Accelerating precision agriculture to decision agriculture: The needs and drivers for the present and future of digital agriculture in Australia

A cross-industry producer survey for the Rural R&D for Profit 'Precision to Decision' (P2D) project

Airong Zhang, Isaac Baker, Emma Jakku, Rick Llewellyn

July 2017

RDC Partners

Australian Government Cotton Research and Development Corporation; AgriFutures Australia; GRDC Grains Research & Development Corporation; Sugar Research Australia; Horticulture Innovation Australia; Wine Australia; Dairy Australia; awi Australian Wool Innovation Limited; mla Meat & Livestock Australia; AMPC; LiveCorp; Australian Pork; FRDC Fisheries Research & Development Corporation; Forest & Wood Products Australia; Australian Egg Corporation Limited

Research Partners

DATA 61; CSIRO; Data to Decisions CRC Unlocking the value of Australia's data; Australian Farm Institute; Griffith University; USC Australia; une University of New England; School of Science and Technology

This project is supported by funding from ….

Australian Government Department of Agriculture and Water Resources

Rural Research and Development for Profit
Keeping Australian farmers at the cutting edge

Citation

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-industry producer survey for the Rural R&D for Profit 'Precision to Decision' (P2D) project. EP175936, CSIRO, Australia.

Copyright

© Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Cotton Research and Development Corporation (CRDC) 2017. To the extent permitted by law, all rights are reserved and no part of this publication covered by copyright may be reproduced or copied in any form or by any means except with the written permission of CSIRO and CRDC.

Important disclaimer

CSIRO advises that the information contained in this publication comprises general statements based on scientific research. The reader is advised and needs to be aware that such information may be incomplete or unable to be used in any specific situation. No reliance or actions must therefore be made on that information without seeking prior expert professional, scientific and technical advice. To the extent permitted by law, CSIRO (including its employees and consultants) excludes all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it.

The project that delivered this report is led by the Cotton Research and Development Corporation and is jointly funded by the Department of Agriculture and Water Resources, Rural R&D for Profit Programme and all 15 Rural Development Corporations.

For further information

Dr Airong Zhang
t +61 7 3833 5908
e airong.zhang@hotmail.com

Dr Emma Jakku
t +61 7 3833 5739
e emma.jakku@csiro.au

Dr Rick Llewellyn
t +61 8 8303 8502
e rick.llewellyn@csiro.au

Table of Contents

List of figures

List of tables

Acknowledgments

This project is supported by funding from the Australian Government Department of Agriculture and Water Resources as part of its Rural R&D for Profit programme.

We acknowledge and thank the 'Precision to Decision' project supporters and research partners (below) and the team at KG2. We also thank all of the producers who took part in the survey.

Project supporters:

Cotton Research and Development Corporation
Meat and Livestock Australia
Dairy Australia
Grains Research and Development Corporation
Sugar Research Australia
AgriFutures Australia (previously RIRDC)
Australian Wool Innovation
Horticulture Innovation Australia
Australian Pork Limited
Wine Australia
Forestry and Wood Products Australia
Fisheries Research and Development Corporation
Australian Meat Processing Corporation
Australian Livestock Export Corporation Ltd (LiveCorp)
Australian Egg Corporation Limited

Research providers:

Data to Decisions CRC
University of New England
Australian Farm Institute
Griffith University
University of the Sunshine Coast
CSIRO

Executive Summary

The aim of the project was to benchmark Australian producers' needs, perceived risks and benefits, and expectations associated with digital agriculture and big data context. Such understanding will inform strategies aimed at 1) better utilising agricultural data to enhance productivity and profitability, and 2) better capitalising on the opportunities created by digital agriculture and big data.

In consultation with P2D project members and participating RDCs, CSIRO designed the survey questionnaire and conducted a survey of 1000 producers across 17 agricultural industries during the period of 7 March to 18 April 2017. The sampling specifications for each industry was defined in consultation with relevant participating RDCs.

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.

Key findings

Telecommunication infrastructure

- The vast majority of respondents (94%) had an internet connection for their business, dominated by mobile phone networks (55%) and landline (30%), with NBN associated technologies still at an early stage in application, including NBN fixed wireless (16%), NBN interim satellite service (15%), NBN sky muster (12%), and NBN fibre/fibre-to-node (1%). There were variations in how internet was connected across industries.
- Satisfaction with home office internet connectivity was evenly divided, with 30% of respondents being satisfied or extremely satisfied, meanwhile another 30% being not satisfied or not satisfied at all. There were variations across industries, with respondents from wine grapes, sugarcane, and dairy reporting higher levels of satisfaction, and those from cotton, poultry, beef/grain mixed, pork, and grain only reporting the lower levels of satisfaction.
- Mobile coverage across entire farm was commonly poor, with only 34% of respondents having most or full coverage, and 43% having no coverage at all or little coverage. There were variations across industries, with sugarcane, dairy, wine grapes, and aquaculture reporting comparatively better coverage.
- There was limited adoption of on-farm telecommunication infrastructure, with only 25% of respondents having radio links to devices (e.g., connecting weather station to farm office), or mobile data linked devices (e.g., weather station being directly linked to the mobile network), or both. Among those users, 72% found it moderately-to-extremely challenging to keep on-farm telecommunication systems working.
- Nearly half (49%) of the respondents did not have any on-farm telecommunication infrastructure and had no plan to install in the next 5 years.

- There were great variations in the adoption rates of on-farm telecommunication infrastructure across the industries. Comparatively, respondents from cotton (60%), aquaculture (45%), and vegetables (43%) had higher adoption rates, while those from beef/sheep mixed (17%) and sheep wool (18%) had the lowest rates.
- Knowledge of on-farm telecommunication options was limited across all industries, with 61% of respondents stating that they knew nothing at all or very little. Respondents from cotton and aquaculture appeared to be comparatively knowledgeable.
- More than half (53%) of respondents reported that they relied on themselves only (including family members and employees) to sort out their telecommunication needs.

The status of current data collection

- *In cropping industries*, 87% of respondents collected at least one type of data. The most collected data was financial data (72%), followed by yield mapping data (51%) and soil mapping data (41%), while weed pressure mapping data (11%) had the lowest rates of collection. In general, respondents valued the data quite positively in helping them making farm management decisions.
- There were variations in the types of data collected across the cropping industries. Respondents from cotton industry appeared to be the most active collectors. There were also variations across states and farm sizes.
- *In livestock industries*, 91% of respondents collected at least one type of data. The most collected data was financial data (79%), followed by veterinary medicine record (63%), animal breeding data (57%), and individual animal or herd production data (56%). In general, all types of data were regarded as quite useful in informing farm management decisions.
- There were variations in the types of data collected across livestock industries. Respondents from dairy and pork industries reported the highest data collection rates. There were variations in data collection rates across states and farm sizes.
- The overall data evaluation by respondents who have collected data was very positive in relation to the data helping farm management decisions, efficiency of running farm, and risk management, but comparatively less so for farm business profit.
- Overall, the more types of data collected by respondents, the more positive they were in valuing the overall contribution the data made. And respondents who did not collect any data regarded the data much less useful in all aspects.
- The majority of respondents (74%) knew nothing at all or very little about the terms and conditions for their data collection agreement with service providers. Nearly half of respondents would not be comfortable if service providers had direct access to the data, with only 24% of respondents would be comfortable or extremely comfortable.
- The trust in service providers maintaining privacy and not sharing data with third parties was very low. More than half respondents (56%) did not trust service

providers would maintain the privacy of their data, and 62% did not trust service providers not to share their data with third parties.

- The majority respondent (67%) would not be comfortable if service providers make profit out of their data without sharing the profit with them.

Attitude towards data sharing and concerns in the big data context

- There was no consensus in relation to who would benefit the most from aggregated farm data. Thirty four percent of respondents regarded farmers and another 34% regarded agribusinesses as the main beneficiaries, 21% indicated government, while 11% were not sure.
- There was great variations across industries on who would benefit the most from aggregated data. For example, more respondents from aquaculture (57%), cotton (47%), and rice (47%) believed that farmers would benefit the most; more respondents from grain mixed (48%), beef/sheep (43%), beef/grain mixed (41%), sheep meat only (41%), and pork (40%) believed agribusiness would benefit the most; and more respondents from beef only (29%) and sheep wool (28%) believed the government would benefit the most.
- Regarding sharing various data with different actors (other farmers, agricultural industry-based organisations, technology and service providers, research institutions, and Australian Bureau of Statistics(ABS)), respondents were more willing to share their data with other farmers and research institutions, and least willing to share with technology and service providers.
- In general, the majority of respondents were comfortable in sharing data. Comparatively, respondents were more willing to share weather station and soil test data than farm input and production data.
- Beliefs of who would benefit the most from aggregated farm data affect attitude towards data sharing. Comparatively, respondents who thought farmers would benefit the most were more willing to share data with all actors.
- Positive evaluation of data was also associated with greater willingness to share data with all actors, especially with research institutions and ABS.
- Despite a general willingness to share data, farmers need reassurance to address concerns about how the aggregated data will be governed and used. The majority of respondents reported great concerns over aggregated data in relation to privacy, financial advantage taken by other businesses, and the potential for it to be used to influence the markets such as produce prices and land value.

Implications

The findings of the present survey have explored producers' needs, attitudes, and concerns in relation to the current status of telecommunication infrastructure for, adoption of, and perceived value of digital agriculture technologies, as well as the future application of aggregated agricultural data. This broad and in-depth benchmark has great implications for key stakeholders including governments, RDCs, and research institutions to develop targeted strategies and policies, which will enable producers better utilise agricultural data

for productivity and profitability and capitalise on the opportunities created by digital agriculture and big data.

The following are the key implications:

- The potential utilisation of agricultural data technologies remains limited by the fact that only a minority of farms have reliable mobile data coverage over their farm area and the NBN is still in the roll-out phase. This will constrain potential utilisation of agricultural data at least in the short term.
- Given the generally low level of awareness and the very early stage of development and adoption, a concerted effort among all stakeholders to help identify the potential value proposition of on-farm telecommunication infrastructures and agricultural data applications could be influential. The experiences of cotton producers who are on relatively more advanced adoption paths may be worth further investigation for other industries to learn from. Further investigation to identify the underlying barriers is also needed.
- As most current users report it challenging to keep on-farm telecommunication systems working, potential adopters are less likely to gain positive learnings from existing adopters. Targeted support and improvements for current users, where potential industry benefits are identified as being high, may be warranted.
- Given that producers heavily relied on on-farm skills to sort out their telecommunication needs, a platform using plain language to provide technical information, training, and support will be very beneficial for producers.
- The terms and conditions for data collection agreement with service providers need to be provided in plain English. In addition, data privacy and ownership needs to be clearly defined and communicated to producers, and agreed by producers.
- The development of aggregated farm data should be centred on the benefits and needs of producers, with other stakeholders (especially farmer organisations and research institutions) playing key roles to enable the development. Such structural establishment will encourage producers to share their data and, in turn, help realise the potential value of big data.
- Improved governance frameworks for aggregated farm data should be established to address producers' concerns and build their trust. Such frameworks should aim to build producers' trust in the systems through addressing transparency, privacy, data ownership, and control.

Future research

With the rapid advancement of digital agriculture technologies and application of big data, it is imperative to have up-to-date information about Australian producers' needs and issues so that valuable opportunities for intervention can be identified early. A general survey across the industries in three years is recommended. More targeted studies focusing on particular aspects for particular industries on a more regular basis will help to inform strategies at the industry level.

1. Introduction

Advances in digital technologies offer the potential for transformational change in Australian agriculture, providing new ways to improve productivity and profitability for Australian producers. Rapid developments in computing power, sensing technologies, robotics, Big Data, the Internet of Things, and Cloud Computing are creating opportunities for more data-driven approaches to farm management, sometimes referred to as 'smart farming' (Wolfert, Gee, Verdouw, & Bogaardt, 2017) or *decision agriculture* (Heath 2017).

Computers and sensor technologies have been used by some Australian farmers to help manage in-field variability for the last couple of decades, a practice known as *precision agriculture* (Bramley, 2009; Robertson et al., 2012). The term precision agriculture tends to be more commonly used in the cropping sector and refers to information technology tools (e.g. global positioning system (GPS), variable-rate technology (VRT), soil sensors and yield monitors) that enable farmers to electronically monitor soil and crop conditions and develop targeted crop management treatments (Aubert, Schroeder and Grimaudo 2012; Llewellyn and Ouzman 2014). Similarly, digital agriculture is a related but broader term that refers to the use of digital sensors and information more generally to support farm management decisions (Keogh and Henry, 2016).

More recently, advances in digital agriculture and big data analytics are being applied in the agricultural sector via new software tools that can capture, store, and manipulate increasing volumes of data to create decision-support tools for guiding better farm management decisions (Griffith et al., 2013; Keogh and Henry, 2016; Wolfert et al., 2017), creating the opportunity for decision agriculture. In contrast to precision agriculture which involves a collection of individual enabling technologies that may or may not be connected, decision agriculture uses a more integrated system of systems, connecting multiple datasets and drawing on advances in data analytics (Heath 2017). Thus, moving from precision agriculture to decision agriculture captures the idea that, while precision agriculture has primarily focused on bringing together information about in-field variation, decision agriculture refers to the new potential to aggregate multiple data sources through big data analytics to improve on-farm decision-making processes and modify practices at a whole-of-business level. Big data analytics are an important enabler for decision agriculture. The term big data refers to the capability to extract information and insights at a large scale, where previously it was economically and technically not possible to do so (Sonka, 2015). This is achieved through the use of "computerised analytical systems that interrogate extremely large databases of information in order to identify particular trends and correlations" (Keogh and Henry, 2016, p. 4).

The application of digital agriculture tools and big data analytics through decision agriculture can increase farm productivity through input efficiencies and increased output—these gains have been estimated to be approximately 10-15% in the cropping sector (Keogh and Henry, 2016). However, analysis of early experiences with big data applications reveals that their success hinges upon multiple factors. These include the willingness of stakeholders to share and integrate data, end-user acceptance of new technologies, and the existence of protocols for protecting farmers' rights to privacy, and data ownership and control (Eastwood and Yule, 2015; Griffith et al., 2013; Kaloxylos et al., 2014; Poppe, Wolfert, Verdouw, & Renwick, 2015).

Realising the potential benefits of digital agriculture and big data, therefore, requires conducive technical, social, and institutional conditions. The adoption of new technologies in agriculture is a complex activity influenced by many factors (Kuehne et al., 2017; Pannell et al., 2006; Pierpaoli, Carli, Pignatti, & Canavari, 2013). Much like some of the precision agriculture technologies that preceded it (e.g. variable rate application), decision agriculture is not a simple 'plug-and-play' technology. This means that unlike technologies that can provide immediate and obvious benefits (e.g., autosteer), decision agriculture requires a higher level of skill, interpretation, and judgement, which makes it a more challenging adoption scenario (Robertson et al., 2012). This is further complicated by the technical requirements needed to make adoption of these new technologies possible, which often rely on smart devices connecting to and interacting via network infrastructure (Wolfert et al., 2017), thus needing to be supported by appropriate telecommunications infrastructures.

The ability of new farm machinery to collect many types of on-farm data, and the potential of big data applications to make use of aggregated farm data, also raises questions about the ownership, access, and use of farm data (Keogh and Henry 2016). These may be important factors influencing producers' willingness to adopt new precision agriculture technologies and share farm data. For instance, Jakku et al. (2016) found that there was a high degree of concern among grain growers about the potential for third party use of and benefit from on-farm data. The authors also found that there was a desire for transparency about who would be using the data, for what purpose, what value this would generate, and how that benefit would be distributed. Issues of trust appear to be central to concerns about data ownership and transparency, which in turn depend on appropriate institutional, legal and regulatory arrangements.

2. Objectives

The objective of this survey was to enhance the understanding of effective data technology adoption and data sharing pathways, which take into account producers' needs, perceived risks and benefits, and expectations across a wide range of agricultural industries. The results will inform strategies aimed at:

1. Ensuring that Australian producers increase their uptake of precision agriculture technologies and can better utilise its data to enhance profitability while also protecting their rights.

2. Addressing producers' data needs and issues so they can better capitalise on the opportunities created by digital agriculture and big data, while proactively managing the potential risks associated with these new technologies.

3. Method

3.1 Measures

The survey questionnaire was designed in consultation with P2D project members and participating RDCs. The full questionnaire is attached in Appendix A. To achieve the goals of the research project, the survey was designed to collect data toward the following objectives:

- To benchmark the current state of agricultural data systems, which include types of telecommunication infrastructure used, types of data collected and how they were stored, and software used to manage the data;
- To examine how producers perceive the usefulness of the data in supporting farm management outcomes, their concerns over the ownership and privacy of the data they have collected, and the potential uses of aggregated agricultural data; and
- To explore producers' willingness to share various types of data with different actors, which include other farmers, agricultural industry-based organisations, technology and service provider businesses, research institutions, and the Australian Bureau of Statistics (ABS).

3.2 Participants and procedure

A specialised agricultural research survey company (KG2) was engaged to conduct the data collection. The survey was conducted via computer-assisted telephone interviewing (CATI) during the period of 7th March to 18th April in 2017. The sampling specifications for each industry were defined in consultation with participating RDCs. Potential participants were drawn from KG2's database. In addition, various RDCs publicized the survey in their newsletters and invited their members to participate by contacting KG2 on a specially designated phone line and email address. The survey response rate is presented in Appendix B.

In total, 1,000 producers across 17 industries participated in the survey. For respondents who had multiple components to their business (i.e., it spanned more than one industry; for example, beef and grain), they were asked to indicate the major component of their business. The survey items were answered in relation to the major component of their business. For example, if the respondent had both beef and grain, and indicated beef as the major component to their business, the respondent would be classified as beef/grain mixed, and all answers would refer to their beef component. On the other hand, if the respondent indicated grain, the respondent would be classified as grain/beef mixed, and all answers would refer to their grain component. This classification principle applies to all other mixed combinations (i.e., beef/sheep mixed, sheep/grain mixed, and grain - grain/beef/sheep).

Table 1 presents the number of respondents from each state and industry. Table 2 presents the average farm size and business intensity for each industry. Table 3 presents the demographics of the respondents for each industry.

Table 1. Number 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

Table 2. Average farm size and business intensity by industry

Note: For business intensity, two respondents from aquaculture, one from beef/sheep mixed, and one from sheep for wool did not provide production data.

Industry	Average farm size (hectares)	Business Intensity		
		Unit	Average	Median
Beef only	11,723	Total Number of Beef Cattle	1,868	775
Beef/Grain Mixed	6,779	Total Number of Beef Cattle	1,516	430
Beef/Sheep Mixed	6,792	Number of beef cattle	662	270
		Number of sheep	4,046	3,000
Sheep Meat Only (Lamb)	8,726	Total Number of Sheep	21,154	2,800
Sheep/Grain Mixed	3,466	Total number of sheep	4,287	3,000
Sheep Wool	7,281	Total Number of Sheep	4,954	3,000
Dairy	397	Total Number of Cows Milked	314	240
Pork	998	Total Number of Sows	1,809	700
Poultry Eggs/Meat	140	Total Number of Hens/Birds	199,193	42,500
Aquaculture	130	Annual production in kg or dozen	434,855	63,500
Grain only	3,936	Hectares planted to grain	2,464	2,020
Grain – Grain/beef/sheep	4,569	Hectares planted to grain	2,516	2,023
Cotton	6,866	Hectares planted to cotton	3,595	403
Rice	2,424	Hectares planted to rice	171	100
Sugarcane	335	Hectares planted to sugarcane	159	80
Vegetables	589	Hectares planted to vegetables	110	28
Wine grapes	882	Hectares planted to wine grapes	144	24

Table 3. Demographics of respondents by industry

Industry	Number of respondents	Gender (women)	Average age (years)	Average years in industry	Education							
					Did not complete year 12	Completed year 12	Post-secondary qualification – agriculture	Post-secondary qualification – other	Undergraduate degree – agriculture	Undergraduate degree – other	Postgraduate degree – agriculture	Postgraduate degree – other
Aquaculture	30	3%	52	24	20%	13%	0%	3%	10%	10%	30%	13%
Pork	15	20%	55	34	47%	13%	7%	7%	27%	0%	0%	0%
Beef only	126	16%	60	41	44%	27%	8%	4%	10%	6%	1%	1%
Beef/Grain Mixed	64	13%	57	37	44%	17%	9%	8%	13%	8%	0%	2%
Beef/Sheep Mixed	94	19%	58	40	33%	20%	13%	6%	14%	9%	2%	3%
Dairy	94	9%	58	39	57%	14%	7%	9%	8%	3%	3%	0%
Poultry Eggs/Meat	30	13%	62	35	57%	17%	7%	10%	0%	7%	0%	3%
Sheep Meat Only (Lamb)	59	3%	58	39	54%	19%	12%	2%	9%	3%	2%	0%
Sheep/Grain Mixed	94	12%	56	37	47%	20%	12%	6%	9%	1%	3%	2%
Sheep Wool	89	17%	60	38	42%	25%	10%	8%	6%	3%	5%	2%
Cotton	30	17%	50	23	10%	17%	23%	3%	17%	17%	3%	10%
Grain Only	77	8%	53	33	34%	25%	7%	7%	12%	8%	5%	4%
Grain - Grain/Beef/ Sheep	73	10%	55	36	40%	27%	11%	3%	8%	8%	3%	0%
Rice	15	27%	56	35	27%	13%	13%	13%	0%	20%	7%	7%
Wine Grapes	15	13%	54	25	33%	20%	20%	0%	13%	7%	7%	0%
Sugarcane	65	5%	58	39	54%	14%	12%	12%	2%	3%	3%	0%
Vegetables	30	3%	58	30	40%	10%	7%	10%	7%	10%	7%	10%
Total	1000	12%	57	35	42%	20%	10%	6%	9%	6%	4%	2%

4. Results

The report's findings are presented in three parts:

4.1. Telecommunication infrastructure

4.2. The status of current data collection

4.3. Attitude toward data sharing and concerns about aggregated farm data

In addition to the cross-industry comparisons, cross-state and cross-farm size comparisons were also conducted.

Cross-state comparisons were conducted separately for grain (including grain only, and grain mixed with beef and/or sheep) and broadacre livestock industries (including beef only, beef/grain mixed, beef/sheep mixed, sheep meat only, sheep/grain mixed, and sheep wool).

These two categories were chosen because the industries within each category grouped together due to the similarity in the nature of their business operations and their sufficient number of respondents across the five major states. Tasmania and the Northern Territory were not included in the cross-state comparisons due to their limited number of respondents. Only statistically significant differences between states were presented in the following sections.

Cross-farm size comparisons were conducted separately for broadacre cropping industries (including grain only, grain mixed with beef and/or sheep, cotton, and rice), and broadacre livestock industries (including beef only, beef/grain mixed, beef/sheep mixed, sheep meat only, sheep/grain mixed, sheep wool, dairy, and pork).

The farm sizes were divided into four categories using quartile values of land area responses: small, medium, large, and extra-large farms (see Table 4). Only statistically significant differences between farm sizes were presented in the following sections.

Table 4. Farm size categories for broadacre cropping and broadacre livestock industries

Broadacre cropping industries		Broadacre livestock industries	
Farm size category (sample size)	Land area	Farm size category (sample size)	Land area
Small (48)	212 – 1,439 ha	Small (160)	11 – 608 ha
Medium (49)	1,440 – 2,629 ha	Medium (159)	608.5 – 1,400 ha
Large (46)	2,630 – 4,999 ha	Large (162)	1,400.5 – 3,240 ha
Extra-large (52)	5,000 – 100,000 ha	Extra-large (154)	3240.5 – 108,000 ha

4.1 Telecommunication infrastructure

4.1.1 Importance of internet connectivity

There was a strong consensus regarding the importance of internet connectivity to businesses (see Figure 1). Seventy-nine percent of respondents regarded internet connectivity to be important or extremely important to their business. However, there was some variation in its importance across industries (see Figure 2). On average, sugarcane and sheep meat producers placed the lowest importance on internet connectivity and cotton the highest.

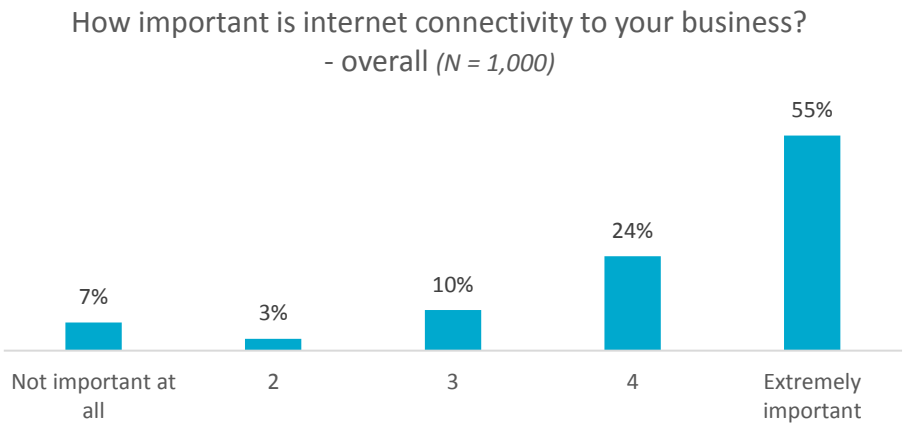


Figure 1. Importance of internet connectivity to business

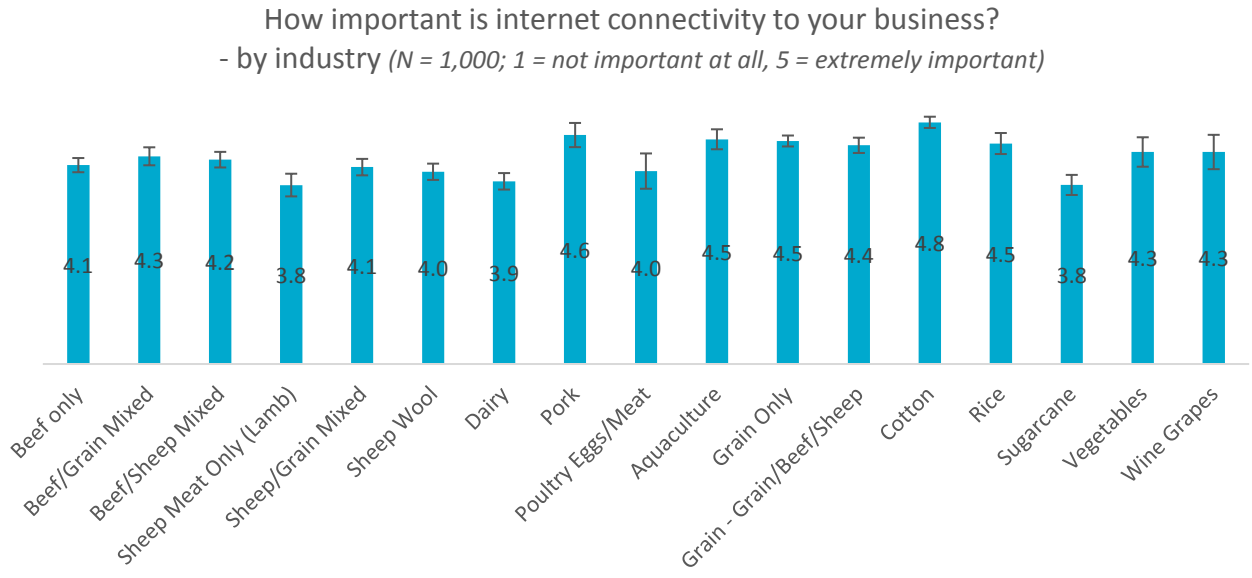


Figure 2. Importance of internet connectivity to business by industry
Note: Error bars represent the variability of data. A larger error bar represents a greater uncertainty for a reported mean.

4.1.2 Current internet connection and telecommunication infrastructures

Internet connection

The vast majority of respondents (94%) had an internet connection for their business, with landline and mobile phone networks the most prevalent connection options. The low rates of NBN associated technology use revealed that it is still in its early stages of application. Figure 3 presents the percentage of respondents who used each of the particular technologies to connect to the internet (note: respondents could choose multiple options). Although multiple choices were sought, the results need to be treated with caution as landline use was unusually low. Further investigation is needed to verify this finding.

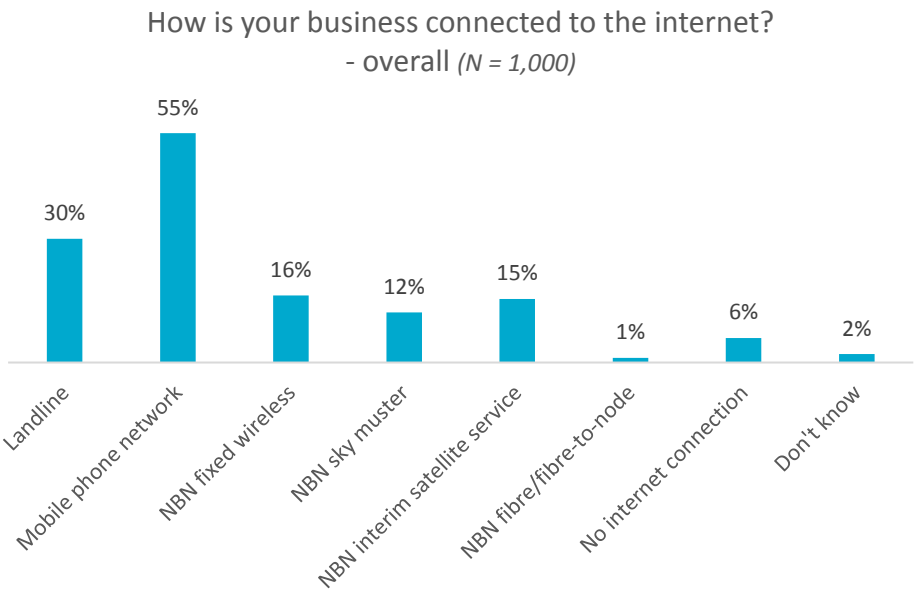


Figure 3. Types of internet connection to business

Across industries, there was considerable variation in the adoption rates of technologies used to connect businesses to the internet. Landline, one of the two major types of internet connection methods, was more popular among respondents from more intensive industries (including vegetables, poultry eggs/meat, sugarcane, and dairy), and less so for broadacre industries (including beef/grain mixed, grains, and sheep) (see Figure 4).

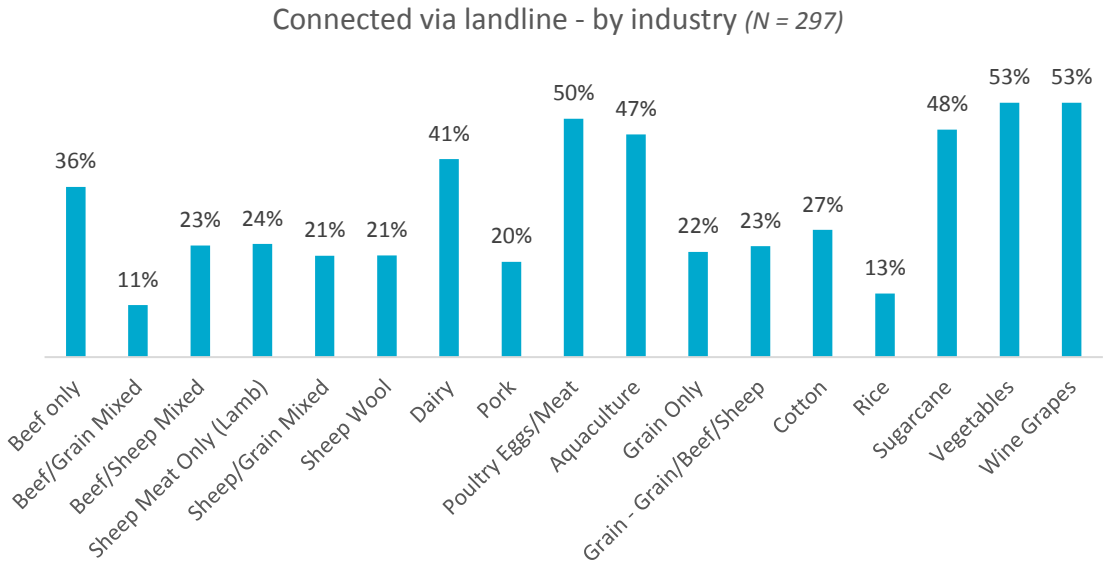


Figure 4. Internet connection to business via landline by industry

Compared to the other connection options, the mobile phone network was the most used connection method, and had particularly high use in cotton, aquaculture, and grain only industries (see Figure 5).

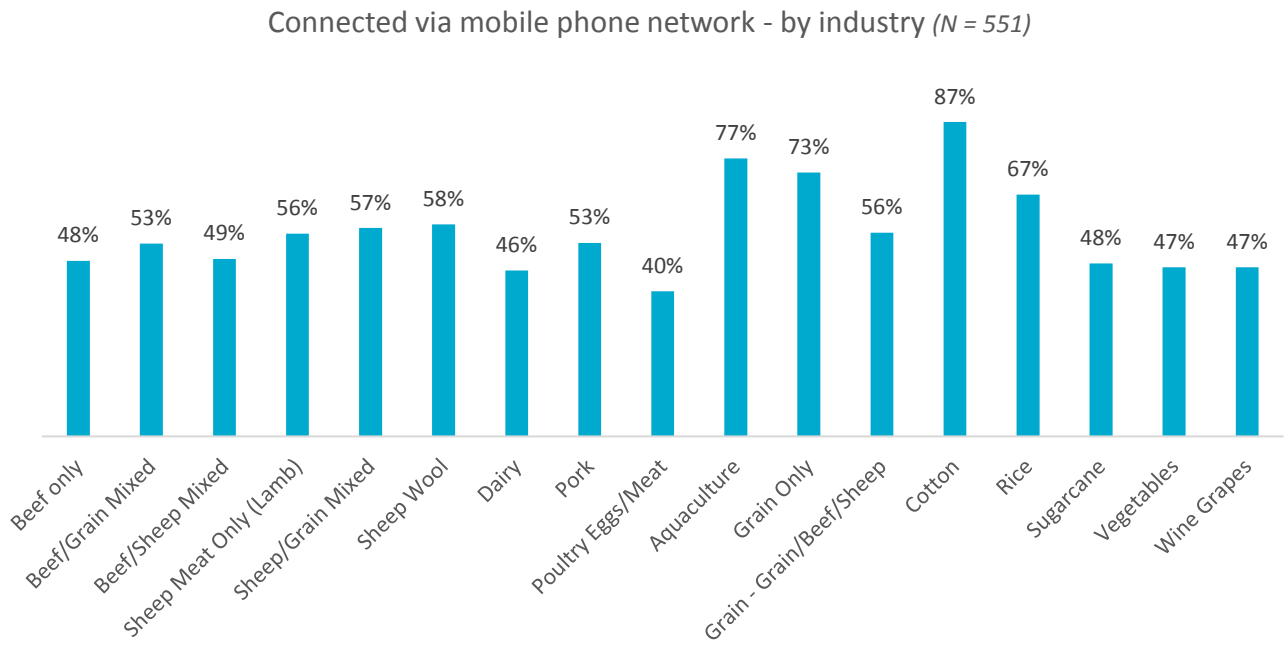


Figure 5. Internet connection to business via mobile phone network by industry

Among the NBN associated technologies, NBN fixed wireless (16%), NBN interim satellite service (15%), and NBN sky muster (12%) were more in use than NBN fibre/fibre-to-node, but their adoption rates varied across industries (see Figure 6, Figure 7, Figure 8). Dairy (36%), pork (33%), and sugarcane (28%) industries had the highest rates of adoption for NBN fixed wireless technology. The use of NBN interim satellite service was most prevalent for rice (33%) and grain/beef/sheep mixed (25%) industries. Finally, beef only (21%), beef/sheep mixed (21%), pork (20%), and grain/beef/sheep mixed (19%) industries had the highest rates of use for NBN sky muster.

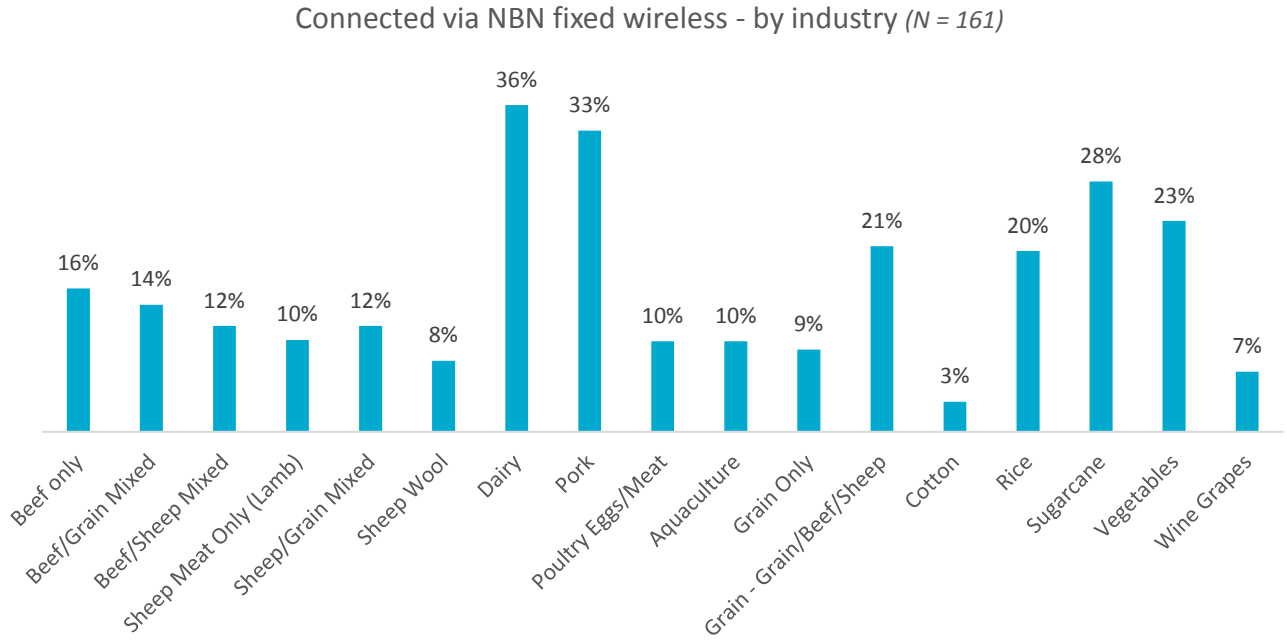


Figure 6. Internet connection to business via NBN fixed wireless by industry

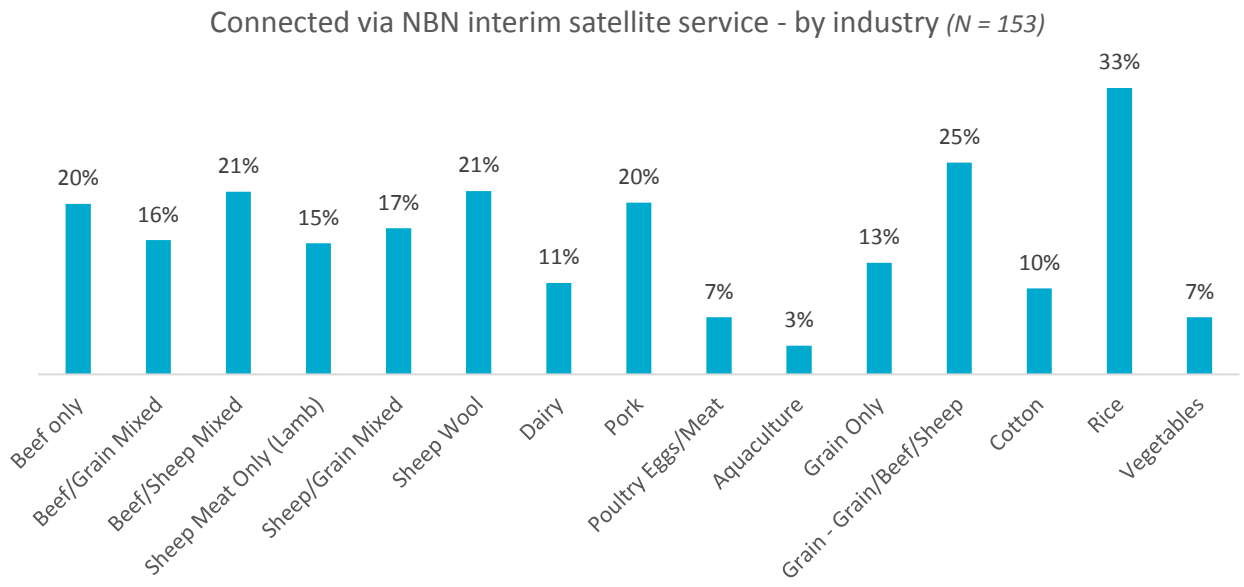


Figure 7. Internet connection to business via NBN interim satellite service by industry

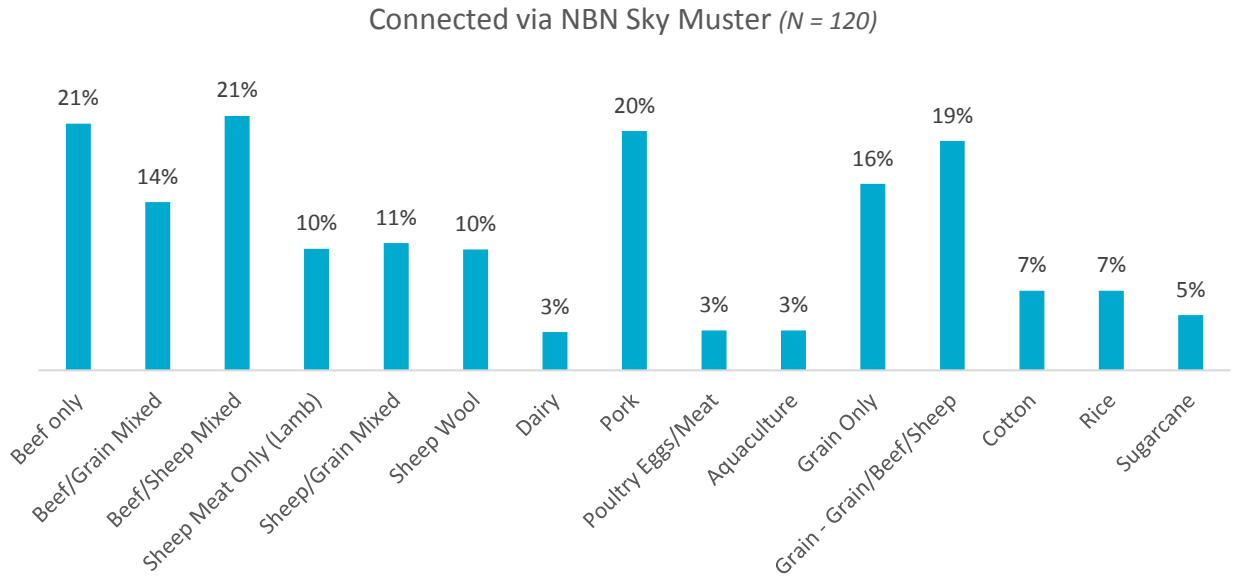


Figure 8. Internet connection to business via NBN sky muster by industry

In broadacre livestock industries, there were differences for the use of NBN associated technologies across farm sizes. A significantly greater proportion of respondents from small farms (25%) were connected to the internet via NBN fixed wireless, followed by medium (16%), large (14%), and extra-large farms (10%). Additionally, a significantly greater proportion of producers from extra-large farms (26%) were connected to the internet via NBN sky muster, followed by large (15%), medium (9%), and small farms (5%).

In broadacre livestock industries, there were differences across states for the use of the NBN associated technologies. Respondents from WA were the heaviest users of NBN interim satellite services (31%), followed by QLD (24%), VIC (20%), NSW (15%), and SA (13%).

Respondents from QLD were the heaviest users of NBN sky muster (29%), followed by NSW (15%), WA (14%), SA (11%), and VIC (8%).

On-farm telecommunication infrastructure

Figure 9 presents the percentage of respondents who had one of various on-farm telecommunication infrastructure arrangements. Only 25% of respondents had either links to devices (e.g., connecting weather station or gate back to farm office or other location on farm), or mobile data linked devices (e.g., weather station was directly linked to the mobile network), or both. Another 26% did not have any on-farm telecommunication infrastructure, but were considering installing something within the next 5 years. Nearly half (49%) of the respondents did not have any, and had no plans to install.

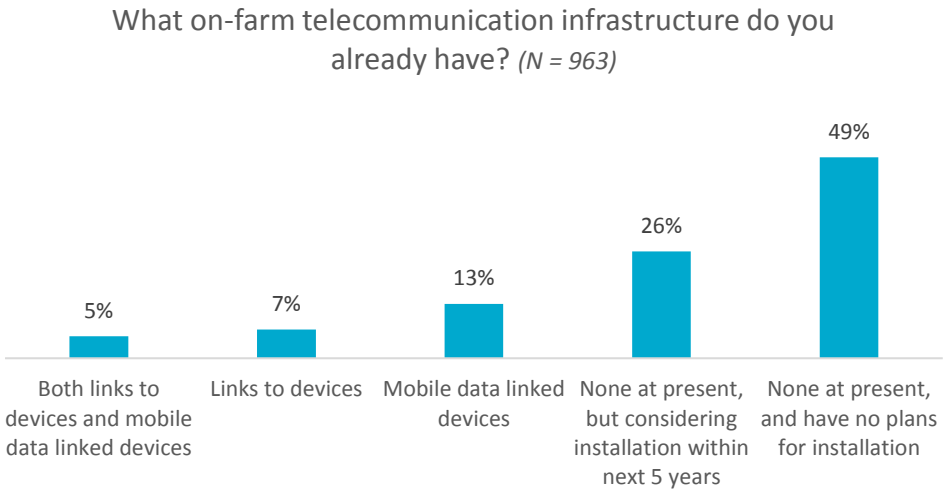


Figure 9. Types of on-farm telecommunication infrastructure

Among the users of telecommunication infrastructure (see Figure 10), the cotton industry (60%) was well-equipped with telecommunication infrastructures, followed by aquaculture (45%) and vegetable industries (43%). On the other hand, some industries had a low percentage of respondents with on-farm telecommunication infrastructure, including beef/sheep mixed (17%), sheep wool (18%), and beef only (21%) industries.

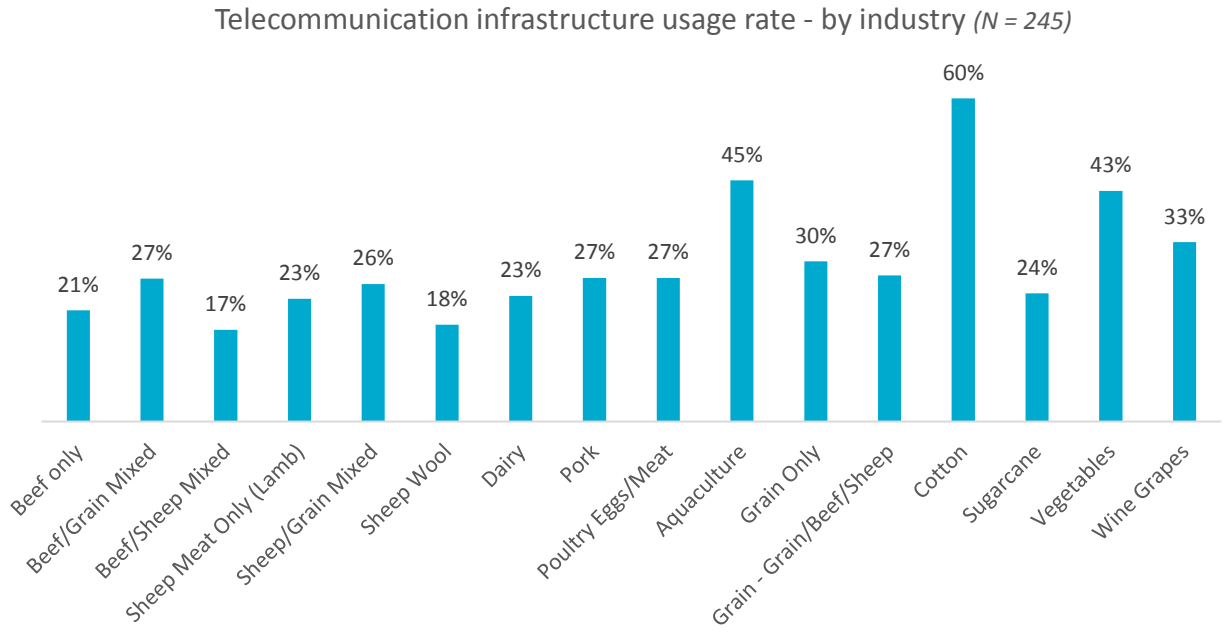


Figure 10. Telecommunication infrastructure use by industry

There were differences between the states for the grain industry's adoption of various telecommunication infrastructures.

Table 5 shows the percentage of grain growers from each state that have one of various on-farm telecommunication infrastructure arrangements.

Table 5. Types of on-farm telecommunication infrastructure for grain industries by state

State	Both — radio links to devices and mobile data linked devices	Radio links to devices only	Mobile data linked devices only	None at present, but considering to install something within next five years	None at present, and have no plans to install any telecommunication infrastructure
NSW (*N* = 35)	0%	9%	31%	40%	20%
QLD (*N* = 11)	9%	0%	9%	18%	64%
VIC (*N* = 24)	8%	0%	8%	46%	38%
SA (*N* = 24)	8%	0%	17%	17%	58%
WA (*N* = 50)	0%	12%	18%	28%	42%

In addition, there was variations in telecommunication infrastructure use across farm sizes. Within broadacre livestock industries, a significantly greater proportion of respondents from medium (19%) and large farms (19%) used mobile data linked devices, followed by small (16%) and extra-large (9%) farms. Within broadacre cropping industries, a significantly greater proportion of respondents from extra-large farms (23%) used radio links to devices, followed by large (17%), small (13%), and medium farms (9%).

Challenge in keeping on-farm telecommunication systems working

Among the 244 respondents who already had links to devices and/or mobile data linked devices as their on-farm telecommunication infrastructure, approximately three-quarters of respondents (72%) found it challenging or extremely challenging to keep on-farm telecommunication systems working (see Figure 11).

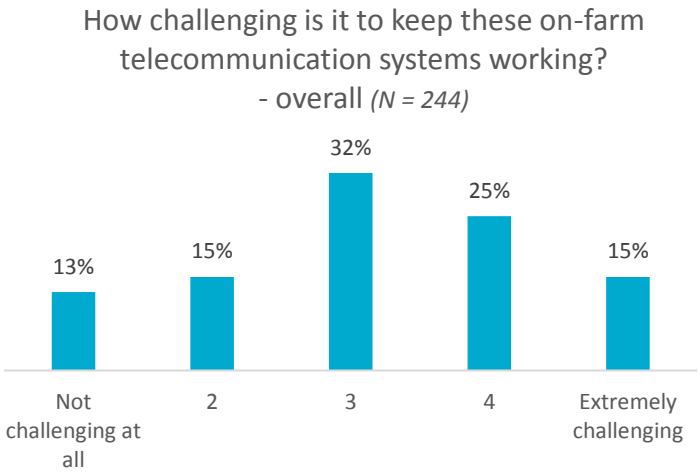


Figure 11. Challenge in keeping on-farm telecommunication systems working

Knowledge of on-farm telecommunication options

In general, respondents had very limited knowledge about the options available to connect devices on their farm (see Figure 12). Sixty-one percent of respondents reported that they knew nothing at all or very little, with only 5% of respondents knowing a lot about the options available.

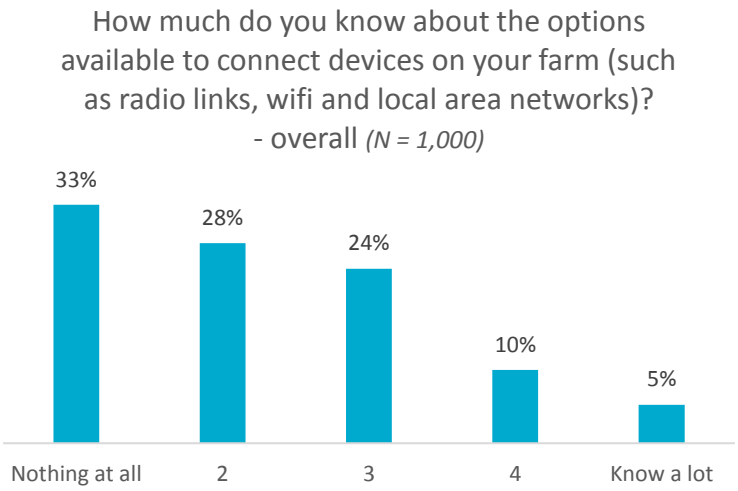


Figure 12. Knowledge of on-farm telecommunication options

Respondents from the cotton industry knew the most about options to connect devices to their farm, while sugarcane, sheep/grain mixed, dairy, and beef only industries knew the least (see Figure 13).

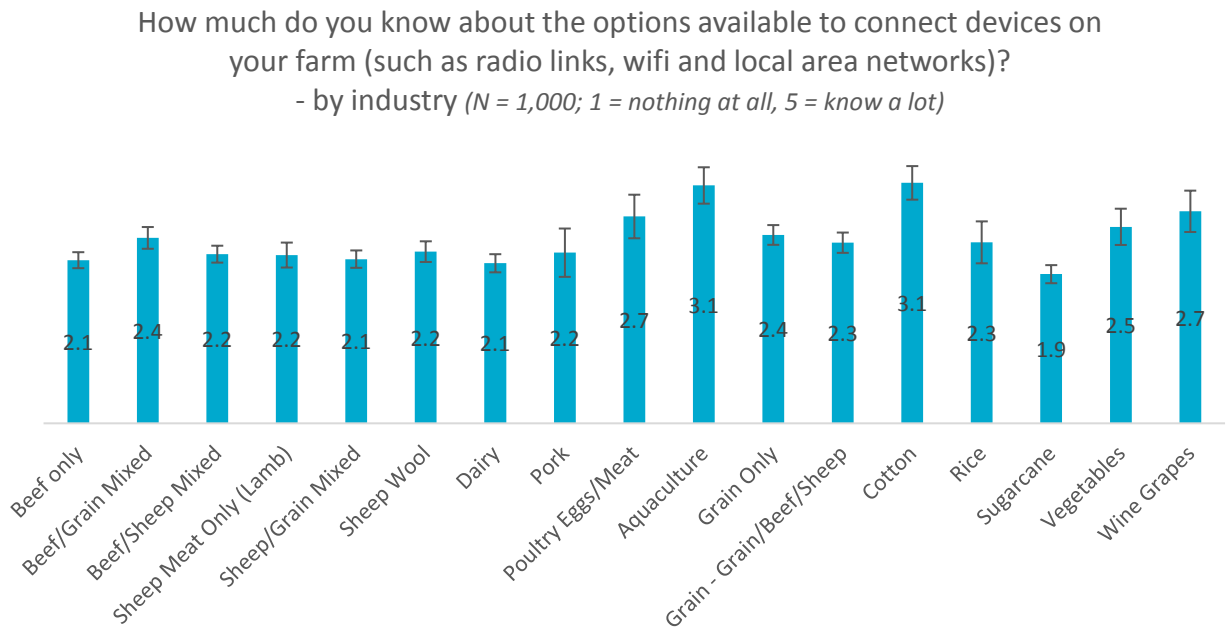


Figure 13. Knowledge of on-farm telecommunication options by industry

Internet coverage and satisfaction with internet connectivity

Coverage across farm

Thirty-four percent of respondents had almost complete or full internet coverage on their farm, while 43% of respondents had very patchy or no coverage across their farm (see Figure 14). Figure 15 displays the percentage of respondents across industries that had very patchy or no coverage across their farm. On average, dairy and sugarcane industries had the best coverage across their farms, while beef and cotton had the patchiest coverage (see Figure 16).

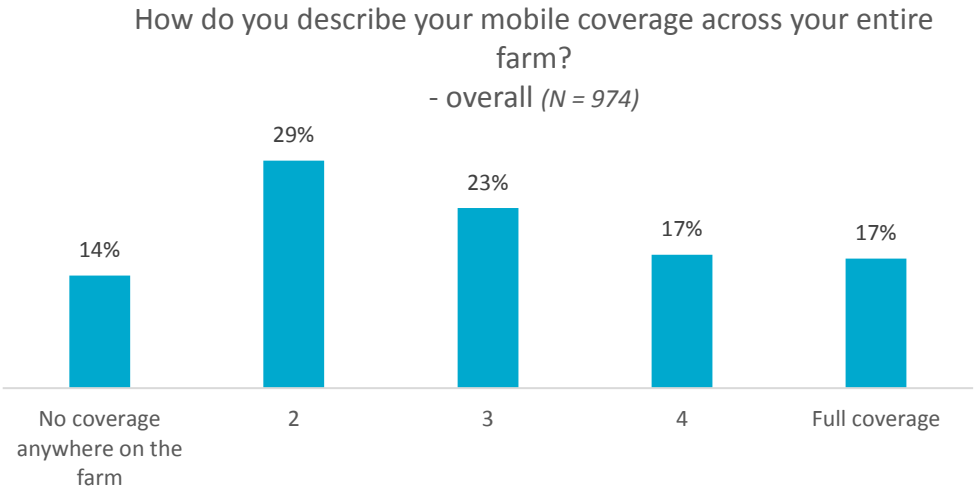


Figure 14. Mobile network coverage across entire farm

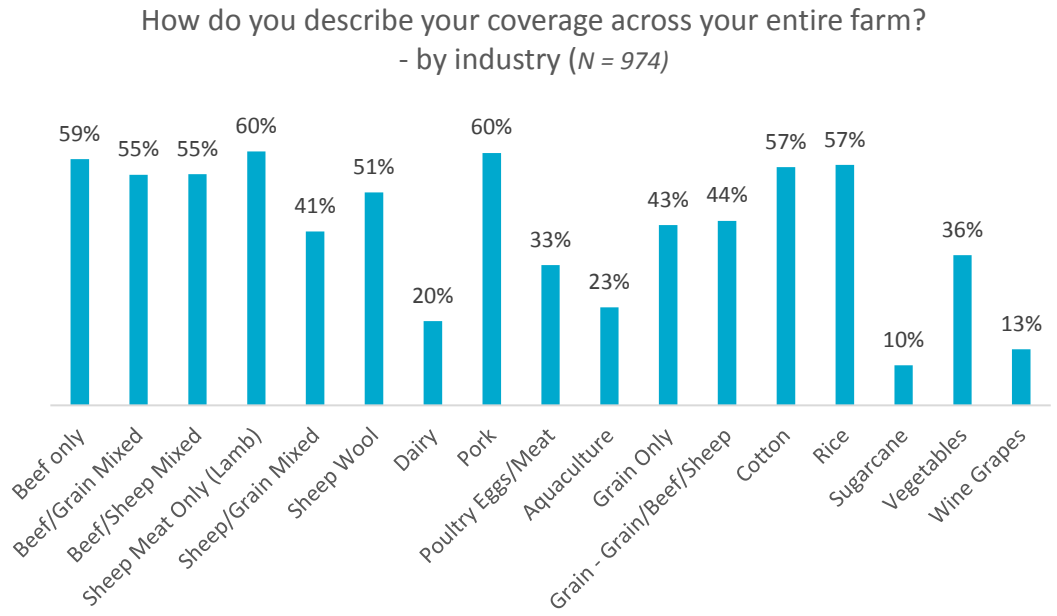


Figure 15. Respondents with very patchy or no coverage on their farm by industry

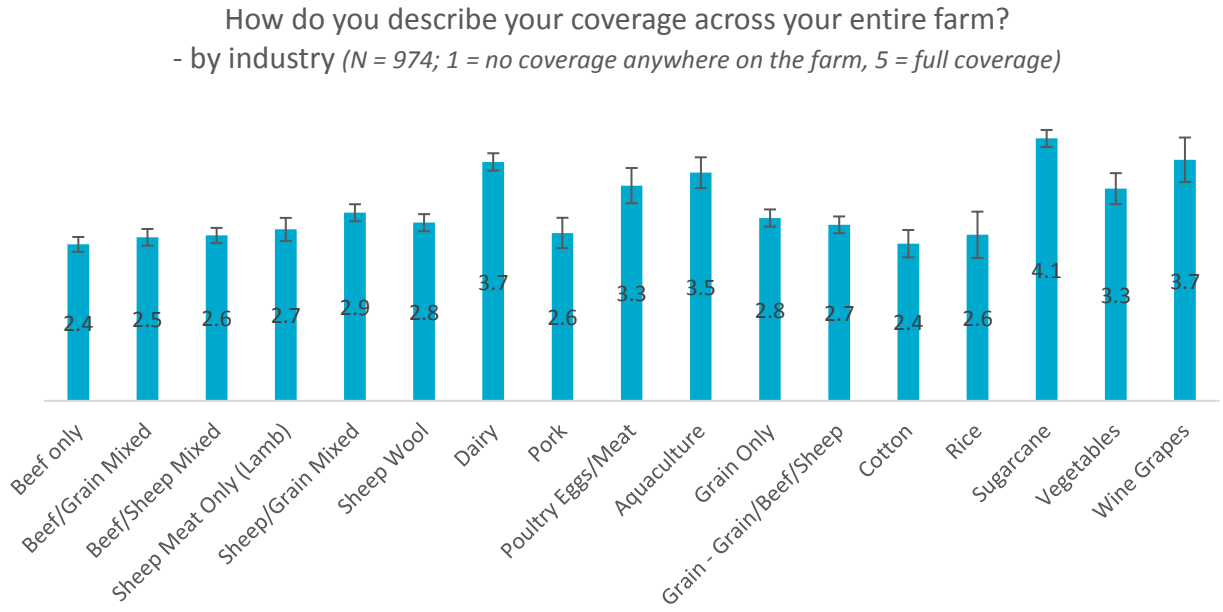


Figure 16. Mobile network coverage across entire farm by industry

In broadacre livestock industries, there were significant differences across states in mobile network coverage. Respondents from VIC (*M* = 3.30, *SD* = 1.13) reported the highest coverage, followed by NSW (*M* = 2.68, *SD* = 1.20), WA (*M* = 2.52, *SD* = 1.19), SA (*M* = 2.49, *SD* = 1.03), and QLD (*M* = 2.07, *SD* = 1.06).

Unsurprisingly, large farm sizes were associated with poorer coverage for both broadacre cropping and broadacre livestock industries. In broadacre cropping industries, coverage was rated as poorest by respondents from extra-large farms (*M* = 2.25, *SD* = 0.95), followed by large (*M* = 2.80, *SD* = 1.07), medium (*M* =2.84, *SD* = 1.23), and small farms (*M* = 3.00, *SD* = 1.27). In broadacre livestock industries, coverage was rated as poorest by

respondents from extra-large farms (*M* = 2.02, *SD* = 1.02), followed by large (*M* = 2.72, *SD* = 1.09), medium (*M* = 2.98, *SD* = 1.26), and small farms (*M* = 3.39, *SD* = 1.34).

Satisfaction with internet connectivity

Among the respondents who had an internet connection (*N* = 941), approximately one-third of respondents (30%) were satisfied or extremely satisfied with their home office internet connectivity, with nearly one-fifth (18%) not satisfied at all (see Figure 17).

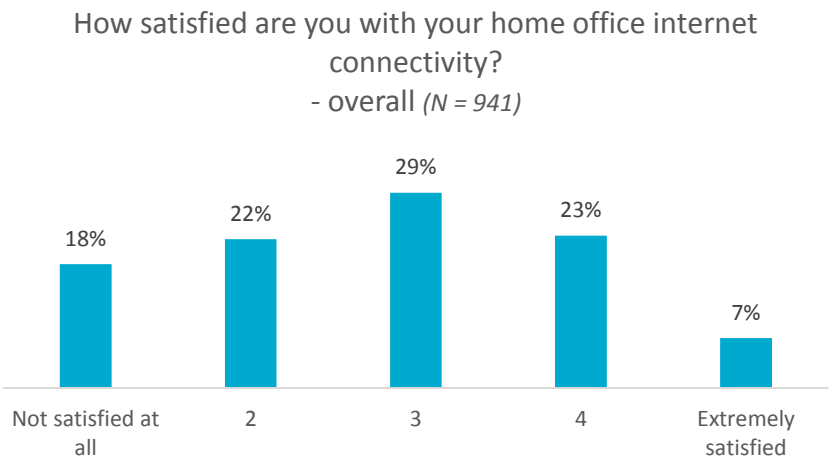


Figure 17. Satisfaction with home office internet connectivity

There was notable variation across industries for internet connectivity satisfaction (see Figure 18). Most industries showed neutral levels of satisfaction, around the mid-point of the scale (i.e., 3). Relative to other industries, beef/grain mixed, poultry eggs/meat, cotton, and grain only industries were least satisfied.

A correlation analysis revealed that satisfaction with internet connectivity was positively associated with coverage across the farm ($r = .26$, $p < .001$).

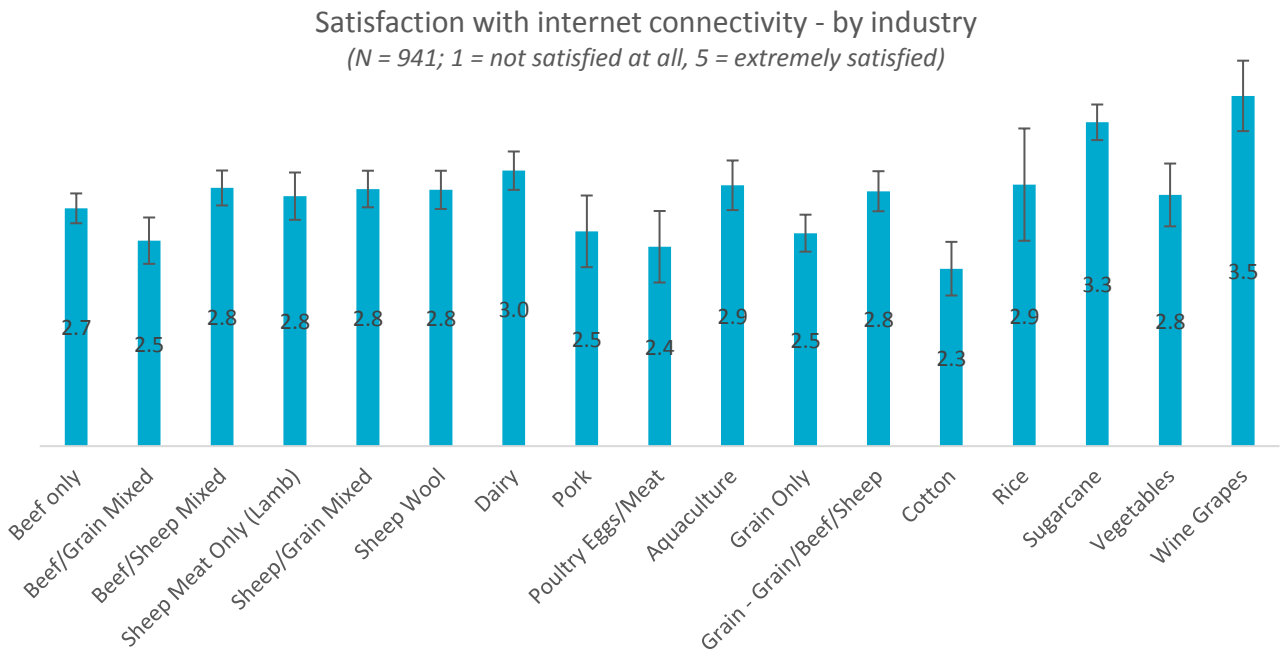


Figure 18. Satisfaction with home office internet connectivity by industry

Help with telecommunication needs

To sort out their communication needs, approximately half of the respondents (53%) used only themselves (including family members and employees), and 21% used a combination of themselves and a telecommunication service provider (see Figure 19). There was some variation across the industries (see Appendix D).

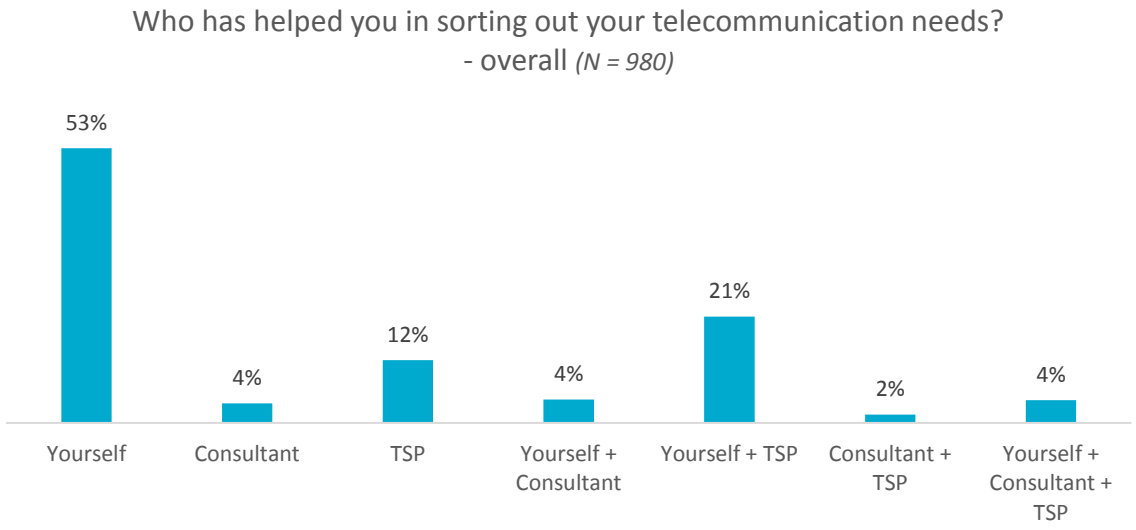


Figure 19. Types of assistance sought for telecommunication needs

Note: Yourself = Yourself (including family members and employees); Consultant = Fee-for-service consultant; TSP = Telecommunication Service Provider.

4.2 The status of current data collection

This section includes the types of data that were collected, where they were stored, and how useful producers regarded them in helping them making farm management decisions.

4.2.1 Types of data collected, stored, and perceived usefulness

Cropping and livestock industries collected different sets of data due to their divergent business operation needs. Hence, in the following section, the survey findings are presented separately for cropping and livestock industries.

Cropping industries

Among cropping industries, 87% of respondents collected at least one type of data. Figure 20 presents the average number of different types of data that were collected in each industry.

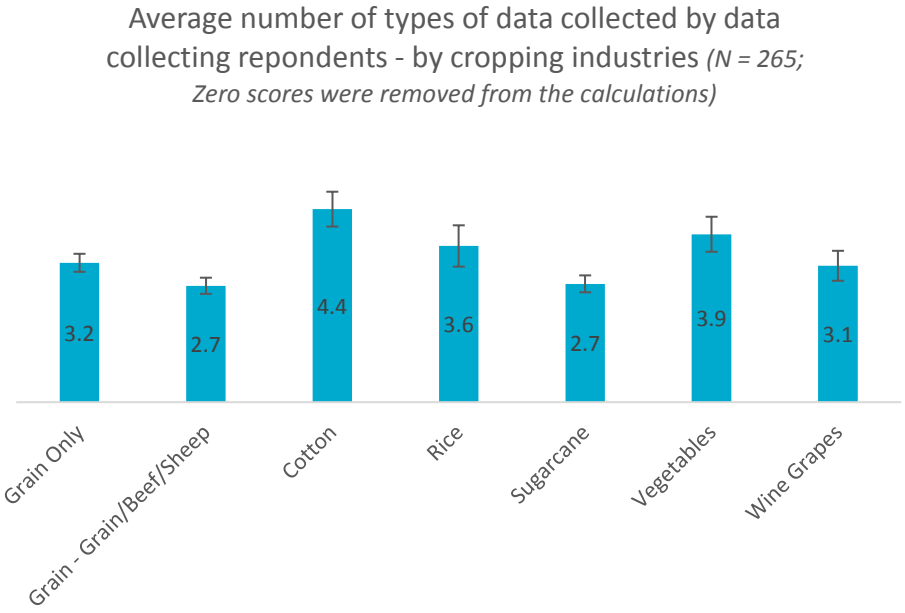


Figure 20. Average number of data types collected by cropping industries
Note: Zero scores were removed from the calculations.

Types of data collected

Table 6 presents the percentage of respondents from each cropping industry that currently collected major types of data. Of note, financial data (72%) was the most collected data across industries, followed by yield mapping data (51%) and soil mapping data (41%). Of the listed data types, weed pressure mapping data (11%) had the lowest rates of collection.

There was variation in the types of data collected across cropping industries. In particular, respondents from the cotton industry were the most active in collecting the various types of data.

For the grain industry (including grain only and grain mixed), there were differences in collection rates of soil mapping data, financial data, and no data collection across states. With the soil mapping data, respondents from NSW reported the highest collection rate (60%),

followed by WA (54%), QLD (25%), VIC (24%), and then SA (19%). With the financial data, again those from NSW reported the highest collection rate (78%), followed by WA (78%), VIC (72%), SA (54%), and then QLD (33%). With no data collection at all, respondents from QLD reported the highest rate (42%), followed by SA (23%), VIC (16%), WA (10%), and then NSW (3%).

In addition, there were variations in collection rates of yield mapping data and soil mapping data across farm sizes. A significantly greater proportion of respondents from extra-large farms (75%) collected yield mapping data, followed by producers on small (48%), medium (53%), and large (57%) farms. A significantly greater proportion of respondents from extra-large farms (60%) collected soil mapping data, followed by producers from small (35%), medium (35%), and large (46%) farms.

Table 6. Data collection rates for types of data by cropping industries

Industry	Data Collected by Cropping Industries								
	Yield mapping	Soil mapping	Crop sensing (e.g., NDVI)	Weed pressure mapping	Soil moisture sensor	On-farm weather station	Finance	Irrigation use	None of the listed data is collected
Grain Only (*N* = 77)	61%	46%	25%	12%	22%	36%	70%	4%	14%
Grain/Beef/Sheep (*N* = 73)	49%	38%	12%	11%	19%	26%	69%	7%	14%
Cotton (*N* = 30)	73%	53%	33%	13%	67%	47%	83%	60%	3%
Rice (*N* = 15)	60%	47%	20%	20%	20%	33%	93%	67%	0%
Sugarcane (*N* = 65)	51%	40%	17%	11%	8%	22%	68%	15%	15%
Vegetables (*N* = 30)	33%	27%	23%	7%	37%	40%	70%	60%	23%
Wine grapes (*N* = 15)	0%	33%	7%	0%	53%	47%	73%	80%	7%
Total (*N* = 305)	51%	41%	20%	11%	26%	32%	72%	25%	13%

Data storage

Table 7 displays a percentage breakdown of how various types of data were stored by respondents from cropping industries. 'On farm electronically' was the most prominently used storage option for most types of data, accounting for approximately half of the storage for most types of data. The next most used method was 'on farm on paper', followed by 'in-cloud services'. The least utilized method was a 'service provider'.

Table 7. Data storage methods for types of data in cropping industries

Data type	Location of stored data				
	On farm on paper	On farm electronically	In-cloud	Service provider	Not sure
Yield mapping (*N* = 157)	21%	59%	11%	8%	2%
Soil mapping (*N* = 125)	36%	48%	9%	7%	-
Crop sensing (e.g., NDVI) (*N* = 60)	23%	50%	13%	8%	5%
Soil moisture sensor (*N* = 80)	15%	44%	23%	15%	4%
On-farm weather station (*N* = 99)	30%	49%	15%	5%	1%
Finances (*N* = 219)	12%	71%	12%	5%	1%
Irrigation use (*N* = 76)	28%	54%	13%	4%	1%

Usefulness of the data

Table 8 presents the findings on how useful respondents believed that each type of data that they had collected was in helping them make farm management decisions. Overall, as indicated by the average scores, all types of data were regarded as quite useful for informing farm management decisions. In particular, financial data was rated as the most useful, followed by irrigation use data, weed pressure mapping data, and soil moisture sensor data.

Table 8. Reported usefulness of types of data for farm management decisions by data collectors in cropping industries

Data type	Usefulness of data					
	1 = No use at all	2	3	4	5 = Extremely useful	Average
Yield mapping (*N* = 157)	3%	12%	23%	34%	27%	3.7 (SD = 1.09)
Soil mapping (*N* = 125)	2%	7%	22%	36%	33%	3.9 (SD = 0.99)
Crop sensing (e.g., NDVI) (*N* = 60)	3%	10%	25%	40%	22%	3.7 (SD = 1.04)
Weed pressure mapping (*N* = 33)	-	6%	27%	21%	46%	4.1 (SD = 0.99)
Soil moisture sensor (*N* = 78)	3%	5%	21%	28%	44%	4.1 (SD = 1.04)
On-farm weather station (*N* = 99)	2%	13%	25%	25%	34%	3.8 (SD = 1.12)
Finances (*N* = 216)	1%	1%	9%	24%	66%	4.5 (SD = 0.74)
Irrigation use (*N* = 76)	1%	1%	18%	36%	43%	4.2 (SD = 0.88)

Livestock industries

Among livestock industries, 91% of respondents collected at least one type of data. Figure 21 presents the average number of different types of data that were collected for each industry.

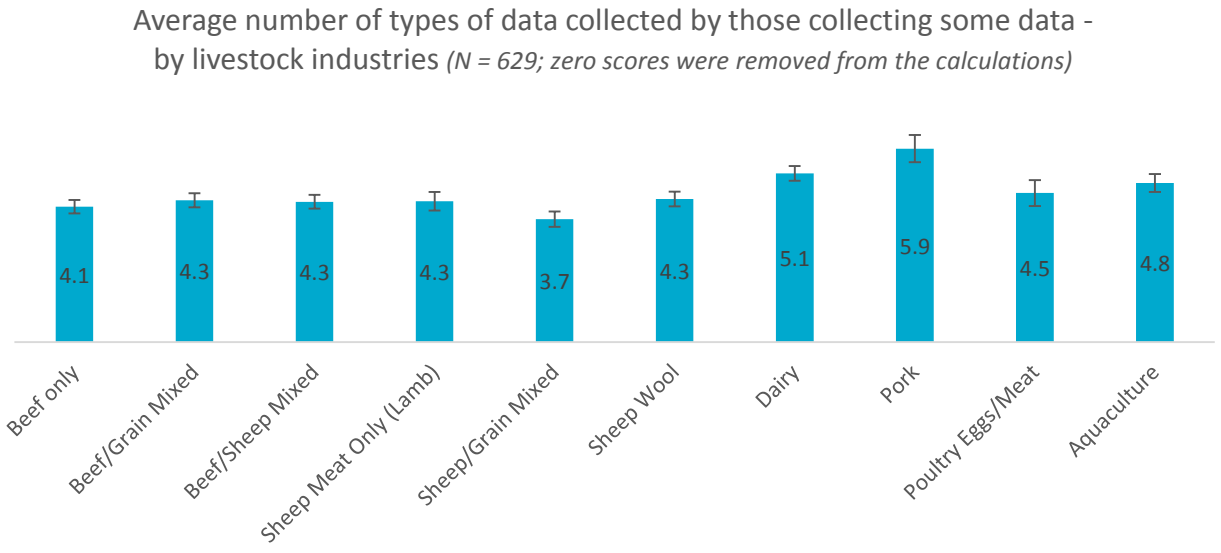


Figure 21. Average number of data types collected by livestock industries

Types of data collected

Table 9 presents the percentage of respondents for livestock industries that currently collected major types of data. Across the livestock industries, financial data (79%) was the most

collected, followed by veterinary medicine record (63%), animal breeding data (57%), and individual animal or herd production data (56%).

There was variation in the types of data collected across livestock industries. Respondents from dairy and pork industries reported the highest data collection rates across all data type categories.

Table 9. Data collection rates for types of data by livestock industries

Industry	Data Collected by Livestock Industries									
	Soil mapping	Pasture/vegetation mapping	Individual animal or herd production	Individual animal or herd feeding	On-farm weather station	Animal breeding	Finances	Veterinary medicine record	Water use/quality	None of the listed data is collected
Beef only (*N* = 126)	23%	33%	54%	23%	26%	50%	78%	63%	25%	9%
Beef/Grain Mixed (*N* = 64)	28%	30%	52%	25%	45%	41%	86%	67%	23%	8%
Beef/Sheep Mixed (*N* = 94)	29%	29%	52%	23%	42%	61%	83%	70%	19%	4%
Sheep Meat Only (Lamb) (*N* = 59)	20%	24%	44%	29%	49%	54%	70%	63%	17%	14%
Sheep/Grain Mixed (*N* = 94)	27%	19%	31%	16%	31%	47%	71%	45%	23%	17%
Sheep Wool (*N* = 89)	23%	24%	56%	27%	38%	67%	79%	72%	19%	7%
Dairy (*N* = 92)	37%	27%	80%	50%	17%	77%	82%	70%	38%	7%
Pork (*N* = 15)	20%	13%	93%	80%	27%	93%	93%	100%	67%	0%
Poultry Eggs/Meat (*N* = 30)	10%	17%	60%	43%	17%	20%	70%	53%	57%	23%
Aquaculture (*N* = 30)	0%	0%	87%	47%	47%	63%	90%	37%	97%	3%
Total (*N* = 693)	25%	25%	56%	30%	33%	57%	79%	63%	29%	9%

In broadacre livestock industries, there were some statistically significant differences across states in the collection rates of breeding data. Respondents from SA (63%) reported the breeding data collection rate, followed by VIC (63%), NSW (55%), WA (48%), and QLD (39%).

In addition, across farm sizes there was variation in the collection rates of pasture/vegetation mapping, individual animal or herd production and feeding, on-farm weather station, and animal breeding data. Regarding pasture/vegetation data, respondents from extra-large (32%) and large farms (31%) reported the highest collection rates, followed by medium (23%) and small farms (20%). Regarding individual animal or herd production data, respondents from small farms (68%) reported the highest collection rate, followed by extra-large (52%), medium (49%), and large (48%) farms. Regarding individual animal or herd feeding data, respondents from small farms (38%) reported the highest collection rate, followed by large (28%), medium (25%), and extra-large farms (23%). Regarding on-farm weather station data, respondents from extra-large (40%) and large (40%) farms reported the highest collection rates, followed by medium (33%), and small farms (22%). Regarding animal breeding data, respondents from small farms (69%) reported the highest collection rate, followed by those from medium (57%), large (56%), and extra-large (50%) farms.

Data storage

Table 10 displays a percentage breakdown of how various types of data were stored by respondents from livestock industries. Overall, 'on farm on paper' storage was the most prominent storage option, followed closely by 'on farm electronically'. Conversely, storing data through 'in-cloud' and 'service provider' were the least used options.

Table 10. Data storage methods for types of data in livestock industries

Data type	Location of stored data				
	On farm on paper	On farm electronically	In-cloud	Service provider	Not sure
Soil mapping (*N* = 171)	53%	32%	6%	8%	1%
Pasture/vegetative mapping (*N* = 173)	49%	40%	4%	6%	1%
Individual animal or herd production (*N* = 387)	42%	50%	5%	2%	1%
Individual animal or herd feeding (*N* = 208)	50%	43%	5%	1%	1%
On-farm weather station (*N* = 232)	63%	27%	7%	2%	2%
Animal breeding (*N* = 392)	53%	42%	4%	2%	-
Finances (*N* = 546)	21%	68%	7%	4%	0.4%
Veterinary medicine record (*N* = 437)	65%	31%	2%	1%	1%
Water use/quality (*N* = 204)	49%	40%	4%	3%	3%

Usefulness of the data

Table 11 presents the findings on how useful respondents believed each type of data was in helping them make farm management decisions. Overall, as indicated by the average scores, all types of data were regarded as quite useful for informing farm management decisions. In particular, financial data was rated as the most useful, followed by individual animal or herd feeding and production data, and animal breeding data. On-farm weather station data was rated comparatively least useful.

Table 11. Usefulness of types of data for farm management decisions in livestock industries

Data type	Usefulness of data					
	1 = No use at all	2	3	4	5 = Extremely useful	Average
Soil mapping (*N* = 171)	3%	9%	28%	28%	33%	3.8 (SD = 1.09)
Pasture/vegetative mapping (*N* = 173)	1%	12%	30%	31%	27%	3.7 (SD = 1.01)
Individual animal or herd production (*N* = 387)	3%	3%	17%	32%	46%	4.2 (SD = 0.99)
Individual animal or herd feeding (*N* = 208)	1%	7%	20%	30%	42%	4.1 (SD = 0.99)
On-farm weather station (*N* = 232)	7%	11%	29%	29%	24%	3.5 (SD = 1.18)
Animal breeding (*N* = 390)	1%	2%	18%	34%	45%	4.2 (SD = 0.88)
Finances (*N* = 546)	2%	2%	9%	24%	64%	4.5 (SD = 0.86)
Veterinary medicine record (*N* = 436)	5%	12%	25%	24%	34%	3.7 (SD = 1.19)
Water use/quality (*N* = 204)	3%	8%	28%	26%	36%	3.8 (SD = 1.09)

4.2.2 Software use

Only the respondents who collected one or more types of data were asked what types of financial management and production management software they used to manage their data.

The findings presented here need to be interpreted with caution. As the phone survey covered a broad range of issues and was not focused on software use, respondents may not have had enough time to identify all the software they use.

Financial management software

The heaviest users of financial management software were from pork, cotton, grain mixed, and vegetable industries, where about three-quarters of respondents used a financial management software (see Figure 22). The sugarcane industry had by far the lowest usage rate of 22%.

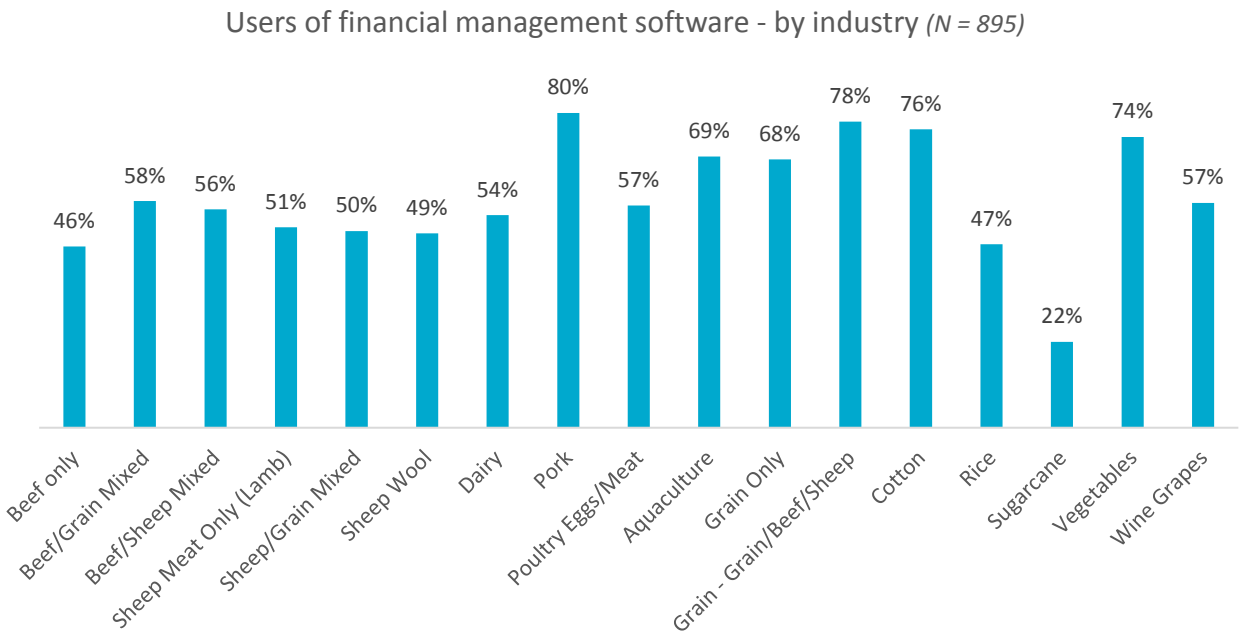


Figure 22. Financial management software use by industry

For respondents who used financial management software to manage their financial data, they were asked about the details of the software. Table 12 displays the types of financial management software used, and the proportion of users within each industry who used each financial management software.

Table 12. Types of financial management software use by industry

Industry	Financial management software											
	AgData	Agrimaster	BankLink	CashBooks	CashFlow	MYOB	QuickBooks	Quicken	Reckon	Xero	Don't know	Miscellaneous
Beef only (*N* = 53)	28%	6%	4%	4%	4%	13%	13%	4%	4%	8%	8%	13%
Beef/Grain Mixed (*N* = 34)	38%	3%	3%	3%	0%	6%	9%	3%	3%	9%	9%	18%
Beef/Sheep Mixed (*N* = 50)	18%	2%	4%	2%	4%	4%	16%	6%	4%	10%	10%	18%
Sheep Meat Only (Lamb) (*N* = 26)	23%	4%	4%	4%	0%	8%	8%	12%	4%	19%	12%	8%
Sheep/Grain Mixed (*N* = 39)	28%	10%	0%	5%	13%	8%	10%	5%	3%	0%	18%	3%
Sheep Wool (*N* = 41)	17	12%	2%	7%	12%	10%	10%	2%	5%	7%	10%	5%
Dairy (*N* = 47)	0%	0%	2%	6%	13%	6%	11%	11%	11%	15%	21%	11%
Pork (*N* = 12)	17%	0%	0%	0%	0%	33%	25%	0%	8%	0%	8%	17%
Poultry Eggs/Meat (*N* = 13)	8%	0%	8%	0%	15%	15%	15%	0%	0%	8%	23%	15%
Aquaculture (*N* = 20)	5%	0%	0%	0%	0%	35%	20%	0%	20%	5%	10%	10%
Grain Only (*N* = 45)	27%	31%	0%	0%	2%	7%	4%	2%	2%	4%	9%	18%
Grain - Grain/Beef/Sheep (*N* = 49)	20%	47%	0%	2%	4%	4%	8%	0%	4%	4%	8%	6%
Cotton (*N* = 22)	55%	5%	0%	5%	0%	5%	0%	5%	0%	9%	9%	23%
Rice (*N* = 7)	57%	0%	0%	0%	0%	0%	14%	0%	14%	0%	0%	29%
Sugarcane (*N* = 12)	0%	0%	8%	0%	0%	33%	33%	0%	0%	0%	8%	17%
Vegetables (*N* = 17)	6%	0%	0%	0%	0%	35%	24%	6%	12%	6%	12%	12%
Wine grapes (*N* = 8)	13%	0%	0%	0%	0%	50%	0%	0%	0%	0%	13%	25%
Total (*N* = 495)	21%	11%	2%	3%	5%	11%	12%	4%	5%	7%	11%	13%

Production management software

Among the 895 respondents who collected one or more types of data, only 191 respondents indicated that they used production management software to manage their data. Again, this figure needs to be interpreted with caution. It is likely that the findings underestimated the real practice due to the survey method not being designed for this purpose. For example, 48 respondents could not recall the name of the software they used, and only 4 respondents reported the use of the common software Excel (see Appendix C).

Figure 23 presents the percentage of data collectors across industries that used at least one type of production management software. Respondents from grain only, pork, grain mixed, cotton, and vegetable industries were the highest users, with sheep meat only, beef only, poultry, and wine grapes industries the lowest users.

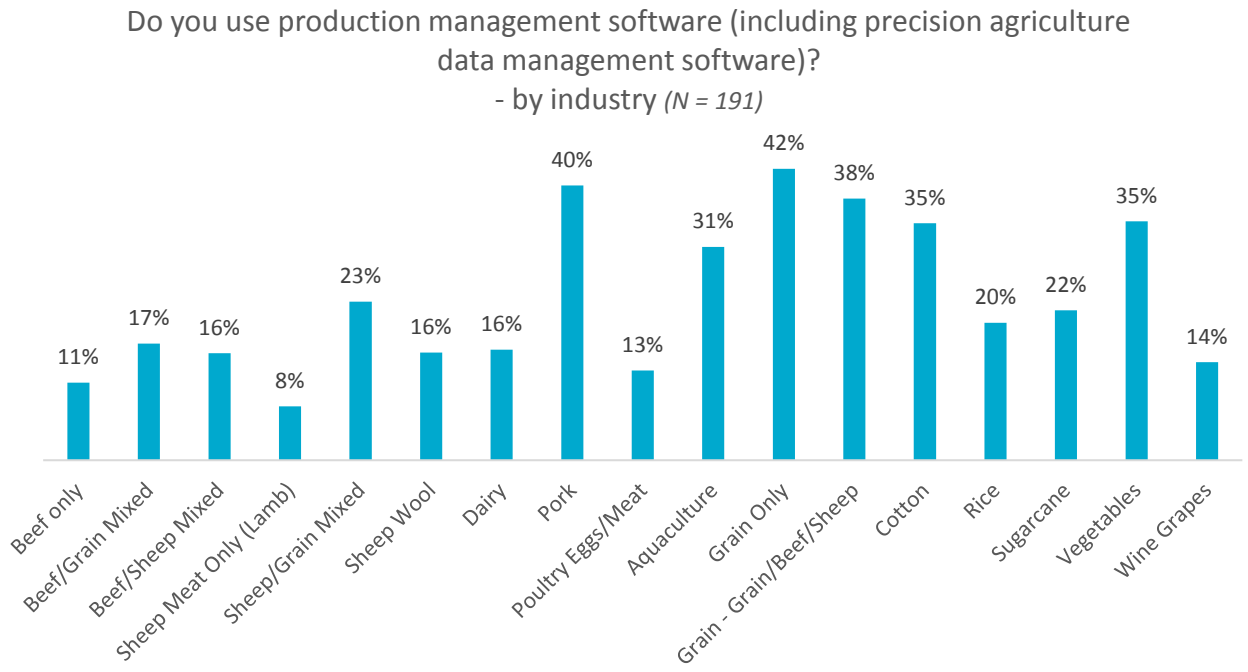


Figure 23. Production management software use by industry

4.2.3 Overall evaluation of contributions made by the data collected so far

For the respondents who collected one or more types of data (*N* = 895), they were asked to evaluate the overall contributions these data made to various aspects of their business. In general, evaluations were quite positive. The following findings are from the respondents who had collected one or more types of data.

Farm management decisions

Overwhelmingly, 92% of respondents reported that the data they had collected was useful or extremely useful in helping them make farm management decisions (see Figure 24). In particular, respondents from aquaculture, pork, cotton, and vegetable industries found that the data they were currently collecting was highly useful in helping making farm management decisions (see Figure 25).

Compared to those who collected data (*M* = 3.94, *SD* = 0.99), respondents who didn't collect any data (*N* = 105, *M* = 2.34, *SD* = 1.25) thought that data, if they were to collect it, would be significantly less useful in helping make farm management decisions.

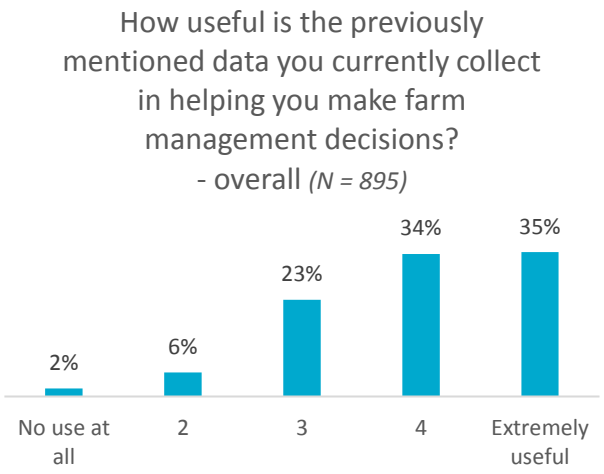


Figure 24. Usefulness of data for making farm management decisions

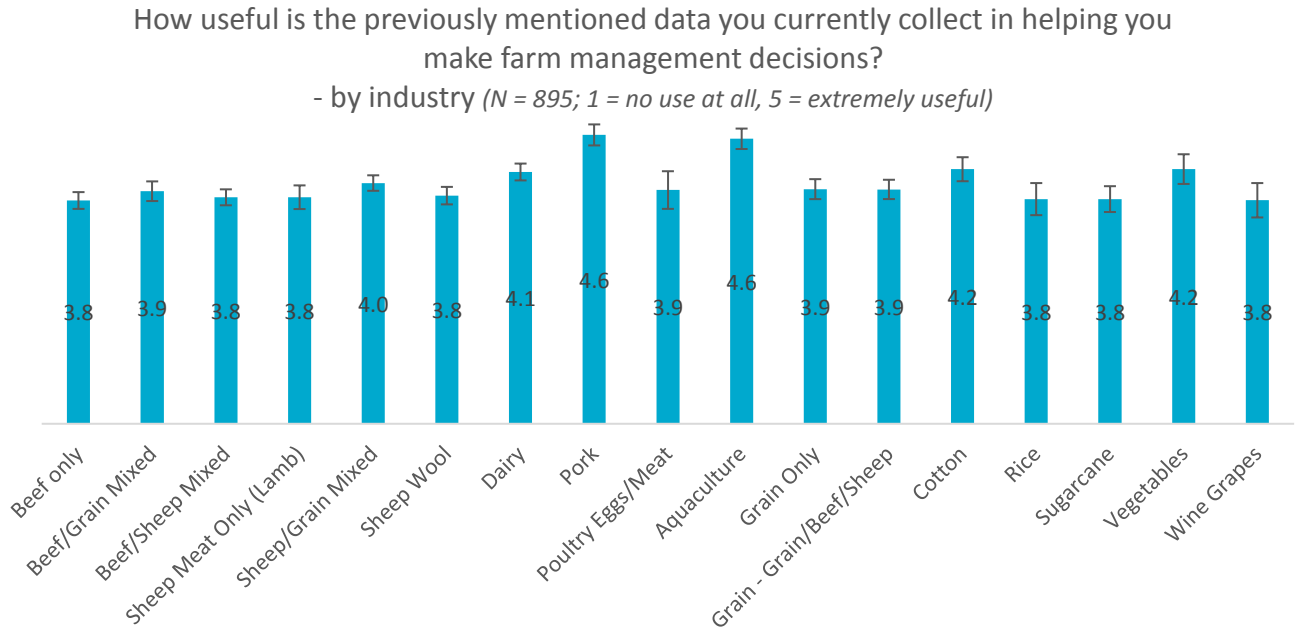


Figure 25. Usefulness of data for making farm management decisions by industry

Farm business profit

Overall, respondents found that the data had made quite a positive contribution to their farm business profit (see Figure 26). About half (51%) believed that the data helped increase their business profit to a moderate or great extent, especially among the respondents from aquaculture and pork industries (see Figure 27). Only 15% found it had little or no positive contribution.

Compared to those who collected data (*M* = 3.46, *SD* = 1.03), respondents who didn't collect any data (*M* = 2.01, *SD* = 1.13) thought that data would make significantly less contribution to business profit if they were to collect it.

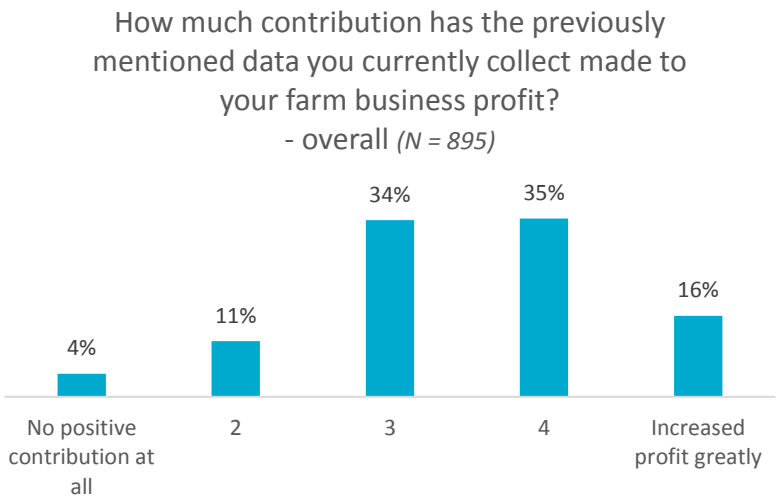


Figure 26. Contribution of data to farm business profit

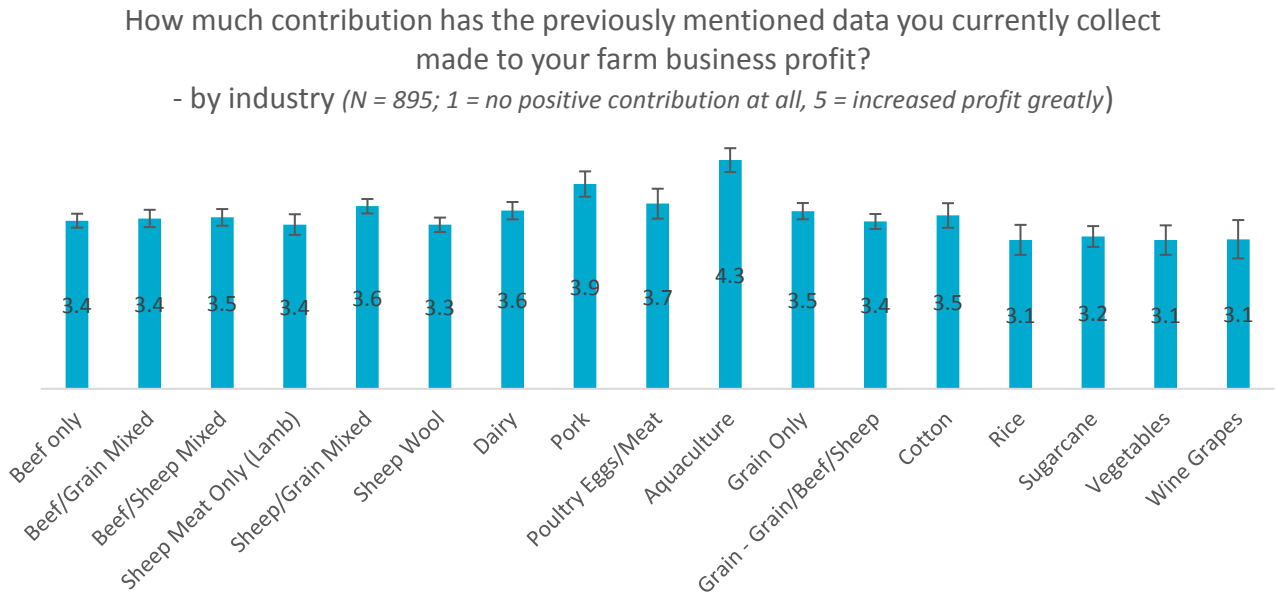


Figure 27. Contribution of data to farm business profit by industry

Efficient running of the farm

Overall, the majority of respondents found that the data had been useful in increasing efficiency on their farm, with 19% claiming that the data increased efficiency greatly, and only a cumulative 12% finding it had little or no positive contribution to farm efficiency (see Figure 28). Again, aquaculture and pork industries reported the greatest contribution of the data to farm efficiency (see Figure 29).

Compared to those who collected data (M = 3.58, SD = 1.01), respondents who didn't collect any data (M = 2.18, SD = 1.25) thought that collecting data would make significantly less contribution to the efficient running of their farm if they were to collect it.

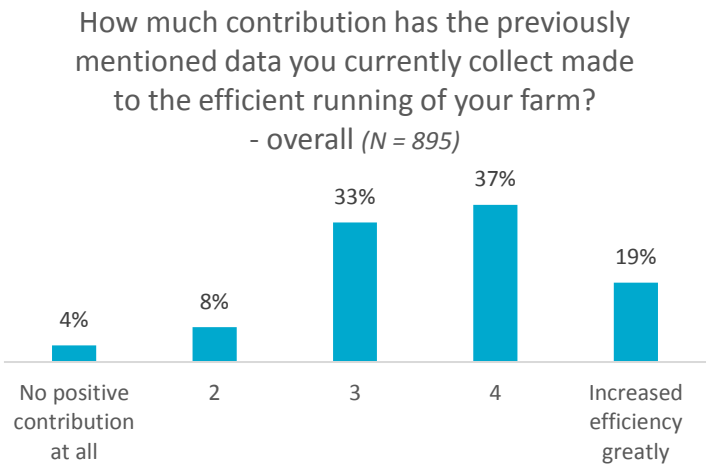


Figure 28. Contribution of data to efficient running of farm

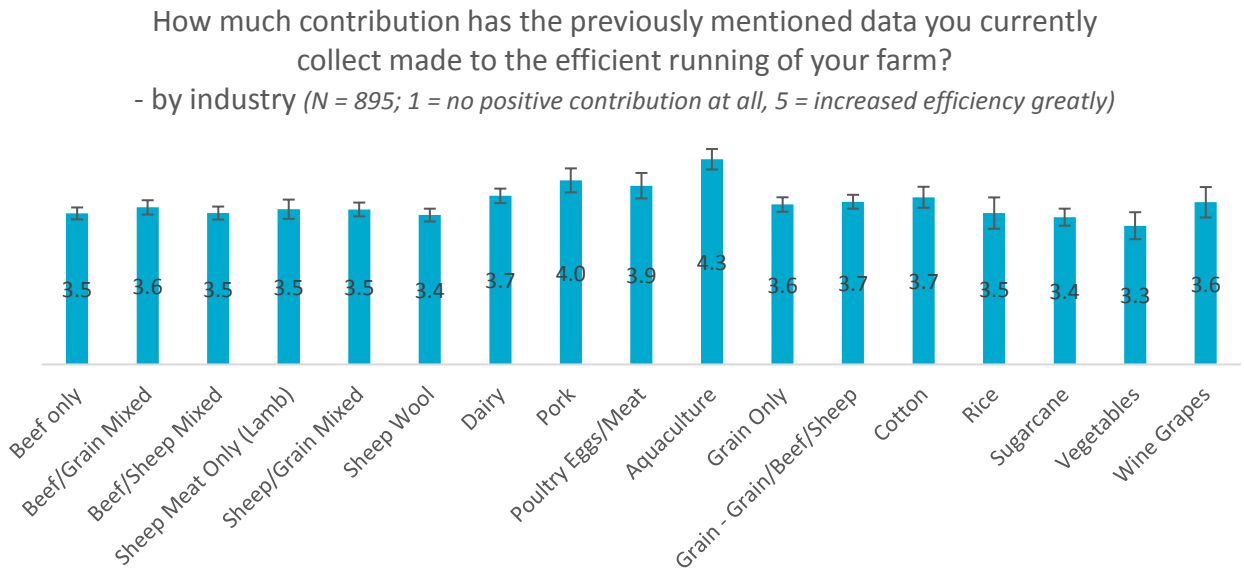


Figure 29. Contribution of data to efficient running of farm by industry

Risk management

Overall, 16% found that the collected data improved risk management greatly, and the majority (64%) found that it made a positive contribution, with only 6% finding it had no positive contribution at all (see Figure 30). There was not much variation across industries (see Figure 31), apart from aquaculture and pork industries that indicated the greatest contribution of the data to improved risk management.

Compared to those who collected data (*M* = 3.40, *SD* = 1.11), respondents who didn't collect any data (*M* = 2.25, *SD* = 1.31) thought that the data would make significantly less contribution to risk management of their farm operations if they were to collect it.

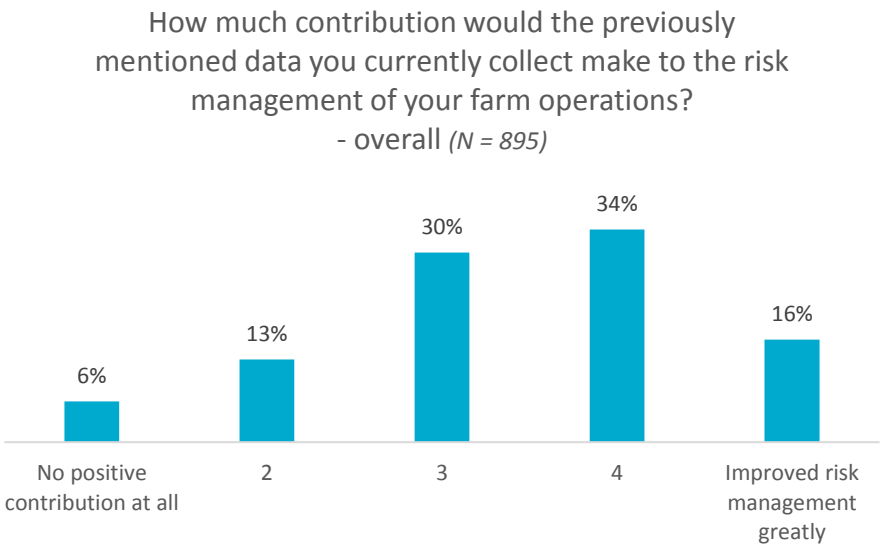


Figure 30. Contribution of data to risk management of farm operations

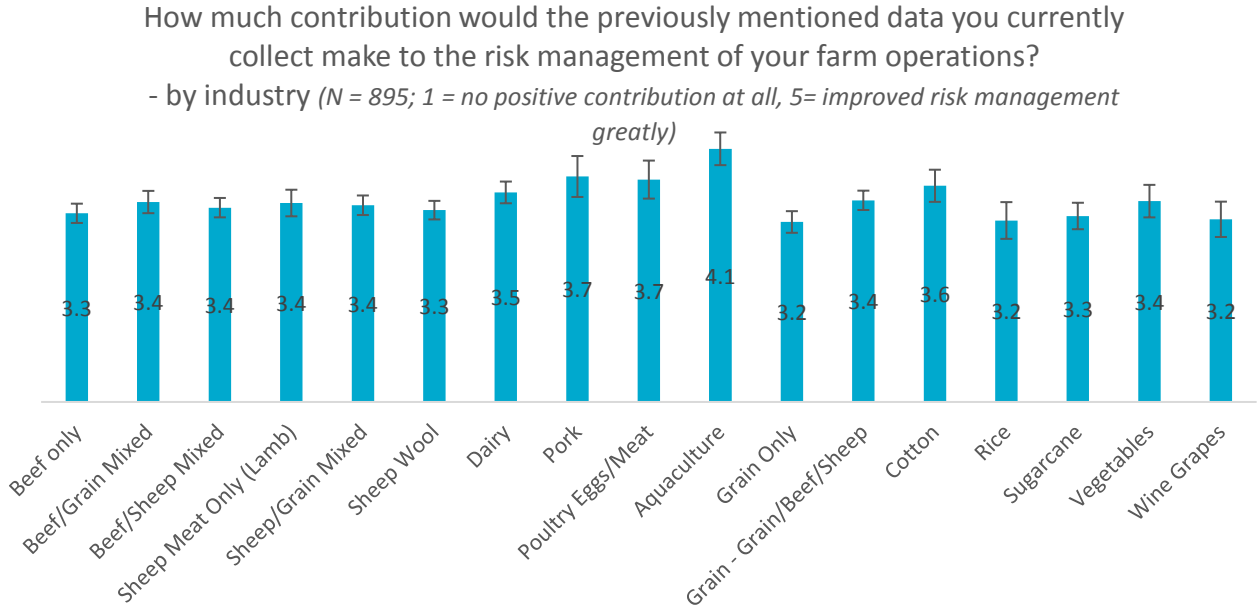


Figure 31. Contribution of data to risk management of farm operations by industry

4.2.4 Drivers for positive evaluation of the data collected

For producers to actively engage with precision agriculture and fully utilise digital agricultural technologies, it is essential for them to appreciate the benefits of these technologies. Hence, it is important to understand the drivers of producers' positive evaluations toward agricultural data enabled through digital agricultural technologies.

Data appreciation was calculated by averaging the overall evaluations of contributions to 'helping farm management decisions', 'increasing business profit', 'increasing efficiency of running farm', and 'improving risk management' (see above section; *1 = no use at all, 5 = extremely useful*). Hierarchical multiple regression analyses were conducted to identify the key predictors of data appreciation.

Due to the divergent nature of business operations, two sub-groups of industries were created based of their similar business operations. These sub-groups are broadacre cropping industries (including grain only, grain mixed, cotton, and rice) and broadacre livestock industries (including beef only, beef/grain, beef/sheep, sheep meat only, sheep/grain, and sheep wool). A hierarchical multiple regression analysis were conducted separately for each sub-group.

Broadacre cropping industries

Table 13 presents the findings of the hierarchical multiple regression analysis for broadacre cropping industries.

When only demographic variables were considered, there was evidence of associations between education and land size with degree of data appreciation; however, when a broader range of predictors (see Table 13) were included and considered simultaneously in the model, education and land size, along with age, gender, and years in industry were not statistically significant predictors of data appreciation (*M* = 3.47, *SD* = 0.88). Poor technical support for digital agricultural technologies (*M* = 3.23, *SD* = 1.12) and perceived low return of agricultural technologies and equipment (*M* = 3.19, *SD* = 1.06) were also not significant predictors.

Instead, regarding maximising production as important (*M* = 4.63, *SD* = 0.68), knowledge of telecommunication options (*M* = 2.45, *SD* = 1.12), and greater total number of data types collected (*M* = 2.86, *SD* = 1.94) predicted greater data appreciation. Moreover, the knowledge and number of data types collected interacted in predicting data appreciation. As shown in Figure 32, respondents with low levels of knowledge appreciated the value of the data only when they had collected more types of data. However, respondents with higher levels of knowledge of telecommunication options had a high appreciation for the value of the data regardless of how many types of data they collected.

Table 13. Hierarchical multiple regression analysis predicting appreciation of data for broadacre cropping industries.

Note: * p < .05, ** p < .01. Poor technical support, low return in tech/equipment investment, maximising production important, and knowledge of telecommunication options were all measured on a 5-point scale (*1 = strongly disagree/know nothing at all, 5 = strongly agree/know a lot*).

Predictor	Step 1		Step 2	
	R^2 = .093 F (5, 186) = 3.80 p = .003	β	R^2 change= .158 F change (6, 180) = 6.31 p < .001	β
Age		.03		-.04
Gender		.14		.10
Education		.20*		.10
Years in industry		.04		.08
Total land size		.16*		.08
Poor technical support				.07
Low return in tech/equipment investment				-.09
Maximising production important				.19**
Knowledge of telecommunication options (Knowledge)				.15*
Number of data types collected (No. of data)				.26**
Knowledge X No. of data				-.14*

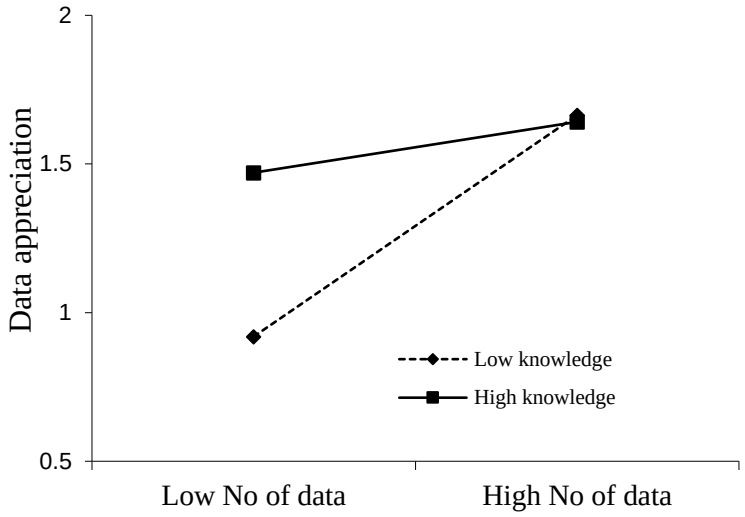


Figure 32. Interaction effect between degree of tech/equipment investment and knowledge of telecommunication options on data appreciation for broadacre cropping industries

Note: * p < .05, ** p < .01. Poor technical support, low return in tech/equipment investment, maximising production important, and knowledge of telecommunication options were all measured on a 5-point scale (*1 = strongly disagree/know nothing at all, 5 = strongly agree/know a lot*).

Broadacre livestock industries

Table 14 presents the findings of the hierarchical multiple regression analysis for broadacre livestock industries.

As in the cropping industries, when only demographic variables were considered, there was evidence of association between education and data appreciation. However, when additional predictors (see Table 14) were included and considered simultaneously in the model, along with the demographic factors, including years in industry, and land size, only age was significantly associated with data appreciation (*M* = 3.40, *SD* = 0.99). That is, younger respondents appreciated the value of the data more than older respondents.

Perceived low return of investment in agricultural technologies/equipment (*M* = 2.98, *SD* = 1.14) and regarding maximising production as important (*M* = 4.47, *SD* = .83) were also not significant predictors.

Instead, poorer technical support for digital agricultural technologies (*M* = 3.02, *SD* = 1.15), greater knowledge of telecommunication options (*M* = 2.18, *SD* = 1.14), and greater total number of data types collected (*M* = 3.76, *SD* = 2.28) significantly predicted greater data appreciation. Moreover, the knowledge and number of data types interacted in predicting data appreciation.

As shown in Figure 33, and similar to the pattern displayed for broadacre cropping industries, respondents with low levels of knowledge appreciated the values of the data only when they had collected more types of data. However, respondents with higher levels of knowledge appreciated the value of the data more even when they had not collected many types of data.

Table 14. Hierarchical multiple regression analysis predicting appreciation of data for broadacre livestock industries

Note: * p < .05, ** p < .01, *** p < .001

Predictor	Step 1		Step 2	
	R^2 = .064 F (5, 516) = 7.03 p < .001	β	R^2 change = .250 F change(6, 510) = 30.98 p < .001	β
Age		-.22**		-.16**
Gender		.02		.00
Education		.14**		.02
Years in industry		.07		.06
Total land size		.00		-.03
Poor technical support				.09*
Low return in tech/equipment investment				-.05
Maximising production important				.04
Knowledge of telecommunication options (Knowledge)				.14***
Number of data types collected (No. of data)				.45***
Knowledge X No. of data				-.11**

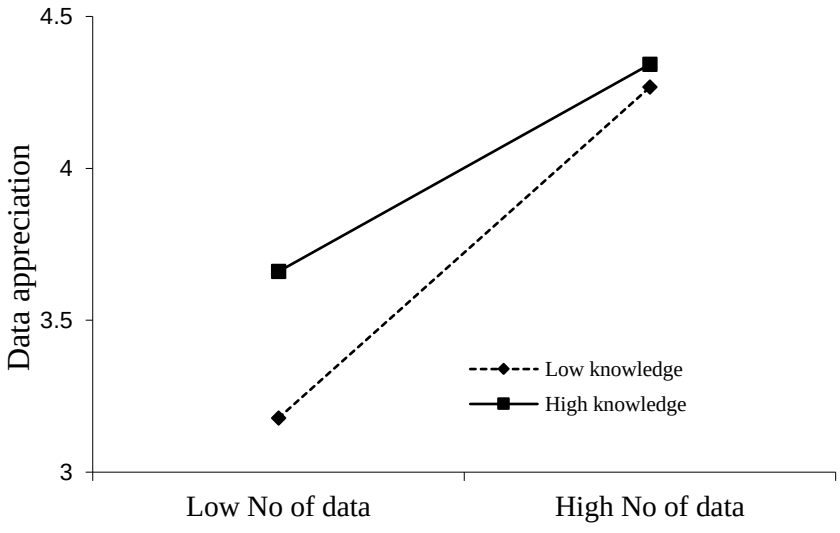


Figure 33. Interaction effect between degree of tech/equipment investment and knowledge of telecommunication options on data appreciation for broadacre livestock industries.

Note: * p < .05, ** p < .01. Poor technical support, low return in tech/equipment investment, maximising production important, and knowledge of telecommunication options were all measured on a 5-point scale (*1 = strongly disagree/know nothing at all, 5 = strongly agree/know a lot*).

4.2.5 Trust in service/technology providers

For respondents who collected data (*N* = 895), they were asked about their understanding of the arrangement they have with their service/technology provider regarding the data collected through their services, and the trust in them to maintain the privacy of the data.

Understanding of terms and conditions

Overall, the majority (74%) of respondents did not know much about the terms and conditions relating to data collection in their agreement with service providers, with only 9% indicating they had a good understanding of the terms and conditions (see Figure 34). There was variation across industries for this knowledge (see Figure 35). Relative to other industries, respondents from the cotton industry reported the most knowledge, though in absolute terms they indicated they did not know much. Conversely, and relative to other industries, sheep wool and vegetable industries had the least knowledge. The remaining industries showed a stable trend of knowing little about their agreement with the service providers.

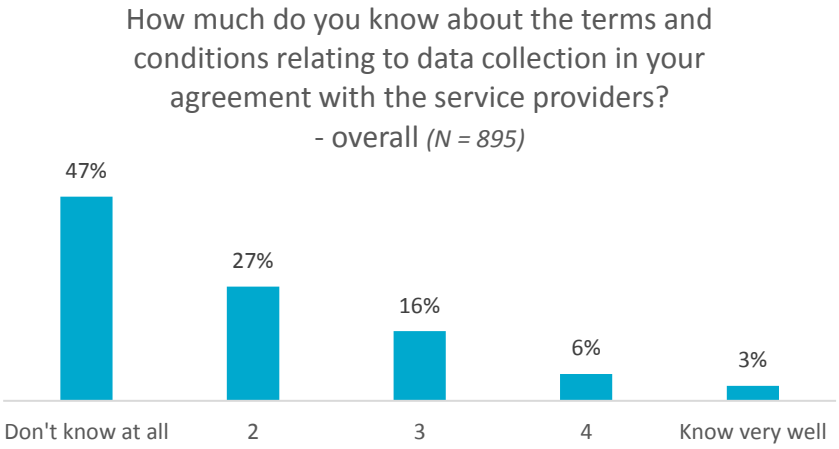


Figure 34. Knowledge of terms and conditions for data collection agreement with service providers

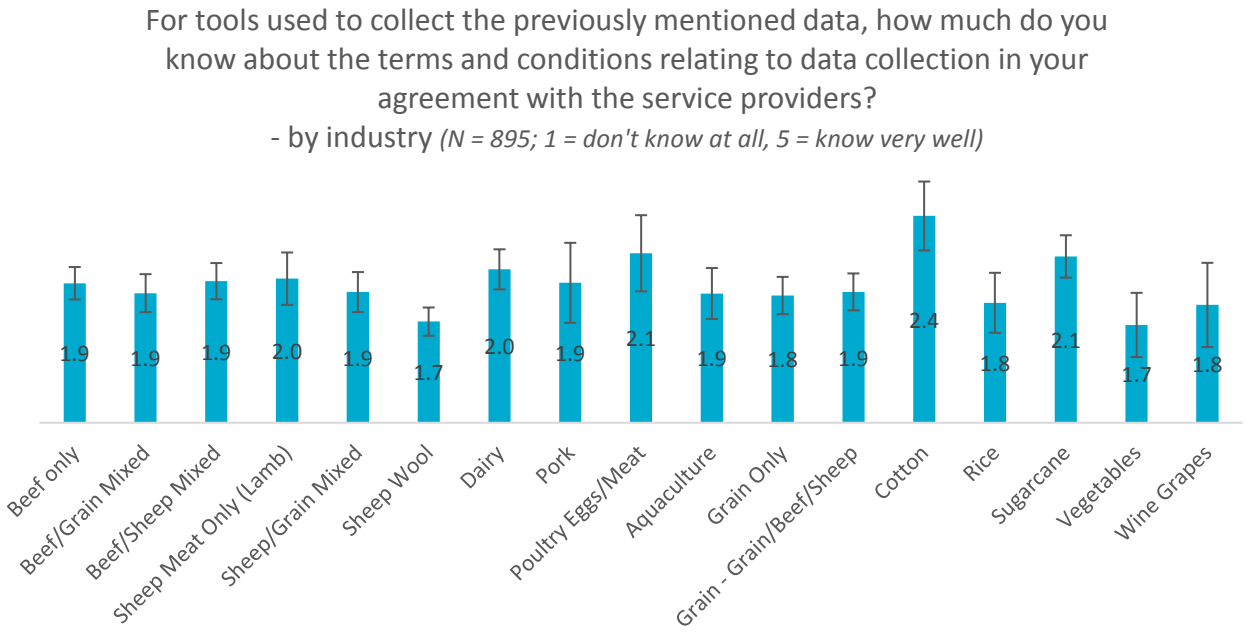


Figure 35. Knowledge of terms and conditions for data collection agreement with service providers by industry

Direct access to data by service/technology providers

Half of the respondents reported they would feel uncomfortable if service/technology providers had direct access to their data through the services they provided them, with only 24% indicating they were comfortable or extremely comfortable (see Figure 36). Again, variation existed across the industries (see Figure 37). In particular, beef/grain mixed and poultry/eggs meat industries were the least comfortable with service/technology providers having direct access to their data. Comparatively, the grain only, rice, wine grape and vegetable industries were the most comfortable.

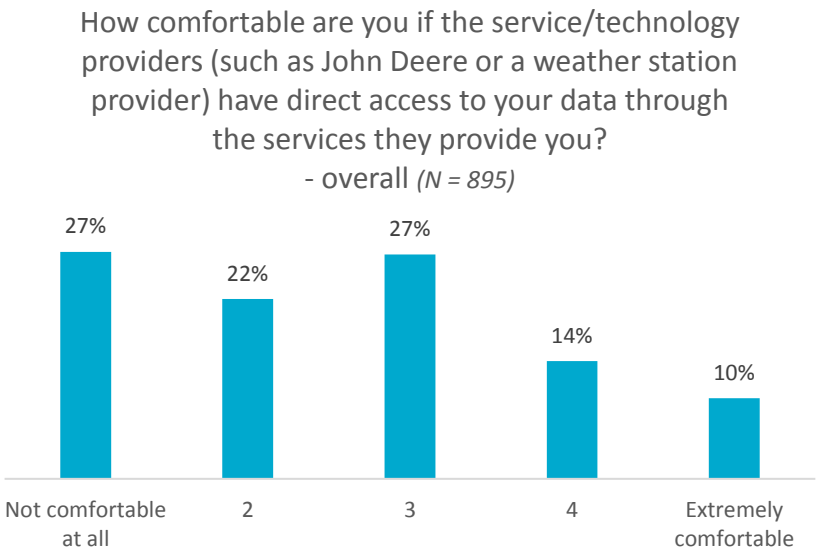


Figure 36. Comfort in service/technology providers having access to producers' data

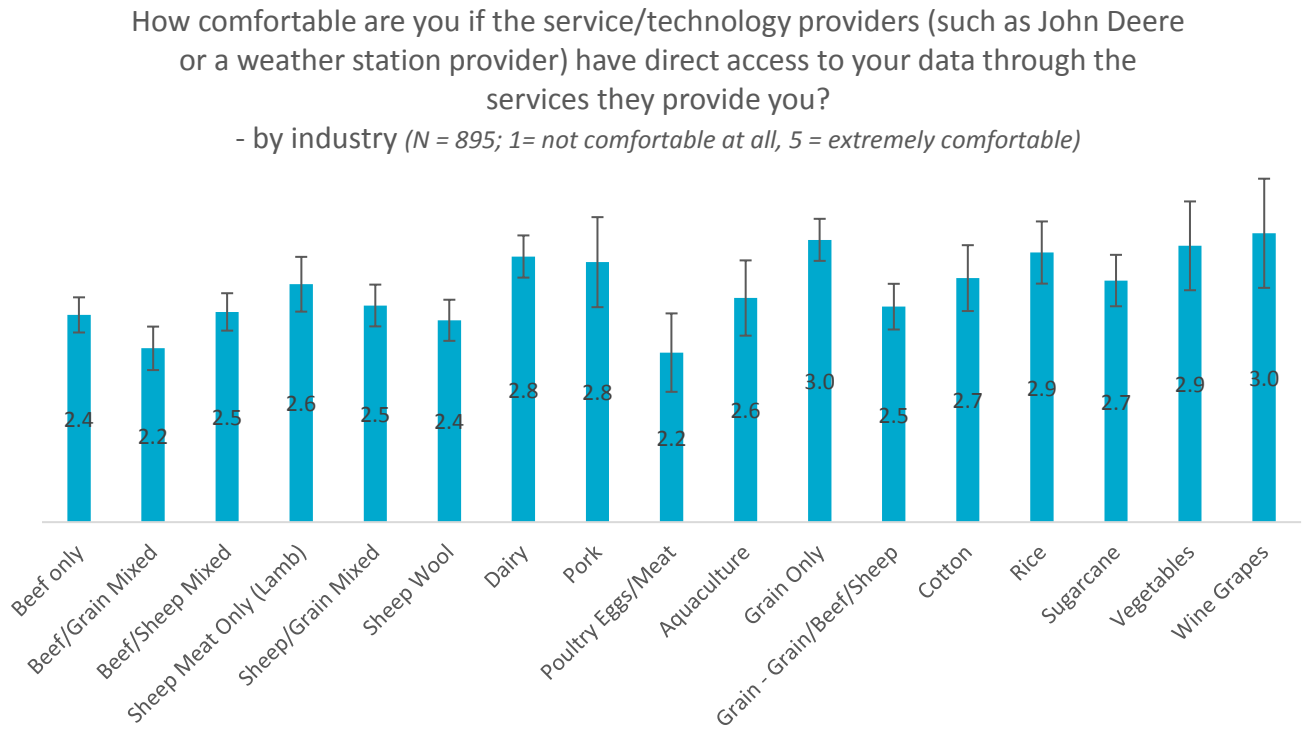


Figure 37. Comfort in service/technology providers having access to producers' data by industry

Trust in service/technology providers maintaining privacy and not sharing producers' data

Overall, if service/technology providers had direct access to respondents' data, more than half (56%) of the respondents displayed no trust at all to little trust in service/technology providers maintaining the privacy of their data, and not to share their data with the third parties (62%) (see Figure 38 and Figure 40, respectively). Comparatively, respondents from the cotton industry showed higher levels of trust (see Figure 39), while those from the poultry eggs/meat reported the lowest (see Figure 41), respectively).

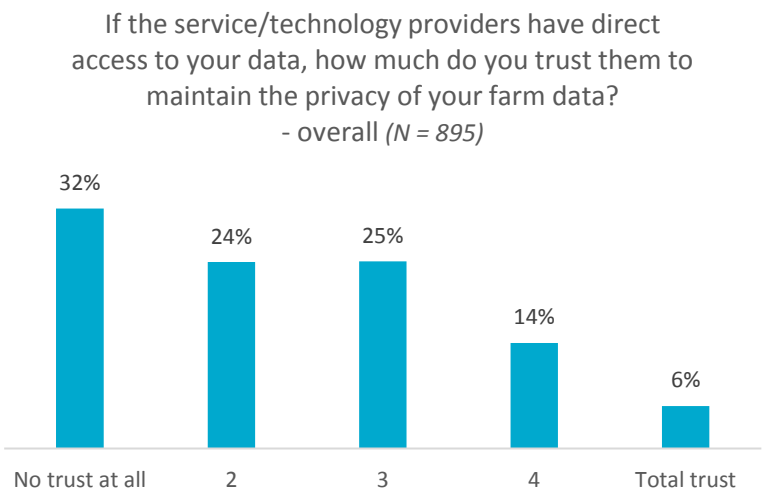


Figure 38. Trust in service/technology providers maintaining privacy of producers' data

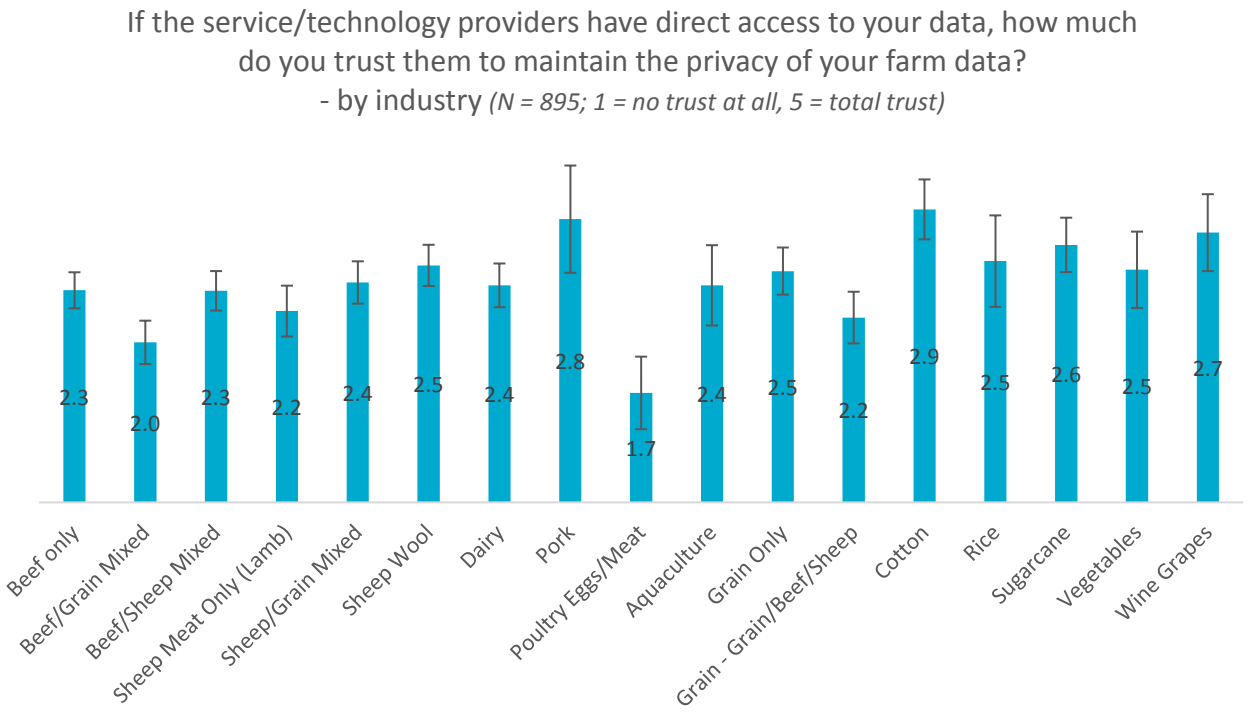


Figure 39. Trust in service/technology providers maintaining privacy of producers' data by industry

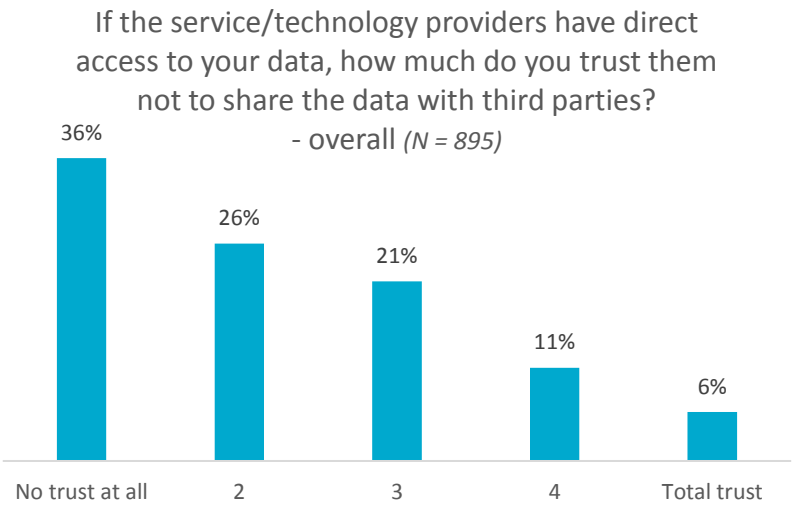


Figure 40. Trust in service/technology providers not sharing producers' data with third parties

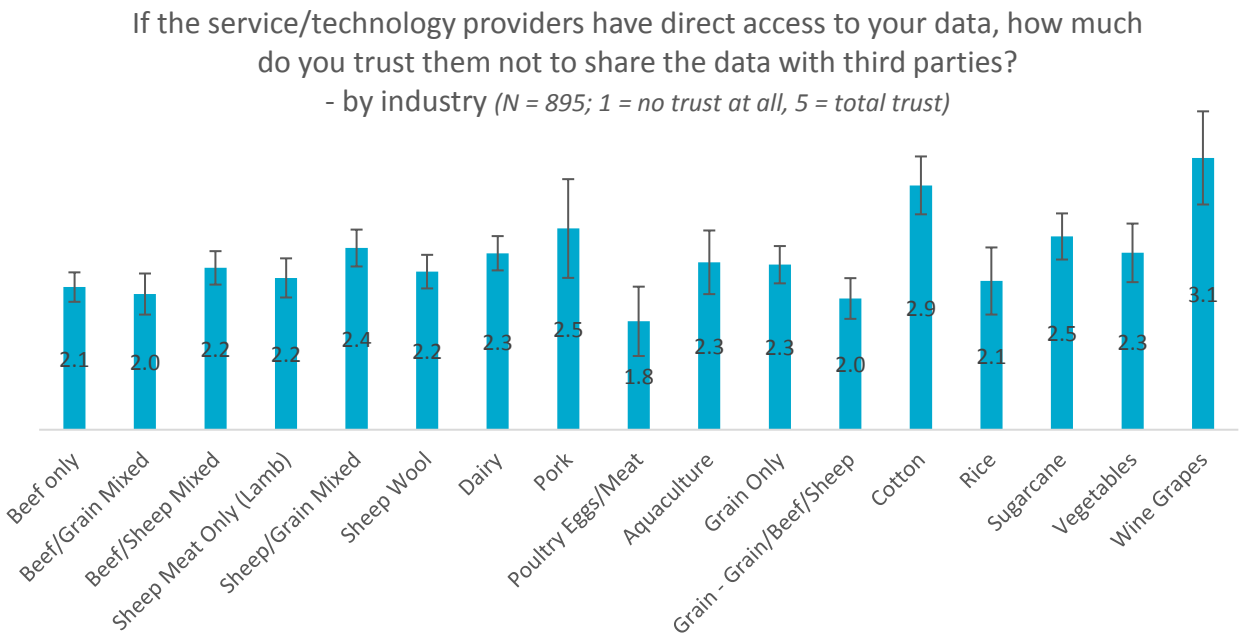


Figure 41. Trust in service/technology providers not sharing producers' data with third parties by industry

Attitude towards profit making by service/technology providers from producers' data

The majority of respondents (67%) did not feel comfortable if service/technology providers used the data to make profits for themselves (see Figure 42). In particular, respondents from aquaculture, poultry, and grain/beef/sheep industries felt the most uncomfortable with service providers making profits from the data (see Figure 43).

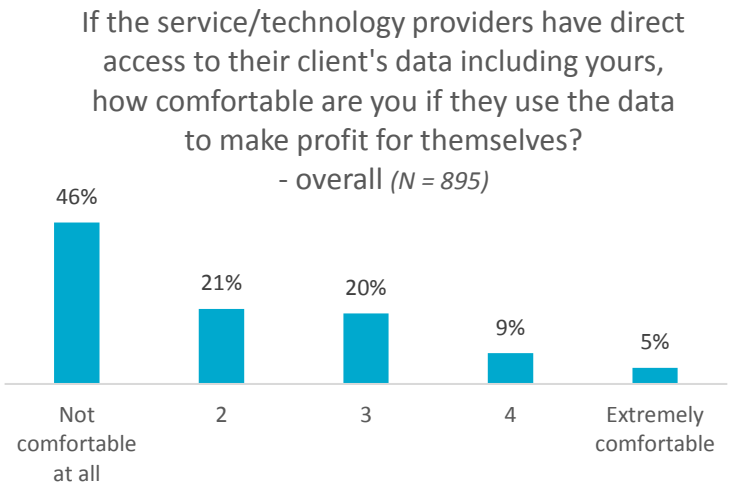


Figure 42. Comfort in service/technology providers using client data to make profit for themselves

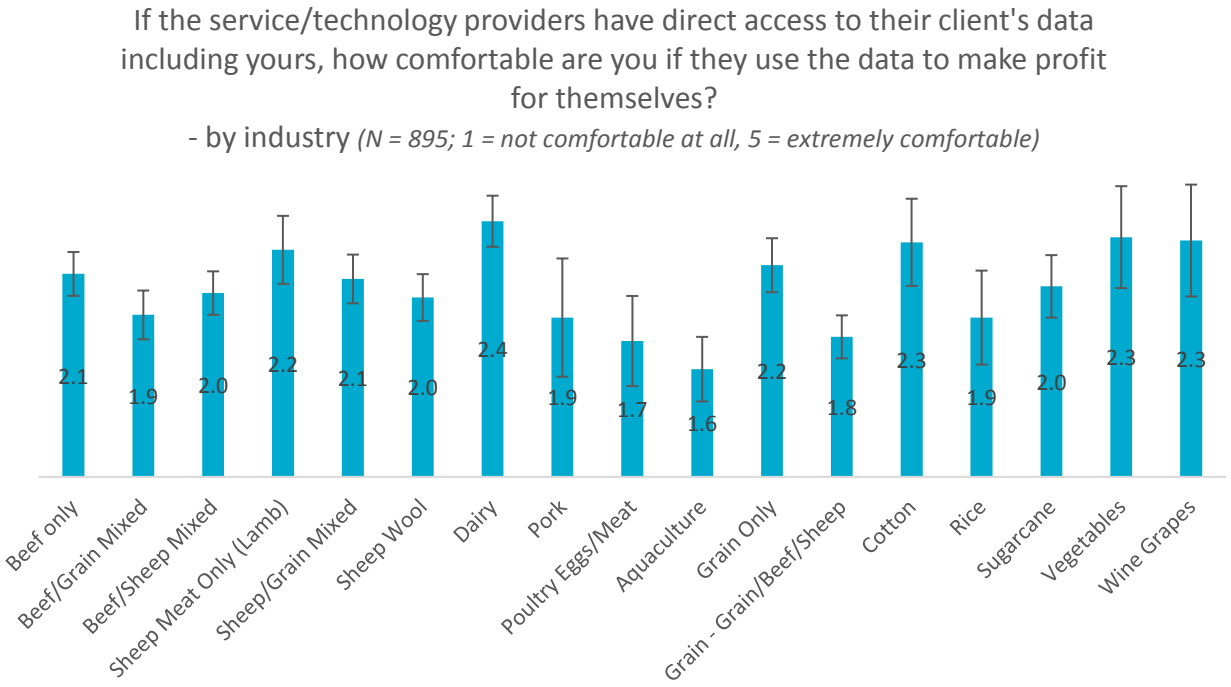


Figure 43. Comfort in service/technology providers using client data to make profit for themselves by industry

4.3 Attitude toward data sharing and concerns about aggregated farm data

The survey explored producers' willingness and concerns about data sharing in the context of *aggregated farm data*. To ensure all correspondents had the same understanding of the concept of aggregated farm data, the following definition was read out to the respondents before their opinions were sought on various questions.

When the data collected from many individual farms are combined together, they can be used to develop tools that support agricultural decision making. This combined data is referred to as "aggregated farm data". For the aggregated farm data to work, it will require individual farms to share their data.

4.3.1 Who will benefit the most from the aggregated farm data?

There was no consensus as to who would benefit most from aggregated farm data. As shown in Figure 44, 34% regarded farmers as the party who would benefit most, another 34% indicated agribusiness, 21% indicated government, and 11% were not sure.

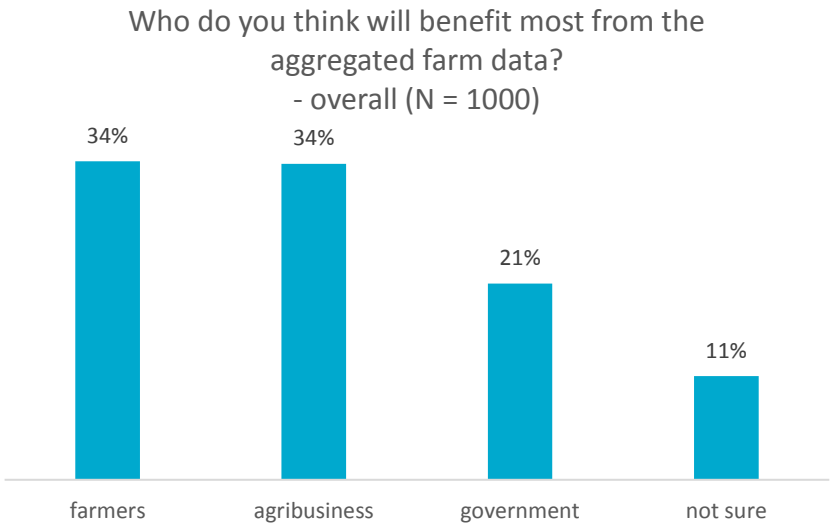


Figure 44. Perceived main beneficiary of aggregated farm data.

There was noticeable variation across the industries as to who would benefit most from aggregated farm data. Comparatively, a greater proportion of aquaculture, cotton, and rice industry respondents thought farmers would benefit the most (see Figure 45); a greater proportion of respondents from grain mixed and beef/sheep mixed industries thought agribusiness would benefit most (see Figure 46); a greater proportion of respondents from beef only and sheep wool industries believed the government would benefit most (see Figure 47); and a greater proportion of respondents from the poultry industry were not sure who would benefit most (see Figure 48).

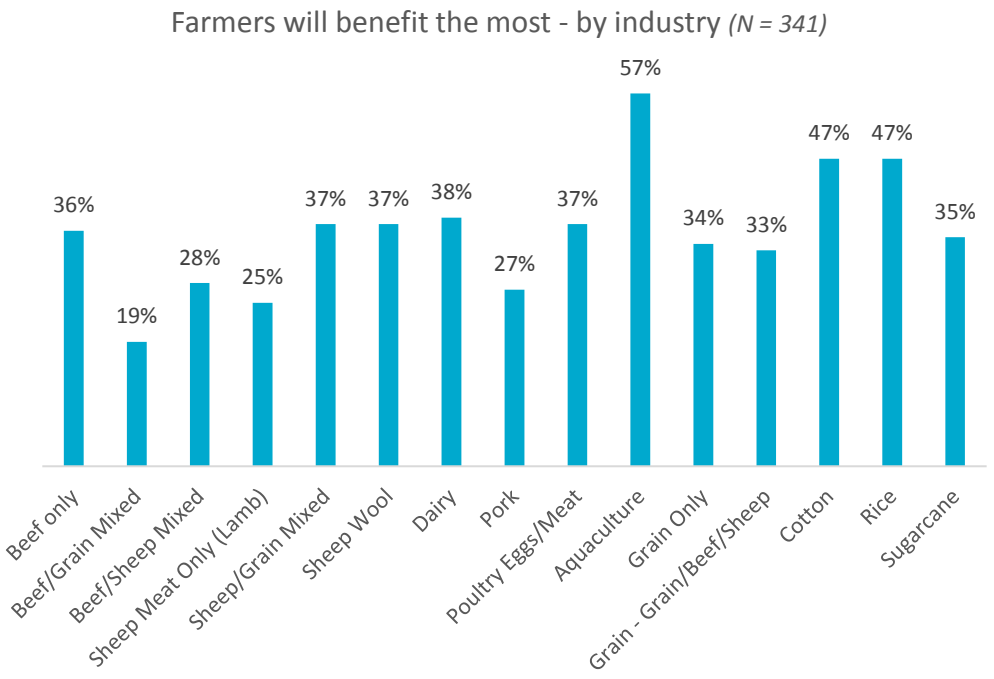


Figure 45. Farmers as perceived main beneficiary of aggregated farm data by industry

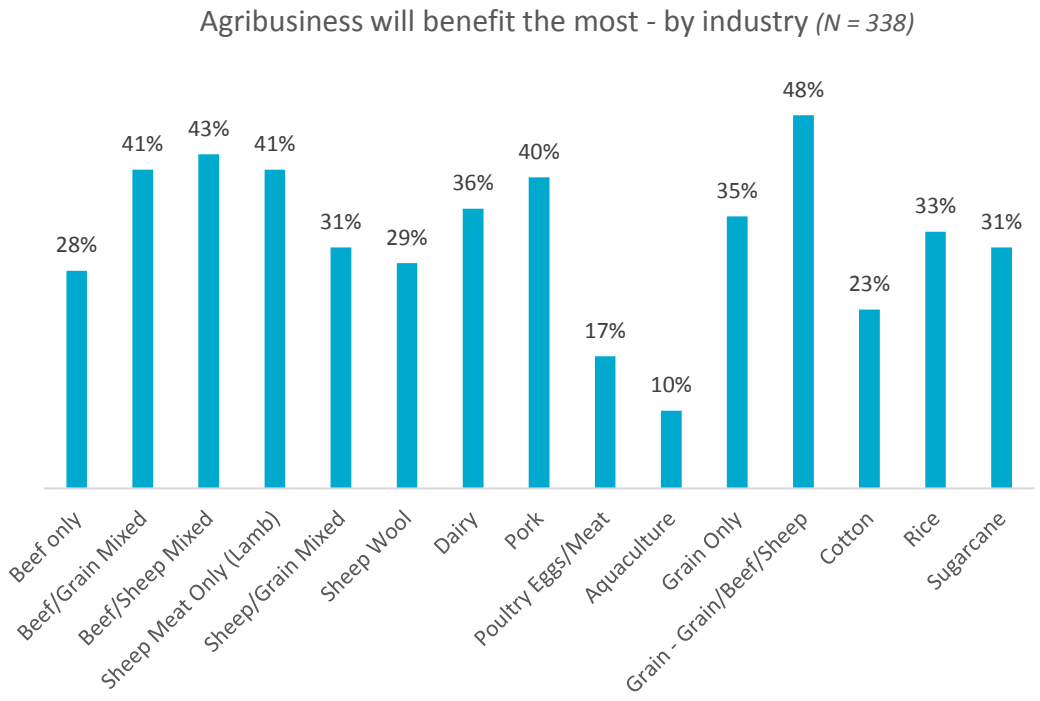


Figure 46. Agribusiness as perceived main beneficiary of aggregated farm data by industry

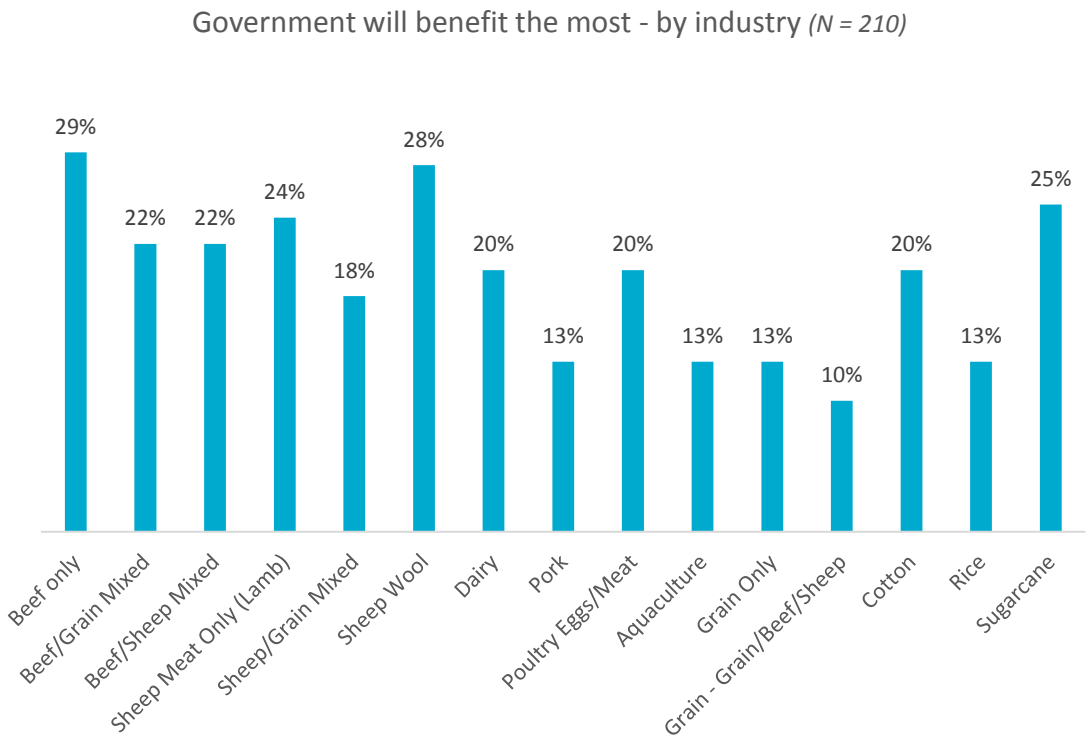


Figure 47. Government as perceived main beneficiary of aggregated farm data by industry

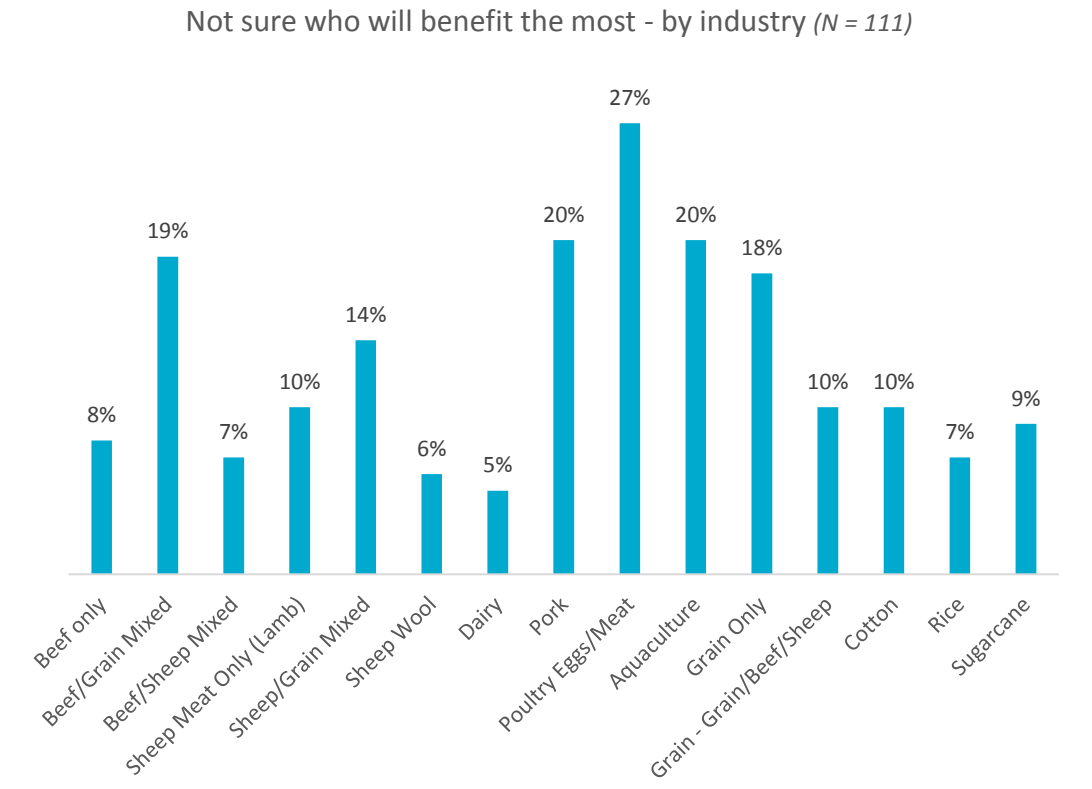


Figure 48. Not sure of perceived main beneficiary of aggregated farm data by industry

4.3.2 Willingness to share data in the aggregated farm data

This section explores producers' willingness to share various types of data (i.e., weather station data, soil test data, farm input data, and production data) with other farmers, agricultural industry-based organisations, technology and service providers, research institutions, and the Australian Bureau of Statistics (ABS).

Weather station data

Overall, respondents were highly comfortable sharing weather station data with the five actors (see Figure 49). In particular, respondents were most comfortable sharing these data with other farmers, but least comfortable sharing with technology and service provider businesses. However, there was variation across industries in the willingness to share weather station data for the five actors.

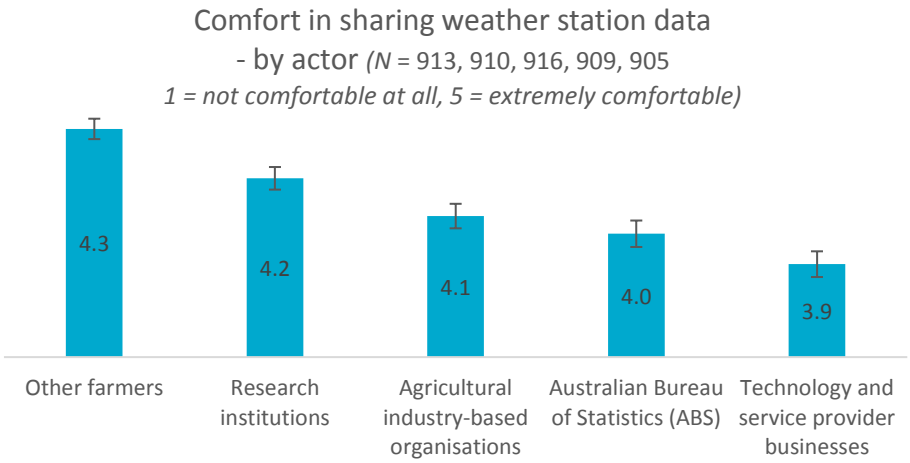


Figure 49. Comfort in sharing weather station data with actors

Sharing with other farmers

As shown in Figure 50, 83% of respondents were comfortable or extremely comfortable sharing weather station data with other farmers, with only 3% being not comfortable at all.

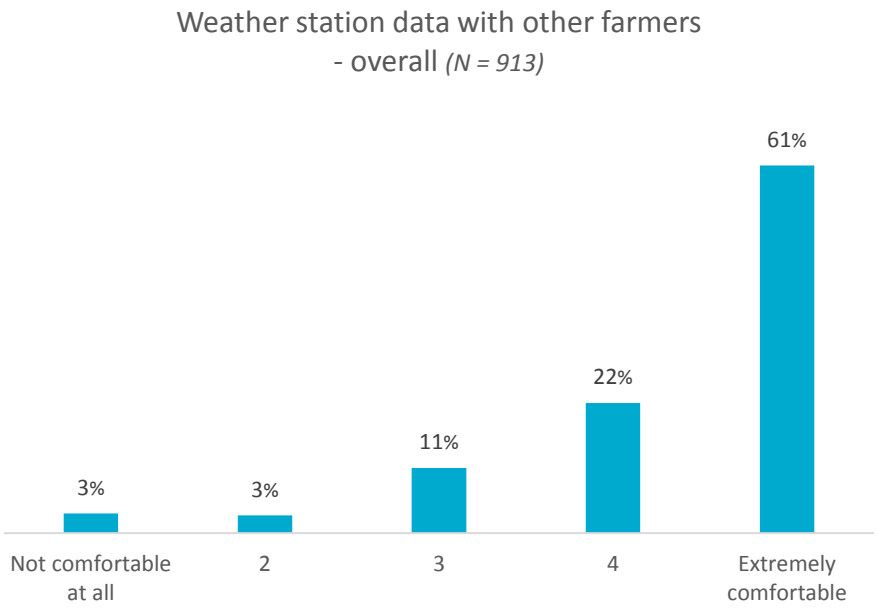


Figure 50. Comfort in sharing weather station data with other farmers

As shown in Figure 51, vegetable, wine grapes, cotton, and grain only industries felt most comfortable sharing weather station data with other farmers. Comparatively, beef only, sheep meat, sheep wool, and sugarcane industries were least comfortable, though in absolute terms still indicted a high degree of willingness to share.

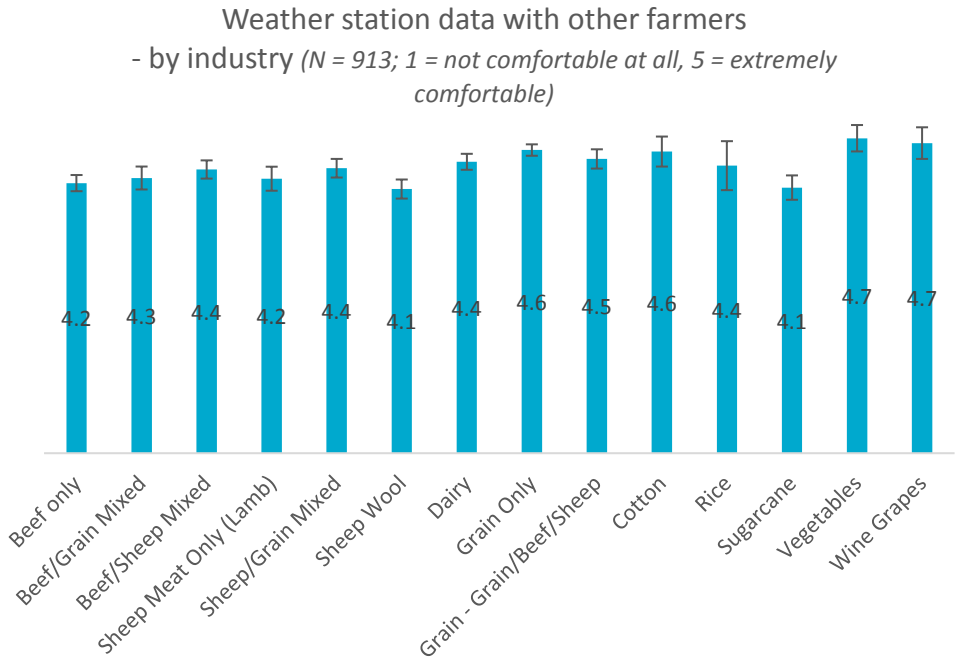


Figure 51. Comfort in sharing weather station data with other farmers by industry

Sharing with agricultural industry-based organisations

As shown in Figure 52, 75% of respondents were comfortable or extremely comfortable sharing weather station data with agricultural industry-based organisations, with only 7% not comfortable at all.

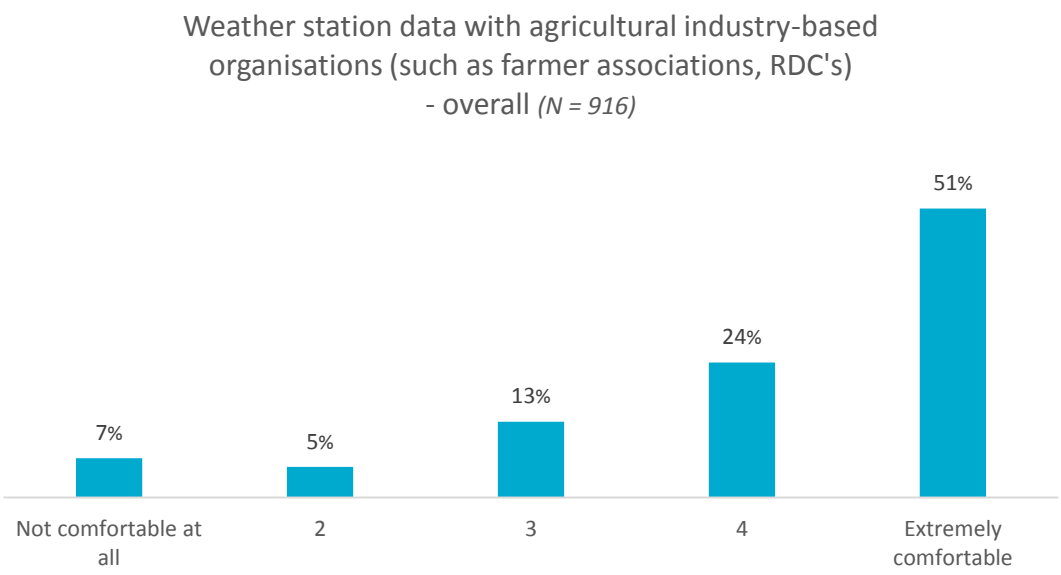


Figure 52. Comfort in sharing weather station data with agricultural industry-based organisations

As shown in Figure 53, cotton, vegetable, and wine grapes industries were extremely comfortable sharing weather station data with agricultural industry-based organisations. In absolute terms, the remaining industries were still highly comfortable sharing these data.

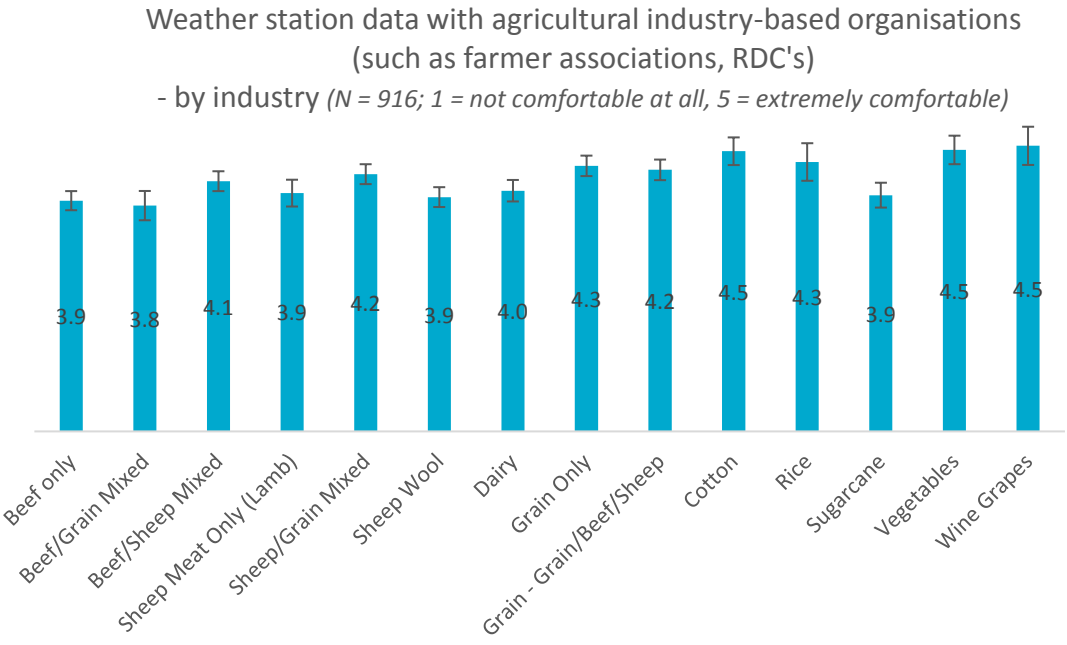


Figure 53. Comfort in sharing weather station data with agricultural industry-based organizations by industry

Sharing with technology and service provider businesses

As shown in Figure 54, 67% of respondents were comfortable or extremely comfortable sharing weather station data with technology and service provider businesses, with only 8% not comfortable at all.

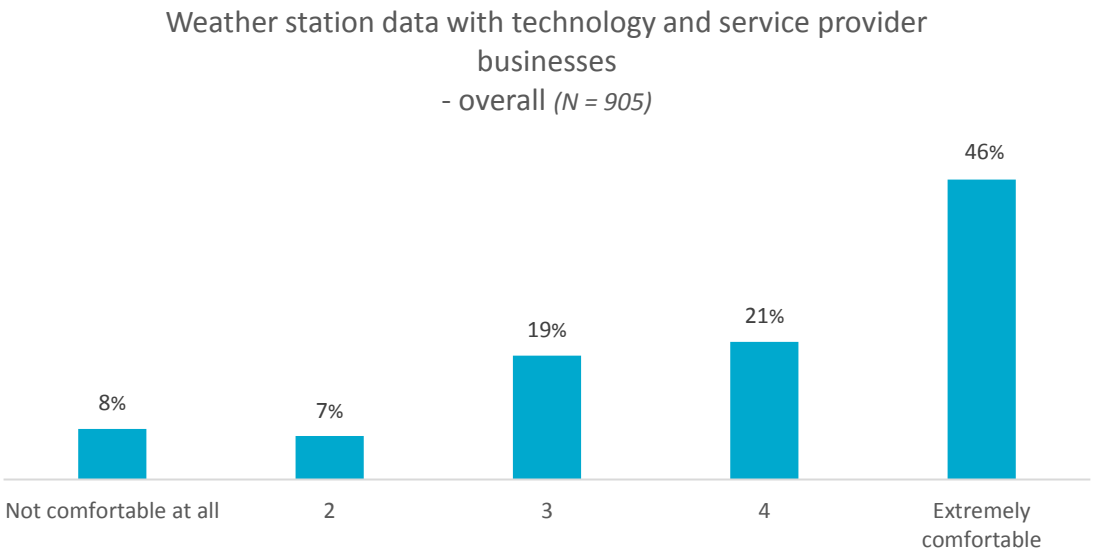


Figure 54. Comfort in sharing weather station data with technology and service provider businesses

As shown in Figure 55, cotton, wine grape, and grain only industries were highly comfortable sharing weather station data with technology and service provider businesses. Comparatively, the least comfortable were the beef/grain mixed, sheep wool and beef only industries, although they were still comfortable sharing these data.

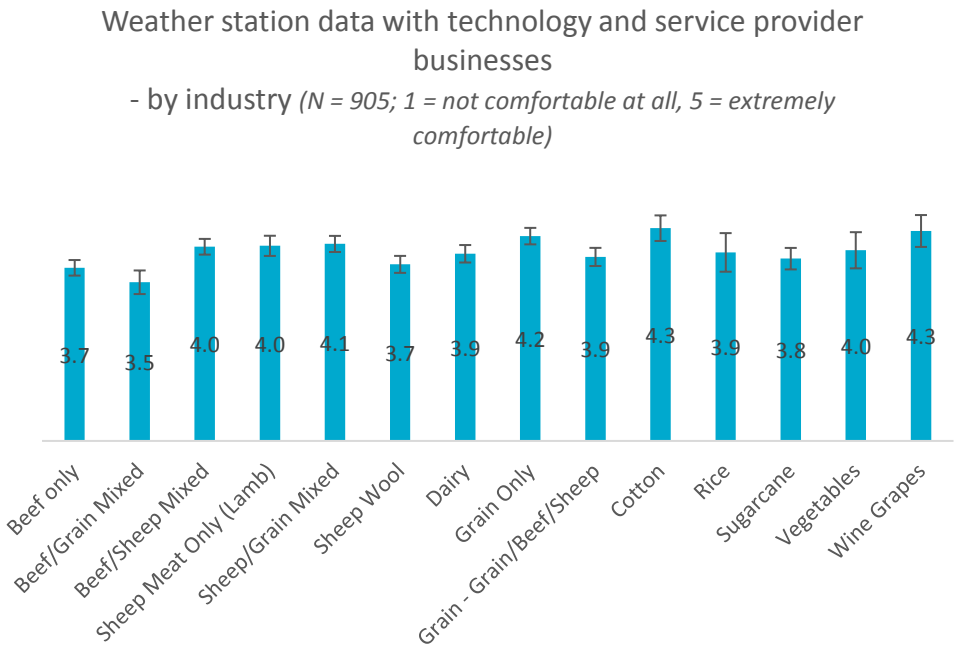


Figure 55. Comfort in sharing weather station data with service/technology provider businesses by industry

Sharing with research institutions

As shown in Figure 56, 78% of respondents were comfortable or extremely comfortable sharing weather station data with research institutions, with only 5% not comfortable at all.

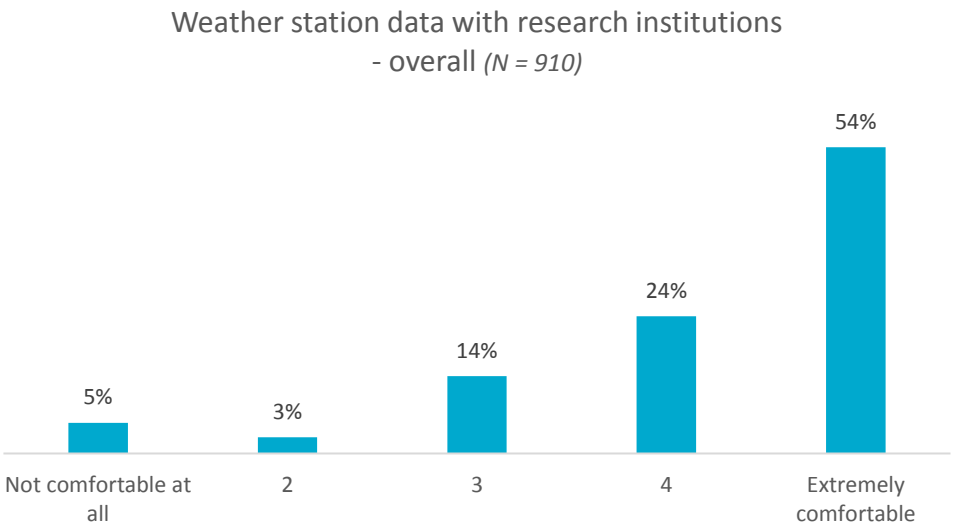


Figure 56. Comfort in sharing weather station data with research institutions

As shown in Figure 57, most industries were highly comfortable sharing weather station data with research institutions. Comparatively, the least comfortable were the sugarcane and beef/grain mixed industries, although in absolute terms their responses still indicated they were quite comfortable sharing these data.

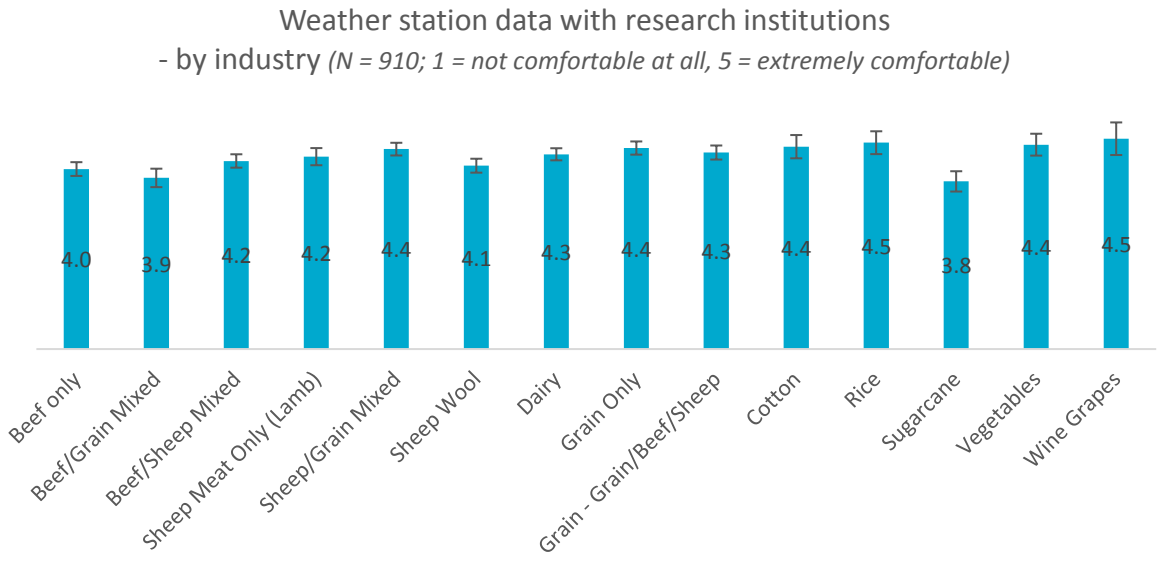


Figure 57. Comfort in sharing weather station data with research institutions by industry

Sharing with Australian Bureau of Statistics (ABS)

As shown in Figure 58, 72% of respondents were comfortable or extremely comfortable sharing weather station data with the ABS, with only 9% not comfortable at all.

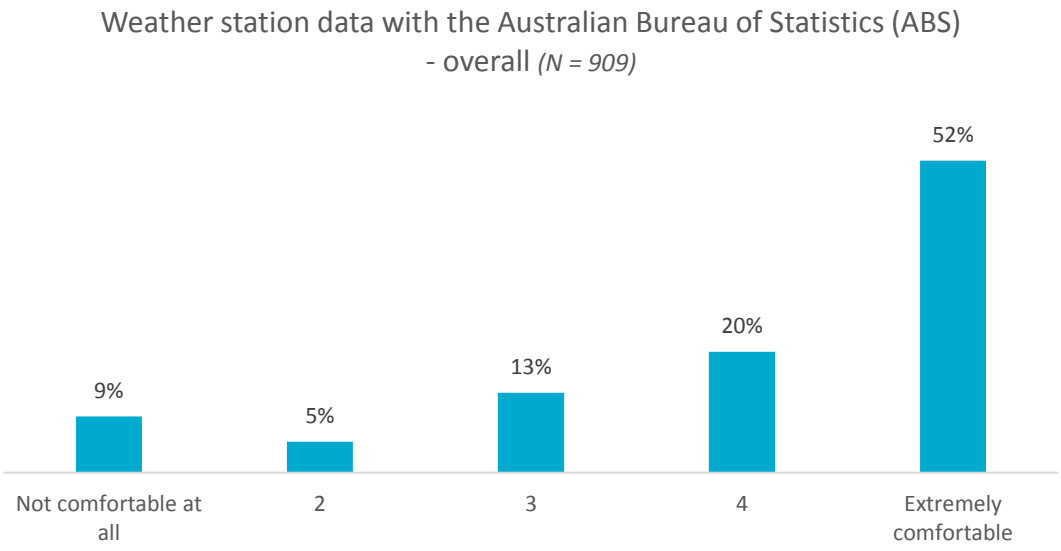


Figure 58. Comfort in sharing weather station data with the Australian Bureau of Statistics (ABS)

As shown in Figure 59, wine grapes, cotton, and vegetable industries were extremely comfortable sharing weather station data with the ABS. Comparatively, the least comfortable were the beef/grain mixed, sheep meat, beef only, and sugarcane industries, although in absolute terms their responses still indicated they were comfortable sharing these data.

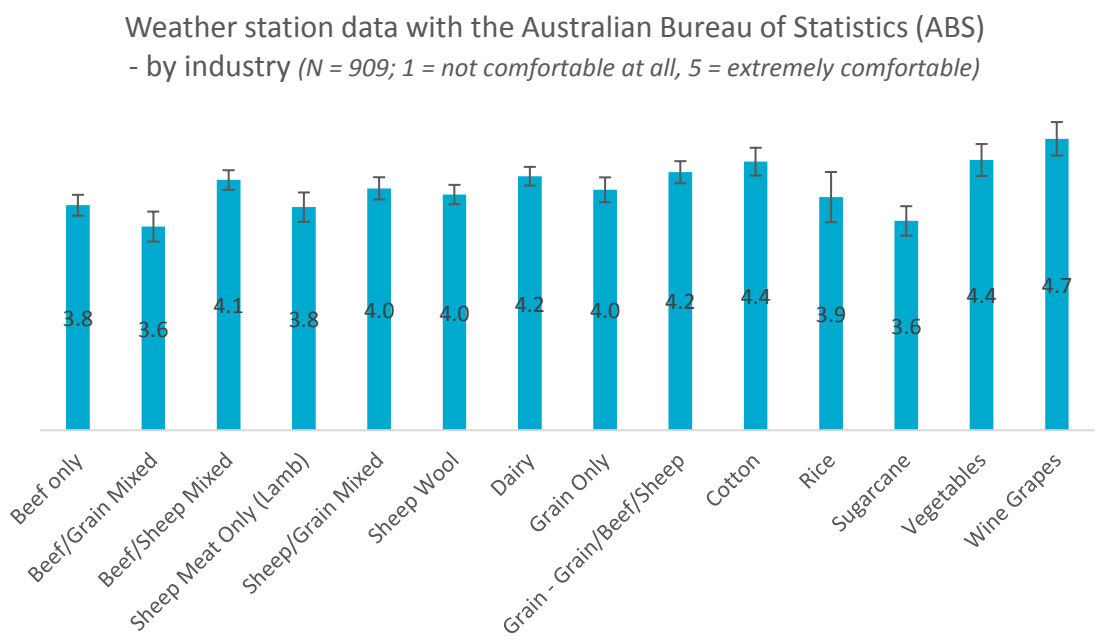


Figure 59. Comfort in sharing weather station data with the Australian Bureau of Statistics (ABS) by industry

Soil test data

Overall, respondents were highly comfortable sharing soil test data with the five actors (see Figure 60). In particular, respondents were most comfortable sharing these data with other farmers, agricultural industry-based organisations, and research institutions. Comparatively,

respondents are least comfortable sharing these data with technology and service provider businesses.

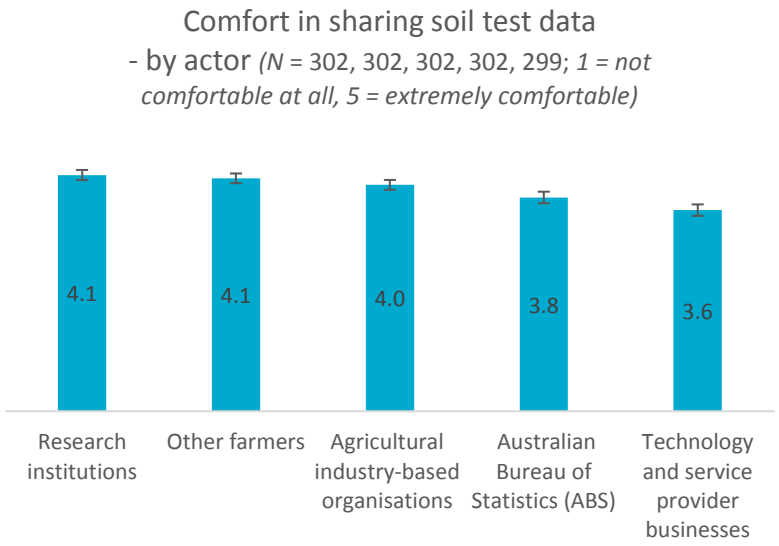


Figure 60. Comfort in sharing soil test data with actors

Sharing with other farmers

As shown in Figure 61, 73% of respondents were comfortable or extremely comfortable sharing soil test data with other farmers, with only 4% not comfortable at all.

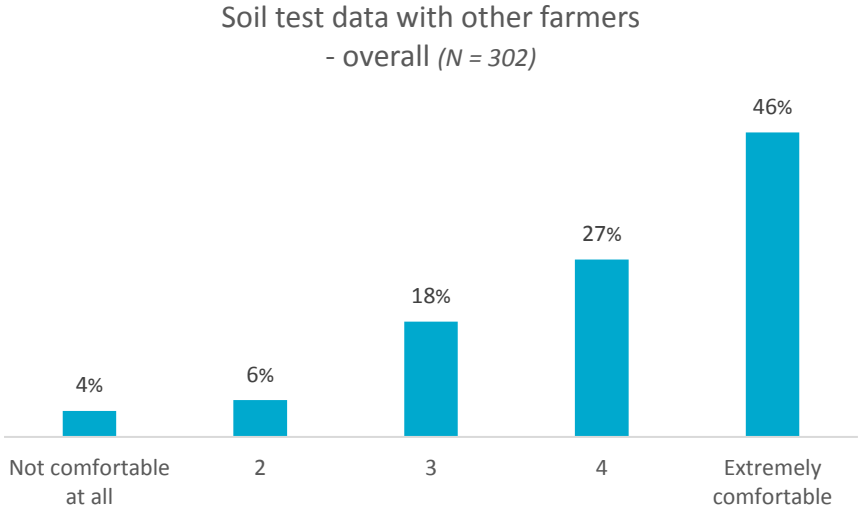


Figure 61. Comfort in sharing soil test data with other farmers

As shown in Figure 62, rice, wine grapes, and vegetable industries were most comfortable sharing soil test data with other farmers. The remaining industries showed a stable pattern of also being highly comfortable sharing these data with other farmers.

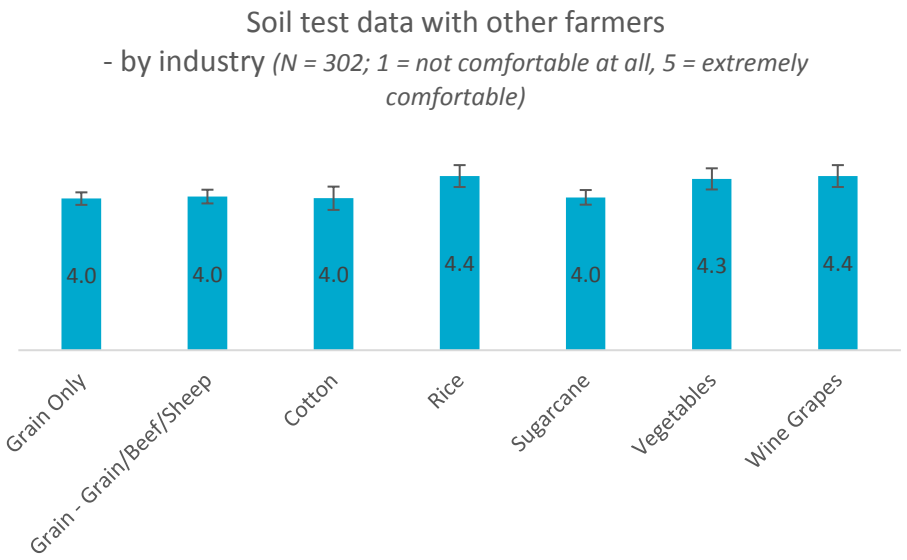


Figure 62. Comfort in sharing soil test data with other farmers by industry

Sharing with agricultural industry-based organisations

As shown in Figure 63, 71% of respondents were comfortable or extremely comfortable sharing soil test data with agricultural industry-based organisations, with only 5% not comfortable at all.

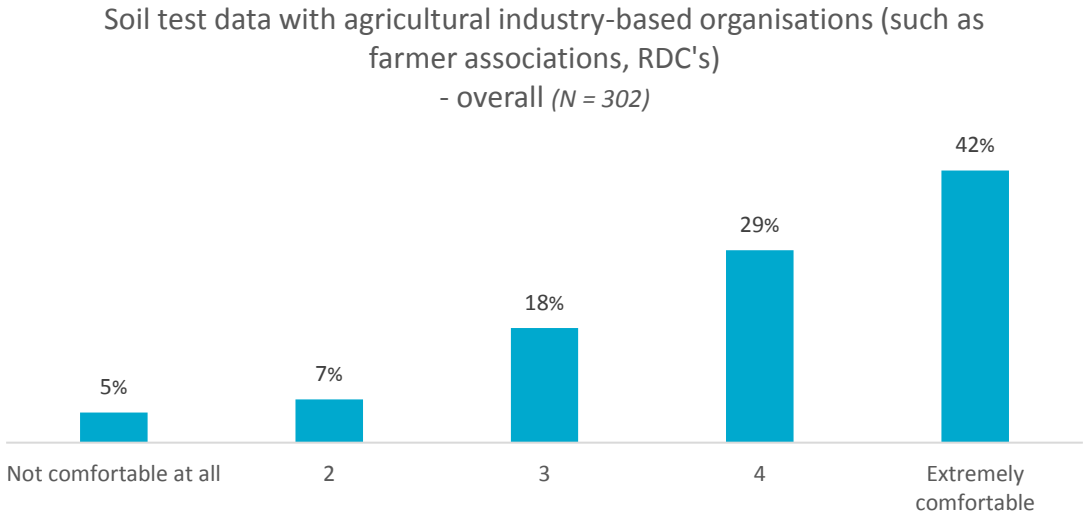


Figure 63. Comfort in sharing soil test data with agricultural industry-based organisations

As shown in Figure 64, rice, wine grapes, cotton, and vegetable industries were most comfortable sharing soil test data with agricultural industry-based organisations. Comparatively, the least comfortable were the grain only, grain (grain/beef/sheep), and sugarcane industries; however, in absolute terms they were still comfortable sharing.

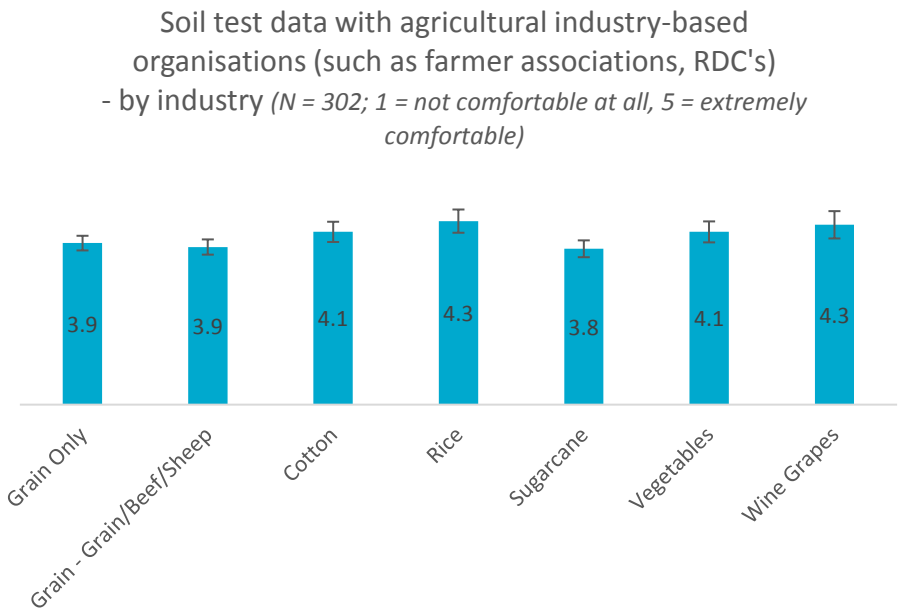


Figure 64. Comfort in sharing soil test data with agricultural industry-based organizations by industry

Sharing with technology and service provider businesses

As shown in Figure 65, 57% of respondents were comfortable or extremely comfortable sharing soil test data with technology and service provider businesses, with only 10% not comfortable at all.

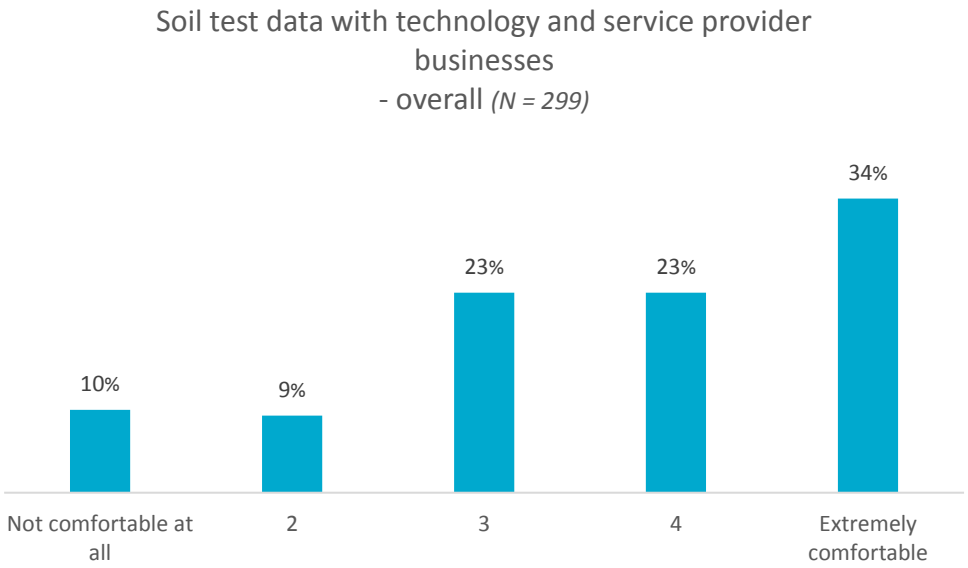


Figure 65. Comfort in sharing soil test data with technology and service provider businesses

As shown in Figure 66, the wine grapes industry was most comfortable sharing soil test data with technology and service provider businesses. Comparatively, the least comfortable in sharing with technology and service provider businesses was the cotton industry.

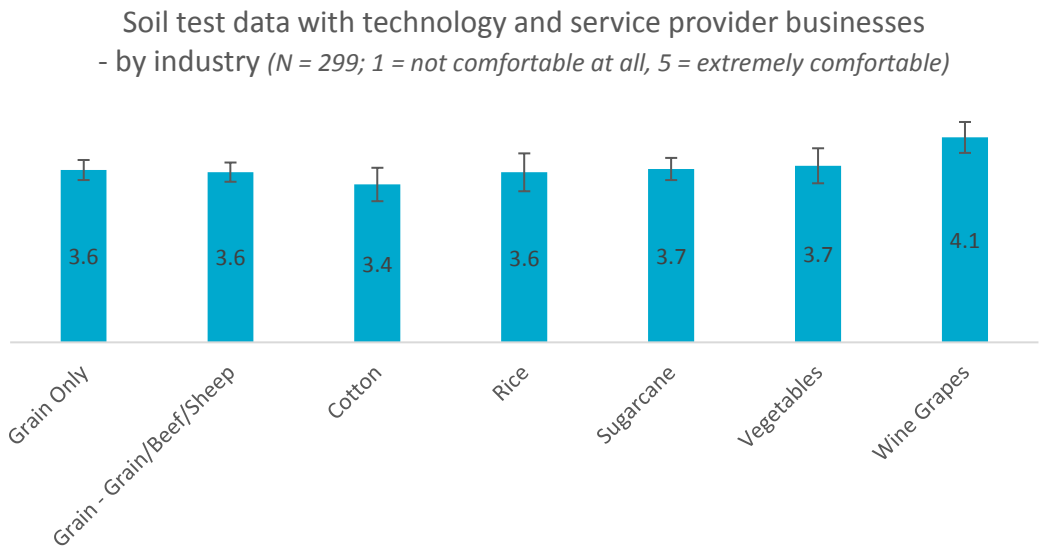


Figure 66. Comfort in sharing soil test data with service/technology businesses by industry

Sharing with research institutions

As shown in Figure 67, 75% of respondents were comfortable or extremely comfortable sharing soil test data with research institutions, with only 5% not comfortable at all.

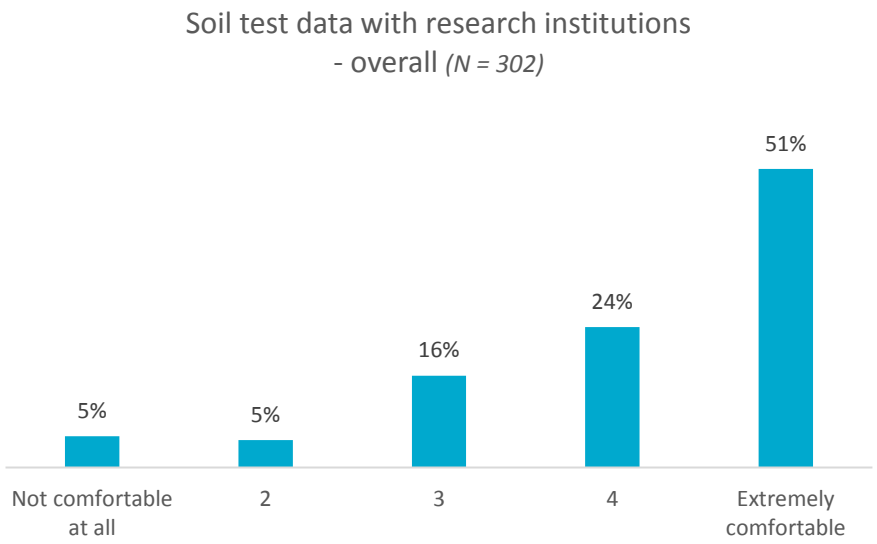


Figure 67. Comfort in sharing soil test data with research institutions

As shown in Figure 68, the rice and wine grapes industries were highly comfortable in sharing soil test data with research institutions. Comparatively, the least comfortable sharing these data was the sugarcane industry. The remaining industries were quite comfortable sharing these data with research institutions.

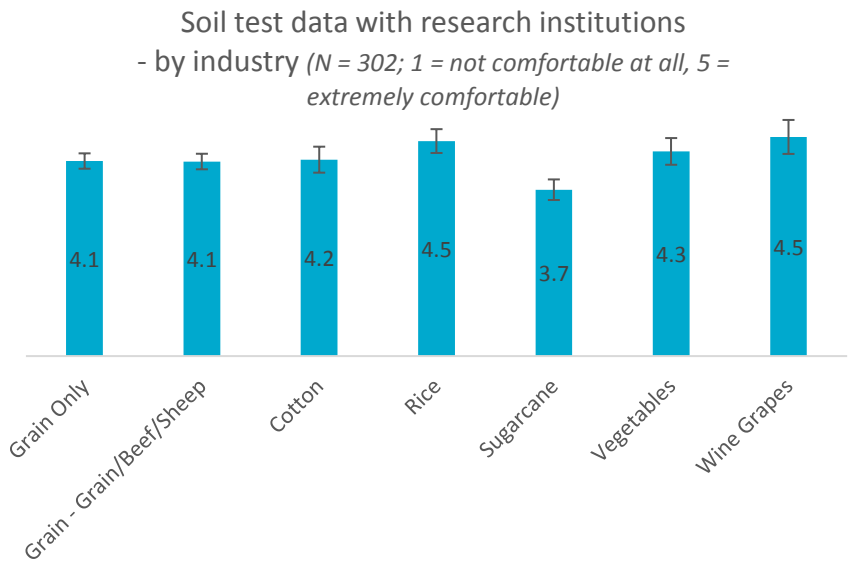


Figure 68. Comfort in sharing soil test data with research institutions by industry

Sharing with Australian Bureau of Statistics (ABS)

As shown in Figure 69, 63% of respondents were comfortable or extremely comfortable sharing soil test data with the ABS, with only 10% not comfortable at all.

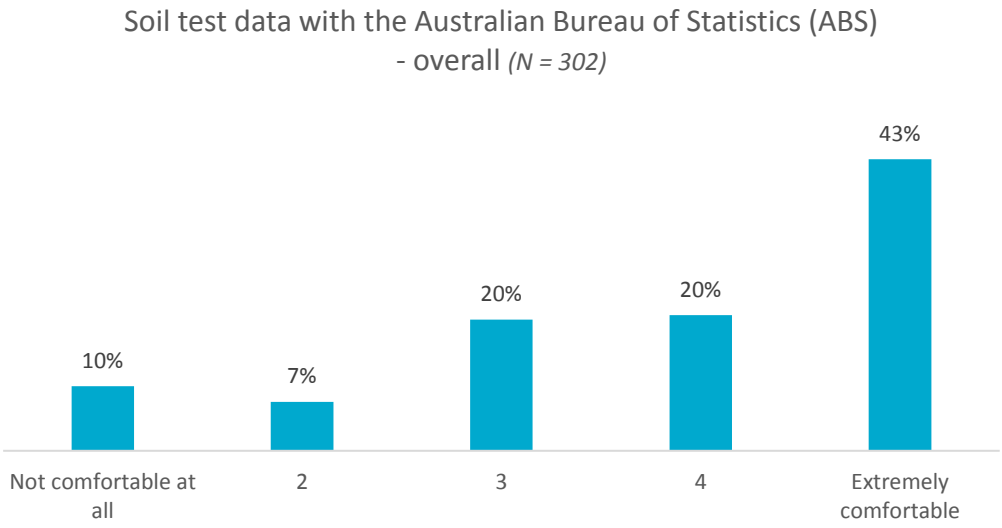


Figure 69. Comfort in sharing soil test data with the Australian Bureau of Statistics (ABS)

As shown in Figure 70, wine grapes and vegetable industries were most comfortable sharing soil test data with the ABS. Comparatively, the sugarcane industry was least comfortable, although in absolute terms they still indicated comfort sharing these data.

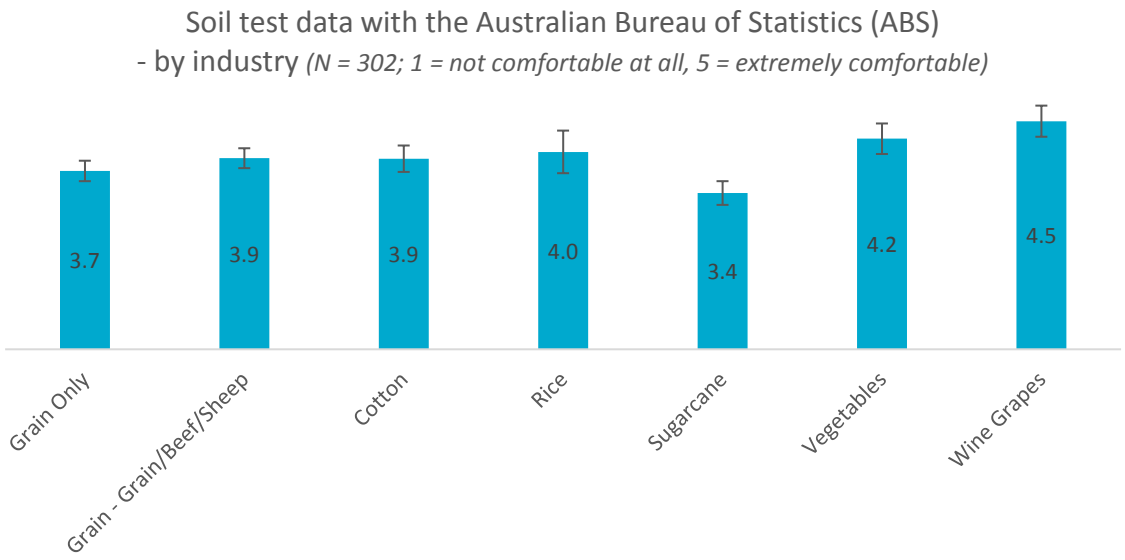


Figure 70. Comfort in sharing soil test data with the Australian Bureau of Statistics (ABS) by industry

Farm input data

Overall, respondents were comfortable sharing farm input data (such as fertilisers and pesticides application) with the five actors (see Figure 71). In particular, respondents were most comfortable sharing these data with other farmers and research institutions, and comparatively least comfortable sharing with technology and service provider businesses.

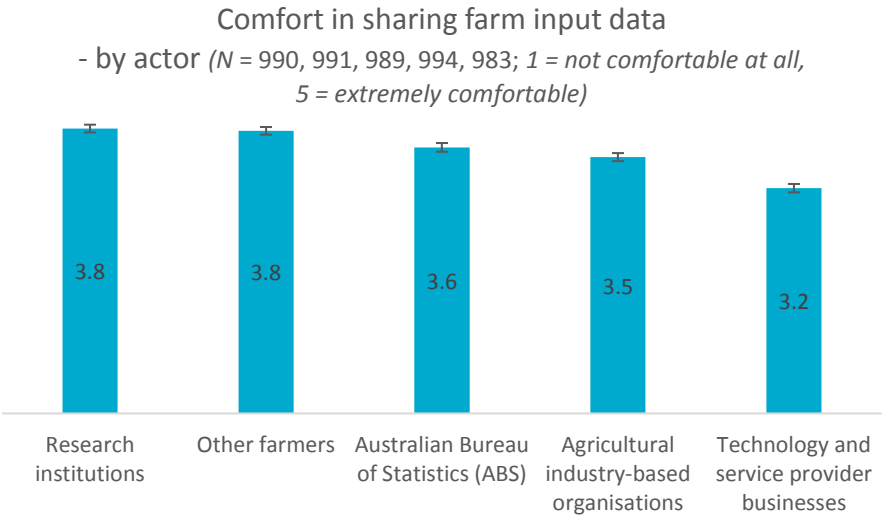


Figure 71. Comfort in sharing farm input data with actors

Sharing with other farmers

As shown in Figure 72, 67% of respondents were comfortable or extremely comfortable sharing farm input data with other farmers, with only 7% not comfortable at all.

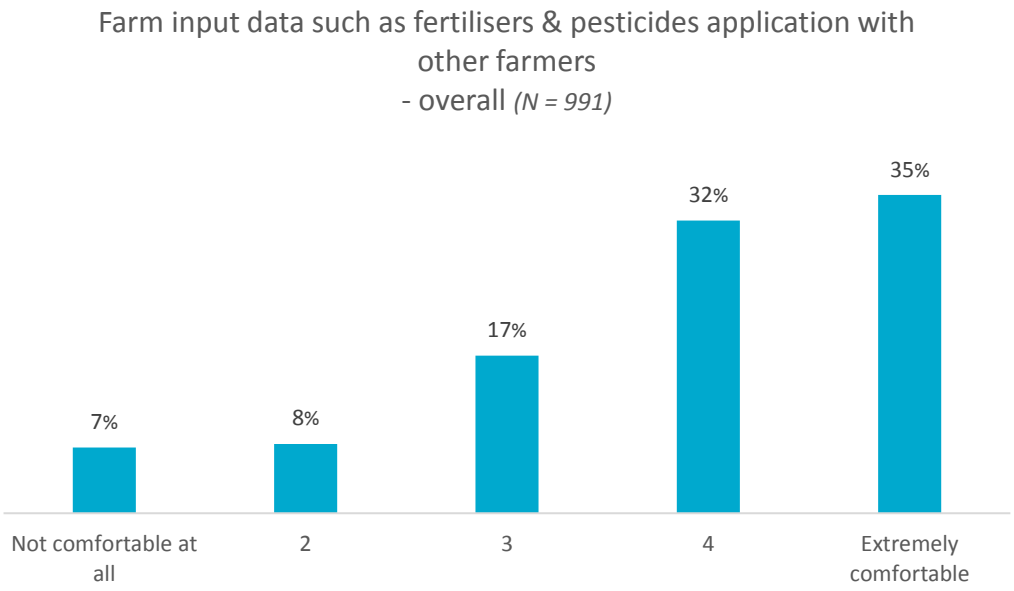


Figure 72. Comfort in sharing farm input data with other farmers

As shown in Figure 73, there was noticeable variation across industries. Comparatively, dairy, rice, and wine grapes industries were most comfortable sharing farm input data with other farmers, while poultry eggs/meat, aquaculture, and grain only industries were least comfortable. The remaining industries were comfortable sharing these data.

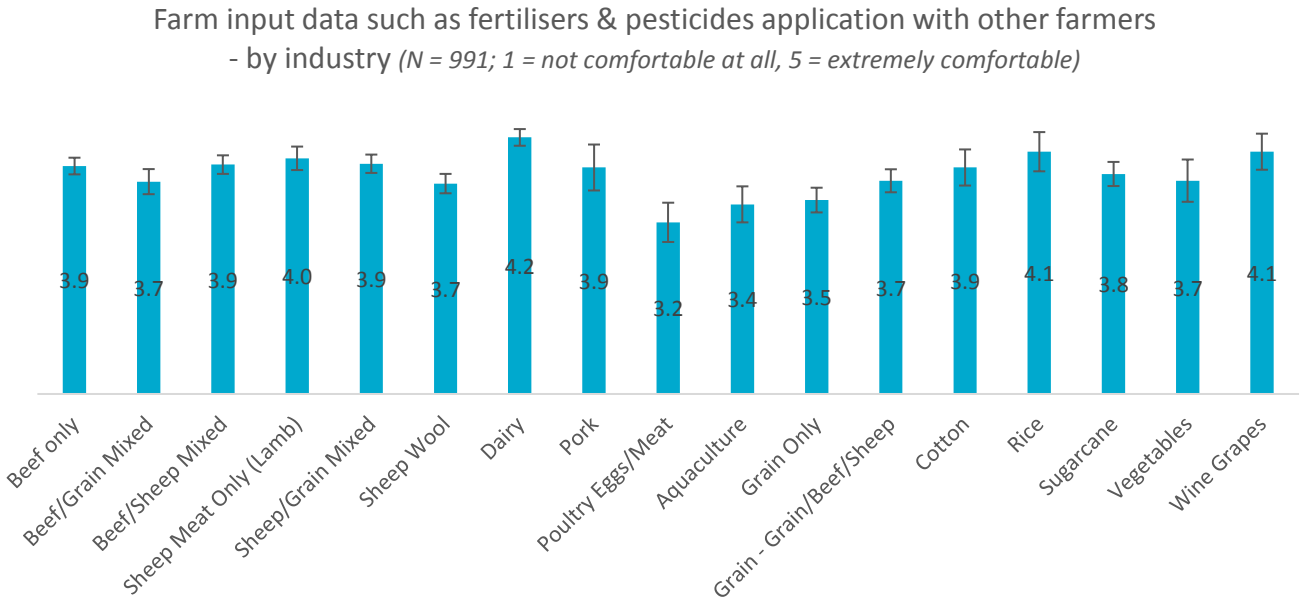


Figure 73. Comfort in sharing farm input data with other farmers by industry

Sharing with agricultural industry-based organisations

As shown in Figure 74, 58% of respondents were comfortable or extremely comfortable sharing farm input data with agricultural industry-based organisations, with only 10% not comfortable at all.

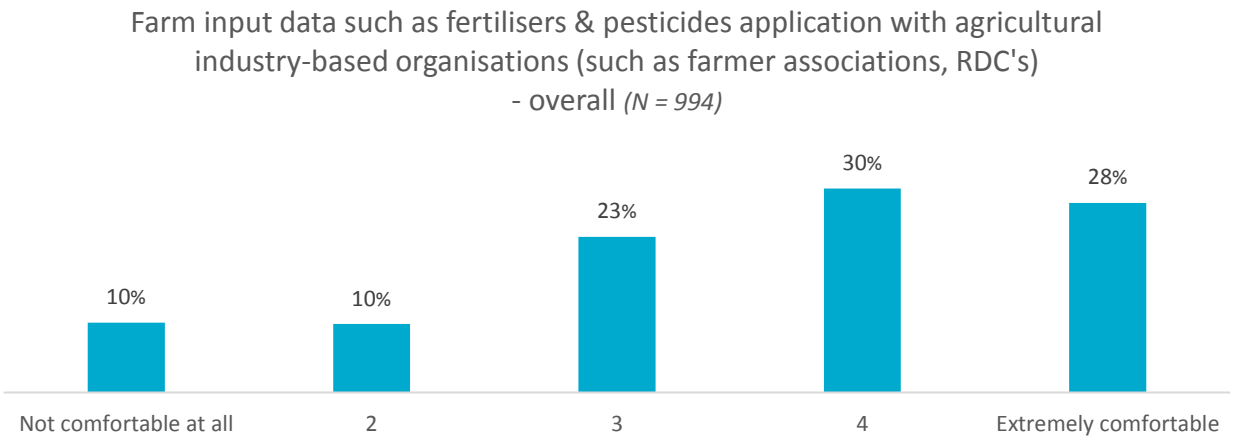


Figure 74. Comfort in sharing farm input data with agricultural industry-based organisations

As shown in Figure 75, rice and wine grapes industries were most comfortable sharing farm input data with agricultural industry-based organisations. Comparatively, the least comfortable in sharing these data was the poultry eggs/meat industry. The remaining industries were slightly comfortable sharing these data.

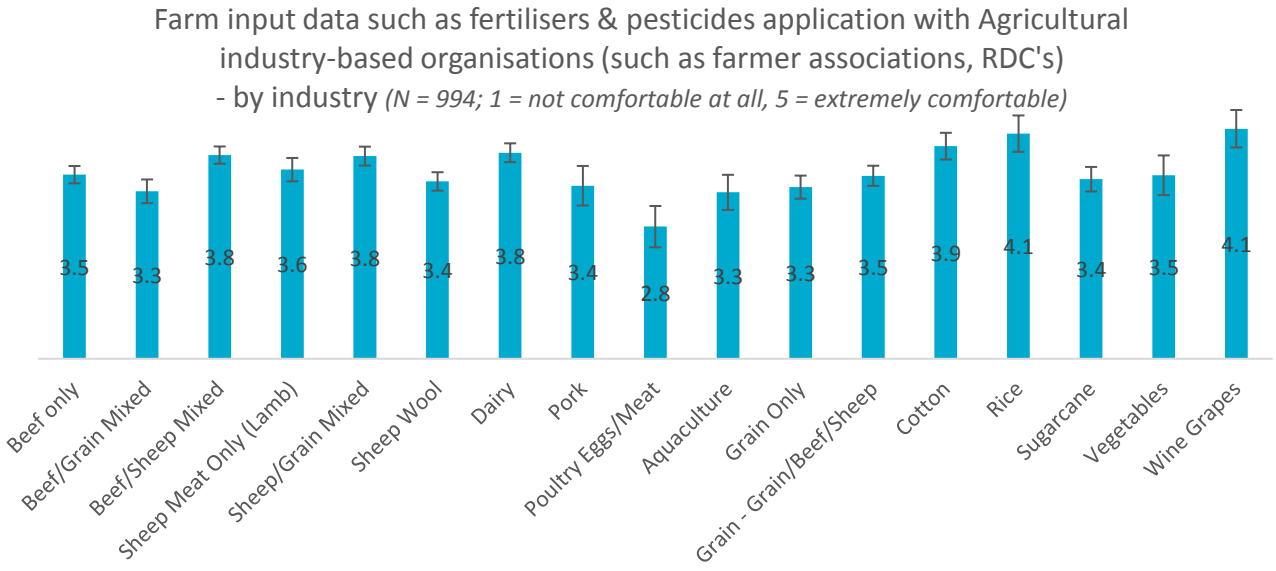


Figure 75. Comfort in sharing farm input data with agricultural industry-based organizations by industry

Sharing with technology and service provider businesses

As shown in Figure 76, 44% of respondents were comfortable or extremely comfortable sharing farm input data with technology and service provider businesses, 28% neutral, and 14% not comfortable at all.

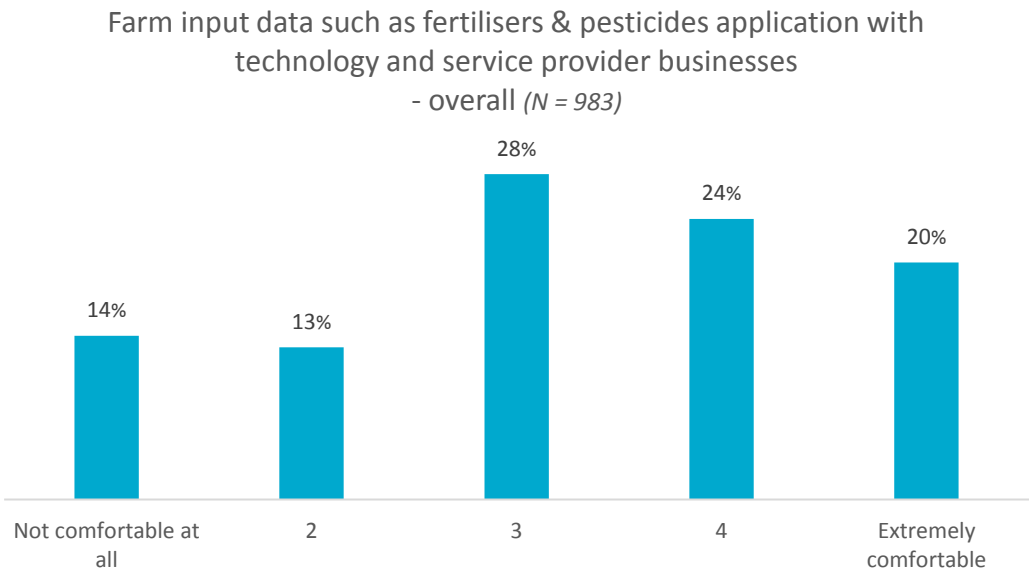


Figure 76. Comfort in sharing farm input data with technology and service provider businesses

As shown in Figure 77, there was noticeable variation across industries. The wine grapes and dairy industries were most comfortable sharing farm input data with technology and service provider businesses. In contrast, the poultry eggs/meat industry was least comfortable sharing these data.

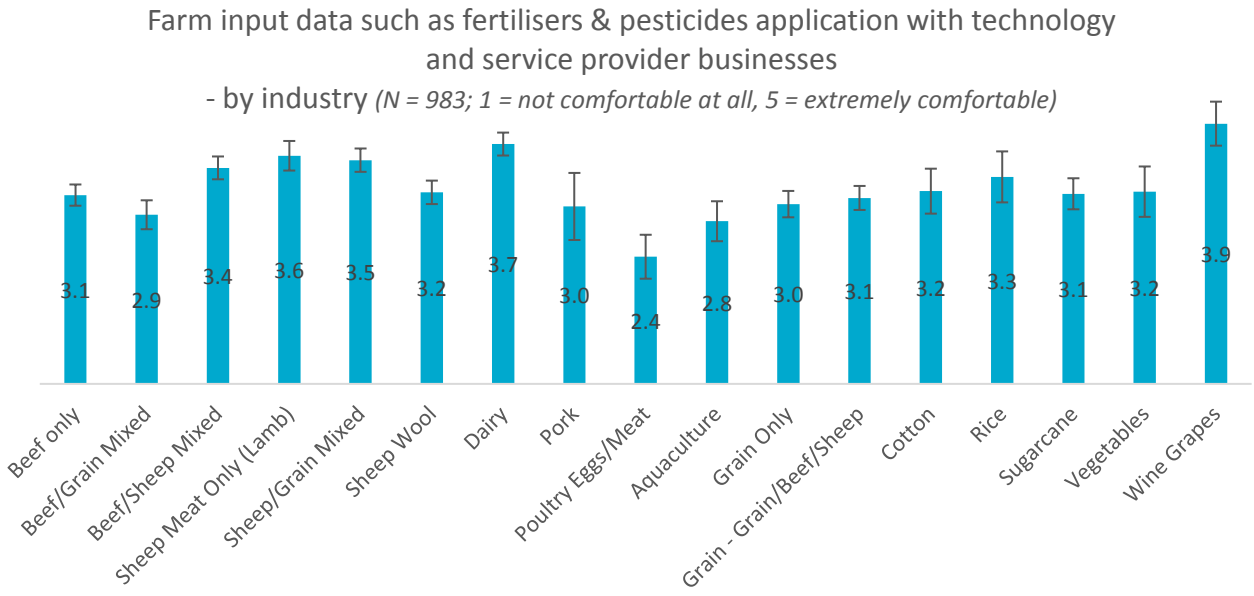


Figure 77. Comfort in sharing farm input data with service/technology provider businesses by industry

Sharing with research institutions

As shown in Figure 78, 67% of respondents were comfortable or extremely comfortable sharing farm input data with research institutions, with only 8% not comfortable at all.

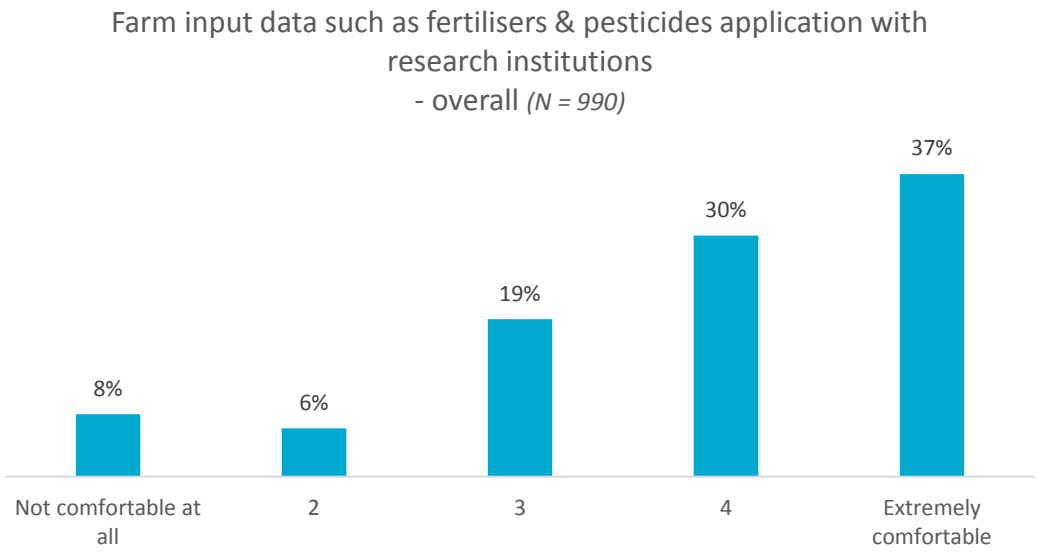


Figure 78. Comfort in sharing farm input data with research institutions

As shown in Figure 79, wine grapes, rice, dairy, and sheep/grain mixed industries were highly comfortable sharing farm input data with research institutions. Comparatively, the least comfortable sharing these data were the poultry eggs/meat and sugarcane industries.

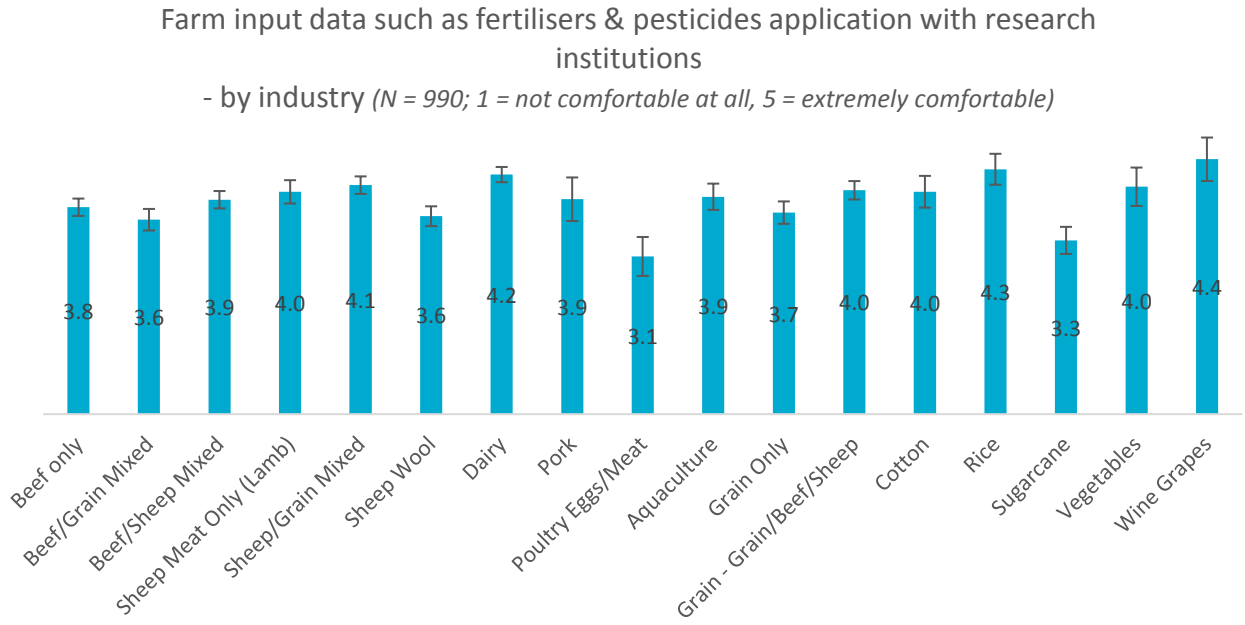


Figure 79. Comfort in sharing farm input data with research institutions by industry

Sharing with Australian Bureau of Statistics (ABS)

As shown in Figure 80, 60% of respondents were comfortable or extremely comfortable sharing farm input data with the ABS, with 12% not comfortable at all.

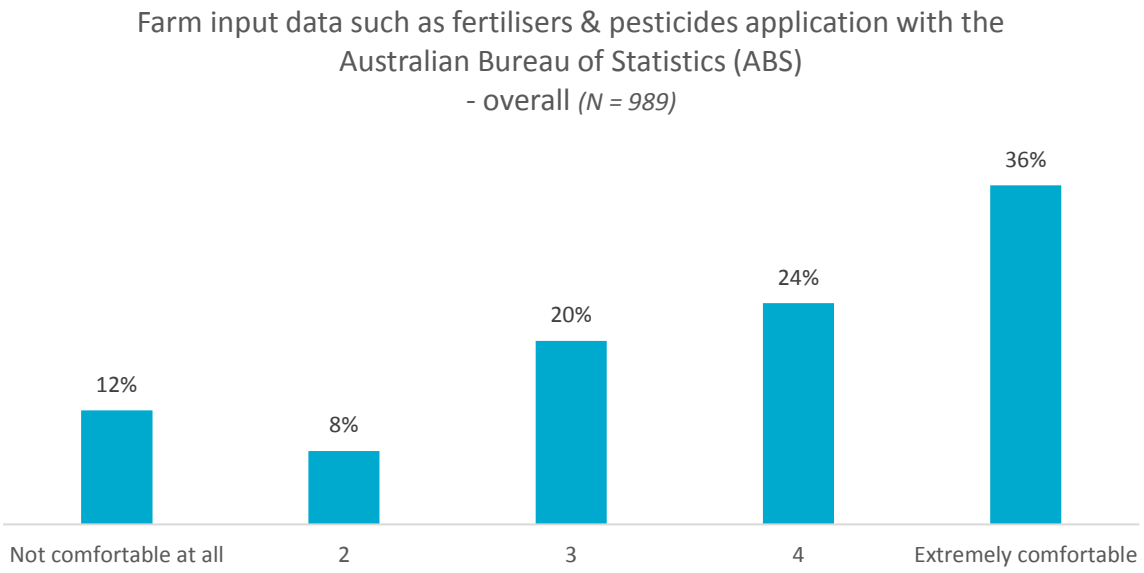


Figure 80. Comfort in sharing farm input data with the Australian Bureau of Statistics (ABS)

As shown in Figure 81, wine grapes and dairy industries were most comfortable sharing farm input data with the ABS. Comparatively, the least comfortable were sugarcane, beef/grain mixed, and grain only industries; however, their responses still indicated they were comfortable sharing these data with the ABS.

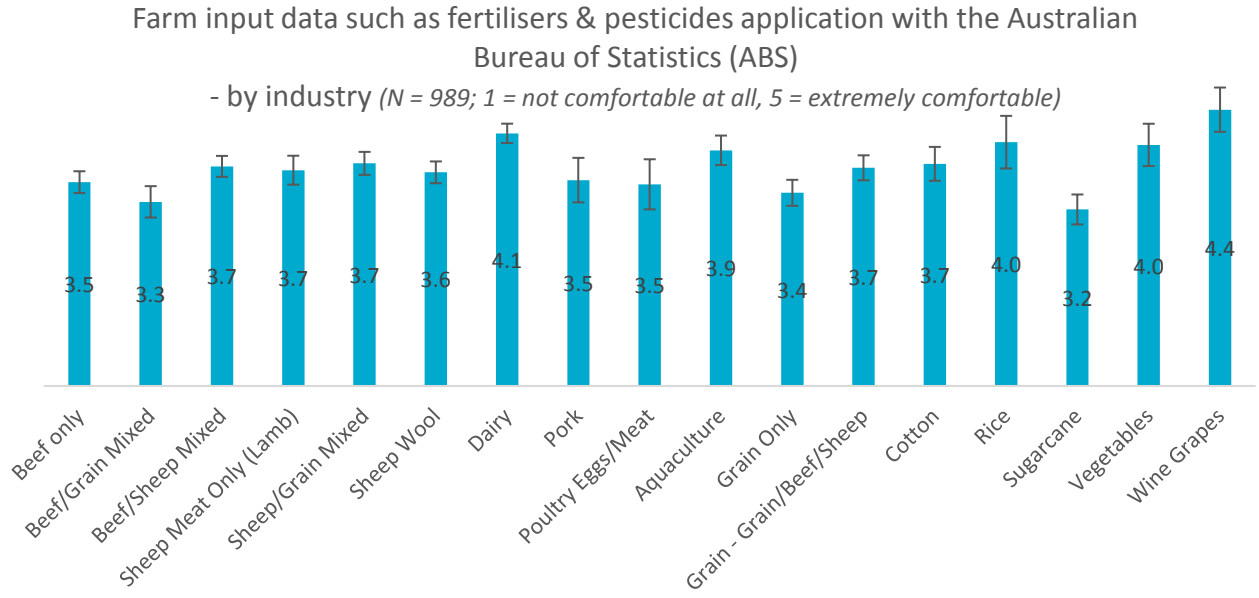


Figure 81. Comfort in sharing farm input data with the Australian Bureau of Statistics (ABS) by industry

Production data

Overall, respondents were slightly comfortable sharing farm production data with the five actors (see Figure 82). In particular, respondents were most comfortable sharing these data with research institutions, and least comfortable sharing with technology and service provider businesses.

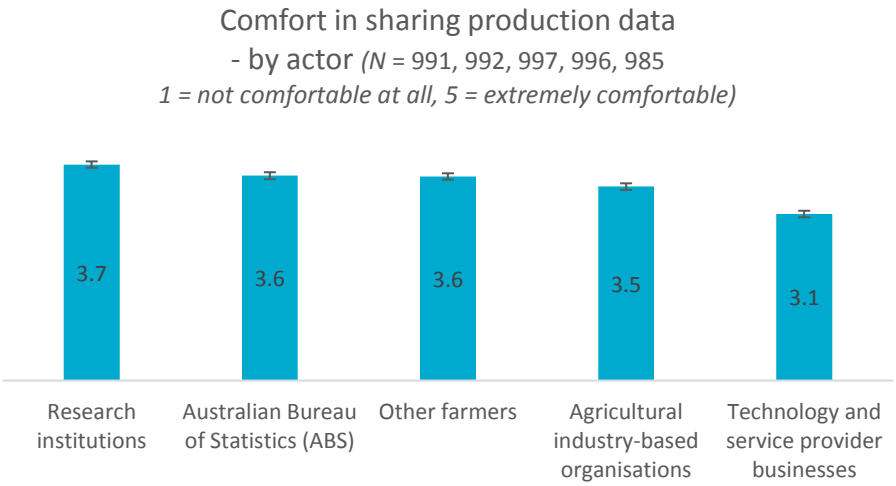


Figure 82. Comfort in sharing production data with actors

Sharing with other farmers

As shown in Figure 83, 60% of respondents were comfortable or extremely comfortable sharing production data with other farmers, with only 10% not comfortable at all.

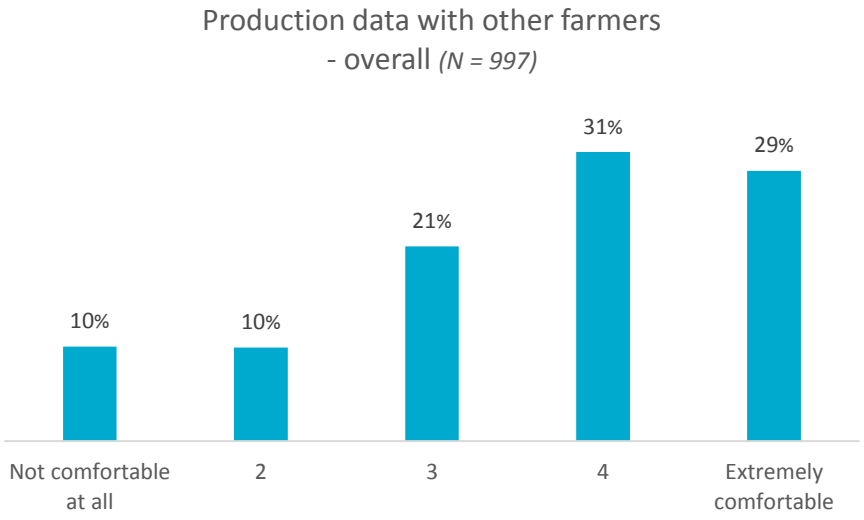


Figure 83. Comfort in sharing production data with other farmers

As shown in Figure 84, the dairy and sheep meat industries were most comfortable sharing production data with other farmers. Comparatively, the poultry industry was least comfortable. The remaining industries were slightly comfortable sharing production data with other farmers.

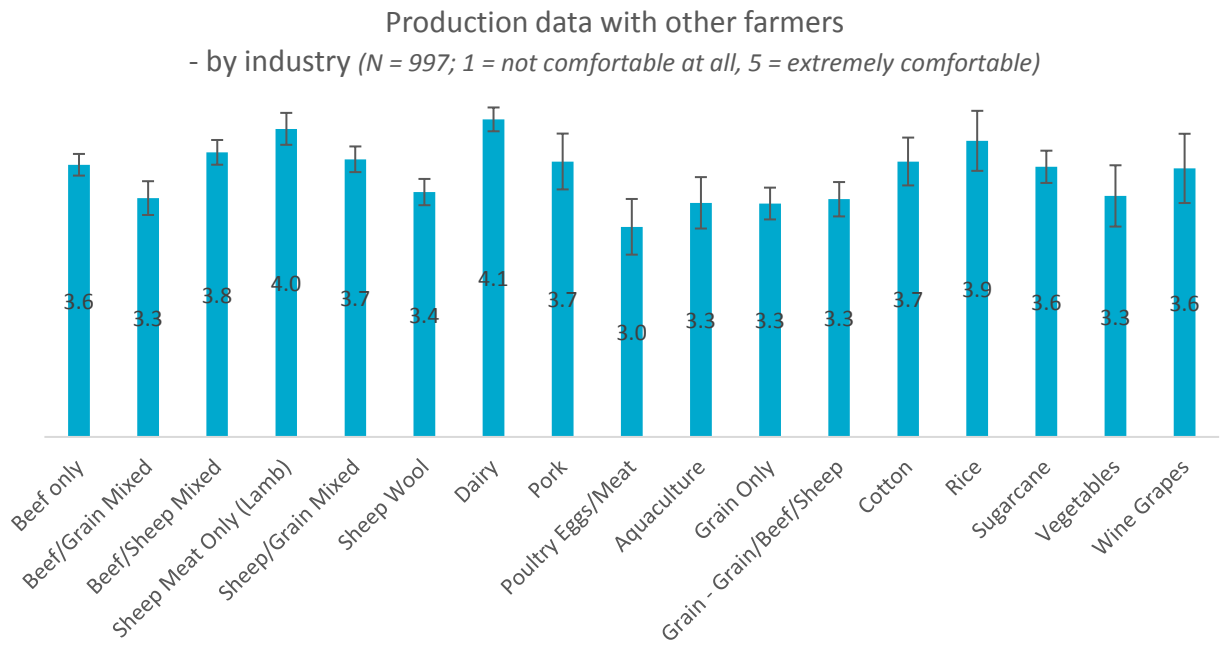


Figure 84. Comfort in sharing production data with other farmers by industry

Sharing with agricultural industry-based organisations

As shown in Figure 85, 55% of respondents were comfortable or extremely comfortable sharing production data with agricultural industry-based organisations, with 12% not comfortable at all.

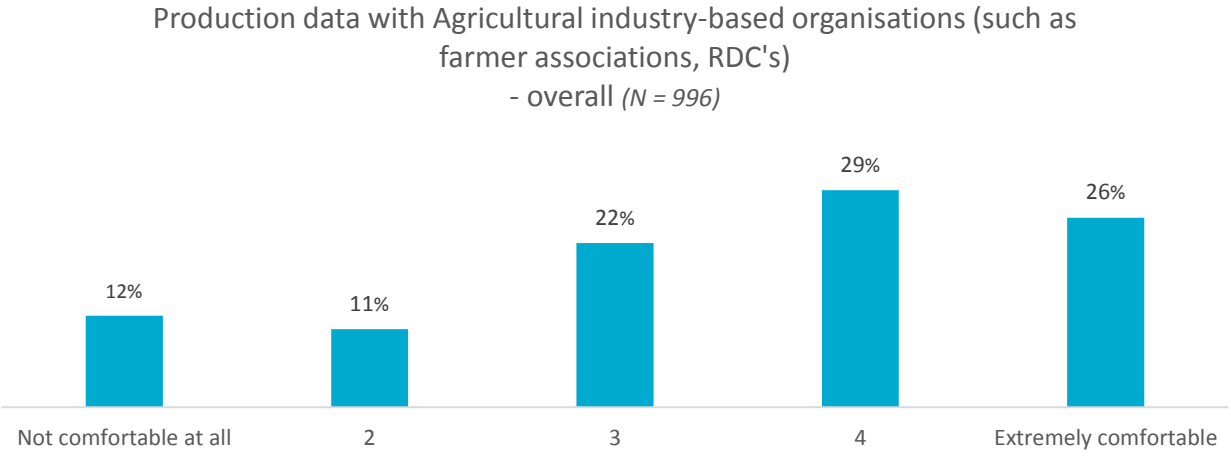


Figure 85. Comfort in sharing production data with agricultural industry-based organisations

As shown in Figure 86, dairy, rice, and wine grapes industries were most comfortable in sharing production data with agricultural industry-based organisations. Comparatively, the poultry industry was the least comfortable. The remaining industries were slightly comfortable sharing these data.

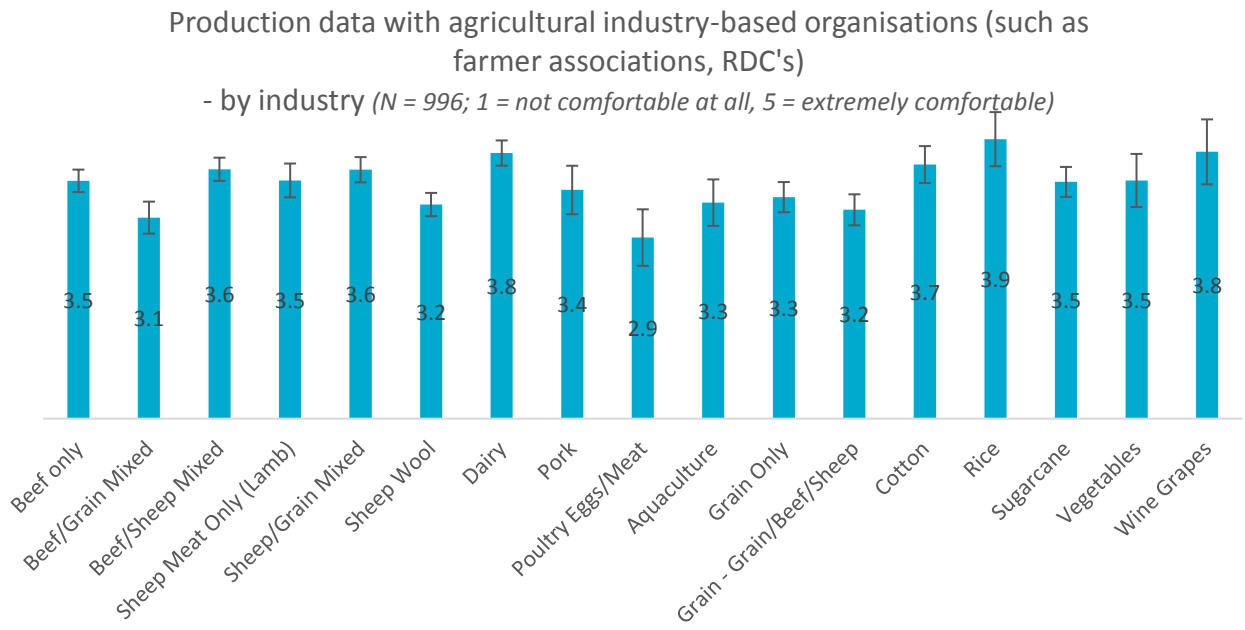


Figure 86. Comfort in sharing production data with agricultural industry-based organizations by industry

Sharing with technology and service provider businesses

As shown in Figure 87, 40% of respondents were comfortable or extremely comfortable sharing production data with technology and service provider businesses, 30% neutral, and 16% not comfortable at all.

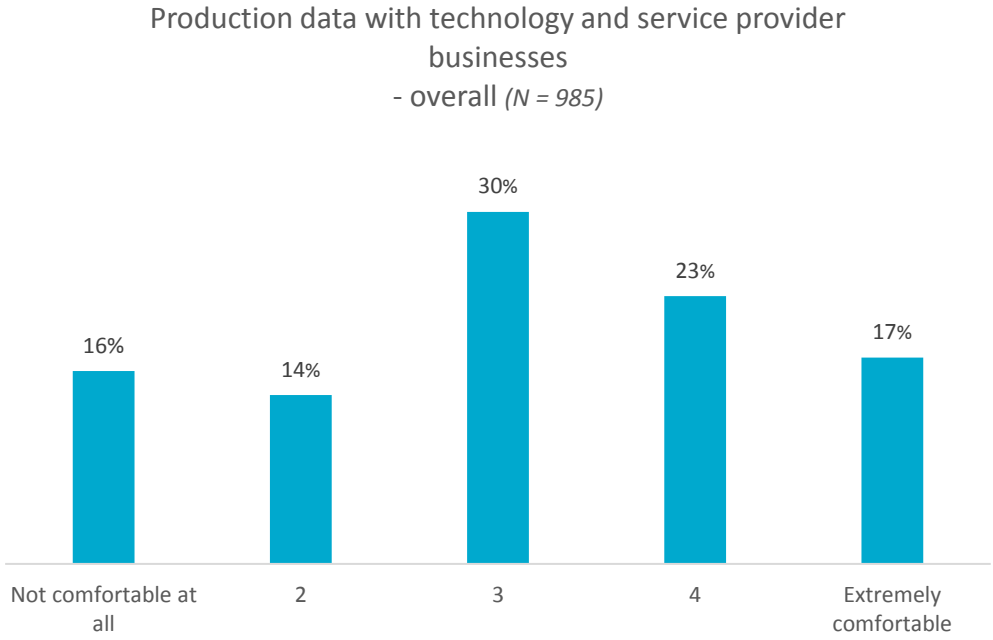


Figure 87. Comfort in sharing production data with technology and service provider businesses

As shown in Figure 88, dairy and wine grapes industries were most, but only slightly, comfortable sharing production data with technology and service provider businesses.

Comparatively, the poultry industry was the least comfortable. The remaining industries were at the middle point in terms of comfort/discomfort sharing these data.

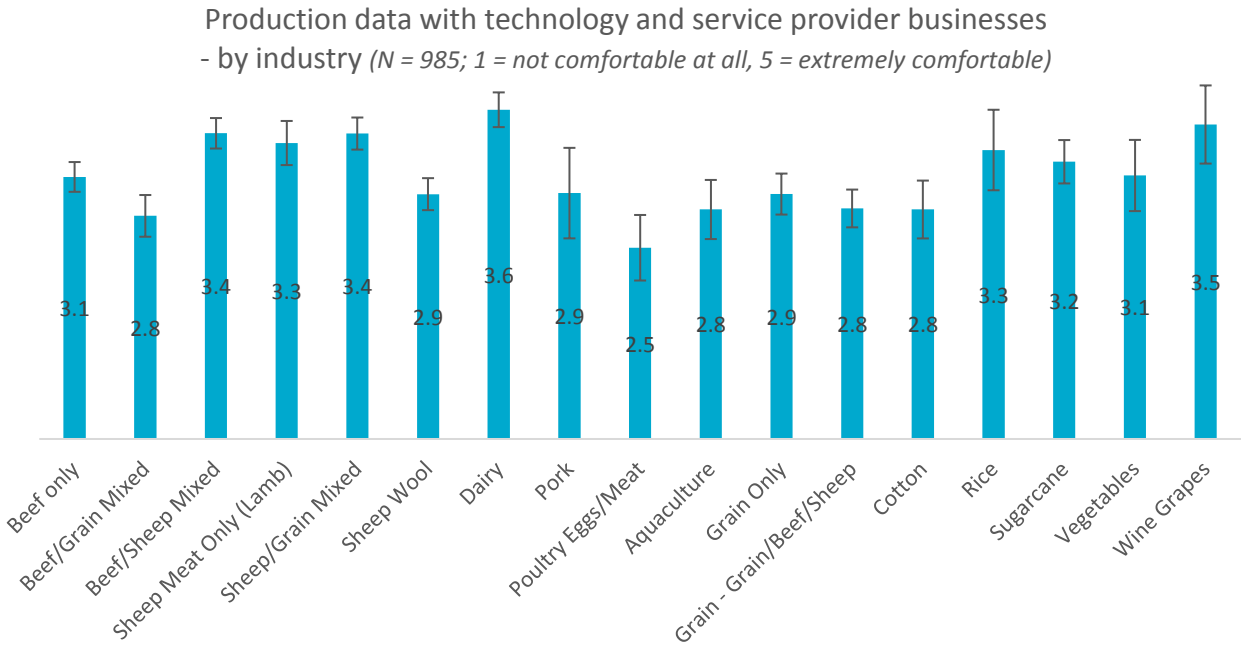


Figure 88. Comfort in sharing production data with service/technology provider businesses by industry

Sharing with research institutions

As shown in Figure 89, 64% of respondents were either comfortable or extremely comfortable sharing production data with research institutions, with only 9% not comfortable at all.

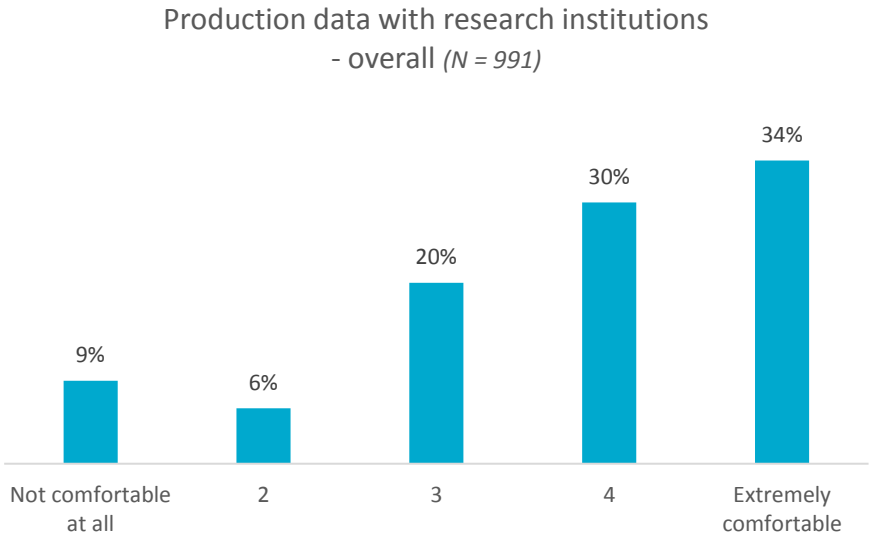


Figure 89. Comfort in sharing production data with research institutions

As shown in Figure 90, dairy, rice, and wine grapes industries were highly comfortable sharing production data with research institutions. Comparatively, the least comfortable sharing

these data were the poultry and sugarcane industries, although their responses still indicated they were slightly comfortable sharing these data.

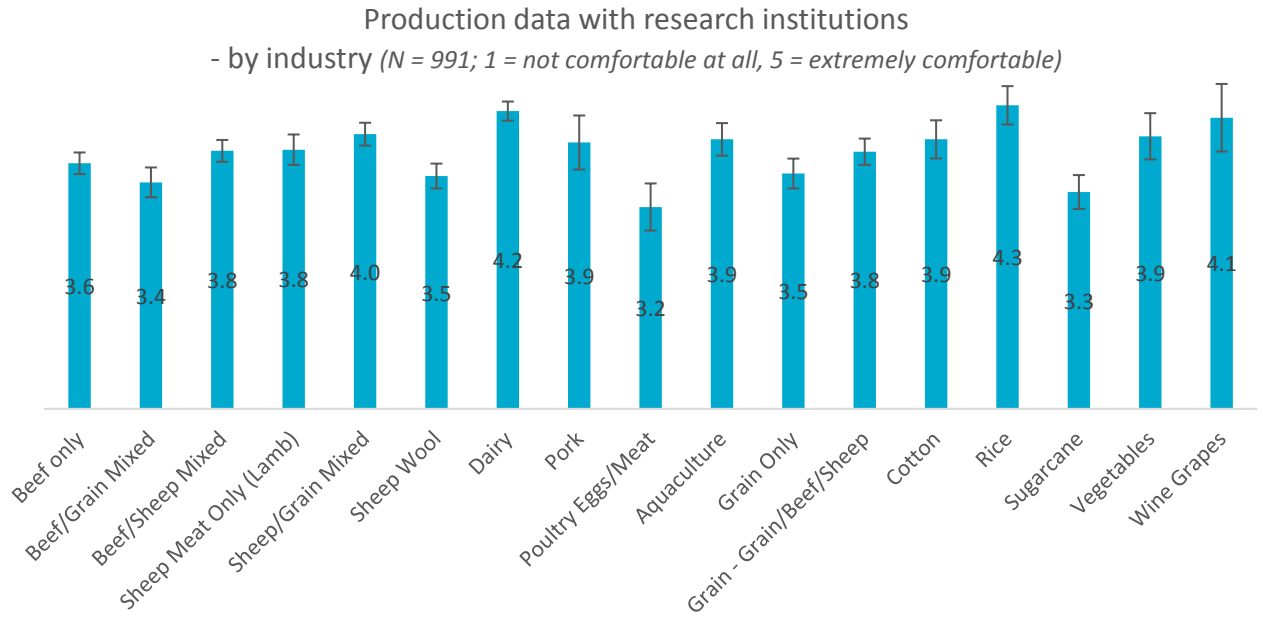


Figure 90. Comfort in sharing production data with research institutions by industry

Sharing with Australian Bureau of Statistics (ABS)

As shown in Figure 91, 59% of respondents were either comfortable or extremely comfortable sharing production data with the ABS, with 14% not comfortable at all.

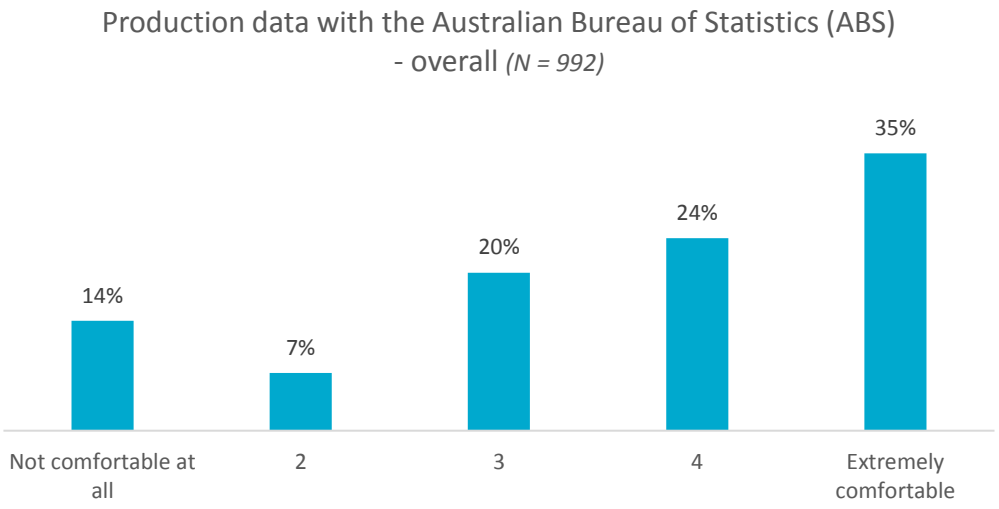


Figure 91. Comfort in sharing production data with the Australian Bureau of Statistics (ABS)

As shown in Figure 92, dairy and wine grapes industries were highly comfortable sharing production data with the ABS. Comparatively, the beef/grain mixed, grain only, and sugarcane industries were least comfortable, although their responses still indicated they were slightly comfortable sharing these data.

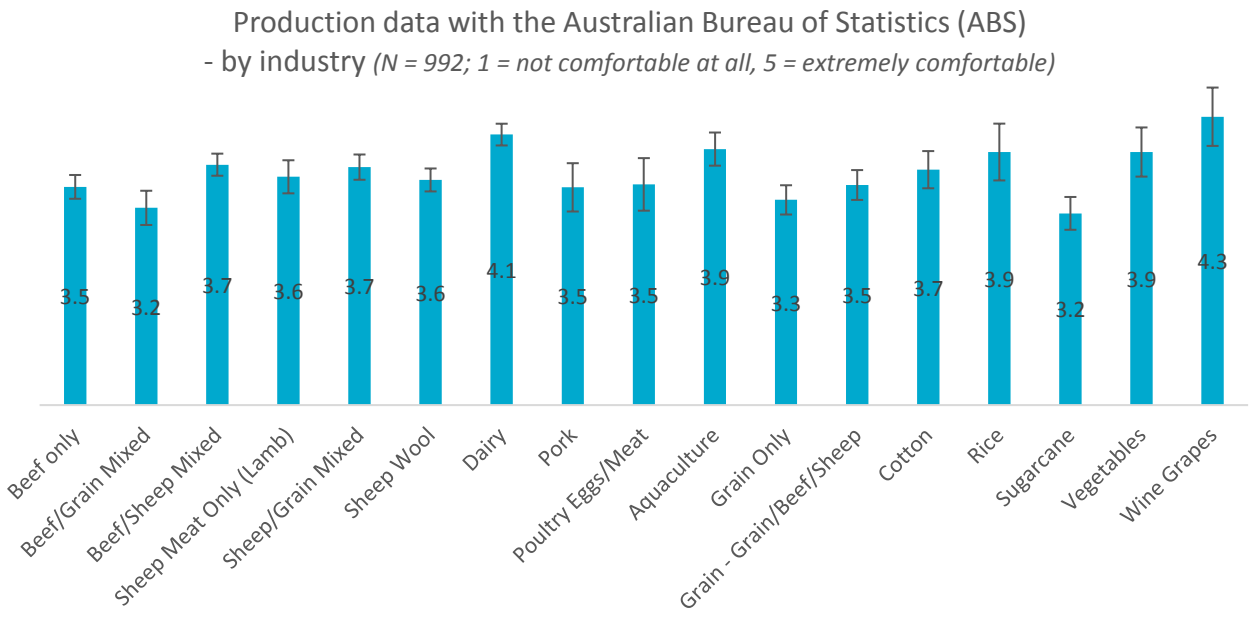


Figure 92. Comfort in sharing production data with the Australian Bureau of Statistics (ABS) by industry

Overall attitudes toward data sharing in the aggregated farm data

Figure 93 presents the overall findings of respondents' willingness to share the four types of data with the five actors. In general, respondents were more willing and highly comfortable sharing data with other farmers and research institutions, and felt least comfortable sharing with technology and service providers.

Moreover, the findings suggested that respondents were more willing to share weather station data and soil test data than farm input data and production data. It appears that respondents were more hesitant to share information which involve their farming operations. For example, farm input data and production data are directly related to farming practices, while weather station data and soil test data were not influenced by farming practices.

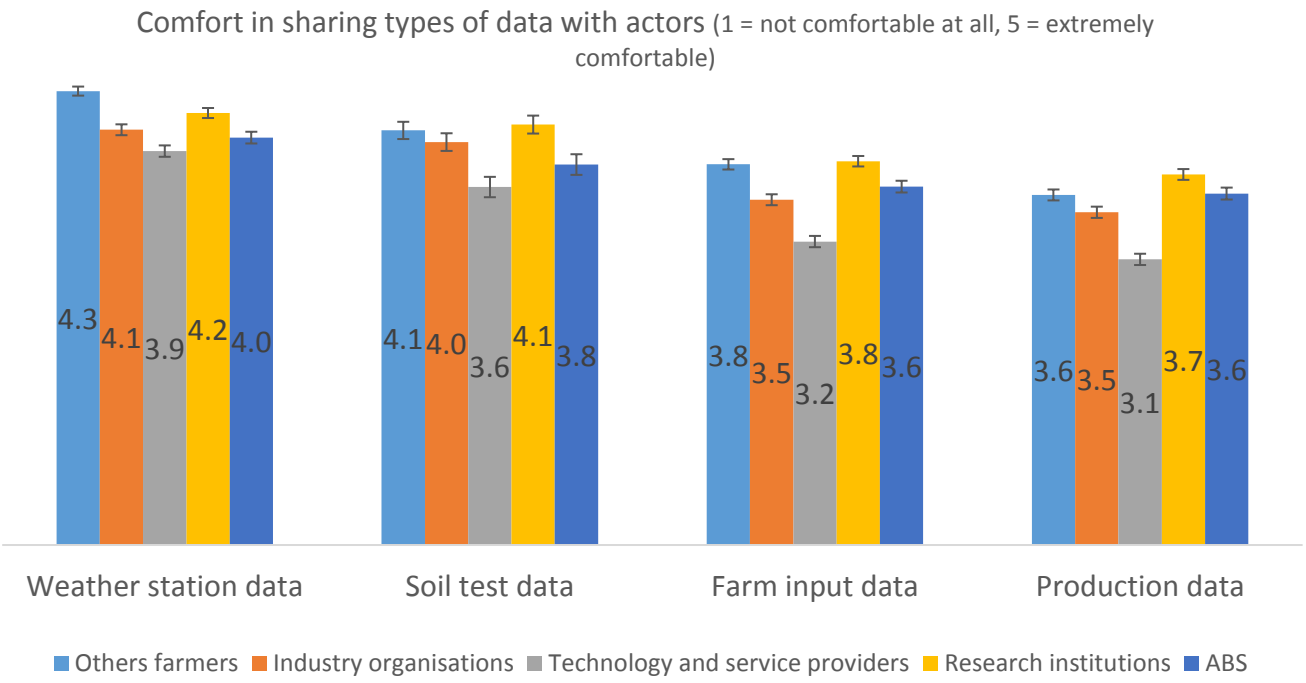


Figure 93. Comfort in sharing types of data with actors

4.3.3 Drivers for attitude toward data sharing

Beliefs of who would benefit the most affect attitude towards data sharing

Regarding who would benefit the most from the aggregated farm data, four groups of respondents were identified from the survey item "Who will benefit the most from the aggregated farm data?" (also see p. 56-58). Three groups corresponded to respondents who regarded farmers, agribusiness, and government as benefitting most, and the final group indicated they were not sure.

The scores on willingness to share each of the four types of data with each actor were aggregated and averaged. The composite score was used as a general indicator of respondents' willingness to share data with a particular actor. For example:

Willingness to share data with 'other farmers' = (willingness to share [weather station data + soil test data + farm input data + output data] with other farmers)/4

To examine whether beliefs in the main beneficiary affected attitude toward data sharing, a series of analysis of variance (ANOVA) were conducted, with the four beneficiary groups as independent factor, and the composite score on willingness to share with each actor as dependent factor.

Figure 94 presents the average willingness to share data with each actor for each beneficiary group. The results of the ANOVA analyses suggested that respondents who thought farmers would benefit the most were significantly more comfortable sharing data with all actors compared to respondents from the other three groups. In addition, respondents who thought agribusiness would benefit the most were significantly more comfortable sharing data with other farmers, industry organisations, research institutions, and the ABS compared to respondents who thought the government would benefit most.

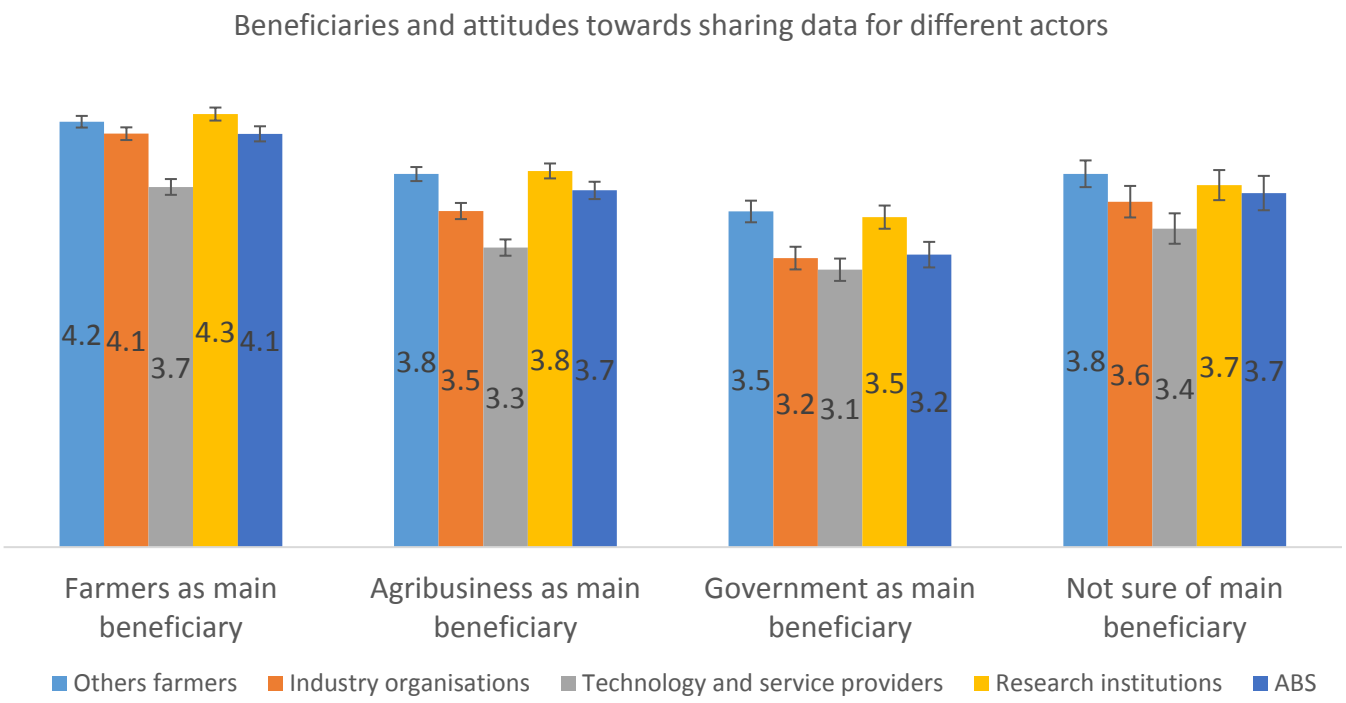


Figure 94. Willingness to share data with actors for different reported main beneficiaries of aggregated data

Appreciation of data currently collected affects attitude towards data sharing

To examine whether the overall evaluation of data usefulness affected respondents' willingness to share data with each actor, correlations were calculated between the composite willingness to share data with each actor (see above section) and the overall evaluation of contributions made by the data in helping farm management decisions, increasing business profit, increasing efficiency, and improving risk management (also see p.59-81).

Table 15 presents the correlations between attitude towards data sharing and overall evaluation of data. The results suggested that evaluations of data were positively associated with greater willingness to share data with each actor. These effects were particularly strong with research institutions and the ABS.

Table 15. Correlations between willingness to share data with actors and data usefulness for farm outcomes

Overall evaluation of data usefulness	Willingness of data sharing with each actor				
	Other farmers	Agribusiness	Technology and service provider businesses	Research institutions	ABS
Helping farm management decisions	0.19***	0.19***	0.13***	0.26***	0.25***
Increasing business profit	0.16***	0.18***	0.17***	0.24***	0.23***
Increasing efficiency	0.15***	0.15***	0.14***	0.20***	0.20***
Improving risk management	0.19***	0.20***	0.16***	0.22***	0.21***

Note: ***$p < .001$.

4.3.4 Confidence in the governance of aggregated farm data

The survey also explored the concerns respondents had towards aggregated farm data. The details are presented in the following section.

Concerns over profit making of the aggregated data by some businesses

Overall, respondents were quite concerned that the aggregated data could be used by some businesses to make money without sharing it with them (see Figure 95). In particular, 61% of respondents were concerned or extremely concerned, while only 18% showed little or no concern at all.

In broadacre cropping industries, respondents from small farms were least concerned (*M* = 3.44, *SD* = 1.25), followed by extra-large (*M* = 3.85, *SD* = 1.24), large (*M* = 4.09, *SD* = 1.01), and medium sized farms (*M* = 4.16, *SD* = 1.16).

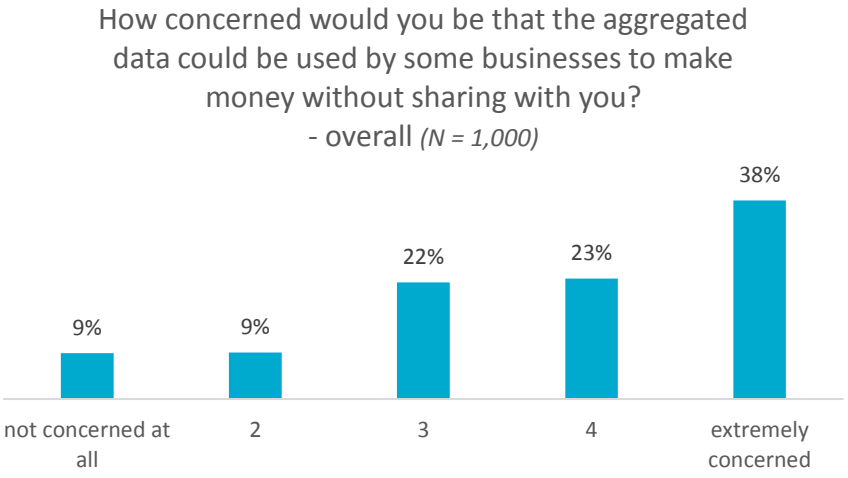


Figure 95. Concern in businesses using aggregated data to make profits without sharing with producers

There was noticeable variation across the industries (see Figure 96). In particular, grain mixed (grain/beef/sheep) and rice industries were most concerned that some businesses may

make money off aggregated data without sharing with them. Comparatively, poultry and vegetable industries were least concerned, although in absolute terms they were still concerned.

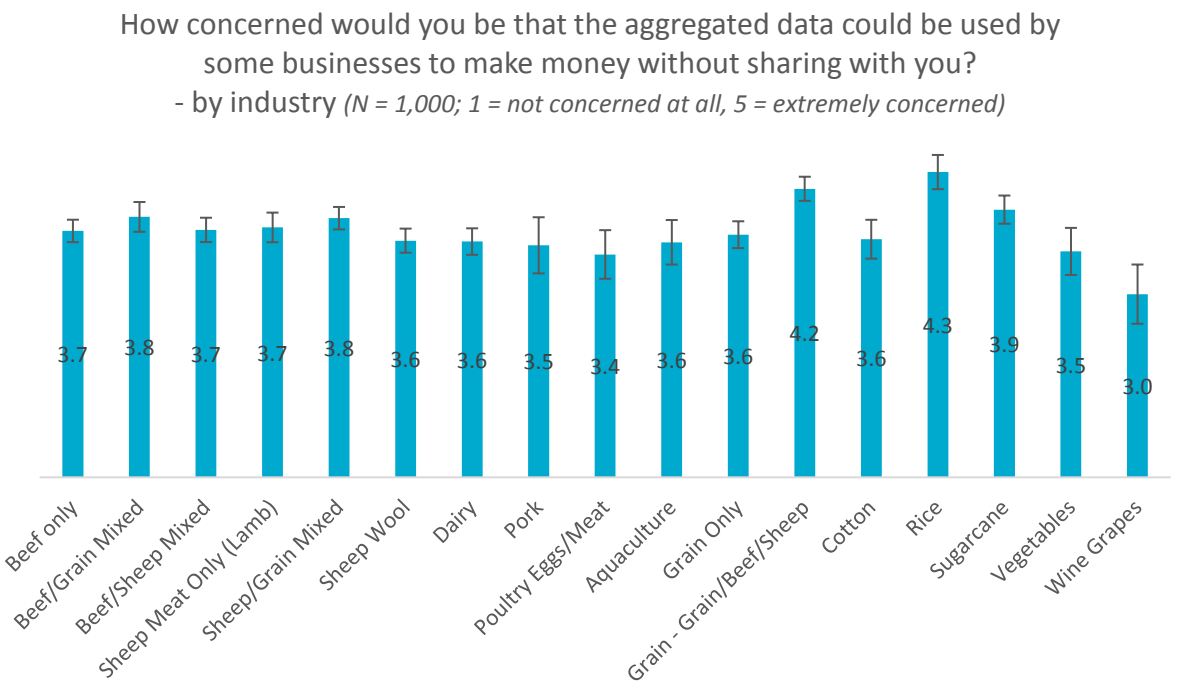


Figure 96. Concern in businesses using aggregated data to make profits without sharing with producers by industry

Concerns over influencing market by some businesses using the aggregated data

Overall, respondents were quite concerned that some businesses may use the aggregated farm data to influence the market such as produce prices and land value (see Figure 97). In particular, 67% of respondents were concerned or extremely concerned, and only 14% showed little or no concern at all.

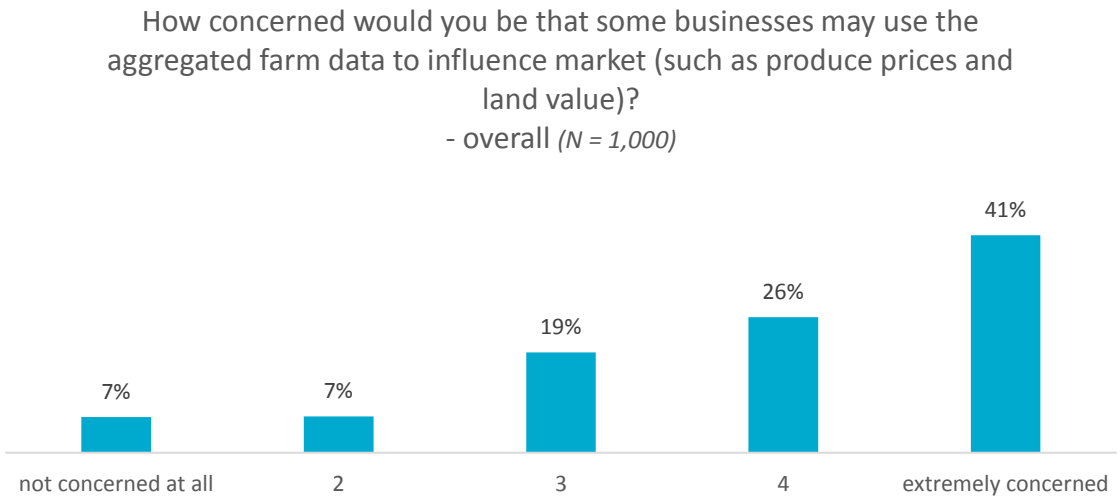


Figure 97. Concern in businesses using aggregated data to influence the market

There was little variation across the industries (see Figure 98). On average, respondents from most industries were highly concerned that some businesses may use the aggregated farm

data to influence the market. In particular, beef only, beef/grain mixed, sheep/grain mixed, pork, grain mixed (grain/beef/sheep), and rice industries were most concerned.

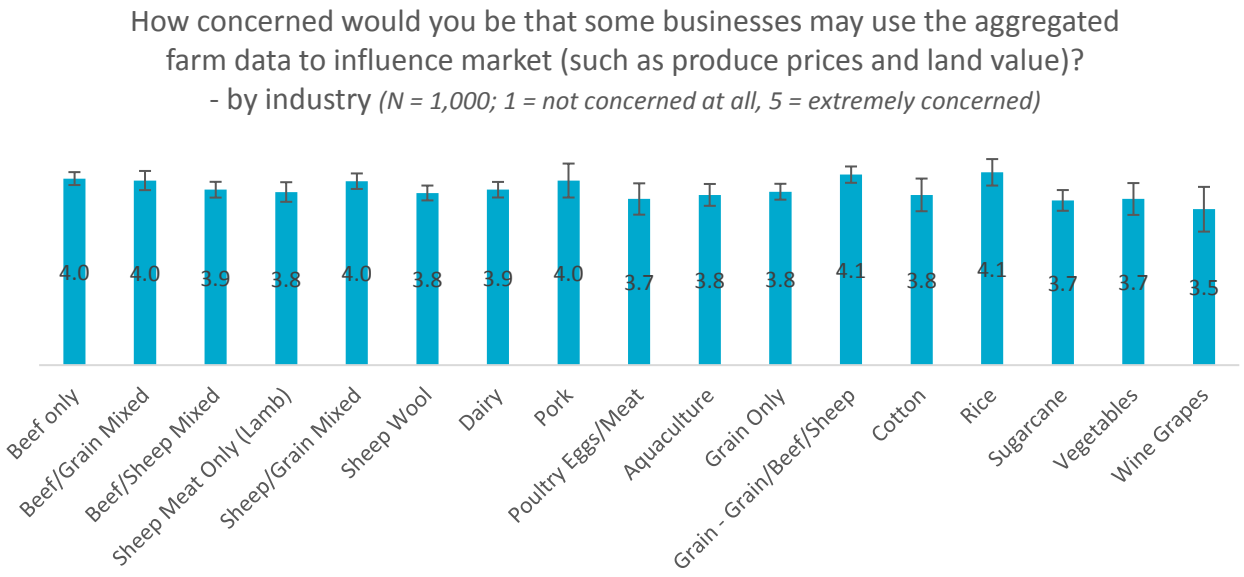


Figure 98. Concern in businesses using aggregated data to influence the market by industry

Concerns over privacy of own farm data in the aggregated data

Overall, respondents were quite concerned about the privacy of their farm data in the aggregated data (see Figure 99). In particular, 58% of respondents were concerned or extremely concerned, and only 18% showed little or no concern at all.

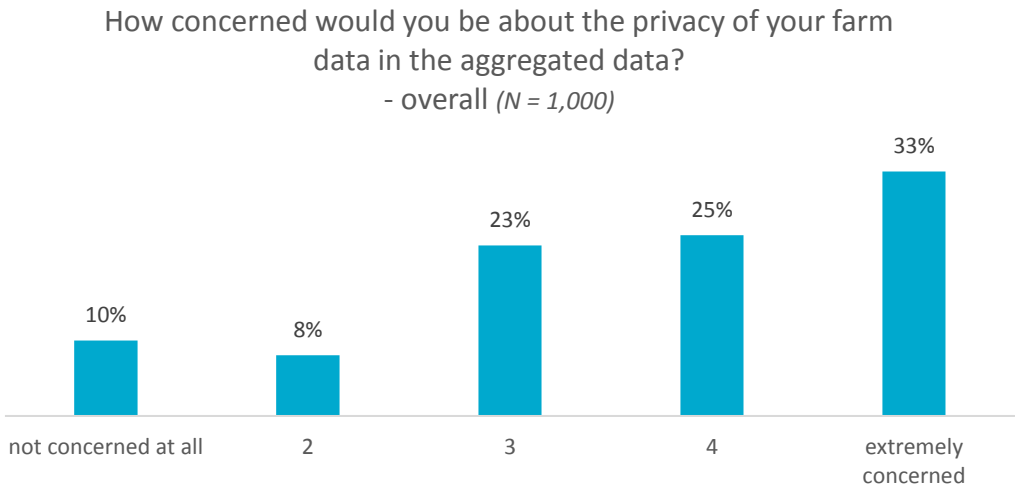


Figure 99. Concern in privacy of farm data when in the aggregated data

As shown in Figure 100, most industries were concerned about the privacy of their farm data in the aggregated data. Respondents from the beef/grain mixed and grain mixed (grain/beef/sheep) industries were the most concerned.

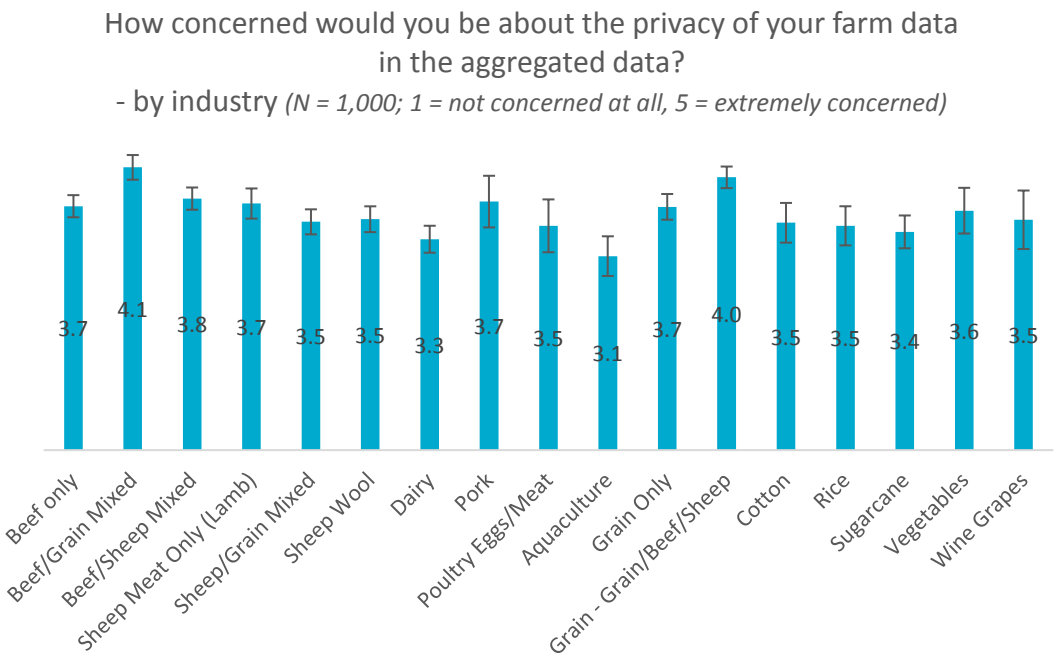


Figure 100. Concern in privacy of farm data when in the aggregated data by industry

5. Conclusion

The present survey has benchmarked Australian producers' needs, perceived risks and benefits, and expectations associated with digital agriculture technology currently and in the big data context. Those key factors were examined from three aspects: telecommunication infrastructure, the status of current data collection, and data sharing and concerns in the big data context.

Telecommunication infrastructure

First, there were pronounced variations across the industries in most of the areas examined, suggesting that the industries were at different stages of digital agriculture technology adoption and recognition of the values of agricultural data, as well as facing different barriers. Hence, it is important for each industry to develop targeted strategies to address its unique issues and challenges. Meanwhile, it is also equally important to recognise that there were shared issues and challenges across the industries, which highlight the necessity for the industries to join forces to address them more effectively. In particular, the concerns over the governance of aggregated farm data were high for respondents from all industries. While aggregated farm data is still emerging in Australia, it will progress quickly given the rapid development of data technology and the trends occurring overseas, especially in the US. It is critical to establish the institutional structure and governance around aggregated farm data with producers' concerns and lessons from overseas taken into consideration.

Second, the present survey indicated that the adoption of on-farm telecommunication infrastructure was very limited, with only 25% of respondents having radio links to devices, and/or mobile data linked devices. The majority of those users found it was challenging to keep the systems working. In addition, knowledge of on-farm telecommunication options was limited across all industries. These findings highlight the urgent needs of concerted efforts to effectively communicate the value proposition of on-farm telecommunication infrastructures and agricultural data, as well as the on-farm telecommunication options, which is essential for producers to recognise the value and take actions. Furthermore, more than half of respondents relied on themselves (including family members and employees) only to sort out their telecommunication needs, it will be beneficial for producers to establish a platform using plain language to provide on-farm telecommunication information, training, and support.

Third, satisfaction with home office internet connectivity was considerably low with only 30% of respondents satisfied. There were differences in the levels of satisfaction across the industries, however, the underlining issues may involve many aspects including the coverage across the farm. For example, respondents from cotton industry reported the lowest level of satisfaction with their home office internet connectivity, though they were the major users of digital technologies. In this case, it is likely that the satisfaction rating reflected their expectations for the internet connectivity to meet their higher levels of demand.

The status of current data collection

First, the findings of the survey revealed that there were variations in the collection rates of various agricultural data. For example, the collection of yield mapping data (51%) and soil mapping data (40%) were the highest in cropping industry, and the collection of veterinary medicine record (63%) and animal breeding data (57%) were the highest in livestock industry. Although improvements may have been achieved, it is still a long way to go for the industries to catch up and fully utilise the precision agriculture technologies.

As suggested by the findings that knowledge of telecommunication options and collection of data were associated with positive evaluation of agricultural data, concerted efforts will be beneficial to effectively communicate the value proposition of agricultural data and provide the associated technologies in plain English.

Second, the current arrangement of data collection between producers and service providers may impose some potential issues and conflicts. Such concerns were underpinned by three key aspects: 1) Respondents had limited knowledge about the terms and conditions in relation to data collection in their agreement with service providers; 2) respondents had very low trust in service providers to maintain privacy and not to share data with third parties; and 3) the majority of respondents were not comfortable for service providers to make profit out of their data without sharing the profit with them.

Certain mechanism should be explored to ensure that producers' rights are protected and benefits are fairly shared. The terms and conditions for data collection agreement with service providers need to be provided by service providers in plain English. In addition, in the agreement, both data privacy, ownership and control needs to be clearly defined and communicated to producers, and agreed by producers.

Attitude towards data sharing and concerns in the big data context

First, the results revealed that there was no consensus in relation to who would benefit the most from aggregated farm data, with farmers as beneficiary (34%) and agribusinesses as beneficiary (34%) equally regarded. Further analysis revealed that believers of farmers as the beneficiary were more willing to share their data with all actors, and those with positive evaluation of data were also more willing to share their data with all actors. These findings suggested that the development and establishment of aggregated farm data should be centred on the benefits and needs of producers, with other stakeholders (especially farmer organisations and research institutions) playing key roles to enable the development. Further, the value proposition of agricultural data as well as aggregated farm data needs to be clearly communicated to producers. Such structural arrangement will build trust and encourage producers to share their data and, in turn, realise the potential value of big data.

Second, although respondents displayed a general willingness to share data, they also reported great concerns over aggregated data in relation to privacy, financial advantage taken by other businesses, and the potential for it to be used to influence the markets such as produce prices and land value. Hence, producers need reassurance to address concerns about how the aggregated data will be governed and used. Institutional structure and governance frameworks for aggregated farm data should be established to address producers' concerns and build their trust in the systems through addressing transparency, privacy, data ownership, and control.

Future research

With the rapid advancement of digital agriculture technologies and application of big data, it is imperative to have up-to-date information about Australian producers' needs and issues, so that the transformational values of the advancements can be fully capitalised. A general survey across the industries in three years is recommended. More targeted studies focusing on particular aspects for particular industries on a more regular basis will help to inform strategies at the industry level.

6. References

Aubert, B., Schroeder, A. and Grimaudo, J. (2012). IT as enabler of sustainable farming: An empirical analysis of farmers' adoption decision of precision agriculture technology. *Decision Support Systems*, 54, 510-520.

Bramley, R. (2009). Lessons from nearly 20 years of precision agriculture research, development and adoption as a guide to its appropriate application. *Crop and Pasture Science*, *60*, 197-217.

Eastwood, C., & Yule, I. (2015). Challenges and Opportunities for Precision Dairy Farming in New Zealand. *Farm Policy Journal, 12*(1), 33-41.

Griffith, C., Heydon, Lamb, D., Lefort, L., Taylor, K., & Trotter, M. (2013). Smart Farming: Leveraging the impact of broadband and the digital economy. New England: CSIRO and University of New England.

Heath, R. (2017) Will digital agriculture deliver on the hype? New research and development projects and industry case studies. GRDC Update Paper, 27 February 2017. https://grdc.com.au /resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2017/02/will-digital-agriculture-deliver-on-the-hype

Jakku, E., Taylor, B., Fleming, A., Mason, C., & Thorburn, P. (2016). Big data, Trust and Collaboration: Exploring the socio-technical enabling conditions for big data in the grains industry. Research Report, CSIRO, Brisbane, Australia.

Kaloxylos, Alexandros, Aggelos Groumas, Vassilis Sarris, Lampros Katsikas, Panagis Magdalinos, Eleni Antoniou, Zoi Politopoulou, Sjaak Wolfert, Christopher Brewster, Robert Eigenmann, and Carlos Maestre Terol. (2014). A cloud-based Farm Management System: Architecture and implementation. *Computers and Electronics in Agriculture, 100*, 168-179. doi: 10.1016/j.compag.2013.11.014.

Keogh, M., & Henry, M. (2016). *The implications of digital agriculture and big data for Australian agriculture*. Research Report, Australian Farm Institute, Sydney, Australia.

Kuehne G., Llewellyn R., Pannell D., Wilkinson R., Dolling P., Ouzman J., & Ewing, M. (2017). Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy. *Agricultural Systems*, *156*, 115-125.

Llewellyn, R. and Ouzman, J. (2014) Adoption of precision agriculture-related practices: status, opportunities and the role of farm advisers. CSIRO Report Published by GRDC. https://grdc.com.au/Resources/Publications/2014/12/Adoption-of-precision-agriculture-related-practices

Pannell, D., Marshall, G., Barr, N., Curtis, A., Vanclay, F., & Wilkinson, R. (2006). Understanding and promoting adoption of conservation technologies by rural landholders. *Australian Journal of Experimental Agriculture*, *46*, 1407-1424.

Pierpaoli, E., Carli, G., Pignatti, E., & Canavari, M. (2013). Drivers of Precision Agriculture Technologies Adoption: A Literature Review. *Procedia Technology*, *8*, 61-69.

Poppe, K., S. Wolfert, C. Verdouw, & Renwick, A. (2015). A European Perspective on the Economics of Big Data. *Farm Policy Journal, 12*(1), 11-19.

Robertson, M., Llewellyn, R., Mandel, R., Lawes, R., Bramley, R., Swift, L., Metz, N., O'Callaghan, C. (2012). Adoption of variable rate technology in the Australian grains industry: status, issues and prospects. *Precision Agriculture*, *13*, 181-199.

Sonka, S. (2015). Big Data: form hype to agricultural tool. *Farm Policy Journal*, 12, 1-9.

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. (2017). Big Data in Smart Farming – A review. *Agricultural Systems*, *153*, 69-80.

Appendix A

P2D producer survey — Full questionnaire

Q1. Good evening, this is (insert your name) calling from KG2, we are a specialist agricultural market research company , how are you? We are conducting a study that aims to identify Australian producers' needs and issues in relation to using agricultural data. The questions will revolve around your experience with agricultural data systems and tools. The study is conducted by CSIRO and funded by the Department of Agriculture and Water Resources....The study will take around 20 minutes to complete. Would you be able to help us with this study? ..Your survey responses are held in the strictest of confidence and will remain anonymous. Results from the study will be shared in scientific publications. . ..If participants have further questions or concerns/complaints about the research: . CSIRO Human Research Ethics Officer on (07) 3833 5693 Project Information: Airong Zhang on (07) 3833 5908

Make sure your are speaking to the decison maker

Yes	1		
No	555	End	Q1

Q2. Ok great. I will let you know that the call is being recorded for quality assurance and training purposes. Firstly, could I confirm the state that you are in? . .

NSW	1	
QLD	2	
VIC	3	
TAS	4	Q2
SA	5	
WA	6	
NT	7	

Q3. What type of farming operation do you run? . . .

Aquaculture (Salmon)	1	
Aquaculture (Prawns)	2	
Aquaculture (Other)	3	
Beef Only	4	
Beef/Sheep Mixed	5	
Beef/Grain Mixed	6	
Dairy	7	
Pigs	8	
Poultry Eggs	9	
Poultry Meat (Chicken)	10	
Poultry Meat (Turkey)	11	Q3
Poultry Meat (Duck)	12	
Sheep Meat Only (Lamb)	13	
Sheep/Grain Mixed	14	
Sheep Wool	15	
Cotton	16	
Grain Only	17	
Rice	18	
Sugarcane	19	
Vegetables	20	
Wine Grapes	21	

*Q3a. What is the total area of your property, including any leased land and any unused land?...

Hectares	1	
Acres	2	Q3a_1

*Q3b. Does the majority of your on farm income come from grain or livestock?...

Do not answer if true

Grain	1

Livestock	2	Q3b

Qdum CLICK NEXT
my.

*Q3c. DUMMY - HIDDEN QUESTION FOR WHAT QUESTIONS THEY GET

Do not answer If true

Grain	1	
Livestock	2	Q3c

Q3d. DUMMY - GRAIN SPECIALIST QUOTA

Do not answer If true

Grain	1	Q3d

*Q5a. For your Aquaculture enterprise, what is your estimated annual production? . . .

Answer If [Q3] = 1 OR [Q3] = 2 OR [Q3] = 3

Make sure you get the exact figure and description - e.g. 10,000 Kilos Salmon

Estimated Annual Production	1	Q5a_1

*Q5b. What is the total number of beef cattle? . . .

Answer If [Q3] = 4 OR ([Q3] = 6 AND [Q3b] = 2)

Total Number of Beef Cattle	1	Q5b_1

If [Q5b_2] <100 go to QTERM

*Q5c. What is the total number of beef cattle and sheep? . . .

Answer If [Q3] = 5

Must have 100 beef cattle & 800 sheep minimum requirement, otherwise flag as beef only or sheep only as main farm type

Beef cattle	1	Q5c_1_1
Sheep	2	Q5c_1_2

If [Q5c_2_1] < 100 OR [Q5c_2_2] < 800 go to QTERM

*Q5d. How many cows milked? . . .

Answer If [Q3] = 7

Total Number of Cows Milked	1	Q5d_1

*Q5e. How many sows? . . .

Answer If [Q3] = 8

Total Number of Sows	1	Q5e_1

*Q5f. How many hens? . . .

Answer If [Q3] = 9

Total Number of Hens	1	Q5f_1

*Q5g. What is the total number of birds you sell/ produce each year? . . .

Answer If [Q3] = 10 OR [Q3] = 11 OR [Q3] = 12

Make sure you get the exact figure and description, e.g. 125,000 Chickens

Total Number of Birds	1	Q5g_1

Q5h. What is the total number of sheep for lamb? . . .

Answer If [Q3] = 13

Total Number of Sheep for Lamb	1	Q5h_1

If [Q5h_2] < 800 go to QTERM

***Q5i.** What is the total number of sheep for wool? . . .

Answer If [Q3] = 15

Must have a minimum of 800 sheep

Total Number of Sheep for Wool	1	Q5i_1

If [Q5i_2] < 800 go to QTERM

***Q5j.** How many hectares/acres planted to cotton? . . .

Answer If [Q3] = 16

Must have a minimum of 200 Hectares

Hectares	1	
Acres	2	Q5j_1

If ([Q5j_1] = 1 AND [Q5j_2] < 200) OR ([Q5j_1] = 2 AND [Q5j_2] < 80) go to QTERM

***Q5k.** How many hectares/acres planted to grain? . . .

Answer If [Q3] = 17 OR [Q3b] = 1

Must have a minimum of 500 Hectares

Hectares	1	
Acres	2	Q5k_1

If ([Q5k_1] = 1 AND [Q5k_2] < 500) OR ([Q5k_1] = 2 AND [Q5k_2] < 202) go to QTERM

***Q5l.** How many hectares/acres planted to rice? . . .

Answer If [Q3] = 18

Hectares	1	
Acres	2	Q5l_1

***Q5m.** How many hectares/acres planted to sugarcane? . . .

Answer If [Q3] = 19

Must have a minimum of 40 Hectares

Hectares	1	
Acres	2	Q5m_1

If ([Q5m_1] = 1 AND [Q5m_2] <40) OR ([Q5m_1] = 2 AND [Q5m_2] <16) go to QTERM

***Q5n.** How many hectares/acres planted to vegetables? . . .

Answer If [Q3] = 20

Hectares	1	
Acres	2	Q5n_1

*Q5o. How many hectares/acres planted to wine grapes? . . .

Answer If [Q3] = 21

Hectares	1	
Acres	2	Q5o_1

*Q5p. What is the total number of sheep? . . .

Answer If [Q3] = 14 AND [Q3b] = 2

Must have a minimum of 800 sheep

Total Number of Sheep	1	Q5p_1

If [Q5p_2] < 800 go to QTERM
Do not answer If true

. Thank you for your time, but we are actually looking for different types of producers for this study. Best of luck with the rest of the season. . . .MAKE SURE YOU UPDATE THE BUSINESS NAME, FARM TYPE AND FARM SIZE BEFORE TERMINATING.

End

*Q6. How many years have you been farming in the ____ industry? . .

Record the applicable years based off main farm type

Q6

Q7. The following questions are about your on-farm telecommunications and internet connections. . . On a 1 to 5 scale, where 1 is not important at all and 5 is extremely important, How important is internet connectivity to your business? . .

1 Not important at all	1	
2	2	
3	3	Q7
4	4	
5 Extremely important	5	

*Q8. How is your business connected to the internet? . .

Read out and multiples allowed - 'Other' eg Optus

Landline	1	Q8_1
Mobile phone network	2	Q8_2
NBN fixed wireless	3	Q8_3
NBN Sky Muster	4	Q8_4
NBN Interim Satellite Service	5	Q8_5
NBN Fibre/ Fibre-to-node	6	Q8_6
No internet connection	7	Q8_7
Don't Know	999	Q8_8
		Q8_O

Q9. On a 1 to 5 scale, where 1 is not satisfied at all and 5 is extremely satisfied, How satisfied are

you with your home office internet connectivity? . .

Do not answer If [Q8_7] = 7

1 Not satisfied at all	1	
2	2	
3	3	Q9
4	4	
5 Extremely satisfied	5	

Q10. When using your mobile phone for voice calls, or a smart tablet, or any other device that communicates via the mobile network, such as a weather station, how do you describe your coverage across your entire farm on a 1 to 5 scale, where 1 is no coverage anywhere on the farm and 5 is full coverage? . .

1 No coverage anywhere on the farm	1	
2	2	
3	3	
4	4	Q10
5 Full coverage	5	
No mobile phone	6	

***Q12. What on-farm telecommunication infrastructure do you already have?...**

Read out and record

Links to devices (eg connecting your weather station or gate back to your farm office or other location on your farm)	1	Q12_1
Mobile data linked devices (eg weather station is directly linked to the mobile network)	2	Q12_2
None at present, but considering to install something within the next 5 years	3	Q12_3
None at present, and have no plans to install any telecommunications infrastructure on your farm	4	Q12_4
		Q12_O

Q13. On a 1 to 5 scale, where 1 is not challenging at all and 5 is extremely challenging, How challenging is it to keep these on-farm telecommunication systems working?. .

Answer If [Q12_1] = 1 OR [Q12_2] = 2 OR [Q12_3] = 3

1 Not challenging at all	1	
2	2	
3	3	Q13
4	4	
5 Extremely challenging	5	

Q14. On a 1 to 5 scale, where 1 is nothing at all and 5 is know a lot, How much do you know about the options available to connect devises on your farm (such as radio links, wifi and local area networks)?. .

1 Nothing at all	1	
2	2	
3	3	Q14
4	4	
5 Know a lot	5	

Q15. Who has helped you in sorting out your telecommunication needs? . .

Read out- Multiple answers allowed

You do it yourselves including family members and employees	1	Q15_1
Fee-for-service consultants	2	Q15_2

Telecommunication Service Provider	3	Q15_3
		Q15_O

*Q16. New farm machines and technologies can collect a lot of data including the status of soil, water, crops, pasture and animals. The following questions are about the data you collect on your farm. . . . What agricultural data do you currently collect on your farm? . . .

Answer If [Q3c] = 1

Read out and record

Yield mapping	1	Q16_1
Soil mapping	2	Q16_2
Crop sensing (eg NDVI)	3	Q16_3
Weed pressure mapping	4	Q16_4
Soil moisture sensor data	5	Q16_5
On-farm weather station data	6	Q16_6
Financial data	7	Q16_7
Irrigation use	8	Q16_8
None	9	Q16_9

If [Q16_9] = 9 go to Q22b

*Q16b. New farm machines and technologies can collect a lot of data including the status of soil, water, crops, pasture and animals. The following questions are about the data you collect on your farm. . . . What agricultural data do you currently collect on your farm? . . .

Answer If [Q3c] = 2

Read out and record

Soil mapping	1	Q16b_1
Pasture/vegetation mapping	2	Q16b_2
Individual animal or herd production data	3	Q16b_3
Individual animal or herd feeding data	4	Q16b_4
On-farm weather station data	5	Q16b_5
Animal breeding data	6	Q16b_6
Financial data	7	Q16b_7
Veterinary medicine record	8	Q16b_8
Water use/quality	9	Q16b_9
None	10	Q16b_10

If [Q16b_10] = 10 go to Q22b

*Q17. Im now going to read out those types of data that you currently collect and could you please tell me where that data is stored? . . .

Answer If [Q3c] = 1

	On farm on paper	On farm electronically	In cloud	Service Provider	Not sure	
Answer If [Q6164o_1] = 1						
Yield mapping	1	2	3	4	5	Q17_1
Answer If [Q6164o_2] = 2						
Soil mapping	1	2	3	4	5	Q17_2
Answer If [Q6164o_3] = 3						
Crop sensing e.g. NDVI	1	2	3	4	5	Q17_3
Answer If [Q6164o_4] = 4						
Weed pressure mapping	1	2	3	4	5	Q17_4
Answer If [Q6164o_5] = 5						
Soil moisture sensor data	1	2	3	4	5	Q17_5
Answer If [Q6164o_6] = 6						
On-farm weather station data	1	2	3	4	5	Q17_6
Answer If [Q6164o_7] = 7						
Financial data	1	2	3	4	5	Q17_7
Answer If [Q6164o_8] = 8						
Irrigation use	1	2	3	4	5	Q17_8

*Q17b. Im now going to read out those types of data that you currently collect and could you please tell me where that data is stored? . . .

Answer If [Q3c] = 2

	On farm	On farm	In cloud	Service	Not sure

	on paper	electronically		Provider		
Answer If [Q10613a_1] = 1						
Soil mapping	1	2	3	4	5	Q17b_1
Answer If [Q10613a_2] = 2						
Pasture/vegetation mapping	1	2	3	4	5	Q17b_2
Answer If [Q10613a_3] = 3						
Individual animal or herd production data	1	2	3	4	5	Q17b_3
Answer If [Q10613a_4] = 4						
Individual animal or herd feeding data	1	2	3	4	5	Q17b_4
Answer If [Q10613a_5] = 5						
On-farm weather station data	1	2	3	4	5	Q17b_5
Answer If [Q10613a_6] = 6						
Animal breeding data	1	2	3	4	5	Q17b_6
Answer If [Q10613a_7] = 7						
Financial data	1	2	3	4	5	Q17b_7
Answer If [Q10613a_8] = 8						
Veterinary medicine record	1	2	3	4	5	Q17b_8
Answer If [Q10613a_9] = 9						
Water use/quality	1	2	3	4	5	Q17b_9

***Q18. Where 1 is no use at all and 5 is extremely useful, how useful is this data in helping you make farm management decisions? . . .**

Answer If [Q3c] = 1

Read out and record

	1 No use at all	2	3	4	5 Extremely useful	
Answer If [Q6164o_1] = 1						
Yield mapping	1	2	3	4	5	Q18_1
Answer If [Q6164o_2] = 2						
Soil mapping	1	2	3	4	5	Q18_2
Answer If [Q6164o_3] = 3						
Crop sensing, e.g. NDVI	1	2	3	4	5	Q18_3
Answer If [Q6164o_4] = 4						
Weed pressure mapping	1	2	3	4	5	Q18_4
Answer If [Q6164o_5] = 5						
Soil moisture sensor data	1	2	3	4	5	Q18_5
Answer If [Q6164o_6] = 6						
On-farm weather station data	1	2	3	4	5	Q18_6
Answer If [Q6164o_7] = 7						
Financial data	1	2	3	4	5	Q18_7
Answer If [Q6164o_8] = 8						
Irrigation use	1	2	3	4	5	Q18_8

***Q18b. Where 1 is no use at all and 5 is extremely useful, how useful is this data in helping you make farm management decisions? . . .**

Answer If [Q3c] = 2

Read out and record

	1 No use at all	2	3	4	5 Extremely useful	
Answer If [Q10613a_1] = 1						
Soil mapping	1	2	3	4	5	Q18b_1
Answer If [Q10613a_2] = 2						
Pasture/vegetation mapping	1	2	3	4	5	Q18b_2
Answer If [Q10613a_3] = 3						
Individual animal or herd production data	1	2	3	4	5	Q18b_3
Answer If [Q10613a_4] = 4						
Individual animal or herd feeding data	1	2	3	4	5	Q18b_4
Answer If [Q10613a_5] = 5						
On-farm weather station data	1	2	3	4	5	Q18b_5
Answer If [Q10613a_6] = 6						
Animal breeding data	1	2	3	4	5	Q18b_6
Answer If [Q10613a_7] = 7						
Financial data	1	2	3	4	5	Q18b_7
Answer If [Q10613a_8] = 8						
Veterinary medicine record	1	2	3	4	5	Q18b_8
Answer If [Q10613a_9] = 9						
Water use/quality	1	2	3	4	5	Q18b_9

***Q20. Do you use financial management software? . . .**

Yes	1	
No	555	Q20

Q20b. What are they?...

Answer If [Q20] = 1

Record verbatim in full

Q20b

***Q21. Do you use production management software including precision agriculture data management software? . . .**

Yes	1	
No	555	Q21

Q21b. What are they?...

Answer If [Q21] = 1

Record verbatim in full

Q21b

Q21c. Who helps you to analyse and interpret the above data?...

Read out and record

Data not used	1	Q21c_1
Yourselves including family members and employees	2	Q21c_2
Fee-for-service independant agronomist	3	Q21c_3
Service Providers	4	Q21c_4
		Q21c_O

Q22. Overall, how useful is the previously mentioned data you currently collect in helping you make farm management decisions? On a scale of 1 to 5 where 1 is no use at all and 5 is extremely useful. . . .

1 No use at all	1	
2	2	
3	3	Q22
4	4	
5 Extremely useful	5	

Q22b. Overall, how useful would the previously mentioned data be in helping you make farm management decisions if you had them? On a scale of 1 to 5 where 1 is no use at all and 5 is extremely useful. . . .

Answer If [Q16_9] = 9 OR [Q16b_10] = 10

1 No use at all	1	
2	2	
3	3	Q22b
4	4	
5 Extremely useful	5	

Q23. Overall, how much contribution has the previously mentioned data you currently collect made to your farm business profit? On a 1 to 5 scale, where 1 is no positive contribution at all and 5 is increased profit greatly, . . .

Do not answer if [Q16_9] = 9 OR [Q16b_10] = 10

1 No positive contribution at all	1
2	2
3	3
4	4
5 Increased profit greatly	5

Q23

Q23b. Overall, how much contribution would the previously mentioned data make to your farm business profit if you had them? On a 1 to 5 scale, where 1 is no positive contribution at all and 5 is increased profit greatly, . . .

Answer If [Q16_9] = 9 OR [Q16b_10] = 10

1 No positive contribution at all	1
2	2
3	3
4	4
5 Increased profit greatly	5

Q23b

Q24. Overall, how much contribution has the previously mentioned data you currently collect made to the efficient running of your farm? On a 1 to 5 scale, where 1 is no positive contribution at all and 5 is increased efficiency greatly, . . .

Do not answer if [Q16_9] = 9 OR [Q16b_10] = 10

1 No positive contribution at all	1
2	2
3	3
4	4
5 Increased efficiency greatly	5

Q24

Q24b. Overall, how much contribution would the previously mentioned data make to the efficient running of your farm, if you had them? On a 1 to 5 scale, where 1 is no positive contribution at all and 5 is increased efficiency greatly, . . .

Answer If [Q16_9] = 9 OR [Q16b_10] = 10

1 No positive contribution at all	1
2	2
3	3
4	4
5 Increased efficiency greatly	5

Q24b

Q25. Overall, how much contribution would the previously mentioned data you currently collect made to the risk management of your farm operations? On a 1 to 5 scale, where 1 is no positive contribution at all and 5 is improved risk management greatly, . . .

Do not answer if [Q16_9] = 9 OR [Q16b_10] = 10

1 No positive contribution at all	1
2	2
3	3
4	4
5 Improved risk management greatly	5

Q25

Q25b. Overall, how much contribution would the previously mentioned data make to risk management of your farm operations if you had them? On a 1 to 5 scale, where 1 is no positive contribution at all and 5 is improved risk management greatly, . . .

Answer If [Q16_9] = 9 OR [Q16b_10] = 10

1 No positive contribution at all	1
2	2
3	3
4	4
5 Improved risk management greatly	5

Q25b

Q26. When you need to work with two or more different datasets (such as soil data and weather data) On a 1 to 5 scale, where 1 is not hard at all and 5 is extremely hard, how hard do you find it to combine them together? . . .

Do not answer if [Q16_9] = 9 OR [Q16b_10] = 10

1 Not hard at all	1	
2	2	
3	3	
4	4	Q26
5 Extremely hard	5	
6 Not applicable	6	

Q27. For tools (such as machines and apps) used to collect the previously mentioned data, on a scale where 1 is don't know at all and 5 is know very well, how much do you know about the terms and conditions relating to data collection in your agreement with the service providers? . . .

Do not answer if [Q16_9] = 9 OR [Q16b_10] = 10

1 Don't know at all	1	
2	2	
3	3	Q27
4	4	
5 Know very well	5	

Q27b. For any of the previously mentioned data, how comfortable are you if the service/technology providers (such as John Deere or a weather station provider) have direct access to your data through the services they provide you, on a 1 to 5 scale where 1 is not comfortable at all and 5 is extremely comfortable? . . .

Do not answer if [Q16_9] = 9 OR [Q16b_10] = 10

1 Not comfortable at all	1	
2	2	
3	3	Q27b
4	4	
5 Extremely comfortable	5	

Q28. If the service/technology providers have direct access to their client's data including yours, on a 1 to 5 scale where 1 is not comfortable at all and 5 is extremely comfortable, how comfortable are you if they use the data to make profit for themselves? . . .

Do not answer if [Q16_9] = 9 OR [Q16b_10] = 10

1 Not comfortable at all	1	
2	2	
3	3	Q28
4	4	
5 Extremely comfortable	5	

Q29. If the service/technology providers have direct access to your data, on a 1 to 5 scale where 1 is no trust at all and 5 is total trust, how much do you trust them to maintain the privacy of your farm data? . . .

Do not answer if [Q16_9] = 9 OR [Q16b_10] = 10

1 No trust at all	1	
2	2	
3	3	Q29
4	4	
5 Total trust	5	

Q30. If the service/technology providers have direct access to your data, on a 1 to 5 scale where 1 is no trust at all and 5 is total trust, how much do you trust them not to share the data with third parties? . . .

1 No trust at all	1	
2	2	
3	3	Q30
4	4	
5 Total trust	5	

Q31. Thinking about your experiences and what you know about digital agricultural technologies, please indicate your agreement with the following statements on a 1 to 5 scale, where 1 is strongly disagree and 5 is strongly agree....

Read out in full and record

	1 Strongly disagree	2	3	4	5 Strongly agree	
There is poor technical support for digital agricultural technologies	1	2	3	4	5	Q31_1
The high costs of digital agricultural technologies/equipment doesn't provide good return	1	2	3	4	5	Q31_2
You keep farm operations very simple	1	2	3	4	5	Q31_3
Maximising production is very important to you	1	2	3	4	5	Q31_4
You are willing to take high risks to get higher financial returns	1	2	3	4	5	Q31_5

Q32. When the data collected from many individual farms are combined together, they can be used to develop tools that support agricultural decision making. This combined data is refered to as "aggregated farm data".... For the aggregated farm data to work, it will require individual farms to share their data. We would like to know your opinions about issues related to data sharing. On a 1 to 5 scale, where 1 is not comfortable at all and 5 is extremely comfortable, Can you please indicate how comfortable you are to share the following data... . . . with other farmers. . . .

	1 Not comfortable at all	2	3	4	5 Extremely comfortable	Not sure	
Do not answer If [Q28646i] = 1 OR [Q28646i] = 2 OR [Q28646i] = 3 OR [Q28646i] = 8 OR [Q28646i] = 9 OR [Q28646i] = 10 OR [Q28646i] = 11 OR [Q28646i] = 12							
Weather Station data	1	2	3	4	5	6	Q32_1
Do not answer If [Q28646i] = 1 OR [Q28646i] = 2 OR [Q28646i] = 3 OR [Q28646i] = 4 OR [Q28646i] = 5 OR [Q28646i] = 7 OR [Q28646i] = 8 OR [Q28646i] = 9 OR [Q28646i] = 10 OR [Q28646i] = 11 OR [Q28646i] = 12 OR [Q28646i] = 13 OR [Q28646i] = 15 OR [Q17792j] = 2							
Soil test data	1	2	3	4	5	6	Q32_2
Farm input data such as fertilisers & pesticides application	1	2	3	4	5	6	Q32_3
Production data	1	2	3	4	5	6	Q32_4

Q33. Using that same scale, can you please indicate how comfortable you are to share the following data with Agricultural industry-based organisations (such as farmer associations, RDC's). ...

	1 Not comfortable at all	2	3	4	5 Extremely comfortable	Not sure	
Do not answer If [Q28646i] = 1 OR [Q28646i] = 2 OR [Q28646i] = 3 OR [Q28646i] = 8 OR [Q28646i] = 9 OR [Q28646i] = 10 OR [Q28646i] = 11 OR [Q28646i] = 12							
Weather Station data	1	2	3	4	5	6	Q33_1
Do not answer If [Q28646i] = 1 OR [Q28646i] = 2 OR [Q28646i] = 3 OR [Q28646i] = 4 OR [Q28646i] = 5 OR [Q28646i] = 7 OR [Q28646i] = 8 OR [Q28646i] = 9 OR [Q28646i] = 10 OR [Q28646i] = 11 OR [Q28646i] = 12 OR [Q28646i] = 13 OR [Q28646i] = 15 OR [Q17792j] = 2							
Soil test data	1	2	3	4	5	6	Q33_2
Farm input data such as fertilisers & pesticides application	1	2	3	4	5	6	Q33_3
Production data	1	2	3	4	5	6	Q33_4

Q34. Using that same scale, can you please indicate how comfortable you are to share the following data with technology and service provider businesses. .

	1 Not comfortable at all	2	3	4	5 Extremely comfortable	Not sure	
Do not answer If [Q28646i] = 1 OR [Q28646i] = 2 OR [Q28646i] = 3 OR [Q28646i] = 8 OR [Q28646i] = 9 OR [Q28646i] = 10 OR [Q28646i] = 11 OR [Q28646i] = 12							
Weather Station data	1	2	3	4	5	6	Q34_1
Do not answer If [Q28646i] = 1 OR [Q28646i] = 2 OR [Q28646i] = 3 OR [Q28646i] = 4 OR [Q28646i] = 5 OR [Q28646i] = 7 OR [Q28646i] = 8 OR [Q28646i] = 9 OR [Q28646i] = 10 OR [Q28646i] = 11 OR [Q28646i] = 12 OR [Q28646i] = 13 OR [Q28646i] = 15 OR [Q17792j] = 2							
Soil test data	1	2	3	4	5	6	Q34_2
Farm input data such as fertilisers & pesticides application	1	2	3	4	5	6	Q34_3
Production data	1	2	3	4	5	6	Q34_4

Q35. Using that same scale, can you please indicate how comfortable you are to share the

following data with research institutions (such as universities, CSIRO). .

	1 Not comfortable at all	2	3	4	5 Extremely comfortable	Not sure	
Do not answer If [Q28646i] = 1 OR [Q28646i] = 2 OR [Q28646i] = 3 OR [Q28646i] = 8 OR [Q28646i] = 9 OR [Q28646i] = 10 OR [Q28646i] = 11 OR [Q28646i] = 12							
Weather Station data	1	2	3	4	5	6	Q35_1
Do not answer If [Q28646i] = 1 OR [Q28646i] = 2 OR [Q28646i] = 3 OR [Q28646i] = 4 OR [Q28646i] = 5 OR [Q28646i] = 7 OR [Q28646i] = 8 OR [Q28646i] = 9 OR [Q28646i] = 10 OR [Q28646i] = 11 OR [Q28646i] = 12 OR [Q28646i] = 13 OR [Q28646i] = 15 OR [Q17792j] = 2							
Soil test data	1	2	3	4	5	6	Q35_2
Farm input data such as fertilisers & pesticides application	1	2	3	4	5	6	Q35_3
Production data	1	2	3	4	5	6	Q35_4

Q36. Using that same scale, can you please indicate how comfortable you are to share the following data with the Australian Bureau of Statistics (ABS). .

	1 Not comfortable at all	2	3	4	5 Extremely comfortable	Not sure	
Do not answer If [Q28646i] = 1 OR [Q28646i] = 2 OR [Q28646i] = 3 OR [Q28646i] = 8 OR [Q28646i] = 9 OR [Q28646i] = 10 OR [Q28646i] = 11 OR [Q28646i] = 12							
Weather Station data	1	2	3	4	5	6	Q36_1
Do not answer If [Q28646i] = 1 OR [Q28646i] = 2 OR [Q28646i] = 3 OR [Q28646i] = 4 OR [Q28646i] = 5 OR [Q28646i] = 7 OR [Q28646i] = 8 OR [Q28646i] = 9 OR [Q28646i] = 10 OR [Q28646i] = 11 OR [Q28646i] = 12 OR [Q28646i] = 13 OR [Q28646i] = 15 OR [Q17792j] = 2							
Soil test data	1	2	3	4	5	6	Q36_2
Farm input data such as fertilisers & pesticides application	1	2	3	4	5	6	Q36_3
Production data	1	2	3	4	5	6	Q36_4

Q38. When your farm data becomes part of the aggregated data, how concerned would you be about the ownership of your farm data, on a 1 to 5 scale where 1 is not concerned at all and 5 is extremely concerned?...

1 Not concerned at all	1	
2	2	
3	3	Q38
4	4	
5 Extremely concerned	5	

***Q39.** Who do you think will benefit most from the aggregated farm data?...

Read out AND ONLY one choice can be made

Farmers	1	
Agribusiness	2	
Government	3	Q39
Not sure	4	

Q40. Using the same scale, how concerned would you be that the aggregated data could be used by some businesses to make money without sharing with you?...

1 Not concerned at all	1	
2	2	
3	3	Q40
4	4	
5 Extremely concerned	5	

Q41. Using the same scale, how concerned would you be that some businesses may use the aggregated farm data to influence market (such as produce prices and land value)?...

1 Not concerned at all	1	
2	2	

3	3	Q41
4	4	
5 Extremely concerned	5	

Q42. Using the same scale, how concerned would you be about the privacy of your farm data in the aggregated data?...

1 Not concerned at all	1	
2	2	
3	3	Q42
4	4	
5 Extremely concerned	5	

Q43. Finally, I just have some demographic questions. Could you please tell me your exact age?..

RECORD THE EXACT AGE

_____ Q43

_____

Q45. What is your highest level of education?...

Read out and record

Did not complete year 12	1	
Completed year 12	2	
Post-secondary qualification - agriculture	3	
Post- secondary qualification - other	4	
Undergraduate degree - agriculture	5	Q45
Undergraduate degree - other	6	
Postgraduate degree - agriculture	7	
Postgraduate degree - other	8	

Q46. Does anyone involved in managing the farm have a university degree?...

Answer If [Q45] = 1 OR [Q45] = 2 OR [Q45] = 3 OR [Q45] = 4

Yes	1	
No	555	Q46

Q51. Gender . . .

DO NOT ASK

Male	1	
Female	2	Q51

Q52. Thank you for your time and best of luck with the rest of the season! . . . END

Appendix B

Survey response rate

Industry	Quotas achieved	Farm records loaded into CATI	Number of calls required to achieve one completed survey
Horticulture - vegetables	30	1118	37
Wine grapes	15	375	25
Sheep only (wool) farms	89	3205	36
Sheep only (sheep meat) farms	59	1690	29
Beef only farms	126	1142	9
Beef/sheep	94	1745	19
Grain and sheep (mixed) - Sheep as main enterprise	94	2608	28
Grain and beef (mixed) - Beef as main enterprise	64	1561	24
Grains – including grains only; and main grain in sheep/grain or beef/grain mixed	150	4932	33
Rice	15	359	24
Sugarcane	65	980	15
Cotton	30	1540	51
Dairy	94	1651	18
Poultry (eggs)	16	410	26
Poultry (meat)	14	320	23
Pigs	15	430	29
Aquaculture	30	292	10
Total	1000	24358	24

Overall, from all calls made: 32% went to an answering machine; 28% had no answer; 21% asked to call back; 14% refused; and 5% completed the survey.

Main reasons for refusing survey	Percentage
Farm size not meeting minimum requirements	23%
Selling farm	17%
Leased out farm	14%
Sheep numbers too small	11%
Cattle numbers too small	7%
Hobby farmer	6%
Other	6%
No reason—hung up	54
Retired	3%
Farm type not relevant to survey	3%
Only do paper based surveys	3%
Don’t do phone surveys	2%

Appendix C

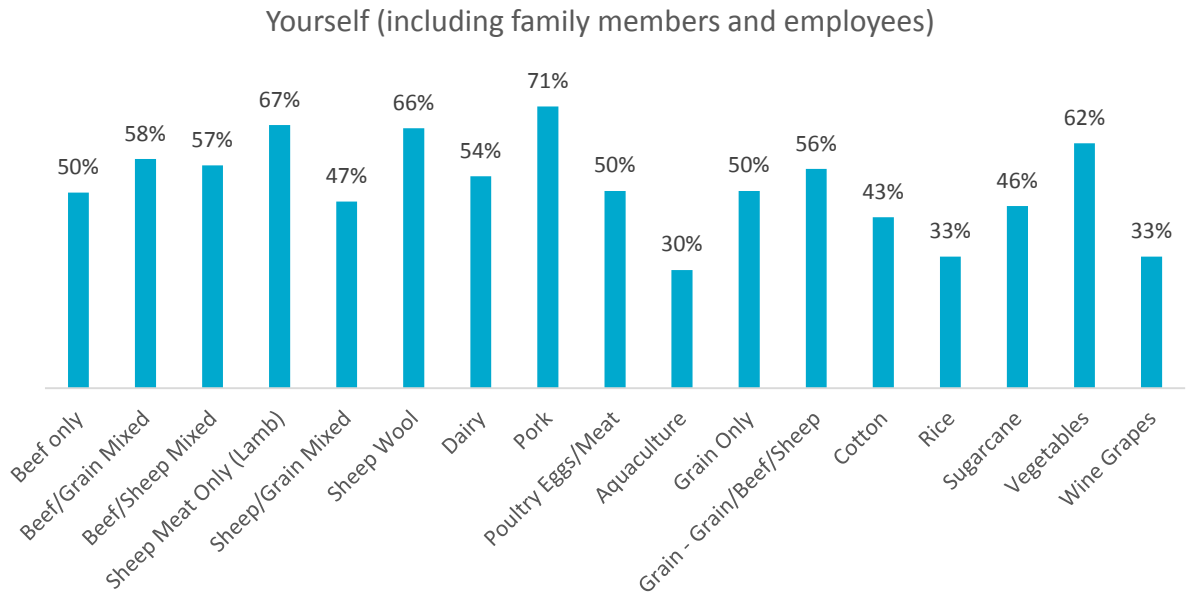
Types of production management software use

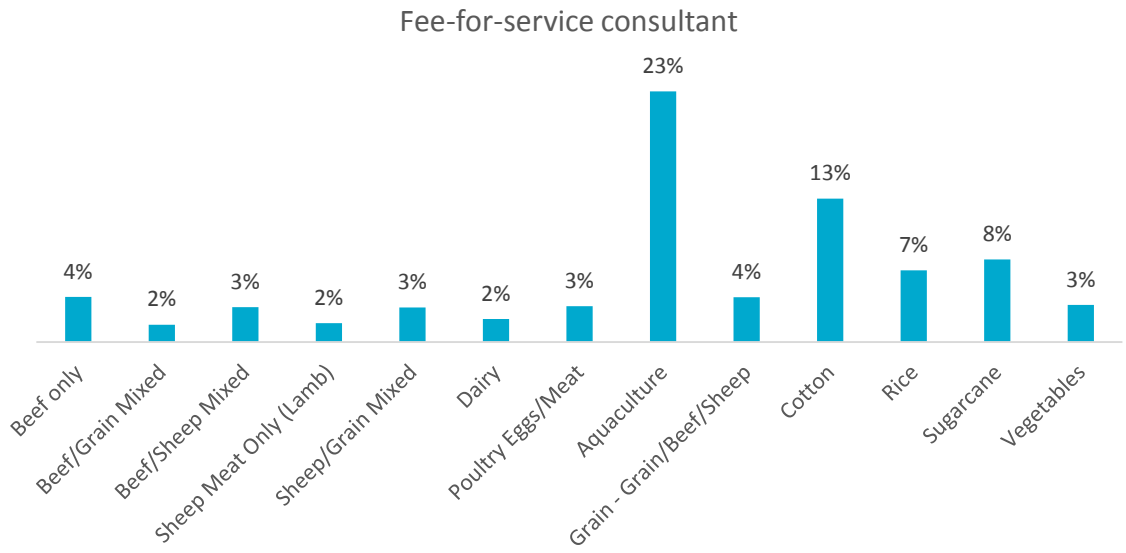
Software	Number of respondents	Software	Number of respondents	Software	Number of respondents
Abtrak	1	Farm Works	4	Pasture from Space	2
AFS Software	2	Farmlink	1	Practical systems-Wunderground.com	1
Agfarm	2	Fieldview	1	Phoenix	7
Agleader	1	Global Precision Management	1	PLM software	4
Agriwear	1	Google Earth	2	Phoenix	1
Agriwebb	3	Green Star	2	Porbitec, edat	1
Agritrack	1	Grow Data	1	Production wise	6
Agworld	7	Herd recording system in NSW - Dairy Express	1	Proprietary data management software	1
Apex	3	Herdmaster	4	Rdex	1
Aqua farm	2	Hico - Mistro	1	Roden Software	1
Aqua Futures	1	Ifarm	1	Shellfish Data Management	1
ATK Guidence	1	Inhouse	1	Smart Oysters	1
Auto Farm	2	Intellisteer- New Holland	1	SmartAg	1
Auto steering tractors	1	It's in conjunction with the DPI	1	SMS software	1
Back Paddock	2	John Deere	13	SST PPT	2
Call Collect	1	Koll Select	1	Stockbook	5
Caypin	1	Lifetimeyou, Grain and grazier, NVT	1	Tractor program	1
Concepts rural	2	MapInfo	1	Trimble	10
Contractor - operates on GPS	1	Maranoa Business	1	TSM total systems management. File Maker Pro	1
Created own software	1	Metafarms	1	VA Gateway	1
Cropwatch	1	MIPS	1	Variable Rate Spreading	1
CSPB Product	1	Mistro	1	Vision Gateway	1
Dairy Express	1	New Holland	1	Web based in the cloud	1
Data comes from Mill records	1	Omni Star	2	Wireless Farmer	1
Easy daisy	4	Own software	1	Yield maps; one of the machines does it	1
Elite Herd	2	Paddock Wise	2	Don't know	48
Excel	4	PAM	9		

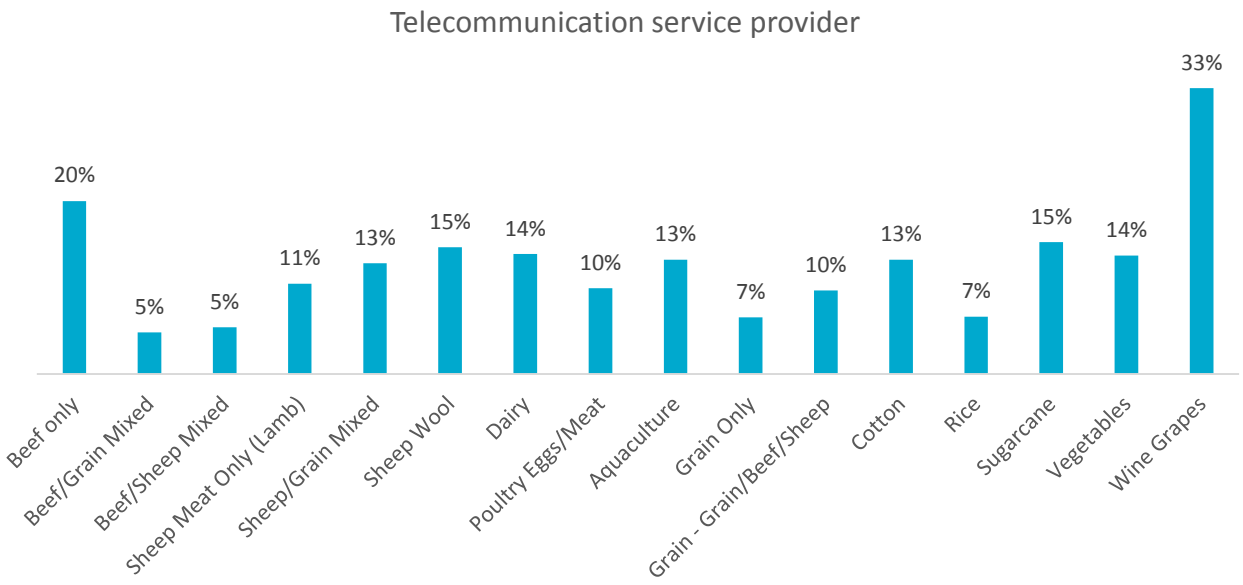
Appendix D

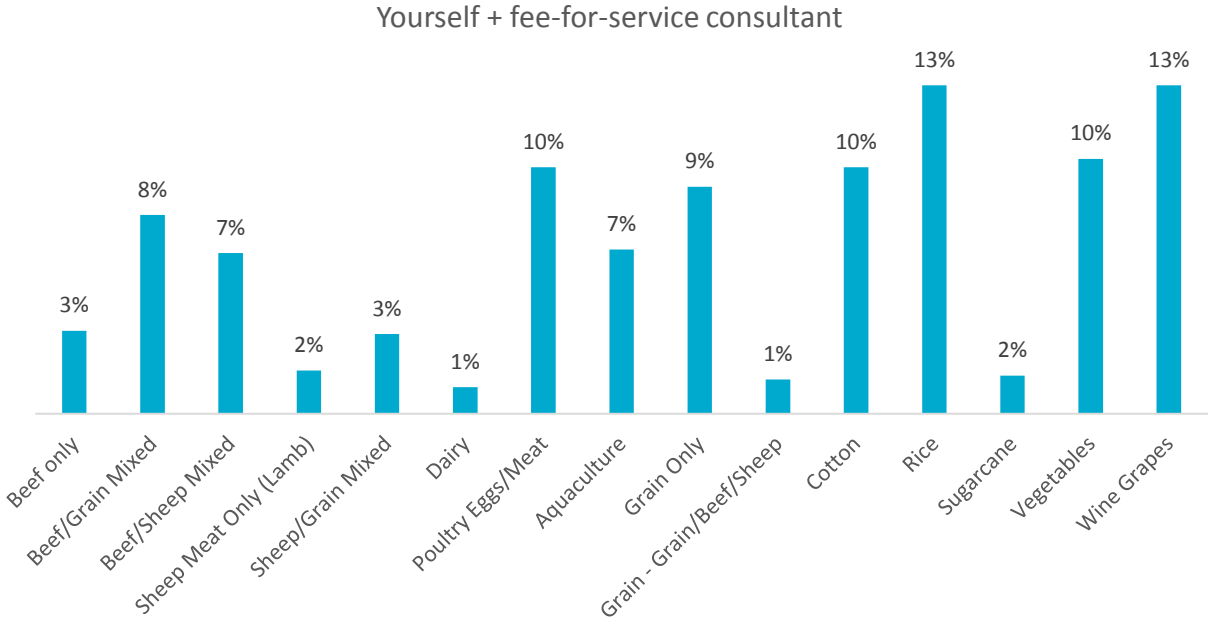
Appendix D displays the rates of using the various options to sort out telecommunication needs across industries.

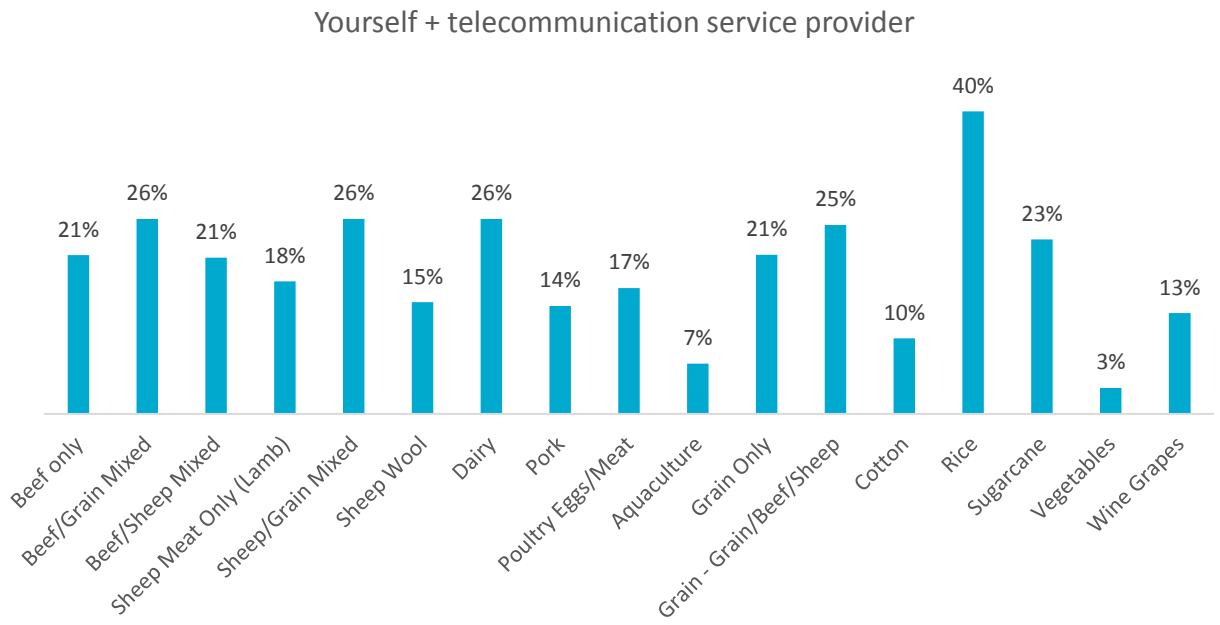
Question: Who has helped you in sorting out your telecommunication needs?

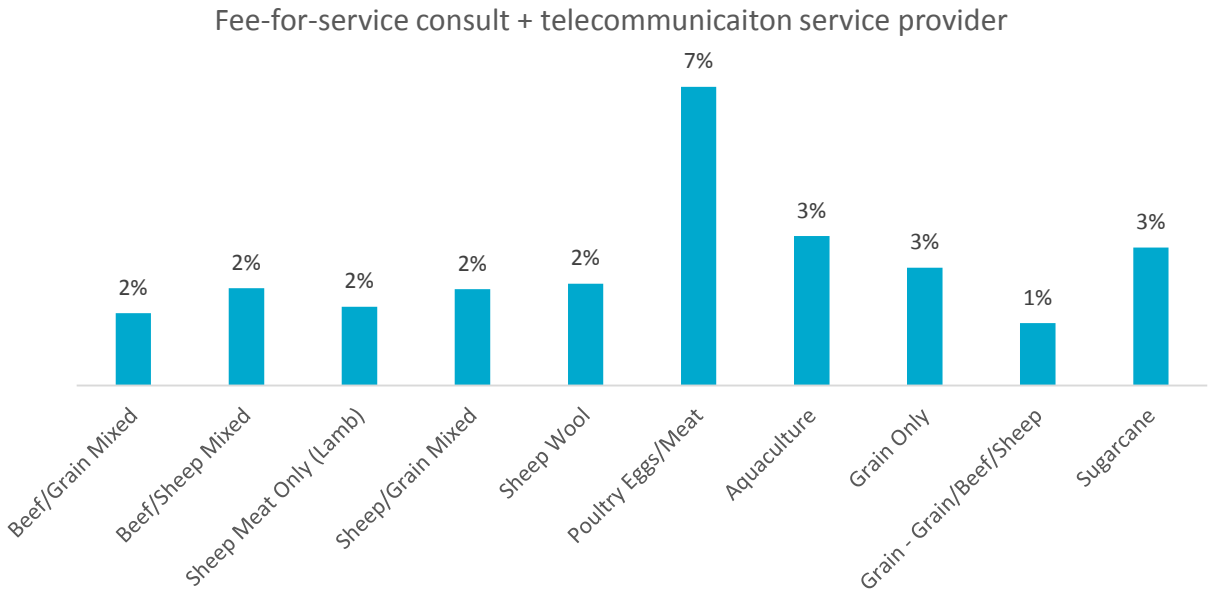


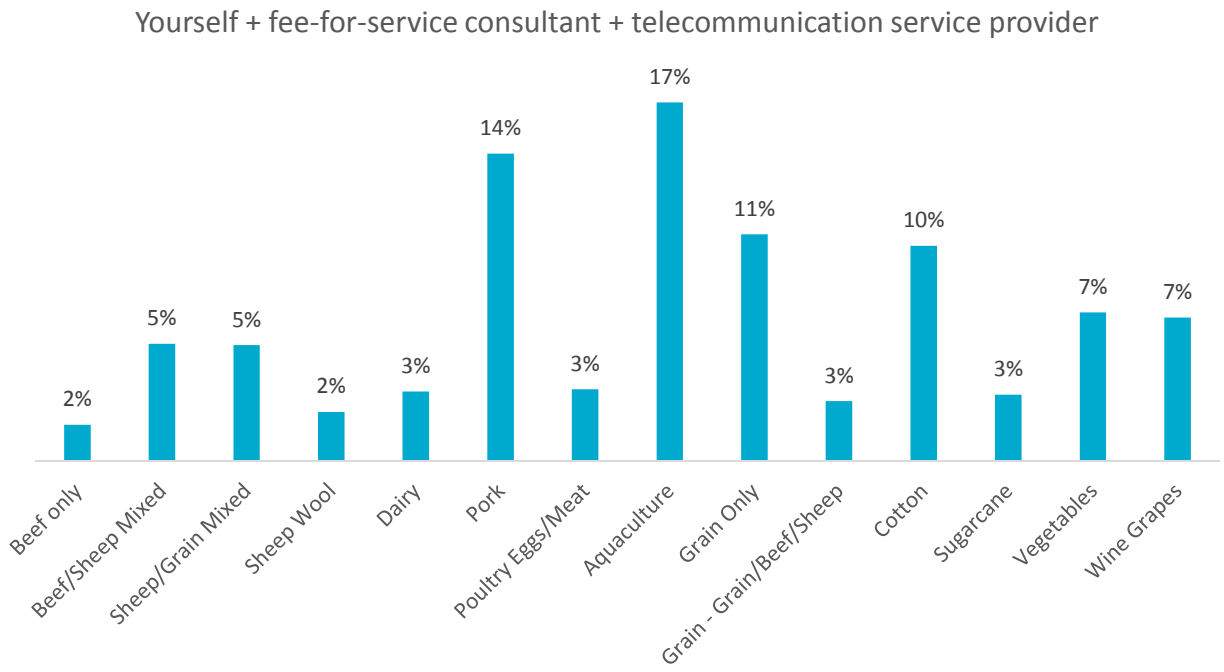



Telecommunication service provider
20%
5%
5%
11%
13%
15%
14%
10%
13%
7%
10%
13%
7%
15%
14%
33%
Beef only
Beef/Grain Mixed
Beef/Sheep Mixed
Sheep Meat Only (Lamb)
Sheep/Grain Mixed
Sheep Wool
Dairy
Poultry Eggs/Meat
Aquaculture
Grain Only
Grain - Grain/Beef/Sheep
Cotton
Rice
Sugarcane
Vegetables
Wine Grapes


Yourself + fee-for-service consultant
3%
8%
7%
2%
3%
1%
10%
7%
9%
1%
10%
13%
2%
10%
13%
Beef only
Beef/Grain Mixed
Beef/Sheep Mixed
Sheep Meat Only (Lamb)
Sheep/Grain Mixed
Dairy
Poultry Eggs/Meat
Aquaculture
Grain Only
Grain - Grain/Beef/Sheep
Cotton
Rice
Sugarcane
Vegetables
Wine Grapes


Yourself + telecommunication service provider
21%
26%
21%
18%
26%
15%
26%
14%
17%
7%
21%
25%
10%
40%
23%
3%
13%
Beef only
Beef/Grain Mixed
Beef/Sheep Mixed
Sheep Meat Only (Lamb)
Sheep/Grain Mixed
Sheep Wool
Dairy
Pork
Poultry Eggs/Meat
Aquaculture
Grain Only
Grain - Grain/Beef/Sheep
Cotton
Rice
Sugarcane
Vegetables
Wine Grapes


Fee-for-service consult + telecommunicaiton service provider
2%
2%
2%
2%
2%
7%
3%
3%
1%
3%
Beef/Grain Mixed
Beef/Sheep Mixed
Sheep Meat Only (Lamb)
Sheep/Grain Mixed
Sheep Wool
Poultry Eggs/Meat
Aquaculture
Grain Only
Grain - Grain/Beef/Sheep
Sugarcane


Yourself + fee-for-service consultant + telecommunication service provider
2%
5%
5%
2%
3%
14%
3%
17%
11%
3%
10%
3%
7%
7%
Beef only
Beef/Sheep Mixed
Sheep/Grain Mixed
Sheep Wool
Dairy
Pork
Poultry Eggs/Meat
Aquaculture
Grain Only
Grain - Grain/Beef/Sheep
Cotton
Sugarcane
Vegetables
Wine Grapes

CONTACT US

t 1300 363 400
+61 3 9545 2176
e csiroenquiries@csiro.au
w www.csiro.au

AT CSIRO, WE DO THE EXTRAORDINARY EVERY DAY

We innovate for tomorrow and help improve today – for our customers, all Australians and the world.

Our innovations contribute billions of dollars to the Australian economy every year. As the largest patent holder in the nation, our vast wealth of intellectual property has led to more than 150 spin-off companies.

With more than 5,000 experts and a burning desire to get things done, we are Australia's catalyst for innovation.

CSIRO. WE IMAGINE. WE COLLABORATE. WE INNOVATE.