1.95	0.28
	Wine	Labour saving	20.3	2.65	0.35
	Forestry	Labour saving	126.6	5.15	0.85
	Forestry	Processing logs for timber	4,102.8	30	27.6
	Forestry	Labour saving	962.9	7.04	6.48
	Red meat processing	Labour saving	400.4	2.86	2.76
	Fishing	Labour saving	101.5	4.3	4.76
Total			7,363.0		

Table 6.2.2. Cross-sectoral boost to GVP from better crop and pasture nutrition.

	Sector	Practice	GVP \$ million	Productivity improvement modelled (%)	Increase in GVP (%)
	Rice	Crop nutrition	11.8	1.62	4.57
	Grains	Crop nutrition	1,000.1	2.85	8.68
	Cotton	Crop nutrition	99.3	11.66	7.03
	Sugar	Crop nutrition	97.6	17.72	7.76
	Horticulture	Crop nutrition	103.1	14.73	10.13
	Beef	Feed, landscape and water management	610.8	11.99	5.84
	Sheep meat	Feed, landscape and water management	163.3	12	5.47
	Wool	Feed, landscape and water management	118.9	10	4.66
	Wine	Irrigation and nutrient application	76.8	10	1.31
Total			2,282.0		



Automation in milk harvesting is the forerunner to the use of robotics and automation across the sectors that could deliver an improvement in GVP of \$7.4 billion.

PHOTO. Emma Leonard

SUMMARY REPORT

Table 6.2.3. displays the opportunity estimated by the modelling that may be a cross-sectoral boost to GVP achieved through management platforms that also form part of broader biosecurity efforts.






















	Sector	Practice	GVP \$ million	Productivity improvement modelled (%)	Increase in GVP (%)
	Rice	Fallow weed control	7.5	1.03	2.9
	Rice	In crop weed and pest control	2.0	0.28	0.79
	Grains	Crop protection and weed control	91.0	0.26	0.79
	Cotton	Crop protection and weed Control	13.4	1.57	0.95
	Sugar	Crop protection and weed control	9.5	1.74	0.76
	Horticulture	In crop weed and pest control	4.2	0.6	0.41
	Beef	Animal health and disease monitoring	254.7	5	2.43
	Sheep meat	Animal health and disease monitoring	136.1	10	4.55
	Pork	Animal health monitoring	7.8	5	0.72
	Wool	Animal health and disease monitoring	118.9	10	4.66
	Dairy	Animal health monitoring	77.4	5	2.31
	Egg	Animal health monitoring	38.1	3	0.45
	Chicken Meat	Animal health monitoring	106.8	3	0.44
	Forestry	Disease and pest control	122.6	5	0.82
	Livestock export	Animal health monitoring	28.1	2	1.75
Total			1,018.0		

Table 6.2.4. Cross-sectoral boost to GVP from better breeding, genetic and rotation decisions.

	Sector	Practice	GVP \$ million	Productivity improvement modelled (%)	Increase in GVP (%)
	Grains	Crop rotation	1,756.0	5	15.24
	Sugar	Crop rotation	55.1	10	4.38
	Beef	Breeding decisions	661.7	12.99	6.33
	Sheep meat	Breeding decisions	176.9	13	5.92
	Wool	Breeding decisions	118.9	10	4.66
	Dairy	Breeding decisions	154.8	10	4.63
Total			2,923.0		

6.3. Digital agriculture and big data tools developed by the project.

The following web based tools have been developed through this research:

- **Data to Decisions CRC** 'A Big Data Reference Architecture for Digital Agriculture' - Incorporating example decision trees defining the data needs for an agricultural data system with full consideration of data systems existing in the broader economy.
- **CSIRO DATA61** - Register of cross-sectoral agricultural and environmental datasets and decision support tools.
- **Griffith University and USC** - an online grower toolbox, best practice guidance material for growers and industry.



Australian Government
Cotton Research and
Development Corporation