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How do farmers use the internet: A mixed methods approach

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Bachelor of Engineering (Computer Systems) with honours

PhD Thesis, James Cook University

This thesis is submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in Agriculture and Environmental Studies.

College of Business, Law and Governance, James Cook University, 1 James Cook Drive, Townsville, Queensland, 4814

**August 2024**

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## Research Outputs

### Publications under development

Harrington, Hay, Atkinson & Lamb (2023). Patterns of behaviour: A longitudinal analysis of the internet usage of select North-West Queensland farmers. *Journal of Rural Studies*

Hay, Rachel, Sparrow, Kristy, Wilson, Carrie-Ann, Marshall, Amber, & Harrington (2022). Conceptualising Connectivity Literacy: A conceptual framework towards understanding technology adoption in rural, regional, and remote Australia. *Telematics and Informatics*, *Under Review*.

Harrington & Hay (2024). The role of internet connectivity in inward and outward migration of rural and remote Australia, *Migrant Settlement in Regional Australia: A Holistic Overview*, Springer Nature.

Jeon, Rykaczewski, Williams, Harrington, Garcia-Guerra, Kinder & Trotter (2024). A holistic paradigm for monitoring health and performance of livestock with a multi sensor data fusion approach, *Animals*.

### Presentations

Harrington, William. (2024). "Pre-Completion Seminar: How do farmers use the internet?" James Cook University. 2<sup>nd</sup> of August 2024

Harrington, William. (2023). "The challenges of internet connectivity in northern Australia". Presented at the Northern Australia Food Futures Conference (2023). 23 May.

Harrington, William. (2022). "Internet connectivity in Australia and the USA". Presented at the AgTAC Seminar Series. 6 October.

Harrington, William. (2022). "Internet connectivity in the USA and Australia – a comparison". Presented at The Ohio State University. 13 June.

Hay, Harrington, Sparrow. (2021). "If you build it, they won't come". Presented at the Developing Northern Australia Conference. 16 August.

## **Media and interviews**

Due to the topical nature of the studies contained in this dissertation, extensive media coverage was obtained. The list below highlights some of the more prominent media coverage. I wrote all of the media releases for approval by James Cook University

Beef TV panel interview, Beef Week, 9<sup>th</sup> of May 2024, Post-grad Uni Student supporting innovation on remote cattle stations,

<https://beef.tv.com.au/about/?playlist=2caeb8f&video=ca0b4a7>

ABC Radio Interview, 6<sup>th</sup> of July 2020, Internet connectivity in regional Queensland,

<https://www.abc.net.au/news/rural/2020-07-10/outback-mental-health-on-woodstock-station/12424768>

ABC TV Interview, 10<sup>th</sup> of July 2020, Internet connectivity in regional Queensland,

<https://www.abc.net.au/news/rural/2020-07-10/outback-mental-health-on-woodstock-station/12424768>

ABC Website, 10<sup>th</sup> of July 2020, Cattle station focuses on mental health of staff despite isolation, slow internet, <https://www.abc.net.au/news/rural/2020-07-10/outback-mental-health-on-woodstock-station/12424768>

ABC Website, 22<sup>nd</sup> of March 2022, Rural residents say \$750m NBN boost 'not enough' to bridge digital divide in the bush, <https://www.abc.net.au/news/2022-03-24/farmers-welcome-nbn-upgrade/100928668>

AgForce QLD Website, 24<sup>th</sup> of March 2023, Help shape the future of regional, rural, and remote connectivity, <https://www.agforceqld.org.au/knowledgebase/article/AGF-01746/>

ABC Radio, 8am the 31<sup>st</sup> of March 2023, News, Story about PhD survey

2GB Radio, 31<sup>st</sup> of March 2023, News, Story about PhD survey

ABC Radio, 31<sup>st</sup> of March 2023, Queensland Country Hour, Story about PhD survey

Stock and Land (Online and Print), 31<sup>st</sup> of March 2023, Farmer internet survey looks at current, and potential, usage, <https://www.stockandland.com.au/story/8129731/farmers-are-being-surveyed-about-their-internet-use-and-what-theyd-like-to-see/>

Home page of the JCU website, 21<sup>st</sup> of December 2021, <https://www.jcu.edu.au/this-is-uni/natural-and-built-environments/articles/future-proofing-outback-internet>

Beef Central News Website, 3<sup>rd</sup> of April 2023, <https://www.beefcentral.com/news/bush-internet-pioneer-looking-for-survey-participants-in-phd-studies/>

The National Tribune Website, 1<sup>st</sup> of April 2023, <https://www.nationaltribune.com.au/farmers-in-cyberspace/>

Mirage News website, 1<sup>st</sup> of April 2023, <https://www.miragenews.com/farmers-in-cyberspace-979296/>

Media Release by James Cook University (William Harrington), 31<sup>st</sup> of March 2023, <https://www.jcu.edu.au/news/releases/2023/march/farmers-in-cyberspace>

ABC Future Tense Program, 25<sup>th</sup> of June 2021, <https://www.abc.net.au/radionational/programs/bigideas/environment-as-financial-investment/13409110>

ABC Landline Program, 25<sup>th</sup> of June 2021 <https://www.abc.net.au/news/rural/2021-07-31/outback-internet-set-to-grow-by-900-kilometres/100333424>

Beef Week Trade show panel, 6<sup>th</sup> of June 2021, Beef Week in Rockhampton

## Other Outputs

Harrington (2020). Bibliometric tool (Version 0.0.1) [Computer software].

<https://doi.org/10.5281/zenodo.7237894>

This bibliometric tool programmatically performed an automated search of the James Cook University library website to identify relevant literature to be used as part of this study. The code that was developed was released under the MIT software licence developed by the Massachusetts Institute of Technology with the intent of it being available for use by fellow researchers free of charge without any warranties (real or implied). Further details are available in Chapter Two.

Harrington (2024). Chapter Image Generation Tool (Version 0.0.1) [Computer software].

<https://zenodo.org/doi/10.5281/zenodo.11495636>

This image generation tool automatically generated the approximately 60 document navigation imaged in this dissertation. It has been released under the [BSD-2-Clause license](#) with the aim of assisting fellow students during the preparation of their own dissertation

## Acknowledgements

You always know that when you start your PhD that it is a large endeavour. It isn't until you actually begin that you realise how large it actually is. It is only by surrounding yourself with the right people that you are able to make it through.

There are many people that I would like to thank for helping me on my PhD journey. First and foremost, I would like to thank my wife Hollie for her love and support, along with the rest of my family including Peter, Carmel, Emily, and Grace. I would also like to thank my supervisors, Associate Professor Rachel Hay, Professor Ian Atkinson and Professor David Lamb for their guidance and support. A special thanks to my primary supervisor Professor Rachel Hay for your time, knowledge, expertise, and patience as I progressed on my PhD journey.

Halfway through my PhD I was fortunate to receive a Fulbright scholarship to travel to the United States of America to study at The Ohio State University (OSU). I would like to thank the Australian Fulbright Association, OSU, Professor Alejandro Relling, Professor Jim Kinder and everyone else who helped make the trip the success it was.

A big thankyou also to my host institution, James Cook University, my research assistant Therese, my college, and its administration staff and to everyone else who helped me along my journey.

I would also like to acknowledge the support of the Australian Government through their RTP Fee Offset which is part of the Australian Government Research Training Program and the support of Food Agility CRC Ltd in the form of a post-graduate research scholarship. The Food Agility CRC is funded under the Commonwealth Government CRC Program. The CRC Program supports industry-led collaborations between industry, researchers, and the community.

## Dedication

I would like to dedicate the work to the farmers and graziers that feed and clothe us all. I believe this is best said by Amelia E. Barr in her poem "The Farmer".

### **The Farmer by Amelia E. Barr**

*The king may rule o'er land and sea,  
The lord may live right royally,  
The soldier ride in pomp and pride,  
The sailor roam o'er ocean wide;  
But this or that, whate'er befall,  
The farmer he must feed them all.*

*The writer thinks, the poet sings,  
The craftsmen fashion wondrous things,  
The doctor heals, the lawyer pleads,  
The miner follows the precious leads;  
But this or that, whate'er befall,  
The farmer he must feed them all.*

*The merchant he may buy and sell,  
The teacher do his duty well;  
But men may toil through busy days,  
Or men may stroll through pleasant ways;  
From king to beggar, whate'er befall,  
The farmer he must feed them all.*

*The farmer's trade is one of worth;  
He's partner with the sky and earth,  
He's partner with the sun and rain,  
And no man loses for his gain;  
And men may rise, or men may fall,  
But the farmer he must feed them all.*

*God bless the man who sows the wheat,  
Who finds us milk and fruit and meat;  
May his purse be heavy, his heart be light,  
His cattle and corn and all go right;  
God bless the seeds his hands let fall,  
For the farmer he must feed us all.*

### Statement of contributions of others

Nature of assistance	Contribution	Name, title and affiliation of co-contributors
Supervision	Primary Supervisor	Professor Rachel Hay, College of Business, Law and Governance, James Cook University, Australia, Townsville, QLD, 4811
	Secondary Supervisor	Professor Ian Atkinson, AI@JCU, James Cook University, Australia, Townsville, QLD, 4811
	Industry advisor	Professor David Lamb, Food Agility CRC Limited, Level 16/175 Pitt St, Sydney NSW 2000, Australia and Precision Agriculture Research Group, University of New England, Armidale, NSW, 2350, Australia
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	Australian Fulbright Association Stipend	The Australian Fulbright Association
	College of Business, Law and Governance, Stipend	James Cook University
	Australian Government	RTP Fee Offset support
Data collection	Better Internet for Rural, Regional and Remote Australia (BIRRR)	Kristy Sparrow, BIRRR

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Data Analysis	Statistics	Professor Rhondda Jones, James Cook University, Australia, Townsville, QLD, 4811
Research Support	Data Extraction	Therese Kaul, Research Assistant, James Cook University, Australia, Townsville, QLD, 4811  Carrie-Ann Wilson, PhD Student, College of Business, Law and Governance, James Cook University, Australia, Townsville, QLD, 4811
Editing	Hollie Harrington	
Media Support	Media Releases	Alistair Bone, James Cook University

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## **COVID-19**

Like many others, this project was affected by the COVID-19 pandemic. I believe that it is fair to say that the COVID-19 pandemic has changed the world and created unique challenges. The pandemic also demonstrated the importance of internet connectivity to our society and, for the briefest moments during lockdowns, broke down the tyranny of distance for people living in regional and remote Australia if they had access to adequate, fit for purpose internet connectivity.

This study took place as the pandemic disrupted our society, changed how it used the internet and created many challenges and opportunities (both personal and professional). This study captures some of these changes that occurred over this period but also suffered from many of the challenges that the pandemic caused.

## Personal Statement

Despite growing up and living on a remote cattle station in North West Queensland, I have always had a passion and an interest in technology. I am an engineer and studied computer systems engineering as my undergraduate degree and used the knowledge gained to design, build, and sell technology that improved the lives of people living in the bush. Starting from the development of some of the first IOT devices on the market in 2007 (even before the term IOT was coined) and moving onto starting a business to improve internet connectivity in regional Australia.

I have experienced the challenges of poor internet connectivity firsthand but fortunately had the technical skill to be able to do something about it. Personally, this is important to me as I don't want my family (particularly my children) to grow up not having access to adequate, fit for purpose internet connectivity or be otherwise disadvantaged when compared to their peers in the city just because of where they lived.

Through my roles as a farmer, founder, and entrepreneur during my career, I have experienced the challenges of poor internet connectivity firsthand. I began to understand that the adoption of technology in agriculture is not a technology problem, it is a people problem.

I felt that the best way to demonstrate this and show the importance of internet connectivity to regional Australians, and in particular farmers was through hard, scientific evidence. I was fortunate enough to be given an opportunity to do this after exiting our IOT business in 2019, by starting a PhD. Like all PhD's, this has been a challenging endeavour, particularly given the change in discipline but I believe that it also allowed me a rare opportunity to examine a social problem with a technical mindset.

Throughout my studies, I have leveraged my anecdotal experience, where appropriate to, in the spirit of social science bring out the colour and the interesting things that we, as humans have, are and do. I hope that I can demonstrate the power of the internet – what better example than completing a PhD remotely and I hope that my research can help improve internet connectivity in regional Australia.

## **Abstract**

Internet connectivity is an integral part of life in today's world, with fast and reliable internet connectivity being taken for granted by many people. However, farmers are still widely acknowledged to have inequitable access to the internet. This dissertation examines how farmers connect to and use the internet and seeks to understand if the internet connectivity available to farmers meets their needs. With many of the services that we use on a day-to-day basis being developed using a principal of "assumed equity" of internet connectivity, this study also examines if the ability of farmers to produce food productively and efficiently and to utilise other services that are used by people in urban areas is being restricted by their internet connectivity.

This dissertation utilises an explanatory sequential mixed method design to examine two unique quantitative datasets and follows on with an online survey that seeks to explain what the farmers are using the internet for and their attitudes and beliefs towards the internet. It also presents a novel methodology and tools to extract and examine these secondary datasets.

The results of this dissertation show that in many cases, the internet connectivity available to farmers is not meeting their needs and that farmers are changing their behaviour as a result rather than making attempts to improve their internet connectivity. This inequitable access to the internet ultimately leads to a profound difference in how farmers live their lives and run their businesses. This dissertation also examines how farmers are using social media in their day to day lives.

## **Key Words**

Farmers, Graziers, Internet, Broadband, Agriculture, Social Media, Connectivity Literacy, Digital Apathy

## **Australian and New Zealand Standard Research Classifications (ANZSRC)**

Fields of Research (FoR) Classification: 44.1007.1302

TOA: Strategic Basic Research

FOR: 44 (Human Society) 1007 (Sociology and social studies of science and technology)

SEO: 1302 (Communication)

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## List of Acronyms

ABC	Australian Broadcasting Corporation
ABS	Australian Bureau of Statistics
ANOVA	Analysis of variance
API	Application Programming Interface
ASN	Autonomous System Number
ASN	Automated System Number
BIRRR	Better Internet for Rural, Regional and Remote Australia
CL	Connectivity Literacy
CWA	Country Women's Association
DA	Digital Apathy
FACRC	Food Agility Commonwealth Research Corporation
FTTN	Fibre to the node
FTTP	Fibre to the premises
HREC	Human Research Ethics Committee
ICPA	Isolated Children's Parents' Association
IOT	Internet of Things
ISP	Internet Service Provider
NBN	National Broadband Network
NISP	Nominated Internet Service Provider
PTMP	Point To Multi Point
PTP	Point To Point
RRR	Rural, Regional and Remote
TNQ Hub	Tropical North Queensland Drought Resilience Adoption and Innovation Hub

## Definitions

### **Farmer**

Farmers produce all the food and natural fibre that we, as a species, need to survive. As a result, there are many different types of farmers. According to the [Collins English Dictionary \(2014a\)](#), a farmer is defined as someone who grows crops such as wheat, cotton, chickpeas, mung beans, sorghum etc and a grazier is defined as a “farmer who rears or fattens cattle or sheep on grazing land” ([Collins English Dictionary, 2014b](#)). In North America, graziers are also called ranchers. For the purposes of this publication and noting the potential international readership, graziers, ranchers, and farmers will be collectively referred to as farmers.

### **Nominated ISP (NISP)**

Secondary data for this study was sourced from an Internet Service Provider (ISP) called Wi-Sky Queensland, that supplies internet connectivity to residents of North West Queensland, Australia. This ISP will be referred to as the “Nominated ISP” (NISP) throughout this publication. More details regarding the NISP are available in 1.2.2.2.

### **Applications**

For the purposes of this document, an application is defined as a website, smartphone or tv app or and other computer program that utilises the internet to operate regardless of the device or of software that is used to access or run it.

### **Broadband**

The terms broadband and internet connectivity will be used interchangeably through this dissertation to describe a connection to the internet.

### **Low Latency**

For the purposes of this work, low latency is defined as an internet connection that has a round-trip time to a typical remote server of less than 100 milliseconds.

### **Download Traffic**

Download traffic is any data that travels from a server or other device connected to the internet to a user. Examples include a movie that is being streamed from a service such as Netflix™ or a software update for a computer or smartphone.

**Upload Traffic**

Any internet traffic that travels from a device to the internet. Examples include uploading a video or image to social media or video conferencing.

**Unconstrained Internet Connection**

For the purposes of this work, an unconstrained internet connection is one that does not have any monthly download and upload data limits, or any other restriction based on the type or source or destination of any internet traffic passing through it.

**Connectivity Literacy**

Connectivity refers to an individual or organisation's ability to get connected and stay connected to the internet.



## How do farmers use the internet?

How do farmers use the internet: A mixed methods approach						
Chapter 1 How do farmers use the internet?	Chapter 2 Methodology	Chapter 3 Demographic analysis	Chapter 4 Understanding how farmers use the internet	Chapter 5 Understanding the internet connectivity requirements of farmers	Chapter 6 How do farmers use social media	Chapter 7 Discussion and conclusion
1.1 Introduction	2.1 Introduction	3.1 Introduction	4.1 Introduction	5.1 Introduction	6.1 Introduction	7.1 Introduction
1.2 Background and research rationale	2.2 Philosophical perspective	3.2 Survey Dataset	4.2 Literature Review	5.2 Literature Review	6.2 Literature Review	7.2 Discussion of findings
1.3 Theoretical Framework	2.3 Methodological foundation	3.3 Data cleaning	4.3 Methodology	5.3 Methodology	6.3 Methodology	7.3 Response to rationale
1.4 Research Objective	2.4 Research Ethics	3.4 Respondent demographics	4.4 Results and Discussion	5.4 Results and Discussion	6.4 Results and Discussion	7.4 Contribution of the thesis
1.5 Thesis Outline	2.5 Study population	3.5 Chapter Summary	4.5 Chapter Summary	5.5 Chapter Summary	6.5 Chapter Summary	7.5 Future research potential
1.6 Chapter Summary	2.6 Data collection instruments					7.6 Limitations
	2.7 Research data storage					7.7 Conclusion
	2.8 Data analysis techniques					7.8 Recommendations
	2.9 Literature review methodology					
	2.10 Risk management					
	2.11 Chapter Summary					

**Figure 1.1 - Thesis Navigation**

This dissertation presents three separate studies that explore farmers relationship with internet including how they use internet in their day to day lives, in their businesses, how they connect to the internet and how they use social media. Each chapter of this work begins with a navigation pane as shown above in Figure 1.1.

Chapter Four presents Study One – “Analysing how farmers use the internet”. This study examines the long-term internet usage patterns of a group of farmers located in North West Queensland. Two secondary datasets provided by the Nominated Internet Service Provider (NISP) over the period of 2018 to 2022 was analysed. Factors including the average daily upload and downloads were studied to understand how these changed over time. The analysis also examined what applications and websites the group of farmers used and examined how this use changed over time.

Chapter Five presents Study Two – “Understanding the internet connectivity requirements of farmers”. It examines the results of an online survey to describe what technologies farmers

## CHAPTER 1 – How do farmers use the internet?

are using to connect to the internet and if these technologies are meeting their needs. It also examines if the technologies and plans available to them are meeting their needs in terms of monthly data allowance, reliability, and several other factors. The study also examines how actively farmers are changing their plans, how they connect to the internet and finally, how much mobile phone coverage farmers have on their farms or stations.

Chapter Six presents Study three – “How farmers use social media” examines how farmers use social media. Social media was identified as one of the largest single components of farmers internet usage in Study One and this chapter examines how the farmers are using social media in more detail including what and how often they use various social media and instant messaging platforms. The study considers various factors including the type and size of the farm the respondent lives or works on and how factors such as the respondents age or gender changes how they use social media and instant messaging platforms. Finally, the study takes a deep dive into how farmers use the most popular social media platform identified in Study One, Facebook.

Together these studies present a description of the relationship between farmers and the internet, how they use the internet and how they get connected. The results of these studies are then triangulated and discussed in further detail along with limitations to this research and recommendations for further research in chapter seven.

### **1.1 Introduction**

Few human endeavours (except perhaps farming) have had such a transformative effect on our society and commerce as the invention of the internet. We now live in a world where almost every person on the planet has the ability to communicate with anyone else on demand in real-time. Few people could have imagined, even one generation ago, the transformative and integral role the internet now plays in our society. We are now at a point where the internet is now considered by many as a utility that is important as access to electricity or water, indeed, the United Nations now consider access to the internet a basic human right ([Rue, 2011](#)).

The internet has the potential to remove the relevance of the geographic location of an individual or business. A good example of this is that the author of this dissertation lives and works on a remote cattle station in North West Queensland. [Ryan \(2010\)](#) described this

## CHAPTER 1 – How do farmers use the internet?

phenomenon as “*killing geography*”. This premise however relies on the assumption that simply having *access* to the internet is both necessary and sufficient. As many of the readers of this dissertation can attest to, this is not always the case.

The development of farming itself approximately 10,000 years ago was so significant for the human race that it resulted in the Neolithic Revolution ([Dow, 2023](#)). Indeed, the growth of human race has been intimately linked to improvements in farming methods. The development of agriculture enabled the global population to increase as humans moved away from hunter gathering and began living in communities ([Dow, 2023](#)). [Mithen \(2007\)](#) goes as far as arguing the economic basis of farming enabled the development of writing, mathematics and digital technologies.

Modern farming methods bear little resemblance to those developed during the Neolithic Revolution. Whilst in prehistory the majority of the population were farmers, the development and availability of technology as a result of the industrial revolution now means that the percent of farmers as part of the global population continues to decrease and as of 2018 is now under 3% in high income countries such as Australia ([OECD, 2018](#)).

Farmers themselves are also changing. Far from the stereotypical image of a farmer with a low income and poor education, modern farmers (in the case of Australia at least) are more educated than they have ever been ([ABARES, 2018](#)). In addition, difficulty accessing technology has contributed to many landholders distrust in technologically derived information ([Shrapnel & Davie, 2001](#)) and arguably, restricts access to information.

It is my belief that farmers themselves are some of the most important members of our society, providing the food and fibre that we need to survive. To do this, farmers use natural resources including land, and water and as a result are often located in remote areas where these resources are available.

## 1.2 Background and research rationale

Internet connectivity is “critical to the growth and resilience of the Australian economy, including in regional, rural and remote Australia” ([Hartsuyker et al., 2021](#))

Poor connectivity is limiting agricultural development in regional and remote regions of the world, including the adoption of new technology and new approaches to farming ([Charmley et al., 2016](#); [Lamb et al., 2008](#); [Lamb, 2018](#); [Rango et al., 2011](#)). Rural areas, and in particular farmers are, with little exception, the most excluded from access to high speed internet connectivity and yet they have the most to benefit from such services ([Townsend et al., 2013](#)). Internet connectivity “enables the free and efficient exchange of information” and “removes the barriers of time and space” ([FCC, 2010, p. 193](#)) and without adequate internet connectivity any benefits are, at best, only able to be partially realised ([Mandel et al., 2012](#)).

A lack of access to adequate internet connectivity has a profound difference in the how farmers live their lives and run their businesses. It also makes it difficult to attract staff that are otherwise accustomed to having access to services such as social media platforms and video streaming. Such challenges, compounded by the difficulty of disseminating new ideas due to poor communications and low levels of digital literacy are reducing the efficiency of food production, increasing the risk to Australian and global food security.

Food production requires large amounts of land with 38% of the earth’s surface dedicated to food production ([Food and Agriculture Organisation of the United Nations, 2020](#)). As a result, farmers, are often located outside of cities and towns. The low population density of these areas make it more expensive to provide internet connectivity to them ([Salemink et al., 2017](#)). Being isolated also means that the use of fixed line connectivity such as direct fibre optic or copper cables to a customer’s premises are impractical. Therefore, telecommunications providers typically use wireless technologies such as 4G or fixed wireless technologies to provide internet connectivity. In extremely remote areas satellite connectivity such as the NBN Sky Muster™ service ([NBN Co, 2024](#)) or SpaceX’s new Starlink™ service ([SpaceX, 2024](#)) are typically used.

Geographical isolation, low population density and slow uptake have been identified as factors that make supplying internet connectivity to farmers difficult ([Hartsuyker et al., 2021](#)). In

## CHAPTER 1 – How do farmers use the internet?

addition, the performance of internet connectivity that is available to farmers is often less than what is available to urban residents due to reduced or expensive backhaul capacity ([West Australian Department of Primary Industries and Regional Development, 2018](#)) or a reliance on wireless technologies that are unable to perform as well as fixed line services such as fibre optic cables ([Bureau of Communications and Arts Research, 2020](#)). Combined, these factors ultimately lead to internet connectivity offerings for farmers to be generally slower than what is available to urban residents. The connections are also often restricted by lower data limits or other artificial restrictions ([Regional Telecommunications Independent Review, 2018](#)).

As a result of these challenges, most internet services in regional Australia are generally subsidised or otherwise supported by governments. Australian examples include the National Broadband Network (NBN) ([Australian Government Department of Infrastructure Transport Regional Development Communications and the Arts, 2024a](#)) and the Regional Connectivity Program (RCP) ([Australian Government Department of Infrastructure Transport Regional Development Communications and the Arts, 2024b](#)). Subsidised programs further reduce the commercial value for ISP's (Internet Service Providers) to offer services in regional areas as subsidised competitors may have received government funding from supported programs and as a result are not operating on a purely commercial basis. Low levels of digital literacy ([Roberts & Hernandez, 2019](#)), education levels and the increasing average age of farmers ([Australian Bureau of Statistics, 2019](#)) have also been identified as factors that reduce the adoption of technology and of the internet on farms.

The definition of a broadband internet connection varies between different countries. In the case of the United States of America, a broadband internet connection is defined as an internet connection with a speed of at least 100mb/s download and 20mb/s upload or (100/20) ([Federal Communications Commission, 2024](#)). The European Union have three classifications for broadband with "Basic" broadband being defined as any internet connection where download speeds are less than 30mb/s, "Next Generation Access" broadband if download speeds are between 30mb/s and 100mb/s and "Ultrafast" broadband if download speeds are greater than 100mb/s ([European Commission, 2024](#)). In Australia, the Universal Service Guarantee (USG) ensures that every resident of Australia can access a broadband internet connection with a minimum download speed of 25mb/s download and 5mb/s upload ([Australian Government, n.d.](#)).

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The education levels of Australian farmers is increasing, with the number of farmers with a certificate level qualification doubling between 1981 and 2011 ([Australian Bureau of Statistics, 2010](#)). As of 2016, only 45% of farmers and farm workers have completed up to a year 12 or equivalent school education compared to 67% of the general Australian workforce ([ABARES, 2018](#)). More recently researchers have identified a positive and significant correlation between a farmer's education and the adoption of technology ([Singh, 2000](#); [The Earth Institute, 2010](#)).

Whilst aging farmers themselves are not contributing to population decline in rural areas, younger people including their children through a long standing movement of younger people migrating to the city ([Regional Australia Institute, 2015, p. 25](#)) are. Compounding this, it is difficult for young people to return to farms after becoming accustomed to certain levels of connectivity ([Marshall & Dale, 2019b](#)). Australia is far from alone with many other nations including the United Kingdom ([Commission for Rural Communities, 2009, p. 11](#)) and Japan ([Johr, 2012](#)) experiencing a similar phenomenon.

Access to internet connectivity is especially important in regional Australia where the population is isolated and has access to fewer services relative to urban areas. Businesses in rural areas are attempting to compete against business that are based in the city for resources and do not have access to what many would consider basic Internet services, causing them to lose their competitive edge ([Park et al., 2019](#); [Philip & Williams, 2019](#)). This ultimately leads to a cycle of population decline ([Milbourne & Kitchen, 2014](#)) in which people leave regional areas and reduce the demand for services, making it difficult for businesses to find workers.

This out migration away from rural areas (including farms) to urban areas that are much more likely to have access to improved connectivity and other services results in a phenomenon often called a "Brain Drain" ([Bowen & Morris, 2019](#); [Townsend et al., 2017](#)). The "Brain Drain" phenomenon describes the out migration of young people away from rural or regional areas towards urban areas. Regardless of the exact cause of out migration the resulting effects on rural communities are the same: a reduction in the sustainability of rural communities, economies ([Commission for Rural Communities, 2009, p. 5](#)) and a reduction of services including business, community, education and health.

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Although not the only factor, reduced equity of services may also contribute to residents in rural Australia having shorter lives, higher levels of disease and injury and poorer access to and use of health services, compared with people living in metropolitan areas ([Australian Institute of Health Welfare, 2019](#)). Services such as telehealth that are delivered over the internet are helping to supply access to medical professionals and improve this situation. However, inadequate access to internet connectivity provides barriers to broad adoption of these services ([Maloney et al., 2022](#))

In addition, the migration of younger people away from rural areas causes many younger people lose connection with their “rurality” ([Rousseau, 1995](#)) and “sense of place” ([Stedman, 2002](#)). This loss of connection and changed expectations with the family farm and of farming life also makes succession planning difficult ([Sappey et al., 2012](#)). Technology, and by extension improved internet connectivity can provide an incentive for younger people to remain on the farm ([Hay, 2018](#)). Although [Rotz et al. \(2019\)](#) argue that this is not always the case. An extreme example of this effect can be seen in Japan where farms are laying fallow as there are no young people interested in taking over the farm ([Yamashita, 2008](#)). The ongoing rural population decline also contributes to a cycle that reduces the justification to provide services (including internet connectivity) in RRR areas ([McManus et al., 2012](#)).

[Whartion \(1966\)](#) argues that *“the fundamental problem of agricultural growth is an education problem”* (pg. 202). In Australia, this has been directly observed by Holden & Zhang (2018) who state *“the proportion of students in very remote areas who meet the criteria of certain milestones [in particular the percentage of students completing year twelve and their Australian Tertiary Admission Rank, which is used to help determine the student’s eligibility for university] is between 19 and 48 percentage points lower than for the Australian population as a whole”* (2018, p. 8). This is supported by [Lamb et al. \(2015\)](#) and by [Cosby et al. \(2019\)](#), who cite that internet connectivity is reducing students in remote areas capacity to access educational services ([Cosby et al., 2019](#)).

There have been numerous attempts to define the digital divide in extant literature. Examples of these include [Furuholt and Kristiansen \(2007\)](#) who consider *“The digital divide is the gap between those with regular, effective access to digital technologies, in particular the Internet, and those without”* (pg. 1). Alternatively, [van Dijk \(2005\)](#) views the digital divide as consisting of four components. These components are “motivational access”, “material or physical

## CHAPTER 1 – How do farmers use the internet?

access”, “skills access” and “usage access (number and diversity of applications and usage time)” (pg. 21). Collectively these definitions describe a phenomenon where different groups have different levels of access to the internet.

There are many direct and indirect benefits to farmers that are associated with improved internet connectivity ([Charmley et al., 2016](#)), for example monitoring livestock, and water supplies with IOT devices, accessing cloud based services, improved staff recruitment and retention, allowing better communications with friends and family and for reducing of rural disadvantage ([Milbourne & Kitchen, 2014](#); [Townsend et al., 2013](#)). Access to Internet connectivity has also been found to reduce farmers sense of remoteness and social disadvantage and isolation ([Park et al., 2019](#)). In addition, the adoption of new technology and farming methods will lead to improved yields and better animal welfare outcomes ([Gaffney et al., 2019](#); [Jukan et al., 2017](#)) and allow existing farm businesses to increase productivity, become more sustainable and remain profitable ([Leonard et al., 2017](#)).

Low levels of digital or technology literacy of farmers ([Australian Government, 2018](#); [Freeman et al., 2020](#)), along with physical isolation makes it more challenging to use traditional data collection instruments such as postal surveys and interviews to understand farmers’ internet use. As such, many of the significant benefits of access and internet connectivity requirements of farmers remain largely anecdotal, or reported as perceived by farmers themselves (e.g., via surveys). The lack of quantitative indicators on the use or useability of the internet and the subsequent knowledge gap makes it difficult to define an adequate internet connection that would meet the needs of farmers now and into the future.

Compounding this, there are many different types of farming enterprise with examples ranging from a small dairy farm in Tasmania to a million hectare cattle station in the middle of Australia ([LaScala, 2020](#)). In addition, different farming businesses have different aims and goals. Some farming businesses are only aiming for self-sufficiency, while other large landholders just want to keep doing what they are doing, as it has been described colloquially, ‘till it sees them out’ i.e., until they retire or leave the workforce. This makes research and applying research outcomes particularly difficult. [Salemink et al. \(2017\)](#) believe that to account for such differences, any research questions “*should be extremely specific to individual geographical areas or problems*” (pg. 368). However, this view also makes it difficult to apply any results more broadly.

## CHAPTER 1 – How do farmers use the internet?

For farmers who live in remote areas, access to adequate internet connectivity democratises access to many services ranging from video streaming to social media, education, and health. In doing so, it also helps break the tyranny of distance experienced by many farmers. In many cases these services are taken for granted in urban areas.

### **1.2.1 Farmers and the adequacy of their internet connectivity**

When discussing access to the internet, it is important to make a distinction between having *access to* the internet and the *adequacy* (or capability) of the internet connection to meet an individual or organisation's needs. There are many cases where this distinction is not made, including by policy makers, technology providers and in academia resulting in an "assumed equity" when discussing internet connectivity in farming. This "assumed equity" is further discussed in Section 5.2.

Despite poor internet connectivity for farmers being referenced extensively in the literature ([Basu & Chakraborty, 2011](#); [Bowen & Morris, 2019](#); [Charmley et al., 2016](#); [Whitacre, 2010](#)) and the clear benefits of such access, the actual internet connectivity requirements of farmers are poorly understood, as is the adequacy of this connection. It is also unknown if there is any relationship between factors such as the type and size of a farm and their internet requirement. In short, we simply do not know if the internet connectivity available to farmers is meeting their needs.

Anecdotally from my experiences growing up on a remote cattle station and living with and interacting with farmers, it is clear that they have a complex relationship with internet connectivity. In some cases, this has led to a feeling they are being forced to use technology more than they would like to, and ultimately for some, to a feeling of resentment towards technology and the internet. Often for RRR farmers, many of the applications for internet connectivity are, as Donald Rumsfeld famously stated, "*Unknown unknowns*" ([Shermer, 2005](#)) as are how their internet connectivity works or their connectivity options. In this context "*unknown unknowns*" are applications for which the internet may be used for that are not known by farmers. [Galloway and Mochrie \(2005\)](#) argue that this phenomenon is caused, in part by poor technological infrastructure and a perceived lack of need.

Access to the internet offers direct benefits to agricultural business, and to the livelihoods of the farmers and their families themselves ([Morris & James, 2017](#); [Richardson, 2005](#)).

[Richardson \(2005\)](#) adds that "*Any ICT intervention that improves the livelihoods of poor rural*

## CHAPTER 1 – How do farmers use the internet?

*families will likely have significant direct and indirect impacts on enhancing agricultural production, marketing and post-harvest activities – which in turn can further contribute to poverty reduction”* (pg. 1). Existing research by ([BIRRR, 2017b](#); [Hay, 2018](#); [Hay & Pearce, 2014](#); [Lamb, 2017](#)) and others have examined various groups of Australian farmers and provide a useful background and context to a farmers relationship with the internet.

Farmers are increasingly required to use the internet as part of their daily business operations ([Hay, 2018](#); [Lamb, 2017](#)). Some of these uses include marketing produce and regulatory compliance (i.e. cloud based accounting and mandatory traceability through RFID tags). However, many farmers experience frustration getting connected and staying connected to the internet prior to being able to use the services. Factors such as actual or perceived lower than average internet connectivity performance identified by extant literature have been identified as cause for this frustration.

Modern farming itself is an increasingly complex endeavour ([Kingwell, 2011](#)) and requires extensive time commitments ([Vayro et al., 2020](#)). In addition, not all farmers farm purely for commercial benefit. This is clearly evident in the USA where only 10% of business are defined as “commercial farms” in 2010 ([Blank, 2005](#); [Schnepf, 2012](#)). Other factors, including isolation and the tyranny of distance result in farmers having difficulty separating business and personal commitments and differences in lifestyles and management practices, even between the same types of farms.

Geographical isolation also makes it more difficult to access trusted advisers. Trusted advisers hold a position of trust with the farmer and function as an advisor ([Linklater, 2019](#)). Trusted advisers may be a consultant actively employed by the farmer or a supplier to the farmer with a commercial interest, for example extension officers, agronomists, or livestock agents. However, trusted advisers that can help farmers specifically with their technology problems are especially difficult to access in RRR areas. There have been many creative solutions to this problem. One example is the Better Internet for Rural, Regional and Remote (BIRRR) Australia group, where a Facebook group and a website was developed and managed by volunteers that aimed to help people in RRR areas with their connectivity problems. At the same time the group collected data to lobby to government and industry to fix common issues amongst RRR connectivity users (<http://birrraus.com>).

Despite poor internet connectivity for farmers being referenced extensively in the literature ([Bowen & Morris, 2019](#); [Charmley et al., 2016](#); [Whitacre, 2010](#)) and the clear benefits of such

## CHAPTER 1 – How do farmers use the internet?

access, the actual internet connectivity requirements of farmers are poorly understood, as is the adequacy of this connection. It is also unknown if there is any relationship between factors such as the type and size of a farm and their internet requirement. In short, we simply do not know if the internet connectivity available to farmers is meeting their needs.

This knowledge gap affects more than just farmers themselves living with poor internet connectivity. Other residents that live on a farm such as family members including the parents and children of farmers also often share the internet that is available to them. As a result, how they use the internet is also constrained by the capabilities of the internet connection available to them.

This also extends to the developers of software and hardware companies that are developing technology for use by farmers. By understanding the types and capabilities of the internet connectivity that is available to farmers, these companies could ensure that their products and services can operate within the constraints of the internet connectivity available to their farmers and help ensure that the farmers themselves have good experiences using the technology, ultimately leading to increased adoption.

### **1.2.2 Internet Service Providers**

In Australia, ISPs operate under the Telecommunications Act ([Australian Government, 1997](#)). The Act lays out the requirements that an ISP needs to fulfill to operate and allows the ISP to sell communication services to the public. For the case of internet connectivity, these services are typically called Plans and come in various configurations as determined by the ISP. These Plans commonly range from a low-speed, consumer grade service that is offered on an “as is” basis, to business grade services that offer higher speeds, larger monthly data allowances and guaranteed levels of reliability. The Plans may also offer services that are either “asymmetrical” or “symmetrical” with asymmetrical internet connections being the most common type. For asymmetrical connections, the ratio of download to upload speeds often ranges from 5 to 20.

### **1.2.2.1 Operating an ISP**

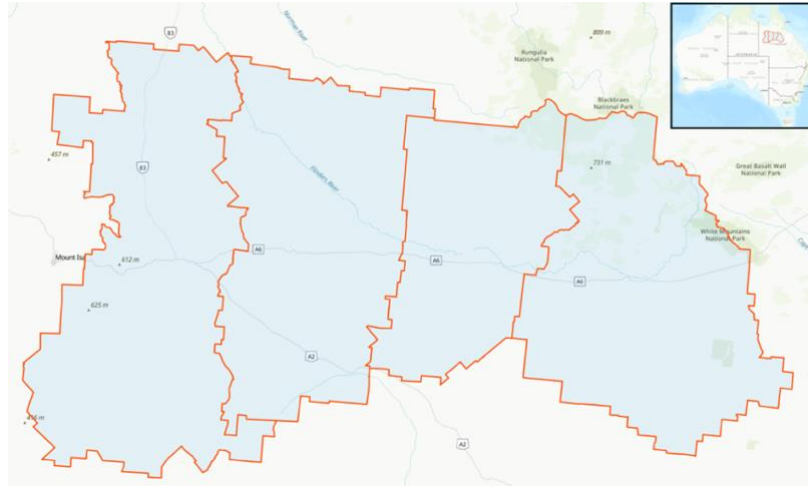
The infrastructure that ISPs use to deliver internet connectivity to a customer require the use of a multitude of different technologies. To ensure the proper operation of an ISP's network, it is industry standard practice that this infrastructure receives constant monitoring and management. To do this, many different pieces of data regarding the performance and operation of this infrastructure, such as the uptime of various pieces of equipment, the traffic volumes for individual subscribers and the types of traffic flowing through the network are recorded. This information is used for many different purposes, including ensuring that their network is operating as expected, to guide product development, measure the effectiveness of advertising and to ensure and support regulatory compliance.

As ISPs are the conduit for individual and businesses internet connectivity, they operate in a position of trust. As a results, any data that ISPs collect regarding the operation of its network may also many include various pieces of metadata and other personally identifiable information such as IP address and physical address. The actual contents of any communications cannot be legally intercepted without a warrant from the Australian Federal Police ([Australian Government, 1997](#)). Data regarding the performance of the network is also commercially sensitive and not typically made available outside the organisation.

### **1.2.2.2 The Nominated ISP**

Two secondary datasets used in this research project were obtained from a Wireless Internet Service Provider (WISP) that operates in the four local government areas in North West Queensland (see Figure 1.2 below). The internet connectivity was provisioned through fixed wireless connectivity and there were no other Wireless ISP's (WISP's) servicing these areas.

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**Figure 1.2 – The NISP's Coverage Area at the time this study took place**

The NISP uses fixed wireless technology to provide internet connectivity to its customers by using a radio mounted on the roof of the customers premises and a matching radio on a telecommunications tower, similar to that shown in Figure 1.3 (below). All of the services that the NISP provides are unconstrained services (i.e., not limited by data or speed) with more details available in Section 2.6.1. At the time of this study, the NISP serviced approximately 19% of the farmers in North West Queensland.



**Figure 1.3 - NISP Customer installation and telecommunications tower**

The Terms and conditions of Use for the NISP in this study permit the scientific analysis of certain internal data such as the traffic volumes and category of traffic for individual services. Data is collected as part of the normal operation of its business on the condition that it is anonymised and cannot be re-identified (see Section 2.6.1 for more information). Access to the two secondary datasets was possible due to my prior association with the NISP as the owner and CEO of the company.

### **1.2.3 Policy**

Due to challenging economics in areas of low population density that are common in farming areas, policy makers also play a key role in the supply of internet connectivity. Factors such as large distances, difficulty attracting and retaining staff and low numbers of potential customers have been recognised by governments in countries such as Australia, the USA and Canada with significant investments being made ([Kandilov et al., 2017](#); [Taylor, 2018](#)). Examples of these efforts include the USDA Broadband Loan Program in the USA ([Kandilov et al., 2017](#)), the Broadband for Rural and Northern Development (BRAND) program in Canada ([Taylor, 2018](#)) and Australia's own NBN™ program ([NBN Co, 2020](#)) (although this program was not specifically targeted at agriculture). Without an understanding of what the connectivity requirements of farmers are, it is difficult for policy makers to ensure that these types of programs meet the requirements of farmers.

These programs all share the common goal of improving broadband for rural residents including farmers. They also share high prices as providing telecommunications services in RRR areas is typically more expensive per user than in urban areas ([Salemink et al., 2017](#)). Anecdotally, these programs are generally inflexible in how services are delivered and the actual service delivery can seem somewhat arbitrary and ineffective ([Salemink et al., 2017](#)).

As a result, some farmers who generally have limited technical skills have built their own internet solutions in a desperate bid to improve their internet connectivity. One example, as reported by the [ABC \(2017\)](#) describes a Queensland farmer building a 53 metre high tower on his property to use a cellular internet connection instead of satellite. Another example is a farmer deploying a fibre network in her village in the UK ([Allmann, 2020](#)). These examples are not one offs and demonstrate the lengths that some farmers go to access an internet connection that meets their needs.

## CHAPTER 1 – How do farmers use the internet?

As noted earlier, in Australia's case, the NBN Sky Muster™ service represents a significant investment from the Australian federal government of over \$1billion AUD for two satellites alone ([Farm Online National, 2015](#)). The Sky Muster™ internet service was intended to provide internet connectivity to Australians that live in remote areas where it may not otherwise be practical or economical to provide another type of internet connectivity, and has in general, led to improvements in on farm connectivity. However, many Australian farmers still generally consider their internet connection inadequate ([ABC, 2017](#); [Marshall & Dale, 2019b](#)) further compounding the digital divide between city and rural regions

These policies can also inadvertently have the opposite effect of cementing the digital divide. By subsidising a commercial internet connectivity for rural areas where there is a very low level of population density, it becomes uneconomical for other local internet suppliers to compete against commercial networks, regardless of whether their service is actually better or not. Therefore, consumers tend to become price (or connectivity) takers and accept the prevailing offering.

### 1.3 Theoretical framework

*"If I have seen further, it is by standing on the shoulders of Giants."*

Isaac Newton (1642–1727)

There is extensive work in extant literature that seeks to understand the phenomenon of technology adoption and the diffusion of new technologies, with many different theories and models being developed. Several of these are examined below to guide and inform the thinking of this work. These including the well-known Diffusion of Innovation (DOI) Theory developed by [Rogers \(1962\)](#), the Technology Acceptance Model (TAM) by [Davis \(1989\)](#), the Technology Upgrade Model ([Wang et al., 2018](#)) and van Dijk's lesser known Digital Technology Access Model (DTAM) ([van Dijk, 2005](#)). Each of these theories and models are discussed below.

Various theories and models are used when conducting research projects examining technology adoption and diffusion. For a complete understanding of the theory of adoption, often more than one theoretical approach is necessary and therefore it is also common for various different models to be combined within in a single study ([Taherdoost, 2018](#)).

### 1.3.1 Diffusion of Innovations Theory

The most well known model applied to the adoption of technology is Everett M. Rogers' "Diffusion of Innovation" (DOI), first presented in 1962 (Rogers, 1962), and now in its 5<sup>th</sup> revision (Rogers, 2003). DOI theory posits that the spread of innovation is influenced by four factors (the innovation, communication channels, time and the social system) (McNeil, 2021). The DOI theory introduced the technology adoption lifecycle which categorise individuals into one of five groups: Innovators, Early Adopters, Early Majority, Late Majority and Laggards and is generally represented as a bell curve as shown in Figure 1.4 (below).

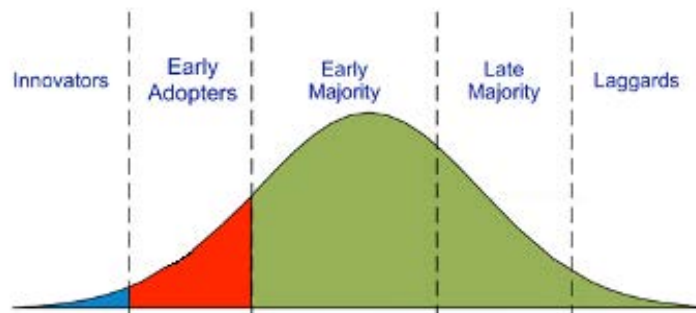


Figure 1.4 – Visualization of the Diffusion of Innovation bell curve (Image adapted from Chelius (2009) CC-BY-3.0)

Moore extended the DOI theory when considering novel innovations by introducing the concept of "The Chasm" (Moore, 1991). The Chasm is represented as a gap between the early adopters and the early majority and describes the phenomenon of members of the early majority tending to trust other members of the "early majority" rather than "early adopters" or "innovators". The chasm is visualised below in Figure 1.5 (below). For an innovation to become mainstream, it must bridge the different expectations between the two different groups.

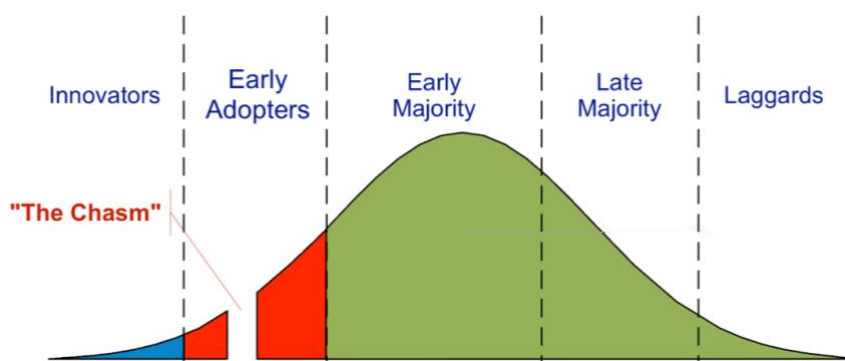


Figure 1.5 -The Technology Adoption Lifecycle (Image by Chelius (2009) CC-BY-3.0)

### 1.3.2 Technology Acceptance Model

The Technology Acceptance Model was adopted by [Davis \(1986\)](#) from the Theory of Reasoned Action (TRA) ([Fishbein & Ajzen, 1975](#)). The TAM posits that an individual's acceptance of computer technology is determined by two primary constructs, Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) ([Davis, 1989, p. 320](#)). Unlike the Theory of Reasoned Action ([Fishbein & Ajzen, 1975](#)), the final conceptualisation of TAM excludes the attitude construct in order to better explain intention parsimoniously ([Venkatesh et al., 2003](#)). The TAM has been used previously to examine broadband adoption in Australia ([Adams et al., 2017](#)) and is one of the most widely cited technology adoption models ([Lee et al., 2003](#)) having received extensive empirical support ([Taherdoost, 2018](#)). A visual representation of the TAM is presented below in Figure 1.6.

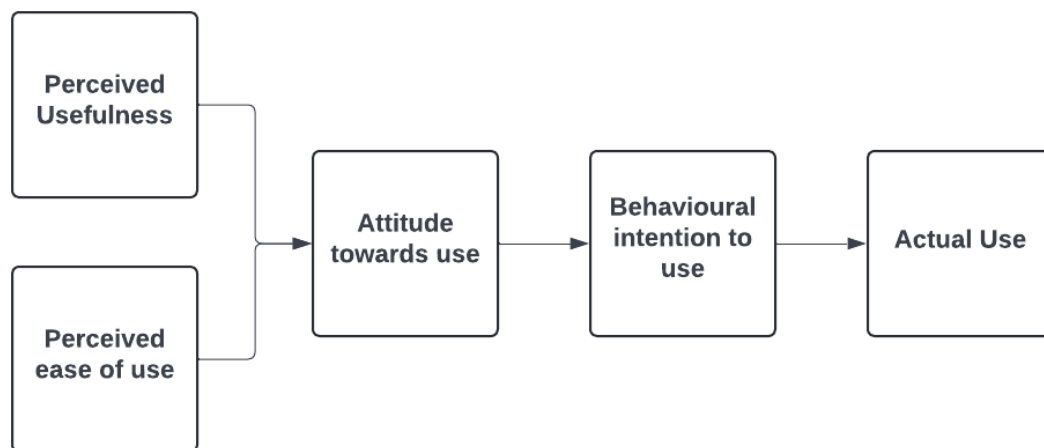
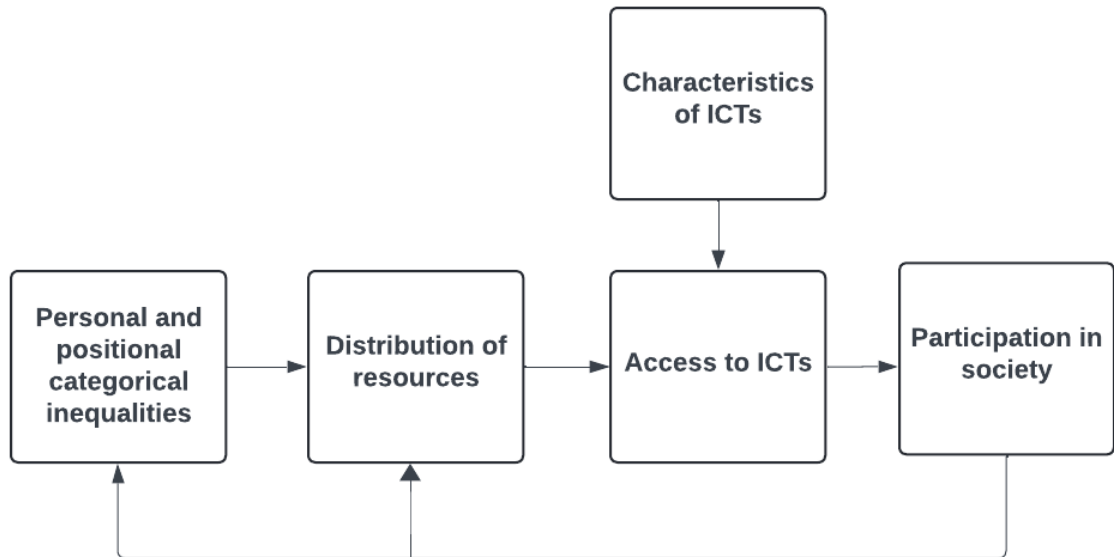


Figure 1.6 – The Technology Adoption Model adapted from ([Davis, 1986](#))

### 1.3.3 Digital Technology Access Model

Van Dijk's Digital Technology Access Model (DTAM) ([van Dijk, 2005](#)) considers the adoption of information technology in terms of a digital divide. Van Dijk argues that the term "digital divide" does not fully describes the cause and consequences of the observed digital divide and considers the adoption of information technology access in terms of the motivational, physical or material, skills, and usage. DTAM argues that categorical inequalities in society create an uneven distribution of resources that ultimately leads to unequal access to digital technologies ([van Dijk, 2005, p. 15](#)). This unequal access (depending on the characteristics of the technology) ultimately leads to uneven participation in society which reinforces the initial categorical inequalities and uneven distribution of the digital technology. This model is

visualised below in Figure 1.7. The Digital Technology Access Model presents a useful way of considering an uneven uptake of internet connectivity.



**Figure 1.7 - The Digital Technology Access Model (van Dijk, 2005)**

#### **1.3.4 Technology Upgrade Model**

The previously discussed models attempt to describe the diffusion and adoption of new innovations or technologies, however, none of these models consider the behaviour of users when upgrading technology products or services. The Technology Upgrade Model (TUM) was developed by [Wang et al. \(2018\)](#) to understand these incremental upgrades. The TUM combines the Purchase Intention Model (PIM) ([Warshaw, 1980](#)) and Status Quo Bias (SQB) ([Samuelson & Zeckhauser, 1988](#)).

The TUM presents a series of constructs to explain a user's upgrade behaviour. These constructs are connected by a series of paths that represent either a positive or negative effect on the users. This research project provides an opportunity to use the TUM provide insight into how farmers manage their internet connection. A visualisation of the TUM is presented below in Figure 1.8

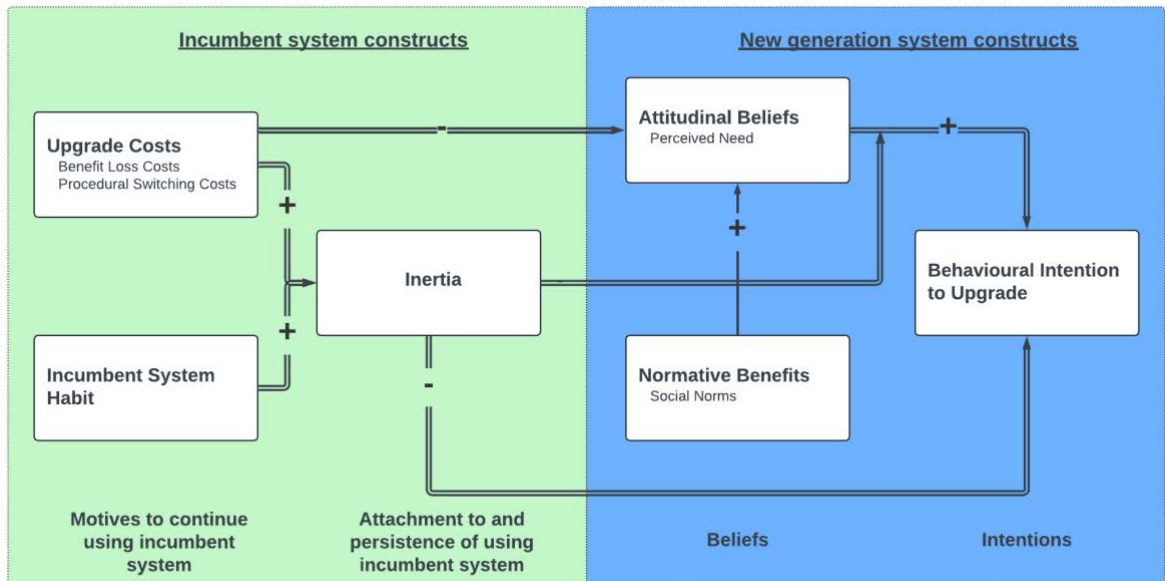


Figure 1.8 – The Technology Upgrade Model (Wang et al., 2018)

#### 1.4 Research Objective

The core aim of this research project is to examine how farmers use the internet. To do so, several different research questions were developed and are presented below in Table 1.1, along with the associated studies that they are examined in.

Table 1.1 - Research questions and associated studies

Study	Research Question	Research Objective
Study 1: How do farmers use the internet	RQ1: Explore how do farmers use the internet?	To explore and understand the day-to-day use of the internet by farmers and identify any long-term trends
Study 2: Understanding how farmers get connected and stay connected	RQ2: Understand how farmers connect to the internet?	To explore how farmers connect to and manage their internet connection
	RQ3: How do farmers stay connected to the internet?	
Study 3: How do farmers use social media	RQ4: How do farmers use social media?	To explore how farmers use social media

### **1.5 Thesis Outline**

This dissertation consists of three separate studies that are designed to answer the research questions previously discussed in Table 1.1. The dissertation begins with a detailed discussion of the philosophical perspective taken, the chosen research methods and information about the data sources and data collection instruments including online survey that were used in Chapter Two. A detailed demographical analysis of the results of the online survey follows in Chapter three. This is then followed by the three individual studies. Each of the studies contains a literature review that situates the study and provides the reader with background to the research topic and a discussion of the study's methodology.

The first study, "Analysing farmers use of the internet" in Chapter Four and examines how farmers use the internet in their day to day lives. Chapter Five contains Study Two, that looks at how farmers connect to the internet and how actively they manage their internet connection. Chapter Six details the final study that examines how farmers use social media. The dissertations results are discussed in Chapter Seven. A visualisation of the thesis structure is presented below in Figure 1.9.

## How do farmers use the internet: A mixed methods approach

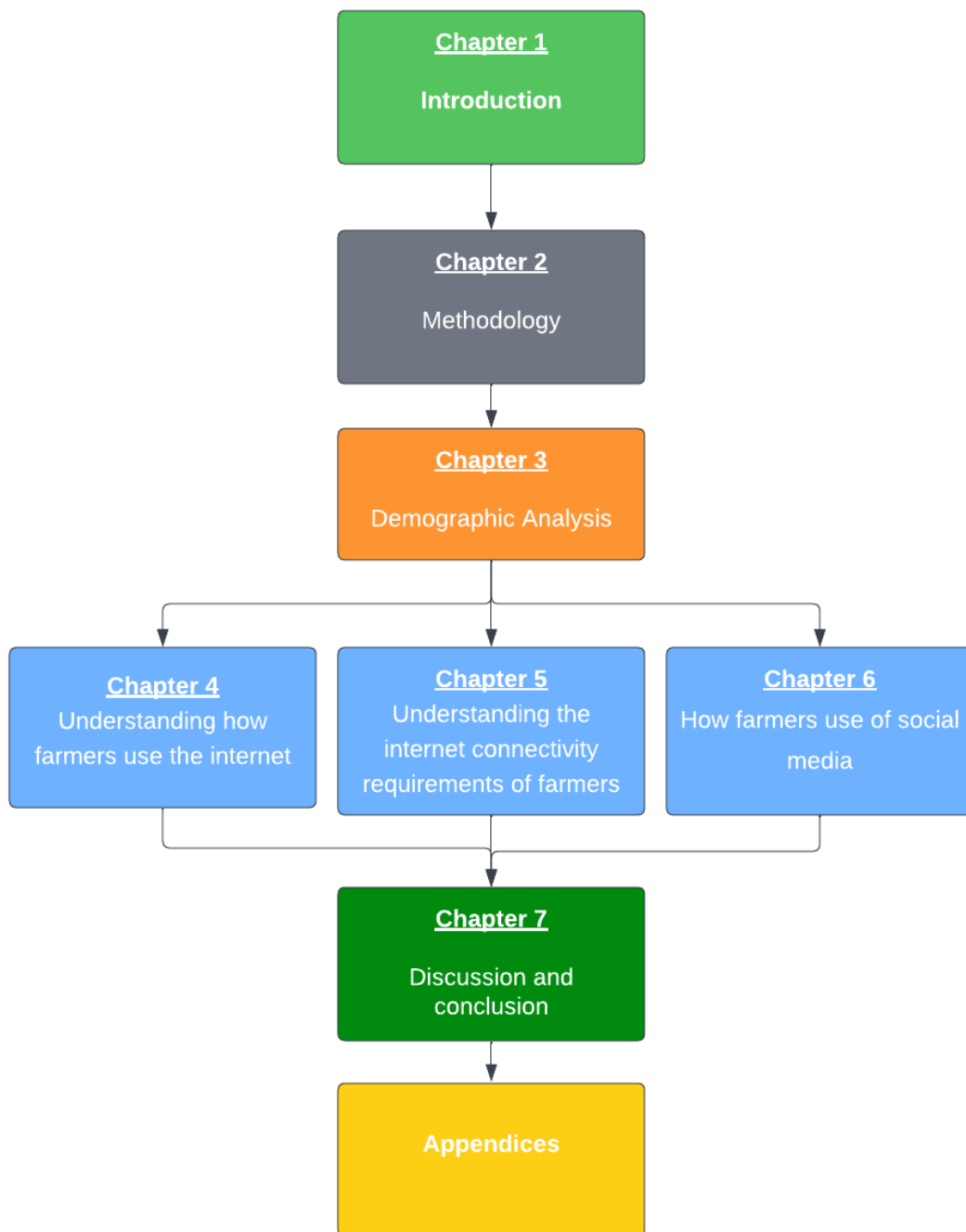


Figure 1.9 - Thesis Organisation

### **1.6 Chapter Summary**

Chapter one discussed the importance of internet connectivity to farmers and introduced this research project. It also provided an outline of its structure. Section 1.2 began by presenting the background to the research topic and the research rationale and then discussed the policy environment that has led to the current state of internet connectivity that is available to farmers in Australia. This was then followed by a discussion of the theoretical framework and research objectives of this dissertation.

## Methodology

How do farmers use the internet: A mixed methods approach						
Chapter 1 How do farmers use the internet?	Chapter 2 Methodology	Chapter 3 Demographic analysis	Chapter 4 Understanding how farmers use the internet	Chapter 5 Understanding the internet connectivity requirements of farmers	Chapter 6 How do farmers use social media	Chapter 7 Discussion and conclusion
1.1 Introduction	2.1 Introduction	3.1 Introduction	4.1 Introduction	5.1 Introduction	6.1 Introduction	7.1 Introduction
1.2 Background and research rationale	2.2 Philosophical perspective	3.2 Survey Dataset	4.2 Literature Review	5.2 Literature Review	6.2 Literature Review	7.2 Discussion of findings
1.3 Theoretical Framework	2.3 Methodological foundation	3.3 Data cleaning	4.3 Methodology	5.3 Methodology	6.3 Methodology	7.3 Response to rationale
1.4 Research Objective	2.4 Research Ethics	3.4 Respondent demographics	4.4 Results and Discussion	5.4 Results and Discussion	6.4 Results and Discussion	7.4 Contribution of the thesis
1.5 Thesis Outline	2.5 Study population	3.5 Chapter Summary	4.5 Chapter Summary	5.5 Chapter Summary	6.5 Chapter Summary	7.5 Future research potential
1.6 Chapter Summary	2.6 Data collection instruments					7.6 Limitations
	2.7 Research data storage					7.7 Conclusion
	2.8 Data analysis techniques					7.8 Recommendations
	2.9 Literature review methodology					
	2.10 Risk management					
	2.11 Chapter Summary					

### 2.1 Introduction

*“There is nothing more deceptive than an obvious fact.”*

*Arthur Conan-Doyle*

This chapter presents the research methods used in this dissertation, including the mixed methods methodological process and the philosophical perspective. This chapter also provides details about the participants that took part in this study and provides details of the secondary datasets that were used. The chapter outlines the development and distribution of the online survey and the secondary datasets and data collection instruments that were used to answer the research questions. This chapter also discusses how bias was managed, research data was stored and the projects risk management plan. Details are also provided about the human ethics approvals for the three studies that make up this dissertation.

## 2.2 Philosophical perspective

This study uses a pragmatic philosophical perspective to guide direction of the mixed method research design ([Saunders et al., 2019](#)). Pragmatic research considers multiple world views to fully describe the phenomenon under study. Knowledge of these multiple realities may be gained through the use and mixing of multiple different research methodologies ([Saunders et al., 2019](#)). Pragmatists believe that groups are bound together by similar or shared experiences and that there are many ways of interpreting the world. As a result, pragmatists view the notion of knowledge as *“one that is directed towards problem solving using data and understandings available at the time”* ([Kelemen, 2008, p. 42](#)).

Pragmatism considers that the best research methods are those that are the most useful for solving a problem ([Johnson & Onwuegbuzie, 2004](#)). Thus, pragmatism is considered by many to be a very practical philosophical perspective ([Morgan, 2014](#)). Pragmatism also recognises that a single method may not be enough to fully explain the phenomenon of interest and allows the selection of the methods that will *“enable credible, reliable and relevant data to be collected to address the research problem”* ([Saunders et al., 2019, p. 181](#)).

## 2.3 Methodological foundation and design

*“Scientific methodology needs to be seen for what it truly is, a way of preventing me from deceiving myself in regard to my creatively formed subjective hunches which have developed out of the relationship between me and my material”*  
([Rogers, 1955, p. 275](#))

A mixed methods approach was chosen for this work as it enables a better understanding of the phenomenon of interest than a purely qualitative or quantitative approach can do alone ([Creswell, 2018](#)). Mixed methods focus on the research outcomes by *“emphasising the importance of the research question rather than the methods of data collection”* ([Dovona-Ope, 2008](#)). Practically, this is achieved by using both quantitative and qualitative approaches in combination to *“enable reliable and relevant data to be collected to address the research problem”* ([Saunders et al., 2019, p. 181](#)). Other approaches to answer the research questions were considered however, no single methodology would enable bringing together both quantitative and qualitative research into one study.

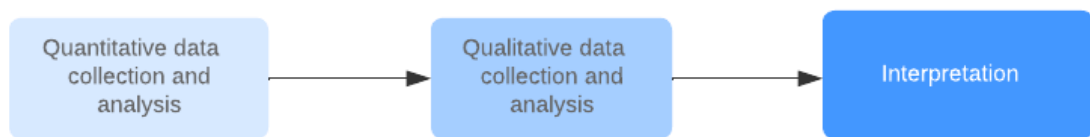
A mixed methods approach draws from the strengths and minimises the weaknesses of qualitative and quantitative approaches within a single study ([Andrew & Halcomb, 2007](#);

[Johnson & Onwuegbuzie, 2004](#)) to ensure that any results are examined objectively.

Interactive and iterative analysis of quantitative and qualitative datasets help to surround the research problem and enables better understanding of the research question ([Creswell, 2018](#); [Saunders et al., 2019](#)). This enables the researcher to “*Synthesize the results into a complementary picture about the phenomenon*” ([Creswell, 2018, p. 188](#)).

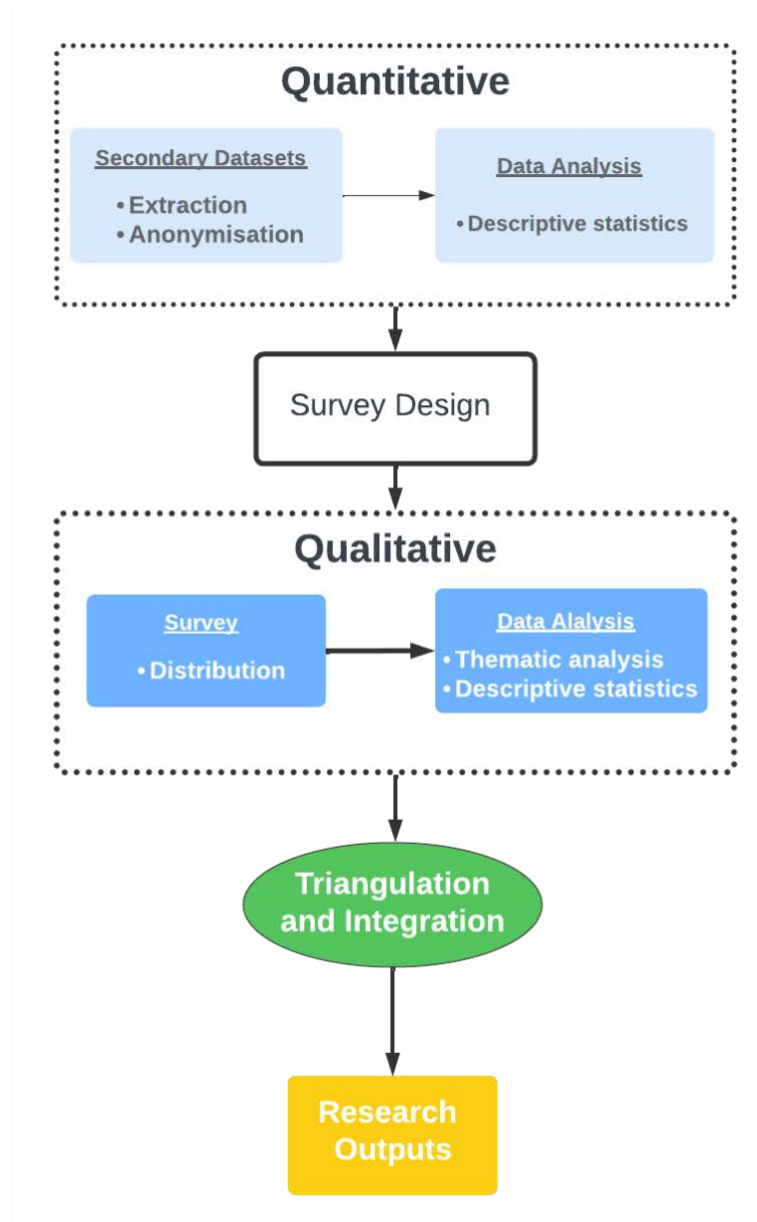
This dissertation utilises explanatory sequential mixed methods ([Creswell, 2018](#); [Saunders et al., 2019](#)). This design was chosen as it enabled the use of secondary data to help guide the development of successive data collection instruments. Due to the simple, sequential nature of this methodology, it is also considered by many to be well suited for early career researchers such as myself ([Creswell, 2018](#)).

An explanatory sequential mixed methods design begins with the researcher exploring quantitative datasets to initial results and insight gained to guide the creation of further qualitative data collection instruments, which are then brought together. This process is visualised in Figure 2.1 below.



**Figure 2.1 - Explanatory sequential mixed methods design**

The explanatory sequential mixed methods design was implemented in this dissertation by applying each data collection method sequentially beginning with the analysis of several quantitative secondary datasets containing data on how a group of farmers use the internet (see section 2.6.1 for more details about these datasets). This was followed by the development of an online survey to expand on and flesh out themes that were identified in the initial analysis in an “*attempt to elicit multiple meanings*” from the results ([Creswell, 2018](#)). This implementation is visualised in Figure 2.2 below.



**Figure 2.2 – Visualisation of study methodology.**

Where appropriate, questions from previous similar studies and existing datasets were used to allow for longitudinal research to evolve an existing data set for continued study of the diffusion of internet into rural, regional and remote areas. Questions that were included in the online survey were sourced from [Hay \(2018\)](#), the Australian Digital Inclusion Index 2021 ([Thomas, 2021](#)), and [Wilson \(2022\)](#). Permission was obtained from the primary researchers of each study (see Appendix X for more details).

The results from each individual data collection instrument were then integrated and triangulated to “*see it [the research] from more than one angle*” ([Denscombe 2021](#)).

#### **2.4 Research Ethics**

This research follows the Code for the Responsible Conduct of Research ([James Cook University, 2019](#)) and the National Statement on Ethical Conduct in Human Research ([Australian Government National Health Medical Research Council, 2023](#)). Two separate ethics approvals were obtained for this research project. The first was H8108 (see Appendix I) was received by James Cook University’s Human Research Ethics Council (HREC) to enable an online survey to be conducted. A second ethics application was approved H8354 (See Appendix II) to enable access to two secondary datasets.

Care was taken to ensure that all analysis methods in this study avoided using stereotypical labels for participants and ensured that any data collection instruments were sensitive to the cultural context of the group being studied. A data management plan was developed to ensure that any personally identifiable information that was collected as part of this research project were stored appropriately in accordance with the *National statement on ethical contact in human research* ([Australian Government National Health Medical Research Council, 2023](#)).

The data management plan for this research project is presented in Appendix VII.

The author of this dissertation is the owner and CEO of the Wireless Internet Service Provider (WISP) called Wi-Sky Queensland that supplied the secondary datasets for this study. The Wireless Internet Service Provider (WISP) operates in four North West Queensland (NWQ) local government areas (Flinders, Richmond, McKinlay and Cloncurry). Wi-Sky Queensland will be referred to as the Nominated ISP (NISP) in this study. Further information is available upon request from the corresponding author.

To manage the risk of real or perceived conflicts of interest, several complex procedures were developed and approved by JCU’s HREC. These procedures include the employment of an appropriately qualified research assistant to extract and anonymize the secondary datasets and the development of complex software to programmatically extract and anonymize raw data where possible to avoid manual handling of data with personally identifiable information. These processes are further discussed in section 2.6.1.

To manage the risk of and real and perceived conflicts of interest due to the direct relationship between the PI and the NISP, several complex procedures were developed and subsequently approved by JCU's HREC. These processes include the employment of an appropriately qualified research assistant to extract and anonymize the secondary datasets at various stages throughout the study to extract and anonymise data obtained from the NISP (see section 2.6.1.1.1 for more details). To ensure that the research assistant was appropriately qualified, a position description was developed. This position description is presented in Appendix IX.

Complex software to programmatically extract and anonymize raw data was also developed and used where possible to avoid manual handling of data with personally identifiable information. Any real or perceived conflicts of interest were managed individually and in line with the Code for the Responsible Conduct of Research ([James Cook University, 2019](#)) and the National Statement on Ethical Conduct in Human Research ([Australian Government National Health Medical Research Council, 2023](#)).

### **2.5 Study Population**

The study population for this research project consists of farmers that are located in Australia. There are a total of 87,800 agricultural businesses in Australia that utilise 369 million hectares of land for agricultural production ([Australian Bureau Of Statistics, 2023a](#)). Of these businesses, broadacre farm businesses represent 61.5% (approximately 54,000). Of these broadacre businesses, livestock production made up 62%, cropping 30% and the remainder dairy farming. Approximately 72% of Australia's agricultural production is exported, with a value of approximately \$76 billion in the 2021 to 2022 financial year ([Australian Bureau of Agricultural and Resource Economics and Sciences, 2023a](#)). These farms employ approximately 239,093 people ([Australian Bureau of Agricultural and Resource Economics and Sciences, 2023b](#)).

#### **2.5.1 Beef Producers**

In Australia, an open grazing system is used for beef production ([Barson et al., 2012](#)) with large areas of land required for production. The state of Queensland is by far the largest beef producer in Australia, contributing 47% of Australian beef production. Australia is also the world's second largest exporter of beef and veal ([Meat and Livestock Australia, 2020](#)). Beef production is one of the key economic drivers of the North West Queensland economy and it

represents over 99% of total agricultural production in North West Queensland ([Department of Agriculture and Fisheries, 2021](#)).

### **2.5.2 Broadacre farmers**

Broadacre farming is of increasing importance in North West Queensland with crops such as cotton, mung beans, chickpeas and sorghum increasingly being grown. The Queensland government has made increasing agricultural production in North West Queensland a key component of the North West Queensland Economic Diversification Strategy ([Queensland Department of State Development Manufacturing Infrastructure and Planning, 2019](#)). Despite the increasing focus on broadacre farming in North West Queensland, broadacre cropping still only represents less than 1% of total agricultural production in North West Queensland ([Department of Agriculture and Fisheries, 2021](#)).

### **2.5.3 Farmers in North West Queensland**

A subset of Australian farmers located in North West Queensland and also customers of the NISP participated in this study. The North West Queensland region itself covers an area of 307,082 square kilometres with a total population of 29,819 ([Queensland Government, 2022](#)). The region is categorised as “Very Remote Australia” by the Australian Bureau of Statistics (ABS) ([ABS, 2018](#)) with agriculture and mining being the primary economic drivers of the region’s economy.

The study population is defined as farmers located within the four local government areas discussed above. These local government areas are presented in Figure 2.3 (below). Within these four local government areas, there are a total of 693 farmers and 364 farming businesses ([Australian Bureau of Statistics, 2016, 2017](#); [Australian Government, 2022](#)).



**Figure 2.3 - Local government areas in North West Queensland where the NISP offers services**

## 2.6 Data collection instruments

Three separate studies have been undertaken that analyse three separate data sets for this research project. `Dataset 1` and `Dataset 2` use secondary data collected from the NISP (see Section 2.6.1 for more details). `Dataset 3` is primary data collected from farmers in Australia (see Section 2.6.2) and was collected by an online survey. Table 2.1 (below) summarises the study and dataset breakdown.

**Table 2.1 - Dataset and study breakdown**

Study	`Dataset 1` (Traffic Data)	`Dataset 2` (Application Data)	`Dataset 3` (Online Survey)
Study 1: How do farmers use the internet	Yes	No	No
Study 2: Understanding how farmers get connected and stay connected	No	Yes	Yes
Study 3: How do farmers use social media	No	Yes	Yes

### **2.6.1 Secondary datasets**

Two separate secondary datasets were extracted from existing data that was collected by the NISP during the normal operation of its business (see Section 1.2.2.2). Access to this data was only possible due to the PI's relationship with the NISP. In addition, the terms and conditions of use of services by customers of the NISP allowed the use of such datasets on the condition they are properly anonymised. The collection of the data in these datasets do not require the active involvement of participants or depend on their knowledge of how their internet connection works.

The raw data was collected during the normal operation of the NISPs business and is commonly collected by Internet Service Provider's (ISP's). Various types of data is regularly collected including how individual customers use their internet connection ([Garcia-Dorado et al., 2012](#); [Marques Neto et al., 2004](#); [Xu et al., 2014](#)), daily aggregate totals of internet traffic volumes and a broad breakdown of what applications such as Facebook™ and Netflix™ each internet connection is using.

Typically, such data is collected to ensure that the services provided by ISP's are performing as expected and to identify any issues with their connection that a customer may be experiencing (such as speed or reliability). Some of this data, such as daily internet traffic values are made available directly to the customer so they can understand their own internet usage. In the case of the NISP and any data that was provided by it, it is important to note that the actual *contents (e.g., text, images, video etc)* of any communications are not seen or recorded.

Datasets such as the secondary data provided by the NISP are, in many cases, commercially sensitive in nature and can contain personally identifiable data. As a result, they are not typically made available for research purposes. The ability of the NISP to categorise participants and make the data available to researchers presents a unique opportunity to allow insight into how farmers are using the internet as it removes any direct contact with participants and avoids with any associated biases.

The customers of the NISP were identified using a unique identifier called an IP address. The IP address was assigned to the customer by the NISP and can be used identify them on the internet. The IP address itself is public (directly accessible from the internet) and static (does not change), meaning that any websites and other services that customers visit can be

## CHAPTER 2 - Methodology

associated with the user. This is a common practice in the telecommunications industry and is used by many other service providers such as Google or Facebook to target advertising and for security purposes. To prevent the re-identification of individual participants in this work, IP addresses were replaced with a random identifier. This anonymisation process is further discussed in Sections 2.6.1.1.1 and 2.6.1.2.1.

Due to the existing association between the NISP and the PI, several processes were developed to ensure that there was no risk of conflict of interests between this research project and the NISP. These processes were assessed and approved by the host institutions HREC committee. All personally identifiable data was extracted and anonymised by either an independent research assistant or by an automated process before it is made available to the PI with each user being assigned a random identifier. In addition, processes were put in place internally in the NISP to avoid any conflicts of interest. Further details about these processes are detailed in Sections 2.6.1.1.1 and 2.6.1.2.1.

Due to the commercially sensitive nature of such datasets, access has historically been difficult. Only a small number of studies have ever accessed similar datasets for example [Finamore et al. \(2011\)](#) and [Trevisan et al. \(2020\)](#), although none of these filtered by the participants occupation, making the datasets used in this dissertation unique. These datasets are also large, making analysis more complex and difficult.

The datasets were drawn from farmers that are located in four local government areas located within the North West Queensland region and that were customers of the NISP. There are 364 farming businesses and 693 farmers located in this area of interest ([Australian Bureau of Statistics, 2016, 2017](#)). Of the 364 farms, 68 were selected for analysis (representing approximately 19% of farming businesses and 10% of the total individual farmers).

The participants of this sample are identified using the following inclusion criteria:

1. The participants internet connection was provided by the nominated ISP.
2. The internet connection was located on a farm or station.

This inclusion criteria were provided to the NISP and data for the participants was returned as shown in the Table 2.2 below.

**Table 2.2 - Number of participants in `Dataset 1` (N=364)**

Year	Number in sample group (n)	Percent of total population (N)*
2018	32	8.8%
2019	41	11.3%
2020	50	13.7%
2021	68	18.7%

\*An assumption has been made that the number of farms in North West Queensland does not change between 2018 and 2021. It is also assumed that each farm business uses the internet connection provided by the NISP as their primary internet connection.

A unique identifier was subsequently allocated to the participants by an independent research assistant to ensure anonymity.

The NISP provides internet connections that are unconstrained and offers three different plans which all provided synchronous, unlimited monthly download and upload traffic volumes. The three plans offered minimum speeds of 20mb/s (megabits per second), 40mb/s or 60mb/s, respectively. For the purposes of this work, all the participants were grouped together regardless of their chosen plan.

It is acknowledged that these farming businesses may have multiple internet services from different providers for various reasons such as redundancy (this is further discussed in Chapter 5) and that their internet connection is not solely used for the purpose of farming. For the analysis in this work, it will be assumed that the participants use the internet connection provided by the NISP as their primary internet connection and any additional internet connections on their farms only being used for redundancy.

#### **2.6.1.1 Dataset 1 – Traffic volumes**

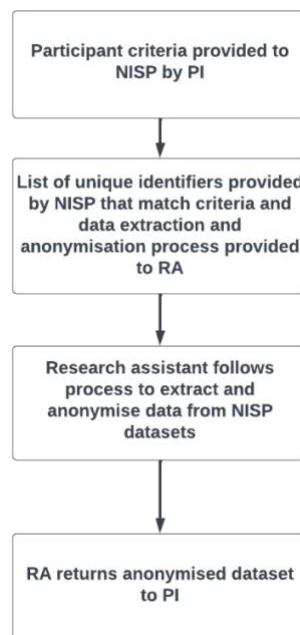
The first secondary dataset ('Dataset 1') includes the daily upload and download totals for 68 individual participants between 2018 and 2022 and contains 138,778 records. The dataset was automatically collected by an industry-standard, ISP management software package 'Splynx' (Splynx s.r.o. Czech Republic; <https://splynx.com/>). Splynx is a software program that provides billing and customer management services for ISPs and directly integrates with a Remote Authentication Dial-In User Service (RADIUS) server. RADIUS servers are often used by an ISP to manage, authenticate and the track the data usage of individual users. Splynx is used by the

NISP to manage various parts of its operations including authentication to its network and for the collection of various statistics. More information about Splynx and its capabilities is available from the company's website <https://splynx.com/>.

#### **2.6.1.1.1 Data Extraction process**

An appropriately qualified and independent research assistant (RA) was employed to extract data directly from the NISP's internal systems with the aid of the NISP. The RA was required to sign a confidentiality agreement to further ensure the confidentiality of the personally identifiable information.

The inclusion criteria for participants in the study were provided to the NISP, allowing the organisation to identify suitable participants for the study. Based on these inclusion criteria, the NISP provided a list of personally identifiable static IP addresses to the RA. At this point, the identity of the participants was known to the PI. However, no data was attached to the IP address list. A data extraction process (See Appendix VI) was developed by the NISP and provided to the RA along with their own login credentials to the NISP's customer management system (CMS). Instructions on how to extract and anonymise the raw data directly from the NISP's CMS were provided to the RA. The data was extracted anonymously and checked by the RA to ensure that it was properly anonymised. A visualisation of this process is shown below in Figure 2.4.



**Figure 2.4 - Data extraction process for 'Dataset 1'**

### **2.6.1.2 Dataset 2 – Application Data**

A second dataset used in this study is ('Dataset 2') which was collected by the industry-standard, software package 'ntopng' (ntop di Deri Luca, Italy; <https://www.ntop.org/>) for the period of October 2020 to December 2021 during the normal operation of the NISP. ntopng is a high speed, network traffic collection and analysis system typically used to provide insights into network traffic.

'Dataset 2' contained metadata of the participants internet traffic including time, upload and download volumes and category. It is important to note that the actual contents of any communications were not recorded by the NISP. 'Dataset 2' contained nearly 70 million records and due to this size necessitated the development of custom software for its processing and analysis.

Initially developed as an open-source product, ntopng has grown into one of the most popular applications in the marketplace. Ntopng collects and sorts the data automatically into categories such as "Video Streaming" and "HTTPS traffic" using a set of pre-defined rules. These rules include many (but not all) of the major applications and platforms on the internet. It is important to note that ntopng does not collect actual content of any internet traffic.

Ntopng professional version 4.1.201023 was used to identify the types and volumes of internet traffic that was passing through the NISPs network and provided an Application Programming Interface (API) to allow other software programs to communicate with it.

#### **2.6.1.2.1 Data Extraction process**

Similar to 'Dataset 1', the criteria for participants in the study were provided to the NISP including the occupation of the individual participant and the service location, allowing the organisation to identify suitable participants for the study. Based on these criteria, the NISP generated a list of personally identifiable static IP addresses. A Python script was then developed to extract and anonymise the data directly from the NISP's database. The use of the python script also reduced manual handling of personally identifiable data and minimising the risk of errors due to the large volume of data. More details about the Python programming language and how it was used are available in Section 2.8.1.2. The Python script is presented in appendix VI.

The Python script performed the following tasks to extract the raw data from ntopng:

- Extract the raw data from ntopng
- Anonymise the raw data
- Store the resulting de-identified raw data in a MySQL database

(<http://www.mysql.com>)

The Python script was executed on the internal infrastructure of the NISP by an employee (not the PI) of the NISP. The script was run over a period of four months of operation where it extracted and anonymised approximately 69,245,488 records, resulting in a file that was approximately 2.69GB. To reduce the dataset to a more manageable size, any rows that did not record traffic were removed. The raw data was then extracted into a CSV (Comma Separated Value) file for analysis with the R-Studio software package. See section 2.8.1.1 for more details about R-Studio.

Ntopng utilises rules to categorise traffic. With its default configuration, ntopng is able to break down internet traffic into 253 different categories for both upload and download traffic. Of the 253 possible categories, those that matched the top 95% of the internet traffic by volume were selected for analysis. Several similar categories were grouped together as shown in Table 2.3 (below). The categories that made up the remaining 5% of the internet traffic were also grouped together, along with unclassified traffic to form the “Other Traffic” category.

**Table 2.3 - Combined traffic categories**

Combined category	ntopng Categories
Web Browsing	HTTP, TLS and QUIC
Streaming	Netflix and RTMP
Microsoft	Microsoft, Microsoft 365
Other Traffic	Unknown and Other remaining categories

Traffic was categorised as Facebook if it was travelling to or from the subnets attached to Facebooks parent company “Meta Platforms Inc.” (Menlo Park, California, USA) ASN (Autonomous System Number). It is acknowledged that this filtering rule may capture a small amount of traffic that is not directly related to Facebook but that is hosted by Facebook.

The resulting categories that were used for analysis are presented below in Table 2.4.

**Table 2.4 - Application categories**

Category	Description
Amazon™	Any traffic to or from Amazon's network including Amazon Web Services (AWS)
Apple™	Any traffic to or from the Apple network including the Apple iTunes Store, iCloud and other traffic
Cloudflare™	Any traffic to or from Cloudflare network. The Cloudflare service is used by various companies to provide content delivers services, cyber security services and denial of service protection
Facebook™	Any traffic to or from the Facebook networks including Facebook and Facebook Messenger
Google™	Any traffic to or from the Google network including services such as Google search
IPSec	A Virtual Private Network (VPN) protocol that is used to create secure connection between two locations.
Microsoft™	Microsoft services including Bing and Microsoft Azure
Other Traffic	Aggregated applications that represent less than 5% of the monthly data usage
Skype™	A voice and video calling service operated by Microsoft
Streaming	Video streaming services that include Netflix and any services that uses the Real Time Messaging Protocol (RTMP) media streaming protocol
Web Browsing	Any Hypertext Transfer Protocol (HTTP), Transport Layer Security (TLS) and Quick UDP Internet Connections (QUIC) traffic

### 2.6.1.3 DUR

To assist with the analysis of the secondary datasets, the novel Download Upload Ratio (DUR) was developed. The DUR is a simple ratio that provides insight into the relationship between the upload and download traffic volumes over a period of time. The Download Upload Ratio (DUR) is calculated as follows:

#### Equation 1 - Download/Upload Ratio (DUR)

$$DUR = \frac{\textit{Total download volume}}{\textit{Total upload volume}}$$

A high DUR indicates that, for the period of time under analysis, more download traffic was consumed relative to the amount of upload traffic. Examples of this consumption include the streaming of movies or downloading of large files. Conversely, a low DUR indicates that more traffic was created by the user relative to the amount of data that was consumed. Examples of upload traffic include the uploading of photos or videos to a social media platform or video conferencing.

It is acknowledged that care should be taken when examining the DUR should multiple technologies be used to deliver internet connectivity to study participants, as the results could easily be skewed by low-bandwidth technologies. In the case of this work, all participants internet connectivity was delivered using the same medium (microwave radio).

### 2.6.1.4 Reliability and validity of secondary datasets

It is acknowledged that it is difficult to assess the reliability and validity of an external organisations dataset ([Saunders et al., 2019](#)). The data in this study was collected using a commercial software package by the NISP with the intention of it being used for regulatory compliance, business decision making and investment purposes. They were also collected in a way that best suited the purposes and continued operation of the NISP. As a result, the business had a commercial interest in ensuring that it was collected reliably and accurately.

### 2.6.1.5 Bias

The risk of measurement bias in these secondary datasets is acknowledged. Due to the unique nature of the datasets, it is not possible to compare them with other datasets to identify any

bias. A decision was made to take a neutral view on the risk of measurement bias in both 'Dataset 1' and 'Dataset 2' due to importance of the secondary data in the day to day operations of the NISP and as the software packages ntopng and Splynx were industry standard ([Saunders et al., 2019](#)). The use of industry standard software is an acceptable practice for reducing the risk of measurement bias and other associated biases ([Saunders et al., 2019](#)).

### **2.6.2 Online Survey**

An online survey was developed to collect quantitative and qualitative data. An online survey was selected as a data collection instrument as it enabled the efficient collection of standardised data from a large number of respondents through a series of identical questions ([Denscombe 2021](#); [Saunders et al., 2019](#)). In addition, online surveys have the significant benefit of reducing costs when compared to traditional survey taking methods and they allow respondents to complete the survey regardless of their geographical location. Online surveys also enable faster data processing as all responses are already digitised ([Denscombe, 2014](#)) and they reduce the amount of time needed to conduct the survey as the researcher does not need to wait for responses to be returned in the mail ([Saunders et al., 2009](#)).

There are many examples of using online surveys to survey farmers with examples including ([Hay, 2018](#); [Lamb et al., 2022](#); [Leonard et al., 2017](#); [Zhang et al., 2023](#)). However, due to the geographical location, it is also acknowledged that there is a risk of non-response bias due to respondents having poor or inadequate access to internet connectivity within the region of study. Some researchers have also reported that a larger proportion of respondents will complete mailed (hard copy) versions compared to online forms (e.g. ([Avemegah et al., 2021](#); [Lamb et al., 2022](#))). In the case of this study, a decision was made that the reduction in costs of conducting the survey, wider distribution of an online survey (with associated snowball sampling) and an offer to mail copies of the survey to potential respondents if requested, would be adequate and reduce the risk of non-response bias caused by any potential reduction in respondents.

The risk of self-selection bias (where a participant chooses to be part of the sample) ([Elston, 2021](#)) in this dataset is also acknowledged due to internet connectivity in regional Australia being a topical issue at the time this study was conducted. This may affect representation of farmers with a higher number of responses being received by respondents with strong feelings

about the issue, resulting in a sample that is not representative ([MacCoun, 1998](#)) of the population as a whole.

Potential survey respondents were filtered using inclusion questions (see Appendix V for the full survey) to ensure that only the target sample group was surveyed. If a respondent identified as under 18 or stated that they do not live or work on a farm, they were redirected to the end of the survey, thanked for their interest, and told that they did not meet the inclusion criteria to continue the survey.

To simplified survey development and HREC approval, a decision was made to not sample children under 18. If a respondent identified as under 18 or that they do not live or work on a farm, they were also redirected to the end of the survey, thanked for their interest, and told that they did not meet the criteria to continue the survey. The data of other participants that did otherwise did not meet the criteria (except for people under the age of 18) was archived for potential use in future research projects. Respondents were included for analysis if they were over the age of 18 and lived or worked on a farm.

Respondents were also asked to provide their postal code to allow the geographical location of survey respondents to be approximated without requiring other personally identifiable information. Post codes are also commonly used by in research projects with examples including [Wilson \(2022\)](#) and [Thomas et al. \(2023\)](#). The resulting survey question breakdown is presented in Table 2.5 (below).

**Table 2.5 – Survey Question and study breakdown**

<b>Study</b>	<b>Question Numbers</b>
Demographic Analysis	1-9
Study 1: How do farmers use the internet	N/A
Study 2: Understanding the connectivity requirement of farmers	1, 2, 7, 9, 32, 34-39, 44-46, 48
Study 3: How do farmers use social media	1, 2, 3, 5, 8, 9, 56-60

### 2.6.2.1 Survey design

A data requirements table as described by ([Saunders et al., 2019, p. 514](#)) was used to ensure that the online survey mapped the research questions to identified objectives and to ensure that all the required data for the survey was collected. The data requirements table is presented in Appendix V. The online survey was designed to be accessible to respondents that were being targeted and to ensure and that the survey was both valid and reliable ([Denscombe 2021](#)). The validity and reliability of the online survey are further discussed in Section 2.6.2.2.

The online survey used several different types of questions including multiple choice, multiple select and free text and asked both open ended and closed questions. Uniform five-point Likert scales (first described by [Likert \(1932\)](#)) were used to measure responses. Where possible, questions were kept under 20 words to assist with readability ([Saunders et al., 2019](#); [Sekaran & Bougie, 2013](#)). Standardised questions were used where possible to ensure that they were interpreted the same way by all respondents. Consideration was also given to the order of the questions to increase completion rates and reduce any unintended bias ([Saunders et al., 2019](#)). Questions were also designed to avoid marginalising any individual groups of vulnerable people by using inclusive language ([Australian Government National Health Medical Research Council, 2023](#)).

A decision was made to not incentivise respondents to complete this survey. This reduced the chance of respondents completing the survey simply for an opportunity to win a prize and increased the validity of the responses ([Sauermaann & Roach, 2013](#)). Due to the topical nature of the connectivity in agriculture at the time the study was conducted, it was anticipated this would not significantly reduce the number of respondents to the survey, nor significantly reduce the respondents motivation to complete the survey (questionnaire fatigue) ([Denscombe 2021](#)). Survey fatigue was minimised by ensuring that the survey followed best practice by avoiding or reducing complex or hypothetical questions ([Stedman et al., 2019](#)) and ensuring that questions are simple, clear and easy to understand ([Denscombe 2021](#)). In addition, respondents were not forced to answer any of the online survey questions.

The survey added value to earlier work by asking additional existing questions to continue a longitudinal study on technology adoption ([Hay & Pearce, 2014](#)). Additional questions from [Wilson \(2022\)](#) and [Thomas \(2021\)](#) were added to the online survey to help reduce the number

of surveys targeting the sample population. The length of the survey was also kept as short as possible whilst retaining its value as numerous researchers have shown that the length of a survey negatively affects response rates ([Biner & Kidd, 1994](#); [Galesic & Bosnjak, 2009](#)). A reflection on the survey is included in Section 7.6.

### 2.6.2.2 Reliability and validity

When designing a survey, care must be taken to ensure that data that is collected is both valid and reliable. Validity is concerned with the survey measuring what it is actually meant to measure, whereas the reliability refers to the consistency of the results and findings.

To ensure validity, several factors need to be considered including internal and external validity, measurement validity and content validity. The validity of the online survey was established by mapping the questions to the identified objectives in the data requirements table (see Appendix V) ([Saunders et al., 2019](#)). Pilot testing was then conducted on the completed survey ([Mitchell & Jolley, 2007](#); [Saunders et al., 2019](#)) amongst individuals who were familiar with the research topic. The results of the pilot testing were used to assess the duration of the survey, test the flow of the survey and test data exporting from Qualtrics (see section 2.6.2.5 for more information about the survey distribution).

The reliability of the survey was established through the reuse of existing questions where possible. Twelve questions were reused from several works including ([Hay & Pearce, 2014](#); [Roy Morgan, 2019](#); [Wilson, 2022](#)). Permission was obtained from the relevant authors when doing so. The remaining 48 new questions in the online survey were developed using an iterative process based on the literature review. The new questions were evaluated amongst experienced academics, peers, and farmers. The resulting survey was also compared to similar surveys that have been collected in the past, to improve reliability ([Saunders et al., 2019](#)).

The questions were also designed to take into account the literacy levels of farmers. For example, Australian survey participants are more familiar with acres than hectares as acres are the most common unit used to describe area in extensive Australian agriculture. Therefore, the units of acres were selected to be used in the online survey questions and subsequent analysis.

### **2.6.2.3 Sampling Strategy**

Cluster sampling, followed by snowball sampling was used to obtain an exploratory sample of the approximately 239,093 people actively involved in agriculture in Australia. The largest cluster was started when the Better Internet for Rural, Regional and Remote (BIRRR) group distributed the survey amongst its members on Facebook (See Appendix VIII for the social media posts). Visitors to the BIRRR Facebook page were also asked to distribute the survey further creating a snowball sample. Several other clusters were also started simultaneously with the PI and other colleagues working in agricultural research, local council, business, and industry also sharing the survey via personal mailing lists and through social media. Social media posts were designed to ensure that they could be easily shared via social media to maximise the amount of people re-sharing and to encourage snowball sampling.

### **2.6.2.4 Consent**

Care was taken to ensure that respondents could make an informed decision to complete the online survey. Consent was given electronically with respondents being presented with an informed consent statement at the beginning of the online survey. By choosing to continue with the survey, respondents automatically implied consent. The full informed consent statement is provided in Appendix V. In the case of a printed copy of the survey, an informed consent page would be included (although there were no requests for a printed survey from potential respondents).

### **2.6.2.5 Survey Distribution**

The online survey was developed and delivered using the software package Qualtrics XM (<https://www.qualtrics.com/>). Qualtrics was selected as it is commonly used by researchers to conduct online surveys. The host institution, JCU, provides access to the Qualtrics software package as part of its PhD program and recommends its use. Potential participants to the online survey were provided with a link and a scannable QR code to complete the survey online. A link to a printable copy of the survey was also made available for participants to complete via mail to allow potential respondents that have poor or limited access to the internet to complete the survey. An email address and phone number were also provided to enable potential respondents to contact the PI if they required a printed copy of the survey to be posted to them.

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The survey was released to the public on the 9<sup>th</sup> of March 2023 and closed at midnight on the 28<sup>th</sup> of April 2023. The survey was open for completion for a total of 51 days, providing the maximum opportunity possible for respondents to complete the survey.

The survey was shared as broadly as possible using a variety of methods, including social media and email lists to maximise the potential respondents and increase the probability that respondents in the target population had the opportunity to complete the survey. A total of 233 respondents opened the link to the survey with 175 completing the survey.

Survey participants were recruited from several different sources including:

- People known to the principal researcher and supervisors (Personal Contacts).
- Marketing by the Food Agility CRC including partner newsletters, email lists and advertisements.
- Social media (Facebook, X (nee Twitter) and LinkedIn).
- The Better Internet for Rural, Regional and Remote Australia organisation.
- Trade shows and conferences.
- Media articles and interviews.

Personal contacts were participants that are already known to the researcher. They may include friends, family, neighbours, and other residents in the community. These contacts were invited personally to participate in the research.

Local governments were contacted via email with the Richmond, McKinlay and Croydon shire councils in North West Queensland agreeing to distribute a link to the survey. Several other organisations, including the BIRRR group, the Food Agility CRC and AgForce also shared the details of the survey in their newsletters and via their social media channels. Further details of the individual distribution channels used follow.

### **2.6.2.5.1 Social Media**

Social media websites such as Facebook, X (Twitter) and LinkedIn were used to distribute the online survey as widely as possible. Two online posts were developed and submitted to the Human Research Ethics Committee (HREC) of James Cook University for approval as part of the HREC application. These posts are presented in Appendix VIII. This ensured that these posts met the ethical requirements of JCU ([James Cook University, 2024](#)). My contact details and the

contact details of the primary supervisor were included on the posts to allow potential respondents to contact either investigator if they had any enquiries.

To ensure that all social media posts met the requirement of HREC approval, the two social media posts were assessed to ensure that they were relevant, targeted the desired groups, and it was necessary that it be posted. Care was taken when distributing the survey to ensure that appropriate permission from the Facebook group administrators was obtained (if required) and that only topical groups were selected to ensure that their members trust that the posts and survey were legitimate ([Quinn, 2020](#)). Where required, social media posts were made on each platform by the PI with a dedicated account opened specifically for the purposes of the research or otherwise were shared with the administrators who posted them. Re-posting and further distribution of the posts was encouraged to increase snowball sampling.

#### **2.6.2.5.2 BIRRR Australia**

The Better Internet for Rural, Regional and Remote Australia (BIRRR) Facebook group was created on 22nd October 2014 by Kristy Sparrow from Alpha, Queensland, Australia and Kylie Stretton from Charters Towers, Queensland, Australia. The Facebook group has grown into a group with over 15,000 members and is focused on providing practical help and support for people located in regional and remote Australia ([BIRRR, 2024](#)).

BIRRR Australia agreed to partner with this research project and supplied a letter of support. BIRRR Australia was provided with a copy of the online survey to review and provide feedback, which was incorporated into the final copy of the survey. BIRRR agreed to distribute information about the online survey and a link to it on their Facebook page. The approved social media post was supplied to BIRRR who then posted in on the BIRRR Facebook page. BIRRR also posted reminders at one week and again at one day to go before the survey closed.

#### **2.6.2.5.3 Food Agility CRC**

The Food Agility Commonwealth Research Centre (Food Agility CRC) was established in 2017 by the Australian Government with a mission to “*deliver maximum impact for research and innovation investment in the Australian agrifood industry, to help it be more profitable and sustainable*” ([Food Agility Commonwealth Research Centre, 2024](#)). More details about the Food Agility CRC are available on their website, <https://www.foodagility.com/>.

I was fortunate to receive a stipend to support my PhD and was able to use this existing relationship with Food Agility CRC to help distribute the online survey. The Food Agility CRC promoted the survey through its social media channels. The survey was also shared with the Food Agility CRC partner networks, many of whom chose to distribute the survey through their email lists, newsletters, and other advertising. Potential respondents that were interested in completing the survey were asked to click on a link that directed them to the online survey.

A letter of support was obtained from the Food Agility CRC to promote the online survey stating that they would distribute details of the online survey through their social media channels and partners. After the survey was developed, it was provided to the Food Agility CRC for review and feedback, which was incorporated into the final copy of the survey. The Food Agility CRC then distributed the link to the online survey and posted reminders at one week and again at one day to go before the survey closed.

#### **2.6.2.5.4 Local Governments**

Several local governments were approached with a request to distribute the online survey with four local governments agreeing to do so. The Richmond, Cloncurry, McKinlay and Croydon local governments agreed to distribute the survey. The social media posts that were approved by the HREC were supplied to the local governments who then used their social media accounts and existing community notice board email lists to distribute them. Doing so ensured that the PI was one step removed from the distribution process to avoid any unintended bias. The mailing lists used by the local government were created for the purpose of disseminating news, marketing material and other information that was relevant to the community. Membership to the mailing lists was voluntary with community members needing to subscribe to receive them. The local governments were requested to send out a reminder email one week before the survey closed with all of them doing so.

#### **2.6.2.5.5 Personal contacts**

The PI used personal contacts where appropriate to distribute the social media post that linked to the online survey. When informing personal contacts, care was taken to minimise the risk of coercion, ensure ethical research practices and to avoid introducing any unintended bias. Any posts made by social media were done by resharing existing public posts that linked to the survey and that were previously posted by other groups.

#### **2.6.2.5.6 Nuffield Australia**

Nuffield Australia is an Australian based organisation that offers scholarships to farmers (more information is available on their website, <http://www.nuffield.com.au>). The scholarships allow scholars to travel overseas to research new and improved farming methods with the intent of adopting them back home. I was fortunate to receive a scholarship in 2016. Nuffield Australia was contacted and agreed to distribute the survey to their extensive list of alumni throughout Australia via a Facebook post and their email mailing list.

#### **2.6.2.5.7 AgForce**

AgForce is a Queensland based organisation that represents producers of cattle, grain, cane, sheep and wool. Further details regarding the AgForce organisation are available on their website, <https://www.agforceqld.com.au>. The PI contacted AgForce using their existing contact networks with the organisation agreeing to promote the online survey to their members in the monthly newsletter.

#### **2.6.2.5.8 The Tropical North Queensland Drought Resilience Adoption and Innovation Hub**

The Tropical North Queensland Drought Resilience Adoption and Innovation Hub (TNQ Hub) was founded in 2021 with a vision to see that “*Northern Queensland becomes drought resilient through an innovative, profitable and sustainable agricultural sector and resourceful and adaptable communities*” ([The Tropical North Queensland Drought Resilience Adoption and Innovation Hub, 2024](#)).

A letter of support was obtained from the TNQ hub to promote the online survey. The letter of support stated that they would distribute details of the online survey through their social medial channels and partners. After the survey was developed, it was provided to the TNQ Hub to review and provide feedback, which was incorporated into the final survey. A sample social media post was also developed and provided to the TNQ Hub. The TNQ Hub then distributed the link to the online survey and posted reminders at one week and again at one day to go before the survey closed.

#### **2.6.2.5.9 James Cook University**

A press release was developed and presented to the media department of the host university, James Cook University for distribution. Approval was received and the university distributed the media release on the 30<sup>th</sup> of March 2023. As a result, several media organisations picked

up the story and several articles were published. The PI was also interviewed by several radio journalists who also redistributed the link, increasing the distribution of the online survey (media interviews are listed in the Research Outputs section).

#### **2.6.2.5.10 Other media**

Several other organisations and media outlets were contacted and requested to distribute the link to the online survey. The organisations that chose to do so included the Agriculture Technology and Adoption Centre (AgTAC) at JCU (<https://www.jcu.edu.au/agtac>) and the Beef Central online newsletter (<http://www.beefcentral.com.au>).

#### **2.6.2.6 Online survey data cleaning**

Data cleaning of all data that is used in a study is necessary to prevent incorrect results that lead to false conclusions and to not do so is considered “very dangerous” ([Saunders et al., 2019, p. 580](#)). To prevent this occurring, the raw dataset was manually checked for errors. As no survey questions were required to be answered, responses where the respondent did not answer all the filter questions or that did not meet the appropriate criteria to complete the survey were removed.

#### **2.6.2.7 Bias**

The risk for volunteer bias is acknowledged due to a possible overrepresentation of respondents that may hold strong opinions regarding the adequacy and availability of telecommunications in RRR areas and the topical nature of regional telecommunications. The risk of uninformed response bias was reduced by not incentivising respondents to complete the survey ([Saunders et al., 2019](#)). Questionnaire fatigue ([Denscombe 2021, p. 216](#)) was managed by using multiple choice questions where possible, informing the respondent of the estimated time required to complete the survey and by keeping the survey as short as possible. A reflection on the length of the survey is discussed in Section 7.6.

### **2.7 Research data storage**

A data management plan was developed for this research project to ensure that all raw and processed data, including personally identifiable data is handled according to the requirements of James Cook University’s “Management of Data and Information in Research Procedure”. A copy of this policy is available at <https://www.jcu.edu.au/policy/procedures/research-management-procedures/management->

[of-data-and-information-in-research-procedure](#). The data management plan is presented in Appendix VII.

### 2.8 Data analysis techniques

Multiple methods are required to analyse the various forms of data that were collected in this mixed methods study. A visualisation of the procedure that was followed is presented in Figure 2.5 (below)



**Figure 2.5 - Data analysis procedure (based on [Creswell \(2018\)](#))**

The individual data analysis techniques for each study is presents below in Table 2.6

**Table 2.6 - Breakdown of data analysis methods**

Study	Quantitative data analysis	Qualitative data analysis
Study 1: How do farmers use the internet	Yes	No
Study 2: Understanding how farmers get connected and stay connected	No	Yes
Study 3: How do farmers use social media	Yes	Yes

#### 2.8.1 Quantitative Data

Quantitative data was analysed using descriptive and inferential statistical analysis methods including factor analysis and summary statistics. The raw data that was obtained during data collection was converted into the common accessible file formats such as CSV and XLSX for analysis and then archiving upon completion of the research project. The raw data was pre-processed and prepared using several software packages tools including Microsoft Excel, IBM SPSS and R Studio. Further details on these software packages are presented below.

The pre-processing of the data included the creation of data dictionaries and ensuring that the units were consistent across all datasets, that time zones were considered and that the appropriate data format was used to store data. Survey data was also coded for analysis. The data dictionaries and code books used as part of this research project were uploaded to the host institutions data repository and the data dictionary for the online survey is presented in Appendix V.

### **2.8.1.1 R Studio**

The quantitative datasets were processed and analysed using the open-source statistical tool RStudio (RStudio PBC, Boston, USA, <https://www.rstudio.com/>). R Studio is commonly used across many different disciplines ranging from agricultural and biological sciences to neuroscience. In 2015, “nearly one in 100 scholarly articles in Elsevier’s Scopus database last year [2014] cites R or one of its packages” ([Tippmann, 2015, p. 2](#)).

### **2.8.1.2 Python**

Several scripts used to extract and process the secondary datasets were written in the Python programming language (Python Software Foundation, Delaware, USA, <https://www.python.org/psf-landing>). The Python programming language is used extensively within the scientific community and was chosen due to its flexibility, ease of use and high degree of type safety (ensuring that variables are accessed in a well-defined and appropriate way) ([Smith, 2022](#)).

### **2.8.1.3 IBM SPSS**

The IBM’s SPSS (IBM Corporation, Armonk, New York, USA, <https://www.ibm.com/products/spss-statistics> ) software package is a statistical analysis program that is commonly used in research projects. A SPSS licence was provided by the host institution. SPSS was used to perform various statistical analyses including frequency analysis, means analysis and cross tabulations.

### **2.8.1.4 Microsoft Excel**

Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA, <https://www.microsoft.com>) is an industry standard spreadsheet application that is commonly used by industry and researchers to store data in tabular form for easy manipulation and analysis.

### **2.8.2 Qualitative Data**

Text based qualitative data was collected as part of this research project to enable the respondents of the online survey to provide richer and more detailed responses to several questions. Various analytic techniques were performed to extract the themes and topics contained in the data.

It is acknowledged that there is a risk of experimenter bias when analysing qualitative data. In order to manage this risk of the experimenter applying their personal biases when analysing the data, the analysis of qualitative data was performed using the methods detailed in [Braun & Clarke, 2006](#), [Creswell \(2018\)](#) and [Maguire \(2017\)](#). This method involves six stages of analysis, coding and identifying themes and is well used in the literature. Raw data was prepared for analysis using various software tools including R Studio and Microsoft.

### **2.9 Literature review methodology**

Literature reviews in this research project were undertaken using the systematic literature review methodology. This methodology was selected to reduce bias, increase rigor and repeatability and to ensure that results will be evidence informed ([Tranfield et al., 2003](#)).

A bibliometric tool was developed to assist with the literature analysis that formed part of this study. This tool was developed to increase the speed of the literature reviews and to enable all relevant literature to be identified. This system communicated with the JCU library programmatically and downloaded the results of predefined queries into a database. These results were then processed by:

- Identifying any duplicates
- Identifying the most common papers
- Counting key word usage
- Determining author prolificacy and links to other authors
- Identifying the most common publications that contain relevant literature

The bibliographical tool then provided a simple interface to access, include or exclude, rate and record bias in the results.

The bibliometric tool is a PHP application based on the CakePHP framework (Cake Software Foundation, <https://cakefoundation.org/>) and runs locally on a computer. It is easily

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expandable and will be used extensively throughout the research project. The tool was made for free on the code repository GitHub at <https://github.com/olgadowns/bibliometric-tool> with the hope that it may assist future researchers. Several images of the bibliometric tool are presented below in Figure 2.6.

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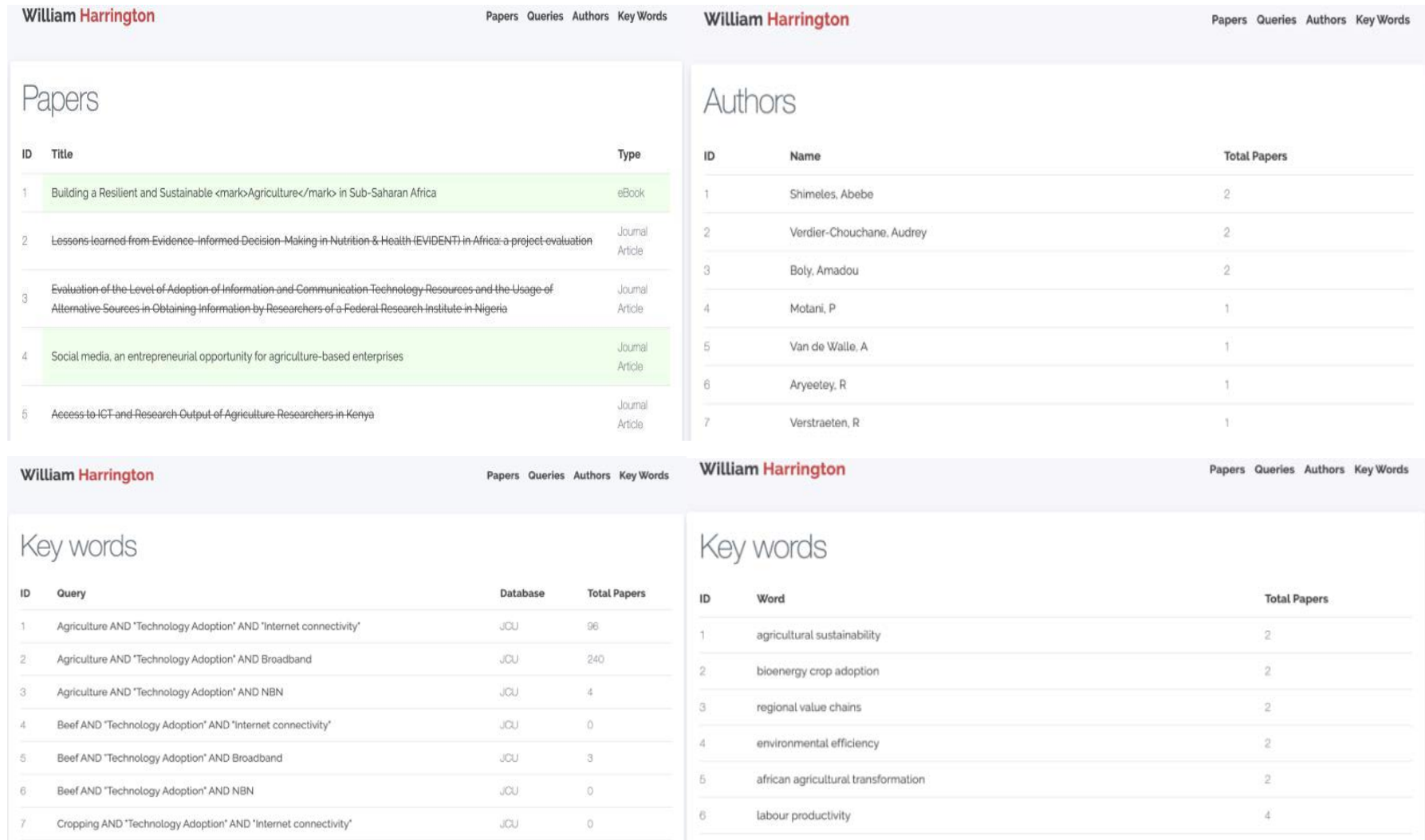


Figure 2.6 - Screenshots of the bibliometric tool in use

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It is acknowledged that there is some debate in the literature regarding how rigorous such tools are ([Donthu et al., 2021](#); [Romanelli et al., 2021](#)). As this bibliometric tool was developed specifically for this research project, it has not been rigorously tested or verified, except for what would normally occur as part of the software development process. As a result, additional manual searches of the literature were also conducted to ensure rigorous review of literature.

The research questions for this project were broken down using the Sample, Phenomenon of Interest, Design, Evaluation, Research type (SPIDER) framework ([Cooke et al., 2012](#)). The SPIDER framework was selected to ensure that relevant literature was identified in an efficient manner and because it has several advantages over the Population Intervention Comparison Outcome (PICO) tool that is commonly used ([Cooke et al., 2012](#)). The SPIDER tool is also more suitable for use with qualitative and mixed methods research.

Grey literature such as news article, census data and other dissertations have been used in this dissertation. The decision to use grey literature was made as it allows for alternate viewpoints, is often more current than extant literature, and in some cases the only source of information regarding certain topics. When grey literature is used, it is appropriately referenced. It is acknowledged that the quality of grey literature can also vary. Care has been taken when such literature is used, with the grey literature that has been used in this dissertation restricted where possible to reputable news organisations, large companies, and government departments. Guidance was obtained from experienced researchers and the JCU library.

## 2.10 Risk Management

A risk management plan is required by the host institution for all research projects. A risk management plan was developed in accordance with the host institutions risk management policy and a risk management register was created. Several risks were identified and presented below in Table 2.7 below.

**Table 2.7 - Risk Management Register**

<b>Risk</b>	<b>Probability</b>	<b>Consequences</b>	<b>Mitigation</b>	<b>Risk Register ID</b>
Travelling in vehicle	Low	Major	Best practice Do not travel for more than 6 hours without a break	11350
COVID 19	Medium	Medium	Follow all government recommendations and university policy	11357
No responses to survey	Low	Major	Identify and work with existing datasets	N/A
Supervisor change	Low	Major	Good communication with all supervisors	N/A
Run out of funding	Low	Major	Budgeting, Existing Food Agility CRC funding will be adequate	N/A

### **2.11 Chapter Summary**

Chapter Two presented the methodological framework and the philosophical perspective that was used to answer the research questions in this study. The chapter provided details about the secondary datasets that are used throughout this dissertation, including details about what they are, how they were collected and details about the NISP that provided the data. The study populations were also discussed.

Details were also provided about the online survey that was conducted, including the design, sampling strategy and how it was distributed. Bias, reliability, and validity were also addressed. Further details about the research project itself were also presented, including a timeline of the project, research data storage plan and risk management. Quantitative and qualitative data analysis techniques were also discussed.

## Demographic analysis

How do farmers use the internet: A mixed methods approach						
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### 3.1 Introduction

This chapter presents descriptive statistics and a demographics analysis, of the responses to the online survey that was conducted as part of this study. This chapter begins by supplying details of the dataset connected to the online survey data collection instrument in Section 3.2. This is followed by discussion of the data cleaning process that was applied to the resulting dataset. Finally, demographic factors including age, gender, the highest level of education of the respondent and factors including the size and type of farm are also examined and presented in Section 3.4.

### 3.2 Survey Dataset

The online survey was open to people who lived or worked on a farm or station (ranch) in Australia and were over the age of 18. More details regarding the filter questions are provided in Section 2.6.2. A total of 233 responses to the online survey were received from farmers or farm workers across Australia, with respondents taking an average of 46 minutes to complete the survey. A reflection on the length of the online survey is presented in Section 7.6.

### **3.3 Data cleaning**

A cleaning process was used to prepare the final dataset for analysis and check for errors ([Saunders et al., 2019](#)). Responses were cleaned by manually checking the survey responses for errors. Responses that stated that they did not live or work on a farm or were under the age of 18 were removed. If a respondent did not select a gender, they were assigned “Other / Prefer not to say”. This resulted in a total n=175 responses being available for analysis.

Incomplete survey responses that met the filter criteria were included to minimise the risk of bias caused by poor internet connectivity that preventing a respondent from completing the survey. As a result, where an individual respondent did not answer the question their response for that question was excluded from the analysis and considered an “*ignorable nonresponse*” ([Tabachnick & Fidell, 2019, p. 54](#)). In this case, an “*ignorable nonresponse*” is identified as a survey question that was not answered by the respondent. Unless otherwise noted, when presenting or interpreting any percentages in this dissertation, percentage are of the total number of valid responses to that question.

### **3.4 Respondent demographics**

A total of five demographic questions were asked in the online survey to provide insight into the individual that completed the survey. An additional series of questions were asked to provide greater insight into the type and location of the farm and farm business that the respondent lived and worked on and to enable responses to be broken down into groups for analysis.

#### **3.4.1 Respondent location**

Respondents were asked to provide their post code. The postal codes that were provided were grouped together by state using a publicly available database of post codes ([Proctor, 2023](#)). A frequency analysis of the postcodes was conducted and shows that of the total responses (N=175) of the survey, over half (55.4%) of the respondents were located in Queensland. Twelve respondents (6.9%) did not supply their postal code. A full breakdown of the postal codes is presented below in Table 3.1.

**Table 3.1 - Frequency analysis of responses to Questions 6: “What is your postcode?”**

State	Full dataset	
	Frequency	Percent
NSW	27	15.4%
NT	5	2.9%
QLD	97	55.4%
SA	7	4.0%
TAS	1	0.6%
VIC	14	8.0%
WA	12	6.9%
Missing or invalid	12	6.9%
<b>Total</b>	<b>175</b>	<b>100%</b>

### 3.4.2 Live or work on a farm

To ensure that respondents were eligible to take part in the survey, respondents were asked if they lived or worked on a farm. A frequency analysis was conducted with the results presented in Table 3.2 (below). The majority of respondents (86.3%) indicated that they lived and worked on a farm with n=16 respondents working on but not living on a farm or station and only n=8 respondents just living on a farm. A total of n=7 respondents indicated that they did not live or work on a farm or station and were therefore ineligible to complete the survey.

**Table 3.2 - Frequency analysis to Question 3: “Do you live or work on a station or farm?”**

Employment option	Frequency	Percentage (%)
I live and work on a farm or station	151	86.3%
I live but don't work on a farm or station	8	4.6%
I work on but don't live on a farm or station	16	9.1%
<b>Total</b>	<b>175</b>	<b>100.0%</b>

### 3.4.3 Type of farm or station

The respondents were asked what produce or livestock the farm that they lived or worked on produced, with respondents being allowed to select more than one entry (see Table 3.3). The majority of respondents indicated that they were beef producers (n=122) followed by cropping (n=47). A total of n=24 respondents selected “Other” indicating that they produced something other than the options provided. Responses for “Other” included pigs, bees, horses, dairy and goats and consulting.

**Table 3.3 – Frequency analysis of Question 9: “What type of farm or station do you live or work on?”**

<b>Farm Type</b>	<b>Frequency</b>	<b>Percentage (%)</b>
Beef	122	69.7%
Wool	31	17.7%
Cropping	47	26.9%
Sheep meat	23	13.1%
Other	24	13.7%
<b>Total</b>	<b>247*</b>	<b>141.1%*</b>

\*Respondents were able to select more than one option

### 3.4.4 Age and gender

The online survey was open to all genders and respondents that were at least 18 years of age. A total of n=99 (56.6%) of respondents were women, and n=68 (38.9%) men. A total of n=8 (4.6%) of respondents did not provide a gender and were categorised as “Other / Not Specified”. The mean age of men that completed the survey is between 50 and 54 years of age and 45-49 for women. Table 3.4 (below) presents a summary of the age and gender of the online survey respondents.

**Table 3.4 – Cross tabulation analysis of Age and Gender for online survey respondents**

Age Group	Man	Woman	Not specified
18-19	1	0	0
20-24	1	4	0
25-29	4	10	0
30-34	2	9	0
35-39	11	12	1
40-44	9	11	2
45-49	7	12	1
50-54	10	14	2
55-59	7	7	2
60-64	7	10	0
65-69	6	4	0
70-74	2	4	0
80-84	0	2	0
85 and over	1	0	0
<b>Total</b>	<b>68</b>	<b>99</b>	<b>8</b>

### 3.4.5 Education

Respondents were asked to provide their highest level of educational achievement. The majority of respondents have a bachelor's degree (n=54) followed by Secondary Education (n=32). Only n=1 respondent in the full dataset only had a Primary School Education. Table 3.5 below shows the full breakdown of the education levels of the respondents and the average education levels for the general population for comparison ([Australian Bureau of Statistics, 2022](#)). The education levels used in the online survey are based on the Australian Standard Classification of Education (ASCED) ([Australian Bureau of Statistics, 2001](#)).

The education level of the study respondents is higher than the national average for all levels of education except Certificate III or IV (n=20) and Primary education (n=1). This finding challenges the narrative that farmers are under educated and whilst outside the scope of this research project, may enlighten future research.

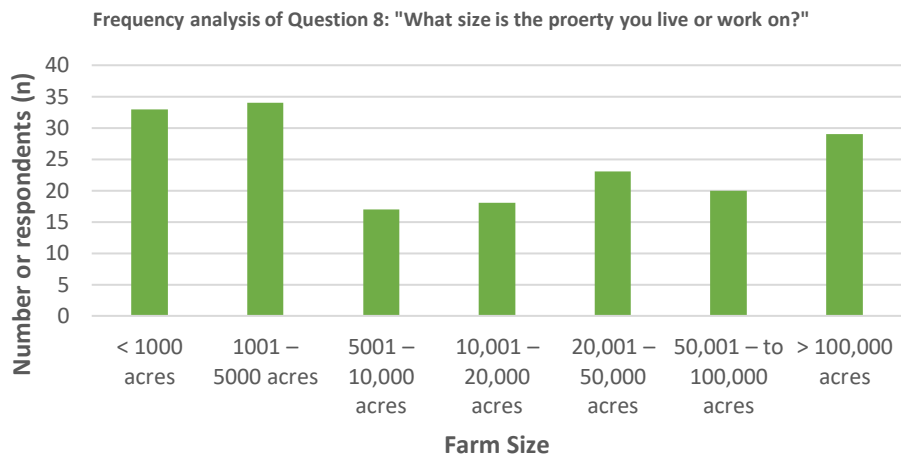
**Table 3.5 - Frequency analysis of Question 4: “What is your highest level of education?”**

Highest level of education	Frequency	Survey Percentage	National average
Postgraduate degree	23	13.1%	8.1%
Graduate diploma or certificate	10	5.7%	3.6%
Bachelor’s Degree	54	30.9%	20.3%
Diploma or advanced diploma	28	16.0%	9.8%
Certificate III or IV	20	11.4%	17.0%
Certificate I or II	7	4.0%	N/A
Secondary education	32	18.3%	32.2%*
Primary education	1	0.6%	6.0%
Unknown	-	-	2.4%
<b>Total</b>	<b>175</b>	<b>100.0%</b>	<b>100%+</b>

\*Includes Certificates I and II \*Due to rounding by [Australian Bureau of Statistics \(2022\)](#), this total does not equal 100%

**3.4.6 Size of farm or station**

Respondents were asked the size of the farm on which they live or work in question eight of the online survey. A frequency analysis of the results is presented below in Figure 3.1.



**Figure 3.1 - Frequency analysis of Question 8: “What size is the property where you live or work?”**

**3.4.7 Distance to the nearest town**

Respondents were asked how far the farm that they lived or worked on was located from their nearest town. A frequency analysis of how far away the nearest town is from where they lived or worked is presented below in Table 3.6.

**Table 3.6 - Frequency analysis of Question 7: “How far is the nearest town from where you live or work?”**

<b>Distance from town</b>	<b>Frequency</b>	<b>Percentage</b>
I live in town	10	5.7%
Less than 5km	5	2.9%
5km to 15km	23	13.1%
16km to 30km	40	22.9%
31km to 60km	40	22.9%
More than 60km but less than 100km	27	15.4%
More than 100km	29	16.6%
No response	1	0.6%
<b>Total</b>	<b>175</b>	<b>100%</b>

**3.4.8 Ownership of farm**

A frequency analysis of the farm ownership is presented below in Table 3.7. The majority (88%) of farms were indicated to be family owned (n=154). Seven percent were company owned and 3% of “Other” responses included “working on a government research station” and a “group of farm investors”.

**Table 3.7 - Frequency analysis to Question 10: “What type of business is the farm or station that you live or work on?”**

<b>Type of business</b>	<b>Frequency</b>	<b>Percentage</b>
Family owned	154	88.0%
Company	13	7.4%
Other	6	3.4%
No response	2	1.1%
<b>Total</b>	<b>175</b>	<b>100%</b>

### 3.5 Chapter Summary

This chapter presented an analysis of the demographic data of the responses that were collected as part of the online survey that was conducted as part of this study. A total of 233 responses were collected, which after cleaning resulted in N=175 responses available for analysis. Of these responses 56.6% of the respondents were women, 38.9% were men and 4.6% did not provide their gender. The average age of the respondents was between 50-54 for men and 45-49 for women.

Respondents were mostly located in Queensland (55.4%) followed by 15.4% in New South Wales. The remainder of respondents (29.2%) were located throughout Australia. The majority of respondents had achieved at least a secondary education with only 1 respondent only completing primary school. The average size of the farm of the respondents that completed the online survey was between 5,001 to 10,000 acres (2,023.4 – 4,046.9Ha).

**Study 1 - Understanding how farmers use the internet**

How do farmers use the internet: A mixed methods approach						
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A paper is currently under development for this dissertation *“Patterns of behaviour: A longitudinal analysis of the internet usage of select North-West Queensland farmers”*. This paper draws from several sections of this study.

**4.1 Introduction**

Poor internet connectivity is limiting agricultural development in regional and remote Australia, impeding the adoption of new technology and new approaches to farming ([Australian Broadband Advisory Council, 2021, p. 360](#); [Griffith et al., 2008](#); [Lamb, 2018](#)). The lack of fit-for-purpose internet connectivity is restricting efforts by farmers to embrace new technologies, such as IOT (Internet Of Things) devices to monitor different aspects of their farm and cloud based software packages ([Charmley et al., 2016](#)). By adopting new technologies, existing farm businesses will be able to increase productivity, become more sustainable and remain profitable ([Leonard et al., 2017](#)). In addition, the adoption of new technology and farming methods will lead to improved yields and better animal welfare outcomes ([Gaffney et al., 2019](#); [Jukan et al., 2017](#)).

Despite the obvious importance of internet connectivity to farmers, to the authors knowledge, no work exists that studies the internet traffic patterns of farmers. Other work such as [Trevisan et al. \(2020\)](#), have focused on larger groups such as a city or country, while a number of surveys such [Department of Agriculture and Water Resources \(2018\)](#) seek to understand farmer reliance upon, and use of the internet. Without a direct understanding of how farmers use the internet, it is difficult to ensure that current internet connectivity solutions available to them are adequate, fit for purpose and that they are not a limiting factor to improvements in production and efficiency of food and fibre production ([Whitacre, Mark, et al., 2014](#)).

The aim of this study is to understand how a group of farmers in North West Queensland with access to unconstrained internet, use it in both their day-to-day life and in their businesses. At the time of publication, the internet connectivity provided by the NISP were the only service available to farmers in the region that was unconstrained. By analysing two unique datasets provided by the NISP that categorises participants by their occupation (in this case farming). The first dataset `Dataset 1` contains daily traffic volumes and the second `Dataset 2` contains the amount of traffic to and from various applications the participants were using on an hourly basis. Further details about these datasets are presented in Section 2.6.1.

This chapter presents a novel methodology to show that farmers are increasing their day-to-day usage of the internet and highlights the importance of understanding farmers' connectivity requirements to ensure that they have access to internet connectivity that is fit for purpose and meets their needs. The outcomes of this study will help Internet Service Providers (ISP's), and policy and decision makers understand farmers connectivity needs and ensure that connectivity infrastructure meets farmer's needs now and as traffic volumes continue to increase into the future.

## **4.2 Literature Review**

There has been extensive research into the trends of internet usage globally, with examples including the [Australian Communications and Media Authority \(2021\)](#) and [Ofcom \(2020\)](#). Whilst based on various methodologies, these reports all show that the average data usage continues to increase year on year. In the case of the ACMA Supply and Use of Services Report ([Australian Communications and Media Authority, 2021](#)), the average data consumption of an NBN™ user increased by almost 50% from 207GB (gigabytes) per month in June 2018 to 297GB as of June 2020. No extra context or details regarding demographic data about the

participants are provided with these results, therefore it is assumed that the sample includes every user of the NBN™, including farmers and all forms of NBN connectivity including FTTP, FTTN, wireless and satellite.

Typically, data on the internal operation of their networks are collected and analysed by the ISP's themselves for internal purposes. These datasets can contain various pieces of information including traffic volumes, speeds, and the type of information. Due to the commercially sensitive and personally identifiable nature of such datasets, it is also difficult for researchers to gain access to them. There are few examples globally where researchers have done so and to the authors knowledge none of these matched the data to an individual's occupation. For example there are numerous instances, where the results of such analyses are made publicly accessible, and they are done with little or no transparency i.e. [ACCC \(2021\)](#) and [\(NBN Co, 2019\)](#). As such, publicly accessible data that is used in this paper is only used to provide context to the study results that are identified as no direct comparison between groups is possible.

In this present work we focus on a specific participant vocation, namely farming, and the participants have all been selected on that basis. Whilst the vocational focus may be clear, farming is a complex mix of business and lifestyle. Farmers in North West Queensland, Australia, like most farmers, generally live and work on their farms and cattle stations (ranches), with very few also working on other nearby farms or in nearby towns ([Australian Bureau of Agricultural and Resource Economics and Sciences, 2021](#)). As a result, their internet connection is used for many different things including business, education and recreation ([Gunn et al., 2021](#)). In addition, due to the physical isolation of many farmers, and the tyranny of distance, farmers also use their internet connection for other less common purposes such as for telehealth and other consultations (for example, finance, legal, fitness classes, art school etc.) and as such, cannot be considered “an average household” ([Lamb, 2017, p. 62](#)).

In this study, we seek to quantify the internet usage of a select group of remotely located farmers by monitoring their actual data traffic without any interaction with the farmers themselves. To do so, this study analyses two datasets that were provided by the NISP. These datasets are unique, in that they identify participants by their occupation (in this case farming).

#### **4.2.1 Internet in Australia**

In Australia, ISPs operate under the Telecommunications Act ([Australian Government, 1997](#)). The Act lays out the requirements that an ISP needs to fulfill to operate and allows the ISP to sell communication services to the public. For the case of internet connectivity, these services are typically called Plans and come in various configurations as determined by the ISP. These Plans commonly range from a low-speed, consumer grade service that is offered on an “as is” basis, to business grade services that offer higher speeds, larger monthly data allowances and guaranteed levels of reliability. The Plans may also offer services that are either “asymmetrical” or “symmetrical” with asymmetrical internet connections being the most common type. For asymmetrical connections, the ratio of download to upload speeds often ranges from 5 to 20. In the case of the NISP, the plans that are available to respondents that participated in this study are detailed in section 2.6.1.

In Australia’s case, every premise in Australia has access to an NBN™ connection that can provide a “25/5” service, meaning a 25mb/s download and 5mb/s upload speed ([Australian Government, 2020b](#)) and is guaranteed by the Universal Service Guarantee (USG). The National Broadband Network (NBN™) uses a mix of technology to deliver internet connectivity to the whole of Australia ([NBN Co, 2021d](#)). In the case of rural and remote areas, the primary technology used to provide connectivity is the NBN Sky Muster™ satellite service. The NBN Sky Muster™ satellite service is also available in a variant called NBN Sky Muster™ Plus that offers a combination of metered and unmetered data, depending on what application the user is using and is still considered a constrained internet connection in this work.

#### **4.2.2 Farmers and the internet**

It is the intent of this study to understand internet usage behaviour of a group farmers who are not constrained by data traffic limits, application filtering and asynchronous connection speeds (where the maximum upload and download speeds are not the same). Consequentially, the participating farmers had access to an internet connection that is both symmetrical (the maximum download and upload speeds are the same) and provides unlimited download and upload traffic volumes. Here we will refer to them as ‘unconstrained’ users.

Farmers use a variety of methods to connect to the internet with each of these technologies having their own advantages, limitations and constraints ([BIRRR, 2020](#)). Connectivity methods that require the installation of cables to the customers' premises such as fibre optic cables and hybrid fibre-coax are uncommon for farms owing to the high cost of installing the cable and the low relative return on investment for both wholesalers (e.g., the publicly owned corporation NBN Co which operates the National Broadband Service (NBN™)) and associated retailers (e.g., Internet Service Providers (ISPs)). In the case of Australia's NBN™ network, this involves a mix of technologies (e.g., Fibre to the node (FTTN), Fibre to the premises (FTTP), Hybrid Fibre Coax (HFC), Wireless, etc) ([NBN Co, 2022](#)) "*according to which is the most economical solution*" ([Ovum, 2017, p. 5](#)). Each of these connectivity technologies have various advantages and disadvantages and it is up to the farmer to try and determine which form of connectivity is available to them and, if they are fortunate enough to have multiple options, which one is most suitable.

The reality in Australia is that many of the connectivity methods that have been mentioned previously are not available in rural areas due to the high cost of providing the service. This is supported by [Salemink et al. \(2017\)](#) who found that there is "*persistent and growing differences in data infrastructure quality between urban and rural areas*" (p.360). As a result, consumers in rural areas typically have fewer choices of ISPs and technologies to access connectivity features (for example only some ISPs that resell NBN™ services in Australia offer access to the newer Sky Muster Plus™ service rather than to older Sky Muster™ service). The Sky Muster Plus™ service offers unmetered data allowances for some internet traffic rather than all traffic as with the older Sky Muster™ service.

The provisioning of internet services by ISPs to their customers is also a complex endeavour that requires a large capital outlay and constant monitoring and management. For example in the case of Australia's NBN™ network in 2018, a single fixed wireless connection costs \$3,784 to install ([NBN Co, 2018](#)). A lack of competition often results in the services that are available being more expensive, and in many cases, the quality and reliability of a farmers internet connectivity is also varied and unreliable ([Gunn et al., 2021](#); [Marshall & Dale, 2019b](#)).

Moreover, the notion of adequacy and fitness for purpose of an internet connection is difficult to define due to the large variety of farming systems and individual farming styles that results in different farmers using or requiring different services. An example of this could be one

farmer using the internet to access basic services such as email and social media with another requiring access to cloud services such as accounting and video conferencing. As a result, connectivity that is considered adequate for one farmer may be regarded as inadequate by another. There are several levels of adequacy required to meet the demands of all farmers and that quantitative indicators of adequacy are necessary.

As previously discussed in Section 1.2, a lack of internet connectivity also makes it difficult to attract and retain staff that are otherwise accustomed to having access to services such as social media platforms and video streaming ([Regional Telecommunications Independent Review, 2018](#)). This lack of access to consistent reliable internet connectivity in turn contributes to the “Brain Drain” phenomenon, where younger people leave regional and remote areas taking knowledge and skills with them ([Bowen & Morris, 2019](#); [Townsend et al., 2017](#)).

Losing young people from farming families means that the average age of farmers globally is increasing to approximately 60 years old ([Food and Agriculture Organisation of the United Nations, 2014](#)) and the average Australian beef producer is now 64 years old ([Meat and Livestock Australia, 2021](#)). This “Brain Drain” contributes to less people being available to be actively involved with farming on a day-to-day basis (see Section 1.2 for further discussion regarding the “Brain Drain”). This contributes to an increasing disconnect between farmers and urban dwellers. Internet connectivity therefore becomes a key enabler to the democratisation of policy issues, which can influence perceptions and attitudes that are relevant or related to farmers ([Willis & Tranter, 2006](#)) such as animal welfare.

Poor or inadequate connectivity also reduces farmers’ ability to access social media platforms and as a result, their ability to experience the benefits of social media platforms. This is particularly problematic for farmers as social media has been found to reduce their sense of social isolation as farmers often live in rural and remote areas and have limited opportunities to meet socially in person ([Gunn et al., 2021](#)). Social media platforms such as Facebook and X (formerly Twitter) allow farmers to communicate, advocate and exchange ideas. One example of this is the Facebook group BIRRR (Better Internet for Rural, Regional and Remote Australia) which was set up by farmers to assist farmers with connectivity issues in Australia and which now has over 15,600 followers ([BIRRR, 2024](#)). There are numerous other examples of farmers using social media to do many things ranging from marketing cattle ([Australian Broadcasting](#)

[Corporation, 2021](#)) to sharing new ideas ([Australian Broadcasting Corporation, 2020](#); [Farm Online National, 2020](#)). How farmers use social media is further discussed in Chapter Six.

Understanding how farmers use the internet and what their requirements are is key to ensuring that the services that are made available to them meet their needs. Previous work ([BIRRR, 2016, 2017a, 2018](#); [Zhang, 2017](#)) has contributed to the understanding of how farmers are actually using the internet. Many of these studies do not fully consider the varying nature of farming caused by factors such as the different types of farmers, the location of these farmers and the different production methods that are inherent in farming. In addition, there is a paucity of research into the effects that the adequacy, pricing and availability of an internet connection has on usage, and in particular, for farmers ([Salemink et al., 2017](#)).

As [Lamb \(2017\)](#) points out, a lack of knowledge of how farmers use the internet can have very real implications. [Lamb \(2017\)](#) goes on to add that *“the breakdown of how farmers use the internet is not known and is often assumed to be the same as an average household”* (pg. 62). A 2017 study by BIRRR ([BIRRR, 2017b](#)) determined that 60% of respondents felt that the current data limits [in 2017] did not meet their needs. Residents of regional Australia are also *“paying a higher proportion of their income on telecommunications than their urban counterparts due to reduced consumer choice in technologies and plan”* ([Hartsuyker et al., 2021, p. 10](#)).

There has been some effort to describe how farmers use the internet such as [Hay \(2018\)](#); [Iowa State University \(2011\)](#) and [Lamb \(2017\)](#). Many of these attempts rely on the direct participation of the farmers themselves and are therefore limited by their levels of digital and connectivity literacy in their responses. This is supported by [van Dijk \(2005\)](#) who argues that the precise daily usage time of computers and the internet is a more valid indicator of usage rather than a declaration by a respondent that they do so at some time or place.

In addition, simply having access to an internet connection is not enough to fully describe how a farmer uses the internet with social, economic and other factors also playing a key role ([Roberts & Hernandez, 2019](#)). [Roberts and Hernandez \(2019\)](#) go on to describe that by simply categorising an internet user as “connected or unconnected” can be highly problematic. Supporting this argument, [Harris et al. \(2017\)](#) add that simply having access to a computer and the internet does not guarantee that it will be used equally.

Other work that has studied internet traffic behavioural patterns and usage directly, have commonly done so through the use of traffic analysis from large datasets such as for a “whole region” or “country” or “city” with examples including [Finamore et al. \(2011\)](#) and [Trevisan et al. \(2020\)](#). [Trevisan et al. \(2020\)](#) provides a comprehensive insight into the form of analytics currently employed. Ultimately, such studies typically collect large sweeping datasets with a wide geographic or demographic spread with [Trevisan et al. \(2020\)](#) focussed on a single nationwide ISP with a multiple connectivity mediums, precluding an assessment of vocation-specific trends. Whilst it is difficult to identify and study any particular demographics, they are nonetheless useful to understand large societal trends and the effect of external influences such as, for example COVID-19 (as demonstrated by [Zachreson et al. \(2021\)](#) and [NBN Co \(2021b\)](#)).

The concept of adequacy is complex. As previously discussed in Section 1.2, different farming businesses require different levels of connectivity and what may be considered adequate and fit for purpose for one may not be for another. In addition, an internet connection that may be considered adequate at one point in time may no longer be so as the business grows and changes. [Marshall and Dale \(2019a\)](#) also show that monthly limitations on the volume of data available to the farmers results in a change of behaviour by the farmer and prevents them from using their internet connection from the way that they would like to.

Compounding this, infrastructure that may be able to meet the requirements of farmers at one point in time cannot service the ever increasing requirements for data ([Hartsuyker et al., 2021](#)). This leads to network congestion and poor experiences for the users of the service. As a result, availability is a necessary but not sufficient condition when determining the adequacy of an internet connection and it is naive to assume that simply having access to the internet means that it is fit for purpose and meets its user’s needs.

Furthermore, the level of internet connectivity that is required to run a successful farming enterprise depends heavily on what type of farming is being performed. [Zhang \(2017\)](#) in their report “*Accelerating precision agriculture to decision agriculture: The needs and drivers for the present and future of digital agriculture in Australia*” provides examples of the importance that internet connectivity plays in a farmer’s business. What is clear is that farmers need access to the internet to run their businesses. However, the individual needs of farmers change

depending on their industry, location, and business goals. It is also poorly understood how the adequacy, pricing and availability of an internet connection affects a farmer's use of the internet and that without understanding the internet connectivity needs for farmers now and into the future, it is difficult to ensure that they have access to adequate connectivity.

In addition, the majority of previous research on how farmers use the internet is several years old and connectivity options and technology requirements have changed significantly in this period. One example is the transition from Sky Muster™ to Sky Muster Plus™ - a predominantly unmetered NBN™ satellite service available in Australia that was rolled out during the COVID-19 pandemic to accommodate the transition to working from home. Issues with the new service include connecting and administrative processes of the roll out, which is to be expected, but also highlights issues with latency while using virtual private networks. This reverts to whether slow uptake of the improved service is related to digital literacy or other factors. Low digital literacy means that increasing the adoption of this improved service may be challenging. The needs of farmers have also significantly changed.

### **4.3 Methodology**

This study analyses of two unique empirical internet traffic datasets from the NISP for a group of farmers located in North-west Queensland, Australia. These datasets contain daily internet download and upload totals, and the hourly data that categorises an individual participant's internet traffic. More information regarding the NISP, the relationship to the PI and how the data was extracted and anonymised is provided in Section 2.6.1. Alternate data collection instruments such as directly sampling internet traffic are attractive as they make it possible to avoid any direct contact with participants along with any associated biases to collect quantitative data. The datasets were analysed using the tools and methods discussed in Section 2.8.1 and more information about the datasets is available in Section 2.6.1.

### **4.4 Results and Discussion**

#### **4.4.1 Data Traffic Trends**

Figure 4.1 (below) presents the average daily download and upload volumes (113,958 total daily usage records) of `Dataset 1` for the period 1 January 2018 to 31 December 2021. A clear upwards trend is visible for both the average daily download and upload traffic volumes

Average daily upload and download totals for the period of study (2018 - 2021)

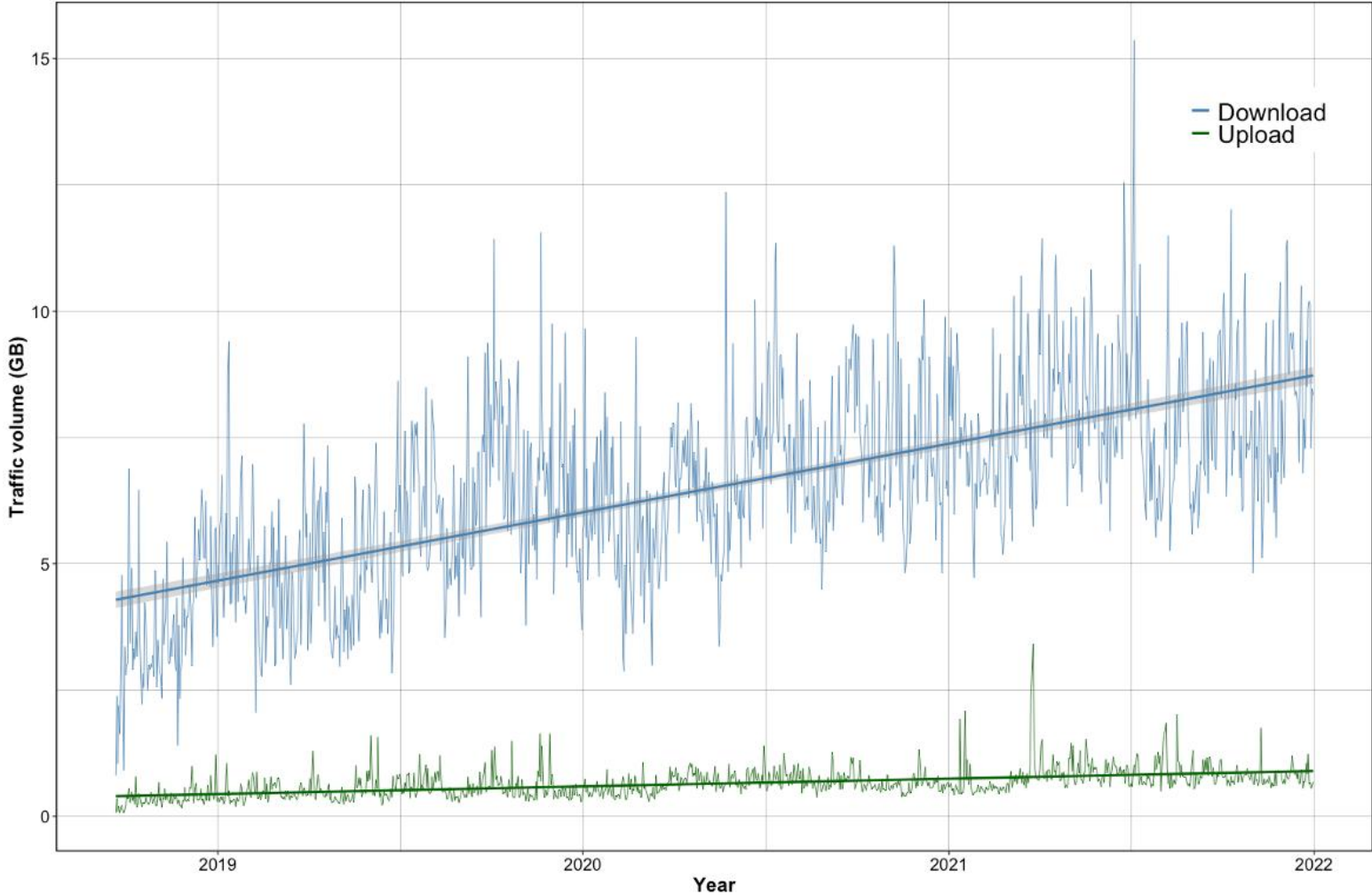


Figure 4.1 - Average daily data usage (GB) of farmers the study period of 2018 to 2021

Table 4.1 (below) summarises the yearly-average, per user, daily upload and download totals. Despite the offer of synchronous speeds (where the maximum upload and download speeds are the same), the download traffic volumes are more than ten times higher than upload volumes. This is not unexpected as most internet users typically consume much more content than they create ([Jiang et al., 2010](#)). Examples of content consumption include the use of streaming video services such as Netflix or Amazon Prime and social media platforms including Facebook, Twitter and Instagram. The dataset also shows a continual year-on-year increase in both download and upload traffic volumes with the average daily download traffic volume almost doubling from 3.92GB per day in 2018 to 7.92GB in 2021. The average daily upload traffic volume has followed the same pattern increasing from 0.37GB per day in 2018 to 0.82GB in 2021. Overall, this shows that both the consumption and generation of internet traffic by participants is continuing to increase year-on-year.

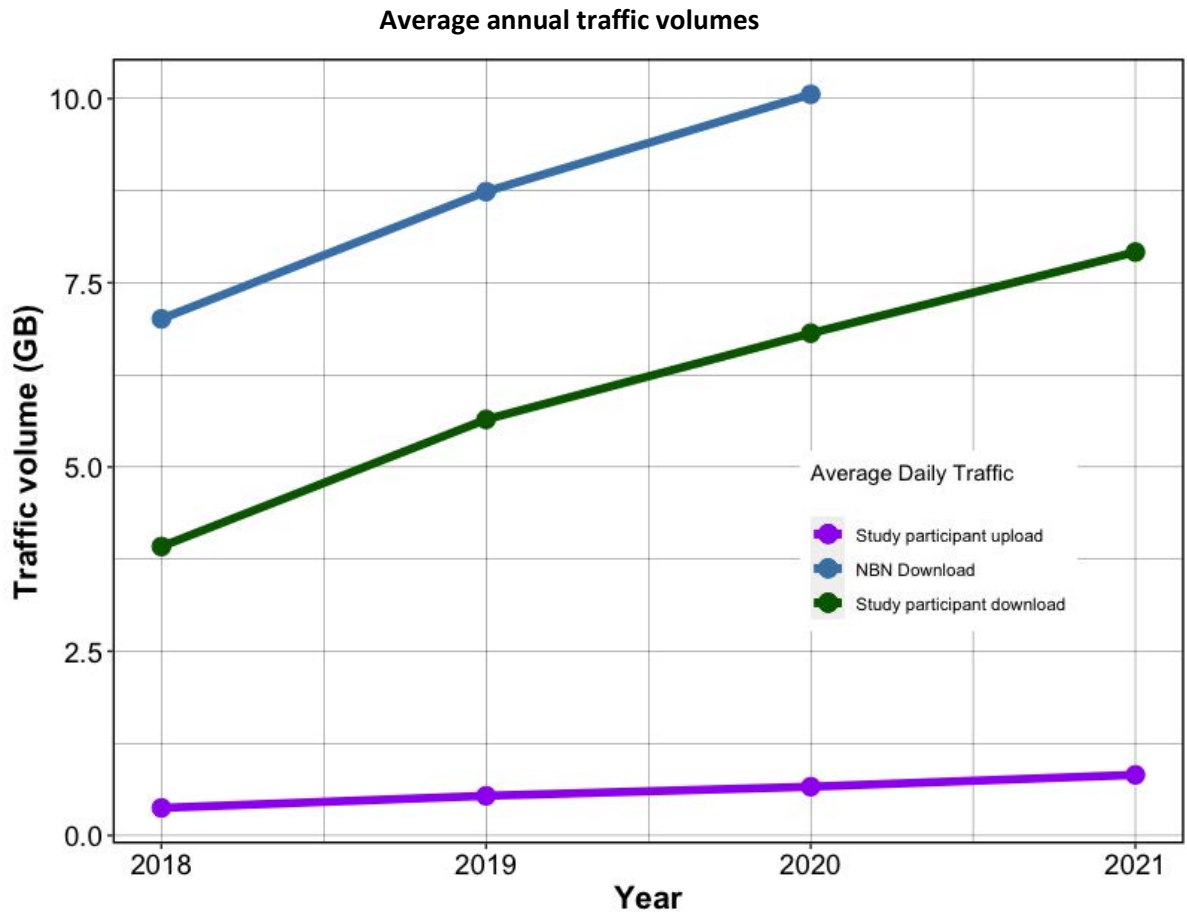
**Table 4.1 - Average daily data use of study participants**

Year	n	Download		Upload	
		Average daily (GB)	Year on year increase (%)	Average daily (GB)	Year on year increase (%)
2018	32	3.92	-	0.37	-
2019	41	5.655	44%	0.54	44%
2020	50	6.82	21%	0.66	23%
2021	68	7.92	16%	0.82	24%

Provided there are no technical or artificial constraints that are implemented by ISPs, it is expected that this growth in data usage will continue into the foreseeable future, following the broader trend of Australian internet users ([Australian Government, 2020a](#)). Any constraints that limit or restrict the internet connectivity of farmers will likely force their internet usage behaviour to change and further research is needed to understand what effect these constraints may have on a farmer's internet usage pattern.

Figure 4.2 (below) graphs the annual average data consumption for the same period of this study for the farmers in the study region and the broader Australian population by comparing a publicly accessible dataset compiled from the [Australian Communications and Media Authority \(2021, p. 10\)](#); [NBN Co \(2019\)](#) and ([NBN Co, 2021c](#)). This dataset represents the

approximately 69% of Australian households that are NBN™ users ([ACCC, 2021](#); [NBN Co, 2021a](#)). The daily upload totals for the broader Australian population of NBN™ users and the NBN™ users download volume for 2021 are not presented as they have not been made publicly by NBN Co at the time of publication.



**Figure 4.2 - Comparison of the average daily data consumption (GB) for the period of 2018 to 2020 for the study participants and NBN™ Users**

An analysis shows that NBN™ users are consuming much more data than the farmers with unconstrained internet connectivity. According to data provided by NBN Co, regional users are consuming approximately 9% less data than their urban counterparts ([NBN Co, 2019](#)). Interestingly, for the period of this study, the average difference in the gap between the participating farmers in this study and the general population is 37.25%, significantly more than 9%.

The farmers themselves are observed to be increasing their consumption of data through the period of study. This increases from 3.92GB/day in 2018 to 7.92GB/day in 2021 (see Table 4.2).

A similar pattern is observed with the upload traffic by the farmers in this study. However, it is not possible to compare the upload traffic with NBN users as NBN Co has not made this data publicly available.

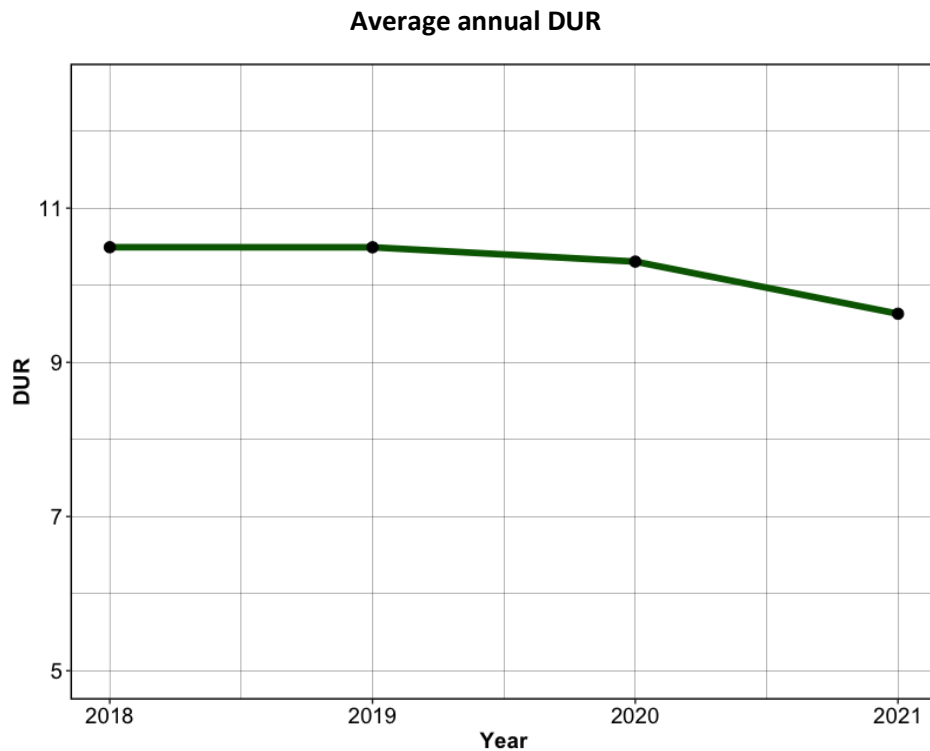
**Table 4.2 - Difference in daily download traffic volumes for farmers compared to the general population**

<b>Year</b>	<b>Participants (GB)</b>	<b>General Population (GB)</b>	<b>Difference (GB)</b>	<b>Difference (%)</b>
2018	3.9	7.0	3.1	44.1%
2019	5.6	8.7	3.1	35.4%
2020	6.8	10.1	3.3	32.3%
2021	7.9	N/A	N/A	N/A

The data also shows that participants are increasing their data consumption at a faster rate than the average Australian NBN™ user. There are many possible reasons for this including how regional and remote areas are defined by NBN Co and various levels of access, digital literacy, availability, and other social economic factors in these groups. As the methodology and datasets have not been made publicly available by NBN Co, it is not possible to examine this in more detail.

#### **4.4.1.1 Download Upload Ratio (DUR)**

The DUR (see Equation 1, Section 2.6.1.3) for the participating farmers calculated for the period of 2018 to 2021 is presented in Figure 4.3 (below). For the first two years of this study (2018 and 2019), there is no significant trend in the DUR. However, from 2019 onwards the participants’ daily upload traffic volumes are increasing at a faster rate than their daily download volumes; in other words, the participants started generating more data relative to their consumption of data. This provides an insight into how the participants’ use of the internet was changing. Due to a lack of publicly accessible data, it was not possible to compare the calculated DUR with an average Australian NBN™ user.



**Figure 4.3 - Download Upload Ratio (DUR) for study participants between 2018 and 2021**

As previously discussed, there are many ways that the participants could be uploading (generating) content via the internet. These may include to access telehealth and the increased adoption of video conferencing systems such as Zoom, Microsoft Teams and Facetime. The COVID-19 pandemic and resulting travel restrictions that forced people and businesses to find other ways to communicate via online means ([Feldmann et al., 2021](#); [Thomas, 2021](#)) may have also contributed to this trend.

#### **4.4.1.2 Daily behaviour**

An analysis of the daily DUR for the period of the study is presented below in Figure 4.4 along with the average daily upload and download traffic totals. There evidence of an annual cyclic pattern in the DUR and is another phenomenon that, to the PI's knowledge has not been reported elsewhere. Given the geographic location of participants and attendant seasons they experience in their location (November – February being hot and wet), this is suggestive of a preference of participants to focus on in-house/in-office activities, as well as possible increased family participation in those online activities (e.g. during the major summer school holidays). At this stage however, it is difficult to offer anything more than speculation to what is an otherwise clear cyclic behaviour. Therefore, further research into specific activities would add to the validity of these findings.

A graph of monthly average weekday DUR (including Monday-Friday) and weekend DUR (Saturday and Sunday) is given in Figure 4.5 (below). Firstly, the weekday DUR values are typically lower than the weekends. This may be attributable to the extra upload traffic generated of online activities such as video conferencing, not only for the farming business, but also for online learning (e.g. home schooling). Like most households, farmers often share their internet connection with everyone in the house. On weekends, this increase may indicate an increase in the use of services such as video streaming, gaming, online shopping, and other activities that they are too busy to do during the week although further investigation is required.

The annual cyclic behaviour of both weekday and weekend is also observed, along with the apparent widening of the gap between the weekday and weekend DUR values over time. This latter trend is consistent with an increase in video streaming activities on weekends, encouraged through the ever-growing number of (in some cases free) streaming services.

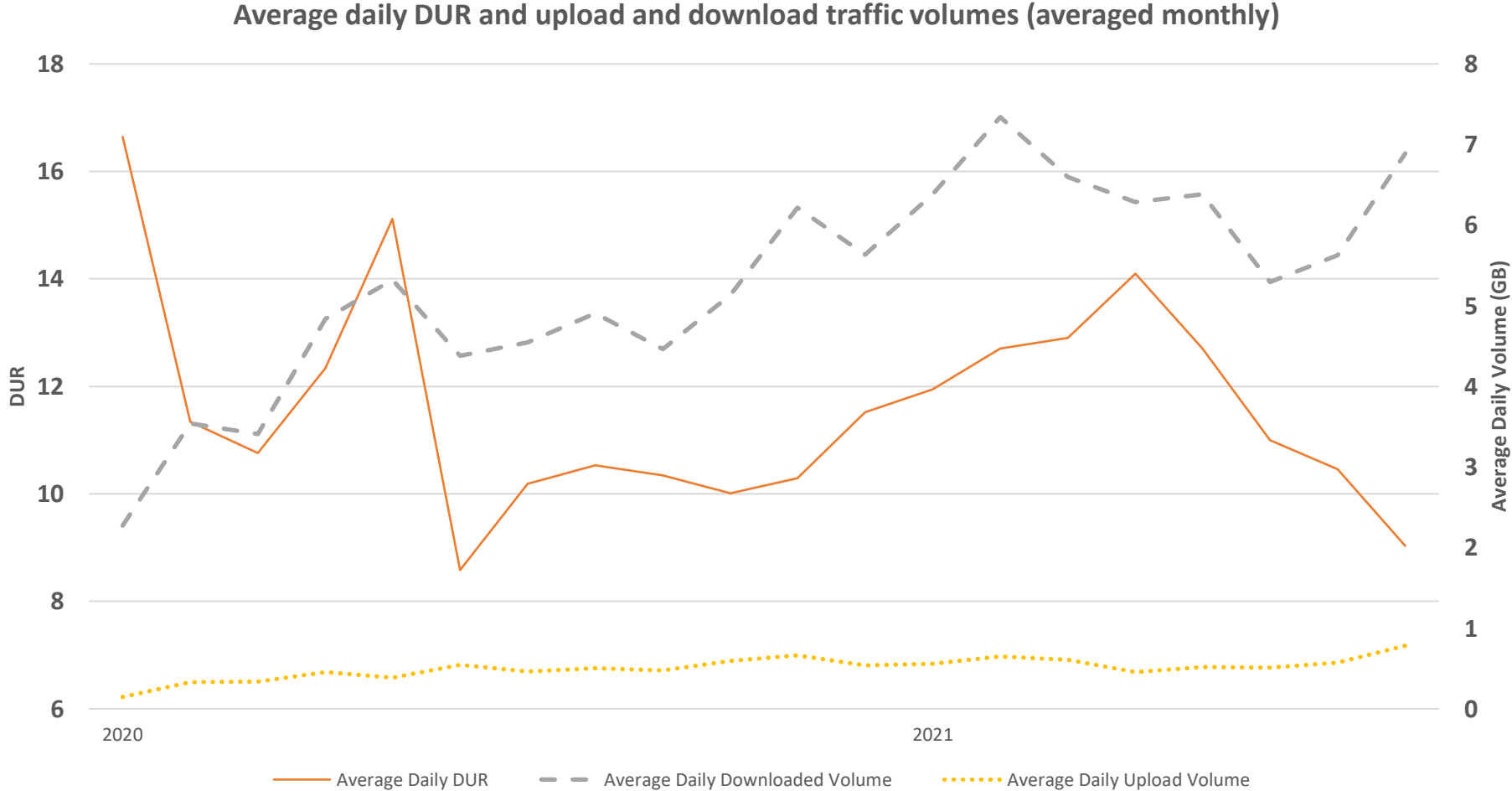


Figure 4.4 - Average daily DUR and upload and download traffic volumes (averaged monthly)

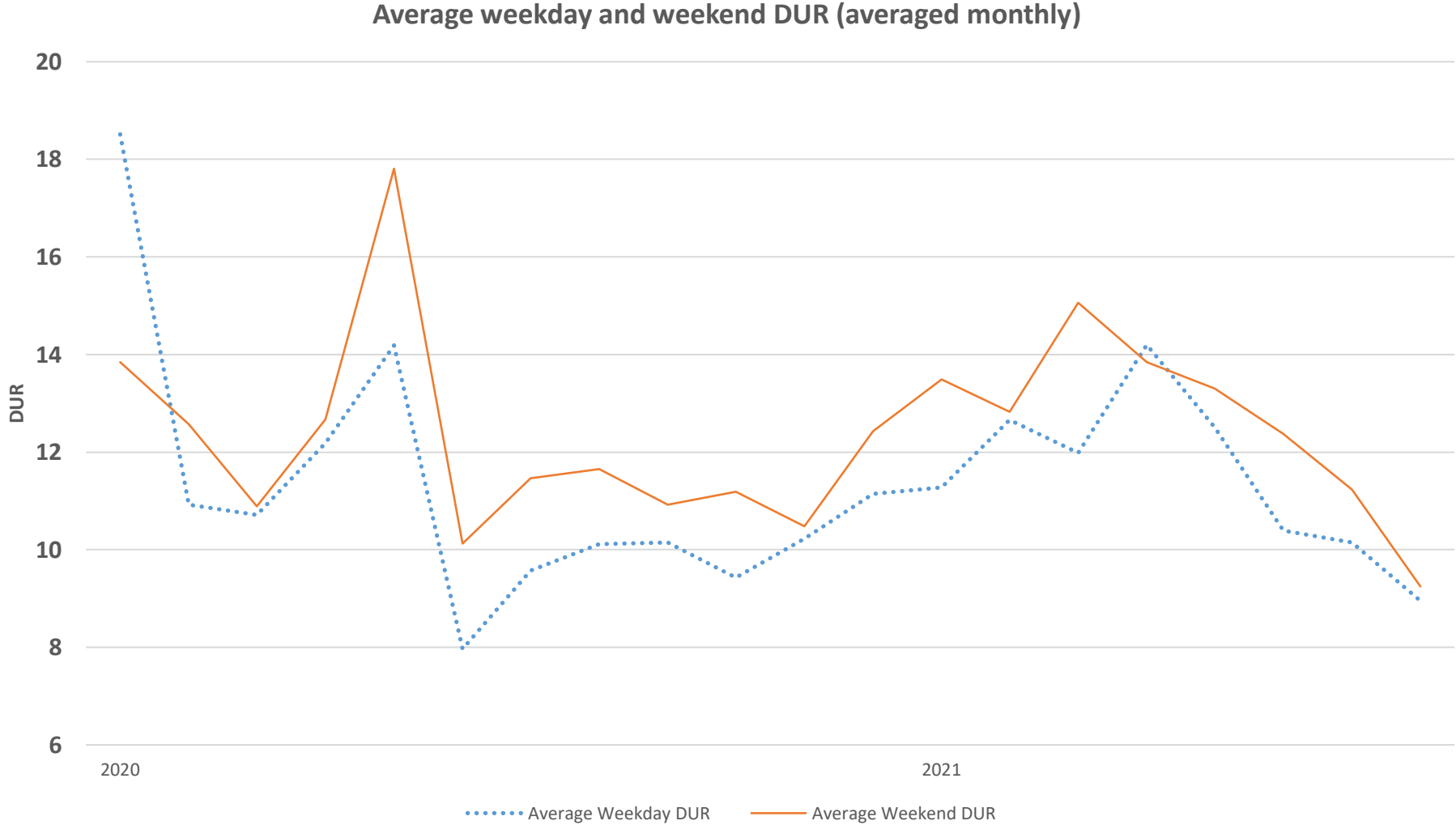


Figure 4.5 - Average monthly DUR values for weekdays (Monday to Friday) and weekends (Saturday and Sunday) averaged monthly

#### 4.4.1.3 Distribution of data usage amongst participants

To gain further insights into the distribution of the average daily download and upload usage for each participant for each year of study, a kernel density plot ([Khosrow, 1987](#); [Silverman, 1986](#)) of the average daily download volume and upload volume is presented in Figure 4.6 and 4.7. (below), respectively. Similar to a histogram, a kernel density plot visualises the probability distribution of a dataset. In the case of Figures 4.6 and 4.7, each graph shows the probability (Y Axis) of the respondent's average daily download and upload totals falling within a certain volume range (X axis). In the case of a normally distributed dataset, this a kernel density plot would appear as a standard bell curve. Both the download and upload distributions in Figures 4.6 and 4.7 respectively show a positive skew for each year and the curves are progressively becoming flatter (increasing variance) in successive years demonstrating changes over time. The variance of the distributions is summarised in Table 4.3 below.

**Table 4.3 - Variance of average daily download and upload volumes for participants**

Year	Annual download variance $\sigma^2$ (GB <sup>2</sup> )	Annual increase in variance (Download)	Annual upload variance $\sigma^2$ (GB <sup>2</sup> )	Annual increase in variance (Upload)
2018	40.67	-	0.81	-
2019	71.28	175%	1.80	222%
2020	77.90	109%	1.78	99%
2021	107.25	138%	5.94	334%

One possible explanation for the progressive increase in variance of the data volumes (both upload and download) over time is, as users gain more experience, the depth and breadth of online usage increases. There is a significant flattening of the distribution and an increase in the variance for both average daily download and upload data volumes over the study period of 2018 to 2021. As download and upload traffic volumes are only ever positive, this means that there are an increasing number of participants consuming and creating more data over the study period. This is especially clear in 2019 and 2021 with a significant jump in both the download and upload variance observed. There could be many reasons for this including greater adoption of services such as video conferences and video streaming, resulting from external factors such as COVID-19.

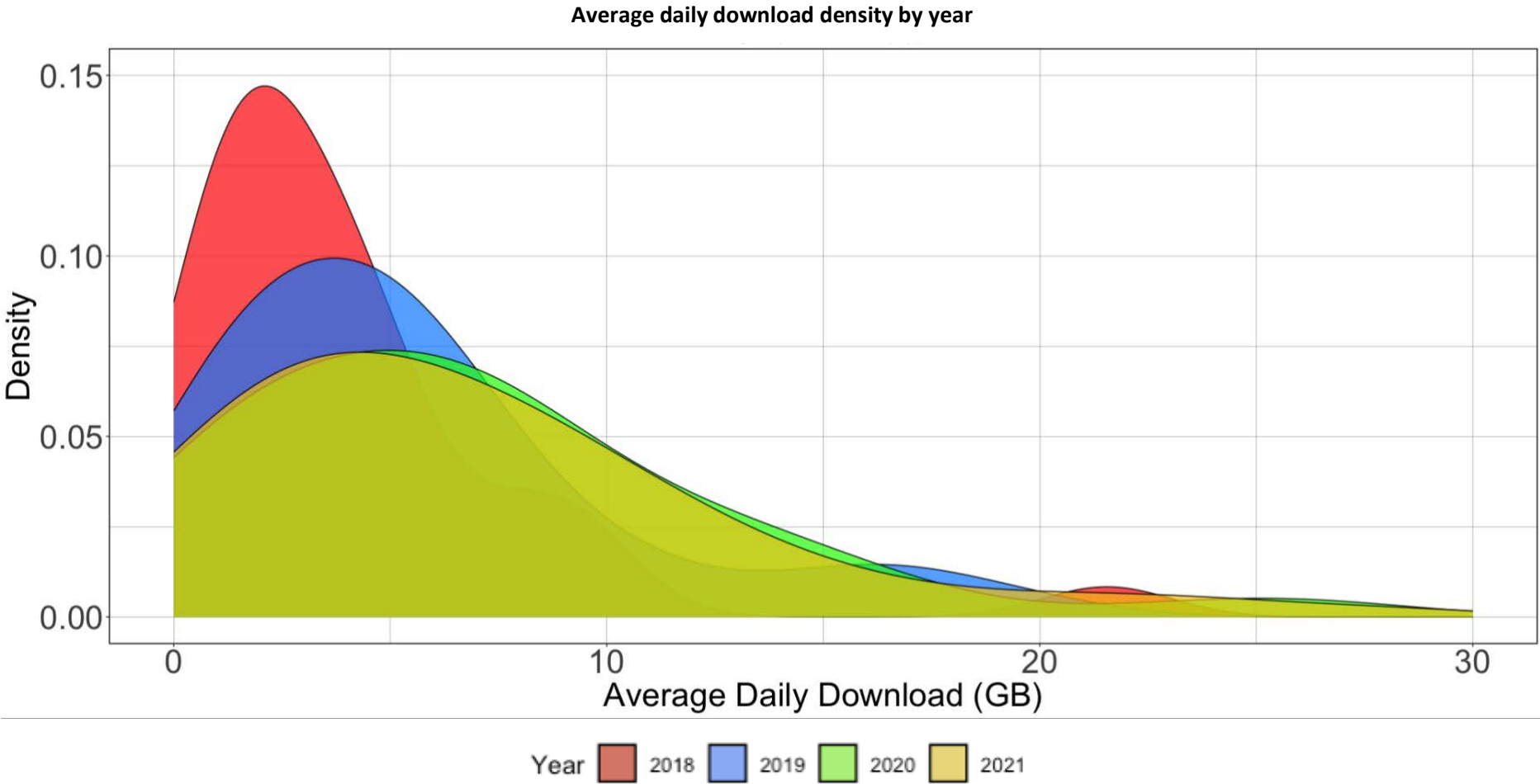


Figure 4.6 - Kernel Density Distribution plot for the average daily upload volume for participants for each year

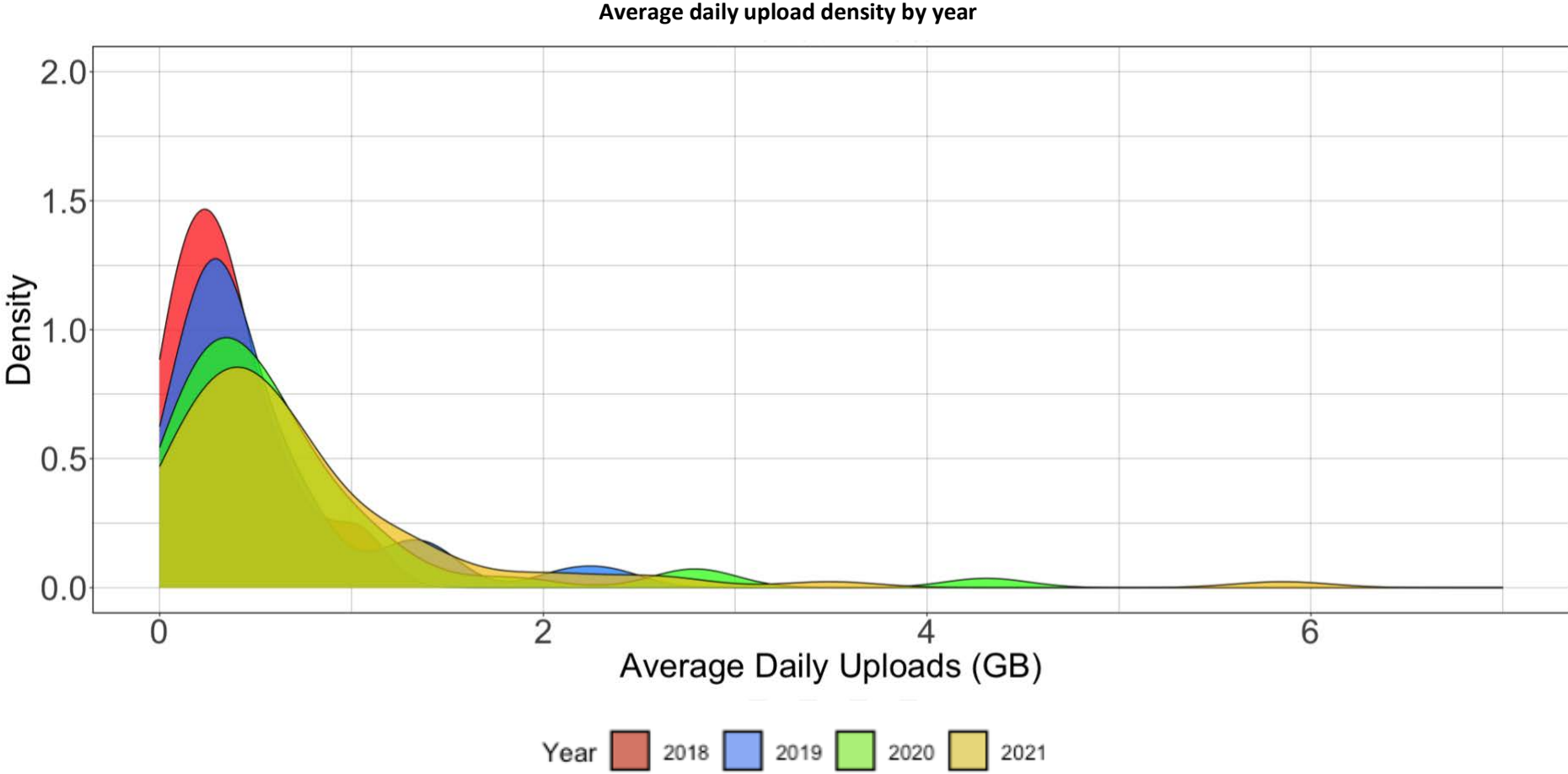


Figure 4.7 - Kernel Density Distribution plot for the average daily upload volume for participants for each year

#### **4.4.1.4 Dataset 1 – Summary**

The publicly assessable data provided by the NBN™ as previously presented in Figure 4.2 shows that the average Australian NBN™ user consumes almost twice as much data on average than the participating farmers in this study. Due to a lack of publicly accessible data on the upload volumes of NBN™ users, it is not possible to compare the upload behaviour of the study participants with NBN™ users. Interestingly however, the gap in monthly download volume between the two groups is narrowing with the difference in data consumption dropping from 44.1% in 2018 to 32.2% in 2020 (as previously shown in Table 4.2).

It is clear that how participants are using the internet is changing in both the short and long term with Figure 4.4 clearly showing a long-term increase in upload traffic relative to download traffic. In the short term, there are also clear cyclic trends that show a seasonal variance in the DUR.

Whilst this study cannot provide a direct measure of individual participant's levels of digital literacy, taken in combination, 'Dataset 1' indicates the farmer participants are both consuming and generating more data each year. There are various factors that may be contributing to this effect including, as discussed, increased digital literacy as the participants become more comfortable with using their internet connection and other external influences such as a move to more online systems for regulatory compliance and, of course, the COVID-19 pandemic. However, more research is needed to fully understand the reasons for this change and how it compares to the average Australian NBN™ user, which is beyond the scope of this study.

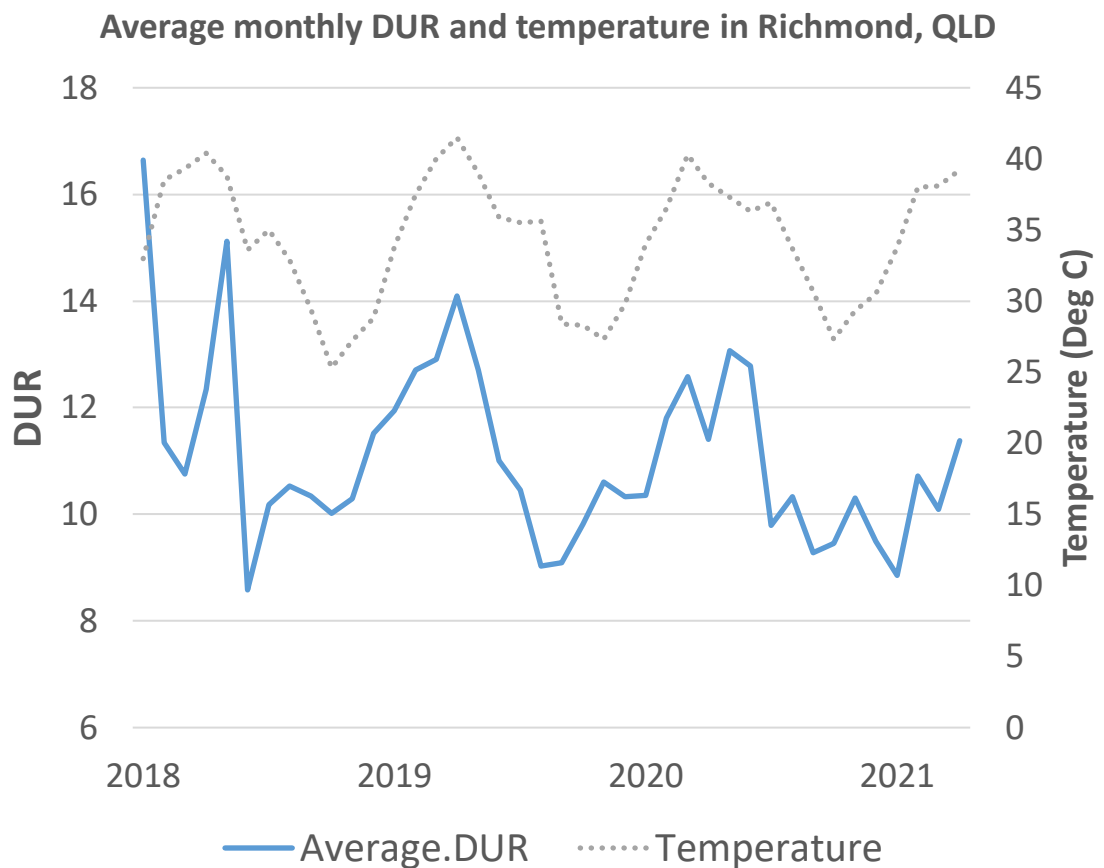
#### **4.4.2 Environmental Factors**

The environmental factors temperature and rainfall were examined to determine if they have any relationship with how farmers are using the internet. The average monthly DUR of this unique dataset was correlated with the average monthly temperature and the average monthly rainfall for the town of Richmond, Queensland. Richmond was selected as it is located in the centre of the area that the NISP services (See section 1.2.2.2 for more details).

Environmental data was sourced from the Australian Bureau of Meteorology ([Bureau of Meteorology, 2024a, 2024b](#))

#### 4.4.2.1 Temperature

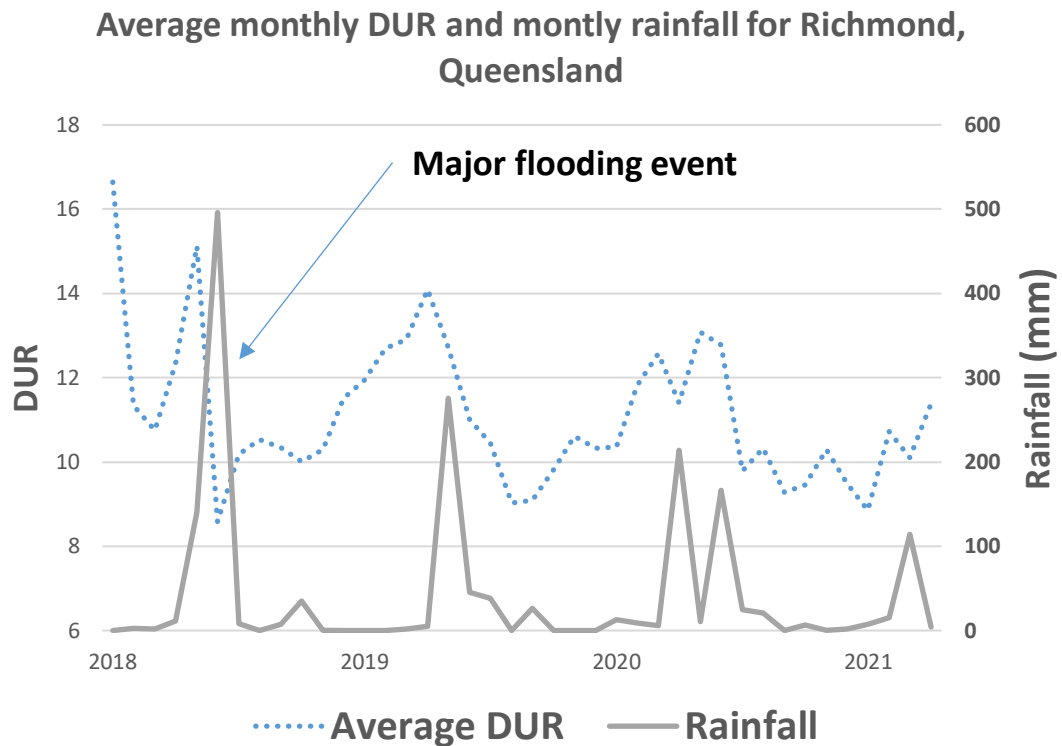
An analysis of the average daily DUR and the temperature of Richmond is visualised in Figure 4.8 (below). A clear correlation between temperature and DUR was observed. Pearson's correlation was used to determine if there is a linear relationship between the two variables. This relationship was found to be strongly correlated,  $r(38) = .489$ ,  $p = .001$ . The relationship between temperature and how an internet connection is used has never been reported before. While further investigation is required, some possible causes for this novel relationship could include an increase in the use of streaming services during the hotter parts of the year or an increase in the uploading of information during prolonged periods of physical isolation due to the wet season.



**Figure 4.8 - Average monthly DUR and temperature in Richmond, QLD**

#### 4.4.2.2 Rainfall

The DUR and the average monthly rainfall for Richmond, Queensland was also considered as an environmental factor. This relationship is visualised in Figure 4.9 (below). Pearson's correlation was used to determine that there is no statistically significant correlation between the two variables.



**Figure 4.9 - Average monthly DUR and monthly rainfall for Richmond, Queensland**

There are several features of interest in Figure 4.9, including a possible pattern of decreased DUR after rainfall events. This is particularly noticeable after the major flooding that occurred in the region in 2019 in which approximately 500,000 head of livestock perished ([Queensland Government, 2019](#)). During this flood event, many farmers were isolate for long periods of time. The change in DUR may be caused by many farmers spending more time in the office and farmers sending photos of flooding events or otherwise dealing with the floods although more work is needed to examine this relationship.

The discovery of lower of DUR corresponding to rainfall events has implications for the design and provisioning of internet services (particularly those delivered via satellite). Periods of intense rainfall can cause satellite based communications to not work as well as they normally do or even stop working completely in heavy downpours ([Lacoste et al., 2024](#)). If this occurs at

the same time that farmers are wishing to work in the office, it may lead to farmers being unable to use the internet as they need to. Restrictions on the ability of farmers to use the internet to communicate via social media and by other means that require the internet, while they are isolated may also lead to negative health outcomes although further research is needed.

#### **4.4.3 What applications farmers are using**

`Dataset 2` returned 5,377,376 records. Due to the size of dataset 2, a subset of the data, the comparative months of December 2020 and December 2021, were selected for analysis as a representative group. In addition, these months were selected firstly, to enable a longitudinal analysis of the dataset and secondly because the farming family is typically assembled at home during December and there are several weeks where business is still being conducted before the Christmas school holiday period begins. This results in a richer subset that contains both business and personal application data. To simplify this preliminary analysis, other factors such as the weather, age and gender of the individuals using the internet will not be considered. This analysis also does not consider any potential biases in usage behaviour such as time of year. Further information on `Dataset 2` is presented in Section 2.6.1.2.

##### **4.4.3.1 Composition of farmers internet traffic**

The average composition of participant traffic for the months of December 2020 and December 2021 that was collected by the NISP are presented in Figure 4.10 and 4.11 below and clearly show a difference in the composition of the participant's upload and download of internet traffic. It is assumed that the participants internet traffic includes any internet traffic that are both related to farming and other household activities such as streaming video.

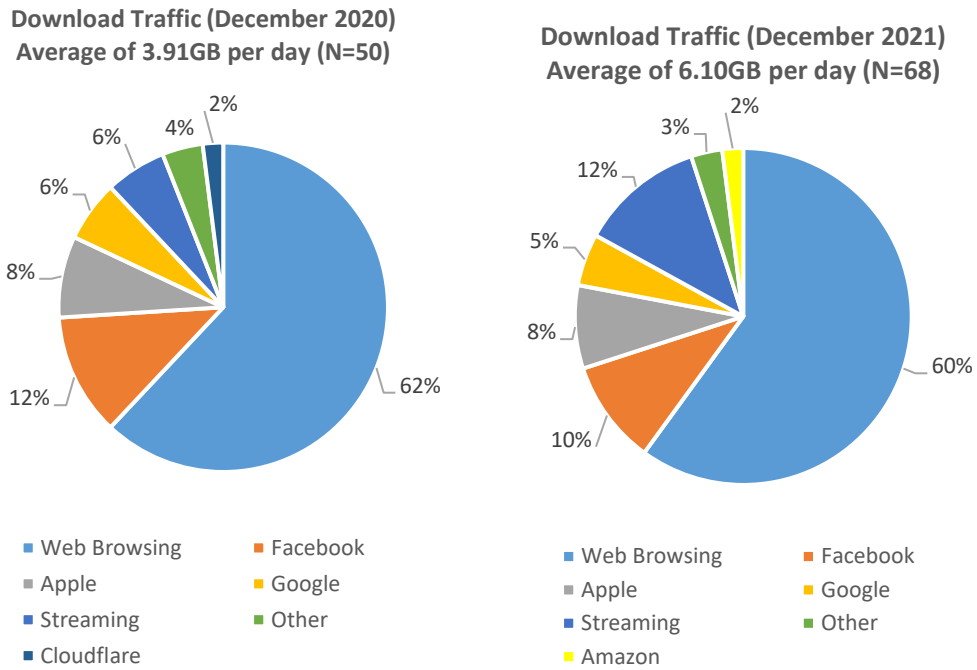


Figure 4.10 - Download traffic breakdown for December 2020 and December 2021

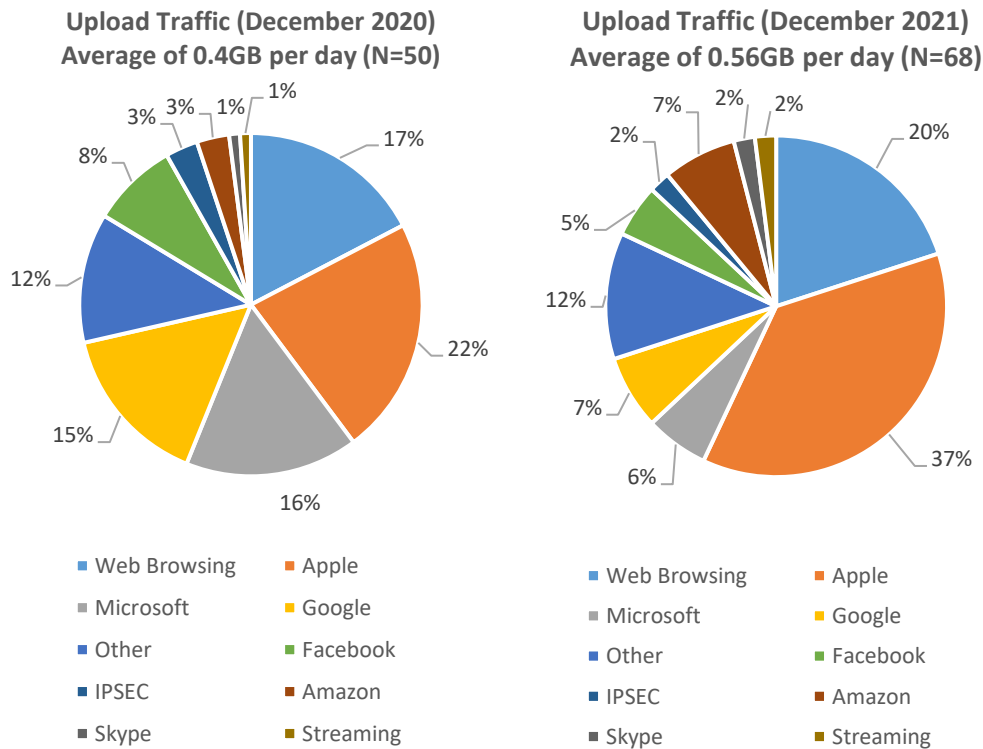


Figure 4.11 - Upload traffic breakdown for December 2020 and December 2021

An analysis of the breakdown of the farmers download traffic is as shown in Figure 4.10, Web Browsing which consisting of 62% of total download traffic in 2020 and 60% in 2021. Web browsing also is a major component of the participants upload traffic, representing 17% of upload traffic in 2020 and 20% in 2021. The HTTP, TLS and QUIC protocols that make up “Web Browsing” are used by almost all websites on the internet to transmit data to and from the user to a remote server, with examples ranging from a participant using a web browser, accessing a website, an app on a smartphone or communicating to a remote server. Over the study periods in 2020 and 2021, there has been very little change in the proportion of the participants traffic being categorised as “Web Traffic” (62% in 2020 and 60% in 2021). Due to the ubiquitous nature of the protocols that make up the Web Browsing category and the sheer number of different services available on the internet, some services may be incorrectly categorised as “Web Browsing”.

#### **4.4.3.2 Social Media**

The single largest individual service that was identified in the participants download traffic was Facebook, representing 12% of the participants download traffic in December 2020, decreasing slightly to 10% in December 2021. Facebook is commonly used by farmers to communicate with each other and to disseminate new ideas. This preliminary analysis clearly shows that social media is being heavily used by participating farmers and that Facebook is a major and important component of their internet usage, although it is unclear in this analysis if the traffic is being used for personal or farming activities. The use of social media is further examined in Chapter 6.

It is also clear that at least some participants are actively uploading data to Facebook with their uploaded data contributing an average of 5-8% of the participants upload traffic. Interestingly, this preliminary analysis also shows that Facebook usage decreased as a proportion of the participants total internet traffic over the 12 months period between December 2020 and December 2021 but the actual download traffic volume from Facebook increased from 468.2MB/day to 610MB/day. The daily upload traffic volume to Facebook remained almost constant, possibly indicating that there was no increase in the rate of posting or uploading images and videos. Further analysis is needed to understand if this represents an ongoing trend and also to investigate what the participants are using Facebook for on a day-to-day basis and what other opportunities this may present for agricultural extension. This is explored further in Chapter Six.

#### 4.4.3.3 Other Traffic

Apple and Google are also significant contributors to the participants internet traffic, together making up 14% of the participants download traffic in December 2020 and 13% in December 2021. This is not unexpected as both companies offer a variety of services including app stores, video messaging and music and video streaming. Google also offers its ubiquitous search engine. These services are accessible with either a smartphone, tablet or computer and combined. Both companies also provide the operating systems that powers over 99% of all smartphones sales globally ([International Data Corporation, 2021](#)).

Interestingly, when comparing the upload traffic for these services, there has been an increase in traffic to Apples servers, rising from 22% (88MB) in December 2020 per month to 37% (207MB) in December 2021. This is a significant increase that appears to be at the expense of Google and Microsoft. Whilst there may be several reasons for this behaviour, one possible explanation is an increase in the market share of the Apple iPhone ([Statcounter GlobalStats, 2022](#)) from 50.84% in 2020 to 52.82 in 2021, or it could be related to a software or configuration change from Apple that causes their devices to upload more data to Apple's servers.

There is also a large increase in adoption of the streaming service Netflix and other services that use the media streaming protocol RTMP with traffic that is identified as streaming increasing from an average of 235MB/day (6% of total traffic) in December 2020 to 732MB/day (12%) in December 2021. Unfortunately, as ntopng requires rules to be created to be able to categorise traffic, additional video streaming services such as the local Australian video streaming service "Stan" (<http://www.stan.com.au>) do not have matching rules and were not identified. As these services can use the industry standard HTTP, TLS and QUIC protocols to deliver their content, some streaming video services may have been categorised as "Web Browsing" rather than "Streaming" and as a result may make up a larger percentage of the participants internet usage.

#### 4.5 Chapter Summary

This study analysed two unique empirical datasets to provide insight into the role that the internet plays in the day to day lives of a group of farmers located in Northwest Queensland. By analysing these two unique datasets provided opportunities to gain insight into the how farmers use the internet, how this usage changed over time and the effects of environmental factors on this usage. This study helps to fill the gap in knowledge about the relationship between the internet and farmers and re-affirms existing beliefs around the importance of the internet to modern society and the continual increase in internet traffic globally.

The empirical nature of the two datasets avoided any subjective responses and associated biases of participants that are common with traditional data collection instruments. Data was collected from a group of farmers from Northwest Queensland for the period of the 1<sup>st</sup> of January 2018 to the 31<sup>st</sup> of December 2021 and in 2021 represented approximately 19% of the farmers in the region (N=364). An analysis of both datasets showed a clear upward trend in internet traffic consumption and generation over the study period. When compared with average Australian NBN™ user, the datasets show that the participants consumed and generated significantly less internet traffic, despite not being subject to any artificial constraints such as data limits.

Temperature was also found to be strongly correlated with the DUR of the farmers in this study. This relationship has not been previously identified and is novel. Whilst the reasons for this relationship are unknown and further research is needed, it is clear that the analysis of internet traffic can provide insight into the day to days lives and businesses of farmers that is not otherwise possible.

Several other patterns were also identified, including a significant difference in the DUR (Download Upload Ratio) between weekends and weekdays, indicating that farmers may be using services such as streaming media that consume more data on weekends. Novel annual cyclical patterns were also observed with additional work needed to fully understand this behaviour. In addition, this study shows that more farmers are using the internet more, which may reflect a broader trend towards technology adoption. The effect of external influences including COVID-19 were also clearly observed through an increase in data at the peak of the pandemic.

## CHAPTER 4 – Study 1 – Understanding how farmers use the internet

Significantly, it was identified that Facebook is a major component of farmers internet traffic, representing the largest individually identifiable largest category that made up farmers daily internet usage in 2020 at 12% and 10% in 2021. Other services such as those provided by Apple, Google and Microsoft also make up a large proportion of the farmers internet traffic with further work needed to understand why and how the farmers are using these services.

Overall, this study clearly demonstrates that the internet is playing an increasingly critical role in the personal and business lives of farmers in North West Queensland, Australia. Whilst these results cannot be generalised across the whole population, they provide a unique insight into how a group of farmers with access to unconstrained connectivity are using the internet and can guide further research projects and demonstrates the importance of access to unconstrained internet connectivity. Unfortunately, without providers such as NBN Co making their data more publicly available it is not possible to extend these results to other groups.

**Study 2 - Understanding the internet connectivity requirements of farmers**

How do farmers use the internet: A mixed methods approach						
Chapter 1 How do farmers use the internet?	Chapter 2 Methodology	Chapter 3 Demographic analysis	Chapter 4 Understanding how farmers use the internet	Chapter 5 Understanding the internet connectivity requirements of farmers	Chapter 6 How do farmers use social media	Chapter 7 Discussion and conclusion
1.1 Introduction	2.1 Introduction	3.1 Introduction	4.1 Introduction	5.1 Introduction	6.1 Introduction	7.1 Introduction
1.2 Background and research rationale	2.2 Philosophical perspective	3.2 Survey Dataset	4.2 Literature Review	5.2 Literature Review	6.2 Literature Review	7.2 Discussion of findings
1.3 Theoretical Framework	2.3 Methodological foundation	3.3 Data cleaning	4.3 Methodology	5.3 Methodology	6.3 Methodology	7.3 Response to rationale
1.4 Research Objective	2.4 Research Ethics	3.4 Respondent demographics	4.4 Results and Discussion	5.4 Results and Discussion	6.4 Results and Discussion	7.4 Contribution of the thesis
1.5 Thesis Outline	2.5 Study population	3.5 Chapter Summary	4.5 Chapter Summary	5.5 Chapter Summary	6.5 Chapter Summary	7.5 Future research potential
1.6 Chapter Summary	2.6 Data collection instruments					7.6 Limitations
	2.7 Research data storage					7.7 Conclusion
	2.8 Data analysis techniques					7.8 Recommendations
	2.9 Literature review methodology					
	2.10 Risk management					
	2.11 Chapter Summary					

**5.1 Introduction**

In response to RQ2 (How do farmers connect to the internet?) and RQ3 (How do farmers stay connected to the internet?) this study seeks to understand how farmers get connected and stay connected to the internet. This study examines what forms of internet connectivity are available to farmers across Australia and which of these forms of internet connectivity farmers are actually using on their farms. It also seeks to understand what, if anything, farmers are doing to manage their connection to the internet. This is done through the use of an online survey data collection instrument that was conducted in conjunction with the other studies in this dissertation.

## 5.2 Literature review

Extensive work has been conducted to date on how residents in regional and remote Australia get connected and stay connected to the internet ([BIRRR, 2020, 2021, 2024](#); [Hartsuyker et al., 2021](#); [Thomas et al., 2023](#)). Historically however, very little work has been done that examines the types of internet connectivity options available to farmers in Australia. For the most part this important work has been published in industry reports, government submissions, regional reviews and through volunteer organisations (e.g. the ICPA and the CWA) and there are very few examples of academic works that examine this issue. Examples of existing academic works examining how farmers use the internet include [Lamb et al. \(2022\)](#), [Marshall et al. \(2020\)](#) and [Zhang \(2017\)](#). In addition, much of both academic and grey literature focuses predominantly on regional and remote Australia and does not consider the occupation of the subjects.

[Marshall et al. \(2020\)](#) and [Willis and Tranter \(2006\)](#) highlight that historically, farmers have limited options to connect to the internet, identifying that a basic lack of telecommunications and internet infrastructure largely underpins low levels of digital inclusion in rural areas. However, over the past five years internet service options have increased and include services such as Sky Muster Plus™ ([NBN Co, 2024](#)), SpaceX's Starlink™ constellation ([SpaceX, 2024](#)) and Wireless Internet Service Providers (WISP's), which now means that farmers have the ability to access internet connectivity with no data limits and in some cases, low latency (less than 100 milliseconds). Despite the increase in connectivity options for farmers, the level of uptake of these newer services is only known to the ISP's that provide them. In Australia to date, the assumption that new and improved services will be adopted if they are available has led to a focus by the Australian Government on building infrastructure ([Edwards, 2018](#)).

The challenge of providing internet connectivity to farmers (particularly in remote areas) is compounded by many technology providers who operate under a principal of assumed equity, with anecdotal evidence showing that software developers do not consider the characteristics of a user's internet connectivity such as high latency or internet connections that are constrained by data limits ([BIRRR, 2024](#); [Hartsuyker et al., 2021](#); [Whirlpool, 2024](#)). Examples of this include video streaming services for example Netflix™ (<https://www.netflix.com/>) and Stan™ (<https://www.stan.com.au/>) that default to high-definition resolutions regardless of whether a viewer has a constrained internet connection and software updates that are unnecessarily large.

## CHAPTER 5 - Study 2 - Understanding the internet connectivity requirements of farmers

It is not known if the ability of farmers to produce food and fibre is being constrained by their ability to connect to the internet. Existing works such as ([Dobson et al., 2013](#)) take a binary view of internet connectivity and only consider the availability of an internet connection, not if it meets the needs of the user or is fit for purpose. [Roberts and Hernandez \(2019\)](#), argue that it is not enough to consider simply having access to the internet.

In the report “Accelerating precision agriculture to decision agriculture” [Zhang \(2017\)](#) demonstrated that different types of farmers (for example Beef or Cropping) used different connectivity options to connect to the internet. Whilst not a key focus of their work, it does show that different types of farmers have different needs and have different levels of digital literacy. This study will examine this phenomenon more directly.

As previously identified in Chapter Four, data consumption by farmers and the broader population has been shown to continually increase, year on year. ISP’s have recognised this and have improved their service offerings, within the limits of the technology that is used to deliver these services. The most relevant example for Australian farmers is the introduction of the Sky Muster Plus™ in 2019 which offered internet connectivity with less constraints than previously available.

It is often assumed that a technology or practice will be adopted immediately once internet connectivity is available. Extensive work has demonstrated that the adoption of a technology does not occur uniformly ([Koul & Eydgahi, 2017](#); [Rogers, 2003](#); [van Dijk, 2005](#); [Wang et al., 2018](#)). As a result, the take-up of any improved internet services does not happen immediately. It is also currently unknown what role factors such as age, gender and farm type have on the adoption of these newer plans and connectivity options.

Despite the importance of internet connectivity in modern day life, the issue of connectivity literacy is a challenging subject that has not had much attention in the literature. To date, the majority of the discussion around this issue has occurred in industry reports, government submissions and through social media. Connectivity literacy itself is a relatively new concept and was first identified by Kristy Sparrow, the Co-Founder of BIRRR, as published in [Hartsuyker et al. \(2021\)](#) who defined connectivity literacy as “*the skills and knowledge needed by a consumer to get connected and stay connected to telecommunications services*” (pg.9). More

succinctly, we will refer to this as the user's ability to "getting connected" and "staying connected" to the internet in this work.

As a new concept, there is a paucity of literature examining the phenomenon through an academic lens. In an attempt to explore the concept of connectivity literacy Marshall, Hay, Dale, Babacan and Dezuanni in the book [Digital Literacy and Inclusion \(2024\)](#) compared digital literacy and digital inclusion data with connectivity literacy criteria within a group of residents and farmers in Far North Queensland.

### **5.3 Methodology**

This study analyses the results of an online survey to respond to RQ2 ("How do farmers get connected to the internet") and RQ3 ("How do farmers stay connected to the internet"). For more information regarding the sampling strategy and survey design, please see Section 2.6.2. More data regarding the online survey methodology and data cleaning process are discussed in section 2.6.2.6. The survey results were analysed using the tools and methods discussed in Section 2.8.

### **5.4 Results and Discussion**

#### ***5.4.1 How do farmers connect to the internet***

To understand what forms of connectivity the survey respondents use, they were asked what types and how many of various forms of internet connectivity were on the farm that they live or work on. A cross-tabulation analysis of the N=175 responses that were received was performed to identify what type of connections the farmers had and is presented in Table 5.1. The various types of farms are identified as columns and the types of internet connectivity as rows. Each respondent may work on a farm that produces multiple outputs and that uses multiple forms of internet connectivity therefore they were able to select more than one option. Whilst an "Other" option was presented to capture any form of internet connectivity that was not listed, however, no respondents selected this option.

**Table 5.1 - Frequency analysis of Question 32: Internet connection types by type of farm (N=175) \***

Internet connection type used by farm	Beef (n=122)		Wool (n=31)		Cropping (n=47)		Sheep Meat (n=23)		Other type of farm (n=24)	
	%	n	%	n	%	n	%	n	%	n
NBN™ Satellite	41.0%	50	25.8%	8	17.0%	8	30.4%	7	25.0%	6
NBN™ Fixed Wireless	6.6%	8	6.5%	2	12.8%	6	13.0%	3	16.7%	4
NBN™ Fixed Line	0.8%	1	0.0%	0	0.0%	0	0.0%	0	0.0%	0
Mobile Broadband	41.8%	51	38.7%	12	46.8%	22	43.5%	10	62.5%	15
Non NBN™ Fixed Wireless	9.0%	11	12.9%	4	8.5%	4	17.4%	4	4.2%	1
ADSL	0.8%	1	0.0%	0	0.0%	0	0.0%	0	0.0%	0
Other Satellite including Starlink™	26.2%	32	29.0%	9	34.0%	16	34.8%	8	41.7%	10
Unsure	2.5%	3	3.2%	1	0.0%	0	0.0%	0	4.2%	1
Other	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0
<b>Total</b>	<b>128.7%</b>	<b>157</b>	<b>116.1%</b>	<b>36</b>	<b>119.1%</b>	<b>56</b>	<b>139.1%</b>	<b>32</b>	<b>154.2%</b>	<b>37</b>

\*Participants could select more than one type of internet connection and as a result totals may be greater than 100%

The cross-tabulation analysis in Table 5.1 (above) shows that mobile broadband was the most common form of internet connectivity used across all the types of farms in this study. Interestingly the second most common form of internet connectivity used by all farmers (with the exception of beef producers) is “Other satellite” which included the newly released Starlink™ service by SpaceX. Historically, the NBN™ Sky Muster Satellite service has been the most commonly used form of internet connectivity in regional Australia ([BIRRR, 2017a](#)). The high and fast adoption of the Starlink™ satellite service (which was only introduced into southern Australia in early 2021 and northern Australia in 2022 ([Australian Broadcasting Corporation, 2022](#))) may be indicative of a real or perceived need for faster internet or lower latency connectivity although further research is needed.

Only a small percentage of respondents were unsure what type of internet connection they had. Of these respondents with the exception of “Other”, all were in livestock production industries including wool (5.56%) and beef (3.45%). Very little uptake of fixed line services, including ADSL and other NBN™ services were observed, which is to be expected due to farms typically being located outside population centres.

#### **5.4.1.1 Frequency analysis of connectivity type**

A means and frequency analysis of the types of internet connections that the survey respondents had on their farms is presented below in Table 5.2. The most common type of internet connection that the respondents stated that they use is mobile broadband which included hot spotting their mobile phone. This is unsurprising due to the market saturation of smartphones that are capable of acting as a wireless hotspot. The second most common connection is the NBN™ satellite service (n=112) followed by “Other” satellite, including Starlink™ (n=70). These results support the work by ([Marshall & Dale, 2019a, 2019b](#)) who describes the concept of the concept of farmers having multiple types of internet connectivity or “layering up” .

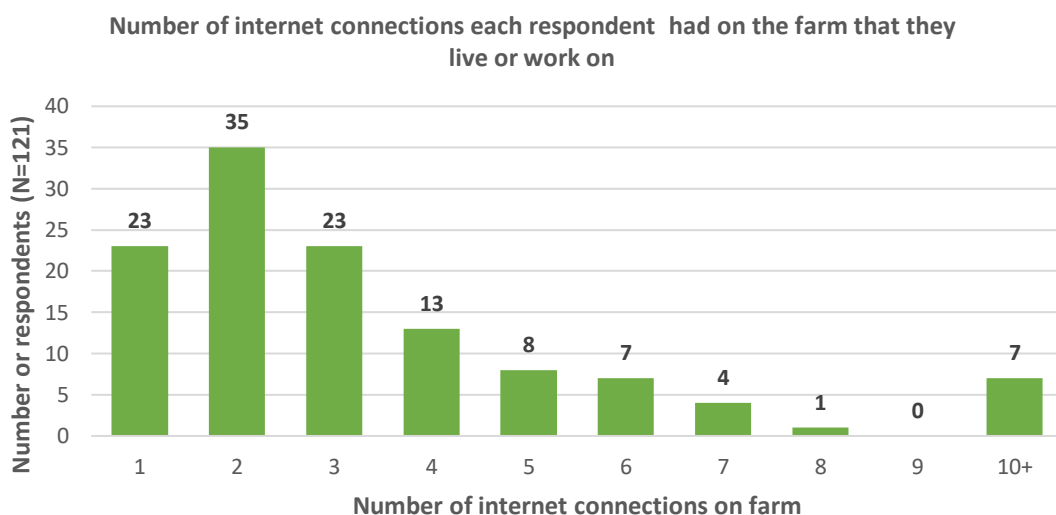
**Table 5.2 – Frequency analysis of Question 32: Number of internet connections on respondent’s farm by type of internet connection**

Type of Connection	Number of farms with connection	Total Number of Connections on Farm* (N=448)
NBN™ Satellite	60	112
NBN™ Fixed Wireless	15	21
NBN™ Fixed Line	1	1
Mobile Broadband	78	216
Non NBN™ Fixed Wireless	15	23
ADSL	1	1
Other Satellite including Starlink™	50	70
Unsure	4	4

\*Respondents could have multiple connections on each farm

#### 5.4.1.2 Number of internet connections per farm

To further explore the phenomenon of “layering up”, a frequency analysis was performed on the number of internet connections each respondent’s farm had. The results of the frequency analyses are presented as a histogram in Figure 5.1 below.



**Figure 5.1 - Frequency analysis number of internet connections on a respondent’s farm**

The majority of respondents 28.93% (n=35) had two internet connections on their farm with only 19.01% (n=23) respondent having one internet connection. A one-way between groups analysis of variance (ANOVA) was conducted to explore the impact of farm type and size on the number of internet connections ( $p < .05$ ). This analysis and showed no statistical difference between the type and the size of a farm and the number of internet connections it had.

#### **5.4.1.3 Breakdown of connectivity by distance to the nearest town**

As previously discussed in Section 1.2, the deployment of telecommunications infrastructure such as mobile phone towers to provide internet connectivity requires large capital investment. As a result, deployments are typically focused around high population areas such as towns or areas with high traffic volumes such as highways. To understand if this extends to farming areas, respondents were asked to state how far they are located from their nearest town. The results are presented as a cross tabulation below in Table 5.3

A one-way between groups analysis of variance conducted to explore the impact of the distance a farmer lives from town and the type of internet connection that they had. This analysis showed a statistically significant difference at the  $p < .05$  level for the use of the NBN Sky Muster™ satellite services ( $F(6, 124) = 2.936, p = .029$ ) and the distance from the farms nearest town. No other statistically significant differences at the  $p < .05$  level for the other types of internet connections were observed. This result is to be expected with survey respondents that are more isolated and located further away from their nearest town having less terrestrial based options for their internet connectivity.

**Table 5.3 – Cross tabulation for internet connection type on the farm where the respondent lives and works and distance from the nearest town\***

<b>Connection Type</b>	<b>In town</b>	<b>&lt;5km</b>	<b>5 to 15 km</b>	<b>15 to 30 km</b>	<b>30 to 60 km</b>	<b>&gt; 60 km</b>	<b>&gt; 100km</b>
NBN™ Satellite	1	0	8	10	10	14	17
NBN™ Fixed	0	1	5	4	2	2	1
Wireless							
NBN™ Fixed	0	0	0	1	0	0	0
Line							
Mobile	3	2	10	26	21	9	7
Broadband							
Non NBN™	0	0	1	6	5	0	3
Fixed Wireless							
ADSL	0	0	2	4	0	0	0
Other Satellite	1	0	5	15	12	9	8
including							
Starlink™							
Unsure	0	0	0	3	0	1	0
<b>Total</b>	<b>5</b>	<b>3</b>	<b>31</b>	<b>69</b>	<b>50</b>	<b>35</b>	<b>36</b>

\*Q32 is a multiple response and respondents could select more than one answer. As a result, totals may be greater than 100%

**5.4.1.4 How did they select their internet connection?**

The survey respondents were asked what factors they considered when they selected their internet connection. A multiple response analysis of the results is presented below in Table 5.4.

**Table 5.4 – Multiple response analysis of Question 46: “How did you choose your internet connection?”**

<b>Factor*</b>	<b>n</b>
Monthly data allowance	65
Speed	65
Value for money	60
Recommended by a friend	43
I have used them for a long time	35
Reviews	25
Customer support	24
Recommended in an online group (e.g. BIRRR or Regional Tech Hub)	21
Recommended by an IT consultant	17
Other (please specify)	13
Bonus offer (e.g. free router)	10
Advertising	8
Letter in the post	1
<b>Total</b>	<b>387</b>

\*Respondents could select more than one option

The multiple responses analysis above shows that “monthly data allowance” (n=65), “speed” (n=65) and to a lesser extent “value for money” (n=60) are the primary factors that the respondents considered when selecting their internet connection. These are followed by “recommendation from a friend” (n=43) and “I have used them for a long time” at (n=35).

Interestingly, only a small number of respondents relied on trusted advisors such IT consultants (n=17) and online groups such as BIRRR or the Regional Tech Hub (n=21) to make a decision on what type of internet connection to use. Many factors may contribute to this

including difficulty in accessing trusted advisors, lack of time or simply now knowing where to look, however further research is needed to fully explore this.

#### 5.4.1.5 Mobile phones on farms

With the ubiquitous nature of mobile phones, mobile phone coverage is becoming more important. To understand what mobile coverage is available to farmers, survey respondents were asked how much mobile coverage was available to them. A frequency analysis was performed and presented below in Table 5.5. Interestingly 46.6% (n=61) of survey respondents stated that they had mobile coverage directly outside a building with only 18.3% (n=24) having mobile coverage inside. Only 2.3% (n=3) stated that they did not have any mobile coverage on the farm where they lived or worked.

**Table 5.5 - Frequency analysis of Question 48: "Do you ever receive any form of mobile service at your business location – even enough to receive a text message?"**

Does the respondent have mobile Coverage	Respondents	
	n	%
Yes - Inside the building	24	18.3%
Yes - Directly outside the building	61	46.6%
On my property - within 5 kms of the building	22	16.8%
On my property - more than 5 kms from the building	21	16.0%
No	3	2.3%
<b>Total</b>	<b>131</b>	<b>100.0%</b>

##### 5.4.1.5.1 Farm type and size

To further understand the adoption of mobile broadband amongst farmers, a one-way between groups analysis of variance was conducted to explore the impact of farm type and size on mobile coverage. This analysis showed no statistically significant difference at the  $p < .05$  level between the type of farm and mobile phone coverage. An additional one-way between groups analysis of variance conducted to explore the impact of farm size on mobile coverage also showed no statistically significant difference at the  $p < .05$  level between the size of farm and mobile phone coverage. These results show that farm type and size have no relationship to the availability of mobile phone coverage and demonstrates the dichotomy of

mobile phone coverage and the random nature of its availability. In addition, it shows that many of the respondents are paying for mobile phones service that they are not able to use at their home.

**5.4.2 How do farmers stay connected to the internet**

**5.4.2.1 How actively are farmers managing their internet connection**

To understand how actively farmers are managing their internet connection, respondents were asked how often they changed various different components of their internet connection. A means analysis was performed which showed that many of the respondents had changed their internet connectivity to the new Starlink™ satellite internet service in Australia. Due to its high level of adoption and as Starlink™ provides a router with their service, this analysis is presented in two parts in Table 5.6 below.

**Table 5.6 - Means analysis of when survey respondent last changed various components of their internet connection**

Component	Other types of internet connection			Starlink™ internet connection		
	n	Mean*	Std. Deviation	n	Mean*	Std. Deviation
ISP	69	1.59	0.975	47	2.79	1.301
Plan	70	2.19	1.094	44	2.93	1.169
Router or other WIFI equipment	74	2.07	0.998	46	2.87	1.147
Type of internet connection	62	1.53	0.863	43	2.49	1.298

\*1 = More than 3 years ago, 2 = Within the last one to two years, 3 = Within the last twelve months, 4 = Within the last six months

The means analysis shows that survey respondents that do not use alternate satellite services such as Starlink™ have not changed the type of internet connection or ISP on average for two to three years (M=1.53, SD=0.863) and (M=1.59, SD=0.975) respectively. The means analysis also shows that respondents have not changed their router or plan within the last one to two years (M=2.07, SD=0.998) and (M=2.19, SD=1.094) respectively. This result is interesting as it is very common for ISPs to change their plans regularly. As a result, the slow rate that

respondents are changing their plans means that a more suitable plan that better meets their needs may be available from their existing ISP. In addition, for respondents using services provided by the NBN it is very easy for them to change their ISP, but respondents are not doing so.

The respondents that are not using alternate satellite services such as Starlink™, also are using much older routers and WIFI equipment. Whilst older hardware may still be fully functional, it is unlikely that they will be having an optimal experience with their internet connection. Older equipment may also open the survey respondents and their business to an increased risk of a cyber security incident.

When considering respondents that use alternate satellite services including Starlink™, it is clear that the new product has been adopted very quickly ( $M=2.79$ ,  $SD=3.01$ ). The Starlink™ service itself is only offered to consumers via SpaceX and includes a new router that must be used to operate the service. This is reflected in this analysis with the Plan ( $M=2.93$ ,  $SD=1.169$ ), Router ( $M=2.87$ ,  $SD=1.147$ ) and type of connection ( $M=2.49$ ,  $SD=1.298$ ) having a similar mean. The rapid adoption of the Starlink™ satellite service (including the recent availability of the Starlink™ internet service through Telstra™ in 2024) may demonstrate a desire by farmers for faster internet connectivity. However, further research is needed to examine the diffusion of Starlink™ and other alternative services.

#### **5.4.2.2 How often do farmers change how they are connected to the internet**

Perhaps one of the most disruptive changes someone can make to their internet connection is to change the medium that they use to connect to the internet (for example satellite to fixed wireless). Despite the challenges in doing so, such a change can, in many cases, enable the user to access a higher performance service that better meets their connectivity needs. To understand how often farmers perform such a change, respondents were asked when they last changed the way they connected to the internet. A frequency analysis of the results is presented below in Table 5.7.

**Table 5.7 – Frequency analysis of Question 44: “When did you last changed the way you connect to the internet?”**

Period	n	Percentage
Within the last 6 months	19	16.5%
Within the last twelve months	9	7.8%
Within the last one to two years	22	19.1%
More than 3 years ago	55	47.8%
I can't remember	10	8.7%
<b>Total</b>	<b>115</b>	<b>100%</b>

Nearly 48% of respondents indicated that they had not changed how they connect to the internet in at least three years. Interestingly, 24.3% of respondents responded that they have changed the method they connect to the internet within the last twelve months. This may be due to the introduction of the Starlink™ satellite service in 2022 ([SpaceX, 2024](#))

#### 5.4.2.3 How actively they manage their devices.

Respondents were asked how often they changed various devices that they use to connect to the internet. A means analysis was performed on the results and is presented in Table 5.8 below. Respondents who stated that they were unsure when they last changed or placed their device were not considered in this analysis.

**Table 5.8 – Means analysis of how often various devices are replaced**

Device	n	Mean	SD
Mobile phone	128	2.31	0.96
Computer or laptop	125	2.03	0.97
Tablet	90	1.99	1.04

1 = More than 3 years ago, 2 = Within the last one to two years, 3 = Within the last twelve months, 4 = Within the last six months

The means analysis shows that the most common device that the survey respondents are changing is their mobile phone approximately every 18 months (M=2.32, SD=0.96). Due to the ubiquitous and consumer nature of mobile phones, this result is unsurprising although further work is needed to understand if this this occurs at a similar rate to the general population. The

survey respondents replace their computer or laptop on average every one to two years ( $M=2.03$ ,  $SD=0.97$ ) and their tablets slightly less regularly ( $M=1.99$ ,  $SD=1.04$ ).

### 5.4.3 Constrained internet connectivity

An unconstrained internet connectivity is uncommon in RRR areas and the effect that constrained internet connectivity has on how farmers use the internet has not previously been examined. When a constrained internet connection exceeds their monthly data allowance, the speed of the connection is often reduced to a near unusable level. As a result of this reduction in speed, the user is unable use their internet connection how they want to, for example they can not relax and play a movie on demand or have a video call with family or friends.

To gain an understanding of how many farmers have access to an unconstrained internet connection, respondents were asked if their internet connection had a monthly download allowance. A frequency analysis was performed with the results presented below in Table 5.9 (below). Only 30.7% of respondents ( $n=42$ ) stated that their internet connection did not have a monthly data allowance with 62.1% ( $n=85$ ) have internet connectivity that is constrained by a data limit for at least some things. This result is interesting as internet connections that have unlimited monthly data allowance have been available to every premises and business in Australia since the introduction of Sky Muster Plus™ service in 2019. A total of  $n=10$  (7.3%) participants were unsure if their internet connection was constrained.

**Table 5.9 – Frequency analysis Question 35: “Does your internet connection have a monthly download allowance?”**

Does your internet connection have a monthly data allowance	Respondents	
	n	%
Yes	63	46.0
Yes, but only for some things	22	16.1
No	42	30.7
Not Sure	10	7.3
<b>Total</b>	<b>137</b>	<b>100%</b>

#### 5.4.3.1 How often farmers exceed their monthly data allowance

Respondents who stated that they had an internet connection that was constrained were asked how often they ran out of data. A frequency analysis was performed and is presented below in Table 5.10.

**Table 5.10 – Frequency analysis of Question 36: How often respondents with a constrained internet connection ran out of data**

<b>Period</b>	<b>n</b>	<b>Percent</b>
Every month	9	9.8%
Every 2-3 months	21	22.8%
Every 4-6 months	9	9.8%
About once a year	7	7.6%
Only during school holidays	7	7.6%
I never run out of data	39	42.4%
<b>Total</b>	<b>92</b>	<b>100.0%</b>

Interestingly, 42.4% (n=39) of respondents stated that despite having an internet connection that was constrained they did not run out of data. The remaining respondents 57.6% (n=53) stated that they run out of data at least once a year, and many times more often. Of these, 22.8% (n=21) ran out of data every two to three months. Typically, when a user runs out of data, they will experience shaping in which the speed of their internet connection is reduced, or they are charged a fee for excess traffic above a pre-agreed limit associated with their chosen plan. That the survey respondents are running out of data at all is interesting due to the wide availability of internet connectivity options that do not have set data limits. This is explored further in Section 5.4.4.

#### 5.4.3.2 Farm Type

To explore the relationship between the type of farm and how regularly the respondents run out of data, a means analysis was performed and is show below in Table 5.11. This analysis shows that sheep meat producers (M=3.80, SD=1.99) and beef producers (M=3.97, SD=1.92) that have a constrained internet connection run out of their monthly data allowance on average between every 4-6 months to once per year. Cropping farmers (M=4.29, SD=1.90) are the most unlikely to run out of data and only do so during the school holidays or about once a

year. This may be due to cropping farmers also having the highest adoption of internet connectivity that is unconstrained.

**Table 5.11 - Means analysis of farm type and how regularly they run out of data**

<b>Farm Type<sup>+</sup></b>	<b>Mean*</b>	<b>SD</b>	<b>n</b>
Beef	3.97	1.92	72
Wool	4.00	2.00	15
Cropping	4.29	1.90	14
Sheep Meat	3.80	1.99	10
Other type of farm	4.11	2.03	9
<b>Total</b>	<b>4.08</b>	<b>1.92</b>	<b>92</b>

\*1=Every month,2=Every 2-3 months,3=Every 4-6 months,4=About once a year,5=Only during school holidays,7=I never run out of data.

<sup>+</sup> Respondents may select more than one type of farm

To gain further insight into the respondent's internet connection and to identify any relationship between the type of farm and the likelihood of having a connection that is constrained, a cross-tabulation analysis was performed in Table 5.12 below. The cross-tabulation analysis shows that Wool, followed by Beef producers were the least likely to have an internet connection that had a download limit (n=25, 25.3% and n=5, 23.8% respectively). Of the farmers that had access to internet connectivity that was not constrained, 55.0% (n=11) were "Other Farmers" and 48.4% (n=15) were farmers that cropped. Whilst more research is needed to understand why the relationship between the type of farmer and the likelihood of having access to internet connectivity that was not constrained, this may be explained by farmers that cropped due to the high adoption of technology in the industry, although further research is needed.

**Table 5.12 - Cross tabulation for constrained internet connections and farm type**

<b>Farm Type</b>	<b>Beef (n=99)</b>	<b>Wool (n=21)</b>	<b>Cropping (n=31)</b>	<b>Sheep Meat (n=18)</b>	<b>Other type of farm (n=20)</b>
Yes	47	12	14	12	4
Yes, but only for some things	18	3	1	0	3
No	25	5	15	6	11
Not Sure	9	1	1	0	2

Interestingly, Wool (n=12), Sheep Meat (n=12) and Beef (n=47) were the most likely types of farms to constrained internet connectivity farmers.

#### **5.4.3.3 Data limits based on distance to town**

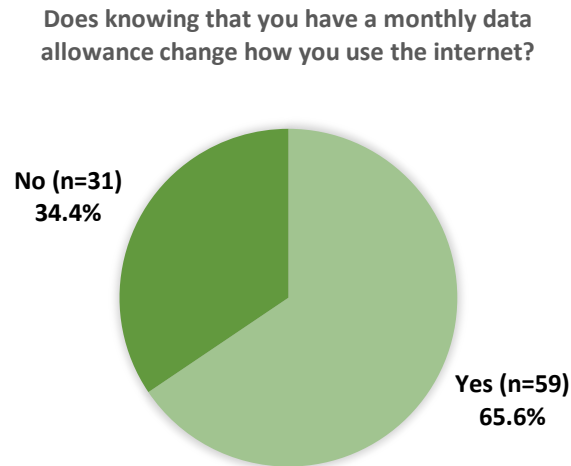
To further understand if there was a relationship between the distance a farmer lives or works from town, a one-way between groups analysis of variance was conducted with a statistically significant difference set at the  $p < .05$  level. This analysis showed that there was no statistical difference between the distance from their nearest town a respondent lives or works at and the likelihood of them having internet connection that was unconstrained ( $F(3, 136) = 1.480, p = .607$ ).

#### **5.4.4 Managing data limits**

In many cases, farmers with a constrained internet connection are required to manage how they use their internet connection so that they do not exceed their monthly data allowances. This behaviour is examined in more detail.

##### **5.4.4.1 Data limits behaviour change**

To understand what the effect having a constrained internet connection has on how a farmer uses the internet, respondents were asked if the knowledge that their internet connection had a data limit changed how they use it. This breakdown is presented below in Figure 5.2.



**Figure 5.2 - Frequency Analysis of Question 37: “Does knowing that you have a monthly data allowance change how you use the internet?”**

A total of 65.6% of respondents (n=59) stated that knowing that they had a monthly download allowance changed how they use the internet. By contrast 34.4% (n=31) of the respondents did not change their behaviour due to allocated data monthly allowance. This may be because, they are either not using all the monthly data allowance or that they accept that they may run out of data although further research is needed to fully understand this phenomenon.

To further explore if the knowledge of an internet connection having a monthly data allowance changes how the respondent uses the internet and if there is any relationship to the type of farmer, a one-way between groups analysis of variance was conducted with a statistically significant difference at the  $p < .05$  level. No statistical difference in behaviour and the type of farmer was observed.

#### **5.4.4.2 Why are survey respondents not changing their internet plan regularly**

As previously discussed, most farmers (57.6%) who completed the survey, that had a constrained internet connection ran out of their monthly data allowance at least once a year. To further explore this, a frequency analysis of farmers with a constrained internet connection that also ran out of data is presented below in Table 5.13.

**Table 5.13 - Frequency analysis of how often farmers with constrained internet connectivity that ran out of data changed their plan (N=51)**

<b>Period</b>	<b>n</b>	<b>Percent</b>
Within the last 6 months	18	35.3%
Within the last twelve months	3	5.9%
Within the last one to two years	14	27.5%
More than 3 years ago	11	21.6%
I can't remember	5	9.8%
<b>Total</b>	<b>51</b>	<b>100%</b>

Of the respondents that changed their plan to avoid running out of their monthly allowance, only 41.2% (n=21) respondents had done so within the last twelve months, indicated that the farmers studied are not actively managing their internet connectivity.

Nearly 27% of respondents who reported that they had exhausted their monthly data allowance at least once a year, had also not changed their plan or ISP within the last two years and (21.6%). To further examine this further, respondents were asked why they had not changed their plan or ISP. A multiple response analysis was performed with the results presented below in Table 5.14.

**Table 5.14 Multiple response analysis of reasons why respondent who had not changed plan or ISP within at least two years and who run out of data at least once a year (N=19)**

<b>Reason</b>	<b>n</b>	<b>%</b>
It's too hard to change plans	5	26.3%
Current plan meets my needs	3	15.8%
Plan choices confuse me	6	31.6%
I don't know how to compare plans	2	10.5%
I don't know where to go to get advice	1	5.3%
Budget	3	15.8%
Other	8	42.1%

\*Respondents were able to select more than one option

This multiple response analysis shows that the most common reason that the farmers had not changed their plan or ISP despite running out of their monthly data allowance at least once a year was that in their view it was "Other" (42.1%) with further research needed to understand why this is the case. The second most common reason for not changing their plan or ISP was "Plan choices confuse me" (31.6%). Budget was only a reason for 15.8% of farmers.

The remainder of the responses "Plan choices confuse me", "It's too hard to change plan" and "I don't know how to compare plans" collectively represented 57.9% of the responses, indicating that the connectivity literacy of farmers is an issue amongst rural, regional and remote farmers. This may also indicate a real or perceived lack of need by farmers although further research is needed to understand why this is the case.

#### **5.4.4.3 How respondents would like to use their internet connection**

As previously discussed in Section 5.4.4.1, survey respondents indicated that knowing that their internet connection had a data limit changed how they used the internet. To explore further how their usage changed and to understand how farmers wanted to use their internet connection were it unconstrained, survey respondents were asked what they would like to do if their internet connection was unconstrained. These results are presented below in Table 5.15. This multiple response analysis of survey showed that only 15.9% (n=14) of respondents would not do anything differently on their farm if they were they to have access to an internet connection that was unconstrained.

**Table 5.15 - Multiple response analysis of Question 39: What respondents would like to do with their internet connection if they had no monthly data allowance\***

Activity*	Responses (N=88)	
	n	%
Stream more movies and tv shows	57	64.8%
Implement more technology on my farm	47	53.4%
Download updates for my computers and devices	36	40.9%
Study	23	26.1%
Use more social media	21	23.9%
Nothing	14	15.9%
Other	8	9.1%
<b>Total</b>	<b>206</b>	<b>234.1%</b>

\*Respondents were able to select more than one activity

The primary activity that farmers indicated that they wanted to do were their internet unconstrained was to stream more movies and television shows (64.8%). This indicated that they are not able to watch shows and movies as regularly as they wish to do so.

The second most common activity that survey respondents indicated that they wished to be able to do was to implement more technology on their farm (53.4%). As previously discussed in Section 1.2, increased adoption of technology in farming is key to increasing the production and efficiency of food production and leads to improved animal welfare outcomes. Further research is needed to examine how unconstrained internet connectivity is restricting the adoption of technology in agriculture.

The third activity that farmers indicated that they wanted to do more of was “Downloading updates for my computers and devices” (40.9%). Updates are important as they improve the reliability and security of devices and introduce new functionality, ultimately leading to better experiences with technology. These software updates and patches are designed to decrease the risk of threat actors attaching devices and networks and reduce the proliferation of cyber-attacks including identity theft and ransomware. An inability to download these security updates is a concerning finding that has the potential to impact the food security and ultimately sovereignty of Australia.

Respondents also indicate that they wished to study more (26.1%) and use more social media (23.9%). Respondents were also given the opportunity to provide additional responses. These responses are presented below in Table 5.16.

**Table 5.16 - Responses to “Other” when asked “What respondents would like to do with their internet connection”.**

---

*“Run the business better”*

*“Allow staff and guests to access”*

*“Webinars. FutureBeef. FBA. NQ Dry Tropics”*

*“Would allow for more online gaming when I have days off. Being remote means not a lot [of] people nearby and needs ways to kill time”*

*“More real-time monitoring of both devices and cameras when not working on the farm”*

*“Let family visitors use it”*

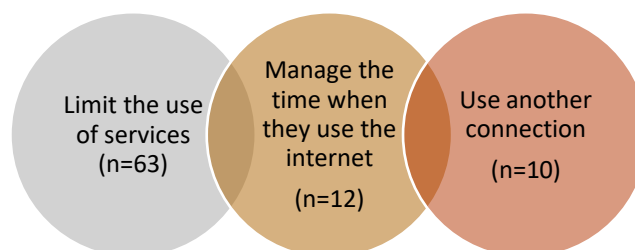
*“Security cameras”*

*“Use it differently”*

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#### 5.4.4.4 How respondents manage their data usage

To help understand how farmers manage their limited data usage, respondents were asked to describe how they managed their monthly data allowance in Question 38. A total of n=76 responses were received and a manual thematic analysis ([Braun & Clarke, 2006](#)) was performed on the raw data. Three themes were identified and are presented below in Figure 5.3.



**Figure 5.3 –Visualisation of identified Themes (N=76)**

**5.4.4.4.1 Theme 1 - Limit or do not use particular services**

Respondents discussed how they would not use particular services that consume a lot of data, including video streaming services and software updates. They would do this a variety of ways including by preventing guests or staff from using their internet connection at all or by requiring that they did not perform certain activities or by simply “going without” themselves as cited in the participants responses below in Table 5.17.

**Table 5.17 – Theme 1 - Limit or do not use particular services**

<i>“I don't stream programs that I would like to, and we just limit what we browse”.</i>
<i>“Don't stream shows that I really want to.”</i>
<i>“Only essential data. Nothing else”</i>

**5.4.4.4.2 Theme 2 – Manage when they use the internet**

Respondents stated that they would change their behaviour to work within the constraints of their internet connection, particularly during on and off-peak times. For example, only downloading software updates in off-peak times. Respondents were also in some cases forced to perform business tasks during these off-peak hours as shown in the participants responses below in Table 5.18.

**Table 5.18 - Theme 2 - Sample responses for theme 2**

<i>“Don't use streaming services until the end of the month. We have had to do things like accounting work during off peak hours due to using all the data (our off peak is 1am-6am). To get up in the middle of night to do banking is crazy.”</i>
<i>“Download movies etc. in the morning.”</i>
<i>“While I was studying my bachelor's degree, I used to have to wake up early to download all of my lectures during off peak data times”</i>

Other examples including respondents managing their internet usage by reducing the resolution of any video that they streamed by only using streaming services at the end of the billing period when they know that they have enough monthly data allowance available to do so.

**5.4.4.4.3 Theme 3 – Using another internet connection**

The final theme identified that respondents performed certain tasks using different internet connections. This was commonly a mobile connection while they were away from home but also included a second internet connection at home. Several examples are presented in Table 5.19 below.

**Table 5.19 - Theme 3 - Sample responses for theme 3**

<i>“Use the Telstra mobile service when possible.”</i>
<i>“Wait until visiting a city service to do major app updates etc.”</i>
<i>“Use data from mobile”</i>

**5.4.4.5 NBN Sky Muster™**

Since the launch of the Sky Muster™ satellite service in 2015 (Co, 2015), many Australians in remote areas, particularly farmers only had access to the internet using the NBN Sky Muster™ service. With the introduction of the NBN Sky Muster Plus™ plans, the NBN™ service began offering plans with unlimited data. It is common within the telecommunications industry for customers not to be automatically migrated across to newer or better plans and as a result, only farmers that actively change to the newest Sky Muster Plus™ plans have access to unlimited data. To further understand how actively farmers manage their internet connection, respondents who use Sky Muster™ services are examined in more detail.

**5.4.4.5.1 Adoption of the Sky Muster Plus™**

Respondent who used the NBN Sky Muster™ service were asked if they used the NBN Sky Muster Plus™ plan. A frequency analysis was conducted with the results presented below in Table 5.20 (below).

**Table 5.20 – Frequency analysis of Q34: “Do you use Sky Muster Plus™?”**

<b>Uses Sky Muster Plus™</b>	<b>n</b>	<b>%</b>
No	77	57.9%
Yes	44	33.1%
Not Sure	12	9.0%
<b>Total</b>	<b>133</b>	<b>100%</b>

It is clear that the NBN Sky Muster Plus™ service has not been widely adopted by farmers despite, as previously discussed, the majority of farmers considering their monthly data allowances inadequate. This phenomenon has previously been examined by the BIRRR group in their Sky Muster™ survey ([BIRRR, 2021](#)). Whilst not focusing on farmers, a similar result was observed with only 36.5% respondents (N=337, n=123) stating that they were using the service in 2021. The BIRRR survey also provides insight into why farmers may not be using the services with 14.5% of their survey respondents stating that it was cost prohibitive and 23.4% stating that their current service met their needs.

### **5.5 Chapter Summary**

This study examined how a group of farmers connect to and manage their connection to the internet. The study showed that the internet connectivity requirements of farmers was influenced by many factors including the size and type of farm and the options that are available to them to connect to the internet. It also demonstrated that for many farmers, an internet connection that is constrained is not meeting their needs.

Although this study did not attempt to define what an adequate internet connection for a farmer is, it demonstrated that different industries have different requirements and that different types of farmers use the internet differently. It also demonstrates that an internet connection that is adequate for one farmer may not be adequate for another and that there is no “one size fits all” internet connection that can meet the needs of all farmers. Study 2 also showed that livestock producers were less likely to have an unconstrained internet connection than respondents who grew crops.

Study two demonstrated that real or perceived constraints to an internet connection can have unintended consequences and that when farmers knew that their internet connection was constrained, it resulted in changes in how they use the internet. These changes in how they use the internet can have real and unintended consequences in how farmers live and work and could ultimately lead to risks to our nation’s Food security and sovereignty.

This study shows that despite some farmers experiencing significant challenges using an internet connection that is constrained, they are not adopting internet connectivity that is unconstrained. These problems could be easily alleviated through the adoption of better plans and connectivity options that are already available and further research is needed to

understand why this may be the case. The results of this chapter also demonstrate the nuances and complexity of how farmers use the internet.

**Study 3 - How farmers use social media**

How do farmers use the internet: A mixed methods approach						
Chapter 1 How do farmers use the internet?	Chapter 2 Methodology	Chapter 3 Demographic analysis	Chapter 4 Understanding how farmers use the internet	Chapter 5 Understanding the internet connectivity requirements of farmers	Chapter 6 How do farmers use social media	Chapter 7 Discussion and conclusion
1.1 Introduction	2.1 Introduction	3.1 Introduction	4.1 Introduction	5.1 Introduction	6.1 Introduction	7.1 Introduction
1.2 Background and research rationale	2.2 Philosophical perspective	3.2 Survey Dataset	4.2 Literature Review	5.2 Literature Review	6.2 Literature Review	7.2 Discussion of findings
1.3 Theoretical Framework	2.3 Methodological foundation	3.3 Data cleaning	4.3 Methodology	5.3 Methodology	6.3 Methodology	7.3 Response to rationale
1.4 Research Objective	2.4 Research Ethics	3.4 Respondent demographics	4.4 Results and Discussion	5.4 Results and Discussion	6.4 Results and Discussion	7.4 Contribution of the thesis
1.5 Thesis Outline	2.5 Study population	3.5 Chapter Summary	4.5 Chapter Summary	5.5 Chapter Summary	6.5 Chapter Summary	7.5 Future research potential
1.6 Chapter Summary	2.6 Data collection instruments					7.6 Limitations
	2.7 Research data storage					7.7 Conclusion
	2.8 Data analysis techniques					7.8 Recommendations
	2.9 Literature review methodology					
	2.10 Risk management					
	2.11 Chapter Summary					

This chapter presents an exploratory study that examines the use of social media and instant messaging platforms by a group of Australian farmers who completed an online survey that was conducted in combination with the other studies in this thesis. An initial literature review is presented in Section 6.2, followed by the study methodology in Section 6.3. The results and discussion follow in Section 6.4. A conclusion is presented in Section 6.5.

**6.1 Introduction**

As previously identified in Study One, social media (and in particular Facebook) makes up a significant proportion of a farmers internet traffic. Whilst there is a plethora of grey literature examining the market share, and in some cases, how individuals use particular social media platforms there is a paucity of academic research that examines how individual farmers use social media and instant messaging platforms.

This study shows that farmers are using social media and instant messaging platforms extensively and differently to the general population of Australia. Factors that may influence this usage, including the size and type of their farm, the gender of the farmers and the type of farm are examined with the aim of providing a broad foundation to guide future research in

this area. Comparisons are also made where possible to the general population to understand if there are any differences between how social media is used between these groups. The result of this study will enable more effective targeting of farmers on social media platforms, aid agricultural extension in improving the efficiency and productivity of farmers.

The data that is collected by social media companies is extremely valuable and by its nature often includes personally identifiable information. Social media companies monetise this data through various business models including advertising and as a result it is intrinsically valuable. Due to the value of this data, it has historically been difficult or expensive to access. In addition, when this data is made available to researchers the social media companies control the volume and type of data that is available, making scientifically valid research difficult.

Some effort has been made to examine farmers relationship with social media. This work typically use survey data ([Aaditi, 2020](#); [Kanjina, 2021](#); [Morris & James, 2017](#); [Xie et al., 2021](#)) or bulk data extracted directly from social media platforms ([Riley & Robertson, 2021](#)). The studies that examine data extracted from social media platforms rely on these platforms making such data accessible to researchers. Historically many of these studies focused on the X (nee Twitter) platform due to it being one of the few platforms that made such data freely available. Recent policy changes at X to remove access to data have made similar studies difficult to replicate ([The Verge, 2023](#)).

## 6.2 Literature review

Social media platforms became popular in the early 2000's. A social media platform facilitates the creation of individual profiles that allow the user to share text, photos, and videos and to communicate with other users. Social media provides new ways for farmers to communicate with each other and interact with like-minded communities and individuals in ways that they could not otherwise do in person due to the tyranny of distance. Social media also provides opportunities for farmers to buy and sell produce or services and access new markets through marketing and marketplace tools.

Social media is a key enabler of agricultural discourse. [Riley and Robertson \(2021\)](#) posit that social media enables an insight into farming that is otherwise difficult to get. This argument is supported by [Zipper \(2018\)](#) who demonstrated how to analyse social media data that might not be accessible by other means and can provide insight into the behaviour of farmers. This

showed that it is possible to use the publicly accessible data from Twitter to map the planting of soy and corn in the United States.

The continued migration of people away from rural areas to the cities over the last hundred years in Australia is contributing to a disconnect where less and less urban residents have a direct connection to agriculture. Social media provides a useful outlet to help farmers tell their story and educate people about agriculture. Examples of this include the Peterson Farm Brothers in the USA (<https://petersonfarmbrothers.com/>) and The Livestock Collective in Australia (<https://www.thelivestockcollective.com.au/>).

Social media provides an opportunity for government to engage with farmers directly and in ways that are not otherwise possible. It also provides opportunities for agricultural extension to disseminate new farming practices or otherwise answer questions from farmers that would otherwise be difficult or expensive to do so.

Social media itself is a relatively new phenomenon that plays a large part of the day to day lives of many people. [Fu and Cook \(2021\)](#) describe social media as “*saturat(ing) multiple spheres of our lives*” ([p. 1235](#)) and farmers, as members of society are not immune from this phenomenon. The geographical isolation of farmers can, in many cases, make it difficult to interact with people that are not living on the farm. Social media provides farmers as avenue to interact with other people without needing to travel large distances and saving time and money. For example, in my case, I need to travel for almost an hour to my nearest town and six hours to reach the nearest city. As a result, in some instances do not meet or interact in person with other people outside my immediate family for weeks.

Social media platforms such as Facebook and Twitter allow farmers to communicate, advocate and exchange ideas ([Phillips et al., 2021](#)). Social media platforms allows for the creation of communities of like-minded individuals to come together regardless of their physical location ([Quinn, 2020](#)). One example of this is the Facebook group BIRRR (Better Internet for Rural, Regional and Remote Australia) which is a grass roots organisation set up by farmers to assist farmers with connectivity issues in Australia. The BIRRR group now has over 15,600 followers ([BIRRR, 2024](#)). Some other examples of farmers using social media range from marketing cattle ([Australian Broadcasting Corporation, 2021](#)) to sharing new ideas ([Australian Broadcasting Corporation, 2020](#); [Farm Online National, 2020](#))

Much of the research that has been conducted to understand what social media platforms that farmers use such as ([Farm Futures, 2016](#)) relies on surveys that are filled out by the farmers themselves. Work such as ([Riley & Robertson, 2021](#)) have analysed sets of social media posts and provide a useful view of how farming is presented and perceived on social media. However, such methodologies are limited by the terms of use that many social media platforms that restriction what data on their platforms can be used for. As a result, more information is needed to fully understand a farmer's use of social media.

Poor or inadequate connectivity also reduces farmers' ability to access social media platforms and as a result, their ability to experience their benefits. This is particularly problematic for farmers as social media has been found to reduce their sense of social isolation ([Gunn et al., 2021](#)), especially as they often live in remote areas and have limited opportunities to meet socially in person. In addition, poor or inadequate internet connectivity can reduce the ability of farmers to use social media for their businesses.

It has been demonstrated that residents of rural areas such as farmers that are unable or unwilling to use social media services are not necessarily socially isolated ([Townsend et al. \(2013\)](#)). This can be due to many reasons, including, in part to a strong sense of community in RRR areas and the need to seek support from other residents of the community due to less access to services ([Raymond et al., 2010](#)). Conversely, [Townsend et al. \(2013\)](#) also argues that for people that do not fit in to the community (such as those that belong to minority groups) who do or cannot using social media may experience more extreme isolation In RRR areas. This is supported by numerous works such as [Escobar-Viera et al. \(2022\)](#), [Karim et al. \(2022\)](#) and [O'Connor et al. \(2018\)](#).

By extension, any disadvantage or restriction on the use of social media (whether real or perceived) that restricts a farmer's ability to use social media also restricts their ability to interact with other people and participate in discussions of relevant issues, such as animal health and management or to help bring trust into the supply chain.

### **6.2.1 Social media in agriculture**

There are many different social media platforms available for use by farmers. Currently, the major social media platforms that are used in Australia include Facebook, Twitter, Instagram, TikTok and YouTube amongst others ([Australian Competition and Consumer Commission, 2023a](#)). As with any business, each social media platform targets different audiences and age groups.

Many of these social media platforms also provide instant messaging services with notable examples including Facebook Messenger and WhatsApp. These instant messaging platforms can be used for individuals and groups to communicate with each other and have been shown to be used in agriculture to allow groups of farmers to share ideas ([Aaditi, 2020](#)).

Social media is fundamentally changing the way we communicate, collaborate, consume and create information ([Aral et al., 2013](#)) and agriculture is not isolated from the societal changes that social media brings. The benefits of social media to agriculture are both direct and indirect. Direct benefits include enabling farmers to communicate with friends, family and other farmers and to access farming resources and groups. Agricultural extension can also provide direct benefits to agriculture and farmers through social media ([Kumar et al., 2023](#); [Mukherjee et al., 2017](#)).

In addition, direct benefits of social media to farmers may include increase their social capital ([Stanley, 2013](#)). [Stanley \(2013\)](#) cites that *“the value of social media for the agricultural industry lies in the value of social capital bringing more transparency, engagement, trust and authenticity to the supply chain”* (pg. 2). Other indirect benefits of social media include reducing the sense of isolation that many farmers experience ([Gunn et al., 2021](#)), exposing farmers to broader audiences, the marketing of farming as a whole leading to positive industry outcomes and increased business opportunities.

The online nature of social media platforms means they are available regardless of the user’s geographical location, provided they have access to an internet connection. As a result, they are an ideal medium for farmers to communicate with each other. Social media is also often used for business purposes such as advertising, selling produce and buying or selling equipment.

Social media has been shown to increase adoption rates of technology and new ideas when compared to farmers that do not use social media ([Zhang et al., 2021](#)). However, as the adoption of social media amongst farmers and how it compares to the general population is unknown, it is hard to know the proportion of farmers that social media campaigns can reach and as such, determine the rates of adoption. [Zipper \(2018\)](#) adds that, “*unknown representativeness of social media users relative to the overall agricultural population are challenges*” (pg. 1). This study will examine the adoption of social media amongst farmers and the factors that influence social media adoption such as the type and size of farm and the distance to their nearest town and their use of social media.

### **6.2.2 How do farmers use social media**

Previous analysis of social media ([Aaditi, 2020](#); [Kanjina, 2021](#)) show that different types of farmers each use social media differently. Both studies took place in developing countries (in this case India and Thailand respectively) and show that the adoption of social media by farmers varies by country, as do the platforms that farmers are using.

To the authors knowledge, no work has examined the use of social media in extensive farming operations that are typical of Australia and are often located in remote areas. Before this study, it was unknown if this remoteness has any effect on the adoption of social media or if, as a result, social media is more or less important to them or their business. [Xie et al. \(2021\)](#) adds that research of social media use by farmers can help support sustainable agriculture and rural development. Therefore, this study responds to prior calls for further research.

### **6.3 Methodology**

This study analyses of two unique empirical secondary datasets from the NISP for a group of farmers located in North-west Queensland, Australia and the results of an online survey to gain insights into RQ4 (“How farmers use social media”). More information regarding the NISP, the relationship to the PI and how the data was extracted and anonymised is provided in Section 2.6.1. Respondents to the online survey were required to be 18 years of age and to live or work on a farm or station. Further details regarding the online survey, design, distribution, and data cleaning process are available in section 2.6.2. A total of N=125 respondents completed the questions relating to their social media use. When analysing the resulting data, a respondent was considered as using social media if they stated that they used at least one

social media platform for business or personal use. The datasets were analysed using the tools and methods discussed in Section 2.8.

For the purposes of the analysis of the secondary datasets, any analysis does not consider any potential biases in usage behaviour such as time of year. The Download Upload Ratio (DUR) was used in this study to help understand the relationship between a respondents upload and download traffic volumes. The DUR is discussed in detail in Section 2.6.1.3.

As previously discussed, it is challenging to obtain a breakdown of social media use in Australia due to its proprietary and commercially sensitive nature. As a result, it is challenging, if not impractical to access it data directly from individual social media platforms. There are numerous commercial organisations that collect and aggregate datasets on social media platforms including Roy Morgan (<https://www.roymorgan.com>), Statista (<https://www.statista.com>) and Sensor Tower (<https://sensortower.com>). Access to these datasets is only available under commercial arrangements. In addition, the data collection and analysis methodologies are often proprietary (meaning that they remain the property of its owner or creator and is used by end-users under predefined conditions) and in many cases, lack transparency.

For the purposes of this analysis, the data that represents social media use from the general Australian population has been sourced from public reports by the Australian Government and are referenced appropriately when they are used throughout this study. Examples of these reports include from the Australian Competition and Consumer Commission, the Australia Bureau of Statistics and the Australian eSafety Commissioner to calculate the percentage of the population that are under 18 that use each platform. Detailed analysis of public datasets has not been included as they are used for comparison purposes only with Table 6.1 (below) presenting how the comparative population level statistics were produced. It is acknowledged that the data in Table 6.1 is not exact, however, it enables a comparison between the farmers that completed the online survey and the general Australian population. Throughout this chapter, X will be referred to as its earlier name, Twitter.

**Table 6.1 - Comparative population level statistics**

Platform	Number of Australians that use platform <sup>1</sup>	Number of Australians aged under 18 that use platform <sup>2,4</sup>	Number of Australians 18 and over that use platform	Percentage of Australian Population over 18 that uses platform <sup>4</sup>
LinkedIn	5,039,688	0 <sup>3</sup>	5,039,688	22.7%
YouTube	21,035,612	1,159,343	19,876,269	89.7%
Facebook	21,620,686	837,303	20,783,383	93.8%
Instagram	10,012,404	917,813	9,094,591	41.0%
TikTok	9,887,561	611,875	9,275,686	41.8%
Twitter	2,966,406	354,244	2,612,162	11.8%
Snapchat	5,970,888	724,589	5,246,299	23.7%
WhatsApp	7,200,000	483,059	6,716,941	30.3%
Messenger	13,800,000	627,977	13,172,023	59.4%

1 Data sourced from [Australian Competition and Consumer Commission \(2023a\)](#) and [Australian Competition and Consumer Commission \(2023b\)](#)

2 Data sourced from [eSafety Commissioner \(2021\)](#) and calculated using data population demographic data from [Australian Bureau of Statistics \(2023b\)](#)

3 Assumes that no children use LinkedIn

4 Population and demographic data sourced from [Australian Bureau of Statistics \(2023b\)](#)

## 6.4 Results and discussion

### 6.4.1 Farmers use of social media platforms

To establish how farmers use social media compared to the Australian population, respondents that stated they used at least one social media platform for either *personal* or *business* activities were selected for a frequency analysis with the resulting breakdown presented below in Table 6.2. Note that respondents were able to select more than one social media platform.

**Table 6.2 - Frequency analysis of social media platform use**

Platform	Percentage of respondents that use platform for <i>personal</i> use	Percentage of respondents that use platform for <i>business</i> use	Percentage of Australian population aged 18 and over that used platform <sup>1</sup>
Facebook	91.2%	72.8%	93.8%
Instagram	57.3%	22.9%	41.0%
TikTok	16.3%	5.0%	41.8%
LinkedIn	37.7%	5.7%	22.7% <sup>3</sup>
Twitter	38.2%	29.3%	11.8%
YouTube	83.8%	41.9%	89.7%
Other	4.6%	2.1%	N/A

<sup>1</sup> See Table 6.1

It is clear that social media is used heavily by the Australian population with the most popular social media platform for both the survey respondents and the general population being Facebook. This is shown in both the publicly accessible dataset (93.8%) ([eSafety Commissioner, 2021](#)) and reflected in the online survey (91.2%). This demonstrates that farmers who responded to the online survey use Facebook for *personal* use at a very similar rate to the general population. The use of Facebook for *business* purposes was also high at 72.8%. How the respondents are actually using Facebook is explored further in Section 6.4.10. This finding supports the finding of Chapter Five which identified that Facebook made up a large proportion of farmers internet traffic.

YouTube is consistently one of the most visited websites in the world ([Arthurs et al., 2018](#); [Semrush, 2024](#)). The frequency analysis presented in Table 6.4 shows that YouTube is the second most popular social media platform in Australia and is used by 89.7% of the general population and 83.8% of the survey respondents for personal use, demonstrating slightly less use by farmers. Interestingly only 41.9% of respondent farmers were using YouTube for business despite video being an important tool organisations can use to build their reputation.

The use of YouTube for Agricultural extension is increasing with Agricultural organisations in Australia such as Queensland’s Department of Agriculture and Fisheries ([Queensland](#)

[Department of Agriculture and Fisheries, 2024](#)) and the Australian Government Department of Agriculture ([Australian Government Department of Agriculture, 2024](#)) using video to deliver extension.

While the reason that YouTube is used less by the survey respondents is unknown although, as discussed in Section 5.4.3, this behaviour may be related to how farmers are managing the data consumption of their internet connection or the quality and content of the videos ([Ford & Moore, 2021](#); [Holt-Day et al., 2020](#)). Further work is needed to fully understand why this is the case.

Instagram is the third most popular platform for farmers who completed the online survey with 57.3% using the platform for *personal* purposes. Instagram is much more popular amongst farmers than the general population with only 41.0% of the general population using Instagram. Instagram can reduce a user's sense of loneliness in some cases ([Mackson et al., 2019](#)) and the visual nature of Instagram may be reason it is used by the survey respondents much more than the general population but further work is needed. Interestingly 22.9% of farmers used also using Instagram for *business* purposes.

The inverse was observed in the case of TikTok which was used much less by farmers. Only 16.3% of respondents stated that they used the platform for *personal* purposes and 5.0% for *business* purposes compared to the 41.9% of the general population. Twitter is much more popular amongst the survey respondents with 38.2% of respondents using the platform, compared to only 11.8% of the general population. Interestingly, 29.3% of farmers used Twitter for *business* purposes however further work is needed to understand what *business* purposes they are using Twitter for.

#### 6.4.2 Farmers use of instant messaging platforms

A Frequency analysis was conducted to examine the adoption rate of instant messaging platforms. The results are presented below along with the percentage of the general population that uses each platform in Table 6.3 below.

**Table 6.3 – Frequency analysis of survey respondents instant messaging platform use**

Platform	Percentage of respondents that use for		Percentage of Australian population 18 and over <sup>1</sup>
	personal purposes	Percentage of respondents that use for business purposes	
Facebook Messenger	92.0%	64.6%	59.4% <sup>2</sup>
Snapchat	29.2%	5.7%	23.7%
WhatsApp	40.6%	25.7%	30.3% <sup>2</sup>

<sup>1</sup> See Table 6.1

The frequency analysis clearly shows that farmers use each of the instant messaging platforms identified in this study more heavily for *personal* use than the general Australian population. The most popular messaging platform Facebook Messenger was used by 92.0% of respondents for personal purposes and 64.6% of respondents for *business* purposes. The use of Facebook Messenger is much higher than the 59.4% of the general population that uses the platform. A similar pattern is shown with the other instant messaging platforms surveyed with WhatsApp and Snapchat being used more by farmers than the general population for *personal* purposes. Whilst Snapchat was not used heavily for *business* purposes (5.7%), WhatsApp was with 25.7% of the respondents doing so.

One possible explanation for this behaviour could be that only 64.9% (n=85) of respondents have mobile coverage in or outside the building they work in (see Section 5.4.1) compared to the 99.5% of the Australian population that Australia's largest mobile carrier Telstra™ services ([Telstra, 2024](#)) and as a result are unable to send and receive SMS messages unless they are close to the building. As the instant messaging platforms examined in this study do not require mobile coverage to operate, the survey respondents may be choosing these platforms instead although further investigation is needed.

### **6.4.3 Social media platforms**

To gain an understanding of social media platforms used by farmers, respondents were asked to identify how often they used social media platforms for personal and business activities. Response rates were high with 100% of respondents stating that they used at least one social media platform for either **business** or **personal** use.

A frequency analysis of the responses to the questions “How often do you use each of the following social media platforms for personal use?” and “How often do you use each of the following social media platforms for business use?” are presented below in Table 6.4 and 6.5. The resulting data shows that the most common platforms that farmers are personally active on are Facebook and Facebook Messenger followed by Instagram, with respondents using these platforms multiple times per day. The remaining platforms were used much less regularly.

By contrast, when considering how the online survey respondents used social media and instant platforms for **business** purposes, it was clear that they used them differently to how they used them for **personal** purposes and much less regularly. Facebook and Facebook Messenger continued to be the most popular platform that was used for **business** purposes however were used much less regularly. Other platforms including the business focused LinkedIn platform was used by only approximately 5% of survey respondents.

Table 6.4 – Question 56: How often do you use each of the following social media and instant messaging platforms for *personal* use? (N=125)

Platform	Almost constantly	Several times a day	About once a day	Several times a week	Once a week	Less than once a week	I do not use this platform
Facebook	8.0%	52.8%	18.4%	4.0%	2.4%	5.6%	8.8%
Facebook Messenger	10.5%	41.1%	12.9%	9.7%	6.5%	11.3%	8.1%
Instagram	1.6%	21.0%	12.9%	4.0%	8.1%	9.7%	42.7%
TikTok	1.6%	4.9%	4.1%	1.6%	0.0%	4.1%	83.6%
LinkedIn	0.0%	5.7%	6.6%	7.4%	0.8%	17.2%	62.3%
Snapchat	0.8%	15.4%	2.4%	4.9%	0.8%	4.9%	70.7%
Twitter	4.1%	11.4%	8.9%	4.1%	0.8%	8.9%	61.8%
YouTube	0.8%	2.4%	3.2%	10.5%	8.9%	16.1%	58.1%
WhatsApp	0.0%	8.1%	5.7%	8.1%	7.3%	11.4%	59.3%
Other (Not listed in survey question)	0.0%	2.3%	0.0%	0.0%	2.3%	0.0%	95.3%

Table 6.5 – Question 57: How often do you use each of the following social media and instant messaging platforms for *business* use? (N=125)

Platform	Almost constantly	Several times a day	About once a day	Several times a week	Once a week	Less than once a week	I do not use this platform
Facebook	0.8%	12.8%	15.2%	17.6%	8.8%	17.6%	27.2%
Facebook Messenger	3.2%	11.3%	8.9%	10.5%	10.5%	20.2%	35.5%
Instagram	0.0%	3.3%	1.6%	7.4%	1.6%	9.0%	77.0%
TikTok	0.0%	0.0%	0.0%	0.0%	1.7%	3.3%	95.0%
LinkedIn	0.0%	0.8%	0.8%	0.8%	0.0%	3.3%	94.2%
Snapchat	0.0%	0.8%	0.8%	0.8%	0.0%	3.3%	94.2%
Twitter	2.4%	4.1%	2.4%	7.3%	3.3%	9.8%	70.7%
YouTube	0.8%	2.4%	3.2%	10.5%	8.9%	16.1%	58.1%
WhatsApp	0.8%	5.0%	3.3%	5.0%	3.3%	8.3%	74.2%
Other (Not listed in survey question)	0.0%	0.0%	0.0%	0.0%	2.1%	0.0%	97.9%

**6.4.4 How often farmers use social media platforms**

Table 6.6 presents a frequency analysis of survey respondents and the general Australian population daily users of each social media platform. To examine in more detail how regularly farmers used social media and instant messaging platforms, a frequency analysis was conducted on respondents that used each platform daily. The result of this analysis is presented below in Table 6.6.

**Table 6.6 - Percentage of users that use each social media platform daily in 2022**

<b>Platform</b>	<b>Percent of farmers that use platform for <i>personal</i> use daily</b>	<b>Percent of farmers that use platform for <i>business</i> use daily</b>	<b>Percent of general population that use platform daily <sup>1</sup></b>
Facebook	79.2%	28.8%	69.8%
Instagram	35.5%	4.9%	33.8%
TikTok	10.6%	0.0%	58.6%
Twitter	24.4%	8.9%	47.2%
YouTube	16.2%	6.4%	57.1%
LinkedIn	12.3%	1.6%	11.9%

<sup>1</sup> See Table 6.1

Table 6.6 shows that the only platforms that farmers are using at least as often as the general population are Facebook and LinkedIn. Facebook itself is being used daily by 79.2% of farmers compared to only 69.8% of the general populations. LinkedIn is used by 12.3% of farmers daily as opposed to 11.9% of the general population. Interestingly, despite the percentage of farmers using YouTube being very similar to the general Australian population (83.8% and 89.7% respectively), farmers use it much less regularly, with only 16.2% of farmers using it daily compared to 57.1% of the general population. Further research is needed to understand why YouTube is used less regularly; however, this may reflect farmers concern for managing their monthly data allowance (See section 5.4.3 for a further discussion).

An additional frequency analysis was conducted to examine what instant messaging platforms are used by farmers at least once a day. Daily usage data for the general Australian population of these instant messaging platforms is not presented due to lack of data with the results presented in Table 6.7 (below).

**Table 6.7 – Percentage of users that use each instant messaging platform daily in 2022**

<b>Platform</b>	<b>Percent of farmers that use platform <i>personal</i> use daily</b>	<b>Percent of farmers that use platform for <i>business</i> use daily</b>
Facebook Messenger	64.5%	23.4%
Snapchat	18.6%	1.6%
WhatsApp	13.8%	9.1%

Of the three social media platforms that were examined as part of this study, 64.5% of farmers stated that they used Facebook messenger at least once a day for *personal* reasons and 23.4% for *business* purposes. Snapchat was used for predominately personal reasons by 18.6% of farmers compared to 1.6% of farmers for *business* purposes. WhatsApp was used less regularly with only 13.8% of farmers using it daily although it was used by 9.1% of respondents for *business* purposes.

#### **6.4.5 Age and social media use**

To understand the relationship between the age of the farmers that responded to the online survey and what social media platforms they use, a frequency analysis was performed. A farmer was considered as using the social media or instant messaging platform if they stated that they used it at least “Less than once a week” for either *business* or *personal* use. Table 6.8 shows a clear downwards trend in the use of social media in the general population, with social media use decreasing with age, with the exception of YouTube and Facebook which increased.

Interestingly for farmers, the use of Facebook and YouTube by all the age groups was higher than that of the general population. A similar relationship was seen with Instagram, TikTok and Twitter where the farmers that use these platforms are more likely to be older than the general population. This highlights the importance of these platforms to farmers with further work needed to fully understand why this is the case.

**Table 6.8 – Frequency analysis of age and percentage of respondents that use social media platform and the general population.**

Age	Facebook		Instagram		TikTok		LinkedIn		Twitter		YouTube	
	Farmers (N=114)	General population*	Farmers (N=71)	General population*	Farmers (N=21)	General population*	Farmers (N=49)	General population*	Farmers (N=48)	General population*	Farmers (N=103)	General population*
18-19	100.0%	72.8%	100.0%	68.5%	0.0%	43.3%	100.0%	21.1%	100.0%	31.1%	100.0%	78.8%
20-24	100.0%	72.8%	100.0%	68.5%	66.7%	43.3%	0.0%	21.1%	0.0%	31.1%	100.0%	78.8%
25-29	100.0%	74.7%	77.8%	62.9%	44.4%	26.3%	44.4%	21.8%	44.4%	21.1%	66.7%	73.6%
30-34	100.0%	74.7%	83.3%	62.9%	16.7%	26.3%	50.0%	21.8%	16.7%	21.1%	66.7%	73.6%
35-39	94.4%	77.2%	61.1%	47.7%	38.9%	18.3%	33.3%	24.3%	50.0%	18.8%	83.3%	69.2%
40-44	100.0%	77.2%	66.7%	47.7%	0.0%	18.3%	50.0%	24.3%	41.7%	18.8%	75.0%	69.2%
45-49	92.3%	75.1%	69.2%	40.1%	15.4%	14.1%	69.2%	20.8%	53.9%	18.7%	92.3%	68.1%
50-54	94.7%	75.1%	52.6%	40.1%	10.5%	14.1%	21.1%	20.8%	21.1%	18.7%	79.0%	68.1%
55-59	81.8%	70.3%	54.6%	26.3%	27.3%	6.4%	54.6%	15.7%	45.5%	13.4%	100.0%	62.0%
60-64	92.3%	70.3%	38.5%	26.3%	0.0%	6.4%	30.8%	15.7%	38.5%	13.4%	92.3%	62.0%
65-69	77.8%	63.2%	33.3%	14.6%	0.0%	3.7%	44.4%	7.6%	55.6%	6.9%	88.9%	51.3%
70-74	100.0%	63.2%	40.0%	14.6%	0.0%	3.7%	20.0%	7.6%	20.0%	6.9%	80.0%	51.3%
75-79	100.0%	46.2%	50.0%	8.8%	0.0%	1.9%	50.0%	4.0%	0.0%	2.8%	100.0%	39.8%
80-84	100.0%	46.2%	0.0%	8.8%	0.0%	1.9%	0.0%	4.0%	100.0%	2.8%	100.0%	39.8%

\*The age groups for the general population were split for ease of readability. Respondents over 85 are not presented due to a lack of data. ([Australian Bureau of Statistics, 2023b](#)), [Australian Competition and Consumer Commission \(2023b\)](#)

An additional frequency analysis was conducted to understand the relationship between age and the use of instant messaging platforms for various instant messaging platforms that formed part of this survey. As previously observed in Table 6.8, there is a clear trend within the general Australian population where the use of instant messaging platforms decreases with age. In Table 6.9 (below), a similar pattern is observed within the survey respondents for Snapchat and WhatsApp where the frequency of farmers that use the platform decreasing with age. By contrast, this is not the case with Facebook Messenger where survey respondents use the platform more than the general population across all age groups.

To further examine the relationship the age of the survey respondent and their usage of social media, a one-way analysis of variance was conducted. A statistically significant relationship where  $p < .05$  was only observed for TikTok ( $F(2.45,122)$ ,  $p = .006$ ), Instagram ( $F(2.238,124)$ ,  $p = .009$ ), and Snapchat ( $F(7.745,123)$ ,  $p < .001$ ) indicating that these platforms are used more regularly by younger people. No other statistically significant relationship between age and the frequency of use of the remaining social media and instant messaging platforms were observed.

**Table 6.9 - Age and percentage of respondents that use instant messaging platforms cross tabulated with the general population.**

Age	Facebook Messenger		Snapchat		WhatsApp	
	Farmers (n=113)	General population*	Farmers (n=37)	General population*	Farmers (n=51)	General population*
18-19	100.0%	83.0%	100.0%	49.1%	100.0%	39.1%
20-24	100.0%	83.0%	100.0%	49.1%	0.0%	39.1%
25-29	100.0%	74.4%	100.0%	28.7%	55.6%	53.1%
30-34	100.0%	74.4%	66.7%	28.7%	33.3%	53.1%
35-39	100.0%	75.4%	22.2%	15.6%	38.9%	53.0%
40-44	100.0%	75.4%	8.3%	15.6%	41.7%	53.0%
45-49	100.0%	68.6%	38.5%	11.9%	46.2%	45.5%
50-54	94.7%	68.6%	26.3%	11.9%	31.6%	45.5%
55-59	81.8%	64.7%	18.2%	6.9%	45.5%	37.4%
60-64	76.9%	64.7%	7.7%	6.9%	46.2%	37.4%
65-69	77.8%	52.6%	22.2%	2.9%	66.7%	32.7%
70-74	80.0%	52.6%	0.0%	2.9%	40.0%	32.7%
75-79	100.0%	37.6%	0.0%	0.7%	0.0%	21.0%
80-84	100.0%	37.6%	0.0%	0.7%	0.0%	21.0%

\*The age groups for the general population were split for ease of readability. Respondents over 85 are not presented due to a lack of data.

#### **6.4.6 Farm size**

To understand if there is any relationship between the size of a farm that a farmer lives or works on and their use of and type of social media and instant messaging platforms survey respondents were asked how large the farm that they lived or worked on is.

##### **6.4.6.1 Facebook**

A one-way between groups analysis of variance conducted to explore the impact of farm size on **personal** Facebook usage showed no statistically significant difference at the  $p < .05$  level for the seven land sizes ( $F(6, 125) = 1.158, p = .333$ ). A one-way between groups analysis of variance was conducted to explore the impact of farm size on **business** Facebook also showed no statistically significant difference at the  $p < .05$  level for the seven land sizes ( $F(6, 125) = 1.125, p = .352$ ) between farm size and **business** Facebook usage.

##### **6.4.6.2 Facebook Messenger**

A one-way between groups analysis of variance conducted to explore the impact of farm size on **personal** Facebook Messenger use showed a statistically significant difference at the  $p < .05$  level for the seven land sizes ( $F(6, 124) = 2.936, p = .011$ ) between farm size and **personal** Facebook Messenger usage. A statistically significant difference between small farms (1001-5000 acres) and large farms (greater than 100,000 acres) at the  $p < .05$  level when using Facebook Messenger ( $F(6, 124) = 2.936, p = .011$ ) for **personal** usage was found. The results of this analysis are presented in Table 6.10 (below).

The effect size, calculated using eta squared, was 0.131 indicating that the difference between mean scores between the groups was large. Tukey's HSD test for multiple comparisons found that the mean value of Facebook Messenger use was significantly different between small ( $M=3.92, SD=2.09$ ) and very large farms ( $M=2.25, SD=1.73$ ). This may be because small farms are typically closer to large regional centres making it easier for people to meet face to face due to the shorter distance that needs to be travelled to meet face to face and an increased sense of isolation for farmers on larger farms.

A one-way between groups analysis of variance conducted to explore the impact of farm size on *business* Facebook Messenger use showed no significant difference in usage regardless of farm size.

**Table 6.10 - ANOVA Analysis of farm size and how regularly Facebook Messenger is used for *personal* purposes**

Farm Size (acres)	n	Mean*	Std. Dev.	Std. Error	95% Confidence Interval		Min	Max
					Lower	Upper		
					Less than 1,000	23		
1,001 – 5,000	25	3.92	1.730	0.346	3.21	4.63	2	7
5,001 – 10,000	10	3.60	2.011	0.636	2.16	5.04	1	6
10,001 – 20,000	11	3.55	1.968	0.593	2.22	4.87	2	7
20,001 – 50,000	17	3.41	1.770	0.429	2.50	4.32	2	7
50,001 – to 100,000	14	2.36	.745	0.199	1.93	2.79	2	4
Greater than 100,000	24	2.25	1.726	0.352	1.52	2.98	1	7
<b>Total</b>	<b>124</b>	<b>3.27</b>	<b>1.857</b>	<b>0.167</b>	<b>2.94</b>	<b>3.60</b>	<b>1</b>	<b>7</b>

\* 1=Almost constantly, 2=Several times a day, 3=About once a day, 4=Several times a week, 5=Once a week, 6=Less than once a week, 7= I do not use this

**6.4.6.3 TikTok**

A one-way between groups analysis of variance conducted to explore the impact of farm size on *personal* TikTok Messenger use showed a statistically significant difference at the  $p < .05$  level between farms less than 1,000 acres and large farms (greater than 100,000 acres) ( $F(6, 122) = 4.778, p = .050$ ). The results of this analysis are presented in Table 6.11 (below).

The effect size, calculated using eta squared, was 0.102. indicating that the difference between mean scores between the groups was medium to large. Tukey’s HSD test for multiple comparisons also found that the mean value of TikTok use was significantly different between farms of less than 1,000 acres ( $M=7, SD=0.000$ ) and medium farms that were 20,001 to 50,000 acres ( $M=5.53, SD=2.157$ ) in size however this is because none of the farmers that lived or worked on farms less than 1000 acres used TikTok.

There was no statistical difference observed between *business* use of TikTok and farm size.

**Table 6.11 - ANOVA Analysis of farm size and how regularly TikTok is used for *personal* purposes**

Farm Size (acres)	n	Mean*	Std. Dev.	Std. Error	95% Confidence Interval		Min	Max
					Lower	Upper		
					Less than 1,000	23		
1,001 – 5,000	24	6.79	0.833	0.170	6.44	7.14	3	7
5,001 – 10,000	10	6.60	1.265	0.400	5.70	7.50	3	7
10,001 – 20,000	11	6.45	1.508	0.455	5.44	7.47	2	7
20,001 – 50,000	17	5.53	2.154	0.522	4.42	6.64	2	7
50,001 – to 100,000	13	6.00	1.915	0.531	4.84	7.16	2	7
Greater than 100,000	24	6.17	1.880	0.384	5.37	6.96	1	7
<b>Total</b>	<b>122</b>	<b>6.40</b>	<b>1.525</b>	<b>0.138</b>	<b>6.13</b>	<b>6.67</b>	<b>1</b>	<b>7</b>

\* 1=Almost constantly, 2=Several times a day, 3=About once a day, 4=Several times a week, 5=Once a week, 6=Less than once a week, 7= I do not use this

#### 6.4.6.4 LinkedIn

While there was no statistical difference between farms size for *personal* use of LinkedIn, there was a statistical difference between the use of LinkedIn for *business* use between larger farms at the  $p < .05$  level with  $p=.007$ ,  $F(6,121) = 3.155$ . The results of this analysis are presented in Table 6.12 (below).

The effect size, calculated using eta squared, was 0.142 indicating a large difference between mean scores. Tukey's HSD test for multiple comparisons found that the mean value of LinkedIn use was significantly different between farms of 10,000 to 20,000 acres ( $M=5.36$ ,  $SD=1.86$ ) and those between 20,001 to 100,000 acres (20,001 to 50,000  $M=6.94$ ,  $SD=0.250$ ; 50,000 to 100,000 acres  $M=6.92$ ,  $SD=0.277$ ). There was no statistical difference between other farm sizes and LinkedIn use.

**Table 6.12 - ANOVA Analysis of farm size and how regularly LinkedIn is used for *personal* purposes**

Farm Size (acres)	n	Mean*	Std. Dev.	Std. Error	95% Confidence Interval		Min	Max
					Interval			
					Lower	Upper		
Less than 1,000	23	6.26	1.453	0.303	5.63	6.89	2	7
1,001 – 5,000	24	5.92	1.412	0.288	5.32	6.51	3	7
5,001 – 10,000	10	6.80	0.632	0.200	6.35	7.25	5	7
10,001 – 20,000	11	5.36	1.859	0.560	4.11	6.61	2	7
20,001 – 50,000	16	6.94	0.250	0.063	6.80	7.07	6	7
50,001 – to 100,000	13	6.92	0.277	0.077	6.76	7.09	6	7
Greater than 100,000	24	6.33	1.167	0.238	5.84	6.83	3	7
<b>Total</b>	<b>121</b>	<b>6.33</b>	<b>1.261</b>	<b>0.115</b>	<b>6.10</b>	<b>6.56</b>	<b>2</b>	<b>7</b>

\* 1=Almost constantly, 2=Several times a day, 3>About once a day, 4=Several times a week, 5=Once a week, 6=Less than once a week, 7= I do not use this

#### 6.4.6.5 Snapchat

No significant difference between the use of Snapchat and the size of farm was observed for both *business* and *personal* use. A statistically significant difference was observed between farms that were less than 1,000 acres farms and farms that were greater than 100,000 acres at the  $p < .05$  level when using Snapchat ( $p = .035$ ) for *personal* usage. This may indicate that farmers may use Snapchat to communicate with friends due to an increased level of isolation. The results of this analysis are presented in Table 6.13 (below).

**Table 6.13 - ANOVA Analysis of farm size and how regularly Snapchat is used for *personal* purposes**

Farm Size (acres)	n	Mean*	Std. Dev.	Std. Error	95% Confidence Interval		Min	Max
					Interval			
					Lower	Upper		
Less than 1,000	23	6.74	1.054	0.220	6.28	7.19	2	7
1,001 – 5,000	25	5.68	2.174	0.435	4.78	6.58	2	7
5,001 – 10,000	10	5.20	2.201	0.696	3.63	6.77	2	7
10,001 – 20,000	11	6.09	2.023	0.610	4.73	7.45	2	7
20,001 – 50,000	17	6.18	1.667	0.404	5.32	7.03	2	7
50,001 – to 100,000	13	6.23	1.536	0.426	5.30	7.16	2	7
Greater than 100,000	24	5.00	2.341	0.478	4.01	5.99	1	7
<b>Total</b>	<b>123</b>	<b>5.87</b>	<b>1.954</b>	<b>0.176</b>	<b>5.52</b>	<b>6.22</b>	<b>1</b>	<b>7</b>

\* 1=Almost constantly, 2=Several times a day, 3=About once a day, 4=Several times a week, 5=Once a week, 6=Less than once a week, 7= I do not use this

**6.4.6.6 Twitter**

A one-way between groups analysis of variance conducted to explore the impact of farm size on *personal* use of Twitter showed a statistically significant difference at the  $p < .05$  level for the seven land sizes ( $F(6, 123) = 2.418, p = .031$ ). No significant difference between the use of Twitter for *business* purposes and the size of farm was observed. The results of this analysis are presented in Table 6.14 (below).

**Table 6.14 - ANOVA Analysis of farm size and how regularly Twitter is used for *personal* purposes**

Farm Size (acres)	n	Mean*	Std. Dev.	Std. Error	95% Confidence Interval		Min	Max
					Lower	Upper		
					Less than 1,000	23		
1,001 – 5,000	25	5.08	2.178	0.436	4.18	5.98	2	7
5,001 – 10,000	10	4.70	2.452	0.775	2.95	6.45	2	7
10,001 – 20,000	11	4.91	2.343	0.707	3.33	6.48	1	7
20,001 – 50,000	17	6.53	1.231	0.298	5.90	7.16	2	7
50,001 – to 100,000	13	6.92	0.277	0.077	6.76	7.09	6	7
Greater than 100,000	24	5.42	2.430	0.496	4.39	6.44	1	7
<b>Total</b>	<b>123</b>	<b>5.60</b>	<b>2.075</b>	<b>0.187</b>	<b>5.23</b>	<b>5.97</b>	<b>1</b>	<b>7</b>

\* 1=Almost constantly, 2=Several times a day, 3=About once a day, 4=Several times a week, 5=Once a week, 6=Less than once a week, 7= I do not use this

#### 6.4.6.7 WhatsApp

A one-way between groups analysis of variance conducted to explore the impact of farm size on *personal* use of WhatsApp use showed a statistically significant difference at the  $p < .05$  level for the seven land sizes ( $F(6, 123) = 2.264, p = .042$ ). No significant difference between the use of WhatsApp for *business* purposes and the size of farm was observed. The results of this analysis are presented in Table 6.15 (below).

**Table 6.15 - ANOVA Analysis of farm size and how regularly WhatsApp is used for *personal* purposes**

Farm Size (acres)	n	Mean*	Std. Dev.	Std. Error	95% Confidence Interval		Min	Max
					Interval			
					Lower	Upper		
Less than 1,000	23	6.30	1.490	0.311	5.66	6.95	2	7
1,001 – 5,000	25	5.08	1.824	0.365	4.33	5.83	2	7
5,001 – 10,000	10	6.00	1.764	0.558	4.74	7.26	2	7
10,001 – 20,000	11	5.27	1.902	0.574	3.99	6.55	2	7
20,001 – 50,000	17	6.59	1.176	0.285	5.98	7.19	3	7
50,001 – to 100,000	13	6.31	1.548	0.429	5.37	7.24	2	7
Greater than 100,000	24	5.71	1.654	0.338	5.01	6.41	2	7
<b>Total</b>	<b>123</b>	<b>5.86</b>	<b>1.676</b>	<b>0.151</b>	<b>5.56</b>	<b>6.16</b>	<b>2</b>	<b>7</b>

\* 1=Almost constantly, 2=Several times a day, 3=About once a day, 4=Several times a week, 5=Once a week, 6=Less than once a week, 7= I do not use this

#### 6.4.6.8 Other Platforms

There was no statistical difference for Instagram or YouTube for either personal or business use regardless of property size.

#### 6.4.7 Type of farm and social media use

To understand if there is any relationship between the type of farm and what social media and instant messaging platforms farmers used, a means analysis was performed. The results of this analysis are presented below in Table 6.16 and Table 6.17 and ignores the effects of gender, farm size and other external influences that may change what type of social media platforms that a farmer may use.

Table 6.16 - Means Analysis of Farm type and social media and instant messaging platform usage for *personal* purposes\*

Platform	Beef (N=93)			Wool (N=17)			Cropping (N=26)			Sheep Meat (N=14)			Other (N=18)		
	Mean	n	Std. Dev.	Mean	n	Std. Dev.	Mean	n	Std. Dev.	Mean	n	Std. Dev.	Mean	n	Std. Dev.
Facebook	2.81	93	1.63	3.59	17	2.09	2.77	26	1.53	3.29	14	1.90	3.50	18	2.04
Facebook Messenger	3.00	92	1.74	3.53	17	2.07	3.12	26	1.56	3.29	14	1.86	4.50	18	1.95
Instagram	4.80	92	2.11	5.41	17	2.21	4.73	26	2.33	5.21	14	2.29	5.39	18	2.03
TikTok	6.26	91	1.67	7.00	15	0.00	6.38	26	1.65	7.00	13	0.00	6.47	17	1.51
LinkedIn	6.20	91	1.49	6.00	15	1.46	5.85	26	1.74	5.92	13	1.55	5.71	17	1.57
Snapchat	5.92	91	1.91	5.88	16	1.93	4.88	26	2.32	5.85	13	2.04	6.17	18	1.92
Twitter	6.05	91	1.82	4.44	16	2.37	4.42	26	2.35	3.85	13	2.27	5.28	18	2.14
YouTube	5.03	91	1.55	5.25	16	1.57	4.81	26	1.86	5.08	13	1.50	4.83	18	1.47
WhatsApp	6.11	91	1.46	5.13	16	1.75	5.50	26	1.82	5.54	13	1.81	5.50	18	2.07
Other	6.79	33	0.93	7.00	5	0.00	7.00	7	0.00	7.00	4	0.00	6.71	7	0.76

\*Frequency of use: Almost constantly = 1, Several times a day = 2, About once a day = 3, Several times a week = 4, Once a week = 5, Less than once a week = 6, I do not use this = 7

Table 6.17 - Means Analysis of Farm type and social media and instant messaging platform usage for *business* purposes\*

Platform	Beef (N=93)			Wool (N=17)			Cropping (N=26)			Sheep Meat (N=14)			Other (N=18)		
	Mean	n	Std. Dev.	Mean	n	Std. Dev.	Mean	n	Std. Dev.	Mean	n	Std. Dev.	Mean	n	Std. Dev.
Facebook	4.81	93	1.75	5.12	17	2.03	4.58	26	2.18	4.36	14	2.02	5.06	18	1.8
Facebook Messenger	5.15	92	1.85	5.24	17	2.05	5.27	26	2.15	5.07	14	1.94	5.44	18	1.92
Instagram	6.54	90	1.06	6.56	16	1.03	6.19	26	1.83	6.31	13	1.55	6.33	18	1.14
TikTok	6.94	90	0.28	7	15	0	6.88	26	0.43	7	13	0	6.94	17	0.24
LinkedIn	6.48	89	1.1	6.44	16	1.09	6.15	26	1.52	6.46	13	1.13	6.28	18	0.9
Snapchat	6.97	90	0.18	7	15	0	6.62	26	1.24	7	13	0	6.76	17	0.75
Twitter	6.47	91	1.29	5.25	16	1.92	5.23	26	2.22	5.15	13	2.12	6.17	18	1.47
YouTube	6	92	1.51	5.94	17	1.48	5.92	26	1.6	5.93	14	1.59	6.33	18	0.97
WhatsApp	6.49	89	1.21	5.53	15	1.89	6.04	25	1.7	5.83	12	1.9	5.61	18	2.03
Other	6.94	35	0.34	7	6	0	7	11	0	7	4	0	6.75	8	0.71

\*Frequency of use: Almost constantly = 1, Several times a day = 2, About once a day = 3, Several times a week = 4, Once a week = 5, Less than once a week = 6, I do not use this = 7

The means analysis indicates that Beef producers are using Facebook (M=2.81, SD=1.63) and Facebook Messenger (M=3.00; SD=1.74) several times per day for personal use. Beef producers are the most frequent users of Facebook Messenger of farm types that were examined. Of the remaining platforms, only Instagram (M=4.8; SD=2.11) and YouTube (M=5.03; SD=1.55) are used at least once a week by Beef producers. The remaining platforms that are used for **personal** reasons are used less than once a week. The only platforms that Beef producers use more frequently than “Less than once a week” are Facebook (M=4.81; SD=1.75) and Facebook Messenger (M=5.15; SD=1.85).

A similar pattern is observed with Wool producers who use Facebook and Facebook Messenger for personal purposes the most regularly (M=3.59; SD=2.09) and (M=3.53; SD=2.07) respectively. Interestingly, wool producers were the highest users of WhatsApp for **personal** and **business** reasons (M=5.13; SD=1.746) and (M=5.53; SD=1.885). Wool producers indicated that they do not use Snapchat (M=7.00, SD=0.00), TikTok (M=7.00, SD=0.000) or Other social media platforms at all (M=7.00, SD=0.000) for **personal** reasons or Snapchat for **business** reasons (M=7.00, SD=0.000).

The means analysis shows that farmers who Cropped used Facebook (M=2.77; SD=1.531), Instagram (M=4.73; SD=2.325), Snapchat (M=4.88; SD=2.321) and YouTube (M=4.81; SD=1.855) for **personal** reasons more than any other type of farmer. Cropping farmers also used Instagram (M=6.19; SD=1.833), TikTok (M=6.88; SD=0.431), LinkedIn (M=6.15; SD=1.515); Snapchat (M=6.62; SD=1.225) and YouTube (M=5.92; SD=1.235) more regularly for **business** reasons than any other type of farmer.

Finally, Sheep Meat farmers were found to be the largest users of Facebook and Facebook messenger for **personal** and **business** purposes (M=5.07; SD=1.94) and (M=4.36; SD=2.023) respectively. Sheep Meat farmers were also the largest users of Twitter for both **personal** and **business** reasons (M=3.85; SD=2.267) and (M=5.15; SD=2.115). Like Wool producers, they were also found to not use TikTok (M=7.00, SD=0.000) or Snapchat for business and **personal** reasons (M=7.00, SD=0.000).

#### **6.4.8 Gender and social media use**

The relationship and role of gender and the use of social media and instant messaging platforms is examined in the following sections.

##### **6.4.8.1 Facebook**

A one-way between groups analysis of variance was conducted to explore the relationship and gender on the use of social media and instant messaging platforms. This analysis showed that there was no statistically significant difference at the  $p < .05$  level for any of the genders considered and how regularly they use Facebook for **business** or **personal** use.

##### **6.4.8.2 Facebook Messenger**

A one-way between groups analysis of variance conducted to explore the impact of gender on the use of Facebook Messenger. This analysis is presented below in Table 6.18. A statistically significant difference at the  $p < .05$  level shows that women use Facebook Messenger significantly more regularly than men for **personal** purposes ( $F(2,124) = 5.201, p = .007$ ). The effect size, calculated using eta squared, was 0.079 indicating a medium difference between mean scores. Tukey's HSD test for multiple comparisons found that the mean value of Facebook Messenger use was significantly different between men ( $M=3.86, SD=2.030$ ) and women ( $M=2.94, SD=1.641$ ) but not for other genders (transgender, non-binary/non-conforming, prefer not to respond) as identified in this study.

The opposite was observed when analysing the business use of Facebook Messenger with a statistically significant difference at the  $p < .05$  level shows that men use Facebook Messenger significantly more regularly for **business** purposes than women ( $F(2,124) = 3.771, p = .026$ ). The effect size, calculated using eta squared, was 0.059 indicating a small to medium difference between mean scores.

**Table 6.18 – ANOVA Analysis of the effect of gender on the Facebook Messenger**

Gender	n	Mean	Std. Deviation	Std. Error	95% Confidence		Min	Max
					Interval			
					Lower	Upper		
<b>Personal use of Facebook Messenger</b>								
Man	50	3.86	2.03	0.287	3.28	4.44	1	7
Woman	67	2.94	1.641	0.2	2.54	3.34	1	7
Prefer not to respond	7	2.14	1.345	0.508	0.9	3.39	1	5
<b>Total</b>	<b>124</b>	<b>3.27</b>	<b>1.857</b>	<b>0.167</b>	<b>2.94</b>	<b>3.6</b>	<b>1</b>	<b>7</b>
<b>Business use of Facebook Messenger</b>								
Man	50	4.9	1.972	0.279	4.34	5.46	1	7
Woman	67	5.51	1.7	0.208	5.09	5.92	1	7
Prefer not to respond	7	3.71	2.498	0.944	1.4	6.02	1	7
<b>Total</b>	<b>124</b>	<b>5.16</b>	<b>1.902</b>	<b>0.171</b>	<b>4.82</b>	<b>5.5</b>	<b>1</b>	<b>7</b>

\* 1=Almost constantly, 2=Several times a day, 3=About once a day, 4=Several times a week, 5=Once a week, 6=Less than once a week, 7= I do not use this

### 6.4.8.3 Instagram

A one-way between groups analysis of variance conducted to explore the impact of gender size on the use of Instagram and is presented in Table 6.19. A statistically significant difference at the  $p < .05$  level shows that women use Instagram significantly more regularly than men for *personal* purposes ( $F(2,122) = 4.345$ ,  $p = .015$ ). The effect size, calculated using eta squared, was 0.067 indicating a medium difference between mean scores. Tukey's HSD test for multiple comparisons found that the mean value of Instagram use was significantly different between men ( $M=5.62$ ,  $SD=1.894$ ) and women ( $M=4.48$ ,  $SD=2.198$ ) for *personal* use.

**Table 6.19 - ANOVA Analysis of the effect of gender on the *personal* use of Instagram**

Gender	n	Mean	Std. Dev.	Std. Error	95% Confidence		Min	Max
					Interval			
					Lower	Upper		
Man	50	5.62	1.894	0.268	5.08	6.16	2	7
Woman	67	4.48	2.198	0.268	3.94	5.01	1	7
Prefer not to respond	7	4.86	2.116	0.8	2.9	6.81	2	7
<b>Total</b>	<b>124</b>	<b>4.96</b>	<b>2.131</b>	<b>0.191</b>	<b>4.58</b>	<b>5.34</b>	<b>1</b>	<b>7</b>

\* 1=Almost constantly, 2=Several times a day, 3>About once a day, 4=Several times a week, 5=Once a week, 6=Less than once a week, 7= I do not use this

#### 6.4.8.4 Snapchat

A one-way between groups analysis of variance conducted to explore the impact of gender on the use of Snapchat (See Table 6.20). A statistically significant difference at the  $p < .05$  level shows that women use Snapchat significantly more regularly than men for *personal* purposes ( $F(2,123) = 2.638, p = .076$ ). The effect size, calculated using eta squared, was 0.042 indicating a small to medium difference between mean scores. Tukey's HSD test for multiple comparisons found no significant differences between men ( $M=6.28, SD=1.617$ ) and women ( $M=5.50, SD=2.186$ ) for *business* use of Snapchat.

**Table 6.20 - ANOVA Analysis of the effect of gender on the *personal* use of Snapchat**

Gender	n	Mean	Std. Dev.	Std. Error	95% Confidence Interval		Min	Max
					Interval			
					Lower	Upper		
Man	50	6.28	1.617	0.229	5.82	6.74	2	7
Woman	66	5.5	2.186	0.269	4.96	6.04	1	7
Prefer not to respond	7	6.43	1.134	0.429	5.38	7.48	4	7
<b>Total</b>	<b>123</b>	<b>5.87</b>	<b>1.954</b>	<b>0.176</b>	<b>5.52</b>	<b>6.22</b>	<b>1</b>	<b>7</b>

\* 1=Almost constantly, 2=Several times a day. 3=About once a day, 4=Several times a week, 5=Once a week, 6=Less than once a week, 7= I do not use this

No significant difference was observed between genders and the personal or business use of TikTok, LinkedIn, Twitter or YouTube.

#### 6.4.9 *Distance to nearest town and social media use*

Farmers in Australia are, in many cases, extremely isolated. To understand if there is any relationship between the distance a farmer lives from their nearest town and their use of social media for both *business* and *personal* purposes a one-way between groups analysis of variance conducted. The platforms that showed a statistically significant difference at the  $p < .05$  level and is presented below in Table 6.21.

**Table 6.21 – ANOVA analysis of platforms that had a statistically significant relationship between the distance to the nearest town and how regularly they are used**

Platform	n	Df (Degrees of freedom)	F (Ratio)	P (Probability)
Twitter (Personal use)	123	6	3.148	.007
Twitter (Business use)	123	6	3.975	.001
LinkedIn (Business)	121	3.6	2.468	.028

Interestingly a statistical difference was only observed for two platforms, Twitter and LinkedIn. Given the large amounts of users of instant messaging platforms, it is surprising to see that that farmers living large distances from towns or cities do not use these platforms in a significantly different way to those located closer to towns or cities. Further work is needed to be able to explain this phenomenon.

#### 6.4.10 *How are farmers using Facebook*

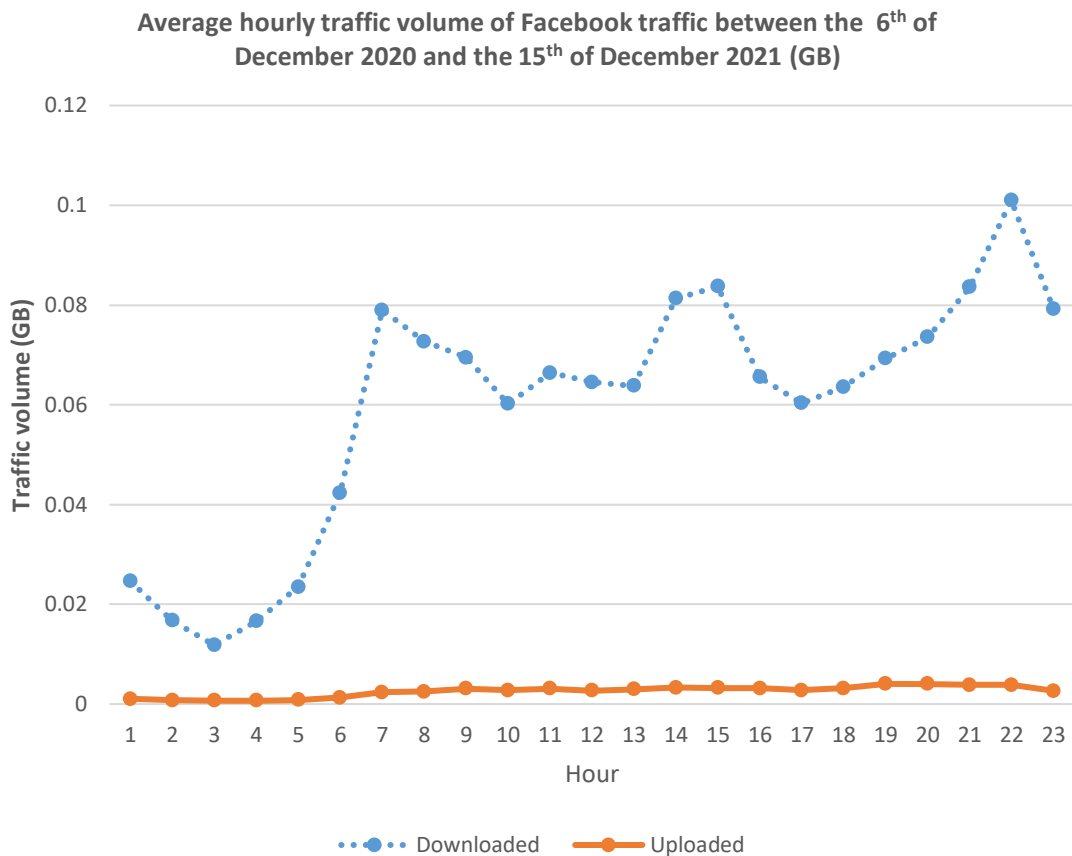
Facebook has been previously identified as an extremely important part of how farmers use the internet and makes up a significant component of farmers internet traffic. This section takes a deeper look at how farmers use and interact with Facebook by analysing the results of an online survey and the two unique secondary datasets. This analysis provides insight that is not typically accessible outside social media companies.

##### 6.4.10.1 **Traffic analysis of how farmers use Facebook**

The previous analysis of application traffic in Chapter Four identified Facebook as a major contributor to the participants internet traffic. To further investigate the use of Facebook by the participants, a DUR analysis of traffic data was conducted. As previously discussed in

Section 2.6.1, obtaining such data is difficult to capture using traditional data collection methods. Whilst the data is only representative of a group of farmers in North West Queensland, this analysis provided useful and novel insight into the time of day that farmers use Facebook.

For the purpose of this analysis, the whole dataset of 1,269,157 records was analysed over the period of twelve months from the 6<sup>th</sup> of December 2020 and the 15<sup>th</sup> of December 2021 resulting in a total of individual 26,466 records. To simplify this analysis any sessional variation, external influences or individual days such as the weekend are not considered. The entire dataset was then averaged on a per hour basis over a 24-hour period. The dataset did not include traffic data between 11pm and midnight for each day and as a result, this hour is not presented in the graph below.

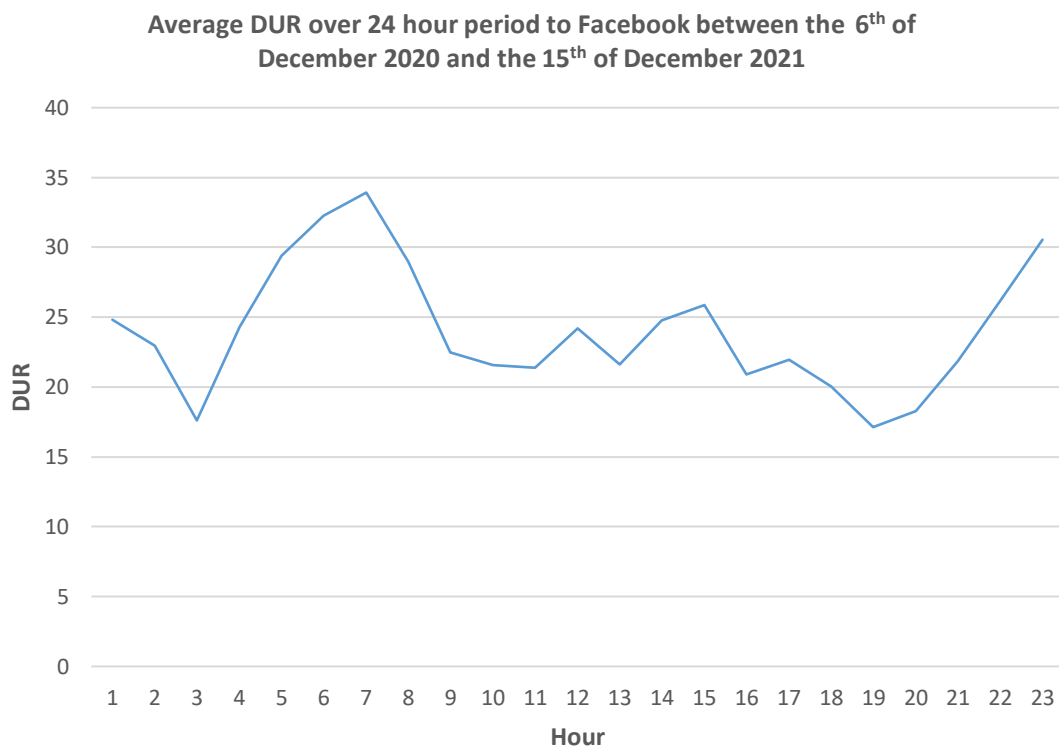


**Figure 6.1 – Average hourly traffic volumes to and from Facebook over a 24-hour period (Gb)**

An analysis of Figure 6.1 (above) shows a clear cycling pattern to both the upload and download traffic with a significant increase in download traffic focusing around the hours of 7am, 2-3pm and 10pm. This trend provides a daily insight into the lives of the group of farmers that participated in this study. From the authors anecdotal experience growing up in this region, these times represent at, or before breakfast in the morning, after lunch during the heat of the day when it is common for farmers to have a rest and just before bed in the evening. It is expected that the exact times that these peaks and troughs occur throughout the year will vary with the seasons.

#### 6.4.10.2 DUR analysis of how farmers were interacting with Facebook

To provide further insight into how the group of farmers were interacting with Facebook and to determine if any relationship between the time of day and when farmers upload to and download from Facebook exists, the DUR was calculated for a twenty-four-hour period. Further information regarding the DUR and how it is calculated is available in section 2.6.1.3. The DUR for the participants use of Facebook is presented below in Figure 6.2



**Figure 6.2 - Average DUR for Facebook traffic calculated over a 24 hour between the 6<sup>th</sup> of December 2020 and the 15<sup>th</sup> of December 2021**

An analysis of Figure 6.2 shows several clear features. The first is a low DUR occurring at 3am. This corresponds to the lowest traffic traveling to and from Facebook. A sharp increase is observed at 7am and represents the highest DUR over a 24-hour period. This may indicate that while farmers getting ready to work in the morning, they are taking the opportunity to catch up with events. A subsequent increase in DUR corresponds to lunch and mid-afternoon is observed, followed by an increase in DUR late into the evening. The most common time for Farmers to upload data to Facebook including pictures and photos occurs in the early evening around 7pm.

The patterns observed in the DUR shows that many farmers are only using Facebook when they are at the homestead. This may be as many farmers cannot use their phone when they are out in the paddock as they do not have any mobile phone coverage (see Section 5.4.1) and correspond to when they are in their home. These results provide insight that is useful to organisations and individuals such as agricultural extension officers to increase interaction with farmers.

#### **6.4.10.3 What are they using Facebook for?**

To provide more context on how farmers are using Facebook, respondents were asked how often they performed a variety of tasks on Facebook for *personal* and *business* purposes in the online survey. A means analysis was performed on the results and the outcome is presented in Table 6.22.

Table 6.22 - Means analysis of how regularly farmers use Facebook for *personal* and *business* purposes\*.

Action	Personal			Business		
	Mean	n	Std. Deviation	Mean	n	Std. Deviation
Write a post	5.5	109	1.31	5.8	85	1.14
Like something	3.7	109	1.68	5.3	85	1.60
Comment on a post	4.6	108	1.55	5.5	84	1.48
Get News	3.6	108	1.93	5.2	85	1.79
To keep up with day-to-day trends	4.7	107	1.99		N/A	
Advertise		N/A		6.2	84	1.12
Find groups of interest	4.8	107	1.56	5.7	85	1.38
To keep up to date with friends	3.6	107	1.66		N/A	
Buy or sell items or services	5.8	108	1.28	5.9	84	1.09
Browse timeline	5	108	1.91	6.2	85	1.24
Create an event	6.5	108	0.52	6.7	85	0.62
Help manage a group	6.2	108	1.41	6.6	85	0.90
React to a post	3.9	108	1.81	5.4	83	1.76
Play games	6.6	108	1.22	6.9	84	0.46
Communicate with customers		N/A		5.9	83	1.46
<b>Total</b>	<b>4.95</b>			<b>5.9</b>		

\*Frequency of use: Almost constantly = 1, Several times a day = 2, About once a day = 3, Several times a week = 4, Once a week = 5, Less than once a week = 6, I do not use this = 7

The means analysis in Table 6.22 (above) shows that farmers use Facebook for *personal* purposes much more often than *business* purposes (M=4.95) and (M=5.9) respectively. The most regular *personal* tasks that farmers use Facebook for was to “Get news” (M=3.6, SD=1.93) and “To keep up to date with friends” (M=3.6, SD=1.66). The *business* task the respondents most often used Facebook for was also to “Get News” (M=5.2, SD=1.79).

Other common tasks that farmers used Facebook for *personal* purposes included “Liking posts” (M=3.7, SD=1.68) and “Reacting to posts” (M=3.9, SD=1.81). The mean scores indicate that other activities occurred less than once a week on average including “Commenting on posts” (M=4.6, SD=1.55) and “Keeping up to date with day-to-day trends” (M=4.7, SD=1.99). The remaining activities occurred less regularly with farmers only “Creating an event” much less than once a week (M=6.5, SD=0.52) and “Playing Games” (M=6.6, SD=1.22).

This analysis shows that farmers are using Facebook for *business* purposes in a similar way to how they are using it for *personal* purposes, although much less regularly. Most activities occurred less regularly than once a week with the most common activity being “Get News” (M=5.2, SD=1.79) and the least common activities being “Playing Games” (M=6.93, SD=0.46) and “Creating an Event” (M=6.69, SD=0.618).

#### **6.4.10.4 Relationship between gender and the use of Facebook**

A one-way between groups analysis of variance was conducted to explore the impact of gender on the various ways that Facebook is used. Of all the activities examined, the only significant difference at the  $p < .05$  level was observed between genders was for respondents reacting to a Facebook post ( $F(2, 108) = 5.150, p = .007$ ). The effect size, calculated using eta squared, was 0.089 indicating that the difference between mean scores between the groups was medium. Tukey’s HSD test for multiple comparisons found that the mean value of “Reacting to a post” was significantly different between Men (M=4.96, SD=1.178) and women (M=3.44, SD=1.646) meaning that women were more likely to interact with Facebook posts than men were. No other statistically significant differences were observed in the personal and business use of Facebook between genders.

#### 6.4.10.5 Relationship between age and how Facebook is used

A one-way between groups analysis of variance conducted to explore the impact of age on how Facebook is used. A statistically significant difference at the  $p < .05$  level was observed for “Get News” ( $F(13, 108) = 2.121, p = .020$ ) and “Creating an event” ( $F(2, 108) = 2.289, p = .11$ ) of *personal* use indicating that younger people being more likely perform these actions. Tukey’s HSD test for multiple comparisons was not used to determine the effect size as several groups did not have at least two cases. No other statistically significant differences were observed in the *personal* use of Facebook.

When considering the *business* use of Facebook, a statistically significant difference at the  $p < .05$  level was observed for “Buying and selling items or services” ( $F(13, 84) = 2.300, p = .013$ ) and “Creating an event” ( $F(2, 108) = 2.289, p = .11$ ). The effect size, calculated using eta squared, was 0.299 indicating that the difference between mean scores between the groups was large. Tukey’s HSD test for multiple comparisons found that the mean value of “Buying and selling items or services” was significantly different between ages with younger people being more likely to do so. No other statistically significant differences were observed in the business use of Facebook.

### 6.5 Chapter Summary

This study demonstrates that social media (in particular Facebook) are a major component of a farmers internet usage and makes up a large part of the time that they spend online. This study has also identified that different types of farms use different social media and instant messaging differently and that farmers that grow crops used social media and instant messaging more than those that produce livestock.

By examining how farmers are using Facebook in more detail, this study found that the daily interactions by farmers with was primarily the consumption of information on Facebook and performing simple actions such as liking or reacting to a post. Farmers also tended to upload the most content to Facebook in the early morning around 3am and in the evenings around 7pm at night. The farmers that were surveyed also used Facebook for business purposes, albeit at a much lower less rate than they did for personal purposes. The finding that farmers use Facebook much more regularly that YouTube is of particular value to agricultural extension given that the latter has previously focused their efforts on using YouTube to disseminate new ideas and farming practices.

Other relationships were examined and shown to affect the types of social media and instant messaging platforms that farmers used. This study demonstrated that the distance a farm is located from their nearest town can have an effect on the type of social media and instant messaging platforms that a farmer uses. Platforms that are targeted at younger demographics including TikTok and Snapchat were also shown to be used less by older Farmers. Interestingly, Facebook was found to be used heavily across all age groups and unlike the general population, the usage of Facebook did not decrease as the respondents got older.

The analysis of the two unique secondary datasets online survey provides insight that is not typically accessible outside social media companies due to the commercially valuable nature of such data. This study provides the opportunity to help target farmers on social media and has a particular application in agricultural extension. Overall, this study demonstrates the importance of social media and instant messaging to farmers and informs future research.

## Discussion and Conclusion

How do farmers use the internet: A mixed methods approach						
Chapter 1 How do farmers use the internet?	Chapter 2 Methodology	Chapter 3 Demographic analysis	Chapter 4 Understanding how farmers use the internet	Chapter 5 Understanding the internet connectivity requirements of farmers	Chapter 6 How do farmers use social media	Chapter 7 Discussion and conclusion
1.1 Introduction	2.1 Introduction	3.1 Introduction	4.1 Introduction	5.1 Introduction	6.1 Introduction	7.1 Introduction
1.2 Background and research rationale	2.2 Philosophical perspective	3.2 Survey Dataset	4.2 Literature Review	5.2 Literature Review	6.2 Literature Review	7.2 Discussion of findings
1.3 Theoretical Framework	2.3 Methodological foundation	3.3 Data cleaning	4.3 Methodology	5.3 Methodology	6.3 Methodology	7.3 Response to rationale
1.4 Research Objective	2.4 Research Ethics	3.4 Respondent demographics	4.4 Results and Discussion	5.4 Results and Discussion	6.4 Results and Discussion	7.4 Contribution of the thesis
1.5 Thesis Outline	2.5 Study population	3.5 Chapter Summary	4.5 Chapter Summary	5.5 Chapter Summary	6.5 Chapter Summary	7.5 Future research potential
1.6 Chapter Summary	2.6 Data collection instruments					7.6 Limitations
	2.7 Research data storage					7.7 Conclusion
	2.8 Data analysis techniques					7.8 Recommendations
	2.9 Literature review methodology					
	2.10 Risk management					
	2.11 Chapter Summary					

### 7.1 Introduction

The final chapter of this dissertation discusses the results of the three previous studies that examined how farmers use the internet and responds to the research questions. This chapter begins with an introduction in Section 7.1 and follows with a discussion of the overall findings of the research project. Section 7.3 then follows with a response to the research rationale and to the contributions of this thesis in Section 7.4. Future research opportunities and the limitations of the results are then discussed in Sections 7.6 and Sections 7.7. Overall, the results and conclusions in this chapter provide important insight for policy and decision makers, researchers and other institutions that provide internet connectivity to farmers.

### 7.2 Discussion of findings

This dissertation represents one of the first academic attempts to take a big picture view of the role the internet plays in the day to day lives of farmers in Australia. The studies help present a wholistic view of the role internet connectivity plays in the day-to-day lives of farmers and their businesses and demonstrating the importance of internet connectivity to farmers. This work is one of the first examples of a study that examines the internet traffic of

how a particular occupation (in this case farmers) uses the internet and it examines how external factors influence this behaviour.

The poor digital literacy of farmers is extensively referenced in literature ([Charmley et al., 2016](#); [Lamb, 2017](#); [Morris et al., 2017](#); [Salemink et al., 2017](#); [Townsend et al., 2013](#)) However, there are very few studies that specifically and directly examine farmers within this phenomenon. As a result, it has been difficult to gain an insight into their digital literacy levels and the effect they have on a farmer's relationship with internet connectivity.

The work shows that farmers are using the internet more than they ever have. This result is not surprising given the increasing role the internet plays in modern society. In the case of farmers that have unconstrained internet access, the rate of increase in upload and download traffic volumes is occurring at a faster rate than the general Australian population.

The findings also demonstrate that how farmers are using the internet is changing. Over the period of the study (2018 to 2022), farmers were observed to increasingly upload more data relative to what they were downloading. This result may be reflective of the COVID-19 pandemic and supports work by [Feldmann et al. \(2021\)](#), [Thomas \(2021\)](#) and [Zachreson et al. \(2021\)](#) that show that the COVID-19 pandemic and resulting travel restrictions forced people and businesses to communicate via online means. Other external effect such as a major flooding event in 2019 were also demonstrated to change how farmers were using the internet.

This research project contributes to the literature by considering if limitations to farmers internet connection are real or perceived. It also demonstrated that any constraints (regardless of if they are real or perceived) that limit or otherwise restricts a farmers internet connection can result in behaviour changes by farmers and how they use the internet. This work also supports the findings by [Marshall and Dale \(2019a\)](#) that a monthly limit of the volume of data available to the farmers results in a change of behaviour by the farmer and can prevent them from using their internet connection the way that they would like to.

This dissertation also fills a gap in current knowledge by examining if farmers considered their internet connection being adequate and fit for purpose. Defining what an adequate internet connection is for a farmer is complex, in part because of the many different types of farming businesses, types and methods that require different levels of internet connectivity to

operate. As a result, what may be considered an adequate and fit for purpose internet connection for one farmer may not be for another. In addition, an internet connection that may be considered adequate at one point in time may no longer be so as the business grows and changes. This supports the work by [Roberts and Hernandez \(2019\)](#) that the availability of an internet connection is a necessary but not sufficient condition to ensuring that farmers have access to adequate internet connectivity that is fit for purpose and meets their needs.

This research project also supports the argument made by [Lamb \(2017\)](#) in their report *“Accelerating precision agriculture to decision agriculture : a review of on-farm telecommunications challenges and opportunities in supporting a digital agriculture future for Australia”* that farmers cannot be assumed to be “average households” when considering how they use the internet or by ISP’s that provide farmers internet connectivity. If farmers do not have an internet connection that they consider adequate and fit for purpose, agricultural development in regional and remote Australia risks being held back and the adoption of new technology such as IOT (Internet of Things) devices to monitor different aspects of their farm and cloud-based software packages and new approaches to farming risks being impeded.

Limiting factors in farmers use of the internet were also identified. For example, the findings highlight that respondents wished to study more but, in many cases, a lack of access to adequate internet connectivity limited their access to education. This finding supports the work by [Holden and Zhang \(2018\)](#) who argued that internet connectivity is reducing residents of regional and remote areas of Australia (including farmers) capacity to access educational services with [Whartion \(1966\)](#) positing that “the fundamental problem of agricultural growth is an education problem”. In addition, the findings show that for the farmers that took part in this study, simply knowing that their internet connection is constrained changed how they used it.

The findings of this work also showed that in many cases, farmers were not adopting new technology on their farm and choosing not to install security updates on their computers, devices, and other electronic equipment. Respondents that had constrained internet connection were prevented from updating the software on their devices as regularly as they wanted due to insufficient monthly data allowances, putting them at increased risk of cyber-attack. Ultimately, inadequate internet connectivity may result in a reduction in efficiency and productivity of these farms. These results support work by the [Australian Broadband Advisory](#)

[Council \(2021\)](#), [Charmley et al. \(2016\)](#), [Griffith et al. \(2008\)](#), [Lamb \(2018\)](#) and [Whitacre, Gallardo, et al. \(2014\)](#); and the argument that internet connectivity acts as an “enabler” ([Mandel et al., 2012](#)) and that without adequate internet connectivity these benefits are only partially realised.

The effect of real or perceived constraints on farmers internet connectivity were also shown to have broader implications and can result in unintended outcomes that can ultimately lead to challenges with the sovereignty and food security of Australia. Difficulties downloading security updates and challenges implementing new technologies on farms reduce or otherwise restrict the ability of farmers to improve their productivity. In addition, a heavy reliance on foreign internet connectivity providers exposes farmers and farm production to risks with a recent example being the Inmarsat (Inmarsat Ltd United Kingdom; <https://www.inmarsat.com/>) outage that delayed the planting of crops across Australian and New Zealand ([Australian Broadcasting Corporation, 2023](#)). The high adoption of the new Starlink™ satellite service supports the argument that there is a desire by farmers to access high speed internet connectivity that is less constrained than many of the internet connections that they typically use.

There is a perception that internet connectivity limitations persist despite the availability of unconstrained internet connectivity to every farmer in Australia. The majority of the farmers in this study, simply accept the perceived or real limitations to their internet connection and made no effort to access internet connectivity that was unconstrained. For the farmers that took part in the study, 69% indicated that they had an internet connection that is constrained and 58% ran out of data at least once a year.

The behaviour of farmers and their use of the internet was shown to be influenced by several factors including the environment, the type and size of farm and their level of isolation. In addition, farmers considered the speed, monthly data allowance and value for money when selecting their internet connection implying basic levels of functional connectivity literacy. This supports research that has found that the adoption of a technology does not occur uniformly ([Koul & Eydgahi, 2017](#); [Rogers, 2003](#); [van Dijk, 2005](#)). These results also support the work by [Marshall \(2023\)](#) who identified that consumers “layer up” multiple types of internet connectivity to ensure that they always have access to the internet.

This dissertation also demonstrates that social media and streaming makes up a significant proportion of farmers internet traffic in the group of farmers with unconstrained internet connectivity that were studied. This result is further supported by the online survey indicating that almost every farmer uses social media, and in many cases, do so more regularly than the general Australian population. This is despite many farmers considering that their usage of social media is being limited by their internet connection. The high level of social media usage may be the result of social media reducing farmers sense of isolation as argued by ([Gunn, Barrett et al. 2021](#)).

This work supports the argument by [Zipper \(2018\)](#) that that insight can be gained into the activities of farmers by examining their social media usage. It also supports the work by [Aaditi \(2020\)](#) and [Kanjiina \(2021\)](#) that show that different types of farmers each use social media differently.

### **7.3 Response to rationale**

The aim of this research project was to provide a broad foundation and guide future research into how farmers use the internet. It achieved its aim of exploring how farmers use the internet, including how they get connected and stay connected and laid a foundation that future research can build on. Like any large project however some parts worked better than others.

Upon reflection, the decision to take a pragmatic philosophical background allowed the selection of tools that best answered the research question and worked well for the purposes of this research project. The use of a mixed methods methodology was also a good fit and was appropriate and that techniques such as statistical and thematic analysis enabled greater insight than either method could provide alone. The use of additional qualitative data collection instruments such as focus groups would also have provided further insight into several of the key findings that were identified.

The access to quantitative data on the actual internet usage of farmers provided insight into the behaviour of farmers that could not be obtained any other way. Access to datasets that also included the participants vocation of farming, provided insight that was to my knowledge not obtained previously for any vocation. In addition, the development of the DUR tool to examine participants internet traffic, whilst being extremely simple provided a way to gain

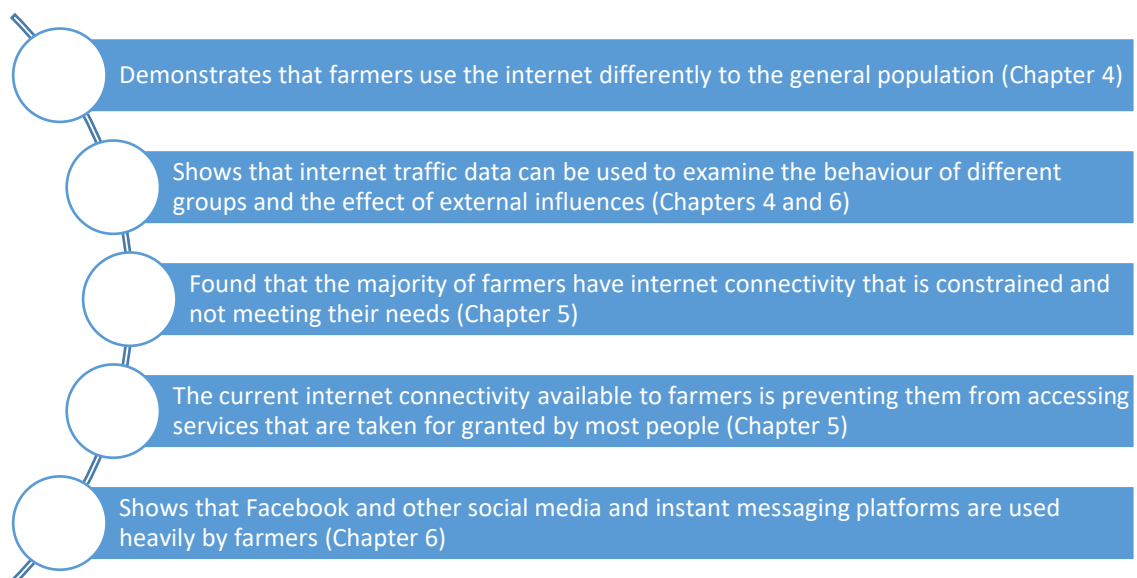
further insight into how respondents were using their internet connection that had also not been seen before.

Upon reflection, whilst analysing the results of the online survey, the additional of additional questions to collected data for several other longitudinal studies resulted in the survey being too long. The length of the survey reduced the number of respondents that completed the survey that may have otherwise done so were the survey shortened.

Like any complex project, a research project can change as it progresses. Upon data analysis of farmers raw internet traffic, it became clear that a significant proportion of the internet traffic of farmers that were studied consisted of social media platforms such as Facebook and YouTube. After a preliminary analysis of the initial datasets showed that social media was a key component of a farmers internet usage, a decision was made to examine how farmers were actually using the social media platforms in more detail.

#### 7.4 Contribution of the thesis

How farmers use the internet in Australia had not previously been examined on a wholistic basis. This dissertation is the first to examine this and contributes to knowledge by providing broad insight into how farmers are using the internet. These contributions are presented in Figure 7.1 below.



**Figure 7.1 - Contributions of this research project**

## CHAPTER 7 – Discussion and Conclusion

The research project found that in many cases the internet connectivity that is available to farmers is not meeting their needs or the needs of their business. This knowledge enables policy and decision makers in government and businesses that provide high speed internet to farmers to ensure that internet connectivity that is offered to farmers is both fit for purpose and meets their needs.

This dissertation showed that how farmers use the internet is different to the general population and can be affected by many factors such as the weather and the size, location and type of farm. This work also examined how farmers get connected and stay connected and demonstrated the importance the internet plays in their day to day lives. It shows that it is important to understand what the internet connectivity requirements of farmers are and that failing to do so risks severe consequences to Australia's food security and sovereignty.

This work demonstrated the importance of having access to adequate, fit for purpose internet connectivity to individual farmers, their businesses and the communities that support these farming businesses. This would lead to better adoption of technology, increased mental health, better data-based business decisions, improved agricultural practices and ultimately lead to increase profitability and more business savvy producers. This would also result in stronger, more resilient farming communities. This work also demonstrated the importance of social media to farmers, examined how it was used and considered factors that influence this usage.

Whilst no direct theoretical contributions were made by this dissertation, the purpose of this research project was to provide a broad foundation and guide future research into how farmers use the internet. It also fills a gap in the literature by providing knowledge that is not dependent on the direct participation of farmers to obtain. This dissertation also provides methodological contributions to knowledge by developing and applying the DUR Ratio, a novel tool to examine the breakdown of a group of farmers internet traffic by upload and download components of their internet traffic.

### **7.5 Future research potential**

To fully understand how farmers use the internet and to increase the robustness and generalisability of the results, additional work is required. Firstly, the online survey data collection instrument needs to be refined using the insight gained from the studies that make up this work. It then needs to be repeated to obtain a statistically meaningful sample size of the various different types of farmers.

Secondly, further work to examining the technical requirements of adequate internet connectivity for various types of farmers is critical to ensure that the internet connections that are and will be available to farmers meet their needs. Technical properties of the connection such as the upload and download speed on the internet connection, latency and reliability need to be considered. In addition, further examination of the effect of monthly data allowances limits and what point any perceived limitations in these allowances begin to change the behaviour of farmers.

Thirdly, more work is needed to examine the connectivity literacy of farmers and the general population. In particular, how a farmer's level of technical knowledge effects their view on the adequacy of their internet connections. Given the poor connectivity literacy of farmers that is evident, future work should also consider why farmers are not regularly using trusted advisors such as consultant to help improve their skills.

The effect of environmental factors on how farmers use the internet has the potential to provide insight into the day-to-day limes of farmers and businesses. Only two environmental factors were examined in this work however additional factors including economic, demographic, and social have the potential to provide additional insight that cannot be gained any other way.

Finally, it is clear that farmers are using social media differently to much of the general Australian population. The heavy use of social media by farmers presents opportunities for agricultural extension officers and other organisations to communicate with farmers in a way that is not otherwise possible. Further wok is needed to understand the reasons for these differences and identify ways that they can be used to engage with farmers.

## 7.6 Limitations

Limitations that should be considered when interpreting the findings and before generalising any of the results of this research project include the small sample size of farmers, especially when considering the wide and varied types of farming businesses. In addition, only a small percentage of farmers represent the majority of Australia's land mass and the challenges that they experience getting connected and staying connected to the internet are different to those located in more populous areas. As a result of these challenges, certain types of farmers and farming businesses may be underrepresented in this research projects findings.

The risk of measurement bias in these secondary datasets that are analysed in this study is acknowledged. A decision was made to take a neutral view on the risk of bias in `Dataset 1` and `Dataset 2` ([Saunders et al., 2019](#)). This is due to importance of the data to the day-to-day operations of the NISP that supplied the data and the use of industry standard software to collect this data.

The risk of bias in the survey results is also acknowledged as the survey was promoted through social media and not all populations may have had access to the internet given that the study's focus is on the lack of connectivity in RRR areas. This risk was managed through the promotion of the survey through other mediums such as email mailing lists and traditional media. There is also a risk of bias cause by respondents having difficulty with their internet connectivity, including having their data plan shaped or their connection not working. The online survey itself was self-reported and as a result allow the possibility that the survey respondents may respond based on their perception or understanding of their internet connectivity rather than their actual internet connection. It is also acknowledged that it is common for an internet connection to be shared across a whole household. Upon reflection, it became evident that the survey was too long, despite efforts being made to keep it as short as possible. As a result, some respondents chose to not complete the survey. Attention checks were not used in the online survey, and it is acknowledged that these may be useful in helping ensure that high quality responses are collected.

Due to the high proportion of beef producers in North West Queensland, the results of the analysis in this study may reflect production methods and behaviours that are different to other regions of Australia. In addition, the fast-moving and topical nature of this research also means that the results are representative at the point of time that this dissertation is

published and may not be in the future. The use of grey literature in this dissertation is also acknowledged.

The COVID-19 pandemic also led to challenges when collecting data, leading to a delay in data collection. Periodic lockdowns and travel restricted also resulted in challenges meeting in person and attending networking events such as conferences.

Care should be taken when generalising any of the results of this research project with consideration made to the design, philosophical perspective and the point in time that this study was conducted. With technology constantly changing and connectivity options improving, what was observed when these studies were undertaken may no longer be true. In addition, the wide and varied nature of farming must be considered when interpreting the results. It is also acknowledged that place-based solutions which may work for one group of farmers may not work for other farmers that are located in a different area.

## **7.7 Conclusion**

This dissertation examined how several groups of farmers use the internet for their business and in their day to day lives. It shows that farmers use the internet regularly and very differently to the general population of Australia. It did this by developing a novel methodology and tools to extract and examine two unique datasets that obtained from an ISP in North West Queensland. In doing so, it demonstrated the importance of access to such datasets and the unique insight into the behaviour of groups that they can provide. Environmental factors such as temperature and rainfall were also shown to change how farmers use the internet.

This dissertation demonstrates the importance of access to adequate and fit for purpose internet connectivity to farmers, the adoption of new and improved farming methods and the role of the internet in helping secure the food security of Australia and around the globe. It also examined the importance to social media and instant messaging platforms to farmers. Ultimately this work demonstrates that in many cases, farmers accessing high speed internet that is fit for purpose and meets their needs is a people problem, not a technology problem.

### 7.8 Recommendations

The findings of this dissertation present opportunities to ensure that farmers have adequate internet connectivity to meet their business and personal needs. The following four recommendations are presented below in Table 7.1 (below) for consideration by policy and decision makers.

**Table 7.1 - Recommendations**

Recommendations	Chapter
<i>Policy and decision makers consider the current and future needs of farmers when developing policy and designing infrastructure</i>	Chapters One and Two
<i>Datasets that can be used to understand how various groups use their internet connection be made available by large carriers and organizations such as NBN</i>	Chapters One and Two
<i>Future work acknowledges that how farmers use the internet is different to the general population and that farmers have different needs</i>	Chapters One, Two and Three
<i>Agricultural extension activities should also use Facebook to disseminate information in addition to YouTube</i>	Chapter Three

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**Appendices**

**Appendix I - Ethics approval notice one**

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**Appendix II - Ethics approval notice two**

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has been removed

**Appendix III - Information Sheet**



**INFORMATION SHEET FOR SURVEY**

**PROJECT TITLE: "Measuring and quantifying the benefits of improved Internet connectivity in regional and remote Australia and its effect on the adoption of technology"**

You are invited to take part in a research project about the benefits of improved Internet connectivity in regional and remote Australia. The study is being conducted by William Harrington and will contribute to a Doctorate of Philosophy in Agriculture, and Environmental Studies at James Cook University.

If you agree to be involved in the study, you will be invited to be participate in a survey. The survey should only take approximately 20 minutes of your time and will be conducted either online or via a printed copy

Taking part in this study is completely voluntary and you can stop taking part in the study at any time without explanation or prejudice.

If you know of others that might be interested in this study, can you please pass on this information sheet to them so they may contact me to volunteer for the study.

Your responses and contact details will be strictly anonymous. The data from the study will be used in research publications and reports including journal articles, a thesis and other publications. You will not be identified in any way in these publications.

If you have any questions about the study, please contact William Harrington or Dr Rachel Hay

**Principal Investigator:**  
**William Harrington**  
**College of Business, Law and Governance**  
**James Cook University**  
**Phone:**  
**Email: [william.harrington@my.jcu.edu.au](mailto:william.harrington@my.jcu.edu.au)**

**Supervisor**  
**Dr Rachel Hay and Prof. Ian Atkinson**  
**College of Business, Law and Governance**  
**James Cook University**  
**Phone:**  
**Email: [rachel.hay@jcu.edu.au](mailto:rachel.hay@jcu.edu.au)**

*If you have any concerns regarding the ethical conduct of the study, please contact:  
Human Ethics, Research Office  
James Cook University, Townsville, Qld, 4811  
Phone: (07) 4781 5011 ([ethics@jcu.edu.au](mailto:ethics@jcu.edu.au))*

**Appendix IV - Informed consent form**



**INFORMED CONSENT FORM**

PRINCIPAL INVESTIGATOR:	<b>William Harrington</b>  Email: <a href="mailto:william.harrington@my.jcu.edu.au">william.harrington@my.jcu.edu.au</a> Phone:
PROJECT TITLE:	Measuring and quantifying the benefits of improved Internet connectivity in regional and remote Australia and its effect on the adoption of technology
COLLEGE:	<b>College of Business Law and Governance</b>

I understand the aim of this research study is study the relationship between availability of internet connectivity and the adoption of technology. I consent to participate in this project, the details of which have been explained to me, and I have been provided with a written information sheet to keep.

I understand that my participation will involve an interview, questionnaire or participation in a focus group and I agree that the researcher may use the results as described in the information sheet.

I acknowledge that:

- taking part in this study is voluntary and I am aware that I can stop taking part in it at any time without explanation or prejudice and to withdraw any unprocessed data I have provided;
- that any information I give will be kept strictly confidential/anonymous and that no names will be used to identify me with this study without my approval;
- confidentiality cannot be assured in focus groups.

*(Please tick to indicate consent)*

I consent to be interviewed	<input type="checkbox"/>	Yes	<input type="checkbox"/>	No
I consent for the interview to be audio taped	<input type="checkbox"/>	Yes	<input type="checkbox"/>	No
I consent to complete a questionnaire	<input type="checkbox"/>	Yes	<input type="checkbox"/>	No
I consent to participate in a focus group	<input type="checkbox"/>	Yes	<input type="checkbox"/>	No

Name: <i>(printed)</i>	
Signature:	Date:

**Appendix V - Online survey and Data Dictionary**

<b>1</b>	<p><b>Informed consent text</b></p> <p>Thank you for participating in this survey. The aim of this study is to understand how farmers are using the internet and technology in their day to day lives and in their business. This survey should take less than 20 minutes, and all responses are anonymous.</p> <p>By clicking on the next arrow, you agree to participate in this study. Your participation is voluntary, and you may stop the survey at any time or choose not to answer any questions. However, due to the anonymous nature of online surveys any answers that you provide cannot be identified and therefore any unprocessed data cannot be removed from the study. All responses and contact details will be strictly confidential and data from the study will only be used in research publications and reports. You will not be identified in any way in these publications.</p> <p>This study is being conducted as part of the requirements of a Doctor of Philosophy degree. The principal investigator for this study is William Harrington from the College of Business, Law and Governance at James Cook University</p> <p>Phone: Email: <a href="mailto:william.harrington@my.jcu.edu.au">william.harrington@my.jcu.edu.au</a></p> <p>If you have any concerns regarding the ethical conduct of the study, please contact: Human Ethics, Research Office James Cook University, Townsville, Qld, 4811 Phone: (07) 4781 5011 (<a href="mailto:ethics@jcu.edu.au">ethics@jcu.edu.au</a>)</p>
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	Investigative questions	Type, Fact, Behaviour or Opinion	Variables	Measurement (Detail in which data is measured)
<b>2</b>	<p><b>What is your age?</b></p> <ul style="list-style-type: none"> <li>• Under 18 (1)</li> <li>• 18-19 (2)</li> <li>• 20-24 (3)</li> <li>• 25-29 (4)</li> <li>• 30-34 (5)</li> <li>• 35-39 (6)</li> <li>• 40-44 (7)</li> <li>• 45-49 (8)</li> <li>• 50-54 (9)</li> <li>• 55-59 (10)</li> <li>• 60-64 (11)</li> <li>• 65-69 (12)</li> <li>• 70-74 (13)</li> <li>• 75-79 (14)</li> <li>• 80-84 (15)</li> <li>• 85 and over (16)</li> </ul>	Fact	Age of respondent	Select one
<b>3</b>	<p><b>Do you live or work on a station or farm?</b></p> <ul style="list-style-type: none"> <li>• I live and work on a farm or station (1)</li> <li>• I live but don't work on a farm or station (2)</li> <li>• I work but don't live on a farm or station (3)</li> <li>• None of the above (4)</li> </ul> <p><u>If No, go to the end of the survey</u></p>	Fact	Does the respondent live or work on a farm or station	Select one

<b>4</b>	<p><b>What is your highest level of education?</b></p> <ul style="list-style-type: none"> <li>• Postgraduate degree (1)</li> <li>• Graduate diploma or certificate (2)</li> <li>• Bachelor’s degree(3)</li> <li>• Diploma or advanced diploma (4)</li> <li>• Certificate III or IV (5)</li> <li>• Certificate I or II (6)</li> <li>• Secondary education (7)</li> <li>• Primary education (8)</li> </ul>	Fact	Highest level of education	Select one
<b>5</b>	<p><b>What is your gender?</b></p> <ul style="list-style-type: none"> <li>• Man (1)</li> <li>• Woman (2)</li> <li>• Transgender (3)</li> <li>• Non-binary/non-conforming (4)</li> <li>• Prefer not to respond (5)</li> </ul>	Fact	Gender of the respondent	Select one
<b>6</b>	<p><b>What is your postcode?</b></p>	Fact	Postcode where the respondent lives	Free text
<b>7</b>	<p><b>How far is the nearest town from where you live or work?</b></p> <ul style="list-style-type: none"> <li>• In town (1)</li> <li>• Less than 5km (2)</li> <li>• 5 to 15 km (3)</li> <li>• 15 to 30 km (4)</li> <li>• 30 to 60 km (5)</li> <li>• More than 60 km (6)</li> <li>• More than 100km away (7)</li> </ul>	Fact	Distance from the respondent’s farm to their nearest town	Select one

<b>8</b>	<p><b>What size is your property? (If more than one property, please specify approximate total size)</b></p> <ul style="list-style-type: none"> <li>• Less than 1000 acres (1)</li> <li>• 1001 – 5000 acres (2)</li> <li>• 5001 – 10,000 acres (3)</li> <li>• 10,001 – 20,000 acres (4)</li> <li>• 20,001 – 50,000 acres (5)</li> <li>• 50,001 – to 100,000 acres (6)</li> <li>• Greater than 100,000 acres (7)</li> </ul>	Fact	Combined size of the station that the respondent lives or works on	<p>Select one</p> <p>I have added several additional options from 20,001 acres +</p>
<b>9</b>	<p><b>What type of farm or station do you live or work on?</b></p> <ul style="list-style-type: none"> <li>• Beef (1)</li> <li>• Wool (2)</li> <li>• Cropping (3)</li> <li>• Sheep Meat (4)</li> <li>• Other (text box) (5)</li> </ul>	Fact	Type of farming enterprise	Select many
<b>10</b>	<p><b>What type of business is the farm or station that you live or work on?</b></p> <ul style="list-style-type: none"> <li>• Family owned (1)</li> <li>• Company (2)</li> <li>• Other (Please specify) (3)</li> </ul>	Fact		

<p><b>11</b></p>	<p><b>Are you involved in the day-to-day decision making on the station or farm?</b></p> <ul style="list-style-type: none"> <li>• Yes (1)</li> <li>• No (2)</li> </ul>	<p>Fact</p>	<p>If the respondent is involved in the day-to-day management on the station or farm</p>	<p>Dichotomous Yes/No</p>
<p><b>12</b></p>	<p><b>Are you involved in making technology decisions for the business?</b></p> <ul style="list-style-type: none"> <li>• Yes (1)</li> <li>• No (2)</li> </ul>	<p>Fact</p>	<p>If the respondent is involved in the day-to-day management on the station or farm</p>	<p>Dichotomous Yes/No</p>
<p><b>13</b></p>	<p style="text-align: center;"><u>If Yes in Q11</u></p> <p><b>Including yourself, family and workers, how many people live and work on the farm or station?</b></p> <ul style="list-style-type: none"> <li>• Adult Family (1)</li> <li>• Children (including at boarding school) (2)</li> <li>• Workers (3)</li> <li>• Workers Children (4)</li> <li>• Non workers (e.g. aged/retired parents) (5)</li> <li>• Other (6)</li> </ul>	<p>Fact</p>	<p>Determine how many people live on the farm or station</p>	<p>Enter a number for each item with a sum calculated automatically</p>

<p style="text-align: center;"><b>14</b></p>	<p style="text-align: center;"><u>If No in Q11</u></p> <p><b>Including yourself, family and workers, how many people live and work on the farm or station?</b></p> <ul style="list-style-type: none"> <li>• Adult Family (1)</li> <li>• Children (including at boarding school) (2)</li> <li>• Owners or managers (3)</li> <li>• Owners or managers children (4)</li> <li>• Non workers (e.g. aged/retired parents) (5)</li> <li>• Other (6)</li> </ul>	<p style="text-align: center;">Fact</p>	<p>Determine how many people live on the farm or station from the workers point of view</p>	<p>Enter a number for each item with a sum calculated automatically</p>
<p style="text-align: center;"><b>15</b></p>	<p><b>What technology are you using on your farm?</b></p>	<p style="text-align: center;">Fact</p>	<p>List of technologies the responded uses</p>	<p>Select more than one</p>

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	<ul style="list-style-type: none"> <li>• Home PC (1)</li> <li>• Tablet such as an iPad (2)</li> <li>• Laptop (3)</li> <li>• Smartphone (4)</li> <li>• Mobile phone without a touchscreen (5)</li> <li>• Satellite Phone (6)</li> <li>• NLIS (with or without wand accessory) (7)</li> <li>• Bore or Remote Water Trough Cameras (8)</li> <li>• Remote Weather Stations (9)</li> <li>• Satellite Imagery (10)</li> <li>• GPS Collars or smart ear tags (11)</li> <li>• Scales in the yards (12)</li> <li>• IVF Technology (13)</li> <li>• Feedlot Technology (14)</li> <li>• Drones (15)</li> <li>• In paddock WIFI (16)</li> <li>• Smart TV (17)</li> <li>• Smart Watch or other fitness wearable (18)</li> <li>• Voice controlled smart speaker (e.g. Amazon Echo, Google Home) (19)</li> <li>• Game console such as an Xbox or PlayStation (20)</li> <li>• Home automation (21)</li> <li>• In paddock weighing (22)</li> <li>• Remote tank monitoring (23)</li> </ul>			
<p style="text-align: center;"><b>16</b></p>	<p><b>Please rate how important each of the following benefits is using technology on your farm or station are to you?</b></p> <ul style="list-style-type: none"> <li>• Save time monitoring the farm or station (1)</li> <li>• Reduce operating expenses (2)</li> <li>• Provide me with peace of mind (3)</li> <li>• Stay in touch with friends, family (4)</li> <li>• Staying in touch with relevant professionals (5)</li> <li>• Enables access to educational services including school of the air and university (6)</li> </ul>	<p>Opinion</p>	<p>How important the various benefits of technology are to the farmer or grazier</p>	<p>5-point Likert Scale with a free text option. Each response coded from 1-5</p> <ul style="list-style-type: none"> <li>• Not at all important (1)</li> <li>• Slightly important (2)</li> <li>• Moderately important (3)</li> <li>• Very important (4)</li> <li>• Extremely important (5)</li> </ul>

17	<p><b>Please rate how strongly each the following are preventing you from using more technology on your farm or station?</b></p> <ul style="list-style-type: none"> <li>• I don't have the confidence (1)</li> <li>• I don't have the technical knowledge (2)</li> <li>• I don't trust the provider with my data (3)</li> <li>• Too hard to select products (4)</li> <li>• My internet connectivity isn't good enough (5)</li> <li>• I don't have enough time to research my options (6)</li> <li>• I don't want to be locked into one provider (7)</li> <li>• The current technology doesn't give me enough information (8)</li> <li>• I have poor mobile phone coverage (9)</li> <li>• Technology does not provide enough value to my business (10)</li> <li>• Not enough other farmers around me are using the technology (11)</li> <li>• Technology is too expensive (12)</li> <li>• The technology is too hard to install (13)</li> <li>• The technology becomes obsolete too quickly (14)</li> <li>• Display This Choice:</li> <li>• If Q11 = 2</li> <li>• It is not available on the farm or station I work on (15)</li> <li>• Other (16)</li> </ul>	Opinion	Identify the reasons that are stopping the respondent implementing technology on their farm	<p style="text-align: center;">5-point Likert scale</p> <ul style="list-style-type: none"> <li>• Strongly disagree (1)</li> <li>• Somewhat disagree (2)</li> <li>• Neither agree nor disagree (3)</li> <li>• Somewhat agree (4)</li> <li>• Strongly agree (5)</li> </ul>
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<p><b>18</b></p>	<p><b>How you feel about the using technology to help run the farm or station?</b></p>	<p>Opinion</p>	<p>Are farmers using AgTech because they want to or because they must</p>	<p>Free text</p>
<p><b>19</b></p>	<p><u>If Q11 = Yes</u></p> <p><b>Please rate how important each of the following are to you:</b></p> <ul style="list-style-type: none"> <li>• Have a good, comfortable lifestyle on the farm or station for me and my family (1)</li> <li>• To operate the farm or station as a purely commercial enterprise (2)</li> <li>• To achieve a consistent return on investment and on my equity each year (3)</li> </ul>	<p>Opinion</p>	<p>Understand if the farm business is purely commercially driven and what their priorities are</p>	<p>5 Point Likert scale</p> <ul style="list-style-type: none"> <li>• Not at all important (1)</li> <li>• Slightly important (2)</li> <li>• Moderately important (3)</li> <li>• Very important (4)</li> <li>• Extremely important (5)</li> </ul>
<p><b>20</b></p>	<p><u>If Q11 = No</u></p> <p><b>Please rate how likely you would use more technology on the farm or station if it was available?</b></p>	<p>Opinion</p>	<p>Help understand if it is the employee or employer that is stopping the farm from using technology</p>	<p>Select one</p> <ul style="list-style-type: none"> <li>• Extremely likely (1)</li> <li>• Somewhat likely (2)</li> <li>• Neither likely nor unlikely (3)</li> <li>• Somewhat unlikely (4)</li> <li>• Extremely unlikely (5)</li> </ul>

<p><b>21</b></p>	<p><b>When was the last time you used a telehealth service to speak to a doctor or other medical professional?</b></p> <ul style="list-style-type: none"> <li>• Within the last month (1)</li> <li>• Within the last 1-2 months (2)</li> <li>• Within the last 3-6 months (3)</li> <li>• Longer than 6 months ago (4)</li> <li>• I have never used Telehealth (5)</li> </ul>	<p>Fact</p>	<p>How long since the respondent last used a telehealth service</p>	<p>Select one</p>
<p><b>22</b></p>	<p><u>If they have used a telehealth service (Q21 != 5)</u></p> <p><b>Please rate the following based on your experience using a telehealth service</b></p> <ul style="list-style-type: none"> <li>• Ease of use to of the software to attend the appointment (i.e. Zoom, Microsoft Teams or Facetime) (1)</li> <li>• Performance of your internet connection during the appointment (2)</li> </ul>	<p>Fact</p>	<p>How the respondent rates each item</p>	<p>5-point Likert scale</p> <ul style="list-style-type: none"> <li>• Extremely bad (1)</li> <li>• Somewhat bad (2)</li> <li>• Neither good nor bad (3)</li> <li>• Somewhat good (4)</li> <li>• Extremely good (5)</li> <li>• N/A (6)</li> </ul> <p>NA added in case respondent incorrectly selects option in 21 to avoid biasing data</p>

<p><b>23</b></p>	<p><u>If they have used a telehealth service (Q21 != 5)</u></p> <p><b>Do you believe that your internet connection is good enough to attend a telehealth appointment?</b></p>	<p>Opinion</p>	<p>Respondents' belief that their Internet connection was not a limiting factor</p>	<p>Yes(1) No (2)</p> <p>The ability to enter additional free text for each option</p>
<p><b>24</b></p>	<p><u>If They are involved in day-to-day decision making</u></p> <p><b>Please rank how important is access to the internet when attracting and retaining staff</b></p>	<p>Opinion</p>	<p>Does the current level of connectivity make it hard for the respondent to attract and retain staff?</p>	<p>5-point Likert scale</p> <ul style="list-style-type: none"> <li>• Not important at all (1)</li> <li>• Slightly important (2)</li> <li>• Moderately important (3)</li> <li>• Very important (4)</li> <li>• Extremely important (5)</li> </ul>
<p><b>25</b></p>	<p><u>If they only work on the farm or station</u></p> <p><b>Please rank how important access to the internet is when deciding which farm or station to work on?</b></p>	<p>Opinion</p>	<p>Importance of access to the internet to the respondent</p>	<p>5-point Likert scale</p> <ul style="list-style-type: none"> <li>• Not important at all (1)</li> <li>• Slightly important (2)</li> <li>• Moderately important (3)</li> <li>• Very important (4)</li> <li>• Extremely important (5)</li> </ul>

<p><b>26</b></p>	<p><b>Have any family member/s that grew up on the farm or station moved away?</b></p> <ul style="list-style-type: none"> <li>• Yes (1)</li> <li>• No (2)</li> </ul>	<p>Opinion</p>	<p>Filter question for the question below</p>	<p>Dichotomous Yes/No</p>
<p><b>27</b></p>	<p><u>If Yes to the question above</u></p> <p><b>To the best of your knowledge please rate the following reasons for them leaving the farm or station.</b></p> <p><b>(If there are more than one family members, please rate all the reasons)</b></p> <ul style="list-style-type: none"> <li>• The internet connectivity could not support their needs (1)</li> <li>• To study or get a trade (2)</li> <li>• The farm or station wasn't big enough for them to stay (3)</li> <li>• The business could not support them (4)</li> <li>• They didn't want to stay on the farm or station (5)</li> </ul>	<p>Opinion</p>	<p>How strongly the respondent believes each of the options</p>	<p>5-point Likert scale</p> <ul style="list-style-type: none"> <li>• Not important at all (1)</li> <li>• Slightly important (2)</li> <li>• Moderately important (3)</li> <li>• Very important (4)</li> <li>• Extremely Important (5)</li> </ul>

<p style="text-align: center;"><b>28</b></p>	<p><u>If Yes to a family member has moved away</u></p> <p><b>Please rate how likely they would be to return if the internet connectivity on the farm or station was better?</b></p>	<p style="text-align: center;">Opinion</p>	<p>How strongly the respondent believes the family members would return to the farm if it had better internet connectivity?</p>	<p>5-point Likert scale</p> <p>Very unlikely / Very likely</p> <ul style="list-style-type: none"> <li>• Extremely unlikely (1)</li> <li>• Somewhat unlikely (2)</li> <li>• Neither likely nor unlikely (3)</li> <li>• Somewhat likely (4)</li> <li>• Extremely likely (5)</li> </ul>
<p style="text-align: center;"><b>29</b></p>	<p><b>Please rate why you use each of the following technologies on your farm or stations:</b></p> <p><u>Only show technologies that they use on the farm/station from Q11 above</u></p>	<p style="text-align: center;">Opinion</p>		<p>5-point Likert scale</p> <ul style="list-style-type: none"> <li>• I only use this technology because I have to, and I don't enjoy it (1)</li> <li>• I only use this technology because I have to (2)</li> <li>• I use this technology but neither want nor don't want to (3)</li> <li>• I use this technology because I want to (4)</li> <li>• I use this technology because I want to, and I enjoy using it (5)</li> <li>• N/A (6)</li> </ul>

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	<ul style="list-style-type: none"> <li>• Home PC (1)</li> <li>• Tablet (2)</li> <li>• Laptop (3)</li> <li>• Smartphone (4)</li> <li>• Mobile phone without a touchscreen (5)</li> <li>• Satellite Phone (6)</li> <li>• NLIS (with or without wand accessory) (7)</li> <li>• Remote Cameras (8)</li> <li>• Remote Weather Stations (9)</li> <li>• Satellite Imagery (10)</li> <li>• GPS Collars (11)</li> <li>• Walk Over Scales (12)</li> <li>• Bore or Remote Water Trough Cameras (13)</li> <li>• IVF Technology (14)</li> <li>• Feedlot Technology (15)</li> <li>• Drones (16)</li> <li>• In paddock WIFI (17)</li> <li>• Smartphone (18)</li> <li>• Voice controlled smart speaker (e.g. Amazon Echo, Google Home) (19)</li> <li>• Game console such as an Xbox or PlayStation (20)</li> <li>• Home automation (21)</li> <li>• In paddock weighing (22)</li> <li>• Remote tank monitoring (23)</li> </ul>			<p>N/A added in case they selected a technology but don't use it</p>
<p>30</p>	<p><b>How often do you use each of the following?</b></p> <p><u>Only show technologies that they use on the farm/station from Q11 above</u></p>			<ul style="list-style-type: none"> <li>• Almost constantly (1)</li> <li>• Several times a day (2)</li> <li>• About once a day (3)</li> <li>• Several times a week (4)</li> <li>• Once a week (5)</li> <li>• Less than once a week (6)</li> <li>• I never use this device (7)</li> <li>• N/A (8)</li> </ul>

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	<ul style="list-style-type: none"> <li>• Home PC (1)</li> <li>• Tablet (2)</li> <li>• Laptop (3)</li> <li>• Smartphone (4)</li> <li>• Mobile phone without a touchscreen (5)</li> <li>• Satellite Phone (6)</li> <li>• NLIS (with or without wand accessory) (7)</li> <li>• Remote Cameras (8)</li> <li>• Remote Weather Stations (9)</li> <li>• Satellite Imagery (10)</li> <li>• GPS Collars (11)</li> <li>• Walk Over Scales (12)</li> <li>• Bore or Remote Water Trough Cameras (13)</li> <li>• IVF Technology (14)</li> <li>• Feedlot Technology (15)</li> <li>• Drones (16)</li> <li>• In paddock WIFI (17)</li> <li>• Smartphone (18)</li> <li>• Voice controlled smart speaker (e.g. Amazon Echo, Google Home) (19)</li> <li>• Game console such as an Xbox or PlayStation (20)</li> <li>• Home automation (21)</li> <li>• Display This Choice:</li> <li>• Display This Choice:</li> <li>• Remote tank monitoring (23)</li> </ul>			
<b>31</b>	<p><b>How would you describe your ability to get connected and stay connected to the internet?</b></p>	Belief	How the respondent rates their connectivity literacy	Free text

<p><b>32</b></p>	<p><b>How many of each of the following types of internet connections are there on the farm or station you live or work on?</b></p> <ul style="list-style-type: none"> <li>• NBN Satellite (1)</li> <li>• NBN Fixed Wireless (2)</li> <li>• NBN Fixed Line (Fibre or Cable) (3)</li> <li>• Mobile Broadband (3G, 4G or 5G - broadband that uses a mobile tower, via a modem or hot spotting off your phone) (4)</li> <li>• Non-NBN Fixed Wireless (WISPs - Wireless Internet Service Providers) (5)</li> <li>• ADSL (6)</li> <li>• Other Satellite (e.g Starlink™) (7)</li> <li>• LPWAN Technologies (including LTE-M, NB-IoT) for IoT (Internet of Things) devices (8)</li> <li>• Unsure (9)</li> <li>• Other (please specify) (10)</li> </ul>	<p>Fact</p>	<p>The number of each type of internet connection on their farm</p>	<p>Enter a number for each item, defaulting on 0</p> <p>For other, a text box</p>
<p><b>33</b></p>	<p><b>Who are your current internet provider/s?</b></p> <ul style="list-style-type: none"> <li>• Activ8me (1)</li> <li>• Ant Communications (2)</li> <li>• Bordernet (3)</li> <li>• Clear Broadband (4)</li> <li>• HarbourISP (5)</li> <li>• IPSTAR (6)</li> <li>• iiNet (7)</li> <li>• Optus (Not mobile phone) (8)</li> <li>• Reachnet (9)</li> <li>• SkyMesh (10)</li> <li>• Southern Phone (11)</li> <li>• Starlink™ (12)</li> <li>• Telstra (Not mobile phone) (13)</li> <li>• Vodafone (14)</li> <li>• Westnet (15)</li> <li>• Wi-Sky (16)</li> <li>• Not sure (17)</li> </ul>	<p>Fact</p>	<p>Respondents' current provider/s</p>	<p>Multiple select with an Other free text box</p>

	<ul style="list-style-type: none"> <li>• Other (18) (please specify)</li> </ul>			
34	<p><u>If they select NBN Satellite in Q25</u></p> <p><b>Do you use Sky Muster Plus™?</b></p> <ul style="list-style-type: none"> <li>• Yes (1)</li> <li>• No (2)</li> <li>• Not Sure (3)</li> </ul>	Fact	Does the respondent use Sky Muster Plus™	Select one
35	<p><b>Does your internet connection have a monthly download allowance?</b></p> <ul style="list-style-type: none"> <li>• Yes (1)</li> <li>• Yes, but only for some things (2)</li> <li>• No (3)</li> <li>• I am not sure (4)</li> </ul>	Fact	Does the respondent's internet connection have a download limit	Select One
36	<p><u>If != Yes in Q35</u></p> <p><b>How often do you run out of data allowance on your internet connection/s?</b></p> <ul style="list-style-type: none"> <li>• Every month (1)</li> <li>• Every 2-3 months (2)</li> <li>• Every 4-6 months (3)</li> <li>• About once a year (4)</li> <li>• Only during school holidays (5)</li> <li>• I never run out of data (6)</li> </ul>	Fact	How often respondent runs out of data allowance	Select one

<p><b>37</b></p>	<p><u>If Yes/Yes but to above (Q35)</u></p> <p><b>Does knowing that you have a monthly download allowance change how you use the internet?</b></p>	<p>Behaviour</p>	<p>Does the participant knowing that they have a data allowance change how they use the internet?</p>	<ul style="list-style-type: none"> <li>• Yes (1)</li> <li>• No (2)</li> </ul> <p>Dichotomous scale</p>
<p><b>38</b></p>	<p><u>If Yes to Q30</u></p> <p><b>What do you do to manage your monthly data allowance?</b></p>	<p>Behaviour</p>	<p>How does the participant manage their data allowance?</p>	<p>Free Text</p>
<p><b>39</b></p>	<p><u>If No in Q35</u></p> <p><b>What would you differently with the internet if you did not have a monthly data allowance?</b></p> <ul style="list-style-type: none"> <li>• Implement more technology on my farm (1)</li> <li>• Study (2)</li> <li>• Use more social media (3)</li> <li>• Stream more movies and tv shows (4)</li> <li>• Download updates for my computers and devices (5)</li> <li>• Nothing (6)</li> <li>• Other (Free text) (7)</li> </ul>	<p>Opinion</p>	<p>What would the farmer do differently if they didn't have a data limit</p>	<p>Multiple select with free text</p>

<p><b>40</b></p>	<p><b>How often would you experience the following with your internet connection?</b></p> <ul style="list-style-type: none"> <li>• Reliability issues (1)</li> <li>• Slower than expected speeds (2)</li> <li>• Poor support from your provider (3)</li> <li>• Poor WIFI coverage (4)</li> </ul>	<p>Behaviour</p>	<p>Identify what and how often the farmer has each issue</p>	<p>Matrix with time scale</p> <ul style="list-style-type: none"> <li>• Less than once a year (1)</li> <li>• At least once a year (2)</li> <li>• Several times a year (3)</li> <li>• Every 2-3 months (4)</li> <li>• At least once a month (5)</li> <li>• I can't remember (6)</li> <li>• I have never had this issue (7)</li> </ul>
<p><b>41</b></p>	<p><b>If you needed help with your internet connection, where would you go for information? (Select all that apply)</b></p> <ul style="list-style-type: none"> <li>• Phone a friend (1)</li> <li>• Local IT Consultant (2)</li> <li>• Internet Service Provider (ISP) (3)</li> <li>• BIRRR Facebook Group (4)</li> <li>• Regional Tech Hub Facebook Group (5)</li> <li>• Phone the Regional Tech Hub Hotline (6)</li> <li>• BIRRR Website (7)</li> <li>• Regional Tech Hub Website (8)</li> <li>• Ask on social media (9)</li> <li>• Google (10)</li> <li>• Display This Choice:</li> <li>• If Q11 = 2 - The owner or manager of the farm or station (11)</li> <li>• Whirlpool or other forums (please specify) (12)</li> <li>• Other (13) (Please specify)</li> </ul>	<p>Behaviour</p>	<p>Where does the respondent go for help</p>	<p>Multiple select plus two free text boxes</p>

<p><b>42</b></p>	<p><u>If they are a decision maker</u></p> <p><b>When you are selecting an internet connection, please rate how important each of the following criteria are:</b></p> <ul style="list-style-type: none"> <li>• Price (1)</li> <li>• Reliability (2)</li> <li>• Speed (3)</li> <li>• Data limits (4)</li> <li>• Latency (5)</li> <li>• Support (6)</li> <li>• Recommendation by a friend or neighbour (7)</li> </ul>	<p>Opinion</p>	<p>Rating for each component when selecting an internet connection</p>	<p>5-point Likert scale</p> <ul style="list-style-type: none"> <li>• Not at all important (1)</li> <li>• Slightly important (2)</li> <li>• Moderately important (3)</li> <li>• Very important (4)</li> <li>• Extremely important (5)</li> </ul>
<p><b>43</b></p>	<p><b>Please rate the following for the internet connection/s on your farm of station:</b></p> <ul style="list-style-type: none"> <li>• Price (1)</li> <li>• Reliability (2)</li> <li>• Speed (3)</li> <li>• Data limits (4)</li> <li>• Support (5)</li> </ul>	<p>Opinion</p>	<p>Rating for each component of the farmers internet connection</p>	<p>Likert scale</p> <ul style="list-style-type: none"> <li>• Extremely bad (1)</li> <li>• Bad (2)</li> <li>• Neither good nor bad (3)</li> <li>• Good (4)</li> <li>• Extremely good (5)</li> <li>• Not sure (6)</li> </ul>
<p><b>44</b></p>	<p><b>Only if Q15 = 1,2 or 3</b></p> <p><b>When was the last time you changed the following:</b></p> <ul style="list-style-type: none"> <li>• Internet Service Provider (1)</li> <li>• Plan (2)</li> <li>• Router or other WIFI equipment (3)</li> <li>• Type of internet connection (i.e. satellite to 4G) (4)</li> <li>• Mobile phone (5)</li> <li>• If Q15 = 1-3 Computer or laptop (6)</li> <li>• If Q15 = 2 Tablet Such as an iPad (7)</li> </ul>	<p>Behaviour</p>	<p>Identify how actively the farmer manages their internet connection</p>	<p>Select one</p> <ul style="list-style-type: none"> <li>• More than 3 years ago (1)</li> <li>• Within the last one to two years (2)</li> <li>• Within the last twelve months (3)</li> <li>• Within the last 6 months (4)</li> <li>• I can't remember (5)</li> <li>• I don't know (6)</li> </ul>

<p><b>45</b></p>	<p><u>If Q44 (1) = 1,2</u> <u>If Q44 (2) = 1,2</u></p> <p><b>Why haven't you changed your internet Service Provider or plan in more than two years?</b></p> <ul style="list-style-type: none"> <li>• Current plan meets my needs (1)</li> <li>• Plan choices confuses me (2)</li> <li>• It's too hard to change plans (3)</li> <li>• I don't know how to compare plans (4)</li> <li>• I don't know where to go to get advice (5)</li> <li>• Budget (6)</li> <li>• Other (Please specify) (7)</li> </ul>	<p>Behaviour</p>	<p>Why the respondent hasn't changed their plan or ISP in a long time</p>	<p>Select all that apply</p>
<p><b>46</b></p>	<p><b>How did you choose your internet connection (type, plan and provider)?</b></p> <ul style="list-style-type: none"> <li>• Advertising (1)</li> <li>• Letter in the post (2)</li> <li>• Recommended by a friend (3)</li> <li>• Recommended by an IT consultant (4)</li> <li>• Recommended in an online group (e.g BIRRR or Regional Tech Hub) (5)</li> <li>• Reviews (6)</li> <li>• Value for money (7)</li> <li>• Data allowance (8)</li> <li>• Speed (9)</li> <li>• Customer support (10)</li> <li>• I have used them for a long time (11)</li> <li>• Bonus offer (e.g free router) (12)</li> <li>• Other (please specify) (13)</li> </ul>	<p>Behaviour</p>	<p>Identify the factors that influence the respondent choosing their internet connection</p>	<p>Select all that apply</p>

<b>47</b>	<p><b>How much money do you estimate you are spending each month on internet connectivity?</b></p>	Fact	Amount the farmer is spending each month on access to the internet	Enter a number
<b>48</b>	<p><b>Do you ever receive any form of mobile service at your business location - even enough to receive a text message?</b></p> <ul style="list-style-type: none"> <li>• Yes - Inside the building. (1)</li> <li>• Yes - Directly outside the building. (2)</li> <li>• On my property - within 5 kms of the building. (3)</li> <li>• On my property - more than 5 kms from the building. (4)</li> <li>• No. (5)</li> </ul>	Fact	Does the farmer have access to mobile phone coverage	Select one
<b>49</b>	<p><b>Please rank how well you are able to use each of the following:</b></p> <ul style="list-style-type: none"> <li>• Computer (1)</li> <li>• Your Internet connection (2)</li> <li>• WIFI (3)</li> <li>• Smartphone (4)</li> <li>• Smart TV (5)</li> </ul>	Opinion	<p>Respondents level of understanding of how to use each item</p> <p>Not well at all to extremely well</p>	<p>5-point Likert scale</p> <ul style="list-style-type: none"> <li>• Not well at all (1)</li> <li>• Slightly well (2)</li> <li>• Moderately well (3)</li> <li>• Very well (4)</li> <li>• Extremely well (5)</li> </ul>

<p><b>50</b></p>	<p><b>On average, how often do you use the internet? This includes streaming movies or tv shows, or using social media?</b></p> <ul style="list-style-type: none"> <li>• Almost constantly (1)</li> <li>• Several times a day (2)</li> <li>• About once a day (3)</li> <li>• Several times a week (4)</li> <li>• Once a week (5)</li> <li>• Less than once a week (6)</li> </ul>	<p>Fact</p>	<p>How often the respondent uses the internet</p>	
<p><b>51</b></p>	<p><b>How often do you do use the internet to do each of the following:</b></p> <ul style="list-style-type: none"> <li>• Check your email (1)</li> <li>• Check the weather (2)</li> <li>• Use social media (3)</li> <li>• Stream a movie or tv show (4)</li> <li>• Browse the internet (5)</li> <li>• Use the internet for business purposes (6)</li> <li>• Video call friends and family (7)</li> <li>• Use video conferencing (8)</li> <li>• Buy something online (9)</li> <li>• Buy or sell livestock at an online auction (10)</li> </ul>	<p>Fact</p>	<p>What the respondent uses each device for</p>	<p>Matrix</p> <p>Only show Home PC, Tablet, Smartphone, Smart TV as option if they use them in Q11</p> <ul style="list-style-type: none"> <li>• Home PC (1)</li> <li>• Tablet (2)</li> <li>• Smartphone (3)</li> <li>• Smart TV (4)</li> <li>• I don't use this device (5)</li> </ul>

<b>52</b>	<p><b>How often do you do use the internet to do each of the following:</b></p> <ul style="list-style-type: none"> <li>• Check your email (1)</li> <li>• Check the weather (2)</li> <li>• Use social media (3)</li> <li>• Stream a movie or tv show (4)</li> <li>• Browse the internet (5)</li> <li>• Use the internet for business purposes (6)</li> <li>• Video call friends and family (7)</li> <li>• Use video conferencing (8)</li> <li>• Buy something online (9)</li> <li>• Buy or sell livestock at an online auction (10)</li> </ul>	Fact	How often the respondent does each activity	<ul style="list-style-type: none"> <li>• Almost constantly (1)</li> <li>• Several times a day (2)</li> <li>• About once a day (3)</li> <li>• Several times a week (4)</li> <li>• Once a week (5)</li> <li>• Less than once a week (6)</li> <li>• I don't do this (7)</li> </ul>
<b>53</b>	<p><b>Overall, please rank how well you consider your internet connection meets your:</b></p> <ul style="list-style-type: none"> <li>• Personal needs (1) If Q11 = 1</li> <li>• Business needs (2)</li> </ul>	Opinion	How farmer views the adequacy of their internet connection for each purpose	<p>5-point Likert scale for each item</p> <ul style="list-style-type: none"> <li>• Does not meet my needs (1)</li> <li>• Partially meets my needs (2)</li> <li>• Neutral (3)</li> <li>• Meets some of my needs (4)</li> <li>• Meets all of my needs (5)</li> </ul>
<b>54</b>	<p><b>Since the relaxation of COVID-19 social and physical distancing restrictions, how has your internet use and access changed?</b></p> <ul style="list-style-type: none"> <li>• The time I spend online has... (1)</li> <li>• The range of activities I do online have... (2)</li> <li>• My investment in internet access (e.g. data allowance, speed of connections, getting computers or devices) has... (3)</li> <li>• The digital skills I use to help with my work, study or home life have... (4)</li> </ul>	Fact	Question from the ADII	<p>Used the ADII scale</p> <ul style="list-style-type: none"> <li>• Decreased (1)</li> <li>• Stayed the same (2)</li> <li>• Increased (3)</li> </ul>

<p style="text-align: center;"><b>55</b></p>	<p><b>How has having access to technology changed your lifestyle? (Select 'Agree' or 'Disagree')</b></p> <ul style="list-style-type: none"> <li>• It has improved my communication with friends and neighbours (1)</li> <li>• Access to the internet saves time because I no longer have to travel to town to pay bills (2)</li> <li>• Technology has removed my feeling of isolation (3)</li> <li>• It allows me to spend more time with family (4)</li> <li>• It allows the male in the partnership to spend more time with the family (5)</li> <li>• I find technology a big waste of time, I would rather not have it (6)</li> <li>• It has increased my workload because I work outside during the day and inside at night (7)</li> <li>• Managing the technology keeps me involved with production practices (e.g. NLIS Management, Stockbook, IVF Programs) on the property (8)</li> <li>• Technology takes me away from outside duties that I would rather be doing (9)</li> </ul>	<p style="text-align: center;">Opinion</p>		<ul style="list-style-type: none"> <li>• Somewhat disagree (1)</li> <li>• Disagree (2)</li> <li>• Neutral (3)</li> <li>• Agree (4)</li> <li>• Strongly Agree (5)</li> </ul>
<p style="text-align: center;"><b>56</b></p>	<p><b>How often do you use each of the following social media platforms for personal use?</b></p> <ul style="list-style-type: none"> <li>• Facebook (1)</li> <li>• Facebook Messenger (2)</li> <li>• Instagram (3)</li> <li>• TikTok (4)</li> <li>• LinkedIn (5)</li> <li>• SnapChat (6)</li> <li>• Twitter (7)</li> <li>• YouTube (8)</li> <li>• WhatsApp (9)</li> <li>• Other (10)</li> </ul>	<p style="text-align: center;">Behaviour</p>	<p>How often the respondent uses each social media platform</p>	<p>Grid with the columns as below:</p> <ul style="list-style-type: none"> <li>• Almost constantly (1)</li> <li>• Several times a day (2)</li> <li>• About once a day (3)</li> <li>• Several times a week (4)</li> <li>• Once a week (5)</li> <li>• Less than once a week (6)</li> <li>• I don't use this (7)</li> </ul>

<p>57</p>	<p><b>How often do you use each of the following social media platforms for business purposes?</b></p> <ul style="list-style-type: none"> <li>• Facebook (1)</li> <li>• Facebook Messenger (2)</li> <li>• Instagram (3)</li> <li>• TikTok (4)</li> <li>• LinkedIn (5)</li> <li>• SnapChat (6)</li> <li>• Twitter (7)</li> <li>• YouTube (8)</li> <li>• WhatsApp (9)</li> <li>• Other (10)</li> </ul>	<p>Behaviour</p>	<p>Identify what platforms that the respondents use for personal and business purposes</p>	<ul style="list-style-type: none"> <li>• Almost constantly (1)</li> <li>• Several times a day (2)</li> <li>• About once a day (3)</li> <li>• Several times a week (4)</li> <li>• Once a week (5)</li> <li>• Less than once a week (6)</li> <li>• I don't use this (7)</li> </ul>
<p>58</p>	<p><u>It they use FB (Q56.1 != 7)</u></p> <p><b>When you use Facebook for personal use, how often do you do each of the following?</b></p> <ul style="list-style-type: none"> <li>• Write a post (1)</li> <li>• Like something (2)</li> <li>• Comment on a post (3)</li> <li>• Get news (4)</li> <li>• To keep up with day to day tends (5)</li> <li>• Find groups of interest (6)</li> <li>• To keep up to date with friends (7)</li> <li>• Buy or sell items or services (8)</li> <li>• Browse your timeline (9)</li> <li>• Create an event (10)</li> <li>• Help manage a group (11)</li> <li>• React to a post (12)</li> <li>• Play games (13)</li> </ul>	<p>Behaviour</p>	<p>Determine what activities the respondent uses Facebook for when using it for personal use</p>	<ul style="list-style-type: none"> <li>• Almost constantly (1)</li> <li>• Several times a day (2)</li> <li>• About once a day (3)</li> <li>• Several times a week (4)</li> <li>• Once a week (5)</li> <li>• Less than once a week (6)</li> <li>• I don't do this (7)</li> </ul>

<p>59</p>	<p><u>It they use FB (Q57.1 != 7)</u></p> <p><b>When you use Facebook for business use, how often do you do each of the following?</b></p> <ul style="list-style-type: none"> <li>• Write a post (1)</li> <li>• Like something (2)</li> <li>• Comment on a post (3)</li> <li>• Get news (4)</li> <li>• Advertise (5)</li> <li>• Find groups of interest (6)</li> <li>• Buy or sell items or services (7)</li> <li>• Browse your businesses timeline (8)</li> <li>• Create an event (9)</li> <li>• Help manage a group (10)</li> <li>• React to a post (11)</li> <li>• Play games (12)</li> <li>• Communicate with customers (13)</li> </ul>	<p>Behaviour</p>	<p>Determine what activities the respondent uses Facebook for when using it for business</p>	<ul style="list-style-type: none"> <li>• Almost constantly (1)</li> <li>• Several times a day (2)</li> <li>• About once a day (3)</li> <li>• Several times a week (4)</li> <li>• Once a week (5)</li> <li>• Less than once a week (6)</li> <li>• I don't do this (7)</li> </ul>
<p>60</p>	<p><b>Is there anything else you do on Facebook that wasn't listed?</b></p>	<p>Behaviour</p>	<p>Free Text</p>	

61	<p><b>Would you be interested in participating in an online focus group to help with this research?</b></p>	Other	Does the respondent want to participate in the focus group?	<p>Dichotomous Yes/No</p> <p>If so, please enter your name and email address</p>
62	<p><b>Redirect to a new page that the respondent can enter their email address in to subscribe to stay updated about the research project</b></p>	Other	Opportunity for the respondent to provide their contact details	<p>If so, please enter your email address</p>

## Appendix VI - Data Extraction and Anonymisation steps- Methodology

### *Dataset 1` – Manual process*

#### Data extraction task 1

##### Aim

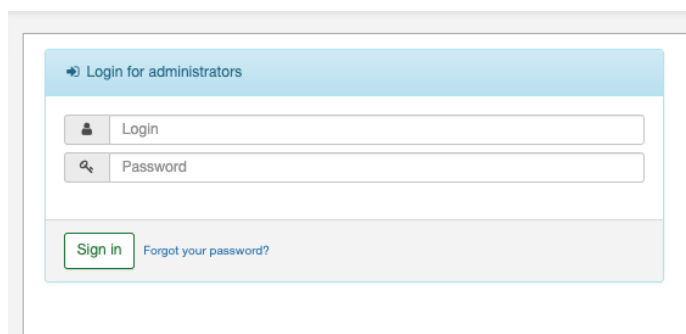
Extract data from the Splynx platform and store in a CSV after successfully anonymizing the data

##### Needed

- Splynx Credentials
- List of IP addresses from NISP of target customers and their type (i.e. Town or Farmer/Grazier)

##### Process

- 1) Visit the following URL: [http://\[REDACTED\]](http://[REDACTED])



➔ Login for administrators

Login

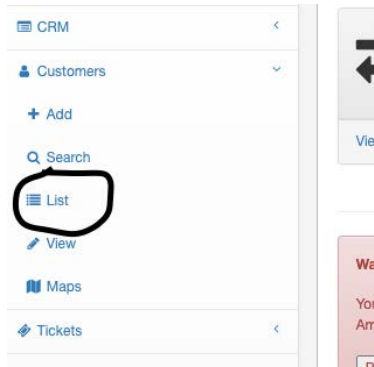
Password

Sign in [Forgot your password?](#)

Log in with the provided credentials

- 2) Select Customers -> List in the menu on the left

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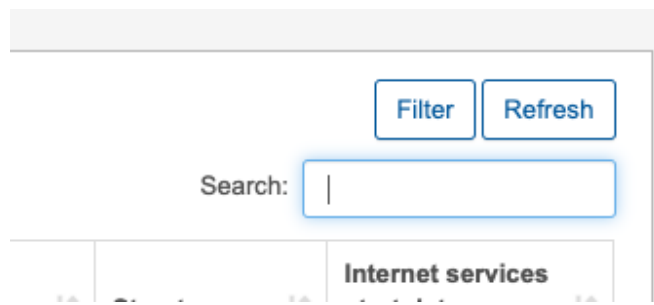
- 3) Create an excel spreadsheet with the following name:

Usage-Data-01-01-2018-<Date of the end of the previous month>-<Your Initials>-<Date Extracted>.xlsx

e.g. Usage-Data-01-01-2021-30-04-2021-WH-24-05-2020.xlsx

For each customer in the list of IP addresses that will be provided

- 4) Enter each IP address in the list provided in the search box on the right



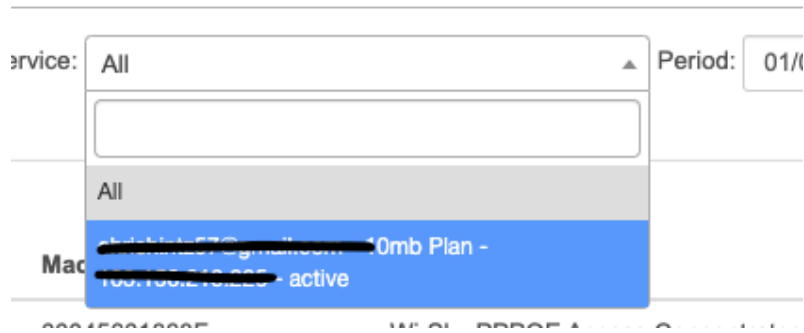
- 5) Click on the id of the customer that appears in the list



- 6) Select "Statistics" from the menu on the top



- 7) For the service where the IPv4 address that matches the one the IP address that you searched for



- 8) Change the period to the 1st of January 2018 to the 31<sup>st</sup> of December 2022 then click refresh



- 9) Scroll down to the "Usage by days" graph and select the table icon



10) Select all the data in the table for the entire date range and the copy it (CTRL-C)

i USAGE BY DAYS			Total	Bonus
Date	Total download	Total upload		
01/01/2018				
02/01/2018				
03/01/2018				
04/01/2018				
05/01/2018				
06/01/2018				
07/01/2018				
08/01/2018				
09/01/2018				
10/01/2018				
11/01/2018				
12/01/2018				
13/01/2018				
14/01/2018				
15/01/2018				
16/01/2018				
17/01/2018				
18/01/2018				

11) Paste the data into columns B to D as below

12) Generate a random identifier for the customer. The random identifier can be obtained from and will look similar to the following: cd053ed4-e503-4f9e-81d7-4c34c83178ea. Ensure that a new random ID is generated for each customer and that there are no duplicates.

13) Paste the random customer identifier into column A next to the data you just pasted. Ensure that when you fill down that the identifier does not change

14) In column E, enter the corresponding customer type from the list of IP addresses spreadsheet (i.e. 1 = Farmer/Grazier, 2 = Town customer). The data will look as follows:

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	A	B	C	D	E
1	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	1/01/2019	16.73	0.53	1
2	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	2/01/2019	2.04	0.48	1
3	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	3/01/2019	9.49	0.95	1
4	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	4/01/2019	4.91	0.99	1
5	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	5/01/2019	6.9	0.21	1
6	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	6/01/2019	15.79	0.72	1
7	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	7/01/2019	12.36	1.28	1
8	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	8/01/2019	16.05	5.29	1
9	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	9/01/2019	7.35	1.36	1
10	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	10/01/2019	12.89	0.99	1
11	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	11/01/2019	7.7	7.4	1
12	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	12/01/2019	7.68	4.56	1
13	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	13/01/2019	29.53	3.31	1
14	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	14/01/2019	8.17	1.45	1
15	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	15/01/2019	9.72	3.18	1
16	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	16/01/2019	10.28	5.07	1
17	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	17/01/2019	12.8	1.52	1
18	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	18/01/2019	10.3	2.58	1
19	cd053ed4-e503-4f9e-81d7-4c34c83178ea.	19/01/2019	5.84	0.64	1

Transferring the data

After completing the following steps for each IP address, copy the file that you have generated into the pre-shared folder in OneDrive that the primary researcher will provide to you.

After confirmation that the files have been uploaded to OneDrive, delete all local copies of the data, including any working files. You MUST also notify the NISP that you have completed the data extraction so that the credentials that you were provided can be disabled to ensure regulatory compliance.

**Dataset 2` - Extraction script – Python Script**

```

import os
import datetime
import time
import csv
import json
import uuid
from calendar import monthrange
import mysql.connector

mydb = mysql.connector.connect(
    host="<REDACTED FOR SECURITY>",
    user="<REDACTED FOR SECURITY>",
    password="<REDACTED FOR SECURITY>"
)
mycursor = mydb.cursor()
mycursor.execute("USE ntopng_data")

print("Connected to MYSQL")

def get_ntoppng_data(current_ip, start_timestamp, stop_timestamp, app):

    command = 'curl -s --cookie "user=<REDACTED FOR SECURITY>; password=<REDACTED FOR SECURITY>"
"http://<REDACTED FOR SECURITY>:3000/lua/rest/get/timeseries/ts.lua?ts_schema=host:ndpi&ts_query=host:{current_ip},ifid:4,protocol:{app}&version=4&epoch_end={stop_timestamp}&tskey={current_ip}&epoch_begin={start_timestamp}&initial_point=true&limit=12&extended=1"'.format(stop_timestamp =
str(stop_timestamp).split(".")[0], current_ip=current_ip,
start_timestamp=str(start_timestamp).split(".")[0], app=app)

    print (command)
    stream = os.popen(command)
    output = stream.read()
    return output

def extractMonthlyData(month, year):

    ip_addresses = get_ip_addresses()

    for ip in ip_addresses:

        for month in range(1, 12):

            for day in range(1, (monthrange(year, month)[1])):

                for hour in range(0, 23):

                    for app in get_applications():
                        try:
                            start_timestamp = datetime.datetime(year, month, day,
hour,0,0).timestamp()
                            stop_timestamp = datetime.datetime(year, month, day,
hour,59,59).timestamp()

                            data = get_ntoppng_data(ip[0],start_timestamp,stop_timestamp, app)
                            data = json.loads(data)

                            total_downloaded_data = 0
                            total_uploaded_data = 0

                            for rate in data['series'][0]['data']:
                                total_downloaded_data += (float(data['series'][0]['data'][rate])
* 60 * 5) #Work out htetotal data for that 5 minute intereval

                            for rate in data['series'][1]['data']:
                                total_uploaded_data += (float(data['series'][1]['data'][rate]) *
60 * 5) #Work out htetotal data for that 5 minute intereval

                            print (total_downloaded_data)
                            print (total_uploaded_data)

                            print ("Saving to database: " , day , "-" , month , "-" , year)

```

## CHAPTER 9 - Appendices

```
        sql = "INSERT INTO `application_data` (`id`, `user`, `user_type`,
`total_downloaded`, `total_uploaded`, `application`, `hour`, `day`, `month`, `year`) VALUES
(NULL, '(Katz et al.)', '{user_type}', '{total_downloaded}', '{total_uploaded}', '{application}',
'{hour}', '{day}', '{month}', '{year}');"
        format(
            application=app,
            user=ip[2],
            user_type=ip[1],
            total_downloaded=total_downloaded_data,
            total_uploaded=total_uploaded_data,
            day=day,
            hour=hour,
            month=month,
            year=year
        )
        print (sql)
        mycursor.execute(sql)
        mydb.commit()

    except ValueError:
        print (ValueError)

def get_applications():
    applications = [
        'AFP',
        'AJP',
        'Aacmazon',
        'Apple',
        'BGP',
        'BitTorrent',
        'CiscoSkinny',
        'CiscoVPN',
        'Citrix',
        'Cloudflare',
        'COAP',
        'DCE_RCP',
        'DNS',
        'DNS',
        'DoH_DoT',
        'Facebook',
        'FTP_CONTROL',
        'FTP_DATA',
        'Git',
        'Google',
        'GRE',
        'H323',
        'HTTP',
        'HTTP_PROXY',
        'ICMP',
        'ICE60870',
        'IMAP',
        'IMAPS',
        'IPsec',
        'Kerberos',
        'LDAP',
        'MDNS',
        'Memcached',
        'Microsoft',
        'Microsoft365',
        'Mining',
        'Modbus',
        'MQTT',
        'MS_OneDrive',
        'MySQL-TDS',
        'MySQL',
        'NetBIOS',
        'NetFlix',
        'NFS',
        'OpenVPN',
        'Oracle',
        'Playstation',
        'POP3',
        'POPS',
        'PostgreSQL',
```

## CHAPTER 9 - Appendices

```
'QUIC',
'RDP',
'Redis',
'RSYNC',
'RTMP',
'RTSP',
's7comm',
'SIP',
'Skype',
'SMBv23',
'SMTP',
'SMTPS',
'SNMP',
'SOCKS',
'SSH',
'STUN',
'Syslog',
'Targus Dataspeed',
'TeamViewer',
'Telnet',
'TFTP',
'TLS',
'Tor',
'Twitter',
'UBNTAC2',
'Unknown',
'UPnP',
'Viber',
'VNC',
'Whois-DAS',
'Xbox',
'Zabbix',
}
return applications

def get_ip_addresses():
    ip_addresses = [
        ["<REDACTED FOR SECURITY>",1, "<REDACTED FOR SECURITY>"],
        ["<REDACTED FOR SECURITY>",1, "<REDACTED FOR SECURITY>"],
        ["<REDACTED FOR SECURITY>",1, "<REDACTED FOR SECURITY>"],
    ];
    return ip_addresses

extractMonthlyData(12,2020)
extractMonthlyData(12,2021)
extractMonthlyData(1,2021)
extractMonthlyData(2,2021)
extractMonthlyData(3,2021)
extractMonthlyData(4,2021)
extractMonthlyData(5,2021)
extractMonthlyData(6,2021)
extractMonthlyData(7,2021)
extractMonthlyData(8,2021)
extractMonthlyData(9,2021)
extractMonthlyData(10,2021)
extractMonthlyData(11,2021)
extractMonthlyData(12,2021)

#!/usr/bin/env python
import fileinput
import csv
import sys

# This prevents prematurely closed pipes from raising
# an exception in Python
from signal import signal, SIGPIPE, SIG_DFL
signal(SIGPIPE, SIG_DFL)

# allow large content in the dump
csv.field_size_limit(sys.maxsize)
```

## CHAPTER 9 - Appendices

```
def is_insert(line):
    """
    Returns true if the line begins a SQL insert statement.
    """
    return line.startswith('INSERT INTO') or False

def get_values(line):
    """
    Returns the portion of an INSERT statement containing values
    """
    return line.partition('` VALUES ')[2]

def values_sanity_check(values):
    """
    Ensures that values from the INSERT statement meet basic checks.
    """
    assert values
    assert values[0] == '('
    # Assertions have not been raised
    return True

def parse_values(values, outfile):
    """
    Given a file handle and the raw values from a MySQL INSERT
    statement, write the equivalent CSV to the file
    """
    latest_row = []

    reader = csv.reader([values], delimiter=',',
                        doublequote=False,
                        escapechar='\\',
                        quotechar='"',
                        strict=True
    )

    writer = csv.writer(outfile, quoting=csv.QUOTE_MINIMAL)
    for reader_row in reader:
        for column in reader_row:
            # If our current string is empty..
            if len(column) == 0 or column == 'NULL':
                latest_row.append(chr(0))
                continue
            # If our string starts with an open paren
            if column[0] == "(":
                # Assume that this column does not begin
                # a new row.
                new_row = False
                # If we've been filling out a row
                if len(latest_row) > 0:
                    # Check if the previous entry ended in
                    # a close paren. If so, the row we've
                    # been filling out has been COMPLETED
                    # as:
                    # 1) the previous entry ended in a )
                    # 2) the current entry starts with a (
                    if latest_row[-1][-1] == ")":
                        # Remove the close paren.
                        latest_row[-1] = latest_row[-1][:-1]
                        new_row = True
                # If we've found a new row, write it out
                # and begin our new one
                if new_row:
                    writer.writerow(latest_row)
                    latest_row = []
                # If we're beginning a new row, eliminate the
                # opening parentheses.
                if len(latest_row) == 0:
                    column = column[1:]
                # Add our column to the row we're working on.
                latest_row.append(column)
        # At the end of an INSERT statement, we'll
        # have the semicolon.
```

## CHAPTER 9 - Appendices

```
        # Make sure to remove the semicolon and
        # the close paren.
        if latest_row[-1][-2:] == ");":
            latest_row[-1] = latest_row[-1][:-2]
            writer.writerow(latest_row)

def main():
    """
    Parse arguments and start the program
    """
    # Iterate over all lines in all files
    # listed in sys.argv[1:]
    # or stdin if no args given.
    try:
        for line in fileinput.input():
            # Look for an INSERT statement and parse it.
            if is_insert(line):
                values = get_values(line)
                if values_sanitary_check(values):
                    parse_values(values, sys.stdout)
    except KeyboardInterrupt:
        sys.exit(0)

if __name__ == "__main__":
    main()
```

**Appendix VII - Data management plan**



# Data Management Plan

## “How farmers use the internet”

**College of business, law and governance  
James Cook University**

**12/10/2021<sub>1</sub>**

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James Cook University eResearch  
Data Management Plan Template

1 of 6

Document History	
Author of this document	William Harrington
Author's relationship to the project/data	Principal researcher
Date document created	11/07/2020
Date document modified/updated	12/09/2021
Date to review this document	
Position or person responsible for reviewing the plan, if applicable	William Harrington and Dr Rachel Hay

About the Research Project		
1.0	Project title	How farmers use the internet
1.1	Project description	This project is an exploratory, descriptive study that analyses the daily internet usage patterns and trends for a group of farmers and graziers in North West Queensland over a period of three years.
1.2	Date project commenced	1/02/2020
1.3	Estimated date of project completion	30/11/2022
1.4	Name of Chief Investigator	William Harrington
1.5	Name/s of Partner Investigators	
1.6	Name of Supervisor (if applicable)	Dr Rachel Hay
1.7	Primary contact for the data	William Harrington
1.8	Name of School/Centre	College of Law, Business and Governance
1.9	Lead partner organisation	
1.10	Other partner organisations	Food Agility CRC

## Data Management Plan

### 2.0 FUNDING BODY

*Provide details of relevant funding bodies and their Grant application numbers.*

The primary researcher is receiving a Food Agility CRC scholarship that included a \$35,000pa stipend and a \$10,000pa operating fund.

### 3.0 DATA TO BE PRODUCED

*Describe the type of data; its characteristics and features; the methods or processes for producing the data; expected file formats; use of existing or third party data and any requirements associated with its us.*

Data to be produced may include:

- Raw and processed numerical data
- Raw and processed survey data
- Notes from interviews and focus groups

Any third party data that is used will be converted to a common file format and handled as per the requirements of the third party that is providing the data. All data will be processed by the primary researcher locally on a desktop computer using the appropriate software that may include Microsoft Excel and RStudio.

### 4.0 DATA DOCUMENTATION AND METADATA

*Provide details of: any supporting information to be developed or documented; any metadata standard, controlled vocabularies or ontologies that will be used to describe the data; quality assurance processes(calibration, validation, etc) to be applied to the data; and any processes that will be followed for documenting or organizing the data such as file name conventions, directory structures, etc.*

All additional data including data dictionaries will be stored along with the raw and processed data in a common, easily readable format such as a CSV or XLSX. There is no requirement for calibration data in this study.

All files and directories will be named and organised in a logical and consistent manner to ensure easy retrieval by a third party.

## 5.0 DATA STORAGE AND SECURITY

*Describe data storage and security arrangements : estimated size/amount of data; the location of where the data will be stored; the location of where the data will be backed-up to; frequency of back-up procedures and person responsible; how access to the data will be managed; any security or restriction issues relating to access or storage; and details of any physical or non-digital outputs that need to be stored including their location.*

An estimated one gigabyte of raw data will be collected over the course of the research project. This raw data will be stored in common and easy to read formats such as CSV and XLXS. During data processing, the data may be temporarily stored in other systems such as a database. Upon the completion of data processing, the data will be converted back to a common format and the temporary data destroyed.

The primary researched will be responsible for ensuring that all data is stored as per the JCU data storage policy on the JCU approved cloud storage platform OneDrive. All project data will be versioned and backed up to an alternate OneDrive cloud storage account at least once a month of which only the primary researcher will have access to. No physical or non-digital outputs will be generated as part of this research project.

## 6.0 ETHICS, COPYRIGHT AND IP

*Provide information on Ethics, copyright and IP arrangements : methods used to manage sensitive, confidential or private information; details of any restrictions due to ethical or privacy considerations on the data; information for consent forms relating to retention of the data and protection of privacy and confidentiality and steps taken to manage these (de-identification, etc); details of any agreements reached with partner organizations concerning ownership of the data; any copyright or licensing restrictions; or legislative regulations or requirements associated with collecting data from/sending to countries/locations outside of Australia.*

Ethics approvals H8108 and H8354 have been obtained before data collection commenced. Any confidential or sensitive data to be handled as per the requirements of the ethics applications and the National Statement on Ethical Conduct in Human Research.

All raw and processed data relating to this research project will be stored on the JCU compliant storage service, Microsoft OneDrive platform while the project is active. The JCU Research Data Management Toolkit states that data stored using this service will remain in Australia. The researchers will not transfer or stored and data outside the country.

<b>7.0</b>	<b>ACCESS, SHARING, REUSE OF DATA</b>
<p><i>Provide information on access, sharing and reuse arrangements including : what data or non digital outputs will be retained on completion of the project; where will these be stored; will some/all of the data be shared or published; any restrictions that negate sharing or re-use of the data; any requirements for mediating access to the data; what supporting information will be available to assist with interpretation of the data; what processes or steps will be taken to protect privacy and confidentiality; intent to deposit in data repository or archive; how soon after completion of the project can the data be shared; and any costs associated with making the data available for sharing or re-use.</i></p>	
<p>As there are only digital outputs from this project, upon completion of the project all raw data will be retained and stored by the tropical research hub along with the appropriate data dictionaries and other information that is required to interpret the data within 60 days. The data will be made publicly available to other researchers to reuse. If there are any restrictions to the sharing of data that provided by third parties, the data will be made available in a form that satisfies any requirements of the third party. If there are any costs that are incurred as part of making the data publicly available, they will be met by the primary researcher using project funds.</p> <p>All data that is shared will be fully anonymised to ensure that any personally identifiable information is removed</p> <p>Any public research outputs including academic papers will be published in the appropriate locations such as journals.</p>	
<b>8.0</b>	<b>DATA RETENTION AND DISPOSAL</b>
<p><i>Provide information on data retention and disposal, including : how long the data should be retained (in line with the JCU Act 1997, and/or Funding Body requirements; the disposal date and data disposal approval process that will be followed, in line with University Policy.</i></p>	
<p>It is not anticipated that any data will be disposed of over the course of the study however if this is required, it will be done in line with the requirements of JCU's Code for the Responsible Conduct of Research.</p> <p>Raw data will be retained and shared in line with the section 7.0 above.</p>	
<b>9.0</b>	<b>PRESERVATION &amp; ARCHIVING</b>
<p><i>Provide information describing preservation and archiving arrangements, including: the sustainable file formats that will be used for long term access; descriptive information details the organization and structure of the data and supporting information that will be made available with the data for re-use and interpretation; the person or position responsible for managing long-term access to the data; and any expected costs associated with long term storage of the data.</i></p>	
<p>The raw data and research outputs from this study will be stored in JCU's Tropical Research Hub. This service is provided by JCU at no cost to the researcher and will be accessible indefinitely. The data will be archived and formatted as per the requirements of the Tropical Research Hub and the researcher will ensure that the data is packed and formatted appropriately for long term storage. In addition the primary researcher will ensure that the archive contains all additional information that is required to interpret the data including data dictionaries.</p>	

### Important contacts

The **Tropical Data Hub** is JCU's central research data repository and discovery service. It provides you with all of your data management needs and a safe place to store your data. The Tropical Data Hub is a metadata repository which makes a record of your data and promotes your research through Research Data Australia and the World Wide Web.

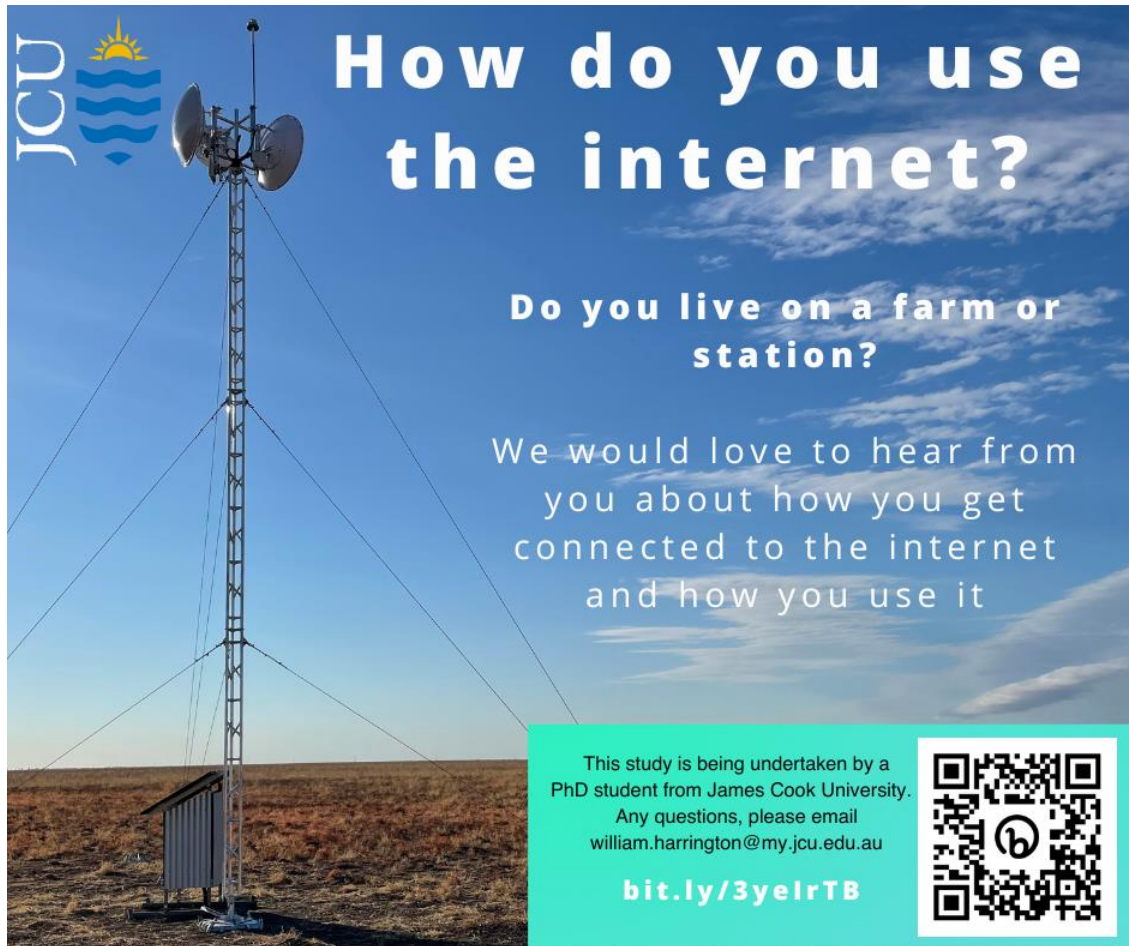
Tropical Data Hub  
eResearch Centre James  
Cook University  
Web address: <https://eresearch.jcu.edu.au/tdh>  
Phone: (07) 47 81 5067  
Email: [eresearch@jcu.edu.au](mailto:eresearch@jcu.edu.au)

Please contact Research Services at James Cook University for information about ethics, copyright and IP.

Research Services Main Office, Townsville  
Kevin Stark Building (DB019)  
Green Close  
James Cook University  
Phone: (07) 4781 5011  
Liaison Officer for Research Services, Cairns Campus  
ATFI building (E2)  
Phone: 4042 1786  
Web address: <http://www-public.jcu.edu.au/researchservices/>

**Appendix VIII - Social media posts distributing survey**

***Social media post 1***



The image is a social media post for a survey. It features a background photograph of a tall metal antenna tower with two satellite dishes, situated in a dry, open field under a clear blue sky. In the top left corner, the JCU logo is displayed, consisting of the letters 'JCU' in white and a blue and yellow sun-and-waves icon. The main text is in white, bold, sans-serif font. The survey title is 'How do you use the internet?'. Below it is the question 'Do you live on a farm or station?'. A paragraph follows: 'We would love to hear from you about how you get connected to the internet and how you use it'. At the bottom right, there is a teal-colored box containing white text: 'This study is being undertaken by a PhD student from James Cook University. Any questions, please email [william.harrington@my.jcu.edu.au](mailto:william.harrington@my.jcu.edu.au)'. Below this text is the URL [bit.ly/3yeIrTB](https://bit.ly/3yeIrTB) and a QR code with a small 'b' logo in the center.

**JCU**


# How do you use the internet?

**Do you live on a farm or station?**

We would love to hear from you about how you get connected to the internet and how you use it

This study is being undertaken by a PhD student from James Cook University.  
Any questions, please email [william.harrington@my.jcu.edu.au](mailto:william.harrington@my.jcu.edu.au)

[bit.ly/3yeIrTB](https://bit.ly/3yeIrTB)



**Social media post 2**



# "How do you use the internet?"

A JCU Research Project

---

Are you a farmers or graziers in North West Queensland? We would love to have a chat about your experiences accessing and using the internet.

If you are interested in participating in this research project, please email [william.harrington@my.jcu.edu.au](mailto:william.harrington@my.jcu.edu.au) or call William Harrington on

If you have any questions regarding this research, please contact Dr Rachel Hay at [rachel.hay@jcu.edu.au](mailto:rachel.hay@jcu.edu.au)

[I am interested in participating](#)

**Appendix IX - Position description of research assistant**

This administrative form  
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**Appendix X - Permission to reuse questions**

*Hay, 2018*

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*Wilson, 2022*

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has been removed

***Australian Digital Inclusion Index (Thomas, 2021)***

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has been removed

This administrative form  
has been removed