Key Factors Affecting Queensland Horticultural Farmers’ Effective Use of Internet Based Extension Tools

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Abstract

Traditionally, farming has played an important role in Australia’s economy but the challenges facing the Australian agricultural industry are immense. Australia’s gross value of agricultural production in 2015-2016 was $56 billion with Queensland’s gross value of agricultural production in this period being $13.2 billion. Australia’s agricultural industry produces over ninety percent of the domestic food supply and contributes over thirteen percent of Australia’s export revenue.

Yet the complex and dynamic challenges facing Australian farmers this century have created a vastly different operating environment to that of the twentieth century. Climate change, biosecurity threats, increasing consumer demands, food safety, escalating costs, acute shortage of skilled labour, import tariffs and quotas, and relatively low levels of government subsidisation compared to Europe, the US, and Japan are some of these challenges. Further challenges include the increasing demand for maximising productivity, maintaining environmental sustainability and social responsibility and remaining economically viable. Agricultural policy reforms have also increased the components in the RD&E environment with services now spread across public, private and industry providers resulting in a pluralistic and decentralised collection of organisations engaged in RD&E.

The Internet and Web 2.0 technologies are being increasingly used as extension tools for the dissemination of agricultural information. The effective use of the Internet has the potential to significantly expand the range of information available to farmers and to change how that information can be used. Hence, the ability for farmers to access, evaluate and apply information accessed from the Internet may facilitate knowledge development and enable more informed decision-making. This has the potential to empower farmers to more effectively address the immense challenges of twenty-first century farming and improve the overall operations, management, marketing and sustainability of farming businesses.

Despite the availability of Internet based extension (IBE) tools in the form of agricultural based websites and Web 2.0 technologies, not enough is known about the uptake and effectiveness of these tools. The overall goal of this research study was to investigate factors that affect the adoption and effective use of IBE tools by Queensland horticultural
farmers. In particular, the researcher endeavoured to explore and understand those factors that affect farmers' perceptions of agricultural based online content including the perceived benefits and ease of use.

A collective case study approach was chosen for this research study with four cases based on avocado, macadamia, pineapple and strawberry industry groups. This research methodology was adopted in part, because of its suitability to achieve a more in-depth understanding of Queensland horticultural farmers and their industry groups, thus providing a solid foundation for the discovery of rich research outcomes. This research methodology was applied within an interpretivist paradigm using Rogers' Diffusion of Innovations Theory.

According to Rogers, the adoption of an innovation is affected by an individual's perception of five key characteristics or attributes of that innovation. Therefore, individual farmers’ perceptions of relative advantage, compatibility, complexity, trialability and observability of Internet based extension tools were explored throughout this research study. The primary data collection techniques for this research study consisted of focus group questionnaires conducted with each of the four industry groups followed by individual face-to-face interviews with farmers from within these industry groups. Based on the research findings, this thesis argues that IBE tools are too difficult for farmers to use effectively and they will continue using their current methods unless IBE tools are better designed, promoted and supported.

The acquisition of new knowledge from this research study makes a practical contribution to local and global agricultural industries. The research findings provide a better understanding of what Queensland farmers think, want and need in relation to their adoption of IBE tools and rural-focused websites. This new knowledge may be used by public and private sector RD&E organisations engaged in the design, development and delivery of IBE tools. Therefore, application of this new knowledge should enable increased adoption and effectiveness of IBE tools. In particular, the research findings will better enable the Queensland Department of Agriculture and Fisheries to develop and share more effective IBE tools, thus improving their extension services. Economic benefits to Queensland farmers in terms of potential cost and time savings may also be achieved. The adoption of more effective IBE tools will also facilitate knowledge development and enable more informed decision-making which could lead to productivity gains and thus contribute to further growth in the agricultural industry.
Statement of Originality

The work contained in this thesis has not been submitted previously for a degree or diploma at any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature:  

Date:  13th July 2018
This thesis is dedicated to my Dad,
a very special man I loved and admired; a man who supported and encouraged me to be strong, open-minded and to believe in myself.

Wing Commander Harry Richard Maurice (Sonny)
13 July 1929 – 6 May 2013
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Chapter 1 — Introduction

1.1 Introduction

The rapid growth of the Internet and emerging digital technologies continue to drive the digital revolution whereby the ubiquitous nature of these technologies is transforming the way people work, live and conduct business. While the Internet enables fast and extensive access to voluminous information, the surge in digital capacity is driving global competition which has a significant impact on Australian agriculture. Innovation and growth are important in the Australian agricultural sector and individual farm businesses need to be supported in their adoption of technology to facilitate productivity growth and maintain competitiveness (Commonwealth of Australia 2016). This thesis addresses the adoption of technology in Queensland horticulture.

Figure 1.1: Interviews - South East Queensland and Wide Bay-Burnett Regions

In particular, this thesis explores the key factors affecting Queensland horticultural farmers’ use of Internet based extension (IBE) tools. Policy reforms and cutbacks in staff and financial resources (Nettle et al. 2017) has largely contributed to the need for IBE tools because traditional extension services, such as face-to-face advice and diagnostic services, require extensive staffing support and are expensive to deliver. To address this issue, IBE tools have been developed as an alternative, thus changing from the
traditional human-centred delivery approach to a digital platform. This substantial change in the delivery format of extension services and information dissemination underlies the fundamental reasons for this research study.

Within this research study, IBE tools are considered to be the use of technologies that access, store or utilise Internet based agricultural information and assist farmers to undertake various farming tasks. Some examples of these IBE tools include a digital spray diary, a website providing access to weather patterns and forecasts, a video link that demonstrates farm machinery, a blog that allows farmers to request advice from other farmers or extension experts, and a service that posts pest risk alerts possibly via a website, email, text message or Twitter. These IBE tools may be accessed via information and communication technologies (ICTs) such as laptops, desktop computers, tablets or smartphones.

This is a qualitative research study and was approached using a collective case study comprising four cases based on avocado, macadamia, pineapple and strawberry industry groups. The case study research methodology was applied within an interpretivist paradigm using key constructs from Rogers’ (2003) Diffusion of Innovations (DOI) Theory. Semi-structured interviews were the primary data collection method and these were conducted with farmers that volunteered following focus groups discussions. These interviews took place in several locations across South East Queensland and the Wide Bay-Burnett regions as shown in Figure 1.1.

1.2 Research problem

Despite Queensland horticultural farmers having access to various IBE tools in the form of rural-focused websites and Web 2.0 technologies, not enough is known about the practical use, acceptance and effectiveness of these tools. Therefore, the fundamental research problem is a lack of knowledge regarding the uptake and effectiveness of IBE tools.

Essentially, the research problem exists because of the extensive integration of digital media resulting in substantial changes in the delivery of extension services and information dissemination to farmers. In contrast to the traditional face-to-face delivery of extension services, there are many unanswered questions regarding the use and effectiveness of digital extension services. Hence, this research study addresses
questions surrounding the overall effectiveness of IBE tools and the digital delivery of extension services. Thus, factors affecting the adoption and effective use of IBE tools, as well as the overall perceived usefulness of various rural-focused websites, were used as guiding elements in this research study.

Restructuring and policy reforms in Queensland agricultural organisations have reduced the extent to which traditional extension services can be offered to farmers (Nettle et al. 2017). Digital technologies have been utilised in the development of IBE tools designed to maintain and supplement these diminishing extension services. The integration of IBE tools enables the digital dissemination of agricultural information to farmers and facilitates the delivery of extension services, thus substantially changing the traditional human-centred approach to a digital platform.

One of the most fundamental factors affecting the use of IBE tools is the possible lack of infrastructure and connectivity enabling fast, reliable and affordable access to the Internet. Inadequate access to the Internet and broadband infrastructure in rural areas of Australia is recognised as a source of inequity (Erdiaw-Kwasie & Alam 2016; Park 2017b; Salemink, Strijker & Bosworth 2017) and therefore may prevent or make it difficult for farmers to use IBE tools effectively. For example, accessing the Internet through ADSL connections with slow speeds and perhaps poor reliability is likely to discourage some farmers from using IBE tools. In addition to fundamental infrastructure and telecommunications services, farmers’ need to have the capacity or digital skills to use ICTs and IBE tools effectively. Again, there is insufficient knowledge on the potential digital exclusion in rural Queensland in terms of infrastructure and also farmers’ digital ability including farmers’ basic computer literacy skills attitudes and online activities (Barraket et al. 2017). These unknown aspects of access and ability to use the Internet are integral to farmers’ effective use of IBE tools and are therefore part of the research problem.

The following questions indicate fundamental aspects of this research topic that need investigation:

- Are Queensland horticultural farmers able to access fast, reliable and affordable Internet services?
• How do Queensland horticultural farmers perceive their skills compared to those skills needed to use rural-focused websites and IBE tools effectively; do farmers believe they have the necessary skills?
• What IBE tools and rural-based websites are being used and for what purpose?
• Why are these IBE tools and websites used as opposed to others that offer similar functionality?
• How are these websites perceived in terms of their complexity and relative advantage?
• How could these IBE tools and websites be improved to enable farmers to use them more efficiently and effectively?
• Are farmers’ information requirements satisfied by rural-focused websites or IBE tools and if not, how can this be resolved?

Answers to these questions contribute to the fundamental basis for this research study with the overall goal of better understanding the factors that influence Queensland horticultural farmers’ use of the Internet and IBE tools. Hence, factors that affect the adoption of these tools and the effective use of these tools need to be ascertained. These factors are of particular interest to the Queensland Government Department of Agriculture and Fisheries (DAF).

1.3 Research background

The proposed research study was originally initiated by the Queensland Department of Primary Industries and Fisheries which, through machinery of government changes amalgamated with the Department of Employment, Economic Development and Innovation (DEEDI). Further machinery-of-government changes resulted in DEEDI’s functions being redistributed and the Department of Agriculture, Fisheries and Forestry (DAFF) was formed in 2012. DAFF was changed to the Department of Agriculture and Fisheries in 2015.

The purpose of the original study was to evaluate a pilot website known as the ‘Queensland Agribusiness Decision Toolkit’ or ‘agbiz’. This website was developed to provide QPI&F clients and service providers with a range of Internet based tools with the aim of enhancing the capacity for informed agribusiness decision making. The pilot website evaluation was initiated with the view to further developing a web-based
agribusiness development site or portal to disseminate essential and relevant economic management tools to clients and stakeholders.

Shortly after the pilot study commenced, the Executive Director of Integrated Service Delivery at DEEDI suggested that it would be more beneficial if the research was undertaken within the context of more recent strategic goals. Hence, the requirements and implications of the Queensland Government’s more recent ‘franchise model’ was to be considered within the proposed research study. DEEDI was responsible for two franchise sites or portals with links from the ‘Business and Industry Franchise’ site but only one of these had specific relevance to the research study.

The ‘Farms, fisheries and forestry’ link (Business Queensland 2018a) and its content, which is accessible from within the ‘Industry sectors’ area of the Business Queensland homepage, was directly relevant to the research study and it has the potential to an online resource used by Queensland horticultural farmers. For example, the ‘Chemical controls’ link and the ‘Health, pests, weeds and diseases’ link on the ‘Land management’ webpage (Business Queensland 2018b) potentially offer useful resources to Queensland horticultural farmers. Similarly, the ‘Tools and software to help agricultural businesses’ link (Business Queensland 2018c) on the ‘Agriculture overview’ webpage also provides potentially useful resources to Queensland horticultural farmers. On this website (Business Queensland 2018c), a farmer would find links to software tools such as Agbiz and Rainman StreamFlow (software available to download or on CD that enables local rainfall patterns to be estimated based on one hundred years of monthly and daily records).

Nonetheless, while the emphasis on evaluating the target websites changed, the research was still quite similar in its focus on providing a better understanding of what Queensland horticultural farmers think and want in relation to IBE tools and rural-focused websites in order to further develop extension services. However, the research was expanded to take into consideration the additional requirements of DAF.

In this context, the research will contribute to DAF’s ability to harness innovative technology and the achievement of some of their strategic objectives including the following (DAF 2018a, p. 2):
• Create the conditions for successful agribusinesses and supply chains that encourage innovation, productivity and new job opportunities.
• Assist people in agriculture, fisheries, forestry and rural businesses respond to challenges and protect environmental values.
• Ensure the sustainable management of natural resources to underpin productivity and protect the environment.

The broader issue of barriers to adoption for rural communities and individual farmers based on access and use of the Internet also needs to be considered. As mentioned previously, one of the most fundamental barriers to accessing and using the Internet effectively in rural and remote areas of Queensland may be the lack of infrastructure and connectivity that enables fast, reliable and affordable access. Other potential barriers include socio-economic barriers such as age, education, gender, and income. A lack of awareness, trust and confidence in the technology may also contribute to limited use of the Internet. In order to provide pervasive and inclusive access to broadband Internet, the Australian Government’s broadband plan (ACMA 2017) acknowledges that three essential components must be strengthened including physical infrastructure, content and services and effective use. Thus, computer literacy skills, support and training may be inadequate, or there may be a lack of relevant and appropriate content. These issues may affect farmers’ effective use of IBE tools and therefore add to the research problem.

In order to address DAF’s objectives and the research study objectives in a rigorous manner, the proposed research study considered various elements and perspectives related to farmers’ potential use of IBE tools including the following:

• Consideration of socio-cultural factors that may impact farmers’ adoption of IBE tools;
• Farmers’ access to the Internet;
• Usability of rural-focused websites and IBE tools;
• Use of IBE tools to complement traditional extension activities; and
• Adoption of technology/innovation in rural areas.

Awareness of the business management perspective and the socio-cultural aspects of farming enabled a more informed understanding of farmers and the rural community in general but also their information requirements and the various factors that may affect
farmers’ use of the Internet and IBE tools. The effective use of the Internet has the potential to expand the range of information available to farmers and to change how that information can be used. Information accessed from the Internet may facilitate knowledge development and decision-making and therefore have the potential to improve the overall operations, management, marketing and sustainability of farming businesses. While the potential of the Internet is vast, not enough was known about farmers’ perspectives on Internet use and whether they were, in fact, using the Internet or IBE tools.

1.4 Research objectives

Despite Queensland horticultural farmers having access to various IBE tools in the form of rural-focused websites and Web 2.0 technologies, not enough was known about the uptake and effectiveness of these tools. Thus, factors affecting adoption and effective use of IBE tools, as well as the overall perceived usefulness of various rural-focused websites were explored in the research study.

The overall objective of the research study was to better understand key factors influencing Queensland horticultural farmers’ effective use of IBE tools. In order to address this objective, the research study included the following tasks:

- Identify websites used by Queensland horticultural farmers that are aimed at operational farming tasks;
- Assess the extent to which these websites have been used and adopted by Queensland horticultural farmers;
- Explore the IBE tools accessible through these websites;
- Determine Queensland horticultural farmers’ perceptions of the effectiveness of these websites and IBE tools including their complexity, relative advantage, quality, and relevance;
- Identify Queensland horticultural farmers’ perceptions of the inadequacies of these websites and IBE tools and how they could be improved;
- Use this new knowledge to develop a framework to guide the development of rural based websites in the future.
1.5 Research questions

The main research questions were developed based on the overall objective of the research study. The goals of the research and knowledge of the subject contribute to the development and justification of the research questions (Maxwell 2013). Given the researcher's background and expertise in IT and business, combined with the researcher's view that farms should be operated as businesses, the researcher has relevant knowledge and understanding of the business and IT perspectives of the research topic. The researcher does not, however, have direct farming experience and is therefore reliant on information sources ranging from journal articles and websites to key informants and of course farmers, to complement and develop her knowledge of agriculture. Published research literature was also examined to identify existing knowledge about the subject. Thus, the research questions were informed by the researcher’s background expertise and supplemented with knowledge obtained from an extensive literature review.

Accordingly, the following research questions were developed and addressed throughout the research:

1. How do Queensland horticultural farmers perceive IBE tools?
2. Why do Queensland horticultural farmers use IBE tools?
3. How can IBE tools better satisfy Queensland horticultural farmers’ information requirements?
4. How can IBE tools be tailored to enable Queensland horticultural farmers to more readily adopt these tools?

These research questions have been considered throughout the entire research journey. For example, they were used to evaluate and guide the adoption of various research methods which are discussed in the following chapters of this thesis.

1.6 Reasons for the research

Alternative methods for providing extension services to farmers and disseminating information need to be developed in light of agricultural restructuring and policy reforms that have reduced staff and funding resources (Nettle et al. 2017; Paschen et al. 2017). The Internet provides the potential for farmers to harness up-to-date knowledge and information from various sources locally and globally and therefore, IBE tools may
represent an effective supplement to traditional extension services. Currently, however, there is little published research to support this claim.

While various IBE tools and rural-focused websites have been developed, DAF’s knowledge of the uptake and use of these technologies is limited to anecdotal evidence and is sketchy at best. Queensland extension services need to understand farmers’ perspectives on IBE tools so that they have the capacity to design and develop relevant and useful IBE tools and provide a better extension service to Queensland farmers. Hence, the primary reason for undertaking this research study is to gain knowledge about the effectiveness of IBE tools, the extent to which Queensland horticultural farmers have adopted IBE tools, and factors that affect adoption and effective use of these tools.

To address this knowledge gap, this research study investigates farmers’ views on using IBE tools and rural-focused websites and explores farmers’ information requirements. Data collected from farmers in this research study has also enabled the establishment of guidelines that will inform the design and development of effective IBE tools that reflect farmers’ requirements. In this context, supporting farmers’ and their information requirements with more effective, useful and user-friendly IBE tools has the potential to better satisfy farmers’ needs and increase the adoption of these tools.

The Internet appears to be an ideal platform for farmers to take advantage of accessing rural based information and extension tools. But despite the Australian Government’s expectation that the NBN will encourage technology use and uptake (nbn co 2018), this outcome is not guaranteed. Even with fast, reliable and affordable broadband services, farmers still may be reluctant to take advantage of the potential of the Internet. This research study directly addresses the gap between farmers being offered an opportunity to actively participate in the digital economy and the uptake of that opportunity. As there is little published research relating to factors that affect Queensland horticultural farmers’ use of the Internet, this research study will reduce that gap.

1.7 Significance of the research

This research contributes to scholarly knowledge in the research domain of Information Systems particularly in the adoption of agricultural innovations. By undertaking qualitative research, it is anticipated that the researcher will acquire an in-depth understanding of the human side of farmers’ use of the Internet, their interpretations and
Chapter 1 – Introduction

perceptions. Therefore, the proposed research study will provide new knowledge about Australian farmers’ perceptions of IBE tools, their needs and how development can meet those specific needs. The research study will also contribute new knowledge in the area of usability of World Wide Web user interfaces, human-centred design and usability of e-government websites.

The acquisition of new knowledge from this research study will also make contributions in a practical sense. This new knowledge may be used in the design, development and delivery of Internet based tools in the future and should increase the adoption rate and effectiveness of these tools. Consequently, Australian farmers should be able to collaborate with other farmers and integrate national and international data into a local context. Using this collective intelligence within their rural information systems provides potential benefits in terms of cost and time savings, and productivity gains may be more readily achieved. By delivering online supporting mechanisms to Queensland horticultural farmers enabling more effective use of rural-focused websites and IBE tools, this research study could essentially contribute to the overall Queensland agricultural industry and economy.

The research also has the potential to contribute to the success of the NBN which is the enabling infrastructure for the Australian Government’s vision of being a world leading digital economy (nbn co 2018). The Government is committed to achieving this vision claiming that it will impact significantly on Australia’s productivity, global competitiveness and improved social wellbeing (ACMA 2009, 2017; nbn co 2017). The NBN has the potential to enable the widespread adoption of IBE tools and rural-focused websites by farmers, thereby increasing their ability to access and share information. If this research study contributes to the increased adoption of IBE tools, then it will increase Internet activity and engagement from a sector of the population that is currently under-represented in digital inclusion across the nation (Barraket et al. 2017; Dezuanni et al. 2017). In this context, two of the Digital Economy Goals are directly relevant to this research study: ‘improved online government service delivery and engagement; and greater digital engagement in regional Australia’ (DBCDE 2011, p. 2). This research study will address these goals by identifying factors that affect Queensland horticultural farmers’ use of IBE tools which will enable IBE tools to be developed that better suit the needs of farmers.
A significant outcome of this research study will be its contribution to DAF’s enhanced ability to provide better extension services to their farmers and other stakeholders.

1.8 Thesis outline
There are eight chapters in this thesis and they are outlined as follows:

• Chapter 1 – Introduction
The first chapter introduces the objectives and research questions which have been designed to address the research problem. The context of the study and the significance of the research are also discussed in this chapter.

• Chapter 2 – Literature Review
The literature review identifies and analyses literature already established in the information systems and rural domains relevant to Queensland horticultural farmers’ adoption and use of IBE tools. The literature review also establishes an understanding of the general nature of agricultural extension and the potential role of IBE tools. Reviewing the literature relevant to the proposed research also highlighted important gaps in the research literature.

• Chapter 3 – Theoretical Framework
This chapter discusses the theoretical framework and highlights its importance as the foundation structure that guides the researcher in gathering, examining, understanding and analysing phenomena within the research. Theories with the potential to be particularly suitable for this research study were also discussed including the Technology Acceptance Model, the Unified Theory of Acceptance and Use of Technology, Script Theory, Structuration Theory and the Diffusion of Innovations Theory.

• Chapter 4 – Research Strategy
Firstly, the conceptual framework which reflects the researcher’s philosophical assumptions and belief system were discussed. Establishing the conceptual framework formed the basis for an interpretivist theoretical paradigm which has been an overarching influence throughout this research study. Research methodologies and research methods were then discussed. The research was conducted using the case study methodology and a variety of data collection techniques including focus groups, face-to-face interviews, observation and examination and analysis of relevant reports and
websites. The researcher’s approach to data analysis and interpretation was also discussed.

• **Chapter 5 – Case Study Analysis**
Rogers’ DOI Theory and the five key attributes perceived to affect the rate of adoption of an innovation were used to guide the collection, analysis and interpretation of data. Chapter 5 presents the data analysis for each of the four case studies in relation to these five key attributes including relative advantage, compatibility, complexity, trialability and observability (Rogers 2003).

• **Chapter 6 – Cross-case Analysis**
The data analysis presented in this chapter is based on a cross-case analysis which extends the knowledge building beyond the individual cases. To achieve this, the researcher conducted a systematic and rigorous analysis, comparing and evaluating the four industry groups within each of the five key attributes. This approach led to a comparison of similarities and differences across the four industry groups thereby increasing the depth of understanding of the factors that affect farmers’ use of IBE tools.

• **Chapter 7 – Discussion**
This chapter discusses Queensland horticultural farmers’ knowledge of IBE tools and the promotion of IBE tools in terms of Rogers’ DOI Theory, agricultural models of engagement and communication strategies. IBE tools are also discussed in terms of improving their usability and design as well as the support and training needed for farmers’ effective use of IBE tools. Change management principles and a set of guidelines are presented to facilitate implementation.

• **Chapter 8 – Conclusion**
The overall research study is summarised in this chapter with a particular focus on the research findings. The outcomes of the research are addressed in terms of the research questions and objectives. The significance of the research and its contribution to knowledge is summarised with guidelines and recommendations that contribute to agricultural policy and practice. The limitations of the research study are also presented and also suggestions for further research.
Chapter 2 — Literature Review

2.1 Introduction

As a result of agricultural restructuring and policy reforms, extension services are fundamentally changing from the traditional face-to-face services to a digital platform. While the Internet appears to be an ideal platform for farmers to take advantage of accessing rural based information through IBE tools, there is little published research relating to factors that affect Queensland horticultural farmers’ use of IBE tools and the adoption of these tools. Hence, the research problem is a lack of knowledge regarding the uptake and effectiveness of IBE tools.

With the increasing reliance on the Internet to provide effective rural extension services, it is important for extension service providers to gain knowledge of farmers’ perceptions of IBE tools, how IBE tools can better satisfy farmers’ information requirements and how IBE tools can be tailored to enable farmers to more readily adopt these tools. This research study investigates this knowledge gap, thereby facilitating the capacity for extension service providers to design and develop up-to-date, relevant and useful IBE tools that may be adopted and used effectively by Queensland horticultural farmers.

Therefore, the overall goal of this research study is to investigate factors that affect the adoption and effective use of IBE tools by Queensland horticultural farmers. In particular, the researcher seeks to explore and understand those factors that affect farmers’ perceptions of IBE tools including the use of agricultural websites and Web 2.0 technologies, and the usefulness and ease of use of these IBE tools. To justify this research and to position it in the context of previous research in this field, an extensive review of relevant research and literature is presented in this chapter.

The literature review identifies and analyses knowledge already established in the information systems and rural domains relevant to Queensland horticultural farmers’ adoption and use of IBE tools. The current practices and processes of agricultural extension are explained as well as the changes that have occurred in the overall extension system that impact the current delivery of extension services to farmers. Research literature on farmers’ information requirements and IBE tools that Queensland horticultural farmers are able to access, is also explored. Literature on Internet access
and other factors that affect the adoption of technologies including sociocultural factors is also included in this review.

Reviewing the literature relevant to the proposed research provides background information on the research topic and highlights important gaps in the research literature. The literature review also aims to establish an understanding of the general nature of agricultural extension and the potential role of IBE tools.

2.2 Agricultural extension

Agricultural extension and its implicit philosophies, practices and processes have changed and evolved. These changes are relevant to this research study as they build an understanding of the meaning and challenging role of agricultural extension. Furthermore, discussion of these changes highlights the impact on farmers, particularly their options for seeking information and advice, and the resulting challenges and complexities within the overall agriculture industry.

2.2.1 Origins of extension

The origins of extension date back to around 1800 B.C. when agricultural information and advice were disseminated to farmers in Mesopotamia, Egypt, Greece, and China according to Jones and Garforth (1998). This was evident through advice on improving crop production, pest eradication and farm management discovered on clay tablets, ancient Egyptian columns and Chinese woodblocks (Jones & Garforth 1998). Jennings (2007), however, argues that these examples of extension practice are not comparable to contemporary agricultural extension, suggesting that the link is too weak between hieroglyphics based agricultural advice and contemporary methods of agricultural communication. Jennings (2007) also suggests that there needs to be a separation of on-farm and off-farm domains for public benefit to be attributed beyond the farm gate and that the extension activities in the previously mentioned examples were not operating such a linkage given that most of the activity was conducted in a rural community.

Although intellectual discussion can be enlightening, Vanclay and Leach (2007) suggest that the semantics can interfere with certainty and positive direction. Thus, it is sufficient to say that agricultural advisory roles were evident, as was the sharing of agricultural knowledge with the intention of improving farm management practices. These activities
may not necessarily fit precisely into a contemporary definition of extension given that extension activities and the relative definitions of extension have changed considerably over time alongside changes in agricultural development. As stated by the State Extension Leaders Network (SELN 2006, p. 6), 'extension necessarily is a continuously evolving system of practice and theory'.

It has been established that by the 1700s, extension practice and theories were evident and displayed more organised and formal agricultural extension activities (Jones & Garforth 1998). During these times, agricultural clubs and societies were formed by landowners, farmers, and men of science to share knowledge, initiate experiments and demonstrations, and to advocate the adoption of innovations (Jones & Garforth 1998). Notwithstanding the different implementation frameworks and focus, these activities were fundamentally similar to contemporary extension activities despite the growth and development of agricultural education, knowledge and practices.

While agricultural education and activities continued to grow and develop throughout the world, so did the meaning and definition of extension. According to McSweeney et al. (2014), the meaning of extension as a construct has changed with changes in its practical application. The term ‘extension’ originated from academia and was commonly used in Britain in the 1840s (Jones & Garforth 1998). Early conceptions of agricultural extension suggest it was significantly influenced by enlightenment thinking (Coutts 2007; Leeuwis 2004). Notwithstanding some variation in the literature, Leeuwis (2004, p. 23), explain enlightenment thinking somewhat disparagingly as

‘common folk’ are to a degree ‘living in the dark’, and that there is a need for well-educated people to ‘shed some light’ on their situation by means of educational activities.

The fundamental approach was to extend scientific research findings to the rural community from university experts adopting a paternalistic approach. Hence, farmers and rural communities would benefit from these insights and achieve improvements across the land. But as the focus of agricultural extension shifts, definitions of the term also change as well as the goals and philosophies. Coutts (2007) and James (2007) maintain that, over time, changes in the meaning of agricultural extension and its roles, approaches and dimensions, have been the outcome of the different needs, issues and contexts being addressed. For example, the following definitions of extension reflect the
shift from paternalistic education to supporting decision-making and innovative problem solving:

- ‘A service or system which assists farm people through education procedures in improving farming methods and techniques, increasing production efficiency and income, bettering their levels of living, and lifting the social and educational standards of rural life’ (Maunder 1972, p. 3).
- ‘Extension is a professional communication intervention deployed by an institution to induce change in a voluntary behaviour with a presumed public or collective utility’ (Röling 1988, p. 49).
- ‘Extension involves the conscious use of communication of information to help people form sound opinions and make good decisions.’ (Van den Ban & Hawkins 1996, p. 9).
- ‘A series of embedded communicative interventions that are meant, among others, to develop and/or induce innovations which supposedly help to resolve (usually multi-actor) problematic situations’ (Leeuwis 2004, p. 27).

The fundamental nature of extension was emphasised at the Australasia-Pacific Extension Network (APEN) National Forum when Coutts (2000, p. 6) described extension as ‘the oil that makes things happen’; the oil is all about the ‘interaction between people - information sharing, dialogue, learning and action’; and irrespective of scientific research and innovations, nothing will change on the ground without the crucial oil base. Similarly, Beilin, Paine and Pryor (2007) advocate that extension encompasses discourse between partners which is based on the facilitation of collaborative learning and the development of shared meaning, and it is this discourse that stimulates change. In particular, these changes impact the extension services available to farmers; how these services are developed and delivered, the interaction with farmers and the collaborative learning opportunities available to farmers.

Later, Coutts (2007, p. 27) described extension essentially as the process of disseminating new ideas. While this gives a basic representation of a complex discipline, its simplistic description provides a practical and realistic depiction of the essence of extension implicitly encompassing referent knowledge sharing developed from a plethora of research and practice. Essentially, agricultural extension assists individual farmers and farming communities by providing information and advice on agricultural
innovations, farming techniques, operations and the overall management and marketing of their farming businesses.

Major shifts in the development and advancement of extension throughout the latter half of the twentieth century are illustrated in the bubble diagram (Figure 2.1) developed by State Extension Leaders Network (SELN). During this period, extension methods essentially changed from a paternalistic approach to a more participative consultative approach. Changing to this participative approach was in part recognition of farmers’ experience, skills and indigenous knowledge which often has been passed from one generation to the next. Through this participative and consultative approach, farmers’ experience, knowledge and skills could provide input to the extension requirements of farmers and the resulting delivery of extension services. As suggested by Vanclay and Leach (2007) the diagram (Figure 2.1) captures the expanding nature of agricultural extension as well as the cycle of change where improvements in theories promoted improved practice and changes in philosophies.

**Figure 2.1**: Twentieth-century extension changes  
*Source: State Extension Leaders Network (SELN) (2006, p. 6)*
2.2.2 Agricultural reforms

In the early 21st century, the changing and challenging nature of agricultural extension continued to evolve. This changed the delivery and content of extension services and farmers’ expectations of these services. Leeuwis (2004) attributes this to changing social and environmental contexts in conjunction with changes in extension funding, theory and communication technologies. More specifically, Sapin (2001, p. 1) links the changing goals and objectives of extension activities to institutional shifts such as the following changes in focus, reflected in the Queensland Department of Primary Industry’s 2000-2005 corporate plan:

- from ‘industry development to food and fibre chain development’;
- from ‘a supply orientation to a market demand orientation’;
- from ‘a production focus to a consumer focus’; and
- from ‘enterprise development to community development’.

For many years, Australia’s agricultural extension services were primarily the responsibility of Commonwealth and State Governments (McSweeney et al. 2014; Murphy, Nettle & Paine 2013; Paschen et al. 2017). According to SELN (2006), the role of improving practice through publicly funded extension is largely realised by targeting the sustainability of production and natural resource management. This is achieved through the following (SELN 2006, p. 2):

- Providing a bridge between science, policy and community stakeholders to facilitate changes in practice;
- Improving communication between industry, agency and community stakeholders;
- Contributing to capacity building; and
- Facilitating solutions for protecting, maintaining and enhancing lifestyles, landscapes and livelihoods.

Currently, in Australian agriculture, the wide variety of extension activities is undertaken by both public and private sectors but increasingly by the private sector. This large increase in private sector participation is the product of changes in government policy with reduced public investment, thus resulting in changes in the delivery and funding of extension services (Murphy, Nettle & Paine 2013). Furthermore, Rivera (2011) states
that Australia’s public sector extension has become less relevant claiming that the private sector can more efficiently provide technical assistance. Hence, Marsh and Pannell (2000, p. 612) describe the extension role as commonly shared by ‘farmer organisations; cooperatives and groups; seed, fertiliser and chemical companies; local government; marketing boards; Research and Development Corporations; Cooperative Research Centres; and university departments’. In this context, Marsh and Pannell (2000, p. 607) broadly define agricultural extension as ‘public and private sector activities relating to technology transfer, education, attitude change, human resource development, and dissemination and collection of information’. Thus, it is evident that Australia’s rural research, development and extension (RD&E) structure operates within a complex, diverse and dynamic environment.

In this context, Australia now has a pluralistic and decentralised collection of organisations engaged in RD&E (Paschen et al. 2017). Australian RD&E services are increasingly industry-driven with extension services spread across several layers of public, private, industry-based and vocational training providers (Murphy, Nettle & Paine 2013; Paschen et al. 2017). Research and development corporations (RDCs) have been established within the Australian government-industry partnership model and have been increasing for over twenty-five years (Commonwealth of Australia 2017).

Currently, there are fifteen RDCs; five of these are Commonwealth statutory bodies and ten are industry-owned companies (Commonwealth of Australia 2017). For example, the Grains Research and Development Corporation (GRDC) and the Rural Industries Research and Development Corporation (previously RIRDC, now trading as AgriFutures Australia) are two of Australia’s Commonwealth statutory RDCs. Horticulture Innovation Australia (HIA), on the other hand, is one of Australia’s largest industry-owned RDCs; Sugar Research Australia Unlimited is another industry-owned RDC (Commonwealth of Australia 2017). Despite this infrastructure for RD&E services, RDCs do not directly conduct RD&E services, nor do they own or manage research facilities.

Instead, RDCs are industry service bodies that administer and manage research and development (R&D) funding. Under Australia’s current rural R&D funding model, RDCs integrate funding from industry levies paid by primary producers with government matched funds and then disperse these funds across private sector organisations. (Hunt et al. 2014, p. 133) describe RDCs as brokers, dispersing ‘funding to private
organisations, government agencies and universities according to determined priorities and the capacity of those entities to deliver’.

Consequently, Australian agricultural policy now reflects a paradigm shift from a predominantly public sector driven approach to a market-oriented extension approach that more effectively responds to farmers’ needs in a global market (Hunt et al. 2014; Rivera & Sulaiman 2009; Swanson 2006). Another perspective of contemporary extension activities emphasises sustainable agriculture including environmental, social and economic components and seeks to develop resilience and capacity building in individuals and communities (Hunt et al. 2011; Leeuwis 2004; Nicholson et al. 2003; Ridley 2007; van de Fliert 2003; Vanclay 2011). This shift in emphasis incorporating capacity building and resilience is also reflected in SELN’s definition of extension SELN (2006, p. 3) which they suggest should have national standing:

Extension is the process of enabling change in individuals, communities and industries involved with primary industries and natural resource management. Extension is concerned with building capacity for change through improved communication and information flow between industry, agency and community stakeholders. Extension seeks outcomes of capacity building and resilience in individuals and communities. Extension contributes to protecting, maintaining and enhancing the landscapes, livelihoods and lifestyles of all Australians.

The Australian agricultural extension system of funding, structure, organisation and operational focus has for many decades been under reform. Furthermore, Rivera (2011) believes that the increasing private-sector dominance is unlikely to abate. Nonetheless, the goal for many reforms to the extension system has been to improve its overall service and capacity, thereby enabling farmers to remain competitive and continue to strengthen Australia’s agricultural industry. Thus, Rivera (2011) suggests that agricultural extension continues to be an increasingly important instrument for fostering Australia’s systems of agricultural knowledge, information and innovation.

2.3 Information requirements

Global, economic and technological changes have had a vast impact on Australia’s rural community. Aside from seasonal and unexpected weather changes, Peart and Shoup (2004) suggest that factors contributing to the complexity of the farming business include legal, political and economic factors; technological changes; global and local competition; and societal trends and demands. From a business management perspective, these factors must be considered in terms of the approach taken by farmers
to increase productivity and profitability, and to optimise efficiency and performance in order to sustain their competitive advantage. To manage within this increasingly dynamic and complex environment of rapid change and development, it is important for farmers to manage their farms as innovative and competitive business ventures. Within this environment, IBE tools have the potential to contribute to farm management and operational activities, but the effective use of these tools is likely to require a shift in the mindset of farmers and their traditional practices. This may be a challenging prospect to be considered in light of the many other challenges experienced by farmers.

In this context, Queensland farmers are under increasing pressure to change or improve existing practices by adapting their farm management and operations, or adopting new practices. The focus of these improvements aims to increase productivity and profitability thereby enabling farms to remain viable and competitive. But farmers also face challenges associated with previously discussed changes within RD&E services. Farmers’ access to timely, accurate and relevant agricultural information has become challenging owing to these institutional shifts, priorities and funding policies; new approaches derived from extension theory developments; and the emergence of new technologies (Leeuwis 2004). Furthermore, farmers’ information requirements extend beyond just production and productivity (Rivera 2000). The agricultural community is also challenged by issues relating to global food security, food safety, agricultural sustainability and environmental considerations and regulations. Therefore, extension delivery methods and content must also adapt to this changing environment and the more specialised needs of farmers.

To address this changing agricultural environment, key components of effective extension should include improving knowledge partnerships and developing the capacity for farmers to make informed decisions (La Grange et al. 2010). Information and knowledge are fundamental to informed decisions which are vital to the overall successful operations, management, marketing and sustainability of farms. This is emphasised by Rivera (2000, p. 33) who claims that ‘knowledge is the power to greater profits and larger markets’. Peter Drucker (2003, p. 158) also stated that ‘knowledge is now fast becoming the sole factor of production, sidelining both capital and labour’. Similarly, Chen and Dahlman (2005, p. 1) highlight the significance of the creation and use of knowledge stating that ‘knowledge is the main engine of economic growth’. 
The acquisition and consideration of appropriate information sources form part of the decision-making process and is an essential farm management function as in any other business. Research suggests there are increasingly vast amounts of information and an increased range of information that farmers need to be aware of in order to effectively manage their farms (Magne, Cerf & Ingrand 2010; Titterton, Eversole & Lyall 2011). Finding and selecting relevant and accurate information is paramount to successful farm management. Moreover, Magne, Cerf and Ingrand (2010) claim that information should be considered as a strategic element in overall farm management. Again, IBE tools have the potential to provide farmers with access to timely and relevant information.

While numerous research studies have explored farmers’ decision-making processes and decision outcomes (Fountas et al. 2006; Klerkx & Proctor 2013; Magne, Cerf & Ingrand 2010), according to Hill (2009), there is little research on the actual information needs of farmers in relation to their decision-making, particularly in regards to the adoption of a new innovation. Nonetheless, Marsh and Pannell (2000, p. 606) suggest that farmers generally require ‘more sophisticated and individually-tailored technical, management and marketing information’. Similarly, Klerkx and Proctor (2013) suggest that farmers not only have a greater demand for information and advice but also, their information requirements are more diversified.

These information requirements are not always adequately addressed through the conventional top-down or linear process that utilises the transfer of technology approach. Essentially, this is a process where farmers are the passive recipients of research information generated in isolation of farmer consultation or context-specific requirements (Klerkx & Jansen 2010; Leeuwis 2004). Findings from the EU Standing Committee on Agricultural Research (Poppe 2012), however, suggest that the trend within this linear process indicates a growing disconnect between farmers' knowledge, research and extension. This is in part because experienced farmers have developed a lifetime of tacit knowledge or indigenous knowledge; thus, they can be more selective and proactive in their knowledge acquisition. Klerkx and Jansen (2010) also suggest that the linear process ignores the nature of agricultural knowledge creation being highly interactive and largely having a local context.

Thus, Morse, Brown and Warning (2006) suggest that farmers should have more control over the information they want or need which, according to La Grange et al. (2010), can
be achieved through a demand-driven extension framework. A demand-driven framework enables farmers to articulate their issues, knowledge gaps and information requirements in contrast to being passive recipients of knowledge. This raises a disparity, however, regarding what farmers know they don’t know, as opposed to what farmers don’t realise they don’t know and therefore don’t know to articulate their knowledge gap. This knowledge relevance paradox was described by Donald Rumsfeld, former United States Secretary of Defense (US Department of Defense 2002) with the following statement:

… there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns -- the ones we don't know we don't know.

While this statement was made in relation to evidence about the supply of weapons of mass destruction, the concept of “unknown unknowns” is relevant to management and decision-making. This concept has been extensively explored in management literature over the last decade (McGrath & MacMillan 2009; Shapira 2008; Starbuck 2009). Feduzi and Runde (2014, p. 270) define an unknown as ‘a hypothetical event that may or may not occur’ and from a decision-maker’s perspective, ‘an unknown may be known or unknown’. Therefore, it is critical that the unknowns are addressed and become known within farmers’ information stores so that they have full capacity for effective decision-making.

Unknown unknowns highlight a shortcoming or gap in the decision-making process because if a farmer does not have all the facts at hand, the generation, framing and evaluation of decision criteria is incomplete. This also highlights a weakness in a demand-driven extension model. In this context, Bennett (2015) suggests that the current Australian extension model is flawed because it is dependent on farmers knowing the unknown, that is, knowing they have an issue and knowing they have an information requirement. Hence, this extension model does not address farmers’ information requirements for the unknown unknowns and may allow for farmers’ cognitive biases.

In this regard, farmers’ decision-making capacity may be diminished until farmers are made aware of these unknowns, even if they are still considered known unknowns. While associated Bayesian decision theory and hypothesis discovery and evaluation of
Baconianism (Feduzi & Runde 2014) may be relevant to broadening agricultural decision frameworks, it is not explored here as it is beyond the scope of this research study.

Nonetheless, information flows and communication are relevant to the research study given that this impacts farmers’ capacity building which should be supported and enhanced through extension. IBE tools may be able to address farmers’ unknown unknowns because these are not necessarily unknown to all participants in the agricultural extension framework. For example, farmers’ unknown unknowns may, in fact, be known knowns to extension agents or the research community.

This emphasises the need for an extension framework that facilitates effective communication and the construction and discovery of unknown unknowns. Bennett (2015) suggests that this conundrum is addressed essentially through an agricultural extension framework that communicates scientific research and technological innovations to farmers and other stakeholders in the agricultural system. While this relevance paradox may appear to be somewhat abstract, the goals of the extension system need to broaden farmers’ decision-making frameworks by expanding their knowledge base and strengthening their capacity to make informed decisions. IBE tools could possibly be designed and developed for this purpose.

2.4 Information, knowledge and innovation

Improving dialogue, understanding and the exchange of information between farmers and rural advisory services is incorporated in the agricultural knowledge and information systems (AKIS) model (Leeuwis 2004; Rivera et al. 2006). The AKIS model was further developed and adapted in the 1980s and 1990s (Röling & Engel 1990) emphasising the collaboration between farmers and the knowledge triangle (extension, research and education). For this model to be effective, however, Röling and Engel (1990) recognised that extension, research, education, farmers and other actors all had to interact synergistically.

While the AKIS model acknowledges the shortcomings of the top-down approach or linear model, it inadequately addresses the pluralistic network of organisations and stakeholders involved in the innovation process. Rivera (2011) emphasises the need to foster and develop innovation in addition to information and knowledge transfer and suggests that the Agricultural Innovation System (AIS) framework is a promising
alternative to the AKIS. This stronger focus on innovation will potentially contribute to the creation of an environment that facilitates capacity building and enables agricultural and rural development. Rivera et al. (2006, p. 587) suggest that the AIS framework is intended to:

... foster the integration of research and education systems, as well as develop public-private partnerships, develop and strengthen farmer organizations, establish technology transfer units, build decentralized regional innovation centres, and implement new governance models for research and extension.

Thus, the AIS framework is more inclusive of the interactions between the various actors and networks, and all stakeholders involved in fostering innovation linkages that support the creation of an environment for agricultural development. Figure 2.2 illustrates that innovation is the outcome of interactions between the various actors (including consumers) within the overall AIS. Another important aspect of this framework is the influence and interaction with the policy environment. Faure et al. (2016, p. 4) suggest that an agricultural innovation system must incorporate ‘the policy environment, consumer demands, and the “rules of the game” that influence the interaction of these actors’.

Figure 2.2: Agricultural Innovation System
Source: adapted from Faure et al. (2016), Rivera (2011) and World Bank (2012)
The central focus is still on knowledge exchange within the knowledge triangle, but the framework also highlights the crucial knowledge exchange and interaction between the inner and outer circles; all of which ultimately enable agricultural development and innovation. As stated by the World Bank (2012, p. 15), AIS actors do not innovate in isolation ‘but through interacting with other actors – farmers, firms, farmer organizations, researchers, financial institutions, and public organizations – and the socioeconomic environment’.

Many researchers promote the AIS framework as a sound instrument to comprehend the complexity of underlying processes of agricultural innovation, knowledge exchange and transformation (Faure et al. 2016; Lamprinopoulou et al. 2014; World Bank 2012). For this research study, however, it is the collaboration and interaction of the actors within the AIS, as well as the coordination and alignment of the system elements, that are of direct relevance to the potential adoption of IBE tools. It is likely that the adoption of IBE tools will be affected by these factors and the level of effective functionality within the AIS.

Regardless of the success or failures of the various extension, knowledge and innovation frameworks, farmers need to acquire knowledge and the capacity to make informed management decisions. The sharing of knowledge has become increasingly complicated through various reforms and the restructuring of the traditional approach to RD&E. Coupled with the global push for innovation, it is therefore crucial that farmers are well informed through processes that enable participatory, collaborative efforts in developing and sharing knowledge within the overall agricultural network of stakeholders. IBE tools have the potential to address some of these information requirements.

Farmers need the ability to acquire current information easily; to create, store, exchange and use information in order to apply their knowledge and improve farming outcomes. Although farmers commonly seek agricultural information through agricultural advisory services and extension agents, there is also a substantial amount of information available to farmers via the Internet. Using the Internet to disseminate information to farmers is a fast and cost-effective extension method that could be used to enhance or complement the traditional face-to-face interactions and distribution of printed materials. Bell (2015), however, suggests that while the Internet increases access to large
quantities of information, not all information is useful. Hence, access to information via the Internet does not guarantee the adoption or effective use of IBE tools by farmers.

2.5 IBE tools

Traditional extension methods such as face-to-face advice and consultancy/diagnostic services, field days, best practice study groups, community workshops and agricultural fairs have been commonly used to communicate with and inform farmers. Print media (such as newsletters and fact sheets), CDs, radio, television, videos and information centres have also been used extensively (Black 2000; Fulton et al. 2003). But traditional extension services have undergone significant changes resulting from agricultural restructuring and policy reforms.

Australian RD&E services are now spread across public, private and industry providers resulting in a pluralistic and decentralised collection of organisations engaged in RD&E (Murphy, Nettle & Paine 2013; Paschen et al. 2017). Agricultural policy reforms have also given rise to less funding allocation for government extension agents and the tyranny of distance also contributes to reduced services such as fewer face-to-face consultations with farmers. Nevertheless, extension services still play a crucial role in assisting farmers to utilise R&D and create and share knowledge, thereby enabling farmers to innovate and change, and to maintain business viability. But changes in extension methods are essential to keep up to date with the rapidly changing agricultural operating environment. IBE tools provide an alternative extension method that may help to address some of these issues and may be a valuable addition to the extension advisory toolkit.

IBE tools explored in this research study are based on Web 1.0 and Web 2.0 Internet capabilities. The Web 1.0 platform delivers web pages that are static and basically read-only, thereby enabling users to search for and read information but with virtually no interactive capabilities. In contrast, Web 2.0 technologies expand the capabilities of the read-only Web 1.0 platform to a read-write platform enabling users to also generate content (such as blogs, product reviews or wikis) and to communicate online (for example, through social media and chat forums).

There are also more advanced web platforms such as Web 3.0 or the Semantic Web, which enables more personalised and contextualised web services, and the Internet of
Things which enables machine-to-machine communication. These technologies also enable the integration of data from sensors and GPS used in precision agriculture and a combination of technologies seen in the use of unmanned aerial vehicles (drones) and robotics. While these more advanced technologies are gradually being developed and adopted by some farmers, they are not specifically explored in this research study as the focus is on the more widely established and accessible technologies and tools available through Web 1.0 and Web 2.0.

The sharing of knowledge and giving advice by farmers is as old as the industry itself. This sharing can be continued and enhanced through the use of Web 2.0 technologies as they have the potential to further expand IBE tools. Web 2.0 technologies extend the functionality and usability of the Internet beyond that of a static webpage by fostering group interaction, sharing and collaboration in a dynamic environment focused on users. A particularly attractive feature of Web 2.0 technologies is that of encouraging human interaction, thereby promoting a greater sense of community in an otherwise cold social environment (Kamel Boulos 2007). Increasingly popular Web 2.0 technologies include wikis, blogs, social networking and podcasts, RSS feeds, audio and video conferencing; and there are many more emerging such as social bookmarking (also known as folksonomies and tagging), crowdsourcing, mashups, and virtual worlds.

The Internet has the potential to further expand the range of information and tools farmers can access thereby providing further opportunity for farmers to manage their farm business more effectively and efficiently. Extension agents realise the potential benefits of the Internet and are keen to utilise this technology to inform farmers about pertinent rural issues and alternative management practices (Hollaway et al. 2015; Hunt et al. 2012; Mills 2011).

For example, if a property was identified as a biosecurity risk with a disease such as Panama (a significant threat to commercial banana production) or fruit-fly as in a recent outbreak in Tasmania which threatened their horticultural industry, it is important for other property owners to be made aware of the situation as soon as possible. Using traditional extension methods of print media would be slow and costly whereas notification utilising the Internet would be fast, cheap and extensive. Email or social media alerts could be sent; fact sheets could be posted to websites as well as community service support details; and a blog could be used to address issues and answer
questions or enable discussion between farmers, biosecurity specialists, and other relevant government departments. Similarly, the outbreak of Hepatitis A in 2015 following the consumption of frozen berries created a storm of controversy on social media. Notwithstanding, ABC Rural (McCarthy 2015) suggests that farmers could take advantage of social media in these circumstances to communicate with consumers about their compliance with food safety regulations, due diligence and the point of difference with locally produced berries compared to the frozen imported berries.

Furthermore, Hollaway et al. (2015) describe how integrated IBE tools in the eXtensionAUS pilot project contributed to the efficient online dissemination of knowledge and online collaboration throughout the Beet Western Yellows Virus outbreak in 2014. Hollaway et al. (2015) suggest that location-based RD&E networks are too limiting especially given the agricultural reforms and restructuring of the National RD&E Strategy, and that a nationally networked approach to extension is essential. This research team established that IBE tools including social media, YouTube and Twitter are also effective as supplementary extension tools providing opportunities to reach large audiences.

There are various ways in which the Internet can be used to disseminate agricultural information. Making information available to farmers on websites is the obvious application; as is using links to other websites or information repositories (e.g. newsletters, alerts, services, current media releases and research reports); and emailing the relevant information to farmers is also an effective option. The Internet, however, not only has the potential to further expand the range of information delivered to farmers. It also provides the platform for the development and widespread use of other IBE tools, again providing further opportunity for farmers to manage their farm businesses more efficiently and effectively, and enabling extension agents to provide a better service to their clients. For example, a set of IBE tools called “Agbiz farm budgeting tools” is accessible via the Queensland Government’s Business Queensland website (Business Queensland 2016a). There are over 250 IBE tools available from this website offering a range of cropping and livestock tools, as well as generic financial management and decision-making tools. For example, whole-farm budgeting spreadsheets are available for various types and locations of fruit and nut farms; some IBE tools are also available for horticultural growers to estimate greenhouse gas emissions, and there are other IBE tools to analyse the costs, risks and benefits of exporting products. In general, these IBE
tools enable farmers to enhance their capacity for informed decision-making simply by downloading spreadsheets from the website and entering relevant data.

The Beatsheet blog (The Beatsheet 2018) is another example demonstrating Web 2.0 technologies currently being used as a communication tool by the Queensland entomology team at DAF to address pest management issues. Charleston, Miles and McLennan (2009) explain that the Beatsheet blog was selected as a fast, readily accessible method available globally but targeted at northern New South Wales and Queensland field crop producers, consultants and researchers. Whenever there is a posting to the blog, a link is sent to all subscribers via email notification. Prior to launching this blog in July 2007, fortnightly newsletters and grower meetings were the main forms of communication, but for communication of urgent issues, farmers were notified by phone, email or media releases (Charleston, Miles & McLennan 2009). These methods were inadequate in crisis situations where notification and advice about pest issues were critical to sustainable production.

Similarly, cloud computing has the capacity to provide farmers with additional methods for using the Internet to share and distribute information. Cloud computing is defined by Plummer et al. (2008, p. 3) as a ‘style of computing where massively scalable IT-enabled capabilities are delivered as a service to external customers using Internet technologies’. Furthermore, cloud computing and Web 2.0 technologies may enable farmers to integrate global information with local information and individual farm information systems.

IBE tools have the potential to facilitate decision-making and provide the opportunity for new ways of interacting, engagement and collaboration. James (2009) suggests that information sharing and collaboration will grow as awareness and availability of IBE tools increases. These IBE tools, however, need to address the individual needs of farmers and in this respect, they need to be contextual and interactive (Easdown & Starasts 2004). Similarly, Caron, Biénabe and Hainzelin (2014) advocate that aside from changing the nature of knowledge, the methods used to create, combine, distribute and exchange knowledge also need to change. Fountas et al. (2006) suggest that while there is no shortage of agricultural information on the Internet, the challenge is to pinpoint the relevant, useful and important information. Furthermore, James (2009) also suggests that as extension agents expand their use of IBE tools, they will be better equipped to
support their clients, thus leading to better outcomes for Australian agriculture. Nonetheless, there is still a valid place for traditional extension methods, and therefore, IBE tools should be considered as complimentary extension methods. This is emphasised by James (2009) who advises that IBE tools be combined with an existing extension strategy aimed at increasing engagement and collaboration.

Agricultural based websites, Web 2.0 technologies and possibly cloud computing are technological platforms from which IBE tools could be delivered effectively to farmers. IBE tools using these technologies, therefore, have the potential to further enhance farming decisions, improve farming performance and maintain competitive advantage. If these tools were developed around the specific needs of farmers, the information seeking process might be improved. Agricultural information commonly sourced through extension agents and programs could be provided online thus enabling farmers to easily acquire relevant, real-time and reliable information in a timelier manner. Accurate, timely and relevant information is essential for farmers needing to resolve critical issues and in general to manage and adapt their farming processes in order to improve performance. The Internet and Web 2.0 technologies provide a platform to deliver IBE tools for extension agents and farming communities. Harris and Rea (2009, p. 137) identify various uses of Web 2.0 technologies that emphasise ‘user generated content, data and content sharing, collaborative effort, new ways of interacting with Web-based applications, and the use of the Web as a social platform’. Using these technologies to collaborate and communicate, and to generate and share information may foster a collective intelligence and may also provide a cost-effective method for increasing productivity and ultimately competitive advantage.

IBE tools are readily accessible to farmers with Internet access and have the ability not only to deliver timely and relevant information but also to serve as a diagnostic and advisory tool or fast response mechanism for critical issues. IBE tools have the potential to complement and improve the extension effort through more efficient and effective communication, collaboration and information flow. While IBE tools have the potential to support farm management effectively, the right tools must be designed and developed around farmers’ information needs and their skills. If the tools are not right for the job at hand, however, they will not be used, regardless of their source.
2.6 Internet access

While Queensland farmers may be able to harness potential benefits through the use of IBE tools, these benefits are largely dependent on fast, reliable and affordable access to the Internet. Research literature confirms that technological infrastructure is essential for enabling farmers to increase productivity by reducing production and transaction costs through better access to markets and innovative techniques thereby increasing sales income and agricultural output (Salim, Mamun & Hassan 2016; Starasts 2015; World Bank 2012).

But the physical infrastructure alone is not sufficient for farmers to use information sourced from the Internet. Practical, easy to use, current and reliable information needs to be made available to farmers that may contribute to enabling sustained productivity increases, or addressing the common challenges of biosecurity threats and climate change, or the information needs for everyday operational farm activities. Taragola and Van Lierde (2010) suggest that the benefits of Internet access are determined by how farmers actually use the Internet rather than them merely having access to the Internet. Similarly, Simpson et al. (2004) and Briggeman and Whitacre (2010) suggest that the deployment of infrastructure alone is insufficient to drive the adoption and effective use of Internet technology.

While taking advantage of technological innovations and the effective use of IBE tools is contingent on farmers’ access to the Internet being fast, reliable and affordable, ongoing research into Australia’s Internet usage suggests there is a digital divide. A redefining of the digital divide, however, has emerged in recent years that changes the focus from a dichotomous viewpoint (haves and have-nots) to one that goes beyond access issues (Barraket et al. 2017; Park 2017b; Salemink, Strijker & Bosworth 2017). The digital divide is not only between those that have access and those that do not, but also between those that have the ability to use the Internet and those that do not (Alam & Salahuddin 2015; Bowles 2011; Erdiaw-Kwasie & Alam 2016; Park 2017b).

Currently, literature about the digital divide commonly takes a broader outlook on barriers to digital inclusion and encompasses social, economic, cultural, demographic and learning inequities, as well as skills in the use of computers and the Internet, and access issues (Barraket et al. 2017; Park 2017b; Salemink, Strijker & Bosworth 2017). According to a recent report on the Australian Digital Inclusion Index (ADII), Barraket et al. (2017)
digital ability is also a necessary component of digital inclusion and the capacity to take full advantage of digital technologies. Thus, digital ability or capacity for farmers to effectively use ICTs and IBE tools is essential and a relevant component of the research study.

Not only is fast, reliable and affordable access a fundamental requirement, but farmers’ digital ability or capacity to use ICTs and IBE tools is also integral to their effective use of IBE tools. However, digital ability includes not only farmers’ basic computer literacy skills but also their attitudes and activities (Barraket et al. 2017). Therefore, farmers’ basic skills, self-efficacy, confidence and enthusiasm as well as the range of online activities they undertake, are important to this research study as these factors may affect their perceptions of IBE tools.

The Australian household use of technology statistics for 2016-17 published by the Australian Bureau of Statistics (ABS 2018b) show that approximately thirteen percent of Australians (aged fifteen years or over) are not online, which is approximately three million people (ABS 2017). While the last ABS collection of statistics specifically targeting Australian farmers’ use of the Internet was in 2007-08 (ABS 2009), other sources of literature with current statistics reporting disparities between country and city areas of Australia, provide relevant information for this research study (Barraket et al. 2017; Dezuanni et al. 2017; EY Sweeney 2017; nbn co 2017). For example, the Australian Digital Inclusion Index (ADII) provides a comprehensive snapshot of Australia’s online participation using data collected up to March 2017 by Roy Morgan Research (Barraket et al. 2017; Dezuanni et al. 2017). The ADII (Barraket et al. 2017) measures three critical dimensions of inclusion (access, affordability, and digital ability) and incorporates social and economic circumstances, as well as geographic location.

Queensland has a population of approximately 4.9 million (ABS 2018a) with one million residents located in rural areas (Dezuanni et al. 2017). As shown in Table 2.1, Australia’s national average digital inclusion score is 56.5 with Queensland being 55.3; a higher ADII score indicates a higher level of digital inclusion (Barraket et al. 2017; Dezuanni et al. 2017). Queensland is placed sixth on the list of Australia’s eight states and territories for digital inclusion and a widening gap (Barraket et al. 2017).
Table 2.1 shows a gap of 7.9 between Australian capital cities compared to rural areas although the overall gap between Brisbane and rural Queensland is 5.1 (Barraket et al. 2017). Compared to the national digital inclusion index shown in Table 2.1, rural Queensland lags behind Australia overall with a difference of 3.0 for overall access and 5.8 for both overall affordability and overall ability (Barraket et al. 2017; Dezuanni et al. 2017). Evidence of digital exclusion in rural Queensland needs to be considered in the research study, particularly farmers’ overall digital ability which lags behind the national score by 6.2 for both attitudes and basic skills (Barraket et al. 2017; Dezuanni et al. 2017). If farmers do not have the ability to access and use the Internet, they will be unable to use IBE tools effectively.

The Australian Government is committed to resolving the issue of inadequate access to the Internet and broadband infrastructure in regional and rural areas of Australia (ACMA 2017). Through the National Broadband Network (NBN) initiative, the policy objectives
of the Australian Government aim to ensure that all Australians have access to very fast and affordable broadband (ACMA 2017; nbn co 2018). Connecting all Australians aims to bridge the digital divide with the potential of enabling all Australians to participate and benefit from the digital economy (DBCDE 2011). Furthermore, EY Sweeney (2017, p. 5) state that national connectivity is fundamental to ‘sustainable economic success, positive social dynamics and ultimately quality of life’.

Although there have been changes in government, the NBN is still a key priority but it is now being rolled out through public-private partnerships (nbn co 2017). Similarly, the primary objective of the NBN has been modified to ‘universal connectivity at affordable prices’ and this is reflected in the modified implementation strategy to the Multi Technology Mix (MTM) model (nbn co 2017, p. 9). Essentially, these changes to the MTM model include the use of alternative telecommunications media with the overall goal of increasing broadband Internet speeds (nbn co 2017). Fixed wireless and satellite services are largely targeted at regional and remote areas of Australia. For example, Sky Muster™I and Sky Muster™II are two broadband satellites launched in 2015 and 2016 offering broadband services to communities in locations where traditional broadband would not ordinarily be feasible (ACMA 2017; nbn co 2016).

2.7 Factors affecting adoption of information technologies

Conceptually, factors affecting the adoption of information technologies are also likely to affect Queensland farmers’ use of IBE tools. In addition to telecommunications infrastructure and access problems (Park 2017b; EY Sweeney 2017), there is an extensive range of research literature that has established other factors that may affect the adoption of information technologies (Carrer, de Souza Filho & Batalha 2017; Erdiaw-Kwasie & Alam 2016; Khatri-Chhetri et al. 2017; Kuehne et al. 2017).

An earlier research study conducted by Urquhart and Rowley (1999) explored issues associated with the adoption of information technologies that emerged with farmers from the Sunshine Coast Sub-Tropical Fruits Association in Queensland. Urquhart and Rowley (1999) explored these issues using the fundamental elements of DOI Theory (Rogers 2003) including the innovation and its five key attributes (relative advantage, compatibility, complexity, trialability and observability), communication channels, time and the social system. These farmers recognised the potential benefits of using software
packages and the Internet but also identified the following barriers to adoption (Urquhart & Rowley 1999, pp. 14-5):

- Set-up costs;
- Finding the right information, training and support;
- IT as a threatening, but necessary change;
- IT as a conflict with lifestyle,
- IT as a problem of literacy.

Despite Urquhart and Rowley (1999) identifying these barriers almost two decades ago, current research literature indicates that these issues still affect the adoption of information technologies (Erdiaw-Kwasie & Alam 2016; Khatri-Chhetri et al. 2017; Kuehne et al. 2017; Sewell et al. 2017). Therefore, these same factors might also affect Queensland farmers’ adoption and use of IBE tools. For example, a farmer’s decision to use IBE tools may initially be based on the financial cost of equipment such as a computer or tablet, Internet access and the ongoing cost of Internet usage. Farmers’ investment of time would also be a cost consideration and would be evaluated against the potential benefits. In addition to the financial outlay, Queensland farmers may also be concerned about their computer literacy and the level of training and support provided and also whether IBE tools would deliver the required information. Furthermore, these farmers may consider that using IBE tools might conflict with their lifestyle expectations of working outdoors. Accordingly, this research study will explore the potential barriers to adopting and using IBE tools identified by Urquhart and Rowley (1999). This will contribute to the data collection required to address the research questions identified in Chapter 1 of this thesis.

Similarly, a poor level of IT literacy was a significant finding in a study undertaken by Erdiaw-Kwasie and Alam (2016) investigating barriers to the adoption of ICTs in the Queensland agricultural and energy resources region of the Surat Basin. Erdiaw-Kwasie and Alam (2016) also found dissatisfaction with the information content on the Internet to be a barrier to future engagement with ICTs because information was perceived to be biased, not relevant, and diminishing in value.

Research on ICT-based initiatives in e-government and e-learning undertaken by Singh (2009) established similar barriers with many rural and regional citizens of Victoria and
Queensland reluctant to use ICTs because they need help with information searches, navigation, and general computer and Internet use; some also believed they were too old to use computers. E-readiness and the design of ICTs are factors commonly emerging in the research literature that affect the adoption of information technologies (Somers & Stapleton 2015; Venkatesh, Hoehle & Aljafari 2017; Zhang, Wang & Duan 2016). For example, Somers and Stapleton (2015) suggest that a human-centred approach to the development of agricultural information technologies that reflects farmers’ values and culture will facilitate the adoption of these technologies. O’Grady and O’Hare (2017) also support the need for user-centred design of innovative technologies without which, these technologies may fail to meet the users’ needs and possibly result in poor usability and functionality. The findings of usability and user-experience studies such as the Obamacare website (Venkatesh, Hoehle & Aljafari 2017) identify various barriers to the adoption of e-government websites. Factors contributing to poor usability and user-experience include a lack of user-friendliness, poor interface design and content issues such as webpages not having up-to-date information, pages not loading, login and transaction failures, and poor quality access (Kumar, Sachan & Mukherjee 2017; Venkatesh, Hoehle & Aljafari 2017). Usability and user experience will also be explored in this research study to establish if these factors contribute to the adoption and effective use of IBE tools.

Briggeman and Whitacre (2010) found various reasons for US farmers’ reluctance to use the Internet including farmers lacking familiarity with ICTs, not owning a computer, no perceived need, and issues relating to Internet connectivity, security, and cost. These barriers to the adoption of ICTs by US farmers are impacted by factors such as income, education and age (Briggeman & Whitacre 2010). Carrer, de Souza Filho & Batalha (2017) also found that age is a factor that affects technology adoption with younger, less experienced Brazilian citrus farmers more likely to adopt ICTs. Education was also found to have a positive impact on the adoption of ICTs with an increase of twenty per cent in the likelihood of adoption by citrus farmers with a university degree (Carrer, de Souza Filho & Batalha 2017). Production revenue, which is generally an indicator of farm-size, was also found to be a determinant for the adoption of ICTs because larger farms have an increased need for the efficiencies of using ICTs (Carrer, de Souza Filho & Batalha 2017). Similarly, Khatri-Chhetri et al. (2017) research on Indian farmers’ preferences for climate-smart agriculture technologies indicated that age,
income and farm-size significantly influenced their decision to adopt certain technologies. In contrast to the previously discussed research, Khatri-Chhetri et al. (2017) found that gender and rainfall zones also affect farmers’ use of information technologies. Certainly, these socio-economic factors including income, education, age and gender are factors that may also influence Queensland horticultural farmers’ perception and use of IBE tools. These are factors that need to be explored in this research study in order to address the research questions identified in Chapter 1 of this thesis.

Furthermore, Khatri-Chhetri et al. (2017) findings indicated that farmers’ preferences differ significantly depending on the potential costs and benefits of these technologies which is referred to as relative advantage (Rogers 2003). Relative advantage was also identified as one of two overarching factors affecting farmers’ adoption of new agricultural practices by Kuehne et al. (2011). The perception and use of IBE tools may also be impacted by the costs and potential benefits of these tools, thus requiring relative advantage to be explored in this research study. In addition to relative advantage, Rogers (2003) DOI Theory recognises four other key attributes that affect the rate of adoption including compatibility, complexity, trialability, and observability. These five key attributes are also used to investigate the adoption of innovations by several other researchers (Robertson et al. 2012; Sewell et al. 2017; Verdouw, Robbemond & Wolfert 2015) and this will be further discussed in the theoretical framework chapter of this thesis.

Kuehne et al. (2017) also identified the learning process as the second overarching factor in their research affecting farmers’ adoption of new agricultural practices. Training, learning and support mechanisms are vital to the competency skills of farmers considering the adoption of ICTs and it has also been established that this may increase farmers’ self-efficacy (Caron, Biénabe & Hainzelin 2014; Pannell & Vanclay 2011; Salim, Mamun & Hassan 2016; Sewell et al. 2017). In addition to ICT literacy, education, awareness and motivation, Zhang, Wang and Duan (2016) suggest that successful adoption of ICTs by China’s agricultural sector also depends on the interconnectedness and interactions of human actors, behaviours and information resources. In this context, the complexity in learning and using IBE tools effectively were considered to potentially affect the adoption of IBE tools. For example, if a farmer finds it difficult to learn to use
IBE tools, if it is challenging to remember how to use them, or if it takes a large investment of time to achieve the necessary skills to use these tools effectively, these factors are potential barriers to the adoption of IBE tools and need to be investigated in this research study.

2.8 Sociocultural factors

Sociocultural factors impact the overall operation and management of farm businesses and in particular, the decision-making process. This is evident in the terminology used and debated in the literature to distinguish farming structures based on changing sociocultural and economic characteristics including family farm businesses, farm family entrepreneurs, contract farms and corporate farms (Fulton & Vanclay 2011; Pritchard, Burch & Lawrence 2007; Tonts et al. 2003). For example, Pritchard, Burch, and Lawrence (2007, p.76) use the term farm family entrepreneurs to highlight the duality of the farm structure where families continue to be ‘the social and economic heart of farm ownership and operation, but … where they relate to their land-based assets through legal and financial structures characteristic of the wider community’. However, the researcher considers that the arguments put forward do not necessarily apply only to farming and agriculture. The development of similar structures can be seen in the general business arena where small family businesses grow into medium business enterprises. Thus, while there is sound discussion about the structures and terminology, the debate itself is not entirely relevant to this research study. What is relevant though, are the sociocultural factors addressed by these researchers forming the basis for their debate and how these factors may impact on the decision-making process and the outcome of decisions or perceptions affecting the adoption and effective use of IBE tools.

Therefore, an understanding of the role of family members in decision-making and their impact on farm operations and management is important and relevant to the proposed research study. This is also supported by Fulton and Vanclay (2011, p. 97) in their research on enabling change in rural Australia emphasising that it is essential to understand that the ‘family farm business is the total of the elements and interactions between the family, the farm and the business’. Thus, sociocultural factors play an important role in the operational and management aspects of farms and the diversity of decision outcomes. In this context, some family members may have considerable influence on the decision to adopt IBE tools.
Vanclay (2011) maintains that in addition to environmental and economic impacts, understanding the broader social issues that impact on farming is essential for agricultural development. A list of twenty-seven principles has been developed by Vanclay, which highlight the importance of acknowledging the diversity that exists between farms, farmers and farm management practices. Of vital importance to understanding farmers are Vanclay’s key principles (2011, p. 213): ‘awareness of farming as a social activity; recognition of the social diversity of farmers and the social drivers in agriculture; and the sociocultural basis of adoption.’ The full list of Vanclay’s (2011) principles is presented in Appendix A. It is this sociocultural basis of adoption that is of particular relevance to the research study. The researcher needs to explore the possibility and the effect of family members and other sociocultural factors influencing the decision to adopt IBE tools.

2.9 Change management

Consideration of change management principles or methods may be appropriate for the development and implementation of IBE tools. While user-involvement has been identified as possibly the most critical success factor in the development and implementation of IS projects, the impact of technological change on human behaviour is often overlooked and underestimated (Schneider & Sarker 2006). This commonly results from the insular view that IS are technology-based systems and not considering the broader concept that IS are used to support human activities. Stair and Reynolds (2010) suggests that the exceptionally high failure rate of IS is probably caused by perceiving them as technical systems when they are better understood as socio-technical entities. IBE tools should be developed and implemented with the farmers as a central focus, but farmers’ acceptance and effective use of these technology tools requires changes to their traditional approaches and changes to their attitudes.

Change management can be defined simply as a planned, managed, and systematic approach applied to the integration of change (Waddell et al. 2017). It provides a structured process for moving from a current state to a desired future state (Johnson 2001; Lawler & Worley 2006). When IBE tools are designed, developed and promoted to farmers, change management principles could be applied to encourage farmers’ participation in the development and implementation to convince farmers of the advantages and to change their behaviour and attitude towards IBE tools. Change management recognises the environment in which the changes will occur, the factors
that will be influenced by the change, and the elements that will need to change (Johnson 2001). This approach would cater for the farmers’ human behavioural perspectives, cultural barriers and cognitive capacities associated with the new technology and new approaches to operational farm activities.

While there are several theories or models of change such as Lewin’s change model, or contemporary action research, Waddell et al. (2017, p. 162) suggest the set of activities or guidelines presented in Table 2.2 is important for planning and implementing change. These change activities are relevant to the changes necessary for farmers to adopt and effectively use IBE tools. This set of guidelines could be considered by extension agents and adapted to the behaviours, attitudes and needs of farmers and their culture.

<table>
<thead>
<tr>
<th>Change activity</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivate change</td>
<td>Creating readiness for change</td>
</tr>
<tr>
<td></td>
<td>Managing resistance to change</td>
</tr>
<tr>
<td>Create a vision</td>
<td>Energising commitment</td>
</tr>
<tr>
<td></td>
<td>Describing a desired future state</td>
</tr>
<tr>
<td>Develop political support</td>
<td>Assessing change agent power</td>
</tr>
<tr>
<td></td>
<td>Identifying key stakeholders</td>
</tr>
<tr>
<td></td>
<td>Influencing stakeholders</td>
</tr>
<tr>
<td>Manage the transition</td>
<td>Activity planning</td>
</tr>
<tr>
<td></td>
<td>Commitment planning</td>
</tr>
<tr>
<td></td>
<td>Management structures</td>
</tr>
<tr>
<td>Sustain momentum</td>
<td>Providing resources for change</td>
</tr>
<tr>
<td></td>
<td>Building a support system for change agents</td>
</tr>
<tr>
<td></td>
<td>Developing new competencies and skills</td>
</tr>
<tr>
<td></td>
<td>Reinforcing new behaviours</td>
</tr>
</tbody>
</table>

Table 2.2: Effective change activities
Source: Adapted from Waddell et al. (2017, p. 162)

2.10 Summary
A range of literature that contributes to the knowledge domain of information systems research has been explored in relation to the research topic. This provides background information on the research topic and highlights relevant gaps in the research literature. Overall, the literature contributes to a broader and more in-depth understanding of the research topic and positions this research study within the current literature.
Chapter 3 — Theoretical Framework

3.1 Introduction

The previous chapters in this thesis have identified the goals and objectives of this research study and explored the relevant research literature. This has developed a foundation of background knowledge and understanding of the agricultural extension domain. Furthermore, it has established where this research study is placed in relation to relevant agricultural and information systems research.

While there are various information technologies and information systems that may be relevant, beneficial and profitable for farmers, adoption of these tools is not guaranteed. Ascertaining the factors that affect the adoption of IBE tools and in particular farmers’ perceptions of these tools, could enable improved extension services and increased success of farming businesses. In order to achieve the overall objectives of the research study, a strategy needs to be designed, developed and planned. Establishing the underlying design and structure of the research study required a theoretical framework to be developed. Developing the theoretical framework as an overall blueprint largely contributes to the research design and will also provide clear direction for data gathering and data analysis strategies (Yin 2009).

This chapter discusses the theoretical framework for this research study including the purpose of a theoretical framework, IS research theories and theories relevant to the research topic. Several theories were considered in planning this research study that had the potential to establish an understanding of why farmers use IBE tools. These theories were mainly from the interpretive IS domain and are discussed in this chapter. In particular, the Technology Acceptance Model, the Unified Theory of Acceptance and Use of Technology, Script Theory, Structuration Theory, the Diffusion of Innovations Theory (DOI) and Design Science were considered for this research study. Ultimately, the researcher selected Rogers’ DOI Theory as the underlying theoretical framework for this research study.
3.2 Theoretical framework purpose

According to Merriam and Tisdell (2016), the theoretical framework establishes the underlying structure or scaffolding of the research study. Similarly, Miles, Huberman and Saldana (2014) suggest that it enables the researcher to identify the main variables or constructs to be studied and analysed and, therefore, identifies the data to be collected. Hence, it provides a foundation structure that guides the researcher in gathering, examining, understanding and analysing phenomena within the research.

Maxwell (2013, p. 49) suggests that the theoretical framework is a guiding light that enables the researcher to make sense of what they see:

Theory is a spotlight. A useful theory illuminates what you see. It draws your attention to particular events or phenomena, and sheds light on relationships that might otherwise go unnoticed or misunderstood.

While this appears to be a rational approach by highlighting the researcher’s focus of attention and setting a clear path, the researcher must also be open to data that may be of consequence to the research study and yet may lie in the shadows. In this context, Maxwell (2013) advises that the researcher needs to be cognisant that not everything can be illuminated by one theory. Similarly, while Walsham (1995) agrees that theory is valuable as a guide in interpretive qualitative research, he advises the researcher to avoid being rigid in their approach to issues and points of interest that fall outside of the theory. Therefore, while this research study is informed through a theoretical framework based on Rogers’ DOI Theory, the researcher was open-minded and flexible in collecting and exploring the data and looked beyond the DOI constructs.

According to Walsham (1995) a more open and flexible attitude to the data and theories enables those initial theories to be revised and adapted in the iterative research process if that seems appropriate. Certainly there were times throughout this research study when the researcher had doubts about the direction of the study and re-evaluated the research design including the DOI constructs. Nevertheless, using the theory as an overall blueprint largely contributes to the research design and will provide clear direction for data gathering and data analysis strategies (Yin 2009).
3.3 Information systems research theories

According to Merriam and Tisdell (2016) the knowledge base for the theoretical framework is closely linked to concepts, models and theories that align with a particular research discipline or domain. While this research study crosses the boundaries of information systems (IS), agriculture and business, there was a more dominant orientation towards the IS domain. This orientation is linked to the researcher’s background as a systems and business analyst and her educational qualifications.

The adoption and use of technology and IS in this research study is not being looked at from an indiscriminate perspective where rural and urban outlooks, behaviours and needs might be considered the same. On the contrary, the researcher considered that Queensland horticultural farmers may have quite diverse views on the value and perceived benefits of IS and technologies compared to technology users in urban areas. Although technology is seemingly ubiquitous, its use is emergent and to some extent, unknown for some farmers in rural Queensland. Accordingly, while this research study has its foundations in IS, the research is not premised on the centrality of IS and technology in the everyday life of Queensland farmers.

Orlikowski and Iacono (2000) suggest that it is individual choice as to whether technology is used and how, why and when it is used. These authors refer to the distinction between “espoused technologies” and “technologies-in-use” in a similar way to Argyris and Schon (1978) distinguishing between “espoused theories” where a person’s own view or description about how they behave is compared to “theories-in-use” which indicate what is revealed about how a person behaves based on their actual demonstrated behaviour (rather than their own account of that behaviour). The relevant point here is that people often don’t realise the distinction because they believe their own perspective and this same concept may be active in the development of IBE tools compared to their actual use. The concept of espoused technologies and technologies-in-use could highlight a situation where there is a lack of realisation in the distinction between the development of IBE tools and their actual use. The researcher’s awareness of this concept was explored in terms of expectations of the use of IBE tools as opposed to farmers’ actual use of IBE tools and how, why, and when they are used.
3.4 Relevant theories

There are numerous theories that may be relevant to this research study and some of these are described below. Many theories from the Information Systems (IS) discipline tend to be from the behavioural science paradigm and have emerged from the natural sciences (Hevner et al. 2004). IS theories seek to inform the research community of the interactions between technological systems, people and organisations (Hevner et al. 2004). Hence, IS theories are relevant to this research study because IBE tools are technology systems expected to be used by farmers belonging to some form of organisation such as a grower group or rural community but also to the wider agricultural organisation where they interact with other stakeholders in the AIS as previously discussed. The designers and developers of IBE tools also belong to extension groups or agricultural organisations and also interact within the AIS.

• Technology Acceptance Model

Initially, the Technology Acceptance Model (TAM) seemed to be particularly relevant and appropriate. This was because TAM considers perceived usefulness and perceived ease of use to determine the intention to use a system (Davis 1989) and these factors are likely to influence farmers’ adoption of IBE tools. However, TAM does not take into account constraints that may impact a farmer’s use of the technology such as limited time and ability and perhaps environmental factors. Furthermore, TAM does not include consideration of sociocultural aspects of technology. These missing constructs are seen as limitations of TAM as the researcher considers these to be directly relevant to farmers’ use of rural-focused websites and IBE tools.

• Unified Theory of Acceptance and Use of Technology

Similarly, the Unified Theory of Acceptance and Use of Technology (UTAUT) Theory was considered relevant to the research. This theory was developed to combine aspects of several competing models including TAM (Venkatesh et al. 2003). The UTAUT addresses the concerns of the researcher in regard to constraints and sociocultural aspects by including constructs such as social influence, facilitating conditions and experience (Venkatesh et al. 2003). The researcher, however, was concerned that the influence of sociocultural elements in farming, particularly the influence that family members may have on adoption decisions, is not as direct as those incorporated in the UTAUT Theory.
Chapter 3 – Theoretical Framework

• **Script Theory**
  Schank and Abelson (1975) define a script as ‘a predetermined, stereotyped sequence of actions that define a well-known situation’. The researcher's consideration of this social theory stemmed from published literature about the sociocultural dimension of agriculture, particularly Vanclay and Enticott (2011) and Casanova-Pérez et al. (2016). Script theory enables the researcher to better understand farmers’ social lives and the impact of culture on perceptions that guide and justify decisions and courses of action (Casanova-Pérez et al. 2016; Vanclay & Enticott 2011). While this would facilitate in the development of adaptation strategies required in the dissemination of extension tools, there seemed to be insufficient scope to address the technological aspects of IBE tools which was necessary in this research study.

• **Structuration Theory**
  Giddens’ Structuration Theory was also considered as a potential theory to use in this research study. Structuration Theory is based on how the relationship between individuals and society is viewed and understood. Jones and Karsten (2008) suggest it is a theory that deals at a high level of abstraction proposing that the dualism of structure and agency should in fact be viewed as the duality of structure. The dualism of structure and agency views the structure and agency constructs as two independent concepts in shaping human behaviour (Rose & Scheepers 2001). Thus, dualism of structure suggests that either an individual acts as a free agent and therefore has the ‘capacity to make a difference’ (Giddens 1986, p. 14) or they act in accordance with social structure.

  In contrast, Giddens’ Structuration Theory proposes that structure and agency be viewed as a duality (not dualism) in that ‘the structural properties of social systems are both a medium and outcome of the practices they recursively organize’ (Giddens 1986, p. 25). Thus, social structure cannot be ignored as largely influencing social action and vice versa. This is relevant to the research study where it is important to acknowledge and understand the role and impact of family members and perhaps even the farming community on decision-making and farm management, particularly their influence on the adoption of IBE tools. This is emphasised by Fulton and Vanclay (2011, p. 97) stating that the ‘family farm business is the total of the elements and interactions between the family, the farm and the business’.
3.5 Diffusion of Innovations Theory

While the researcher acknowledges the relevance of the nature of structuration theory to the research study, the researcher decided that factors affecting Queensland farmers’ use of IBE tools would be more extensively examined in terms of Rogers’ Diffusion of Innovations (DOI) Theory (2003). Nonetheless, the researcher was aware that social structure and sociocultural factors may also influence farmers’ actions. This section discusses Rogers’ DOI Theory and explains the justification for selecting DOI, why it is well-suited to this research study and establishes the link between DOI Theory and the research questions.

Rogers’ DOI Theory was originally based on a research study undertaken in Iowa in 1943 which explored the long period taken for adoption of hybrid corn seed; ‘obviously certain non-economic factors must be at work to explain such seemingly non-rational behaviour’ (Rogers 2004, p. 14). Subsequent research led to Rogers developing a generalised model of diffusion and writing his first book on this topic in 1962 (Rogers 2004). Since then, Rogers (2004) has published a further four editions of his original book expanding the diffusion model from its rural base across various academic fields including communications, health and education; and achieving his vision for a more generalised model. Hence, Rogers’ DOI research is well established in both the rural field and more generally, and has been used extensively in research with thousands of diffusion publications and even more citations to his work.

Rogers (2003, p. 5) defines diffusion as ‘the process in which an innovation is communicated through certain channels over time among the members of a social system’ and that ‘it is a special type of communication, in that the messages are concerned with new ideas’. An IBE tool is considered an innovation because these tools are relatively new in terms of their availability to farmers, the technology being used, and the software itself. Moreover, Rogers (2003) asserts that if an individual considers an idea to be new then it is an innovation and that it may be considered new in terms of an individual’s knowledge about the innovation, or some form of persuasion or decision to adopt the innovation. Thus, based on Rogers’ (2003, p. 12) definition of an innovation: ‘an idea, practice, or object that is perceived as new by an individual or other unit of adoption’, this research study is justified in claiming that an IBE tool is an innovation.
Five key characteristics or attributes that influence the adoption rate of an innovation are identified by Rogers (2003) including relative advantage, compatibility, complexity, trialability, and observability. Relative advantage and complexity are closely related to perceived usefulness and perceived ease of use, which are two constructs in Davis’ (1989) TAM. Perceptions of the five key attributes of the DOI Theory may vary between potential adopters of an innovation and those individuals proposing the innovation adoption. For example, farmers' perceptions of IBE tools may be different to extension professionals' and agricultural educators' perceptions of the same IBE tools. Furthermore, individual farmers' perceptions may differ to other farmers' perceptions of the same IBE tools. Therefore, it is important to identify perceptions of IBE tools from each farmer's perspective in order to identify factors that influence their use of IBE tools.

According to Rogers (2003, p. 223), the perception of these attributes contributes to the rate of adoption of an innovation whereby ‘subjective evaluations of an innovation, derived from individuals’ personal experiences and perceptions and conveyed by interpersonal networks, drives the diffusion process’. In the context of decision support systems and expert systems, Lynch, Gregor and Midmore (2000) found that many farmers decided they were better off spending time on the farm rather than in front of a computer because the economic benefits were not clearly visible (relative advantage); these systems were difficult to use (complexity) and not compatible with current farming practice (compatibility).

Based on Rogers (2003) DOI Theory, however, if a farmer perceives an IBE tool to have greater relative advantage, compatibility, trialability, and observability and to be less complex, it is expected to be adopted more rapidly. Rogers (2003) states that most diffusion research focuses on the five key attributes of an innovation. For example, diffusion research conducted by Al-Jabri and Sohail (2012), Bennett and Bennett (2003) and Gerrard and Cunningham (2003) is based on the five key attributes of an innovation. Gathering data about farmers' perceptions of IBE tools in terms of these five key attributes will contribute to addressing the research questions, particularly the first two research questions. Therefore, investigating farmers' perceptions of IBE tools in terms of Rogers (2003) five key attributes is appropriate and well suited to the proposed research.
Chapter 3 – Theoretical Framework

In addition to the perceived attributes of innovations, Rogers (2003) identifies four other variables that affect the rate of adoption of an innovation including:

1. The type of innovation-decision;
2. The types of communication channels;
3. The nature of the social system; and
4. The promotional effort of change agents.

These variables are also relevant to the proposed research as the adoption of IBE tools is considered to be an innovation-decision process, that is, the decision to adopt a particular innovation (or IBE tool) is not instantaneous but rather it evolves through stages over time. Rogers (2003) explains that the process starts when an individual becomes aware and acquires knowledge about an innovation; then they form an opinion about it, decide to adopt or reject the innovation, apply the innovation, and then re-evaluate or confirm whether it is in fact appropriate for their circumstances. Various factors throughout this innovation-decision process may affect a farmer’s decision to use an IBE tool.

According to Leeuwis (2004), communicating about an innovation is also important. While some farmers might adopt an innovation, other farmers may not even be aware of the innovation or may have rejected the innovation. Through communication within the farming community or social system, those farmers that have already adopted an innovation have the potential to influence other farmers to follow suit, thereby positively affecting the diffusion and possible adoption of that innovation. Similarly, the promotional effort of change agents or extension agents may affect farmers’ knowledge and awareness of the existence and benefits of IBE tools. Therefore, consideration of these variables that affect the rate of adoption and diffusion of an innovation is necessary to provide further insight to the factors affecting Queensland horticultural farmers’ use of IBE tools.
3.6 Summary

This chapter discussed the purpose of the theoretical framework within the research study. It was established that the theoretical framework provides a foundation structure that guides the researcher in gathering, examining, understanding and analysing phenomena within the research. IS research theories were also discussed in general terms and a more detailed discussion was presented on those theories that had the potential to be particularly suitable for this research study.

Relevant theories including TAM, UTAUT, Script, Structuration, DOI and Design Science theories were discussed in this chapter. After evaluating these theories, some were eliminated because the researcher considered that certain elements were not entirely suited to the research study. For example, TAM does not include consideration of sociocultural aspects of the technology which the researcher sees as a limitation because farmers’ perceptions of the IBE tools may be affected by sociocultural factors. While the UTAUT addresses these sociocultural aspects, the researcher was concerned that the influence of sociocultural elements in farming are not as direct as those incorporated in this theory. The researcher considered Script theory’s sociocultural dimension of agriculture as appropriate for the research study and while it would facilitate the development of adaptation strategies for extension tools, there seemed to be insufficient scope to address the technological aspects of IBE tools. Similarly, the researcher decided that Structuration Theory was not the best fit for identifying farmers’ perceptions of the technology and was therefore not as suitable to the research study as DOI Theory. Hence, DOI Theory is used as the dominant theory for collecting and analysing data for this research study.
Chapter 4 — Research Strategy

4.1 Introduction

The previous chapter discussed and justified the theoretical framework for this research study. Several theories were considered in planning this research study including TAM, UTAUT, Script Theory, Structuration Theory and DOI. After discussing these theories and evaluating their appropriateness for this research study, it was established that DOI was well-suited to provide insight to the factors affecting Queensland horticultural farmers’ use of IBE tools.

This chapter explains and justifies the research strategy adopted for the research study. It has been written in the first person as it has been a particularly challenging and thought-provoking part of the research journey. This has been evident not only from an academic perspective but more specifically from the personal experience which invoked a range of thoughts and feelings especially throughout the learning and reflection associated with philosophical assumptions. At times the process was intensive, confronting and confusing and yet also rewarding and empowering. Hyland (2001) suggests that, in the field of philosophy, writing in the first person not only conveys the writer’s unique views and commitment to their work, but also that the writer believes what they are saying. Writing this chapter in the first person has enabled me to better convey my commitment to understanding the rich and vast nature of qualitative research. Furthermore, it has enabled me to be more cognisant of my philosophical assumptions and beliefs, and how these concepts influence, guide and inform the research approach.

The first part of this chapter discusses and justifies the conceptual framework used to further develop the direction of this qualitative research study. Establishing the conceptual framework reflects the belief system and underlying philosophical assumptions or lens that guides the rationale applied in planning and designing the research study. In this context, it drives the natural preference toward an appropriate theoretical paradigm, research methodology and research methods. Essentially, these conceptual foundations underpin the overall approach adopted throughout the conduct of the research study.
The research methodology and research methods adopted for this research study are also discussed in this chapter. The interaction of these elements with the conceptual framework enables a rational, structured and consistent approach to address the research objectives and the research questions. Hence, the research strategy creates the foundations for the design of the research study. In this context, the research strategy also contributes to the establishment of constructs to be studied and analysed, and guides the interpretation and understanding of the research data.

The qualitative research study was conducted using an interpretivist paradigm and the case study methodology. Four cases were established on the basis of individual industry grower groups within Queensland horticulture including avocado, macadamia, pineapple and strawberry industry groups. Data collection techniques included focus groups, face-to-face interviews, observation and examination of relevant reports and websites.

4.2 Qualitative research

The research investigation lends itself to qualitative research, which according to Myers and Avison (2002) will enable a better understanding of people and the social and cultural contexts in which they interact. Similarly, Ormston et al. (2014, p. 4) suggest that qualitative research provides an in-depth understanding of research participants by exploring and interpreting their social world and 'learning about the sense they make of their social and material circumstances, their experiences, perspectives and histories'. I believe that focussing on the farmers and the interaction with their families, managers, farm employees, other farmers and industry groups was the most effective and most appropriate approach to the research study. Given that I was keen to explore how these social and cultural contexts may influence the perception, decisions and needs of Queensland farmers in relation to their use of IBE tools, a qualitative approach to the research was justified and valid for the research objectives.

Yin (2011) also emphasises the outlook that qualitative research enables the views and perspectives of participants to be captured. Similarly, Stake (2010) maintains that qualitative research relies on human perception and understanding. By talking and listening to Queensland farmers, I endeavoured to understand their thoughts and perceptions and explain how these elements influenced their use of IBE tools.
A meaningful universal definition of qualitative research, however, is surprisingly elusive with Schwandt (2007, p. 248) for example suggesting that it is ‘notoriously difficult to define precisely’. Similarly, Creswell (2013) notes that it is becoming increasingly difficult to locate a definition and Yin (2011, p. 7) challenges ‘anyone to arrive at a succinct definition’. Phillimore and Goodson (2004) suggest that it is an enigma and Braun and Clarke (2013) suggest that it may even invoke hostile and heated discussion. Denzin and Lincoln (2008, p. vii) describe the last forty years as a ‘quiet methodological revolution’ and that the qualitative research field was dominated by ‘tensions, contradictions, and hesitations … in a less-than-unified arena’. As the qualitative research field has emerged, its underlying assumptions and inherent qualities have been the focus of much academic and disciplinary debate (Braun & Clarke 2013; Denzin & Lincoln 2008; Phillimore & Goodson 2004). This ongoing conflict has been provoked by individual views and stimulated by strong and passionate beliefs within a field of diverse disciplines, approaches and methods (Burrell & Morgan 2000; Guba 1990; Strauss & Corbin 1998).

Issues commonly argued include the actual meaning of qualitative research, the role of theory and methodologies, the unscientific nature of qualitative research; validity of interpretations, objective truth, the inability to replicate data in other projects, and the disagreement and criticism of various definitions and portrayals from within the field of qualitative research (Braun & Clarke 2013; Bryman & Bell 2015; Phillimore & Goodson 2004). The procedural and political based resistances to qualitative research from academic and disciplinary advocates (and opponents) have contributed to the ongoing debate as evidenced through the Paradigm Wars of the 1980s and Guba’s Paradigm Dialog (Denzin & Lincoln 2011). This ongoing argument has continued largely because of the diversity of the different disciplines and professions engaged in the qualitative research field (Yin 2011). Certainly, each individual academic contributing to the debate would strongly believe in their own personal set of philosophical assumptions, and would argue with passion and vigour over the superiority of their perspective. It appears that this wide backdrop of diversity and the conflicting nature of underlying assumptions that drives this debate.

Consequently, interpreting and understanding the debate and the underlying theoretical perspectives, results in issues sustaining this debate and the differences that epitomise the qualitative research field (Burrell & Morgan 2000; Denzin & Lincoln 2008; Guba
1990). Some of these issues include defining and describing the fundamental concepts, theories and processes in qualitative research. Phillimore and Goodson (2004, p. 5) ask whether qualitative research is ‘a set of methods, a strategy, a critique or an approach?’. In exceptionally broad terms Strauss and Corbin (1998) describe qualitative research basically as any research findings not based on numbers or statistics or any other form of quantification. While this may be true, it simply depicts qualitative research as a huge umbrella but neglects to embrace the characteristics of the qualitative research field in concrete definitive terms. I believe that this negative epithet achieves nothing and this is supported by Grahame (1999, p. 4) in his statement ‘the notion that qualitative research is non-quantitative is true but uninformative: we need more than a negative definition’. Similarly, Guba and Lincoln (1994) suggest that the soft and unscientific nature of qualitative research makes it a substandard approach and useful only if it is used in combination with quantitative techniques. It is apparent that there is a wide spectrum of diversity and it seems that this diversity of beliefs and approaches, combined with the inherent complexity of knowledge encompassed in qualitative research, could continue to drive irreconcilable debate.

Nonetheless, Lincoln, Lynham and Guba (2011) suggest that as the qualitative research field develops, despite the diversity and conflicting nature of the debate, ‘new linkages … and emerging similarities in interpretive power and focus’ will be realised. As a starting point, Denzin and Lincoln (2011, p. 3) offer a generic definition of qualitative research that has evolved with the changing nature and complex history of qualitative research:

Qualitative research is a situated activity that locates the observer in the world. Qualitative research consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them.

While qualitative research intuitively appealed to me, my knowledge of academic research was limited and philosophically shallow. Therefore, I extensively carried out the three R’s: research, reading and reflection. My goal was to design a rigorous and appropriate research strategy that would be congruous with achieving the objectives of this particular research study and at the same time would accommodate my own goals and beliefs.
At this stage of my research career, I acknowledge that I lack the credibility to contribute to the debate on what qualitative research should mean to the research domain. Nevertheless, I have acquired sufficient knowledge and understanding to intelligently evaluate the generic definition offered by Denzin and Lincoln (2011) above. While this definition is still somewhat philosophically inexplicable to the novice researcher, I was able to apply the concepts and was convinced that qualitative research was appropriate to this research study. In particular, the last part of Denzin and Lincoln’s (2011) definition appealed to me because I wanted to talk to farmers on their “home soil” and discover and understand their perspectives in my attempt to identify factors that affect their adoption and use of IBE tools. Thus, I believe qualitative research was appropriate, valid and justified for this research study.

Furthermore, Yin (2011) identifies five features of qualitative research and while this is not offered as a definition, it provides a clear and compelling view of the distinctive nature of qualitative research. These five features capture the essence of qualitative research (Yin 2011, pp. 7-8) and include the following:

1. Studying the meaning of people’s lives, under real-world conditions;
2. Representing the views and perspectives of the people … in a study;
3. Covering the contextual conditions within which people live;
4. Contributing insights into existing or emerging human social behaviour; and
5. Striving to use multiple sources of evidence rather than relying on a single source alone.

The essence of these features is perhaps more pertinent and cogent to the researcher than even Denzin and Lincoln’s (2011) generic definition. Accordingly, one of the goals I strived for was to adopt and apply these features throughout the research study. For example, I was keen to explore the impact of family members’ views and perspectives on the decision to adopt IBE tools as well as the practical on-farm ability of farmers to access and effectively use IBE tools. These elements are emphasised in the second, third and fourth features in Yin’s (2011) above list. In addition, various sources of evidence were considered throughout the research study whereby the on-farm context or real-world setting was observed in conjunction with one-to-one interviews. Considering these elements in this manner adheres to the first of Yin’s (2011) qualitative research features.
Another fundamental consideration throughout the development of the research strategy was that my beliefs, education, and experience would inherently influence my overall thinking, understanding and interpretation. While this is an intrinsic part of human nature it was certainly a critical factor that I needed to consciously consider in the design of my data collection and analysis. My goals were to empathise with the farmers and focus on their perspectives and meanings, albeit through my own interpretations of the research. I needed to be mindful that my interpretations and understanding did in fact reflect the farmers’ perspectives. Thus, I had to be cognisant of the farmers' world and their context when seeking to understand their perceptions. I needed to be cautious of my own perspectives possibly dominating or even obscuring the intended meaning of the farmers; I had to ensure I didn’t obstruct or misinterpret their true meaning.

Essentially, Yin's (2011) five features of qualitative research were not only paramount at the outset of the research study when designing the research strategy, but also as the research study progressed. I used these five elements as guiding principles throughout the research journey and was absolutely convinced that qualitative research was the best approach to achieve the research objectives. Miles and Huberman’s (1994) data analysis guidelines also substantiated my choice of adopting a qualitative research approach. They state that ‘qualitative data … are fundamentally well suited for locating the meanings people place on the events, processes, and structures of their lives … and for connecting these meanings to the social world around them’ (Miles & Huberman 1994, p. 10). These guidelines highlight the fundamental nature of qualitative data and how it enables an understanding of people and the social and cultural contexts in which they interact.

Accordingly, these guidelines directly apply to my research study considering my objective to understand farmers’ perspectives and how/why these are influenced through social and cultural interactions with the farming world. Thus, I believe adopting qualitative research as my primary approach for this research study is an appropriate and justified decision. It is fundamental to the research design and provides congruous guiding principles for achieving the research objectives. Qualitative research also satisfied my own personal goals and beliefs, thus giving me the passion to persevere with the challenging research journey.
4.3 Conceptual framework

The conceptual framework is fundamental to any research study because it reflects the belief system of the researcher and guides the overall research process. This is supported by Saldana (2011) who indicates that the conceptual framework encompasses the overall epistemological, theoretical and methodological approach to the research study. Thus, the conceptual framework essentially drives or gives direction to the research.

Miles and Huberman (1994) also emphasise the importance of the conceptual framework and highlight its significant impact throughout the research process even to the extent of influencing the identification and selection of factors to be explored in the research. It is clear from this account how the conceptual framework is applied particularly throughout the data collection and analysis process whereby the conceptual framework is used as a basis for organising variables and their relationships while gathering and analysing data.

Both views highlight the importance of the conceptual framework to the overall research design where its guiding elements drive each phase of the research study and filter down to the lowest levels of the research process (Miles & Huberman 1994; Saldana 2011). Similarly, Morgan and Smircich (1980) advocate that research methods cannot be determined in isolation of the philosophical assumptions because the characteristics and selection of those methods are shaped by the researcher’s philosophical stance. Morgan and Smircich (1980, p. 499) also state that:

A preoccupation with methods on their own account obscures the link between the assumptions that the researcher holds and the overall research effort, giving the illusion that it is the methods themselves, rather than the orientations of the human researcher, that generate particular forms of knowledge.

Hence, philosophical assumptions play a major role in all facets of the research strategy, the design and conduct of the research, and the interpretation and findings of the research. Consequently, my philosophical assumptions that underlie the approach to this research study, shape the conceptual framework and therefore, I have given considerable thought to the foundation of this conceptual framework and have reflected on this throughout the overall research journey.
Philosophical assumptions including the concepts of ontology, epistemology and axiology are discussed in the next section where the fundamental research principles that I have adopted are also identified and discussed. The interaction of key philosophical assumptions is represented in Figure 4.1 which shows that each of these elements inform the overall research strategy.

![Figure 4.1: Interaction of key philosophical assumptions](image)

### 4.4 Philosophical assumptions

As an early career researcher, my previous encounters with research philosophy were limited. Consequently, the diversity of new concepts and the plethora of definitions in research philosophy were bewildering and to some extent, daunting. Even more challenging and sometimes utterly perplexing was the extensive range of competing perspectives and the inconsistent and even contradictory use of terminology. The complex accounts of historical traditions and how they evolved, termed the ‘successive waves of epistemological theorizing’ and ‘historical moments’ by Denzin and Lincoln (2008, p. 4), were also interminable. The reading and reflection required to acquire some fundamental level of intellectual comprehension and to overcome this sense of inadequacy and unpreparedness, was onerous. It was also an iterative process whereby I would grasp one concept but that would raise more questions. The more understanding I acquired, the more I realised I didn’t understand or simply didn’t know. While this was an arduous journey in itself, it was absolutely necessary, enlightening and in some obscure way, exciting.

One fundamental outcome from this intensive reading was the realisation and awareness that every level of my research would certainly be influenced by my beliefs, education, and personal experience. While my goal was to obtain the perspectives of the farmers I
was now cognisant of the fact that I had to maintain some level of impartiality that would enable the farmers’ viewpoints to be established or constructed and to be given prominence. Therefore, my philosophical stance needed to be established and then considered throughout the design and conduct of the research study.

Burrell and Morgan (2000) support this by suggesting that the researcher needs to understand their own philosophical assumptions and perspectives in order to understand and appreciate alternative perspectives. Similarly, Crotty (1998) suggests that in order to justify the choice of methodology and methods, the researcher needs to consider their assumptions about reality and their understanding of what knowledge is; in other words, their philosophical assumptions and their theoretical perspective. Thus, having this knowledge on which to base decisions about the research strategy to be adopted for this research study is imperative for giving it the appropriate direction and maintaining compatibility but also for enabling a strong and consistent approach to the research study. Furthermore, it is also clear that the researcher should recognise the pervasive nature of these philosophical assumptions and their impact on the research study, thus developing justification for their decisions and approach. Adopting this mindset would also contribute to achieving the quality characteristics aspired to in qualitative research including credibility, reliability, reflexivity, validity and rigour.

Likewise, in designing the research study Huff (2009) suggests that philosophical assumptions will influence the way the research problem and research questions are articulated, and how the researcher will seek to answer those questions. Barbour (2014) agrees that philosophical assumptions guide the research activities from developing research questions through to the approach undertaken to carry out data analysis and interpretation. Hence, it is essential to understand the researcher’s philosophical assumptions behind the research including beliefs about the nature of reality, knowledge and the ways in which knowledge can be acquired.

Burrell and Morgan (2000) suggest that a research framework for analysing assumptions about the nature of social science and the nature of society addresses four interrelated philosophical assumptions including ontology, epistemology, methodology, and human nature. Again, within social sciences research, there are differences in opinion and variations regarding the elements that shape a researcher’s philosophical assumptions and guide the development of their research strategy. For example, Denzin and Lincoln
(2008) refer to ethics or axiology, epistemology, ontology and methodology but not human nature. Crotty (1998) suggests that epistemology and ontology merge together and that there is a conceptual confluence that makes it difficult to address these elements separately. Again, human nature is not directly addressed by Crotty (1998), nor is axiology. Instead, Crotty (1998) suggests that four main questions regarding epistemology (including ontology), theoretical perspective, methodology and methods are the basic elements that inform one another in the development of the research strategy. Each of the key elements identified by these authors is depicted in Figure 4.2 to demonstrate the variations that may be considered central to the research philosophy.

![Figure 4.2: Key elements that may inform the research philosophy](image)

While the terminology used to describe the philosophical beliefs of qualitative researchers has varied over decades, it is widely accepted that there is a presence of four domains in a basic system of assumptions by which researchers approach their research (Creswell 2013; Denzin & Lincoln 2008; Guba 1990; Patton 2002). These four domains inform the guiding philosophy behind qualitative research and include ontology, epistemology, axiology and methodology (Creswell 2013; Denzin & Lincoln 2008). These domains are depicted in Figure 4.3 and are defined as follows:
**Figure 4.3:** Four key philosophical domains underpinning qualitative research

**Ontology** or metaphysics according to Schwandt (2007, p. 190) is ‘the study of reality, of being, of the real nature of whatever is, of first principles’. Walter (2010, p. 16) defines ontology as

‘our understanding of what constitutes reality; how we perceive the world around us … how the world is understood … understandings of reality and the nature of being that inform our view of the world’.

Thus, ontology concerns the researcher’s perceptions or personal view of the nature and structure of reality and its characteristics.

**Epistemology** is defined by Schwandt (2007, p. 87) as ‘the nature of knowledge and justification’. Burrell and Morgan (2000, p. 1) state that epistemological assumptions comprise ‘ideas about what forms of knowledge can be obtained, and how one can sort out what is to be regarded as ‘true’ from what is to be regarded as ‘false’’. Hence, epistemological assumptions are concerned with ways of knowing; the means by which knowledge is acquired, how it is known and how it can be justified as knowledge.

**Axiology** refers to those values and biases brought to the study by the researcher and also the participants (Creswell 2013). Walter (2010, p. 15) defines axiology as the ‘theory of values that inform how we see the world and the value judgements we make within our research’. Thus, axiology is the consideration and awareness of the nature of ethics and values. It embraces deep-seated and acquired values; moral, political and cultural values and value judgements (Creswell 2013). Clearly, researchers need to understand
their own set of values and also the value systems of their research participants and those involved with the research study.

**Methodology** is the ‘theoretical and worldview lens through which the research is understood, designed and conducted’ (Walter 2010, p. 5). A more encompassing definition offered by Walter (2010, p. 5) states that ‘methodology is the worldview lens through which the research question and the core concepts are viewed and translated into the research approach’ and includes the ‘often inextricably entwined’ key components of ‘our standpoint; our theoretical conceptual framework and paradigm; and our method’. Thus, methodology refers to the process and procedures adopted by the researcher or the ways in which the researcher investigates and acquires knowledge in the research study based on the researcher’s philosophical and theoretical stance.

The four domains of philosophical assumptions and how they shape the practice of qualitative research are addressed through the following fundamental questions as suggested by Creswell (2013) and Guba (1990):

- **Ontology:** - What is the form and nature of reality?
- **Epistemology:** - What is the nature of knowledge? What is the relationship between the research participant (the knower) and the researcher (would-be knower) in knowing how knowledge is constructed?
- **Axiology:** - What is the role of the researcher’s values and indeed those of the research participants?
- **Methodology:** - What process or procedures can be used by the researcher to find what they believe can be known?

For each of these four domains or philosophical assumptions, Table 4.1 identifies the related fundamental questions, characteristics and implications for research practice.
Ontology, epistemology, axiology and methodology are the four philosophical domains or philosophical assumptions informing and guiding this research study. These philosophical assumptions underpin further development of the research strategy including the research methodology and research methods. I believe that these key philosophical elements give shape and definition to the design and conduct of the research study. These key elements also establish the rationale used to articulate the research problem and research questions, and to design and implement a coherent set of procedures that will enable those research questions to be answered.
4.5 Philosophical stance

- Ontological perspective

The ontological position identifies the researcher’s perception of reality. It is the researcher’s view of the world and how that interacts with other individuals' understandings and practices as summarised by Braun and Clarke (2013, p. 27):

Ontology determines whether or not we think reality exists entirely separate from human practices and understandings … or whether we think it cannot be separated from human practices, and so knowledge is always going to reflect our perspective.

![Ontology Continuum Diagram](image)

Figure 4.4: The objective-subjective dimension relative to the ontology continuum

Source: adapted from Braun and Clarke (2013); Burrell and Morgan (2000)

While this description suggests a dichotomy of two mutually exclusive views, there is a continuum within which the researcher’s ontological perspective can be positioned. This continuum reflects the objectivist's approach to social science at one end of the scale and the subjectivist's approach to social science at the other end. The terminology varies for this continuum (see Figure 4.4) and is also the subject of scholarly debate, referred to as a ‘philosophical minefield’ by Silverman (2001). For example, the objective dimension is often referred to as realism and the subjective dimension is often referred to as relativism or nominalism; in the middle there are variations including materialism, critical realism and subtle realism (Braun & Clarke 2013; Burrell & Morgan 2000; Ritchie & Lewis 2003).
My ontological belief is that reality is based on an individual's own perceptions, constructions and interpretations with the result that there are multiple realities. Grbich (2013) suggests that reality is socially embedded within the mind and that multiple realities are experienced differently by different people. These realities reflect an individual's perceived view of the world and may be influenced and constructed by an individual's life experiences and circumstances, education, culture and economic, social and personal situations. Thus, we all have our own version or perception of reality and how we view the world.

My ontological position is at the subjectivist end of the ontology continuum depicted in Figure 4.4. Relativism best describes my ontological stance because I believe we all see the world from our own perspective and we therefore interpret and construct individual realities; thus, multiple realities exist. I also believe that my ontological stance has further developed my emotional intelligence and empathy skills and this more readily enables me to acknowledge and understand the individual perspectives of research participants’.

• Epistemological perspective
My epistemological perspective incorporated within this research study is that of constructivism. Research identifies several types of constructivism including cognitive, radical and social constructivism (Raskin 2002; Young & Collin 2004). Social constructivism was strongly influenced by the education philosopher Vygotsky who recognised that participation and interaction in socially situated contexts enabled the construction of knowledge (Vygotskii & Cole 1978). Thus, social constructivism highlights the significance of interacting with people and its impact on the development of knowledge and understanding (Young & Collin 2004).

Grbich (2013, p. 7) states that ‘knowledge is subjective, constructed and based on shared signs and symbols that are recognised by members of a culture’. If knowledge is constructed, then it is not discovered but these constructions can change with an individual's new experiences. Schwandt (2000) adds that while knowledge is constructed, this does not happen in isolation but instead through developing an understanding of the world amidst interaction with others. Crotty’s (1998) view of culture steers away from the usual definition that focusses on customs and traditions. Instead, Crotty (1998) suggests that it is our way of functioning, directing behaviour and
organising our experience; it is the source of our thoughts and behaviour rather than the outcome.

Therefore, the culture in this research study is that of Queensland horticultural farming, the farming communities, families and individual farmers. The knowledge acquired in this research study was constructed jointly by the research participants/farmers and myself. This was achieved jointly through the process of inquiry and through the interpretations and constructions of knowledge. Hence the research findings were created through this interaction and interpretation.

4.6 Interpretivist paradigm

While the overall umbrella of qualitative research relies on human perception and understanding (Stake 2010) there are several theoretical paradigms within the field of qualitative research. My philosophical assumptions or beliefs on how I view the world (including the nature of reality and the nature of knowledge) form the basis for selecting an appropriate theoretical paradigm. According to Guba and Lincoln (1994, p. 107) a paradigm is a 'set of basic beliefs (or metaphysics)' representing 'a worldview that defines, for its holder, the nature of the world, the individual's place in it, and the range of possible relationships to that world'. Based on this definition, clearly it is essential to truly understand the fundamental beliefs of the paradigm and my own beliefs.

In this context, it not surprising that strong personal views and sensitivities have contributed to the ongoing academic dialogue immersed in worldviews of both qualitative and quantitative research philosophies. Published research and dialogues debating the various qualitative research paradigms and worldviews appear to depend on the particular research scholar’s perspective and historical focus (Lincoln, Lynham & Guba 2011; Orlikowski & Baroudi 1991; Stake 2008). Some of these qualitative research paradigms include positivism, interpretivism, critical theory, and participation.

Based on my underlying philosophical assumptions, an interpretivist paradigm was appropriate for the research study. But an interpretivist paradigm is not the same as classifying the research as interpretive, although Schwandt (2007) suggests that sometimes the term is used synonymously with all qualitative research. For example, Denzin and Lincoln (2011, p. 13) state that 'all research is interpretive: guided by a set of beliefs and feelings about the world and how it should be understood and studied'.
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From this stance, it is understandable that the term could be applied to all qualitative research regardless of the particular paradigm. It rightly suggests that the researcher must somehow interpret the meanings of the data whether it is in the form of verbal or written text, observation or data collected through some other technique. Interpretation of the data then enables explanation and understanding of the research and its context. However, the underlying philosophical assumptions and beliefs of the researcher provide the basis for distinguishing between and selecting the appropriate research paradigm.

The interpretivist framework or paradigm was selected for this research study because it reflects my philosophical assumptions and set of beliefs. Furthermore, it is widely accepted that the interpretivist paradigm supports my constructivist epistemology (Ritchie & Lewis 2003; Schwandt 2000; Young & Collin 2004). According to Klein and Myers (1999), the interpretivist paradigm reflects the assumption that access to reality is available through socially constructed interaction including language, consciousness and shared meanings. Orlikowski and Baroudi (1991, p. 5) also state that interpretivist research attempts to 'understand phenomena through accessing the meanings that participants assign to them'. As I was interviewing and interacting with numerous farmers, there were all of their individual views to be gathered and analysed but it was also recognised that interpretation of these views was filtered through my own lens or perspectives which are grounded in my beliefs, values, education and experience. Walsham (2006) describes this as having some level of bias based on the researcher’s background, knowledge and prejudices depending on the researcher’s level of involvement in the field. Yin (2011) refers to this as the researcher’s lens in his discussion of emic and etic perspectives which explain the existence of multiple interpretations or multiple realities. This means that there are multiple realities and that reality is constructed subjectively between the researcher and the participants as the research progresses. Accordingly, this approach matched my philosophical assumptions and beliefs and seemed to be the natural approach to use in this research study. While I acknowledge the existence of these multiple interpretations or realities, Yin (2011) cautions the researcher from allowing their research lens or etic perspective to inadvertently shape a participant’s interpretation.

4.7 Research methodology

Subsequent to establishing the theoretical and conceptual frameworks for this research study, ascertaining the most appropriate research methodology for this research study
was the next phase of developing the overall research strategy. There are numerous research methodologies available within the qualitative research field and they are not bound to any particular theoretical paradigm (Merriam & Tisdell 2016). Instead, a research methodology or strategy of inquiry puts ‘paradigms of interpretation into motion’ and ‘connect[s] the researcher to specific methods of collecting and analysing empirical materials’ (Denzin & Lincoln 2011, p. 14). Similarly, Schwandt (2007) suggests that the research methodology is the middle ground between the philosophical issues and the research methods. However, the choice of research methodology and research methods must, inter alia, enable the researcher (through the research design) to interact with the research participants in such a way to provide credible answers to the research questions. Therefore, the various research methodologies and research methods were evaluated in terms of finding the best research design that would enable me to gather data that would address the research questions. Case study, ethnography, phenomenology, grounded theory and action research are among the many qualitative research methodologies and each of these methodologies was considered in terms of my philosophical assumptions and the most appropriate methodology for fulfilling the objectives of the research study.

• **Case study methodology**

Ultimately, case study was selected as the specific research methodology for this research study. Several researchers offer definitions of case study research (Creswell 2013; Merriam & Tisdell 2016; Miles, Huberman & Saldana 2014; Stake 2008; Yin 2009). Yin (2009, p. 18), is a leading developer of case study theory and the case study methodology, and he defines a case study as:

> an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident and it ‘relies on multiple sources of evidence.

In this research study, the contemporary phenomenon being explored includes the factors that affect the uptake and adoption of IBE tools. The investigation was planned to take place in its real-life context where data could be gathered from farmers attending industry group meetings and subsequently from individual interviews with farmers (some observation also took place on farms). The focus groups were conducted with farmers attending real-life industry group meetings (usually on one of the participant farmer’s properties) and face-to-face interviews were conducted with farmers on their rural
properties. The boundaries between the phenomenon and context were not clearly evident as farmers’ actions (phenomenon) may have been influenced by the real-life context including economic, environmental, technological, sociocultural and demographic factors. However, this was one of the reasons why I favoured this methodology as Yin and Davis (2007) advocate that one of the relative strengths of the case study methodology is its ability to accommodate the blurring of boundaries between the phenomenon and the real-life context.

Yin (2009) also advocates that the form or structure of research questions clearly differentiate the case study methodology from other research methodologies. For example, “what” type questions that lead to numerical answers because they are in effect asking “how many” or “how much”, are better suited to predictive goals where the research objectives focus on the incidence or prevalence of a phenomenon (Yin 2009). Nonetheless, some “what” type questions are suited to case study research but caution is required with these types of questions to ensure that they are designed to achieve the desired goals. For example, a “what” question referring to the factors that affect farmers’ use of IBE tools is in effect asking how farmers’ perceptions of IBE tools and how the various elements within a farmer’s environment affect their use of these tools. In other words, why do farmers use IBE tools or why do they not use them, is the focus of the research questions in this study. Yin (2009) suggests that “how” and “why” questions are likely to lead to explanations and are therefore more readily used in qualitative research and are particularly suited to case study research. The research questions for this research study, identified in Chapter 1 of this thesis, adhere to Yin’s advice.

Different types of case studies can also be distinguished by the intent of the case analysis. Stake (2008) identifies three types of cases: intrinsic, instrumental and collective. An intrinsic case study is one that may be chosen primarily because of the researcher’s intrinsic interest in that case, not because of an objective to ‘understand some abstract construct or generic phenomenon’ (Stake 2008, p. 122). Similarly, an instrumental case study may be appropriate if the researcher is pursuing their interest but that interest is secondary to their main goal of better understanding a particular problem or issue (Stake 2008). In contrast, Merriam and Tisdell (2016, p. 39) suggest that if the phenomenon being studied ‘is not intrinsically bounded, it is not a case’ but this is an extension of their basic definition of a case study which states that a qualitative case study is ‘an in-depth description and analysis of a bounded system’. I believe there
was a limit to the number of farmers that could be interviewed and that the data collection
would have finite time limits; these elements demonstrate that the cases were
intrinsically bounded. Furthermore, while I have an intrinsic interest in social informatics
or the socio-cultural aspects of using technology, this was secondary to the main goal of
the research study, which was to better understand farmers’ use of IBE tools. Therefore,
the research study positions itself as an instrumental case study, not an intrinsic case
study.

An extension of the instrumental case study is where more than one case is investigated
and this is described as a collective case study (Stake 2008). The collective case study
is defined by Stake (2008, p. 122) as ‘studying multiple cases simultaneously or
sequentially in an attempt to generate a still broader appreciation of a particular issue’.
This research study extended across multiple sites or industry groups to provide a more
in-depth investigation of factors affecting farmers’ use of IBE tools and therefore, a
collective or multiple case study was conducted.

Stake (2008) and Miles, Huberman and Saldana (2014) advocate that a collective case
study is chosen because the researcher believes they will acquire a more in-depth
understanding and achieve better research outcomes. Furthermore, Miles, Huberman
and Saldana (2014) also suggest that the interpretation of the data and findings of the
research study are likely to be more compelling if they are based on more cases and
greater variation across cases. Merriam (1998) also acknowledges other terms used for
this type of case study that explores more than one case, for example, valid terms for
this type of case study include collective case study, cross-case, multicase or multisite
cases, and comparative studies. The main difference between a single case and a
multiple case study is that a single case may consist of subunits or subcases while a
multiple case study gathers data from various cases (Merriam & Tisdell 2016). In this
research study, multiple cases exist on the basis of the farmers’ industry group and to a
certain extent their location. The industry groups or cases in this research study include
avocado, macadamia nut, pineapple, and strawberry industry grower groups located in
Queensland.

It could be conceived that each of these cases is in fact embedded within the one single
case of horticultural farmers. However, Yin (2009) describes an embedded single case
study as having different units of analysis. For example, if I was seeking the perspectives
of extension officers and packhouse groups in the research study, these contributions would create different units of analysis. These perspectives, however, were not within the bounds of the research; it was only the farmers’ perspectives that were directly relevant. Therefore, the research study is a collective case study and not an embedded single case study. Hence, I was keen to explore similarities and differences that may become apparent within and between the various grower groups and believed that this would be best achieved through multiple cases. I believed that adopting this approach would enable a more in-depth understanding and result in stronger research outcomes.

Consequently, the collective case study (consisting of multiple cases) was established and designed around individual industry grower groups within Queensland horticultural farming. Each of these grower groups forms a single case within which data was gathered and analysed. In addition, data collected from within each case was also compared across all of the cases resulting in a cross-case analysis. The purpose of this collective analysis approach was to facilitate more in-depth, robust research. It was envisaged that it would also enable a thick description and also support and enhance the external validity of the research findings. Miles and Huberman (1994, p. 29) state that collective case study ‘can strengthen the precision, the validity, and the stability of the findings’.

4.8 Research quality

Essentially, research aims to generate reliable and valid outcomes using an ethical approach (Merriam & Tisdell 2016). In judging the quality of research, Merriam and Tisdell (2016) and Schwandt (2007) suggest that case study researchers should aim to present an in-depth understanding or a rich thick description of the case study. The research findings, therefore, need to be trustworthy and believable which requires the research process to be undertaken with validity, rigour and credibility.

Research scholars emphasise various quality characteristics such as trustworthiness, credibility, reliability, reflexivity, validity and rigour, which are considered essential in any qualitative research study (Flick 1992; Gibbs 2007; Lee & Lings 2008; Silverman 2006; Yin 2011). For example, reflexivity as defined by Gibbs (2007) suggests that while the researcher must try to aim for objectivity, some of the researcher’s background, preferences and biases will inevitably be reflected in the research process.
This research study is concerned with farmers’ perspectives and therefore, my interpretation, analysis and conclusions must accurately reflect the farmers’ views. To achieve this and maintain reliability and credibility, I was not only cognisant of potential sources of bias, but also anticipated and avoided these biases throughout the entire research process. For example, I am an IT specialist and could have assumed that farmers would utilise IT in a similar way to the technology and equipment commonly used on farms. Instead, I avoided this bias and listened to the farmers’ views with an open mind and empathised with the farmers.

Schwandt (2007) also suggests that reflexivity is a useful technique in establishing validity. As a quality control mechanism, Schwandt (2007) describes validity as an argument for true and certain research findings on the basis that these findings are justified by evidence, represent the phenomena accurately and where there is no sound reason for doubting those findings. A slightly different perspective is suggested by Gibbs (2007) emphasising that validity addresses the accuracy of the research by eliminating obvious errors and enabling a richer description of the data. I endeavoured to accurately capture and interpret the farmers’ views and develop the research in a thorough, plausible and credible manner, thereby establishing the grounds for validity in the research findings.

Two commonly used techniques for addressing validity include triangulation and respondent validation (Gibbs 2007; Silverman 2006). Triangulation is a technique that addresses the validity of research conclusions derived from multiple sources of evidence or data collection techniques (Schwandt 2007; Yin 2009). Schwandt (2007, p. 298) describes triangulation as a ‘means of checking the integrity of the inferences’ a researcher makes from the data, and ‘it can involve the use of multiple data sources, multiple investigators, multiple theoretical perspectives, and/or multiple methods’ which enable the researcher’s claims to be examined ‘from more than one vantage point’.

Some scholars, however, suggest that triangulation is ‘inappropriate to qualitative research’ or at least to interpretivist research (Gibbs 2007; Lee & Lings 2008; Silverman 2006, p. 291). The basic argument claims that if the interpretivist researcher believes that there are multiple realities then looking for one truth from multiple perspectives is in fact ignoring the context in which those multiple perspectives have developed. While
Sivermann (2006) challenges the use of triangulation for validating field research, he suggests that it is still beneficial to collect data from multiple sources.

In this context, various scholars agree that triangulation can be used to make better sense of the data and enrich the research (Denzin & Lincoln 2011; Gibbs 2007; Lee & Lings 2008; Silverman 2006). For example, Denzin and Lincoln (2011, p. 5) suggest that rather than a validation technique, triangulation is ‘a strategy that adds rigour, breadth, complexity, richness and depth to any inquiry’. Yin (2011) further suggests that if observation cannot be combined with the interviews, the need to triangulate is less important if interviews are recorded.

Furthermore, Yin (2011) suggests that rival explanations may be revealed when the researcher adopts a ‘continual sense of scepticism’ and that appropriately dealing with these rivals will strengthen the research and enhance its validity. The search for rival explanations is similar to the principle of suspicion in Klein and Myers’ (1999, p. 77) set of principles for conducting and evaluating interpretive field studies in information systems. This principle is used to discover possible distortions in the data and ‘false preconceptions’ (Klein & Myers 1999, p. 77).

Taking these various perspectives into consideration, I appreciate the importance of applying measures throughout the research process to produce reliable and credible research. To a certain extent, triangulation is seen as a strength for this research study, not only for the qualities stated by Denzin and Lincoln, but also for the more obvious reason that it may highlight errors in the analysis. As an interpretivist researcher, however, I believe in multiple realities so there is some conflict in suggesting that dissimilar results may indicate errors in the data collection or interpretation. To mitigate this conflict, I endeavoured to establish a sound approach that strengthened my understanding and interpretation of the data and delivered credible evidence thus enhancing the overall quality of the research study. Triangulation has been accomplished within this research study through analysis of each of the four cases and the cross-case analysis.

In this research study, data was collected from multiple sources including focus groups, face-to-face interviews, observation, and document/web-page analysis. I recorded the focus groups and all of the interviews (subject to the participants’ permission) and these
digital recordings, along with the subsequent transcriptions, form the basis of required evidence. Data collected at focus groups was compared across each of the grower groups and where it was logical, some of this data was also compared to data collected at face-to-face interviews such as demographic and Internet access data. Similarly, data collected from the face-to-face interviews was compared to interviews within the same grower group and across each grower group. Dissimilar results were examined closely with the objective of explaining the results rather than presuming the detection of error. Document analysis was also conducted in the form of identifying relevant data contained in DAF and grower groups’ strategic plans and other relevant reports, handbooks and guides. I also examined the content and quality of various agricultural web sites to determine if they are user-friendly and if they currently deliver or have the potential to deliver IBE tools. The data collected through these different techniques were used to establish and support the research findings, thus contributing to the compelling nature and validity of the research. This approach strengthened my understanding and interpretation and enabled a richer description and discussion of the data, thus delivering credible evidence and enhancing the overall quality of the research study.

4.9 Generalisation of research findings

One of the common criticisms of the case study methodology is that a single case provides insufficient justification to extrapolate the findings to the larger population (Merriam 1998; Yin 2009). These criticisms, however, are based on numeric results of representative samples that can be applied to a larger population (Yin 2009). This was not the approach taken in this qualitative research study where the process of analytic generalisation was applied; a qualitative process of generalisation that is distinctly different to that of statistical generalisation. Yin (2011, p. 100) defines analytic generalisation as a two-step process where:

1. The researcher shows ‘how their research findings are likely to inform a particular set of concepts, theoretical constructs, or hypothesized sequence of events’; and
2. Then the researcher applies ‘the same theory to implicate other similar situations where similar concepts might be relevant’.

If the research supports the theoretical constructs, the researcher must then demonstrate how these theoretical findings can be applied or generalised to situations broader than those studied in the original research (Yin 2011). Various scholars have discussed different perspectives of generalisability or external validity including Cronbach (1975) and Patton (2002) with reference to working hypotheses; concrete
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universals embraced by Erickson (1985); and naturalistic generalisation preferred by Stake (2008). For example, Cronbach (1975) refers to the outcomes of generalisation as working hypotheses rather than conclusions. In contrast, Erickson (1985) talks about concrete universals where the universal is extracted from the particular by studying a case study in detail and then comparing it to other case studies that have been studied in equal detail. Stake (2008, p. 139) suggests that a multiple case researcher seeks to find ‘what is common and what is particular about the case’. In this context, I was keen to explore what was common and what was particular within and between the various grower groups. This was achieved through data analysis of each particular case or industry group (Chapter 5) and further data analysis presented as a cross-case analysis (Chapter 6).

The opportunity to generalise from the research findings depends to a large extent on the design of the research and the findings. Generalisation of the research findings beyond the boundaries of the collective case study may be one of the research outcomes if the research findings enable a better understanding of the implications that apply to all groups in Queensland horticulture and perhaps Queensland farming in general. While generalisation of the research findings across horticultural farming in Queensland may be a valid and justified outcome of this research study, future research of additional cases would strengthen the external validity of the research findings and substantiate more compelling conclusions.

4.10 Research methods

Various design and data collection methods are available to qualitative researchers including methods suitable for case studies. The main data collection technique adopted in this research study was individual face-to-face interviews but focus groups were also conducted. These methods were also complemented through observation and document/web page analysis (as outlined in Section 4.4.2).

The data gathered from the focus groups strengthened my background knowledge and fundamental understanding of each case. Similarly, other forms of data were collected throughout the research study through background reading and analysis of publications about Queensland’s horticulture industry as well as specific industry publications such as growers’ handbooks, strategic plans and annual reports. Further document/web page analysis research was conducted by exploring Australian horticulture websites,
Queensland Government agriculture websites and industry specific websites. While these additional data collection techniques were invaluable in extending my understanding of Queensland horticulture and each case, they also contributed to further establish and support the research findings. Substantial research data was also collected through individual face-to-face interviews thus empowering me not only with a better understanding of the industry but also with a more in-depth understanding of the various operational aspects of the industry, individual farms and farmers’ use of the Internet and IBE tools.

4.10.1 Focus groups
Given that the main data collection technique was individual interviews, I needed access to farmers willing to participate in the research study. It was recognised, however, that directly approaching farmers raised ethical issues and even if DAF provided access to details stored in their databases, information privacy issues would arise. Thus, these constraints had to be addressed before the recruitment of interview participants could progress.

• Planning and organising
Various options were explored and discussed with my principal supervisor and DAF partner. One option was to design an online or printed survey including an invitation for farmers to volunteer for individual interviews. While DAF could deliver the survey to farmers registered on their database without breaching confidentiality, based on previous experience, my DAF partner was sceptical of a successful outcome. While it is becoming increasingly common for surveys to be completed via the Internet, this option could exclude a vital part of the farming community, that is, those farmers that do not have access to the Internet, those that do not use the Internet regularly and those farmers that simply do not have the time to complete a survey.
Inviting farmers to participate in a focus group was another option considered for recruiting farmers to participate in the research study. Asking farmers to sacrifice their time and perhaps travel extensively for the sole purpose of a research exercise just seemed to be an unreasonable option.

Another alternative was for me to participate in prearranged industry group meetings by presenting a segment on the research study. This option was adopted for the research study as it seemed to be the best option for farmers who had already made the
commitment to attend the meeting. This option also seemed like an ideal opportunity to enable me to canvass farmers’ willingness to participate in the research. A weakness with this approach, however, was that farmers not attending the scheduled industry group meeting or field day were excluded from the research.

The next step in the research planning process was the selection of specific Queensland horticulture grower groups. One option was to consider the value of each industry group’s contribution to Queensland horticulture. Based on their gross value, industry groups considered for this research study included vegetables, bananas, stone fruit, avocados, citrus fruit, macadamia nuts, strawberries, pineapples and mangoes. The location and timing of grower group meetings were factors used to narrow down the list of options. The PhD time constraints also influenced the number of groups included in the research. Industry groups selected for this research study include avocados, macadamia nuts, strawberries and pineapples and each of these groups formed an individual research case.

To implement this approach, my DAF partner provided a list of DAF principal horticulturalists or senior extension officers with interests in each specific industry group and informed these extension officers of the research study. Subsequently, I contacted the DAF extension officers to discuss the possibility of attending grower group meetings. Communication was extended to industry group leaders to determine the feasibility of including my research segment within prearranged industry group meetings including growers’ field days, workshops, study group meetings, best practice group meetings, and HIA roadshows. Thus, permission to integrate my researcher segment on IBE tools within the planned industry group meetings was arranged through my liaison with principal extension officers in DAF and the relevant industry group leaders.

**Basic elements of focus groups**

I refer to the research segment in these industry group meetings allocated for this research study as focus groups. The research design fits the criteria presented by Morgan (1996) in his overview of focus groups which acknowledges the following three basic elements:

1. Focus groups are a research method primarily for data collection;
2. The source of data is via group discussion and interaction; and
3. The researcher’s interests direct the discussion.

The purpose of the focus groups in this research study is to collect data. Adherence to the second point, however, is not as clear-cut given that data collection is based on an electronic questionnaire as well as group discussion. Essentially though, there is sufficient opportunity in this context for group discussion when I want to explore deeper into any of the farmers’ perspectives or responses to the questionnaire. In this context, my interests certainly direct the discussion after each question, and any further discussion that I consider appropriate.

Another element that favours the classification of these meetings as focus groups is supported by Yin (2011, p. 141) who states that ‘you have gathered individuals who previously have had some common experience or presumably share some common views’. The farmers in each of the grower groups share their common experience and common views in growing the same produce or belonging to the same farming community.

Furthermore, Morgan (1996, p. 130) states that a ‘broad umbrella’ view of focus groups allows for numerous variations and this approach will avoid ‘pointless debates about what is or is not a focus group’. The focus groups provide a useful starting point for gathering background data and to reveal some of the participants’ views and experiences, an approach supported by Morgan (1997). Thus, I believe that the focus group label and purpose is appropriate and justified.

- **Conduct of the focus groups**

I attended the following scheduled grower group meetings:

- Avocados Australia: March 2013, Bellthorpe;
- Australian Macadamia Society: July 2013, Glass House Mountains;
- Pineapple study group meeting: October 2013, Tinana; and
- Queensland Strawberry Growers’ Association: July 2015, Wamuran.

My researcher segment commenced with a short PowerPoint presentation outlining the purpose of attending the meeting and the purpose of the research study. The focus group was recoded on a digital voice recorder. My main objective was to develop sufficient interest in the research study to encourage farmers to volunteer for individual face-to-
face interviews. This was necessary to enable further data collection exploring in detail, the factors that affect farmers’ use of the Internet and IBE tools.

After the presentation, I answered farmers’ questions and encouraged further discussion with all of the farmers. Subsequently, I conducted an electronic questionnaire using TurningPoint software to display a set of fifteen polling slides. The farmers actively participated using hand-held radio-frequency interactive keypads (clickers) to lodge their responses. The software functionality enabled the results of each question to be captured and immediately displayed graphically on the overhead screen. This provided a fun and engaging atmosphere with immediate feedback not only to the researcher but also to the participants. This immediate feedback ensured that all participants were able to lodge their response before the researcher displayed the next question. Furthermore, this forum enabled time for me to briefly consider the results of each question and to initiate a discussion with participants to clarify their responses and to probe deeper into their thoughts and perspectives.

On completion of the questionnaire and group discussion, participants were asked to register their contact details and whether they would volunteer for an individual interview. This was done by way of an attachment to the research project information sheet issued to all participants at the beginning of my researcher segment. These details were recorded in a spreadsheet with interview volunteers clearly identified so they could be contacted to make arrangements for conducting an interview. The questionnaire, responses and graphical summaries were saved in their original format and also saved in spreadsheet format and the voice recording of the focus group meeting was saved as an Mp3 file. All electronic data files were stored on my private computer and backed up onto an external hard-drive and USB storage. These files were used later in the data analysis and interpretation process.

After leaving the industry group meeting, I spent time reflecting on the day and the learning journey. I wrote notes in a journal that would enable me to revisit and further consider the farmers’ perspectives. These reflective memos also contributed to the researcher’s evaluation of the learning experience and data collection approach. The journal also served as a reminder of various aspects of the research when I was writing various sections of the thesis.
• **Focus group data collection**
  The main purpose of each focus group was to recruit farmers to participate in face-to-face interviews and therefore the data collection at this preliminary stage was of an introductory nature providing fundamental input to the rest of the research. The electronic questionnaire was used as an instrument to collect demographic data, use of electronic devices, data relating to farmers’ Internet access and farmers' perceptions of agricultural websites and IBE tools, for example:

  - Whether or not participants have access to the Internet and their type of access (e.g. dial-up, broadband, satellite, mobile)
  - What they access on the Internet (e.g. email, social networking, Government websites, agricultural websites);
  - Participants' perspectives on the ease of use and usefulness of agricultural websites; and
  - Demographic data about participants including age, education and farm location.

Appendix 2 provides a full list of the questions presented. The questionnaire responses were interpreted from a qualitative perspective, for example, to understand diversity within and across industry groups, rather than a quantitative approach of examining statistical distributions.

Silverman (2006) supports this approach of using quantitative and qualitative data in the same research study. Furthermore, Kirk and Miller (1986, p. 10) suggest that qualitative research does not exclude the use of quantitative techniques in their statement that ‘qualitative research … does not imply a commitment to innumeracy’. The survey or questionnaire approach is suitable for research questions based on the respondent’s beliefs or behaviours (Neuman 2006).

While the questionnaire in this research study creates statistical or numeric data, the results of the questionnaire also established ‘the broad contours of the field’ (Silverman 2006, p. 48). Thus, while the questionnaire approach is generally considered a quantitative research technique, it was used to establish background understanding of the research problem and provide insight to the main concerns, attitudes and
perspectives of Queensland farmers in their use of the Internet and IBE tools. Questionnaire responses were also further discussed with the farmers to provide a better understanding of individual farmer perspectives. Essentially, the data collected from the questionnaire and focus group discussions provided information which further enhanced my knowledge and understanding of the industry groups and also highlighted some elements to be further addressed in the individual interviews.

4.10.2 Interviews
Face-to-face interviews were conducted with individual Queensland farmers that had previously volunteered at the focus groups. Table 4.2 shows the number of farmers that participated in each industry group’s focus group and how many of those farmers volunteered and subsequently participated in individual interviews. Not all of the farmers that volunteered for interviews were available at the time interviews were conducted. While other time options were offered, suitable arrangements for some farmers were not feasible. The interviews were progressively conducted between July 2013 and July 2016.

<table>
<thead>
<tr>
<th>Industry group</th>
<th>Focus group participants</th>
<th>Interview volunteers</th>
<th>Interviews conducted</th>
<th>Interview location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avocados</td>
<td>14</td>
<td>8</td>
<td>6</td>
<td>Bellthorpe, Kumbia, Gympie, Imbil, Maleny</td>
</tr>
<tr>
<td>Macadamia nuts</td>
<td>11</td>
<td>8</td>
<td>8</td>
<td>Elimbah, Glass House, Mountains, Maleny, Peachester</td>
</tr>
<tr>
<td>Pineapples</td>
<td>13</td>
<td>8</td>
<td>7</td>
<td>Beerwah, Bundaberg, Childers, Hervey Bay, Tinana, Maryborough</td>
</tr>
<tr>
<td>Strawberries</td>
<td>20</td>
<td>15</td>
<td>14</td>
<td>Bells Creek, Beerwah, Beerburrum, Elimbah, Glass House Mountains, Wamuran</td>
</tr>
</tbody>
</table>

Table 4.2: Research participants
• Interview questions

Data collected from the focus groups provided background knowledge to support and guide the development of questions used in semi-structured face-to-face interviews. In preparing for these interviews, open-ended questions were planned around gaining a rich understanding in regard to the research questions. Further guidance obtained from qualitative research literature was also used to guide the development of interview questions. Creswell (2013) suggests that the interview questions are focused on understanding the central phenomenon of the research study. Creswell (2013) also suggests the researcher design and use an interview protocol or interview guide. I adopted this approach to ensure that the details of the interview were documented correctly. Theoretical sampling as suggested by Patton (2002) was also an important element that contributed to the development of the interview guide thus ensuring theoretical constructs were reflected in the interview questions and also addressed in the data collection.

Kvale (2007) also suggests that a second guide be designed listing the interview questions and indicating which research questions they relate to or the main themes of the research questions. Hence, the research questions and overall research objective, as well as DOI Theory constructs were reviewed to ensure that the data collected did in fact address each of these elements. The interview questions were also designed with Kvale’s (2007) advice in mind; that a research question can be explored by more than one interview question and similarly, one interview question may provide insight to more than one research question. Approaching the research questions and phenomenon from different angles enables ‘rich and varied information’ to be collected (Kvale 2007, p. 58).

The interview guide is presented in Appendix 3 and was printed out for each interview, listing the participant’s name, date, time, and place of interview as well as the main semi-structured questions to be asked. Essentially, the interview guide was used in each interview as a checklist to keep the interview focused and on track.

• Conduct of interviews

The individual face-to-face interviews were conducted at a location that suited the participant; this may be in their home, a farm shed or perhaps out on the farm. While aiming to guide the focus of the interviews it was important to develop a relaxed atmosphere that would put the farmer at ease and encourage them to do most of the
talking. I was conscious of making the participant feel comfortable and not intimidated by my presence, questioning or language. Thus, informal, relaxed conversational style interviews were conducted using a semi-structured style. Nonetheless, Kvale (2007) reminds the researcher that although the interview is a conversation, it must maintain some structure and purpose. The flexible and dynamic style of the interviews conducted in this research study enabled me to develop a sound understanding of the individual perspectives of farmers, thus providing data to be further explored and analysed.

The purpose of the individual interviews was primarily to gain an understanding of the farmers’ experience and perceptions of using the Internet and IBE tools. I planned to analyse the factors that influence farmers’ use these technologies, their perceived usefulness, complexity, benefits and frustrations. With prior permission from the farmer, the interviews were recorded using a digital voice recorder. On completion of the interviews the audio recordings were transcribed and cross-checked. This contributed to an accurate and reliable record of each interview to be retained for analysis and interpretation.

While some note taking took place throughout the interview, I relied largely on the use of the digital voice recorder for the main documentation of the interview. It was my view that taking extensive notes during an interview was undesirable. Based on my experiential knowledge, the problems that may arise if this is the only technique used for recording the interview include:

- An interruption to the desired free flowing nature of the interview;
- The interviewer and interviewee may be distracted;
- The interviewer may be less effective at actively listening and probing further;
- The inability to accurately document everything that is discussed and the way it is discussed.

Throughout the interviews, I also took the opportunity to have the participant demonstrate their use of electronic devices, the sites commonly accessed and their approach to acquiring information (electronically and through manuals, pocket guides, etc.). The opportunity to observe farmers demonstrate their use of rural based websites and IBE tools allowed more directed and in-depth questions to be addressed and provided specific visual instances of issues that contribute to farmers’ perceptions of IBE tools. Permission was obtained from each farmer to take photos of the farmer, some
features of their farm, documents (such as a pocket guide or manual), and websites/software demonstrated by the participant. The purpose of these photos was to provide additional/multiple sources of data typically collected for case studies and also to serve as a practical reminder of some of the physical attributes of the farm and the interview environment.

After each interview, I spent time reflecting and writing notes in a journal about the interview, the farmer, the location and the general atmosphere and rapport that was built. Initial reflection served as validation that the key points were discussed and reassurance that the required data was in fact collected. These reflections also added to the value and description of the interviews by documenting elements that may not have been captured or explained through the audio such as the setting and atmosphere of the interview, explanation of intonations, facial expressions and body posture. The reflective notes were written up as soon as possible after the interview so that the recollection was accurate and not based on any further interpretation of the interview outcomes. Observations were also written up at this point to reflect a detailed and accurate account of the process. The journal served as a reminder of various aspects of the interview and the farmer when I was conducting further analysis and writing some sections of the thesis. Following the interviews, I also developed basic interviewee profiles and recorded these in a table for later recall and analysis.

The digital photos were downloaded and saved on my private computer along with the voice recordings which were saved as Mp3 files. The Mp3 files were then used to transcribe the voice recordings into word-processed documents. All electronic data files were backed up onto an external hard-drive and USB storage. These files were used later in the data analysis and interpretation process.

**4.11 Data analysis and interpretation**

Creswell (2013, p. 187) describes the data analysis and interpretation process as organising and coding the data, aggregating the codes into categories or themes to form a common idea, and then organizing the themes into ‘larger groups of abstraction to make sense of the data’. Grbich (2007) suggests that the coding process enables the consolidation of meaning and explanation. Furthermore, according to Yin (2011), the goal is to develop themes through which comprehensive interpretation will enable a complete, credible and accurate understanding of the research study. While the process
of data analysis and interpretation can be broken down into logical steps, the process is complex. As Yin and Davis (2007, p. 76) state, rigorous thinking is essential 'questioning questions, testing assumptions, and examining rival explanations as part of interpreting findings'.

Using Yin’s five features of qualitative research previously identified in Chapter 3 of this thesis, also enables the researcher to achieve the goals described through Miles and Huberman’s (1994, p. 10) data analysis guidelines ‘qualitative data … are fundamentally well suited for locating the meanings people place on the events, processes, and structures of their lives … and for connecting these meanings to the social world around them’. Within the process of data analysis and interpretation, I looked for emergent themes relating to the theoretical framework or the research questions. In addition, I was also cognisant of new themes or patterns that may emerge. In order to undertake the data analysis, I organised and coded the data, aggregated the codes into categories or themes to form a common idea, and then further organised the themes into larger groups if appropriate. The objective of this process of data analysis and interpretation is to enable a rich and thick understanding of the data. Analysis and interpretation of the data was conducted using an iterative, logical, coherent, consistent and complete approach using the model in Figure 4.5 as a guide. This approach enabled accurate and credible explanations and contributed to the authenticity, rigour and validity of the research.

The actual data analysis must be conducted in a manner that justifies the researcher’s understanding and interpretation, thus requiring a systematic approach enabling inductive, recursive, and interactive analysis. After making sense of the data and to some extent, interpreting it, I reflected on the core meaning of the text and then encoded the data accordingly. Thematic analysis was adopted to interpret the data from each case. According to Fereday and Muir-Cochrane (2006), the development and identification of codes used in thematic analysis integrates data-driven coding with theory-driven codes. Open coding began with the development of codes or labels based on the research questions and then on the theoretical framework. Codes were applied to the data by reading the interview transcripts and identifying words, sentences or paragraphs relevant to those codes. Further analysis continued in search for patterns, links and explanations. In the data analysis stage, the raw data in each interview transcript was examined and then progressed toward the identification of emergent themes and salient categories. This was a recursive or exhaustive technique that continued until saturation of the data.
I consider the use of qualitative data analysis software (QDAS) as a tool that assists in the traditional method of data analysis and interpretation. Nonetheless, I concede that using the power of QDAS tools to retrieve data as suggested by Davidson and di Gregorio (2011) may provide further insight and a deeper understanding of the data. While the data analysis and interpretation model (Figure 4.5) was developed as a guide for qualitative researchers using QDAS, Davidson and di Gregorio (2011) support the belief that this model also duplicates the detailed steps involved in the traditional method of data analysis and interpretation. As previously stated, this model was followed as a guide to the data analysis in this research study. As shown in Figure 4.5, data analysis entails an iterative interrogation process including the exploration, organisation, interpretation and integration of research data. In order to action these four components, further steps were conducted including data retrieval, rethinking, comparison and identification of patterns and relationships.

Initially, the data analysis and interpretation process was undertaken manually. It was considered that this approach would develop more familiarity and understanding of the data and incite a level of rigorous thinking that can only transpire from a human approach.
to making sense of the data. This approach enabled a complete, credible and accurate understanding and explanation of the research.

To complement the manual approach to data analysis and interpretation, however, the potential benefits from using QDAS were also considered. In this context, NVivo was selected as a software package that suited my objectives at this stage. NVivo was used at a fundamental level as my NVivo skills are basic. Nonetheless, NVivo assisted in the qualitative research through its functionality and power to code, categorise and interrogate large quantities of data. Using NVivo reduced the potential for errors and overlooking relationships in the data but the manual approach also served the purpose of acquiring a deep understanding the data.

4.12 Human ethics approval
Candidature for this PhD commenced in 2010 but shortly afterwards leave of absence was required. A low risk ethics application was submitted to the Human Research Ethics Committee of the University of the Sunshine Coast and Ethics approval was granted on 18 October 2011 with the ethics approval number HREC: S/11/350.

4.13 Summary
This chapter has discussed and justified the research strategy applied to develop and guide the direction of this qualitative research study. This was achieved by discussing and establishing the philosophical foundations as well as the research methodology and data collection techniques. Each of these research elements shaped and established the rationale applied in planning and designing the overall research study.

As discussed in this chapter, relativism best describes my ontological stance because I believe we all see the world from our own perspective and we therefore interpret and construct individual realities. My ontological position or view of the world acknowledges the existence of multiple realities where we all have our own version or perception of reality. This is appropriate for this research study as it is important to recognise that individual farmer’s have their own perspectives. My epistemological stance was also discussed in this chapter highlighting my constructivist view that knowledge is constructed through developing an understanding of the world amidst interaction with others. Thus, knowledge acquired in this research study was constructed jointly through
interaction with the research participants/farmers and myself. Again, this is important to this research study where I relied on the verbal text from farmers as evidence.

Combined with the interpretivist paradigm, my philosophical assumptions enabled me to better understand the farmers and the social and cultural contexts in which they interact. Recognising and understanding the individual perspectives of the farmers was paramount to the validity of the research findings. Furthermore, based on my underlying philosophical assumptions, I believe that an interpretivist paradigm is appropriate for the research study. Establishing the conceptual framework formed the basis for an interpretivist theoretical paradigm which has been an overarching influence throughout this research study.

Case study methodology was used for this research study with four cases established on the basis of individual industry grower groups within Queensland horticulture. The four cases include the avocado, macadamia, pineapple and strawberry industry groups. Data collection techniques used in this research study include focus groups, face-to-face interviews, observation and examination and analysis of relevant reports and websites. This chapter also explained the process for recruiting volunteer farmers for individual interviews. The data analysis for each case is presented in Chapter 5 and a cross-case analysis is presented in Chapter 6 of this thesis.
Chapter 5 — Case Study Analysis

5.1 Introduction

The research design section of the previous chapter explains the data collection techniques used within this research study. Similarly, the previous chapter describes the data analysis process undertaken by the researcher. This chapter presents the data analysis from each of the four case studies in relation to five key attributes from Rogers’ Diffusion of Innovations Theory (Rogers 2003) including relative advantage, compatibility, complexity, trialability and observability. The underlying purpose of this data analysis is to determine how the data gathered for each case, contributes to answering the research questions. Furthermore, this contributes to the knowledge of the key factors affecting Queensland horticultural farmers’ effective use of IBE tools.

The four case studies are based on four industry groups within the Queensland horticulture industry including the avocado, macadamia nut, pineapple and strawberry industry groups. The researcher also conducted a cross-case analysis by interrogating and analysing the data to identify similarities, differences, patterns and links, between all of the cases. The cross-case analysis findings are presented in Chapter 6 - Cross-case analysis.

While the Diffusion of Innovations Theory was discussed in previous chapters, a brief overview of the attributes from the theory is included here, as these were fundamental to the analysis of the case study data. Rogers (2003) claims that relative advantage, compatibility, complexity, trialability and observability are the five key attributes most likely to affect the adoption rate of an innovation. In this research study these attributes are considered in terms of the adoption of Internet based extension (IBE) tools. The five key attributes are defined as follows:

- Relative advantage – ‘is the degree to which an innovation is perceived as being better than the idea it supersedes’ (Rogers 2003, p. 229). This relates to how much better the innovation is over what was previously offered and can be considered in terms of the expected benefits versus the cost of adoption. Therefore, the relative advantage may be affected by potential
adopters' perceptions of the financial outlay, time, effort, social opinion, comfort or convenience, immediacy and level of reward, and usefulness.

- **Compatibility** – ‘is the degree to which an innovation is perceived as consistent with the existing values, past experiences and needs of potential adopters’ (Rogers 2003, p. 240). Thus, an individual’s mindset and lifestyle may affect their evaluation of an innovation in terms of their experience with the current approach that will be replaced by the innovation.

- **Complexity** – ‘is the degree to which an innovation is perceived as relatively difficult to understand and use’ (Rogers 2003, p. 257) and is negatively related to the rate of adoption. If the potential adopter perceives the innovation as complicated or difficult to use, the rate of adoption will be lower. Thus, user-friendliness or the complexity of an innovation may be a barrier to adoption.

- **Trialability** – ‘is the degree to which an innovation may be experimented with on a limited basis’ (Rogers 2003, p. 258). This relates to how easy it is for the potential adopter to trial or experiment with the product or innovation. If an innovation is more trialable or easier to experiment with, it will attract a higher rate of adoption. Thus Rogers (2003) concludes that trialability is positively related to the rate of adoption.

- **Observability** – ‘is the degree to which the results of an innovation are visible to others’ (Rogers 2003, p. 258). This relates to the level of visibility of the results of an innovation to other members of a group or community. More favourable communication and enthusiasm and increased rates of adoption are likely to occur if the results of an innovation are highly visible, observable or even more easily described. Thus, observability is positively related to the rate of adoption of an innovation (Rogers 2003). However, observability may be a barrier to adoption if the results of an innovation are difficult for outsiders to observe or recognise.

Using Rogers’ Diffusion of Innovations Theory and the five key attributes perceived to affect the rate of adoption of an innovation, the following sub-sections present the findings from each of the four case studies. To maintain participants' confidentiality in this thesis, the researcher has applied a code to each of the interviewees (e.g. A1, S1) thereby enabling the citation of farmers’ exact comments and responses. Similarly, codes have been applied to industry representatives (e.g. AE1, ME1) and business
names (e.g. AB1, PB1) to maintain their confidentiality and to prevent deductive disclosure. The use of IBE tools was the innovation explored in this research study and included various Internet based tools, government and industry based agricultural websites, accounting and record keeping software that is Internet based and other websites relevant to horticultural farmers such as weather, fertiliser, insecticide, marketing and distribution websites. As part of the innovation, the researcher also explored farmers’ perceptions and use of web 2.0 technologies including IBE tools that incorporated evidence of some level of interactive sharing or online collaboration such as YouTube clips/online-videos, blogs, wikis, and social media.

5.2 Avocado industry case study

5.2.1 Relative advantage

Most of the interview participants routinely used the Internet for activities such as social media (e.g. Facebook), email, online banking, online shopping and most importantly, weather forecasts. There were some complaints about how much time these activities consumed but the farmers were commonly using these applications.

Some avocado farmers will also use their smartphone in the field to take a photograph and upload it to an advisor (usually the local agronomist) to seek fast, reliable, expert advice.

A1: So now it’s easy to take three or four photos, email them to some bloke, and he’d go, yes, I know exactly what you mean.

A2: You might have a query “is this good enough to be packing?” So you sort of send the photo down and the guy goes “Yep, that’s all right”, or “this needs to be in second grade”

A5: I’ve sent him photos of trees and stuff, yeah. And yeah, it’s a useful thing, no doubt about it. It’s useful.

While these particular farmers were accepting of this process of uploading photos, not all of the avocado farmers were of the same mindset. Some of them were more inclined not to change the status quo, continuing to do things how they’ve always done them and seek advice from their local agronomist.

A3: We really don’t do the bug monitoring. The guy who comes here once a week does that and he just looks at bugs and says, it’s this, it’s this, it’s that.
A4: We don’t do bug checking, because AE1 does it. He knows exactly what the bugs are. He knows what he’s finding on other farms and all that sort of thing.

However, one avocado farmer said they would be interested in a blog where photos could be uploaded and advice would be given but it would need to be monitored and controlled by trained experts. Another farmer also recognised the potential benefits of accessing a blog that had some expert control.

A5: But equally, if we could share that, if people put their photos up and said I’ve got this, and the overseer of the blog would say that is such and such, I’d be really interested to follow people’s photos of problems.

A6: I think a blog with some direction would be great and that could be a government facility. They could employ a group of people to have input into things that are coming up. That would be really useful.

Conversely, some farmers perceived little advantage in sharing information on a blog and felt that it was a pointless exercise preferring to speak directly to people they could see.

A5: Why would we do it though? Am I trying to get someone to say, that’s a great idea?

A6: I think, the way farmers share knowledge … that’s why field days are good, because you can actually talk to people.

Interestingly though, none of the avocado farmers had searched the Internet for an industry specific or general agricultural blog that provided this type of service. None of them had heard of the Beatsheet Blog run by a team of entomologists from DAF. Perhaps this is because the Beatsheet Blog (Queensland Government 2017) is set up for pest issues associated with Queensland grain regions. And yet, three of the avocado farmers interviewed actually live in an area that is primarily a grain cropping region in Queensland. The researcher interpreted this in terms of the cost of time and effort versus the advantage; there seems to be no perceived benefit substantial enough to outweigh the cost in comparison to their current methods.

Overall, it was apparent throughout the interviews with avocado farmers that they perceived IBE tools in general as having little value or usefulness in their day-to-day farming operations. These tools seemed to offer no advantage over what they would
normally use. For example, in response to using IBE tools developed by DAF - Agbiz farm budgeting tools (Business Queensland 2016a), none of the farmers interviewed had even heard of this toolkit. Furthermore, their responses showed considerable scepticism to the benefits of using these IBE tools.

A3: I would except for my accounting program does all that or I would sit down with a calculator … by using some of those sorts of things, you make an easy job hard …

A4: I don’t want to sound condescending, but I think a lot of it’s for people who have got no bloody brain.

In response to what farmers like or dislike about websites, the currency of information was clearly an issue as stated by the following farmers.

A1: Some of the websites, you wish they were updated a bit more regularly.

A2: Some of the stuff on there hasn’t been updated for years and years; it’s three or four years behind the times.

Similar comments were made about likes and dislikes of various agricultural websites but most commonly about Government agricultural sites. For example, DAF’s Avocados webpage was last updated in April 2014 (DAF 2014a). This page includes links to a comprehensive set of relevant and important information maintained by DAF but many of these pages have not been updated for some time. For example, one of the links on DAF’s Avocados webpage opens the ‘Pests and diseases of avocados’ page which was last updated in February 2011 (DAF 2011a). Similarly, another link on DAF’s Avocados webpage opens the ‘Domestic and international markets for avocados’ page and it was last updated in November 2010 (DAF 2010). On this basis, it seems quite plausible that the avocado farmers see little benefit in accessing these Government sites. Apart from the perception that these sites are not current, the level of detailed information provided might also contribute to an avocado farmer thinking they are wasting their time. For example, the following information is displayed under the heading ‘Export markets’ on the ‘Domestic and international markets for avocados’ (DAF 2010):

Export has complex and specialised requirements and is normally only attempted by large growers, marketing groups or cooperatives. It requires strict attention to quality standards and quarantine requirements. Seek the advice of exporters or export market consultants before proceeding.
Essentially this information offers nothing to a farmer that is seriously interested in exploring export markets and is seeking up to date, practical and useful information. At the very least, this section of the webpage could have links to relevant and useful sources of information.

When asked about using the industry specific website ‘Avocados Australia’ there seemed to be little interest or no compelling desire to access it. It was not needed for assistance with operational activities on the farm and yet, some of the videos could be useful but more as a tool to reinforce what is already known.

A5: Well, I never go to it. Because I’m not interested in it, no, no. I’ll read their quarterly magazine, whatever it is they put out.

A4: Training a young person … We’ve taught him how to do it, how we do it. And then we watched what they say to do and how they say to do it (a video clip on Avocados Australia website). So he could see that what we were teaching him was pretty much what the Avocados Australia was saying we should do.

A1: The good part of the website is, I think, is their little videos, because you can reinforce what you do. You can see their interpretation about how things are done. Some of that’s pretty bloody, pretty useless too.

Similarly, the level of detail seems to be inadequate for farmers’ needs as shown by the following responses and therefore there is no benefit to using these websites.

A5: I have yet to find an internet source that is sufficiently detailed to really get your teeth into … so what I’m actually after is some serious science.

A6: They don’t tell us anything we don’t already know.

A6: There’s a fair bit of messing around on there, but as far as farming goes, no.

In general, those farmers interviewed do not place a high value on information available through the Avocados Australia website or Government agricultural websites. For much of their information requirements, other sources are their preferred option. For example, several farmers prefer to acquire information from the hardcopy of the Avocados Pocket Guide, the local agronomist and by word of mouth with other growers and industry advisors.

A5: First of all, we consult our basic text … which is like the bible of avocado growing … because I find it easier than say on the internet (stating a preference
for using the hardcopy Avocados Pocket Guide rather than using a laptop or tablet to access online information)

A1: We just generally ring AE2, the fellow from AB1; he knows what we’re talking about

A5: You talk to the other growers and that’s where you find a lot of your information.

Likewise, when asked about assessing market prices on the Internet, the preference seems to be to contact a local expert rather than using technology. Again, there is no perceived advantage in using the available technology.

A6: No, because AE1 does such a good job. He puts out marketing newsletters and … he does graphs and forecasts and you just call him up, it’s a really good thing.

In relation to relative advantage, the avocado farmers’ responses suggest that IBE tools are not useful or any better than their current methods. They considered information on industry and government websites out of date, not satisfying their information requirements and not giving them anything new. They believed that speaking to other farmers or industry advisors directly was more beneficial than using IBE tools and that IBE tools were not as convenient as their existing methods of acquiring information. Consequently, throughout the interviews and through subsequent data analysis, the researcher interpreted avocado farmers’ perceived views of the relative advantage of IBE tools as a barrier to adoption.

5.2.2 Compatibility

To gauge the level of influence the key attribute of compatibility has on adopting IBE tools, the researcher explored avocado farmers’ methods of doing things, systems used, regulations, and views on technology on the farm. The researcher was endeavouring to find out if IBE tools were compatible with systems and procedures currently being used and whether these systems or procedures were manual or technology based; if they were compatible with technological infrastructure and access in the field and in the office; and whether they were compatible with farmers’ routines, activities, experiences and needs.

All of the avocado farmers interviewed had access to the Internet (mainly ADSL connections, some Mobile and Satellite). They mainly used a PC or a laptop but some
had smart phones as well. Tablets don’t seem to be popular because they’re not really portable and therefore not practical out in the field. Nonetheless, compatibility of telecommunications infrastructure and devices, whether they’re used on the farm or only in the office, does not appear to be problematic.

A2: We have ASDL, whatever it is. It’s not too bad.
A3: Oh yes, we have the Internet but I don’t know what sort, I think it’s broadband.
A5: Smart phone … yes; so for me, it’s a diary. It’s a note keeper which is really important for me, a phone list, a contact list, then just emails and messages. I don’t have a lot of apps … I’ve got a laptop …
A4: But the idea of having these tablets and that all sounds wonderful, but that’s all right if you’re working in an office. If I’m out in a paddock trying to fix sprinklers that’s pumping water everywhere or this morning, like the hose had jumped out and water is going ten feet in the air, the last thing I would want in my pocket is a tablet. And it’s alright to have it with us, but if you just go chucking it into your ute, or sitting at the back of a motorbike, it’s not as convenient as what they like to make it out to be.

In general, avocado farmers know what they’re doing; they’ve seen it all before and have the experience and skills to deal with any issues arising on their farms. This means that the avocado farmers don’t rely on technology or IBE tools for everyday types of issues. Thus, there is some element of incompatibility between the innovation and the adopters’ needs because the avocado farmers don’t need to and prefer not to use IBE tools for common farming activities.

A3: It’s all in your head; I guess a lot of it is your everyday stuff that you’re doing all the time and you don’t really need to be checking the Internet to know what to do, and how to work it out.
A2: A lot of that stuff is stuff that we’ve been dealing with every day. So I don’t need to go and check what scale or bug or fruit fly … You deal with that sort of stuff every day and have been for years.

However, on occasions when avocado farmers do need advice, information or confirmation, they need it to be prompt, reliable, accurate and comprehensive. This is simply how they operate their farms; this is their mindset and they don’t have time to waste on other methods that don’t comply to these needs. If IBE tools are to be adopted
they need to satisfy these criteria otherwise they will not be viable in competing with current farming methods.

Most of the avocado farmers rely on information from hardcopy, the local agronomist, talking with other growers and industry advisors. Again, it is perceived by farmers that IBE tools are not compatible with farmers’ experience and preferred methods.

A3: So we really haven't got other people we can talk to in this region, so yeah, I like to go to meetings and yeah, read all the bloody manuals, old manuals, and quarterly books that they all send out.

A4: When we first started growing, we got this book from the DPI. It's really good … and it is 20 years old, but still as relevant today as it was 20 years ago.

A2: For us, he’s excellent, because he is an ex-grower. He knows where we’re coming from with a lot of questions. The fellow who comes weekly is the fellow that works at AB1. He’s an extension agronomist. He’s not a government man. We hardly ever see government people, no government people at all. They don’t exist anymore … but AE2 is pretty good. And the only other way you can find out is go to all these meetings.

A1: We just generally ring AE3, the fellow from AB2.

A3: So he (AE1) comes once a week, or twice a week … he’s more our information than anything. We get a lot of our information from him.

A4: I like the fact that Avocados Australia, they’re bringing out their Talking Avocados every quarter and have stuff in it, because if you just want to sit down here for 10 minutes, you can sit down and read the book and go back to it.

In order to maintain an awareness of current farming trends and important information, quarterly magazines, industry updates and emails are constantly perused. Again, these methods are preferred over accessing websites and using IBE tools.

A3: Magazines, yeah. That’s basically it. We haven’t really got a whole lot of other places we can find out, if someone sends us a letter or something, yeah.

A4: You sort of get that information first in their quarterly magazine, and then they just put it on the website, so you can just find it later on.

A4: And of course, people like GrowCom, they send you an email like once every three or four days with what’s happening … once you get all those email lists, you just get bogged into email. Now, we just have the computer on every day, because we just have so many emails. And a lot of its rubbish.
IBE tools are not used extensively by avocado farmers; actually they’re rarely used. Therefore, there is a significant compatibility issue in that IBE tools do not seem to have a priority and their uptake is minimal. This is explained through the data collected that indicates that avocado farmers are essentially happy with the way they have always done things. They are happy to read hardcopy books and magazines; they are happy speaking directly to their local agronomist and they are happy attending industry group meetings where they talk to other like-minded avocado farmers. Furthermore, they know little about IBE tools that are available and are not aware of any tools that answer their questions.

A2: IBE tools offer …nothing that I desperately need. The few little things that I want to chase up, I’ll jump on to Google and have a look.

A3: But we got no one really to teach us anything that’s new to feed the world.

A5: But we use the Internet a lot to look at research on the effects of Round Up or Glyphosate or whatever brand you’re using on soil health. And there were a lot of articles on that. It was surprising how many there were, because it’s not an area that’s ever talked about.

A6: We needed information as to how prices were going and so on, I don’t know how we’d get it. It’s good to be part of that co-op group.

Certainly there are websites that farmers set as favourites and most of the farmers will use the Avocados Australia website and perhaps the DAF website.

A3: Avocados Australia have a really good one.

A4: Sometimes, it can get frustrating. Don’t ask me which ones. I couldn’t find it. It’s a nightmare if I don’t know.

A4: I just think that once I know where something is, that’s where I keep going back to, but then it’s not there.

A3: Don’t really do a lot with the government ones. I don’t really check a lot of that … But we tend to just stick to the ones like Avocados Australia and the co-op and Google.

Google is commonly used to research various elements of the farmers’ operational activities and video clips are also accessed on occasions. The farmers perceive the use of these tools to be a standard information search option that fits in with their experience and existing needs.

A3: Just type it into Google and see what pops up.
A6: But Google is great, you can look up anything.
A4: We just look at YouTube. It’s surprising what you can find on there.

Some software programs are also used for operational tasks such as financial budgeting and accounting, tracking fertilisers and chemicals, superannuation and payroll. These activities fit well with farmers’ experience and existing needs and therefore there is no compatibility issue.

A3: I’ve got the Super Fund that I deal with. I’ve got the Australian Weather and News. I’ve got the Bureau of Meteorology, local Weather, Elders, AE4 (avocado marketing cooperative) check it every now and then, Avocados Australia (as favourites).

A1: I’ve been using GrowData, that’s what the neighbours have been using as far as a spray program, like records, keep records of spray programs and stuff. So it’s through a university or somewhere I thought, or New South Wales DPI, I’m not sure exactly where it’s from.

A2: I use a spray program and QuickBooks mainly. And the spray diary - it will do a lot of other things like keeping track of pruning, thinning, and picking and packing and all those other things.

A2: We are with AusSafe Superannuation. Their website used to be a pain, but they’ve improved it, updated it. It’s better now to use.

While there appears to be some growing interest in the Avocados Australia website, farmers’ responses suggest that IBE tools are not consistent with their experience and needs. IBE tools do not provide more than their existing methods in their day-to-day farming operations, and it is their perception that these tools are not as good as their existing methods. The experience of these farmers was that IBE tools were not comparable to the service provided by the local agronomist and their only other options were to read books and newsletters/magazines, talk to other farmers and attend industry group meetings. Hence, the researcher interpreted avocado farmers’ perceived views of the compatibility of IBE tools as a negative contributor to adoption rates.

5.2.3 Complexity

There seems to be very few IBE tools specifically designed for and available to avocado farmers. There are no tools, video clips, or links on DAF’s Avocados webpage. Furthermore, ‘Agbiz farm budgeting tools’ which is a webpage with links to various IBE
tools developed by DAF is not even a link on the main DAF webpage. To access these IBE tools, a farmer would need to be aware that they need to start on the Business Queensland main webpage and then link to the Farms, fishing and forestry webpage, then they have to link to the Agribusiness laws, tools and support webpage (Business Queensland 2016a).

It is apparent that avocado farmers are inadequately informed about any IBE tools that may be relevant or useful to them and seem to only discover them by chance.

A3: But, you know, there’s probably things there that are probably wonderful, but until I fall across it, or somebody tells me…

However, the issue is not related to complexity of the innovation. The associated technology is not perceived as relatively difficult to understand or use. A lack of skills or training might be considered a factor but this was not evident in the data collection and certainly not perceived as an issue by those avocado farmers that were interviewed. The farmers’ responses suggest that IBE tools, the Internet and software programs are not that difficult or complex to use.

A1: The Internet, the beauty of that is that it’s becoming easier. And I think it’s just then being a matter of, gee, I can do that now and it’s simple to do so we do it.

A2: It is something that (we are doing now) because it’s so much simpler nowadays whereas five or six years (ago), you wouldn’t have even worried.

Yet their experience with agricultural websites demonstrates that frustrating irregularities lower their user-friendliness thus reducing the time and effort farmers are willing to invest. Lower levels of user-friendliness will impact the complexity rating of an innovation and understandably can lower the likelihood of adoption.

A1: Sometimes you find something and then you go back two days later on the Internet to find it again, and you don’t know where it went.

A5: I think because the Internet is so infinitely changeable, they can just tweak the website or do this or do that, you expect it … and I am not really aware of one that I think, well, that’s just, oh, I can go there every time. I’ll go there but then it doesn’t exist.

A2: Before you used to have to have their number and their birthdate and something else, and if you didn’t have that, you then got to enter it, and they’d go, oh, there’s someone already with that number. But because you didn’t have
something quite matching up, you couldn't put them in. I remember once, I had identical twins, same birthday date, same last name, and same initial. It wouldn't accept them.

The instability of websites and IBE tools lowers farmers’ confidence in them as a viable option; they are unable to depend on them and despite these tools being simple enough to learn and operate, they become frustratingly difficult to use effectively. Therefore, the low level of user-friendliness of IBE tools is perceived as unnecessary complexity and this is a clear barrier to adoption.

5.2.4 Trialability

The avocado farmers are not averse to trialling IBE tools however, it does not seem to be a straightforward activity and there are elements that deter farmers from even trying. The farmers are not aware of the availability of many of these tools and even if they are, it seems that these tools are not easy to find. Thus, if a farmer does not know a particular IBE tool exists or where it resides, the farmer will find it difficult or impossible to trial.

A1: And you think, this stuff should have been up here and we should have been trialling it, but unless you know it's there, you're none the wiser
A3: There's so much bloody information that I wouldn't have a clue.

There is also a trust issue and a lack of knowledge about these tools. Blogs in particular cause considerable concern for many of the avocado farmers and this negatively impacts the likelihood of farmers trialling these types of IBE tools.

A5: I think it could be useful … but it's completely uncontrolled, isn't it, blogs? People just sign in. So the danger I suppose would be … that you get a whole lot of rubbish.
A2: But there's some (blogs) … you might get information back, but you've got no idea whether that fellow has any idea or whether he's the greatest farmer in the world.
A6: I like to see the people, so you can kind of see if they've got three heads or not … and just the quality of their answers is kind of giving you a bit of an inkling as to how switched on they are basically.
A2: There’s other things, I know, especially as far as chemicals and fertiliser programs, spraying, that sort of thing where it can affect your livelihood, we’re a little bit more hesitant.
These and many similar responses suggest that it seems unreasonable to expect farmers to spend their time trialling an IBE tool if they don’t know where to access it or even if it exists in the first place. Currently, the opportunity to trial or experiment with IBE tools seems to be speculative. Furthermore, a lack of trust in that innovation is also a deterrent to any potential trial of an innovation. If the farmers are unsure about the source and the quality of the information, they will be reluctant to venture in that direction. Therefore, the researcher believes that avocado farmers’ inability to trial or experiment with IBE tools is unquestionably a barrier to their adoption.

5.2.5  **Observability**

Given that the avocado farmers lack knowledge and awareness of existing IBE tools, observability of the results of these tools is virtually non-existent. Certainly these farmers share knowledge about various aspects of their farming at industry group meetings but if they don’t know about IBE tools they will not be a topic for discussion. Accordingly, industry group meetings would be the ideal forum for industry experts to publicise these tools and develop some awareness and interest. Magazines, newsletters, emails and website news would also be appropriate options for increasing farmers’ awareness of these tools as favourable communication and enthusiasm are likely to increase adoption of an innovation if it is visible.

According to Rogers’ Diffusion of Innovations Theory (2003), IBE tools equate to the software component of a technological innovation and these are inherently less observable than other innovations. This is certainly the perceived situation with the avocado farmers because of the lack of communication and knowledge of these tools. Therefore, in the absence of awareness and visibility of IBE tools, observability is considered to be a barrier to adoption given that they are difficult for outsiders to observe or recognise.

5.3  **Macadamia industry case study**

5.3.1  **Relative advantage**

Most of the macadamia farmers routinely access weather and industry group websites but they also access news, email, online banking, online shopping and social networking. Understandably, weather sites seem to be particularly important and there is no doubt that the Internet provides excellent weather data that macadamia farmers can use as the foundation for their short term and long term planning. The farmers perceive a clear
advantage to using this functionality on the Internet rather than maintaining manual records.

   M1: I use the Queensland Meteorological website where I go on to the radar locally and then I go on to the forecast and then you can go onto long range.
   M4: Probably the most important thing I use it for is the weather.
   M5: I watch the weather so closely … months ahead trying to plan, I'm in a dry period so I already know I can start dropping sprays out and certain products out because I just won't need them.
   M6: I use the BOM site, it's usually when a storm's bearing down on you.

Similarly, macadamia farmers’ use of chemicals and the required record keeping is maintained through the use of software and the Internet. This functionality enables farmers to meet strict regulations in a more efficient and effective manner compared to manual record keeping thus demonstrating the relative advantage.

   M1: This is what's going to drive people to better record keeping because it's demanded for accreditation purposes.
   M6: All my chemical applications, whether they're fertilisers or sprays, are recorded on there.
   M7: They get the information in and we also fill in the form and tell them what fertilizers, what sprays we put on, so it's part of our management of the nuts.

Blogs were another IBE tool reviewed with macadamia farmers. The benefits and use of these tools was discussed in relation to the blogs originating from the Australia Macadamia Society (AMS) website or the macSmart website. Despite one favourable view on this, most of the farmers prefer to look at their hardcopy reference books, consult with an industry expert or talk to other growers. Consequently, the discussion forum link on the macSmart website was removed from the menu due to the function not being utilised. A member of the macSmart team recently stated that at that time, there was an active email account which was very much the preferred option for growers. However, this email discussion group account has also since closed. It appears that farmers do not gain benefits from these IBE tools so the innovation is perceived as not being better than their current methods. Hence, the macadamia farmers perceive no relative advantage for this innovation.

   M1: All I know is that it comes to me and you can respond and other people respond and you see what they say … so that's quite helpful.
M3: Um, the opportunity hasn’t presented itself and also I just haven’t thought of it.

M4: Rather than go in there, we would just go straight to the person; we’ll get our own entomologist.

M5: I would be far happier to go and ring say ME2 and say ‘mate this is what I’m thinking, what have you seen in the industry’.

M7: No, I’ve never used it, probably won’t because I’ve got the entomologist comes through.

M7: See, everything here sort of doesn’t change much. Day to day, it’s fairly static and we get the entomologist guy and he’ll do 40, 50 farms so he’s got his finger on the pulse what everybody’s doing.

Dedicated IBE tools are not required for general searching of farming information, but the Google search engine appears to be compatible with farmers’ current needs and methods. However, not all macadamia farmers are enthusiastic Internet users because the Internet does not contribute greatly to their farming practices and they see little or no value returned for the time and effort it takes. Therefore, advantages and usefulness are sometimes limited and this will lower the rate of adoption.

M2: I’ve Googled that, how to make compost on YouTube and tried to buy a moisture probe on eBay.

M4: We’ve got a manager, a fellow who does quite a bit of research on the internet about macadamias.

M5: Just discovered YouTube in the last few years and like looking at ploughing equipment and machinery imported from California.

M6: Yeah you do find a lot of information online if you start sitting down and searching for it.

M4: We just don’t rely on it; as far as the farming goes – no, it’s not the panacea of practices.

M7: The Internet … we could probably do without it. We don’t need it to survive but it probably helps with research but I just don’t do it myself. We don’t use the internet to grow better macadamias. End of story.

Industry websites such as the AMS and to a certain degree macSmart are used selectively by macadamia farmers. These farmers don’t just access websites to browse and fill in time; there’s a purpose or need that prompts their searching and enquiries.
Certainly, several of the farmers' perceptions are positive with the information available being useful so the relative advantage is positive for some of the farmers.

However, while the macSmart site is still active in the fact that subscribers can still log in and access content, there is no current project that is funding the generation of new content. There is however some new video content that has been recently uploaded to the site with these videos being developed as part of other current macadamia projects.

Nevertheless, not all farmers see a need to access the AMS website to resolve farming issues or access research material. Interestingly, some very successful farmers voiced this opinion. So again, when perceptions about the innovation are negative, the rate of adoption will be lower.

\[M1: \text{If you know you want something, if you've got a brain you go look (online) but until I see that the payback is going to be more than the investment, I'm not likely to make the investment.}\]

\[M3: \text{I had a look at (a video clip) on different techniques of soil preparation, those sorts of things are good.}\]

\[M6: \text{I don't often go to the AMS website. It's got to have some reason to drag me in there.}\]

\[M6: \text{If you were having trouble with fruit spotting bug or something, you can go into the website but I hate reading through those papers.}\]

\[M5: \text{It's mainly they'll send out emails telling you what's on, like if there's a field day coming up and you just press the button and reply and you say you're coming.}\]

\[M7: \text{If you need a problem sorted out you can get on there and find the information, so that's good but really you only hear about that from other growers.}\]

\[M8: \text{If you know you've got a fruit spotting bug problem then you wanna find out what the breeding cycle is, so you just get on there and find information.}\]

\[M4: \text{Australian Macadamia Society? Wankers. We know more than them. No, that sounds wrong … they're not farmers; they're a society of intelligent people.}\]

In relation to relative advantage, the macadamia farmers' responses suggest that IBE tools are not useful and for many farmers, not as good as their current methods. They preferred looking at books or speaking to other farmers and industry advisors directly as this was easier. However, some aspects of the Internet were better than the manual
approach. Video clips offered benefits to some of the macadamia farmers but they’re not as readily available now. Many farmers believed that they had no need to access industry and government websites because the Internet does not contribute greatly to their farming practices. Therefore, they see little or no value returned for the time and effort it takes and that the relative advantage is limited. Consequently, throughout the interviews and through subsequent data analysis, the researcher interpreted macadamia farmers’ perceived views of the relative advantage of IBE tools as a barrier to adoption.

5.3.2 Compatibility

ADSL and Mobile are the most common means of accessing the Internet by macadamia farmers but satellite access is also used. Generally, access to the Internet is satisfactory but for some of the macadamia farmers it is unreliable. Therefore, some of the macadamia farmers have compatibility issues in terms of their needs and their current approach that may affect their ability or interest in pursuing IBE tools. This will have a negative effect on the rate of adoption of IBE tools.

M6: So if I go to that shed over there you will lose the connection.

M7: They’ll work a little while and then the connection will disappear for some reason and you have to reboot it.

M4: There’s just something wrong with the access here. We have more issue with the access rather than the actual Internet. There are times you can’t rely on it.

M5: It’s horrible. We’re in a black spot. The letter box is fine. Mobiles are horrible here too.

Macadamia farmers that have Internet access undertake a variety of activities online. In addition to accessing information on weather and chemicals as discussed in the previous section, some of the other online activities include email, news, online banking, bill paying, online shopping, accounting, and payroll. In general, these activities appear to be compatible with macadamia farmers’ past experiences, mindset, lifestyle and their needs.

M1: I can do my banking, I can do—paying bills, I can correspond with people that I know will get the message the next morning.

M2: I pay most of my bills by internet now and I book things on the Internet. I’ll look online if I wanna buy something from somebody locally or I want to get some pallets and stuff.
M4: We do emails, yes, online banking, news, weather, GraysOnline - it’s got a couple of sweepers up for auction.

M5: Most of the equipment that’s used, a lot of it you can’t buy off the shelf so you have to build it yourself so I often look at second hand machinery for sale.

M7: I used to use MacMan; I just put all that in, press the button and out will spit all this - my whole work schedule for the year, which is all they need to do their final tick for the audit. So, yeah, that MacMan thing was good, yeah. Totally worthwhile.

M6: One of the guys was using EnviroSCAN which is just a hole in the ground that measures how much water was in the dirt; it would take readings and then … he’d analyse them and send the information back to me. So that was great but it cost a lot of money; I wasn’t paying that sort of money for that … But you could sit in your office and know that you need to water your trees.

Accessing IBE tools on a tablet, laptop or desktop computer in an office is quite a reasonable expectation and certainly carried out by many macadamia farmers. However, using IBE tools out on the farm may have disadvantages such as effort, convenience, comfort, and risk, that outweigh the benefits and therefore reduce the rate of adoption.

M1: I mean when you’re working on a farm, honestly that’s the last thing you want, things hanging off you and worrying whether something’s going to fall out of your pocket or whether you’re going to crash against something.

M2: I will not carry my phone when I’m out in the orchard. I’ve already had a phone that’s fallen off a tractor.

M3: The keyboard (on the tablet) is so sensitive and I’ve got big hands, big fingers so it’s just awkward and annoying.

M5: I don’t like going online (using a tablet in the field) because I can’t read, it’s too small. I can’t tap properly whereas the big ones are just fantastic.

M5: We’ve tried some monitors and we’re just trying a new monitor now which we had in our harvester but the vibration everywhere seems to wreck everything.

M6: Don’t see a need to go out to the paddock with an iPad

For some of the farmers there seems to be no need for using technology; some don’t trust the technology, some don’t have the need for information available through IBE tools or on websites. Their past experiences and approaches have enabled them to successfully operate their farms. They prefer to maintain this approach and the use of
IBE tools, industry and government websites is not compatible with their long established approach to farming.

M4: We don’t sort of go looking – if we think of something, we would research it, but generally speaking, we wouldn’t search how to grow better macadamias for example.

M5: I don’t trust the internet; I’d rather just still go face to face.

M6: We don’t change our pattern much at all. I mean we do the same thing year in and year out. You can go into the website but if it hasn’t changed for twenty or thirty years, I’m not really going to be delving into the archives too much.

M7: At this stage, I’ve been doing it for about 20 years; you sort of know what you’re looking for (in the orchard) and nothing much changes too drastically so things just sort of roll on.

M7: I still don’t see there’s a need for it. Going on to a website, I wouldn’t do that very often unless I had to.

M6: I might try online first because it’s free.

M1: And I get bombarded with stuff all the time so I don’t encourage people to send me a whole lot of stuff that I don’t want. I hate people who send you stuff and copy it to every man and his dog. People are just going to spend their life mucking around with computers but I’ve got other things I want to do.

While many of the macadamia farmers use the Internet and IBE tools, several expressed a preference for speaking directly to other farmers, industry experts, and reading books. Their past experiences and approaches have enabled them to successfully acquire information from hardcopy written material, industry experts and other farmers. They prefer to maintain this approach and the use of IBE tools, industry and government websites is not as good in terms of time, ease and trust and thereby not compatible with their current methods.

M1: But the number one information source, for me, is to talk to people who know what they’re talking about; I can talk to people rather than engage in technology. At the end of the day I will go to somebody and have a chat with them.

M1: If I had a problem with I’d just talk to a field fellow.

M2: I much prefer face-to-face … I like to support local … that’s a moral situation.

M2: Well, I’ve got voluminous books with all the pictures so I refer to them when I’ve got issues. I’ve also got an entomologist, who I employ, who comes regularly.

M3: The personal approach with ME1 … that works for us.
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Overall, macadamia farmers’ responses suggest that IBE tools are not consistent with their experience and needs. IBE tools do not provide more than their existing methods in their day-to-day farming operations, and it is their perception that these tools are not as good as their existing methods. While this may be in part due to access issues, essentially these farmers did not believe that IBE tools were as reliable and trustworthy as the service provided by the local agronomist or entomologist. They also believed that accessing online information was not as satisfactory as reading reference books and newsletters/magazines, talking to other farmers and attending industry group meetings; it did not conform to their past experiences and their mindset. Hence, the researcher interpreted farmers’ perceived views of the compatibility of IBE tools as a negative contributor to adoption rates.

5.3.3 Complexity

Macadamia farmers are not aware of IBE tools specifically designed and available to them. Not one macadamia farmer had even heard of the ‘Agbiz farm budgeting tools’ with links to various IBE tools developed by DAF.

Furthermore, accessing resources on the Macadamias webpage from the main DAF website does not seem to be a useful information source despite having various links to resources such as crop management, pests and diseases, harvesting and more. This webpage was last updated in April 2014 which is a deterrent but then the users have to click link after link. When they get to their destination page, the currency of that page is also dubious, for example, the fruit-spotting bug page was last updated in January 2012. These elements detract from the user-friendliness of the DAF website and therefore increases the complexity.

Scientific research resources are another example of IBE tools that are perceived by farmers as misleading, difficult to navigate, and irrelevant, thereby contributing to the complexity of using these resources. Published research resources are available on the DAF website within each of the respective industry webpages via a link to DAF’s eResearch Archive. For example, a macadamia nut farmer would navigate through the
following links: Home > Business priorities > Plants > Fruit and vegetables > Fruit and nuts > Macadamias, and then click on the eResearch Archive link (DAF 2018c). Seventy articles are listed in chronological order; the most recent are from 2017 with the first three titles as follows:

- A guide to manufacturing rotary veneer and products from small logs.
- *Can the productivity of mango orchards be increased by using high-density plantings?*
- *Construction timbers in Queensland. Book 1 and Book 2: Properties and specifications for satisfactory performance of construction timbers in Queensland. Class 1 and Class 10 buildings (houses, carports, garages, greenhouses and sheds).*

Macadamia farmers would expect to click on eResearch Archive link and have a list of research resources relevant to the macadamia nut industry. Given that the word ‘macadamia’ appears twice in the body of the above resources, which are over three hundred and fifty pages in total, it is discernible that these articles have no relevance to macadamia nut farmers.

The technology, however, is not perceived as relatively difficult to understand or use. While a lack of skills or training might be considered a factor in complexity and low adoption rates, this was not evident in the data collection and certainly not perceived as an issue by most of the macadamia farmers interviewed. The farmers’ responses suggest that IBE tools, the Internet and software programs are not that difficult or complex to use.

*M1:* I don’t find it difficult at all; these days it’s so easy to just tap into a website and read all you want.

*M2:* I’m reasonably efficient at finding things on the internet.

*M3:* Easy to use? Absolutely.

*M6:* Well most things are easy to use. Most of them are just point and click. So we can use the technology; it’s just whether or not we have to or want to.

*M7:* It’s pretty fool proof.

However, some elements of complexity were raised by the macadamia farmers. Some of them lack proficient search techniques and the vast number of links can be daunting.
Chapter 5 – Case Study Analysis

M1: Put a word into Google and it will bring you up forty thousand sites. So you know, the big problem is to be able to sift it.

M3: … particularly moving from one section to another on the website. They’ve got an awful lot of different areas that you can go to on the website.

Furthermore, confidence levels of some of the macadamia farmers were low and some believed their mindset impacted on their ability to use the technology efficiently and effectively even though some of them didn’t think the technology was difficult to use.

M1: I’m flat out getting my tax return done and doing my BAS statements
M2: I’m not being brought up on the computers. It’s not – mentally, I just don’t think that way.
M3: I just don’t utilise it. I’m usually pretty wiped out by the end of the day too.
M5: I’m illiterate with the computer, I really am, I don’t like them … had to send him a photo of it but I wouldn’t know how to do that; I’m just too slow and I don’t want to waste my time in front of a computer.

Passwords certainly appear to be an issue for some of the macadamia farmers and this contributes to complexity. If they are unable to enter a valid password, they will not be able to access the website and this is viewed as unnecessary and not user-friendly.

M1: I think a lot of websites could be made a lot user friendlier.
M3: Maybe all those bloody passwords you’ve got to have to get in is a bit of a worry.
M6: You have to log on to the website and I didn’t have the password with me. I had forgotten it; there are so many to remember.
M7: I didn’t go on to this harvester web YouTube thing cause as soon as you click on the link in the email you have to log on to the website and I didn’t have the password with me and I never remember it.

Despite software and technology being simple enough to learn and operate, macadamia farmers perceive them to be frustratingly difficult to use effectively. The frustrating aspects of websites and IBE tools requiring passwords, being out of date and requiring so many links to get to the destination webpage are a deterrent to farmers as the process is not perceived as user-friendly. This increases the complexity of an innovation. Therefore, the low level of user-friendliness of IBE tools is perceived as unnecessary complexity and this is a clear barrier to adoption.
5.3.4 Trialability

The ease with which a farmer can trial or experiment with a product or innovation depends firstly on whether they have access to that product or innovation. In general, macadamia farmers are not aware of IBE tools that are up to date and relevant to their farming needs. Essentially this means that these farmers cannot trial IBE tools; from their perspective, these tools do not exist. Therefore, farmers need to be informed about these tools before they are able to trial them.

M1: Some sessions on user friendly websites and where to go for various things would be something that I would use because I do need to develop my list of good websites and get them.

M1: People have got to show me, if they want me to use it they’ve got to show me that there’s some value in that for me.

M6: If it’s a clip, it’s something recent, yeah I’m quite interested to know about that.

In addition to being informed about the availability of IBE tools, farmers would be more likely to trial or experiment with a product or innovation if a demonstration or some form of guidance was provided. This is very similar to purchasing farm machinery and equipment where the farmer would insist on trialling the machinery before making a substantial investment. IBE tools require an investment of time and effort and farmers need support and encouragement before they will trial a product or innovation.

M3: I’m much more likely to learn if I were shown rather than if I tried to read an instruction book because I get lost.

M2: Just a bit of old fashioned help and I might be interested in learning about this stuff.

M5: I’d like to be able to get a lot more out of my fertiliser companies.

The many responses from macadamia farmers suggest that they are not averse to trialling IBE tools but it is impossible for a farmer to trial or experiment with an IBE tool if they do not know where to access it or even if it exists in the first place. Farmers need to be made aware of these tools and where to find them otherwise trialling them is impossible. With this current lack of knowledge and awareness of IBE tools, the researcher believes that macadamia farmers’ inability to trial or experiment with IBE tools is definitely a barrier to their adoption.
5.3.5 Observability

The software component of a technological innovation is inherently less observable than other innovations (Rogers 2003), however, it is impossible to observe IBE tools if the farmers have no knowledge of the innovation or are not aware of their existence. While macadamia farmers share knowledge about various aspects of their farming at industry group meetings, if they don’t know about IBE tools they will not be a topic for discussion. There is no communication or enthusiasm about IBE tools because they are not visible or observable; the farmers simply don’t know about them. The researcher asked farmers about their knowledge and awareness of IBE tools such as the Beatsheet blog or the macSmart discussion forum but clearly they had no knowledge of these IBE tools.

M1: No, never heard of it.
M2: I’d need to know that there was a blog for this sort of stuff.
M4: It seems to me that not a lot of people use it, I don’t know anyone, which is unfortunate.
M6: Haven’t heard of it.
M7: Never heard of it, oh really?

Given that the macadamia farmers’ lack knowledge and awareness of existing IBE tools, observability of the results of these tools is virtually impossible. Consequently, adoption of this innovation is essentially non-existent. Therefore, in the absence of awareness and visibility of IBE tools, observability is considered to be a barrier to adoption given that outsiders are unable to observe or recognise them.

5.4 Pineapple industry case study

5.4.1 Relative advantage

All of the pineapple farmers interviewed routinely access the Internet for weather information and some also access online banking, email, and the news. Online shopping and social networking are not popular amongst the pineapple farmers. Weather sites are particularly important as farmers check their specific location and the nearby district daily. The Bureau of Meteorology (BOM) site in particular, provides data that enables farmers to review current weather conditions but data from this site is also crucial to their short term and long term planning.

Rogers (2003) states that relative advantage is established by the degree to which an innovation improves the existing practice. He further explains that elements such as
financial cost, time, effort and discomfort, contribute to perceived relative advantage (Rogers 2003). Pineapple farmers perceive a clear advantage in time and effort by using the functionality on weather sites rather than maintaining manual records because it is centrally located, useful, convenient, comprehensive and up to date.

P1: The weather technology, no question at that. That is useful, there’s no question at all.

P2: The weather is a consistent one. I got three that I go to, but I’ve got a favourite one. And then I like BOM’s radar, I look at that pretty well every day. … but the others are local Bundaberg weather, Childers weather.

P3: … Elders and BOM nearly every morning checking the two-day forecast, monthly forecast, and checking the long range forecast for planting.

P4: BOM website. You get everything you need on that, if you know where to look. You get the written forecast for Maryborough every day, as well as what they say for the general district.

P6: It just seems better to me, it’s all laid out. It’s got all of the data. It seems easy to read. I find it reasonably accurate, as accurate as they are. It’s got a 3 monthly outlook and a monthly and a 12-monthly outlook.

Conversely, those pineapple farmers interviewed have not adopted the use of electronic based spray diaries. According to the Agricultural Chemical Users’ Manual (DPIF 2005) the use of agricultural chemicals is regulated by control-of-use legislation (six separate sets of acts and regulations for Queensland) and accurate records of all chemical application practices should be maintained. Similarly, DAF suggest that maintaining a spray diary is critical documentation providing evidence of farmers’ chemical application procedures and practices (DAF 2014c). However, neither the DAF website or the Agricultural Chemical Users’ Manual suggest a system for maintaining a spray diary. Nonetheless, Internet based spray diaries are available commercially (e.g. PestGenie, Croptracker, PocketPAM2) at a cost to the farmers, but pineapple farmers continue to maintain hardcopy spray diaries as they don’t see any advantage that outweighs the simplicity and minimal cost of hardcopy records.

P1: The spray diary online, well, we have them hard copy. We carry it around. There, again, unless you’re carting an iPad around with you all day, every day, it’s really not much of an advantage.

P2: It’s all done by paperwork. I did it on an Excel thing for a while but I don’t think it was actually helping; it was interesting, but I don’t think it actually helped
or changed what I did on farm, so it wasn’t necessary and it’s so much easier just writing it down, I reckon.

P5: If I’ve gotta find anything I use InfoPest. That’s a good thing ’cause you can access all your labels, materials, safety data sheets, all that type of stuff. And it’s up to date information. Any permits or anything like that, that’s all held there as well. But I just write it all down in this book.

However, if a spray diary was more readily available as an IBE tool, some of the pineapple farmers would be interested.

P3: You can do it all by hand, but I’m sure a computer program would be invaluable. And that would also help out with your quality assurances and that type of thing.

P5: I’d love to see the government develop a generic spray diary programme. But I’d like to see calculations incorporated so I can look and know over the next 12 months for me to have perfect crop of pineapples, I’ve got to apply another 400 kilos of nitrogen. So I’m going to have to actually do so many sprays of urea to get exactly so many kilos of nitrogen.

Blogs were another IBE tool reviewed with pineapple farmers. While the researcher attempted to discuss the farmers’ use of blogs, it was evident through comments such as those following, that the pineapple farmers don’t use these IBE tools.

P1: I don’t know anything about blogs. No one knows about it.

P3: Never heard of one for pineapples.

P4: Nup, I don’t even know where you’d get onto one.

The researcher pursued the discussion to determine why the farmers were not showing any signs of enthusiasm or even a basic level of interest in accessing blogs.

P1: Blogs won’t work for pineapple growers because there is little expertise through the government and there are only about 80 growers in Australia … purely for the reason that the crop we’re talking about is just so unique.

P3: The only reason not is because the pineapple industry and the pineapple plant, are pretty specialised. There’s not many people on that. There’s no one anymore that even knows how to write a soil sample for pineapples.
While the researcher understood the farmers’ perceptions associated with seeking feedback from advisors with limited industry expertise, there are some agronomists and extension agents that specialise in pineapple growing. Accordingly, the researcher continued the discussion after highlighting the potential advantages of using an IBE tool like the Beasheet Blog where photos can be uploaded and expert diagnosis and advice provided.

P1: No, I’ve done it once or twice, but it takes me a while to do that. It’s generally easier just to make the phone call and tell the person what it looks like.

P1: The only problem is I think if you send a picture of a pineapple in to them, I don’t think they would have any idea what is wrong with it, purely for the reason that the crop we’re talking about is just so unique.

P2: A few years back, we had a problem in the zucchinis and actually sent it down on email – photos of it. ...Yeah, they were pretty good; would do it again.

P5: But all things aside, if you had a bug or something in the field, it would be feasible to take a photo of it, search for it online, something like that.

These responses reveal that pineapple farmers are not entirely averse to uploading photos to a blog to seek advice, however, the uptake of this type of IBE tool would depend largely on the level of expertise in the responses given to the farmers. Currently, pineapple farmers’ limited confidence and awareness of this type of IBE tool outweighs any potential benefits that they might gain. Therefore, pineapple farmers in this research study do not perceive any relative advantage to using these types of IBE tools.

Similar views were expressed by the pineapple farmers regarding the Agbiz farm budgeting tools on the Business Queensland website. Some of the 250 tools available include whole of farm budgeting, loan calculators, and a calculator for estimating greenhouse gas emissions (Business Queensland 2016a). The farmers’ responses below indicate that they do not perceive any advantage in this set of IBE tools. They are not relevant or useful and therefore not worth the investment of time and effort over their current practices.

P1: If you start talking to a farmer about carbon emissions, surely you can see the blank look. It pales into insignificance with the Australian dollar going down and fertiliser price going through the roof. It’s not going to help pay the bills.
P3: It’s not current and it’s not useful. And if you wanted to calculate how much fencing material you need or how much that's going to cost, you just know that in your head anyway. A farmer already knows how long that stretch of fence is. 
P5: No, if you go into a website, you don’t want to be bothered with that sort of thing.

Likewise, many of the pineapple farmers expressed negative views about Government and industry websites. These farmers perceive little relative advantage in these types of websites over their existing practices as shown in the following responses. This is mainly due to the perception that the information is not current on these websites and that farmers simply don't have the time to invest in an innovation they don’t believe will improve their farming methods and outcomes.

P1: there isn’t a healthy respect there, if I go onto a government DPI website or HAL [HIA] website, you really don’t have a lot of confidence that what you’re gonna find is relevant. Most of it is very old; there is just so little research being done now.

P2: The pineapple industry thing, there is a website (part of DAF). I’ve actually never used it; probably just never get around to it, but there’s probably nothing I don’t already know.

P2: I don’t think it actually helped or changed what I did on-farm.

P3: First you gotta see a use for it is always the thing. So unless you convince me of something I really should know, then I don't really need to know more.

P4: If I can see a need for it or advantage of using it or maybe cheaper cost or something like that. Unless I can see a direct need for it or something like that. Time is limited.

P5: And there has to be something in it for me. There has to be a reason for me to do it. Otherwise, I'm too time-poor to want to do it. So it has to have an economic influence, or cut down on labour, so it might increase productivity.

Rogers (2003) reports that past research on the perceived attributes of an innovation almost unanimously identify a positive relationship exists between the relative advantage of an innovation and its rate of adoption. He also states that elements such as financial cost, time, effort and discomfort, contribute to perceived relative advantage (Rogers 2003), however, pineapple farmers do not perceive advantages relative to any of these elements. Consequently, the researcher believes that the pineapple farmers' perceptions
about the lack of advantages of IBE tools directly contributes to a low rate of adoption of these tools.

5.4.2 Compatibility

The compatibility component of Rogers’ Diffusion of Innovations Theory is not determined purely by the technical compatibility of IBE tools with, for example, the operating system on a farmer’s PC. Certainly the researcher discussed this aspect of compatibility with the farmers but there are several other aspects of compatibility that were explored. Sociocultural factors such as existing values and beliefs, as well as past experiences and the potential adopter’s needs, are aspects that may affect the compatibility of an innovation (Rogers 2003). Therefore, the researcher explored the compatibility of IBE tools with systems and procedures currently being used and whether these were manual or technology based; if they were compatible with technological infrastructure and access in the field and in the office; and whether they were compatible with pineapple farmers’ current routines, activities, experiences, beliefs and needs.

Access to the Internet is a crucial component impacting the compatibility attribute of adopting IBE tools. ADSL and Mobile are the most common means of accessing the Internet by pineapple farmers but satellite access is also used. Generally, access to the Internet is poor and for many of the pineapple farmers it is unreliable. Therefore, the pineapple farmers have compatibility challenges in terms of their needs and their current approach that affect their ability or interest in pursuing IBE tools. This will have a negative effect on the rate of adoption of IBE tools.

*P1:* Sometimes during the day, you got to walk out the house around the back and up to the top.

*P3:* Yeah, ADSL. But it depends, if you stand on that top step with one leg up and twist to the left you’ll get it. But in other spots, we’ve got very bad reception out there.

*P4:* We can’t get it through the phone. We’re right on the end of the exchange; it stops just past us; down on the end of the road is the end of the line.

*P6:* I got broadband at home, but here, I can’t get it. But just across the road he’s got broadband.

The cost of the Internet is another issue that pineapple farmers perceive as a barrier to using IBE tools as suggested in the following responses. The farmers need fast, reliable
and cost-effective access to telecommunications infrastructure that supports the adoption of IBE tools.

P4: they’ve got to make the country equal to the city in service to help with the cost, just got to absorb the cost right through the entire system.

P5: They wanted us to go to NBN, and I said no because they couldn’t match the plan that I was on for the amount that we were doing. So the NBN at this stage for me is 25 percent dearer than what I’m currently on.

P6: And broadband - ridiculous prices now; it costs a fortune.

While Internet access is poor, the pineapple farmers are persistent with their attempts to access online activities. In addition to weather information, the following responses identify some of their other online activities including email, news, online banking, online shopping and general searching. Despite access challenges, these activities are compatible with pineapple farmers’ past experiences, their mindset, lifestyle and their needs.

P1: I have used Google Earth at times; it is useful. Check my emails, check the news, check the weather.

P2: All the paperwork, bills are paid, all the banking, lots of emails, weather check, sometimes go looking for something on Google; I love Skype.

P3: I run an Excel spreadsheet - like I can know how many pineapples I’ve sold for the week right down to the local trade. Always checking Gumtree - for machinery, YouTube; I’d be searching stuff on it every day.

P4: Instead of going out and looking at the label, which has probably peeled off the bottle anyway, I just Google it.

P5: If I wanna hydraulic pump or a diesel pump, I’ll Google it and YouTube it. I had to pull the carburettor down; it was all on YouTube.

P6: I do a lot of machinery research.

P6: On the irrigation there it’s got sensors for all the paddocks - we can go to the website and check what’s happening.

Many pineapple farmers have smart phones but usually access the Internet using a tablet, laptop or desktop computer in their office or at home. Providing they can actually access the Internet, these devices do not raise any compatibility issues.

P1: We just got a laptop; tablet and a desktop computer, but no smart phone
P3: We have a laptop and a desktop computer; two iPads, one smart phone.
P6: I got a desktop at home and two laptops; tractors are all full of GPS and all that sort of stuff.

However, the following responses reveal that using devices outside of the office or their home is perceived by the farmers as impractical, particularly because of their rugged outdoor activities. As Rogers (2003) suggests, compatibility is affected by a potential adopter's mindset and lifestyle and this may affect their evaluation of an innovation. Therefore, pineapple farmers perceive the outdoor use of IBE tools on devices such as a smartphone or tablet, as unsuitable for their farming lifestyle and activities.

P1: There’s no real need to carry an iPad around.
P1: It would be a waste of time trying read that on your phone.
P3: My other phones have spent quite a bit of time in water troughs; you're always bending over and they fall out.
P5: Screens are hard to use in the field. And there's sunlight screens; they're worth a fortune, but you still gotta go to a dark corner to be able to read in the daylight.
P5: We don't carry 'em. I haven't come across too many ruggedized iPads that would stand up to the abuse and I just don't have pockets big enough to carry one.
P6: Yeah, it's a smartphone but I just find the mobile version is always harder to use.

The researcher further discussed pineapple farmers’ use of agricultural, industry based and government websites. Conceivably, there are several websites that aim to be relevant and a potential information source for pineapple farmers including Growcom, HIA, Infopest, Freshcare, DAF, and Business Queensland. Some of the farmers’ responses were positive, confirming that some websites were consistent with their needs. These views support the compatibility of IBE tools with the pineapple farmers’ current farming practices.

P5: Yeah, I've used it a couple of times (Growcom) and found it quite okay.
P5: I used Infopest and that's a good thing 'cause you can access all your labels, materials, safety data sheets, all that type of stuff from Info Pest. And it's up to date information. Any permits or anything like that, that's all held there as well.
P6: Yeah Golden Circle have their own homepage. We go in there and check on a lot of things.
Conversely, the following responses indicate that many of the pineapple farmers have a different outlook. They don’t believe they need to change their current farming practices and don’t believe these websites will improve their current approach. Their mindset and lifestyle affect their view of IBE tools to the extent where IBE tools are not compatible with their current approach to farming.

P1: So many the government sites and the corporate sites, there’s just so much there but it’s not relevant.

P2: The pack houses have been fairly supportive of trial work and that information, it’s not really documented on the website.

P3: No. I only go there if I have to or I think there’s a better way of doing it. I sort of don’t do it for the sake of doing it. I don’t change for the sake of change.

P5: There’s Growcom websites and that type of stuff … I don’t use them.

P5: The DAF websites? No, I haven’t used it; I’ve had no need to go there. I’ll hang on to the old technology ‘cause it’s servicing our needs.

P6: I think Australian Pineapple has one, yeah, I don’t visit that one.

While many pineapple farmers use the Internet, several expressed a preference for speaking directly to other farmers and reading magazines and books to acquire information and to resolve farming issues. Their current approach has enabled them to successfully operate their farms and they already have a vast knowledge of their industry. Therefore, pineapple farmers believe that agricultural websites and IBE tools are not compatible with their experience and existing practices.

P1: I went down to a grower class just last week, and saw his rig, and you find out a heap of stuff while you’re there. That traditionally, is the way things are done. Now if I Google a pineapple de-topper, I’m not sure what I’d get. I’ve tried Googling a Telone rig, and even that’s not really available.

P1: But really, by and large it’s farmer to farmer.

P2: The way information is getting to us is through the study group. We actually go to different farms, and you can see what everyone else is doing and then you get your own ideas from that; you get ideas off other people.

P3: Usually, if I wanna know something, I pick up the phone and ring the IDO [industry development officer]

P4: We’ve got the Pineapple Press (newsletter) that they’re putting out that comes to us once a quarter.

P5: Study groups, certainly the study groups.
P6: No, once you got experience, you’ve been on the same property for 50 years, you go out there every day, you know a fair bit.
P6: Pineapple pests and disorders, now that is really valuable; easy to find exactly the bit you want. I’d rather cart that book around than look online.

Pineapple farmers’ perceptions of agricultural websites and IBE tools indicate that these tools are not consistent with the farmers’ experience and needs. Their current approach has enabled them to successfully operate their farms and they already have a vast knowledge of their industry. They also believed that acquiring information was best achieved through reading reference books and newsletters/magazines, talking to other farmers and attending study group meetings. Thus, accessing information through websites and IBE tools did not conform to their past experiences and their mindset. Rogers (2003) states that the compatibility attribute is determined through the potential adopter’s evaluation of the innovation in comparison with their current practice and this is influenced by their mindset and lifestyle, existing values, past experiences and needs. Hence, IBE tools are not compatible with pineapple farmers’ existing practices which are based on their values and long established approach to farming.

5.4.3 Complexity
Pineapple farmers do not have IBE tools specifically designed for their industry group. Nor do they have access to an industry group website specifically for the pineapple industry. This is a consequence of not having a unique industry representative body dedicated solely to pineapple growers. The peak industry body for pineapple growers is, in fact Growcom but Growcom is an overarching industry representative body for all Queensland horticulture. Therefore, the Growcom website and others such as Infopest, HIA and Freshcare, have agricultural information available to pineapple growers but this is targeted to the overall horticulture industry rather than specifically to the pineapple industry. Other websites such as Golden Circle and Heinz Australia are targeted at the consumer. The lack of specialised information on these websites makes pineapple farmers’ searching for information difficult. Rogers (2003) suggests that if the innovation is perceived as difficult to use, its complexity increases and is negatively related to the rate of adoption.

Likewise, pineapple farmers expressed negative views on accessing resources on the Pineapples webpage from the main DAF website. Despite various links to resources
such as research and development, crop management, pests and diseases, harvesting and more, the information is perceived to be out of date and the farmers don’t believe it will improve their farming methods and outcomes. DAF’s Pineapples webpage was last updated in February 2014 which supports the farmers’ views. Similarly, the pests and diseases page was last updated in September 2012. Furthermore, if the farmer follows three links to view the Residue Disease page, not only is the file not found, but this webpage was last updated in July 2003. These elements diminish the user-friendliness of the DAF website and hinder their adoption. The responses below further emphasise the perceived poor user-friendliness of the DAF website.

P3: they don’t make it very user friendly sometimes – a lot.
P4: I try and steer clear of them because they’re just horrific to try and negotiate.
P4: I’m no expert at websites, but – yeah – I know that they’re damn hard to use.
P6: I’d rather go to a chemical company site rather than that department site to get the same thing, because they’re generally a lot simpler to use.

This barrier to adoption is explained by Rogers (2003) in his example of the poor uptake of home computers in the 1980s due to their perceived complexity, compared with the increased rate of adoption by 2000 due to the increased user-friendliness. Thus, the farmers’ perception of poor user-friendliness of the DAF Pineapples website is a barrier to adoption.

Likewise, the Agbiz farm budgeting tools on the Business Queensland website are criticised by the pineapple farmers for being out of date and irrelevant as highlighted in Section 5.4.1 Relative Advantage. These perceptions contribute to the perceived complexity of technological innovations and are, therefore, barriers to adoption which contribute to the poor adoption rate.

In addition to the complex nature of accessing agricultural websites and IBE tools, some of the pineapple farmers find the technology difficult to use. According to Rogers Diffusion of Innovations Theory (Rogers 2003), the perceived difficulty experienced by these farmers contributes to the complexity of the innovation and this lowers the adoption rate. The following responses demonstrate their difficulties.

P1: I tend to get stuck so I used to always ask the kids. But if you’re by yourself, you can be pretty stuck ‘cause I’m a bit of a dinosaur on that stuff.
P2: The stuff I do on there I can do fine but I think I’m just a dinosaur. I tend to do what I gotta do. But when I gotta learn something new, it’s a bit hard.
Chapter 5 – Case Study Analysis

P4: If I knew how to use it, I’d Google it. But it’s probably like a lot of that stuff, if you knew how to use it, I suppose you’d use it a lot more.

P6: there was people in that room that were very illiterate with this computer stuff. That’s about the way I saw myself ... you really are at the distinct disadvantage.

In contrast, some of the pineapple farmers expressed more confidence in their computer literacy skills, generally believing their ability to effectively use computers as satisfactory. Therefore, the degree of complexity for these farmers is not sufficient to be a barrier to adoption.

P3: I’d love to know more about computers but I’m getting by with what I know.

P5: I reckon I’d be, maybe middle of the road. I’m certainly not frightened of pushing buttons, but I think that’s what you’ve gotta be, is prepared to have a go.

P5: Online tutorials are great 'cause you can refer back to 'em at a later stage. As well as that you can then involve other people in business such as your wife or your workmen.

Overall, however, the researcher believes that the complexity perceived by pineapple farmers is a barrier to adoption and negatively relates to the rate of adoption. This conclusion is based on the pineapple farmers’ negative responses, issues of poor user-friendliness, and the difficulty for some farmers to use computers and effectively search agricultural websites.

5.4.4 Trialability

Rogers (2003) trialability attribute relates to how easy it is for the potential adopter to trial or experiment with the product or innovation and is positively related to the rate of adoption. As discussed in the previous section, pineapple farmers do not have IBE tools designed specifically for their industry group. Nor is there an industry group website specifically aimed at the pineapple industry. Hence there is no potential for trialability of IBE tools and agricultural sites specific to pineapple growers.

Nonetheless, pineapple farmers could trial the Agbiz farm tools offered by Business Queensland but are not aware of their existence. Furthermore, there is no potential for pineapple farmers to trial IBE tools via the DAF website. Given the critical nature of maintaining chemical usage records, the researcher expected DAF or Business Queensland would offer some form of generic digital spray diary. The researcher failed
to locate any such tool or link to an external app; not even a template for manual record keeping was available through these Government websites.

Nevertheless, generic tools and general horticulture websites are accessible for pineapple farmers. For example, Growcom (2016c) is the peak industry representative group for Queensland horticulture and is:

- An information hub for the horticulture industry.
- Promotes innovative and responsible farming.
- Provides services to improve efficiency and profitability.

A computer based program currently being promoted by Growcom is ‘Hort360’. This is a comprehensive whole of farm business analytical tool designed to give the farmer a 360-degree view of their business operations. This program could be trialled by pineapple farmers and appears to be beneficial as stated by Ben Gowen of Sahara Farms (Growcom 2016a) ‘I was concerned that the Hort360 process might be arduous but it was actually quite easy’.

Similarly, pineapple farmers may trial IBE tools from a range of commercially available digital apps. For example, PestGenie, Croptracker and PocketPAM2 are mobile apps offering a digital spray diary. While these apps offer a free trial period, the majority of pineapple farmers are unlikely to trial these products because of the financial outlay required on expiry of the trial period. However, Google Earth could be considered an IBE tool and it is free and certainly trialable. Pineapple farmers use this enthusiastically when it is required, for example:

P3: So if I've gotta do a big fence, I'll measure it on Google Earth. And I know well – I need so many round posts, so much wire, so many stays all on Google Earth. It’s great. I love Google Earth.

In summary, pineapple farmers are generally not aware of IBE tools that they can trial or experiment with. Given that these tools are perceived to be non-existent, it is reasonable to conclude that these tools currently are impossible to be trialled. Rogers (2003, p. 258) defines trialability as ‘the degree to which an innovation may be experimented with’ and generalises that trialability is positively related to the rate of adoption. The researcher believes that pineapple farmers’ inability to trial or experiment with IBE tools is a barrier to adoption and is therefore negatively related to the rate of adoption.
5.4.5 Observability

Rogers (2003) observability attribute encompasses the visibility of an innovation and any favourable communication or enthusiasm used to describe the innovation. He also states that observability is positively related to the rate of adoption of an innovation. While the software component of a technological innovation is inherently less observable than other innovations (Rogers 2003), it is impossible to observe IBE tools if they don’t exist or if the farmers are not aware of their existence.

In this context, it is impossible for the pineapple farmers to observe IBE tools if they have no knowledge of their existence. While pineapple farmers share knowledge about various aspects of their farming at the pineapple study group meetings, if they don’t know about IBE tools they will not be a topic for discussion. Consequently, there is no communication or enthusiasm about IBE tools between farmers because they are not visible or observable; the farmers simply don’t know about them. To explore their knowledge and the opportunity to observe IBE tools, the researcher asked farmers about tools such as the Beatsheet blog or and the Agbiz farm tools. It became clear that they had no knowledge whatsoever of these IBE tools.

P1: Never heard of that one.
P2: I haven't heard the name of that website.
P3: No. (have not heard of Agbiz)
P5: No, I've never heard about it.

Pineapple farmers are essentially excluded from a digital environment that could potentially offer direct links to pineapple specific news and updates, pineapple specific best management practice video clips and techniques, and perhaps a pineapple growers’ discussion forum or links to farm planning and management apps. Given that IBE tools designed specifically for pineapple farmers do not exist, these farmers are unable to readily embrace this technology. Consequently, the researcher believes there is no potential for observability of IBE tools designed specifically for pineapple growers. According to Rogers (2003), this low level of observability may be a barrier to adoption.
5.5 Strawberry industry case study

5.5.1 Relative advantage

Rogers (2003) states that relative advantage is established by the degree to which an innovation improves the existing practice. Factors such as financial cost, time, effort and discomfort, contribute to perceived relative advantage (Rogers 2003). Most of the strawberry farmers are not averse to using the Internet and technology. They routinely access the Internet for activities such as the news, email, online banking, online shopping, social networking and most importantly, weather forecasts. The farmers perceive a clear advantage to using the functionality of weather websites rather than maintaining manual records. Accessing the weather online provides data that is centrally located, useful, convenient, comprehensive and up to date.

S2: *Mainly the Bureau of Meteorology or the Elders Weather website.*

S4: *We look at the long term weather forecast.*

S6: *I just use the BOM website mainly for the radar. I use Elders too; they’re quite good.*

S11: *I have the weather app – Weather AU*

S12: *We use BOM and WillyWeather.*

Most of the strawberry farmers have smartphones and use them out in the field. Using phones to take photos of irregularities on plants and record the location of chemical applications is popular with some of the farmers who perceive a clear advantage in terms of convenience, immediacy and usefulness.

S6: *You can take a photo immediately of something and then go back to the office and look at it. You’ve got that record and you can put it into your computer.*

S9: *We take photos when we’re out in the field and we’ll show the agronomist.*

S13: *I can take pictures of things and send them to my agronomist.*

S14: *Yes, always. I take a photo, send it away, just on my phone, just send it to them, they look at it. If they know what it is, they tell me; if they don’t, they’ll come out, have a look and then take a sample.*

Conversely, some of the strawberry farmers were sceptical of uploading photos and questioned the potential benefits in terms of their time and effort and the outcome. Some were not aware of a website to upload them to and others were dubious of the successful outcome. Hence, these farmers did not perceive any relative advantage over their existing practices.
S1: Yeah, if I knew it was existing; how do I know I can do that?
S6: If you don't know what to look for then I'm not doing it.
S12: Some of the websites that involve you to be able to contact them and upload a file just don't work properly.

Similar views were expressed by the strawberry farmers regarding the Agbiz farm budgeting tools on the Business Queensland website. These IBE tools deliver numerous options including whole of farm budgeting, loan calculators, and a calculator for estimating greenhouse gas emissions (Business Queensland 2016a). Rogers (2003) suggests that relative advantage may be evaluated in terms of immediacy of reward and time/effort savings compared to an existing practice. In this context, the farmers’ responses below indicate that they do not perceive any advantage in this set of IBE tools; they are not relevant or useful, and not worth the investment of time and effort compared to their existing practices.

S5: It's not kind of relevant to what we do – parts of it probably is but I don’t sit on the computer all night and research stuff.
S8: A lot of what happens with those sorts of things are people sit behind a desk and come up with stuff. You've got to get out in the paddock and realise what's actually useful.
S11: How does that make your farm more efficient, though?
S14: Well, to be honest, I'll probably never use them.

Likewise, many of the strawberry farmers expressed negative views about Queensland based government and industry websites. These farmers perceive little relative advantage in these types of websites over their existing practices as shown in the following responses. This is mainly due to their perception that the information is not current or not posted on these websites and that it is pointless investing their time in these sites.

S2: I only go to DAF if I need their phone number. They don’t have the information there.
S6: I don't need that. I don't even know that they have one to be honest. If I wanted information about something I usually just type in to Google. I found the New South Wales DPI was good.
S11: No, never use DAF. The Cabot [Chemicals] website from the UK, that’s pretty good. It tells you a lot of chemicals and how it affects the beneficial bugs.
S13: No, there’s nothing there for us, it’s always out of date anyway.

Some of the farmers offered their suggestions on features that would improve the attractiveness and usefulness of a centralised agricultural website for strawberry farmers. It is their perception that relative advantage would be achieved if these types of features were implemented.

S8: Wages, workplace practices, what’s expected at work as an industry and what we’re expected to do as an industry from Woolworths and Coles and standards for your sheds. Almost like a health and safety sort of standard for everybody, that everyone’s going to abide by.
S9: The website put together with everything on it that we use would be handy, so we could jump on that and have a look, at the moment you just gotta Google it and find it and then do it that way
S14: It would be good if the Strawberry Association would put up a website or an app that had all your chemicals and fertilisers so we could get straight on to look at the application rates or what it treats.
S12: A click-on site, so you don’t have to go anywhere else but your industry body website for everything a strawberry grower would ever need.

According to Rogers (2003) financial outlay is one of the factors that can affect potential adopters’ perceptions of relative advantage. This is demonstrated by some strawberry farmers unable to take advantage of technologies because of the prohibitive costs.

S4: On this size farm it’s not really appropriate. It’s not cost-effective.
S6: Well, some of them are thousands of dollars to begin with, and then you’ve got to pay three hundred dollars a month to be able to store your stuff, it’s not worthwhile; we’re too small.
S12: There’s far more farms out there utilising technology ‘cause they’re larger scale, there’s more money.

Rogers (2003) states that factors such as financial cost, time, effort, social opinion, comfort or convenience, immediacy and level of reward, and usefulness, can affect potential adopters’ perceptions of relative advantage. Several of these factors were the underlying reasons for many of the strawberry farmers’ negative perceptions about IBE tools and agricultural websites. They considered information on industry and government websites out of date, irrelevant or not satisfying their information requirements,
inconvenient, not useful, or financially unviable. Rogers (2003) states that the relative advantage of an innovation is positively related to its adoption rate. Consequently, throughout the interviews and through subsequent data analysis, the researcher interpreted strawberry farmers’ perceived views of the relative advantage of IBE tools as negatively contributing to the rate of adoption.

5.5.2 Compatibility

The compatibility of an innovation is determined by the potential adopter’s perceived level of consistency with their existing values and beliefs, past experiences and needs (Rogers 2003). The researcher explored the compatibility of IBE tools with strawberry farmers’ current systems and procedures and whether these were manual or technology based; if they were compatible with existing technological infrastructure including access in the field and in the office; and whether they were compatible with strawberry farmers’ current routines, activities, experiences and needs.

Initially, technological infrastructure was discussed to determine if the strawberry farmers had fast, reliable cost-effective Internet access. All of the strawberry farmers interviewed had access to the Internet, mainly with ADSL connections, although satellite and mobile were also used; none of the farmers had the NBN service. Access was slow, unreliable and costly for some of the strawberry farmers. This reduces compatibility as IBE tools are reliant on the Internet and the Internet service is not consistent with the farmers’ needs.

S5: We don’t even have ADSL out here. Everything is wireless.
S9: It sucks because it drops out a lot. So, then you’re in the middle of a paddock and the satellite’s not picking up, and you can’t work until it picks up again.
S11: We’ve got ADSL which is pretty slow and intermittent, so if it bombs out, I’ll hotspot it to my iPhone. That happens quite a lot and if it’s wet and raining, we have no internet. NBN? They did the estate across the road but not these three properties.
S11: So, the Internet is important, yes. And now the girls use a 4G dongle if it plays up. All of our data management is hosted remotely in the cloud because we’ve got four sites. That way, other sites can access the system – so our payroll system is hosted up there and so on.
S12: ADSL here, it’s generally good. NBN is across the road, but not to us.
S4: So it’s a lot of money. It’s not even decent service really ‘cause it’s so slow.
S5: But for the field stations, the service is more reliable, but we have to pay big money.

Despite some of the strawberry farmers experiencing compatibility issues with Internet access, a wide variety of online activities are undertaken. In addition to accessing weather information as previously discussed, some of the other online activities include email, news, online banking, bill paying, online shopping, accounting, and payroll. In general, these activities are compatible with farmers’ existing values, mindset, lifestyle and needs, hence there are no perceived compatibility issues.

S2: There’s the APVMA (Australian Pesticides and Veterinary Medicines Authority) website for all the chemical labels and permits. If I’m looking at new varieties, I’ll look up their patents from overseas.

S3: I use the Industrial Relations website all the time, a taxation website and banking website. Sites for second hand machinery, new packing belts or new green crates and pretty well everything we buy.

S3: Another one is for soil, like, the soil technology to make the soil aerate get all the good bacteria in.

S6: Mainly paying bills, finding out information.

S11: A software package called MTrack; tracks all the yields and wages. And then the girls put it through the payroll system to do all the transfers, super and payroll tax.

S12: Certain chemicals, I go to that company’s website and downloaded their MSDS sheets or searched for the permits.

S12: Google Earth and Google for searching. I quite like watching YouTubes; I did that to get information about organics. But there’s not as many about the strawberry growers of Queensland.

S12: Our farm would utilise Dropbox, TeamViewer, Facebook, and your basic Google to access relevant industry bodies.

S14: I do use YouTube sometimes with different things or techniques of laying plastic or whatever, pest management.

Similarly, several strawberry farmers utilise their smartphones to access a variety of generic agricultural apps. Access and functionality of these apps is compatible with strawberry farmers’ existing needs, hence, there are no perceived compatibility issues with these apps.
S7: There are heaps of different apps on fertilizers and chemical mixing that we use.
S12: There's the toolbox app has a flashlight as part of it, some levelling tools, some measuring tools.
S13: It's a mapping tool. It's got a laser measure and it'll incorporate that into a picture on my phone, so I can look at the map of the farm and see how it's situated.
S14: Heaps of different apps on fertilizers, chemical mixing and those sorts of things, weather.

Strawberry farmers use various other digital devices in their homes and offices/sheds including PCs, laptops, and tablets. It is common for laptops to be integrated with weigh stations outside in the field whereas some farmers consider it impractical to use iPads/tablets in the field. While Rogers (2003) suggests compatibility is affected by a potential adopter's mindset and lifestyle, the digital devices used by most of the strawberry farmers integrate effectively with their farming lifestyle, hence there are no perceived compatibility issues with the various devices.

S8: We have two laptops in the shed. So we check labelling and all kind of records get kept in there, all the packers and how many they get every day.
S13: So, in the field, we have a weigh station – it has electronic scales and a laptop. All our trays have bar codes and all our workers have a bar code. So when they bring their fruit in, their bar code is associated with the fruit they've picked.
S5: Three mobile workshop computers with mobile access plus these two PCs here, and we got a tablet and we got our smartphones.
S14: Yeah, smart phone. Main computer system is up in the house. We run three or four computers in the shed and another three or four up in the house.
S4: Your iPad, it's an expensive piece of equipment and then you're going to take it down there. Sometimes it's raining, you're on your motorbike and running here, there, and everywhere. So it's not all that easy to carry.

The researcher discussed strawberry farmers’ use of agricultural, industry based and government websites. Several websites might be considered relevant and a potential information source for strawberry farmers including Growcom, HIA, Infopest, Freshcare, DAF, and Business Queensland. Most of the strawberry farmers strongly suggested that
these types of websites were inconsistent with their needs. The following views support this perception indicating that these websites are not compatible with the farmers’ current farming practices and needs.

S6: DPI … It's easier to find information there because they've uploaded the information just under the DPI so that's what I use. I've got stuff off there quite easily. It's the first site that you've been able to select some legitimate information relevant to approximately what I want.

S12: We had a problem to fix but could anything on the DAF site tell us about that? No. We worked it out ourselves. There was nothing on the website; spent hours trying. It was really something simple – didn’t get cold enough and calcium.

S13: Horticultural websites really don’t have a lot to offer.

S14: Yeah, Growcom does a bit. We don’t really need to go on there.

Strawberries farmers do not use their peak industry body’s website: Strawberries Australia Inc. as this is perceived as having little or no information that addresses these farmers’ needs. Similarly, there were no responses about the Queensland Strawberry Growers’ Association (QSGA) website. This is a relatively new site and is still under construction with new features and functionality being developed and released progressively. This website, however, is currently targeted at consumers rather than growers.

While strawberry farmers are not averse to using the Internet and integrating technology, there are some aspects of their farming operations that they prefer to undertake using traditional methods rather than adopting technological solutions. For example, some strawberry farmers expressed a preference for speaking directly to industry experts and other farmers, reading hardcopy magazines and horticulture books, and to walk the farm with an agronomist. The mindset and lifestyle of these strawberry growers affect their perceptions of some technological methods in terms of their experience and traditional approach. Thus, for some strawberry farmers, there are inconsistencies that negatively impact the compatibility of IBE tools for certain aspects of their farming methods.

Some farmers prefer to acquire information by speaking directly with another farmer or industry expert.

S4: Word of mouth, what different growers are doing, a lot of us talk to each other, a lot of us don’t.
S5: We haven’t been farming strawberries for 30 years so we need to find out stuff all the time. It’s easier to talk to someone that knows.
S12: It's actually just easier to call them.

Some farmers believe in seeking advice from an agronomist on a regular basis.
S11: Because he’s physically walking. And it’s not just looking for hotspots for mites but we’re also looking at grubs, nutrition. So, we’re doing several activities at once, weekly across all the plants. And my farm managers walk with the agronomist and point out things.
S13: So weekly, I get a bloke on the strawberries looking at flowers, bud levels, mite levels, crop levels; then he gives us any recommendations by email. You can’t have too many people walking the farms.
S14: We get an agronomist out every week. He’s here every week just to keep an eye on things; just to make sure we don’t have any big dramas over the pests.

The following farmers prefer to read hardcopy books or magazines at times rather than using technology.
S1: Technology doesn’t interest me one little bit. If I wanna know something information-wise, I’ll find it in a book.
S6: Well, I’ve got a pocket guide and we’ve got references; don’t need to look it up on the web.
S12: QSGA will continue to do the hard copy (newsletter) because like I have found with Growcom, I’m more likely to have a bit of time to sit down and read that magazine than I am to sit in front of the computer and read the same magazine.

Some strawberry farmers have had so much experience they successfully run their farms based on their knowledge and traditional methods. They perceive there is no requirement for IBE tools thus they are inconsistent with the farmers’ beliefs and values.
S1: Just because it is available, doesn’t mean we should do it.
S9: I think lots of farmers are old-school so they know how to work it out themselves without a computer.
S14: I know growers that have got it automated and they have more trouble than it’s worth, so just go the old way. I mean it works.
Overall, strawberry farmers’ responses were mixed with some aspects of IBE tools being consistent with their experience and needs and other aspects being inconsistent. Certainly, strawberry farmers are not averse to using technology for many operational aspects of their farming. A wide variety of online activities are undertaken and they use the functionality of their smartphones effectively, taking photos out in the field and using mobile apps quite readily. However, limiting the analysis to strawberry farmers’ use of IBE tools and agricultural websites reflects the researcher’s observation that these tools are not entirely consistent with farmers’ past experiences, their needs and their mindset. Rogers (2003) claims that the compatibility attribute is determined through the potential adopter’s evaluation of the innovation in comparison to their current practice. Thus, the researcher considers that IBE tools and agricultural websites are not compatible with strawberry farmers’ current practices and this negatively impacts on the adoption rate.

5.5.3 Complexity

Strawberries farmers do not use their peak industry body’s website: Strawberries Australia Inc. as this is perceived as having little or no information that addresses these farmers’ needs. Furthermore, there are twenty links on this site that are supposed to navigate to other berry industry sites but eight of these links fail to open the target site. Strawberry farmers do not have IBE tools specifically designed for their Queensland industry group and the QSGA website is a relatively new site. It is still under construction and is currently targeted at consumers rather than growers. However, the strawberry farmers access a variety of other webpages. Therefore, the researcher analysed and evaluated the complexity attribute in relation to agricultural websites such as DAF, the AgBiz farm tools, Growcom, HIA, Infopest, and Freshcare.

The complexity attribute is affected by the level of difficulty (Rogers 2003), whereby the rate of adoption will be lower if the innovation is perceived as complicated to use; thus, complexity may be a barrier to adoption. If a strawberry farmer perceives the technology to be complicated, difficult to use or understand, or if it is not user-friendly, these perceptions may create a barrier to adoption.

Navigation of websites may be perceived as difficult if there are numerous links to follow, if it is not intuitive or if a webpage is cluttered. Webpages with these shortcomings are not perceived by strawberry farmers as user-friendly.
S1: Their websites (DAF) are just very hard to manoeuvre. If you’re just trying to find a certain little snippet of information, it’s just – you end up going through ten different pages to try and find.

S3: Trying to find something sometimes, it’s just very, very frustrating and you just don’t do it. You just don’t go there.

S8: I find it easier to go to somebody who has the answer instead of trying to scroll through website after website, blog after blog.

S9: You want to make it easy for people and quick because you don’t wanna just go over all the stuff you really aren’t interested in. Trying to find the one thing that you’re looking for is hard.

S12: There’s a fundamental problem with website design, accessing information, and the uploading and swapping of information. It’s not stupid-proof enough or formatted enough.

S13: Infopest, I find it complicated. It has to be made more streamlined. I can navigate partially but you get sick of clicking and clicking and it goes on forever.

Likewise, strawberry farmers expressed negative views on accessing resources on the main DAF website. Despite various links to resources such as an eResearch Archive, crop management, pests and diseases, harvesting and more, the information is perceived to be out of date and the farmers don’t believe it will improve their farming methods and outcomes. DAF’s Strawberries webpage was last updated in April 2014 which supports the farmers’ views. Similarly, if a farmer links to the eResearch Archive page, several of the articles are only accessible to members of the International Society for Horticultural Science. Furthermore, some of the articles are scientific research and quite likely would not be read by strawberry farmers as they want practical knowledge that they can apply to their farming methods. For example, the first article the researcher was able to open was titled ‘Genera of phytopathogenic fungi’, was 118 pages long and had twenty-nine authors (Marin-Felix et al. 2016). Similarly, navigating the links to ‘Pests and diseases of strawberries’ opens a page that was last updated in February 2011 and a further link to ‘Aphids in field crops’ was last updated in June 2010 (DAF 2011b). These elements of unnecessary complexity diminish the user-friendliness of the DAF website and hinder the adoption of such a website. The responses below further emphasise the perceived poor user-friendliness of the DAF website.
Farmers may become quite frustrated if they search for information and discover that it is not current or it is not relevant to their needs.

\[S1\]: If I could improve my growing abilities and learn more on the plants I would probably sit down in front of the screen to read it but then it's more on the scientific side, not actually growing it; that's not what I want.

\[S4\]: When I'm looking for information about like diseases, plants' pests, weed identification, and charts, I find the New South Wales Department of Primary Industries has a lot more information than DAF.

\[S5\]: Look at the picture; the pixels have all gone 'cause it was probably taken in 1980 something or 1990s. That's what you get from DAF so we go to DPI

\[S13\]: But even then, that information that we got was three years out of date; and it wasn’t what I was looking for.

Some farmers’ perceptions about the complexity of websites is based on their self-efficacy; they don’t believe they have the ability or the necessary computer literacy skills to use the technology effectively. According to Rogers (2003) Diffusion of Innovations Theory, the perceived difficulty experienced by these farmers contributes to the complexity of the innovation and this lowers the adoption rate. The following responses demonstrate more of their difficulties.

\[S3\]: My husband can build anything but he couldn’t find his way around the computer. He would not even know how to open my payroll system, or mail, or anything like that.

\[S4\]: It’s not that we’re scared of technology. We use it, but we could do better if we knew how.

\[S5\]: There’s no training aids at all available industry wide.

\[S9\]: We’re still a bit computer illiterate.

\[S6\]: Basically that's the one thing that stops me because I haven't got anyone to actually help set it up and get it started.

Some seemingly simple elements of a website such as the requirement for a username and password or the type of language displayed on a webpage, are perceived as unnecessarily complex by some strawberry farmers. These types of elements contribute to the farmers' perceptions that some webpages lack user-friendliness and are difficult to use effectively as the following responses demonstrate.
S9: And remember that most of us are just people who didn’t go to school. So we like things to be kept simple; words need to be simple for me. Otherwise I get to the website and I don’t know what they’re saying.

S13: It becomes very time-consuming because in a lot of places, you can’t actually go do anything unless you’ve got a username and a login and a password. Oh my god! That takes you another 45 minutes. So it annoys me.

The negative perceptions expressed by strawberry farmers highlight elements such as out of date websites, excessive navigation processes, irrelevant information, and other unnecessary complex elements. Furthermore, some strawberry farmers have difficulty using computers and effectively searching agricultural websites. These elements diminish the user-friendliness of a website and contribute to the perception of a website that is difficult to use or understand. In effect, these difficulties increase the complexity of the technology. On this basis, the researcher believes that the complexity of these technologies perceived by strawberry farmers is a barrier to adoption and negatively relates to the rate of adoption.

5.5.4 Trialability

Rogers (2003) trialability attribute relates to how easy it is for the potential adopter to trial or experiment with the product or innovation and is positively related to the rate of adoption. Strawberry farmers do not have IBE tools designed specifically for their industry group. Similarly, there is no potential for strawberry farmers to trial IBE tools via the DAF website as there are none available. Furthermore, the QSGA website is a relatively new site with new features and functionality targeted at consumers rather than growers. The strawberry farmers could trial the Agbiz farm tools offered by Business Queensland but this is virtually impossible given that none of the farmers are aware of their existence. Hence there is limited potential for trialability of IBE tools and agricultural sites specific to strawberry growers.

Nonetheless, some generic tools and general horticulture websites are accessible by strawberry farmers. Similarly, strawberry farmers may trial IBE tools from a vast range of commercially available digital apps. For example, AgDNA, FTrack, ConnectedFarm, Farm Records and Farm at Hand are mobile apps offering complete farm management.
Some features of these apps generally include the ability to sync data across devices, record full planting and harvesting history, sharing data, and linking photos to data and field maps. The cost of some of these apps may be prohibitive to some farmers but some apps are free. Those apps that charge upfront costs or subscriptions usually offer a free trial period between fourteen days and three months. Therefore, it seems quite viable for strawberry farmers to trial a range of total farm management apps.

There is also a range of specific purpose apps that could be trialled by strawberry farmers. APVMA in particular is an app released by the Australian Pesticides and Veterinary Medicines Authority (APMVA) to help provide safe and effective chemical use on Australian farms. WeedSmart and BackPaddock are examples of other specific purpose apps that could easily be trialled by strawberry farmers.

The researcher asked the strawberry farmers if they would expect to trial an app before committing to it. The responses indicated that they were interested in using apps but they would definitely want a trial period.

S4: Yes.
S12: Yes, definitely.
S8: Yes, for sure. When we got our packer program, that’s what he did, he gave us the free trial here so that was good.

While IBE tools have limited availability through DAF, QSGA and other agricultural websites, strawberry farmers are prepared to trial mobile apps if there is a free trial period available. Rogers (2003, p. 258) defines trialability as ‘the degree to which an innovation may be experimented with’ and generalises that trialability is positively related to the rate of adoption. Given the limited availability of IBE tools through DAF, QSGA and other agricultural websites, the researcher believes that strawberry farmers’ ability to trial or experiment with IBE tools is a barrier to adoption and is therefore negatively related to the rate of adoption.

5.5.5 Observability

Rogers (2003) observability attribute encompasses the visibility of an innovation and any favourable communication or enthusiasm used to describe the innovation. He also states that observability is positively related to the rate of adoption of an innovation. While the software component of a technological innovation is inherently less observable than
other innovations (Rogers 2003), it is impossible to observe IBE tools if they don’t exist or if the farmers are not aware of their existence.

For this reason, it is impossible for the strawberry farmers to observe IBE tools that might be available through DAF, Business Queensland, QSGA or other agricultural websites. The strawberry farmers have no knowledge of their limited existence. While some strawberry farmers share knowledge about various aspects of their farming at their meetings, if they don’t know about IBE tools they cannot be discussed. Consequently, there is no communication or enthusiasm about IBE tools between farmers because they are not visible or observable; the farmers simply don’t know about them. To explore their knowledge and the opportunity to observe IBE tools, the researcher asked farmers about tools such as the Beatsheet blog or and the Agbiz farm tools. It became clear that they had no knowledge whatsoever of these IBE tools.

S6: Yeah, if I knew it was existing.
S8: I didn’t even know that.
S9: AgBiz? No.
S9: BeatSheet blog? No.

IBE tools that enable direct links to strawberry specific news and updates, best management practice video clips and techniques, and a strawberry growers’ discussion forum are limited and therefore not easily observed. Given that IBE tools designed specifically for strawberry farmers do not exist, these farmers are unable to readily embrace this technology. Similarly, while there is a vast range of general farming apps commercially available, the strawberry farmers are unlikely to be made aware of them and that suggests that, essentially they are not observable. Consequently, the researcher believes there is limited potential for strawberry farmers to observe IBE tools. According to Rogers (2003), this low level of observability may be a barrier to adoption.

5.6 Summary
The data analysis presented in this chapter was based on investigating the five key attributes from Rogers’ Diffusion of Innovations Theory (Rogers 2003) perceived to affect the rate of adoption of an innovation. Within each of the four case studies, the dimensions of the data were explored and analysed using these five key attributes including relative advantage, compatibility, complexity, trialability and observability.
While these key attributes were used as the focus for the data analysis, the overarching goal was to analyse, interpret and extract the relevant data for each of the industry groups that would ultimately contribute to answering the research questions. These research questions form the foundations for conducting the research study and building the knowledge to determine the factors affecting Queensland horticultural farmers’ effective use of IBE tools. Thus, throughout the iterative data analysis and interpretation process, the researcher looked for emergent themes that related to the research questions. This enabled a rich and thick understanding of the data and the development of links and explanations that addressed the first three research questions in particular.

For example, at this stage of the data analysis and interpretation process, it was evident that most of the farmers in each of the four industry groups generally have a poor regard for IBE tools and because of this, the adoption of these tools is low. It was also apparent that these farmers do not perceive that their information requirements are satisfied through the use of IBE tools and they prefer their traditional methods of acquiring information.

The case studies are based on four industry groups within the Queensland horticulture industry including the avocado, macadamia, pineapple and strawberry industry groups. A summary of the findings for each of these industry groups is presented below:

- **Avocado industry**

Avocado farmers perceived the information on industry and government websites to be out of date, not satisfying their information requirements and not giving them anything new. These farmers believed that acquiring information by speaking directly to other farmers, industry advisors or their local agronomist was more beneficial than using IBE tools. The avocado farmers’ perceptions of the relative advantage of IBE tools is therefore a barrier to adoption.

Avocado farmers generally perceived IBE tools as not consistent with their experience, needs and values because they do not provide more than their existing methods in their day-to-day farming operations. Also, the credibility of IBE tools such as blogs is mistrusted because farmers are unsure about the source and quality of the information. Avocado farmers’ perceived views of the compatibility of IBE tools negatively contributes to adoption rates.
The perceived irregularities and instability of IBE tools lowers avocado farmers’ confidence in them as dependable information sources. This causes avocado farmers to perceive IBE tools as lacking in user-friendliness and difficult to use effectively. This results in unnecessary complexity and establishes an underlying barrier to the adoption of IBE tools.

The opportunity for avocado farmers to trial or experiment with IBE tools is limited because the farmers are generally unaware of the existence of IBE tools or where to access them. Avocado farmers’ inability to trial or experiment with IBE tools is a barrier to adoption.

Avocado farmers have limited knowledge of IBE tools primarily because these tools are not discussed or promoted. This results in an absence of awareness and visibility of IBE tools and therefore, observability is considered to be a barrier to adoption.

**Macadamia industry**

Macadamia farmers generally believe that industry and government websites do not contribute greatly to their farming practices, with little or no value returned for their investment of time and effort. While video clips are useful, macadamia farmers believe that IBE tools are not as good as their current methods. These perceived views of the relative advantage of IBE tools are a barrier to their adoption.

Macadamia farmers do not believe that IBE tools are as reliable and trustworthy as reading hardcopy reference books and newsletters, talking to other farmers, or consulting their agronomist or entomologist. Their perceptions of IBE tools are not consistent with their experience, needs and values. Therefore, macadamia farmers’ perceived views of the compatibility of IBE tools negatively contributes to adoption rates.

IBE tools are perceived by macadamia farmers as simple to learn and operate but frustratingly difficult to use effectively. Usernames and passwords, excessive navigational links and out of date information contribute to a lack of user-friendliness and is perceived by macadamia farmers as unnecessary complexity. The complexity of IBE tools is a barrier to their adoption.
Macadamia farmers are not averse to trialling IBE tools but they have limited opportunity to trial or experiment with these tools because they have little knowledge of their existence or whereabouts. Macadamia farmers’ inability to trial or experiment with IBE tools is a barrier to their adoption.

Given that macadamia farmers have limited knowledge and awareness of IBE tools, observation of other macadamia farmers using these tools is limited. This absence of awareness and visibility of IBE tools or observability, is a barrier to the adoption of IBE tools.

• **Pineapple industry**

Pineapple farmers do not believe that the potential advantages of using IBE tools sufficiently outweigh their financial cost, time, effort and discomfort. Perceptions about the lack of advantages of IBE tools directly contributes to the low rate of adoption of these tools by pineapple farmers.

Accessing information through websites and IBE tools is not consistent with pineapple farmers’ experiences and needs. Pineapple farmers believe that information is best acquired through reading hardcopy reference books and newsletters, talking to other farmers and attending study group meetings where the information is specific to their industry. IBE tools are not compatible with pineapple farmers’ existing practices which are based on their values and long established approach to farming. Therefore, pineapple farmers’ perceived views of the compatibility of IBE tools negatively contributes to adoption rates.

Several pineapple farmers perceive difficulties in using computers and effectively search agricultural websites; this is exacerbated by a perceived lack of user-friendliness on agricultural websites. This complexity perceived by pineapple farmers is a barrier to the adoption of IBE tools.

While pineapple farmers are prepared to trial mobile apps if there is a free trial period available, they are unaware of IBE tools designed specifically for the pineapple industry, that they can trial or observe. This is largely due to pineapple farmers not having an industry specific representative body or website, nor IBE tools designed specifically for
their industry group such as video clips. Pineapple farmers’ inability to trial or experiment with industry specific IBE tools is a barrier to their adoption.

Similarly, there is no potential for observability of IBE tools designed specifically for pineapple growers because these IBE tools do not exist. This absence of visibility of IBE tools or observability, is a barrier to the adoption of IBE tools.

• **Strawberry industry**

Strawberry farmers perceived the information on industry and government websites to be out of date, inconvenient, irrelevant, not satisfying their information requirements, or not useful. Their perceived views of the relative advantage of IBE tools is a barrier to adoption.

A wide variety of online activities are undertaken by strawberry farmers and they use the functionality of their smartphones effectively, taking photos out in the field and using mobile apps quite readily. Strawberry farmers, however, believe that IBE tools are not entirely consistent with their past experiences, needs and mindset and they are not compatible with their current practices. Therefore, strawberry farmers’ perceived views of the compatibility of IBE tools negatively contributes to adoption rates.

Strawberry farmers suggest that the user-friendliness of websites is compromised with out of date and irrelevant information and by excessive navigational links. This is perceived by strawberry farmers as unnecessary complexity. Some strawberry farmers also have difficulty using computers and effectively searching agricultural websites; these difficulties increase the complexity of the technology. The complexity of IBE tools perceived by strawberry farmers is a barrier to adoption.

Queensland strawberry farmers do not have an industry specific website that delivers IBE tools as it is targeted towards consumers. This reduces the opportunity for strawberry farmers to trial or experiment with IBE tools. Strawberry farmers are prepared to trial mobile apps if there is a free trial period available but the cost factor limits this option. Therefore, the inability to trial or experiment with IBE tools is a barrier to adoption for strawberry farmers.
Furthermore, there is no potential for observing IBE tools designed specifically for strawberry growers because these IBE tools do not currently exist. This absence of visibility of IBE tools or observability, is a barrier to the adoption of IBE tools.
6.1 Introduction

This research study is based on a collective or multiple case study where the dimensions of the data were explored and analysed using five key attributes from Rogers' Diffusion of Innovations Theory. The data analysis presented in the previous chapter was based on investigating these five key attributes within each of the four individual cases or industry groups. The outcome of the case analysis approach was a synthesis of findings and knowledge building for each individual case.

The data analysis presented in this chapter is based on a cross-case analysis which extends the knowledge building beyond the individual cases. To achieve this, the researcher conducted systematic and rigorous analysis, comparing and evaluating the four industry groups within each of the five key attributes. This approach leads to a comparison of similarities and differences across the four industry groups thereby increasing the depth of understanding of the factors that affect farmers' use of IBE tools.

The following sections present the cross-case analysis based on Rogers (2003) five key attributes: relative advantage, compatibility, complexity, trialability and observability. The researcher compares and contrasts the perceptions of farmers from the avocado, macadamia, pineapple and strawberry industry groups within each of these five attributes.

6.2 Relative advantage

As stated in Chapter 4, Rogers (2003) explains that relative advantage is established by the degree to which an innovation improves an existing practice. Relative advantage may be viewed as the ratio between the expected benefits of an innovation compared to the cost of adopting the innovation including financial cost, time, effort and discomfort (Rogers 2003). Most of the farmers from each of the four industry groups are not averse to using the Internet and technology, and routinely access the Internet for a variety of activities. Some of these online activities include news, email, banking, shopping and social networking. The majority of farmers in each of the four industry groups perceive a
clear advantage to using these online activities in contrast with more traditional approaches.

Weather sites are particularly important to all farmers interviewed from each of the four industry groups. Accessing the weather online provides data that is centrally located, useful, convenient, comprehensive and real-time or near real-time. It enables farmers to review current weather conditions and also access data that is crucial to their short term and long term planning. All of these benefits outweigh any associated costs of time, effort, discomfort and convenience and all of the farmers perceive a clear advantage to using the functionality of weather websites rather than maintaining manual records. Therefore, all four of the industry groups perceive a relative advantage to using IBE tools in the form of online weather data.

The researcher also explored farmers’ perceptions of using blogs or discussion forums but most of the farmers were unfamiliar with these types of IBE tools. The researcher explained how these tools might assist farmers to resolve issues and queries. While most of the farmers showed virtually no interest in these types of IBE tools, some avocado farmers recognised the potential benefits of using a blog or discussion forum in a similar way to their use of smartphones to upload photographs to their local agronomist. These farmers are not aware of a blog or discussion forum that provides this service; therefore, they are unable to take advantage of the potential benefits. In contrast, some strawberry farmers who perceive a clear advantage in terms of convenience, immediacy and usefulness, use their smartphones to take photos of irregularities on plants and record the location of chemical applications. These strawberry farmers, however, are also unaware of a blog or discussion forum where they can upload their photos and seek advice. Instead, the strawberry farmers are able to use their photos at a later time comparing their photos to hardcopy reference books or online images. Using their smartphones to record the location of chemical applications enables the strawberry farmers to manually transfer the details to their hardcopy spray diaries.

Despite recognising the potential benefits of using these IBE tools, the avocado and strawberry farmers are not aware of a blog or discussion forum they could actively utilise. Consequently, they send or show their photos to their agronomist or store them on their computer for their own analysis. Macadamia farmers no longer have access to a discussion forum and email discussion group previously offered through the macSmart
website as these services were not being utilised and were subsequently removed. The pineapple farmers interviewed had no knowledge about blogs or their potential functionality. Hence, farmers from across all four industry groups are not utilising blogs or discussion forums and most of them do not have direct experience with these IBE tools.

Furthermore, strawberry farmers were sceptical of the advice that may be given through these forums. Some avocado farmers were also concerned about the control of advice being posted with no guarantee that the source of advice was necessarily from an expert. Similarly, pineapple farmers were apprehensive about the potential benefits of these IBE tools because they consider their crop to be unique and expert advice would not be available from a blog or discussion forum.

Consequently, most of the farmers from each of the four industry groups prefer to look at their hardcopy reference books, consult with industry experts or speak directly to other growers. These current methods are perceived by the farmers from each of the four industry groups to be easier, more convenient and more reliable. With the exception of specific information provided by a reputable source such as the Bureau of Meteorology, farmers’ responses from each of the four industry groups suggest that IBE tools are not useful, nor are they any better than their current methods. Therefore, the researcher believes there is currently no perceived relative advantage for any of the industry groups in using blogs or discussion forums over their existing methods of acquiring information and resolving issues.

Nonetheless, there are certainly potential advantages for farmers to use blogs and discussion forums. Currently, the main reasons for farmers using their existing methods of acquiring information and resolving issues are that these methods work and there is not an obvious alternative. Farmers are not aware of viable technological alternatives because blogs and discussion forums designed specifically for the individual industry groups do not exist. Yet these IBE tools have the potential to achieve the same results as farmers’ current methods but with additional advantages of faster advice and widespread sharing of information. To generate a relative advantage over existing methods, these IBE tools firstly would need to be marketed to the farmers so they were aware of them. Secondly, the farmers would need to know how to use these tools and understand the potential benefits over their current methods. Lastly, these IBE tools
would have to be monitored and controlled by industry experts in order to satisfy farmers’ confidence in the information and advice being delivered from these tools.

Similar views on blogs and discussion forums were expressed by farmers in response to using a set of IBE tools developed by DAF - Agbiz farm budgeting tools (Business Queensland 2016a). None of the farmers in any of the four industry groups had even heard of this toolkit. The researcher showed farmers where the toolkit is located and opened a selection of the 250 tools available including a gross margin calculator, farm budget and cash flow calculator, fence calculator and carbon emissions calculator. These tools confounded farmers who questioned the time and effort required to go online, navigate through various links and download a spreadsheet when they have much easier access to a calculator and their accounting software; they already know how to do the various calculations and they also know from years of experience the quantity of fencing materials required. Furthermore, carbon emissions are not a priority for several farmers interviewed who are more focussed on the challenging economic environment. The farmers’ disparaging responses show general contempt for these IBE tools suggesting that they are not relevant or useful and therefore not worth the investment of their time or effort. Thus, none of the industry groups perceive any relative advantage in using these IBE tools compared with their existing practices.

In response to the perceived advantages and disadvantages of the DAF website, farmers from each of the industry groups criticised the currency of information and the usefulness of the information available on these sites. Rogers (2003) states that factors such as time, effort, immediacy and level of reward, and usefulness, can affect potential adopters’ perceptions of relative advantage. Several of these factors were the underlying reasons for farmers’ negative perceptions specifically about the DAF website. Information on this website was criticised by farmers from across the four industry groups, for being out of date, irrelevant, not useful or not satisfying their information requirements. They believed that speaking to other farmers or industry advisors directly was more beneficial and more convenient than accessing information on the DAF website. These issues contributed to the perception across each of the industry groups, that the DAF website offers no benefits relative to their current methods of acquiring information. Rogers (2003) also states that relative advantage is established by the degree to which an innovation improves the existing practice. To improve farmers’ existing methods and provide some
level of relative advantage, the DAF website should at least have easily accessible links to current, relevant and useful sources of information.

The researcher also explored farmers’ perceptions of industry specific websites. Avocado farmers revealed little interest and no compelling need to access their industry website ‘Avocados Australia’. It was not needed for assistance with operational activities on the farm and several avocado farmers prefer to acquire information from the hardcopy of the Avocados Pocket Guide, by word of mouth with their local agronomist, other growers and industry advisors. Using the Avocados Australia website, therefore, afforded no relative advantage over their existing methods of acquiring information.

Conversely, there are some positive views from macadamia farmers regarding information available from the Australian Macadamia Society (AMS) industry website. Some macadamia farmers consider information such as video clips and some fact sheets, to be useful and therefore perceive a relative advantage. Several macadamia farmers including some extremely successful farmers, however, do not derive any benefit from the AMS website. These farmers believe that the AMS website is not useful for resolving farming issues and does not contribute anything new to their farming practices. Similar to the avocado farmers, the general perception from macadamia farmers was that there were few benefits gained from the AMS website and they preferred looking at books or speaking directly to other farmers and industry advisors.

Strawberry farmers were unable to comment specifically about the Queensland Strawberry Growers’ Association (QSGA) website as this is a relatively new site. Similarly, pineapple farmers were unable to comment about an industry specific website as a pineapple website dedicated to pineapple growers is not available. This situation is unlikely to change given that the pineapple industry does not have a representative body dedicated solely to pineapple growers.

Nonetheless, both the strawberry farmers and pineapple farmers have strong views about other agricultural websites such as Growcom, Horticulture Innovation Australia, Infopest, and Freshcare. Potentially, these websites should be valuable information sources as they aim to provide relevant, up-to-date, and practical information and services for horticultural farmers. Growcom, for example, claims to be the ‘voice of Queensland horticulture’ and ‘embraces and promotes innovative, responsible farming
and business practices’ (Growcom 2016c). But the strawberry farmers considered information on these websites to be irrelevant, not useful, or not current. Likewise, many of the pineapple farmers expressed negative views on accessing resources on these websites claiming that the information is not relevant, it is not specific to pineapple growers and expected information such as trial work results is not published.

Similar to the avocado and macadamia farmers, most of the strawberry and pineapple farmers prefer speaking directly to other farmers, consulting local agronomists and reading magazines and books to acquire information and resolve farming issues. According to Rogers (2003, p. 229) relative advantage is ‘the degree to which an innovation is perceived as being better than the idea it supersedes’. Thus, industry websites are perceived by most farmers across each of the four industry groups as having little relative advantage over their existing methods.

### 6.3 Compatibility

As stated in Chapter 4, Rogers (2003, p. 240) suggests the compatibility attribute 'is the degree to which an innovation is perceived as consistent with the existing values, past experiences and needs of potential adopters'. To ascertain the compatibility of IBE tools, the researcher explored farmers’ existing technological infrastructure; devices they use, their current routines, systems, activities, past experiences and needs. These factors were evaluated against their consistency with the potential use of IBE tools.

The effective use of IBE tools is contingent on farmers having fast, reliable and affordable access to the Internet. Within this context, technological infrastructure was investigated with a particular focus on farmers’ access to the Internet from their home, office, and in the field, and whether their access was fast, reliable and affordable. ADSL is the most common Internet connection across the four industry groups but some farmers do not have this option and are limited to Mobile or Satellite access. None of the farmers from any of the industry groups had an NBN connection; for the very few that were in an area where the NBN had been rolled out, the cost was prohibitive. While all farmers had some form of satisfactory Internet access, some constantly experienced problematic issues. Unreliable access to the Internet was commonly experienced by some of the macadamia, pineapple and strawberry farmers. Another issue for some of the pineapple and strawberry farmers was the cost and some strawberry farmers also complained about the slow speed.
It is vital that farmers have fast, reliable and affordable access to the Internet in order to use IBE tools effectively but many farmers in this research study do not have access to this fundamental service. Therefore, these farmers are unable to effectively take advantage of the potential benefits of IBE tools. If the needs of potential adopters are not perceived to be consistent with an innovation, Rogers (2003) states that the degree of compatibility will be negatively affected. Hence, the compatibility of telecommunications infrastructure is consistent with the needs of avocado farmers but not for the needs of macadamia, pineapple and strawberry farmers.

In addition to the infrastructure requirements, farmers also need compatible devices and the ability to use these devices in order to effectively use IBE tools. Farmers from each of the four industry groups commonly use desktop computers, laptops or tablets to effectively access the Internet from their home, office or sheds. However, using devices to access IBE tools outside of these locations raises compatibility issues for most farmers in the four industry groups. In particular, tablets are perceived as impractical for most farmers’ rugged outdoor activities; they are inconvenient, a discomfort and a risk. Rogers (2003) suggests that compatibility is affected by the perceived consistency between an innovation and the existing values and needs of potential adopters. Therefore, the compatibility of some digital devices is perceived by most farmers across the four industry groups as inconsistent with the use of IBE tools because they do not integrate effectively with most farmers’ lifestyles.

Online activities perceived to integrate effectively with the mindset and lifestyle of most farmers include weather, news, email, banking, shopping and social networking. Several other operational tasks are undertaken online such as financial budgeting and accounting; superannuation and payroll; acquiring industrial relations, taxation and workplace safety information; and acquiring information on fertilisers, chemicals and soil management. These general farming activities and information requirements, however, do not specifically require dedicated agricultural IBE tools. The majority of farmers in each of the four industry groups use general websites such as Google, YouTube, Google Earth, Skype, GraysOnline, Gumtree, Dropbox, TeamViewer, and APVMA. Subject to Internet access, these online activities satisfy most farmers’ needs and are compatible with their past experiences, mindset, and lifestyle. Rogers (2003) compatibility attribute is determined by the extent to which ‘an innovation is perceived as consistent with the existing values, past experiences and needs of potential adopters’. Based on farmers’
perceptions, therefore, the researcher believes that the online activities undertaken by most farmers across the four industry groups for general operational tasks are compatible with the existing values, past experiences and needs.

Nonetheless, while most of the farmers across the four industry groups are not averse to using the Internet and technology, several expressed a preference for seeking industry specific information from hardcopy reference books, consulting with industry experts or speaking directly to other growers. Most of the farmers across each of the four industry groups prefer to read about industry updates, current trends and industry specific pursuits in a published hardcopy industry magazine. Similarly, IBE tools and the Internet are not the preferred source of advice when resolving problems and do not contribute greatly to farming practices. The researcher believes that this is in part due to the issues of relevancy, currency and availability of digital information as highlighted in the previous section on relative advantage. Furthermore, many of these farmers already have a vast knowledge of their industry and the current approach and methods adopted by farmers from across the four industry groups have enabled many of them to successfully operate their farms. Thus, IBE tools are not consistent with farmers’ past experiences and therefore not compatible with their current methods.

6.4 Complexity

As stated in Chapter 4, Rogers (2003) defines the complexity of an innovation as the perceived level of difficulty experienced in the use and understanding of that innovation and advocates that for some innovations, complexity may be a significant barrier to adoption. Thus if farmers perceive IBE tools as complicated, difficult or tedious to use or navigate, difficult to understand, or if it is not user-friendly, the rate of adoption will be negatively impacted.

Farmers from across each of the four industry groups demonstrated a lack of knowledge and awareness of IBE tools designed for their specific industry. For example, there are no links to IBE tools, video clips, discussion forums or mobile apps on DAF’s Avocados, Macadamias, Pineapples or Strawberries webpages. Similarly, not one farmer from any of the four industry groups had even heard of the ‘Agbiz farm budgeting tools’. This is a webpage with links to a set of IBE tools developed by DAF but there are no links to this webpage from the DAF website. Instead of being able to access these IBE tools directly from the DAF website, a farmer needs to know that they reside within the Business
Queensland website. From this website, the farmer can link to the Farms, fishing and forestry webpage, and then link to the Agribusiness laws, tools and support webpage (Business Queensland 2016a). Even if farmers were aware of the existence and location of these tools, the tedious nature of accessing them makes them difficult to use and this increases the complexity level. According to Rogers (2003) this is likely to be a barrier to adoption of these IBE tools.

Furthermore, resources on the industry webpages from the main DAF website is perceived by farmers from across all four industry groups as lacking in user-friendliness despite this website having various links to potentially useful information resources such as research and development, crop management, pests and diseases, harvesting and more. Farmers from across each of the four industry groups suggest that the information is out of date and they don’t believe it will improve their farming methods and outcomes. For example, DAF’s Pineapples webpage was last updated in February 2014 and the pests and diseases page was last updated in September 2012. DAF’s Avocados, Macadamias and Strawberries webpages were last updated in April 2014. When farmers are unable to access up to date information after searching agricultural websites they become frustrated and perceive these websites to be lacking in user-friendliness, thus increasing the complexity of use.

Likewise, if a pineapple farmer follows three links from DAF’s Pineapples webpage searching for the Residue Disease page, not only is the “page not found”, but this webpage was last updated in July 2003. Similarly, strawberry farmers can follow a potentially valuable link on the DAF website under the heading ‘Incorporating best practice into your business’. The destination page offers a ‘Strawberry Information Kit … a growing guide to better farming’ but it was published in1997. DAF (1997) acknowledges the age of the publication by displaying the following message: ‘This publication was last revised in 1997. The information is not current and the accuracy of the information cannot be guaranteed by the State of Queensland’. After navigating through several links and then finding the destination page is not current or does not even exist is a frustrating outcome to say the least. Again, farmers from across all four industry groups are frustrated by the unproductive use of their time and perceive these websites to be difficult to use through the lack of user-friendliness.
Similarly, several of the articles on DAF’s eResearch Archive page are only accessible to members of the International Society for Horticultural Science thereby excluding many of the farmers. Strawberry farmers in particular, were frustrated by the scientific nature of the articles and were reluctant to consider this a useful resource. Farmers from across each of the four industry groups require practical knowledge that they can apply to their farming methods and extracting practical knowledge from these scientific research articles is difficult. In this context, the eResearch Archive page is perceived as difficult to use and understand, thus increasing the complexity.

In addition to the complex nature of navigating and accessing agricultural websites and IBE tools and the user-friendliness issues, some of farmers find the technology difficult to use. According to the Diffusion of Innovations Theory (Rogers 2003), the perceived difficulty experienced by these farmers contributes to the complexity of the innovation and lowers the adoption rate. Pineapple farmers in particular, expressed difficulty using computers and effectively searching agricultural websites. Many of these farmers suggested their computer literacy skills were equivalent to those of a dinosaur although some expressed a little more confidence but still only rated their skills as satisfactory.

While many macadamia farmers suggest that IBE tools, the Internet and software programs are not that difficult or complex to use, some lack skills in proficient searching techniques and considered the vast number of links on agricultural websites to be daunting. Usernames and passwords also appear to be an issue for some of macadamia farmers and this contributes to complexity. Furthermore, confidence levels of some of the macadamia farmers were low and some believed their mindset impacted on their ability to use the technology efficiently and effectively.

Similarly, some strawberry farmers do not believe they have the ability or the necessary computer literacy skills to use the technology effectively. With this mindset, many strawberry farmers view some elements of technology use as unnecessarily complex and difficult to understand such as the type of language and jargon and the constant requirement for usernames and passwords. These elements of complexity will negatively impact the rate of adoption of IBE tools.

Conversely, most of the avocado farmers suggest that IBE tools, the Internet and software programs are not that difficult or complex to use. Yet their experience
demonstrates that frustrating irregularities and instability of agricultural websites lowers the user-friendliness of these websites thus reducing the time and effort avocado farmers are willing to invest in the technology. Therefore, IBE tools in their current form are perceived by avocado farmers as too complex to use effectively.

Hence, farmers from across all four industry groups perceive IBE tools in their current form as too complex to use effectively or difficult to use or understand. This results in the overall view that IBE tools are too complex and not viable extension resources in their current form. Despite these tools being simple enough to learn and operate for many farmers, some IBE tools become frustratingly difficult to use effectively. Elements such as out of date or irrelevant information, excessive navigation links, scientific rather than practical advice, recondite language and jargon, and the perceived emphasis on usernames and passwords all contribute to the perception that IBE tools are not user-friendly and therefore considered complex. In effect, these difficulties create a barrier to adoption whereby, increased complexity of the technology reduces their rate of adoption.

6.5 Trialability

Rogers (2003, p. 258) trialability attribute, as defined in Chapter 4, ‘is the degree to which an innovation may be experimented with on a limited basis’ and is positively related to the rate of adoption. Thus, in this research study, trialability relates to how readily farmers may trial or experiment with IBE tools. However, a prerequisite to trialling or experimenting with any innovation is that the potential adopter must be aware that the innovation exists. Furthermore, the potential adopter must also know how or where to access the innovation.

Avocado farmers are not averse to trialling IBE tools such as blogs or video clips, provided they are from a reliable source, up to date and useful. Video clips on the Avocados Australia website, for example, are not perceived by the avocado farmers as being useful; these videos are not teaching the farmers anything new and therefore cannot be classed as extension tools for experienced farmers. In effect, there are no IBE tools available to avocado farmers that satisfy these fundamental constraints. Furthermore, avocado farmers are generally unaware of the existence of any other IBE tools or even where they might be located. Thus, if a farmer is unaware of the existence of a particular IBE tool or where it resides, it is impossible for the farmer to trial that IBE tool.
Similarly, macadamia farmers are not aware of IBE tools that are up to date, relevant and useful to their farming practices. Video clips reside on the AMS website but like the avocado farmers, the macadamia farmers don’t perceive these as IBE tools. Essentially this means that macadamia farmers cannot trial IBE tools; from their perspective, these tools do not exist. Macadamia farmers suggested they would likely trial IBE tools if they were aware of their existence, if these tools were demonstrated and if some form of guidance or support was provided.

Likewise, a lack of knowledge and awareness of IBE tools is common within the pineapple industry group. The pineapple farmers, however, do not have an industry specific website and consequently do not even have video clips or information relevant to their specific industry. The pineapple farmers are generally unaware of any IBE tools they can trial or experiment with. In this context, it is impossible for pineapple farmers to trial IBE tools that they perceive to be non-existent.

The awareness and availability of IBE tools for strawberry farmers is also limited through DAF, QSGA and other agricultural websites. Conversely, strawberry farmers are aware of IBE tools through mobile apps more so than through agricultural websites. While strawberry farmers have a greater awareness of these IBE tools, trialability is limited by the constraint that they are prepared to trial mobile apps only if there is a free trial period available.

IBE tools accessed through mobile apps would also be well suited to avocado, macadamia and pineapple farmers. There are numerous mobile apps readily available for downloading on to smartphones and tablets providing general agriculture and horticulture specific tools. Accordingly, farmers from each of the four industry groups could trial IBE tools residing on mobile apps. There are some issues, however, that reduce the likelihood of farmers adopting these tools. Cost is a major factor and despite free trial periods, the majority of farmers are well aware of the financial outlay required on expiry of the trial period. Furthermore, the issue of awareness is again, a stumbling block. Many farmers do not have the time and perhaps the skills to identify the most relevant and useful apps for their particular needs; hence they are not aware of specific mobile apps they could trial. Therefore, trialability of IBE tools on mobile apps is limited.
If an innovation can be easily tried or experimented with, Rogers (2003) posits that it will be adopted more rapidly; that is, triability is positively related to the rate of adoption. Most of the farmers from each of the four industry groups are not aware of the existence of IBE tools on agricultural websites and therefore it is impossible to trial these tools. Therefore, the inability to trial or experiment with IBE tools is a barrier to adoption. Avocado, macadamia and pineapple farmers’ lack of awareness of IBE tools on mobile apps precludes the trialability of these tools and is therefore, a barrier to adoption. Conversely, strawberry farmers have a greater awareness of IBE tools on mobile apps, and therefore these apps are more easily tried thus increasing the rate of adoption.

### 6.6 Observability

As stated in Chapter 4, Rogers (2003) defines the observability attribute of an innovation as the extent to which the results of that innovation are visible by other members of a group or social community. Favourable communication and enthusiasm as well as increased rates of adoption are likely to occur if the results of an innovation are highly visible.

IBE tools are predominantly a software component of a technological innovation and they are accessed via hardware such as a PC, tablet or smartphone. Rogers (2003) explains that the software component of a technological innovation is less visible or observable by others. For example, mobile apps are software components on a mobile phone and are significantly less visible or observable to others compared with the highly visible aspect of the actual mobile phone which can be seen by others in close proximity or from a distance. Regardless of whether they reside on a mobile device or computer, IBE tools are less visible or observable by other farmers. Furthermore, the inherent nature of farming activities, which generally sees farmers working individually in the fields or in their offices, further limits the opportunity for the results of IBE tools to be viewed by other farmers.

IBE tools observed by farmers from each of the four industry groups include those accessible through DAF, Business Queensland, and other agricultural websites such as Growcom, Infopest and Horticulture Innovation Australia. The results of using these IBE tools, however, are not observable because farmers do not adopt them in the first place and therefore there are no results. The low adoption rate is more likely to be the outcome
of farmers’ negative perceptions of these IBE tools as discussed in previous sections on relative advantage, compatibility and complexity rather than the level of observability.

Another factor affecting the observability of IBE tools is that farmers lack knowledge and awareness of existing IBE tools that are from a reliable source, up to date and useful. In this context, IBE tools are virtually non-existent and therefore observability of the results of these tools is impossible. Farmers from across each of the four industry groups perceive limited opportunity to observe IBE tools and this is reflected in the low adoption rate of these tools.

Pineapple farmers perceive even less opportunity to observe IBE tools than the other industry groups primarily because pineapple growers are not represented by a unique industry body dedicated solely to the pineapple growers’ industry. Consequently, pineapple farmers do not have an industry specific website nor IBE tools designed specifically for their industry. Therefore, in contrast with the avocado, macadamia and strawberry farmers, the pineapple farmers do not have access to a pineapple industry website that could potentially enable direct links to pineapple specific news and updates, pineapple specific best management practice video clips and techniques, and perhaps a pineapple growers’ discussion forum or links to farm planning and management apps. Hence there is no opportunity for pineapple farmers to observe IBE tools specific to the pineapple growers’ industry.

Mobile apps are not readily used by avocado, macadamia and pineapple farmers and therefore the results of these IBE tools are not observable or visible. A lack of awareness and knowledge of these tools is the main reason for these tools not being utilised. Time and perhaps the skills needed to identify the most relevant and useful apps contributes to that lack of awareness. Hence if the avocado, macadamia and pineapple farmers are not aware of specific mobile apps, it is impossible for the results to be observed.

Conversely, strawberry farmers demonstrated a greater awareness of IBE tools available through mobile apps compared with the avocado, macadamia and pineapple farmers. As discussed in the previous section on trialability, however, cost is a constraint that limits strawberry farmers’ use of mobile apps. The limited use of mobile apps therefore precludes any meaningful observability of the results of these IBE tools.
6.7 Summary

All four of the industry groups perceive a relative advantage to using IBE tools in the form of online weather data. Other IBE tools, however, are relatively unknown. For example, avocado and strawberry farmers are not aware of a blog or discussion forum they could actively utilise despite recognising the potential benefits of using these IBE tools. Avocado and strawberry farmers were also sceptical of the legitimacy of advice that may be given through these forums. Macadamia farmers no longer have access to a discussion forum and email discussion group previously offered through the macSmart website as these services were not being utilised. The pineapple farmers are worse off with no knowledge about blogs and no understanding of their potential functionality and benefits. Pineapple farmers also believe that expert advice would not be available for their unique crop.

Similarly, none of the farmers in any of the four industry groups had any knowledge of a set of IBE tools developed by DAF - Agbiz farm budgeting tools. Furthermore, their disparaging responses show general contempt for these IBE tools suggesting that they are not relevant or useful and therefore not worth the investment of their time or effort.

Negative perceptions were also expressed by farmers from across each of the four industry groups in relation to the resources on the DAF website. Information on this website was criticised for being out of date, irrelevant, not useful or not satisfying their information requirements. The strawberry farmers, in particular, complained that research articles on the DAF website are difficult to access and too scientific for their practical needs.

Avocado farmers expressed little interest and no compelling need to access their industry website ‘Avocados Australia’ as it had minimal usefulness for operational activities on the farm. Conversely, some macadamia farmers consider information such as video clips and some fact sheets on the AMS website to be useful. Several macadamia farmers, however, believe that the AMS website provides no assistance in resolving farming issues, nor does it contribute anything new to their farming practices.

Data regarding strawberry and pineapple farmers’ perceptions of industry specific websites were not collected because neither industry group had access to a current industry specific website at the time of interviewing. Both industry groups, however, had
negative views about agricultural websites such as Growcom, Horticulture Innovation Australia, Infopest, and Freshcare. Strawberry and pineapple farmers stated that information on these websites was not relevant to their specific industry, not useful, or not current.

Further issues were also identified regarding the compatibility of IBE tools with farmers’ values, past experiences and their current methods and needs. Farmers from each of the four industry groups have some level of Internet access although none of them are connected to the NBN. Macadamia, pineapple and strawberry farmers experienced unreliable and inconsistent Internet access. Cost of Internet services was another issue for pineapple and strawberry farmers and strawberry farmers also complained of slow Internet speed.

Farmers also need compatible devices in order to effectively use IBE tools. Digital devices are commonly used by farmers from each of the four industry groups to access the Internet from their home, office or sheds. Outside of these locations, however, raises compatibility issues for most farmers in the four industry groups. In particular, tablets are perceived as impractical for most farmers’ rugged outdoor activities; they are inconvenient, a discomfort and a risk. Some avocado and pineapple farmers have the same reluctance to use smartphones out in the fields. Conversely, strawberry farmers commonly integrate laptops effectively with outdoor weighing stations.

While most of the farmers across the four industry groups are not averse to using the Internet and technology, IBE tools and the Internet are not their preferred source of agricultural information and advice. The general perception is that IBE tools do not contribute greatly to farming practices. The researcher believes that this is in part due to the issues of relevancy, currency and availability of digital information. Another contributor to this perception is that many of these farmers already have a vast knowledge of their industry and the current approach and methods adopted by farmers from across the four industry groups have enabled most of them to successfully operate their farms without the need for IBE tools. In this context, IBE tools are not consistent with farmers’ past experiences and therefore not compatible with their current methods.

The difficulty farmers experience when using IBE tools is another deterrent to their adoption. Pineapple farmers, in particular, expressed difficulty using computers and
effectively searching agricultural websites. Some strawberry farmers do not believe they have the ability or computer literacy skills to use the technology effectively. Most of the avocado and macadamia farmers suggest that IBE tools, the Internet and software programs are not that difficult or complex to use. Yet, some macadamia farmers lack skills in proficient searching techniques and some believed their mindset impacted negatively on their ability to use the technology efficiently and effectively. Avocado farmers suggest that irregularities and instability of agricultural websites are frustrating and lowers the user-friendliness of agricultural websites. Most of the farmers from across each of the four industry groups complained about agricultural websites with out of date or irrelevant information, excessive navigation links, scientific rather than practical advice, recondite language and jargon, and the perceived emphasis on usernames and passwords. These elements contribute to the perception that IBE tools are not user-friendly and therefore considered difficult to use or understand.

Trialability of IBE tools is essentially impossible as most of the farmers from each of the four industry groups are not aware of the existence of IBE tools on agricultural websites. Avocado, macadamia and pineapple farmers also lack awareness of IBE tools on mobile apps. Conversely, strawberry farmers have a greater awareness of IBE tools on mobile apps but the cost of these apps is a constraint that limits the adoption of these tools.

Similarly, observability of IBE tools is severely limited given farmers from across each of the four industry groups lack knowledge and awareness of existing IBE tools that are from a reliable source, up to date and useful. Therefore, the results of using these IBE tools are not observable because farmers do not adopt them in the first place.

Pineapple farmers perceive even less opportunity to observe IBE tools than the other industry groups primarily because they do not have an industry specific representative body or website, nor IBE tools designed specifically for their industry. Pineapple farmers do not readily adopt mobile apps either; nor do avocado and macadamia farmers. As mentioned previously, strawberry farmers demonstrated a greater awareness of IBE tools available through mobile apps but with minimal adoption. Therefore, the results of these IBE tools are also not observable or visible.
6.8  Position of overall research

Analysis and interpretation of the research data discussed in Chapter 5 and Chapter 6 of this thesis, has largely contributed to knowledge gained in response to the research questions and overall objectives of this research study. A brief summary indicating the position of the research with regard to the research questions is provided here:

1. How do Queensland horticultural farmers perceive IBE tools?
   While various IBE tools are available to Queensland horticultural farmers, it has been established that most of the farmers in this research study have a poor perception of these IBE tools with the exception of online weather data. The general perception is that IBE tools do not contribute greatly to farming practices and there little or no perceived value in using these tools compared to farmers’ traditional methods.

2. Why do Queensland horticultural farmers use IBE tools?
   It has been ascertained that there is limited use of IBE tools by Queensland horticultural farmers in this research study. These farmers considered that information provided by these tools was difficult to locate, out of date, irrelevant, not useful or not satisfying their information requirements. Fundamental Internet access issues such as unreliable, inconsistent, slow and/or costly Internet access, were also commonly stated as barriers. Furthermore, farmers from across each of the four industry groups lack knowledge and awareness of existing IBE tools. Some farmers are also lacking in confidence and computer literacy skills.

3. How can IBE tools better satisfy Queensland horticultural farmers’ information requirements?
   Analysis and interpretation of the data indicates that Queensland horticultural farmers’ information requirements are not satisfied through IBE tools. The information delivered to farmers by IBE tools needs to be useful, relevant and current. It also needs to be easy to find, easy to use and easy to understand and apply.

4. How can IBE tools be tailored to enable Queensland horticultural farmers to more readily adopt these tools?
   The potential adoption of IBE tools by Queensland horticultural farmers largely depends on IBE tools being designed to meet the needs of Queensland horticultural farmers.
While this may be stating the obvious, the results of this research currently suggest that this has not been satisfactorily achieved. The design of IBE tools need to be user-friendly and tailored to address the issues highlighted above. An extensive discussion highlighting the need for better design, support and promotion of IBE tools and how this can be achieved, is presented in the following chapter of this thesis.
Chapter 7 — Discussion

7.1 Introduction

The previous two chapters explored and analysed the data collected for four individual cases incorporating the Queensland avocado, macadamia, pineapple and strawberry industry groups. These analyses are based on investigating the five key attributes of Rogers’ Diffusion of Innovations Theory (2003): relative advantage, compatibility, complexity, trialability and observability (Rogers 2003). In Chapter 5, the data was analysed for each individual industry group against each of Rogers’ five key attributes resulting in a synthesis of findings and knowledge building for each individual case. This was followed by a cross-case analysis in Chapter 6 where the industry groups were compared to each other. Comparing and evaluating the four industry groups within each of the five key attributes led to the identification of similarities and differences across the four industry groups thereby extending the knowledge building beyond the individual cases and increasing the depth of understanding of the factors that affect farmers’ use of IBE tools.

None of the farmers in this research study are averse to using the Internet although access is problematic for many. Several of these farmers commonly use the Internet for weather, email, news, online banking, bill paying, online shopping, and payroll. Most of the farmers across the four industry groups have similar perceptions about IBE tools. With the exception of weather sites, these farmers believe that IBE tools are out of date, irrelevant, not useful, and difficult to find. Thus, in terms of Rogers’ Diffusion of Innovations Theory (2003), farmers in this research study perceive IBE tools to have little or no relative advantage, poor compatibility and a high degree of complexity thereby contributing to low adoption rates of IBE tools.

The cross-case analysis in Chapter 6 revealed a difference in availability of IBE tools offered to each industry group by their peak industry body. The avocado, macadamia and strawberry groups are represented by peak industry groups specific to their industries and each of these groups has an industry website. Unlike the Strawberries Australia Inc. website, the Avocados Australia and AMS websites both have a members’ area specifically targeting their growers. Nonetheless, the avocado and macadamia farmers in this research study perceive their industry websites to be lacking in useful and
relevant information although the macadamia farmers were more positive in their perceptions about the usefulness of some of the video clips and fact sheets. The strawberry farmers in this research study also perceive their industry website to be lacking in useful and relevant information but to a greater extent than the avocado and macadamia growers. In contrast, the pineapple farmers do not have an industry specific website as they are represented by Hort Australia which is not specific to the pineapple industry.

The cross-case analysis in Chapter 6 also revealed a difference in computer literacy skills and self-efficacy between the grower groups. While most avocado and macadamia farmers suggest that IBE tools, the Internet and software programs are not that difficult or complex to use, many macadamia farmers believe they lack skills in proficient web searching techniques. Conversely, some strawberry farmers do not believe they have the ability or the necessary computer literacy skills to use the technology effectively. Similarly, pineapple farmers expressed difficulty using computers and effectively searching agricultural websites.

Based on the findings in the previous chapters, this thesis argues that IBE tools are too difficult for farmers to use effectively and they will continue using their current methods unless IBE tools are better promoted, supported and designed. Therefore, this chapter discusses the research findings in relation to the relevant scholarly literature, the research questions and the theoretical framework.

As stated in Chapter 1 of this thesis, the following research questions were designed to address the overall objective of the research study which was to better understand key factors influencing Queensland horticultural farmers’ effective use of IBE tools:

1. How do Queensland horticultural farmers perceive IBE tools?
2. Why do Queensland horticultural farmers use IBE tools?
3. How can IBE tools better satisfy Queensland horticultural farmers’ information requirements?
4. How can IBE tools be tailored to enable Queensland horticultural farmers to more readily adopt these tools?
More specifically, this chapter discusses farmers' knowledge of IBE tools and the promotion of IBE tools in terms of agricultural models of engagement and communication strategies. This chapter further discusses and examines IBE tools in terms of improving their usability and design as well as the support and training needed for farmers' effective use of IBE tools.

7.2 Knowledge of IBE tools

As discussed in Chapter 4 of this thesis - the Research Strategy, Rogers (2003) describes the decision to adopt an innovation as a five-step process whereby knowledge is the first step as shown in Figure 7.1. Persuasion, decision, implementation and confirmation are the remaining steps and these are strongly influenced by the potential adopter's attitude to the innovation (Rogers 2003). One of Vanclay's (2011) principles relating to the social nature of farming and the sociocultural foundations of agricultural adoption suggests that a common extension viewpoint is that it is necessary to change farmers' attitudes for successful adoption whereas, Vanclay explains that farmers are justified in having different views and that their attitude is not problematic (Social Principle 14 – refer Appendix 1). Rogers (2003) is not referring to the adopter's attitude in a derogatory fashion or even in the context of suggesting that adopters' attitudes need to change. Essentially, a potential adopter's attitude or opinion is based on their evaluation of the five key attributes of the innovation: relative advantage, compatibility, complexity, trialability and observability (Rogers 2003).

An innovation may be described by these five attributes and potential adopters’ perceptions of these attributes may affect the nature of the adoption process and the innovation’s rate of adoption (Rogers 2003). Other variables may also affect an innovation’s rate of adoption including the nature of the innovation-decision, the type of communication, the nature of the social system and the extent of the change agent’s promotion effort. Rogers (2003), however, states that most diffusion research focuses on the five key attributes of an innovation and this is evident in the DOI research literature, for example, the research conducted by Al-Jabri and Sohail (2012), Bennett and Bennett (2003) and Gerrard and Cunningham (2003). Similarly, the research in this thesis has focused on these five perceived attributes of an innovation. Nonetheless, the researcher has also been cognisant of the other constructs that shape Rogers’ (2003) DOI Theory and their potential impact on the adoption of IBE tools.
For example, other constructs that are discussed in this chapter because of their relevance to IBE tools and the farmers in this research study include knowledge and awareness of an innovation, the type of communication, the social system and the change agent’s promotion of the innovation.

In the first step of the process of deciding to adopt an innovation, Rogers (2003) states that a potential adopter needs to learn of the existence of an innovation (awareness knowledge) and acquire some appreciation of how it functions (principles knowledge), thus developing some basic knowledge and appreciation of the innovation. The findings of this research study show that farmers have limited knowledge or awareness of the existence of some IBE tools and this impedes their ability to adopt these tools. For example, none of the farmers interviewed were aware of the Agbiz farm budgeting tools (Business Queensland 2016a) nor the Beatsheet Blog (Queensland Government 2017). This is also apparent in a study by Ofem et al. (2011) where local farmers rely on their indigenous knowledge and traditional practices largely because they are unaware of alternative approaches and extension communication is poorly delivered.
Furthermore, Pannell et al. (2011) emphasise that knowledge or awareness of an innovation must be more extensive than just knowing it exists; potential adopters must also be sufficiently informed to appreciate the practical relevance and benefits of the innovation. Many of the IBE tools that farmers in this research study are familiar with have been discovered to a certain extent by chance and therefore these farmers have not been sufficiently informed of the practical relevance and benefits (principles knowledge) of these IBE tools. Similarly, farmers in this research study are not sufficiently informed about the practical relevance of scientific research articles available from agricultural websites which was highlighted by farmers’ perceptions of the difficulty of understanding these articles and applying the scientific findings to their farm activities.

The findings of this research study indicate that farmers in this study have limited knowledge about the existence of IBE tools, how they function, their practical relevance or their potential benefits. Hence, the knowledge requirement that should be addressed and fulfilled in the first requisite step of the innovation-decision process, has not been realised.

### 7.3 Promotion of IBE tools

Not only were farmers in this research study uninformed of the existence of some IBE tools, but many of these farmers have only discovered other IBE tools by chance. The researcher believes that this suggests a failure to realise the importance of effective communication about IBE tools, or an absence of promotion or marketing of IBE tools. The corollary is that farmers will not use IBE tools if they are unaware of their existence and farmers may not realise the usefulness and relevance of these tools if these features or benefits have not been communicated. Hence, the researcher believes that effective communication and interaction with farmers is a vital step in the diffusion process to inform farmers of the existence of IBE tools and to further develop their knowledge and awareness of the functionality and potential benefits of these tools.

#### 7.3.1 Agricultural extension models

The provision of extension services generally follows a model or framework of agricultural extension and engagement (Klerkx & Jansen 2010; Vanclay & Leach 2007). A traditional model of engagement adopted in rural extension, and possibly adopted in the development of some IBE tools, was criticised by James (2011) for its lack of stakeholder interaction; a technique he suggests is perfected by the government sector.
Specifically, James (2011) refers to the DAD model which embraces a technique of Decide, Announce and Defend which incorporates the actions of possibly only one person working in isolation, deciding what needs to be done, announcing or applying it, then steadfastly defending the concept but ultimately abandoning it because of poor adoption. The researcher was unable to locate other research literature referring to the DAD model, but it is conceptually feasible and indeed, may have been the fundamental approach used in the development of the Agbiz farm budgeting tools (Business Queensland 2016a). While the developers’ expertise and objectives are recognised as aiming to provide a useful service to farmers, the findings of this research study suggest that this toolkit may have benefited from more engagement with farmers from the onset of designing these tools.

Collaboration and engagement with farmers would more effectively take account of their practical needs and at the same time would build farmers’ awareness of these tools (Klerkx & Jansen 2010). For example, the findings of this research study identified little use of electronic spray diaries with the exception of two avocado farmers and a strawberry farmer that uses his smartphone to record the location of chemical applications. According to the Agricultural Chemical Users’ Manual (DPIF 2005) the use of agricultural chemicals is regulated by control-of-use legislation (six separate sets of acts and regulations for Queensland) and accurate records of all chemical application practices must be maintained. Similarly, DAF suggest that maintaining a spray diary is critical documentation providing evidence of farmers’ chemical application procedures and practices (DAF 2014c). Despite these critical requirements, however, neither the DAF website or the Agricultural Chemical Users’ Manual suggest a system for maintaining a spray diary. Similarly, the ‘Chemical controls’ webpage under ‘Land management’ on the Business Queensland website (Business Queensland 2016b) provides comprehensive guidance and information on agricultural chemicals but despite following thirty links to a variety of these pertinent topics, there is no link to an electronic record keeping system. Furthermore, there is not even a template that could be used for manual record keeping and yet the Agricultural Chemicals Distribution Control Act 1966 and Regulation requires substantial details to be recorded for every application of chemicals including herbicides, insecticides and fungicides. While critical information on chemical controls is extensive, this example demonstrates that the full extent of farmers’ practical needs have not been considered. Therefore, the findings of this research study suggest that the importance of stakeholder interaction in the design and publication of
IBE tools needs to be recognised in order to take into account farmers’ practical needs and to improve the availability and usability of these tools which may increase their adoption rates. From these findings it is also implied that traditional models of engagement adopted in rural extension are not sufficiently effective for the development and promotion of IBE tools.

Essentially, the dissemination of information through IBE tools has utilised a traditional top-down or linear process that utilises the transfer of technology approach (Leeuwis 2004). As discussed in the Literature Review chapter of this thesis, researchers confirm that when the transfer of technology approach is utilised, farmers are the passive recipients of information generated in isolation of farmer consultation or context-specific requirements (Klerkx & Jansen 2010; Leeuwis 2004). Many farmers have a lifetime of farming experience and are comfortable operating their farms using traditional tried-and-true methods. Vanclay (2011) also regards the top-down approach as inappropriate as it tends to marginalise farmers’ tacit knowledge and ignores the sociocultural aspects of agriculture and innovation adoption behaviour (Social Principle 17 – refer Appendix 1).

Furthermore, findings from the EU Standing Committee on Agricultural Research (Poppe 2012), indicate that rural extension’s use of the transfer of technology approach developed a growing disconnect between farmers’ knowledge, research and extension. Similarly, Glendinning, Mahapatra and Mitchell (2001) suggest that weaknesses in forestry extension have been linked to the one-way flow of communication common in the transfer of technology approach. Many experienced farmers have developed a lifetime of tacit knowledge or indigenous knowledge that empowers them to be non-passive recipients. Thus, farmers have the wherewithal to critically evaluate IBE tools, especially agricultural websites and they also recognise that alternative information sources exist (located through a Google search) thereby enabling farmers to be more selective and proactive in their knowledge acquisition. This is supported by Vanclay (2011) advocating that farmers are empowered through their own construction of knowledge and their own beliefs and this leads to their critical evaluation of extension information rather than just acceptance.

Rather than the traditional models of engagement, James (2011) suggests a more contemporary approach to extension and the diffusion of innovations based on progressive and inclusive principles that engage stakeholders early in the process of delivering fundamental extension services. As discussed in the Literature Review
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Chapter of this thesis, Morse, Brown and Warning (2006) suggest that farmers should have more influence and control over their information requirements rather than being passive recipients. Klerkx and Jansen (2010) also suggest that the transfer of technology approach or top-down approach ignores the nature of agricultural knowledge creation being highly interactive and largely having a local context. According to La Grange et al. (2010), access to information that addresses farmers’ needs can be achieved through a demand-driven extension framework. A demand-driven framework enables farmers to articulate their issues, knowledge gaps and information requirements. This framework would enable farmers to articulate their information needs and expectations of IBE tools in fulfilling these requirements.

Some of the shortcomings of the top-down approach or linear model are acknowledged in the agricultural knowledge and information systems (AKIS) model which is discussed in the Literature Review chapter of this thesis. The AKIS enables improved dialogue, understanding and exchange of information between farmers and rural advisory services (Leeuwis 2004; Rivera et al. 2006). Development and adaptation of the AKIS by Röling and Engel (1990) further emphasised the collaboration between farmers and the knowledge triangle (extension, research and education). While Röling and Engel (1990) recognised that extension, research, education, farmers and other actors had to interact synergistically, the AKIS inadequately addresses the complexity of the pluralistic network of organisations and stakeholders involved in the innovation process.

An alternative to the AKIS is the Agricultural Innovation System (AIS) framework. Rivera (2011) suggests that the AIS recognises the need to foster and develop innovation in addition to information and knowledge transfer. Klerkx et al. (2012) explains that the AIS framework facilitates combined technical, social and institutional change and recognises the emerging nature of innovation from a complex network of multiple actors. Similarly, Percy et al. (2015) suggest that the AIS framework enables a greater focus on the collaborative network with people and institutions involved in the transfer of knowledge and technology. Caron, Biénabe and Hainzelin (2014) further emphasise this stating that farmers’ experience and expertise is critical to the production and exchange of knowledge.

Many researchers promote the AIS framework as a sound instrument to comprehend the complexity of underlying processes of agricultural innovation, knowledge exchange and
transformation (Faure et al. 2016; Lamprinopoulou et al. 2014; World Bank 2012). Essentially, farmers need to be well informed through processes that enable participatory collaborative efforts in developing and sharing knowledge within the overall agricultural network of stakeholders. The collaboration and interaction of the actors within the AIS, in addition to the stronger focus on innovation establishes a promising structure for facilitating the promotion and diffusion of IBE tools. Nonetheless, (Vanclay 2011) suggests that farmers’ knowledge must also be recognised in this collaborative arena and that any knowledge created through scientific research is not necessarily perceived as credible or legitimate by farmers who have their own tacit knowledge which they will use to evaluate other information (Social Principle 15 - refer Appendix 1)

Certainly, the AIS model would broaden farmers’ decision-making frameworks by expanding their knowledge base and strengthening their capacity to make informed decisions. However, this approach does not satisfactorily emphasise the need for engagement of stakeholders early in the process of developing IBE tools. Furthermore, while the AIS model has the potential to facilitate communication, the model does not necessarily ensure the effective promotion of IBE tools.

### 7.3.2 Communication of IBE tools

It is pertinent to revisit Rogers’ (2003, p. 5) definition of diffusion which states that diffusion is a process whereby ‘an innovation is communicated through certain channels over time among the members of a social system’. Rogers (2003) also describes diffusion as a distinct type of communication where a new idea is the core message content. Hence, the effective diffusion of IBE tools requires an exchange of information about these tools through some communication channel among farmers and extension agents or other stakeholders.

In contrast, Pannell and Vanclay (2011) suggest that the traditional extension process was criticised for its primary focus on communication. These criticisms were based on the apparent misconception that the extension process failed to effectively communicate and this caused poor adoption rates (Pannell & Vanclay 2011). It is suggested by Pannell and Vanclay (2011) that this approach was implemented because of incorrectly assuming that farmers were information-deprived. The farmers interviewed in the research study for this thesis are not deprived of information readily available from agronomists, agribusiness consultants and other farmers. Conversely, the findings of
this research study indicate that farmers are deprived of information relating to the existence of IBE tools.

In this context, Pannell and Vanclay (2011) note that one of the primary roles of extension is to raise awareness and to some extent, change farmers’ perceptions of the value and relevance of innovations. As discussed in the Literature Review chapter of this thesis, the essential nature of extension services suggests that communication and interaction stimulate change and innovation. For example, Leeuwis (2004, p. 27) defines extension as ‘a series of embedded communicative interventions that are meant … to develop and/or induce innovations which supposedly help to resolve (usually multi-actor) problematic situations’. Similarly, Vanclay and Leach (2011) also highlight communication as a fundamental component of extension, whereby change is enabled through the improved flow of communication and information between rural industries, agencies and community stakeholders. Del Castello and Braun (2006, p. 3) define rural communication as:

an interactive process in which information, knowledge and skills, relevant for development are exchanged between farmers, extension/advisory services, information providers and research either personally or through media such as radio, print and ICTs. In this process all actors may be innovators, intermediaries and receivers of information and knowledge.

These definitions emphasise the fundamental nature of communication in the delivery of traditional extension services through human interaction, where some action has to be taken for the communication flow of sending and receiving information to be achieved.

For example, the delivery of printed newsletters follows the basic communication model of sending and receiving messages because the industry group or sender takes some action to identify the target audience and then takes further action by posting the newsletters to individual farmers, thereby achieving extension’s communication goal. Similarly, the delivery of electronic newsletters by email is an effective form of communication because each individual farmer receives the intended message or information.

This communication process, however, highlights the problem with the current approach of using online delivery of extension services where IBE tools are delivered to the Internet, not the farmers. By chance farmers may receive the intended information but there is little or no action taken to ensure that individual farmers receive the intended information.
Targeting and tailoring communication

In order to facilitate effective communication and interaction with farmers in the diffusion process of informing farmers and expanding their knowledge of IBE tools, an effective communication strategy needs to be developed and implemented. In support of this, Del Castello and Braun (2006, p. 50) found that significantly improved communication can be achieved through the development of a comprehensive communication strategy based on ‘research, clear objectives, identification and assessment of audience groups, careful message design and choice of channels, monitoring and feedback’.

Glendinning, Mahapatra and Mitchell (2001) describe extension communication as a strategic instrument for the diffusion of innovations and change among farmers. Similarly, Del Castello and Braun (2006) suggest that in addition to better knowledge and increased information sharing, rural development and change requires a communication strategy that is appropriate and therefore, targeted and tailored.

Vignare (2013), however, recommends that communications must be designed around the end-users to enable rural extension services to effectively utilise ICTs as an extension tool. Therefore, a communication strategy needs to be tailored around informing farmers of the existence, functionality and potential benefits of specific IBE tools. According to Malcolm, Makeham and Wright (2005) marketing requires identification of objectives to be achieved via an exchange process and taking action to achieve those objectives. In essence, an effective communication strategy is required to promote or market IBE tools to relevant farmers or potential adopters.

The design of a communication strategy should consider that the success of a diffusion program is largely dependent on the extent to which it satisfies clients’ needs (Leeuwis & Aarts 2016; Rogers 2003; Starasts 2015). Therefore, the objective of a communication strategy for IBE tools would include promoting the existence of specific IBE tools and engaging with a targeted group of farmers to effectively inform them of the features, functionality, benefits and relevance of those IBE tools.

Rogers (2003) suggests that a communication strategy needs to be designed and customised according to the characteristics and needs of the target audience. For example, some IBE tools would be specific to particular grower groups whereas other IBE tools would be more general. The communication strategy would, therefore, need to
be designed to target the relevant audience. In order to develop a targeted communication strategy, Leuwis (2004) suggests that the choice of media is an important consideration.

Rogers (2003) claims that mass media communication channels such as television, radio and newspapers are an efficient form of broadcasting information to a wide audience of potential adopters. While Vignare (2013) agrees that broadcast technologies may target a wide audience, she highlights the disadvantage that these communication channels have limited audience participation. Furthermore, television and radio communication are unlikely to be effective for the communication of IBE tools because of their prohibitive cost. Newsletters, however, may be appropriate for the communication of IBE tools early in the diffusion process as part of an awareness campaign that targets a wide audience. Leeuwis (2004) agrees that one of the functional qualities of mass media is mobilising attention and creating awareness. For example, the Grains Research and Development Corporation (GRDC) regularly advertises comprehensive e-guides, mobile apps, reports and back-pocket guides in their GroundCover bi-monthly hardcopy newsletter. This newsletter is also available online via the Resources and Publications link on the main GRDC website where links to several other resources also appear including fact sheets, mobile apps, online guides, regional trial results and technical manuals (GRDC 2018). DAF, industry groups and Growcom could include similar newsletters in their online or hardcopy promotion of IBE tools delivering farming advice, information and resources. Furthermore, some of these resources could include a range of mobile apps including some advertised by GDRC and others such as GrowData, PestGenie, Croptracker and PocketPAM2.

In contrast to mass media, Rogers (2003) and Leeuwis (2004) suggest that interpersonal communication is a more effective form of communication particularly with face-to-face interaction. Interpersonal communication includes group meetings and bilateral meetings which have a more limited audience but this enables in-depth interactive dialogue and immediate feedback or insight into audience perceptions (Leeuwis 2004). This communication environment would facilitate the promotion of IBE tools and could be tailored to specific audiences attending regular grower group meetings, field days and best practice study groups. These meetings would be ideal for highlighting the benefits and relevance of particular IBE tools and for demonstrating their functionality and ease of use. Similarly, this communication environment would also promote audience
participation where farmers could also ask questions and possibly trial IBE tools. Therefore, demonstrating an IBE tool in this interpersonal environment would develop farmers' knowledge of the existence, relevance and benefits of IBE tools and would likely affect their perceptions of relative advantage, compatibility, complexity, trialability and observability.

Rogers (2003) also states that interpersonal communication may be more effective when one individual has already adopted the innovation and other individuals are homophilous or have similar interests, and share common personal and social characteristics. This is because communication exchange occurs more commonly between homophilous individuals and this not only contributes to knowledge exchange but also to persuasion which is the second step in Rogers' (2003) five-step process of adopting an innovation.

This is consistent with research conducted by Charatsari and Lioutas (2013) who found that farmers prefer social-network based information channels within their rural communities. Queensland horticultural farmers studied in this thesis have homophilous associations with other farmers, particularly those from their own industry group and possibly industry group leaders, but not necessarily with extension agents. While this would not preclude extension agents leading the communication exchange about IBE tools, extension agents might benefit from an appreciation of this concept and reflect that in their communication design.

In this context, Leeuwis and Aarts (2016) advocate some level of diagnostic research to facilitate the development of an effective communication strategy. Regular grower group meetings, field days and best practice study groups would be the ideal forum to arrange for a farmer already using a particular IBE tool to demonstrate its features, relevance and functionality to other farmers and address their questions and concerns. Similarly, this forum may also benefit from utilising an intermediary or innovation broker to communicate with farmers about IBE tools which would also facilitate linkages within the innovation system (Caron, Biénabe & Hainzelin 2014; Klerkx et al. 2012; Percy et al. 2015). The role of an innovation broker is described by Klerkx et al. (2012) as one that does not create knowledge or use it in innovation; instead, they bind together various elements of an innovation system and ensure that information flows and learning occurs. This is also supported by Sharma and Mishras' (2017) research emphasising the
importance and effectiveness of an intermediary as a distribution channel for the delivery of e-government services.

A communication strategy designed to promote IBE tools, that uses a variety of communication methods or channels, should be developed in order to create awareness knowledge and principles knowledge (Rogers 2003). A communication strategy of this nature will generate and reinforce farmers’ knowledge and awareness of IBE tools and also their knowledge of the functionality, relevance and benefits (principles knowledge) of IBE tools. This is supported by several researchers (Bell 2015; Hall et al. 2013; Leeuwis & Aarts 2016; Pannell et al. 2011) suggesting that effective extension is facilitated through using multiple methods of communication, including multiple channels, multiple deliverers and repetition. Potentially, this could result in more positive perceptions of IBE tools (which impacts the next step in the innovation-decision process) and lead to greater acceptance or adoption of IBE tools. As suggested by Leeuwis and Aarts (2016) therefore, it is important to understand the effects of using different roles or sources for information delivery and different media at different stages in the adoption process.

7.4 Support and training for IBE tools

In addition to better promotion of IBE tools, the findings of this research study also highlight the need for better support and training. Low self-efficacy and poor computer literacy skills were observed by the researcher and openly discussed by numerous farmers. Several farmers also stated that they lack skills in proficient web searching techniques which limits their efficient and effective use of IBE tools but also contributes to their negative perceptions of these tools. While many farmers in this research study did not specifically suggest they would benefit from IBE tools training, some declared that they do not have the ability to use technology effectively. Furthermore, those farmers that were unaware of the existence of IBE tools would benefit from fundamental support and training because the underlying nature of adoption is a learning and changing process (Pannell et al. 2011). Firstly, farmers need to learn of the existence (awareness knowledge), relevance, functionality and benefits (principles knowledge) of IBE tools as already established in Section 7.2 and Section 7.3 of this chapter. The other part of the learning process is developing the capacity, or skills and ability to use the IBE tools effectively and efficiently (Pannell et al. 2011). Farmers in this research study are more
likely to adopt IBE tools and use them more effectively if appropriate support and training is readily available and designed around the farmers’ needs.

As discussed in the Literature Review chapter of this thesis, various definitions of extension suggest that training and learning are core elements of extension services (Beilin, Paine & Pryor 2007; Coutts 2000; Marsh & Pannell 2000; Rivera et al. 2006). Similarly, Röling and Engel (1990) refer to the collaboration between farmers and the knowledge triangle (extension, research and education) which are the main constructs in the Agricultural Knowledge and Information Systems model. The knowledge triangle is also the central construct in the Agricultural Innovation System framework which fosters innovation linkages that support the creation of an environment for agricultural development (Faure et al. 2016; Rivera 2011). Thus, education is an integral component of agricultural extension services. Given that IBE tools are an innovation developed by extension agencies, as well as promoting these tools and communicating with farmers about their functionality, relevance and benefits, extension agencies also have the responsibility to ensure that farmers are equipped with the skills to use these tools efficiently and effectively. Therefore, the development and publishing of IBE tools not only requires the promotion of these tools using an effective communication strategy but there must also be training and support mechanisms put in place so that farmers can learn how to use these tools.

Rogers (2003) identifies three types of knowledge associated with the innovation-decision process: awareness knowledge, how-to knowledge and principles knowledge. These concepts and their relevance to this research study have been discussed in the previous sections of this chapter, particularly awareness knowledge and principles knowledge. ‘How-to’ knowledge relates to the ability to use an innovation; more specifically, how-to knowledge is based on the information that is essential for the correct use of an innovation (Rogers 2003). For example, in this research study, farmers need to know how to access and use IBE tools to their full potential; they need to know how to use a computer effectively and they need to know how to efficiently access agricultural websites and easily locate the information they are searching for. How-to knowledge is essential for the potential adoption of an innovation because an inadequate level of this knowledge is likely to result in either rejection or discontinuance (Rogers 2003). The findings of this research study support Rogers’ claim as evidenced through the rejection
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of IBE tools by some farmers not having the confidence or skills (how-to knowledge) to effectively and efficiently use IBE tools.

While farmers could take on the responsibility for their own learning, there are potential barriers that may inhibit the desire, feasibility and success of such a venture. It would be highly unlikely that a farmer could undertake online training to successfully develop their computer literacy skills. Many farmers live in remote areas so attending a formal training course to develop their computer literacy skills or web searching techniques would only be feasible if the benefits were worthwhile, but this is predicated on a strong enough desire to learn and reap those benefits. In this research study, the desire to learn computer literacy skills, for example, is not sufficient to offset the travel distance, time and possibly the financial cost without some assurance of the benefits. The desire to learn these skills is limited because there is no perceived relative advantage compared to their current practices. Notwithstanding, several farmers in this research study stated that they would sacrifice time on the farm to attend training if they were convinced that the training would advance their skills and be useful.

Relative advantage has been shown to play a crucial role in the adoption of an innovation (Pannell & Vanclay 2011; Rogers 2003; Sewell et al. 2017). Therefore, to influence these perceptions about training, farmers would need to be convinced that the benefits outweigh the cost. Again, this requires the awareness knowledge and principles knowledge to be effectively communicated to farmers. According to Pannell et al. (2011), raising awareness of an innovation and informing farmers of the performance and relevance of an innovation is likely to be the main contribution of extension. In contrast, Strachan (2011) found that non-adoption of an innovation may be related to a particular temperament commonly exhibited by farmer’s. Rural culture is more traditional and conservative which Strachan (2011) suggests may result in resistance to change whereby farmers are unlikely to change just for the sake of it.

Nonetheless, if farmers are aware of the benefits of IBE tools, which can be achieved through tailored and targeted promotion, their decision to adopt may still be determined by other perceptions such as complexity and compatibility. One of the reasons for not using IBE tools suggested by farmers in this research study relates to the practicality of using a smartphone or tablet while out on the farm where an electronic device would be subject to harsh conditions. While this is certainly legitimate it was somewhat
disconcerting to find that the farmers in this research study were generally unaware of ‘rugged’ or protective phone and tablet covers. Anecdotally, the researcher is aware of rugged phone and tablet covers used by the Queensland Ambulance Service and a simple Google search also reveals an extensive variety of covers that enable an electronic device to withstand shock, moisture and extreme temperatures. Advertising equipment such as these covers that would enable farmers to use IBE tools more readily could be included in any extension support or communication program such as advertising in a newsletter or a demonstrating them at a field day or workshop. Providing training and support in the practical and technical use of IBE tools may develop their skills to a level that may result in more positive perceptions of these tools. Nettle and Paine (2011) suggest that adaptive management achieved through learning is the core of capacity building and this is paramount for agricultural productivity, development and sustainability.

Therefore, enhancing the capacity for farmers to adapt and change is vital. This can be achieved by developing their skills in the effective use of IBE tools by implementing training and support mechanisms as essential grounding for the potential adoption of these tools. Increased availability of training and assistance in the use of technologies was found to increase the diffusion of technologies in the Brazilian citrus industry (Carrer, de Souza Filho & Batalha 2017). Not only will farmers’ skills in the use of IBE tools be enhanced; farmers may also develop a sense of empowerment and higher level self-efficacy (Caron, Biénabe & Hainzelin 2014).

• **Methods of training and support**

Once a communication strategy has been developed and implemented, a training and support strategy also needs to be developed. Various factors need to be considered in the planning process to attract and engage participants and to satisfy their needs but this is premised on the effectiveness and outcomes of the communication strategy. The potential success of training and support mechanisms will depend largely on farmers’ awareness knowledge and principles knowledge of IBE tools having already been established. This will have developed their desire to acquire the how-to knowledge, that is, to learn how to use IBE tools efficiently and effectively. If this has been established, farmers will recognise the benefits of using IBE tools and realise that these benefits will outweigh the costs of participating in training activities to develop their skills.
In order to develop a professional training and support strategy, ideally learning theories such as behaviourism, cognitivism and humanistic learning would be analysed. Adult learning theories and principles as well as instructional design strategies should also be considered (Leeuwis 2004; Salim, Mamun & Hassan 2016; Sewell et al. 2017). Research and analysis of these educational components is beyond the scope of this thesis but it is expected that a training and support strategy for farmers using IBE tools would be developed by a skilled educator with appropriate educational knowledge and understanding.

Nonetheless, several factors should be considered when designing a training program to develop skills for digital inclusion including socioeconomic factors, current and desired uses, required skills, timing, intensity and sequencing (Park 2017a). Different learning styles should also be considered and this can be addressed by offering different methods and combinations of these methods of training that enable farmers to learn by watching, listening, reading and practical hands-on-learning (Pannell & Vanclay 2011). Different learning models should also be considered such as formal versus informal training and support versus training programmes (Vignare 2013). Training methods can also be supplemented with fact sheets or hardcopy notes/booklets and video-clips posted on agricultural based websites.

A variety of training locations can also be considered and whether to combine a training session with an already planned event. Suitable options include face-to-face workshops, field days, producer demonstration sites.

7.5 Design and usability of IBE tools

Various shortcomings of IBE tools perceived by farmers in this research study have been highlighted in the previous two chapters. In the context of Rogers’ (2003) DOI, these research findings demonstrated that most of the farmers in this research study perceive IBE tools to be lacking in relative advantage, they are not compatible with their current methods of farming and the degree of complexity makes them difficult to use. While the data collection was analysed in the context of Rogers’ (2003) DOI Theory, the research findings can also be interpreted in the context of usability and user experience (UX).

The International Organization for Standardization (ISO) describe usability as an outcome of use of a website or interface (ISO 2018) and define UX as a person's
perceptions and responses following the use of a product, system or service. Therefore, usability of IBE tools is determined by the extent to which farmers can efficiently and effectively use these tools to achieve a specific goal and whether their expectations and needs have been adequately achieved in a positive manner. Farmers’ UX relates to their overall perceptions, reactions and responses resulting from their experience of using of an IBE tool such as an agricultural based website. Applying and discussing the constructs of usability and UX relates to each of the research questions in this thesis but particularly to the following research question:

- How can IBE tools be tailored to enable Queensland horticultural farmers to more readily adopt IBE tools?

Overall, farmers from each of the industry groups criticised IBE tools for being out of date, irrelevant, not useful, difficult to find or not satisfying their information requirements. These criticisms are similar to a recent study on usability and users’ experience with e-government websites in India (Kumar, Sachan & Mukherjee 2017). Participants claimed that their experience was unsatisfactory and criticised the websites for not having up-to-date information, pages not loading, login and transaction failures, and poor quality access and design with limited features (Kumar, Sachan & Mukherjee 2017). Addressing these issues, Kumar, Sachan and Mukherjee (2017) recommended that e-government websites be more user-friendly, fast, and up-to-date with current and complete information to enable a more satisfactory UX. A usability study of the Obamacare website conducted by Venkatesh, Hoehle and Aljafari (2017) identified several user interface and usability problems such as citizens having difficulty finding information, excessive navigation links, and unnecessarily complex webpages. The results of a usability study of three e-government websites in the United Kingdom, identified serious usability problems with content update, ease of use and design look (Huang & Benyoucef 2014). These usability studies support the findings of this thesis where farmers’ perceptions of IBE tools indicate a lack of user-friendliness through poor interface design and content issues. Thus, IBE tools should be more user-friendly and up-to-date with current and complete information to enable a more satisfactory UX.

While there appears to be a general understanding of the term usability, Lewis (2014) argues that there has not been a generally accepted definition because usability is an evolving quality that is dependent on individual users and their unique activities, requirements and environments. In terms of the usability of IBE tools, farmers often work
in isolation undertaking their farming activities in their own way but they could all potentially benefit from IBE tools that were more usable and would provide a more satisfactory user experience. Lewis (2014, p. 665) describes a product as usable ‘when people can use it for its intended purpose effectively, efficiently, and with a feeling of satisfaction’ which is almost identical to the definition published by ISO. The definition of usability published by ISO (2018) has evolved over many years and currently states that usability is ‘the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use’. This definition of usability appears to be commonly accepted and is cited repeatedly in the literature albeit with some slight wording differences (Aizpurua, Harper & Vigo 2016; Fernandez, Insfran & Abrahão 2011; Lewis 2014; Moumane, Idri & Abran 2016; Rodríguez, Acuña & Juristo 2015; Sagar & Saha 2017). In this context, the common acceptance of ISO’s definition of usability refutes the claim by Lewis (2014) that usability is too difficult to define and that it is impossible to derive a generally accepted definition.

In applying the concept of usability to farmers’ use of IBE tools, the effectiveness component of usability relates to the farmers’ negative perceptions of the level of accuracy, currency, relevance and completeness of the information obtained from their use of IBE tools. As a result of these perceptions, this research study found that farmers were unable to achieve their goals effectively through the use of IBE tools. The efficiency component of usability is based on resources, such as time, effort and cost, used to achieve the specified goal (ISO 2018). Farmers in this research study indicated that using IBE tools was not worth the investment of their time and effort in obtaining the required information; thus, IBE tools were not able to be used efficiently by farmers in this research study. The satisfaction component of usability relates to whether expectations and needs are satisfied without discomfort and negative attitudes (ISO 2018). Again, farmers using IBE tools in this research study expected to successfully acquire current, relevant and useful information without exerting excessive amounts of time and effort but these needs and expectations were not met and resulted in their negative attitudes. Hence, the goals of using IBE tools by farmers in this research study are not achieved with satisfaction. Given that effectiveness, efficiency and satisfaction are the three critical components of usability (ISO 2018), the farmers’ perceptions of IBE tools therefore reflect poor usability.
While farmers indicated IBE tools were lacking in user-friendliness and ease of use, the concept of usability is a more comprehensive and more significant outcome assessment. Indeed, Fernandez, Insfran and Abrahão (2011) and Rodríguez, Acuña and Juristo (2015) suggest that usability is critical to website quality and success. Earthy, Jones and Bevan (2012) also suggest that a quality interface and interaction is essential for achieving usability. Based on farmers' negative perceptions of IBE tools, the research findings of this thesis indicate that poor usability of IBE tools resulted in poor adoption levels. Based on the research outcomes of Fernandez, Insfran and Abrahão (2011) and Rodríguez, Acuña and Juristo (2015), it can therefore be established that farmers' perceptions of poor usability of IBE tools studied in this thesis also demonstrates that these tools may be lacking in quality and are not perceived to be successful.

In addition to the critical nature of usability to website quality and success, ISO (2010) suggest that usability can be used to assess aspects of user experience (UX). ISO (2010, p. 3) define UX as a ‘person’s perceptions and responses resulting from the use and/or anticipated use of a product, system or service’ and further note that it encompasses human factors such as ‘emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors and accomplishments that occur before, during and after use’. Rosenzweig (2015) also suggests that designing for the UX is multidisciplinary through the integration of fields such as cognitive science, human factors, human memory, perception, accessibility and learning styles. Furthermore, Rosenzweig (2015) emphasises the philosophy that UX places people at the centre of the experience and therefore the design of systems and user interfaces also needs this user-centric focus. The US Department of Health and Human Services (DHHS 2018c) suggests that core factors influencing UX are represented in Morville’s (2018) User Experience Honeycomb as depicted in Figure 7.2. Morville (2018) suggests that the User Experience Honeycomb advances website design thinking beyond usability and that this core set of information related criteria must be satisfied in order to achieve a meaningful and valuable UX. Therefore, integrating these core attributes into the design of IBE tools is likely to improve the UX for farmers using IBE tools.

Kumar, Sachan and Mukherjee (2017) relate usability to the UX of e-government websites and recommend that service providers recognise the impact of UX on the success of e-government services. Similarly, Hui and See (2015) highlight the impact of the satisfaction component of usability claiming that if users do not perceive a website
to be easy to use, the UX would be rated poorly and this may inhibit further use of the website. In this regard, farmers’ perceptions and responses from using IBE tools demonstrates a poor UX based on their negative perceptions of the three usability components of effectiveness, efficiency and satisfaction. Therefore, IBE tools cannot be considered successful from the farmers’ UX perspective.

![User experience honeycomb](source: Morville (2018))

Figure 7.2: User experience honeycomb

In a similar context, Hornbaek and Hertzum (2017) examine the factors that shape the adoption and use of IT by comparing literature on the Technology Acceptance Model (TAM) and UX. TAM considers perceived usefulness and perceived ease of use to determine the intention to use a system (Davis 1989). While TAM was not used for this research study, a pertinent statement made by Hornbaek and Hertzum (2017) can be applied to the five key attributes that affect adoption in the DOI Theory. Hornbaek and Hertzum (2017, p. 2) state that while TAM and UX appear to have different goals and constructs, they are related by the rationale that ‘prediction should ideally inform design and new constructs should ideally solidify and support prediction’. Creating IBE tools with an emphasis on UX and usability concepts should result in good quality and successful IBE tools and this in turn, would improve farmers’ perceptions of the attributes of IBE tools including relative advantage, compatibility, complexity, trialability and observability. Applying the rationale of Hornbaek and Hertzum (2017), IBE tools
designed and developed with usability and UX constructs would then predict a better rate of adoption.

Similar to Hornbaek and Hertzum (2017) suggesting that TAM and UX appear to have different goals and constructs and yet they are related, the researcher proposes that the findings of this thesis suggest that there is an underlying relationship between three of Rogers’ (2003) key attributes and the usability of a website or interface. Like TAM and UX, DOI and usability also appear to have different goals and constructs and yet, they appear to be related. In this thesis, a perceived lack of relative advantage, compatibility and complexity of use resulted in farmers’ perceptions that IBE tools lack user-friendliness. Since usability emerged from the concept of user-friendliness, and user-friendliness is still a component of usability, this thesis indicates that the perceived attributes of relative advantage, compatibility and complexity are related to the concept of usability of a website or interface. The researcher however, has not discovered discussion of this underlying relationship in the literature studied for this thesis. Nonetheless, the findings of this research study suggest that if farmers’ perceptions of IBE tools were more positive they would be more likely to adopt IBE tools. Therefore, designing IBE tools as high quality and more usable tools is likely to increase the adoption rate of IBE tools.

The importance of high quality, usable websites has led to the emergence of various methods and techniques to address and evaluate website usability issues. Moumane, Idri and Abran (2016) suggest that heuristic evaluation, observation, surveys and experimental evaluation are all valid usability evaluation techniques that can be applied either through laboratory tests or field tests. While the interviews conducted with farmers in this research study were based on DOI Theory, the research also addressed concepts of usability through an experimental evaluation technique. Objective and subjective evaluation measures used by Moumane, Idri and Abran (2016) to identify and highlight usability issues with mobile apps, included effectiveness, efficiency and satisfaction. Similarly, Venkatesh, Hoehle and Aljafari (2017) recommend using analytics in future research to predict usability of e-government websites.

7.6 Design of IBE tools

The previous section highlighted the importance of usability and the user experience (UX) and related these concepts to the perceived shortcomings of IBE tools. This section
Chapter 7 – Discussion

discusses design characteristics of web based user interfaces and identifies design principles and guidelines that would increase the usability of IBE tools and enhance the farmers’ overall UX with these tools. Tailoring the design and content of IBE tools relates directly to the following research questions in this thesis:

- How can IBE tools better satisfy Queensland horticultural farmers’ information requirements?
- How can IBE tools be tailored to enable Queensland horticultural farmers to more readily adopt these tools?

Integral to achieving the goals and applying the principles of usability, ISO (2018) advocate a human-centred design approach to the development of interactive systems and websites. A human-centred design approach focusses on the users, their needs and their requirements with the aim of creating more usable and useful interactive systems (ISO 2018). Human-centred design (HCD) is the terminology favoured by ISO (2018) rather than user-centred design, as this expression acknowledges the broader impact on other stakeholders, not just the interface or system users. Earthy, Jones and Bevan (2012) also suggest a user-centred or HCD approach is necessary to create a quality interface and interaction. Therefore, a HCD approach not only enhances effectiveness, efficiency and user satisfaction, but also overall quality. Furthermore, ISO (2018) explains that a HCD approach and usability in particular, also consider users’ personal goals, perceptions, emotional responses and attitudes to the website or system being designed, developed or used.

Therefore, adopting a HCD approach for the design and development of IBE tools should address the UX from the farmers’ perspective. The results of this research study suggest that if farmers perceived IBE tools to be more usable, adoption of these IBE tools would increase. Thus, IBE tools and particularly agricultural websites explored in this research study are likely to be more readily adopted by farmers if a HCD approach, including usability criteria, is utilised for the design and development of these IBE tools. This approach would lead to creating usable, quality and successful IBE tools by enhancing effectiveness, efficiency and user satisfaction and the overall UX.
7.6.1 Human-centred design approach to IBE tools

The overarching purpose of HCD is to consider the end-users and their goals as the driving force behind the design and development of a system, thus focusing on human factors and the way humans interact with computer interfaces. In this context, Del Castello and Braun (2006, p. 4) emphasise that 'successful rural development calls for the conscious and active participation of the intended beneficiaries at every stage of the development process'. Furthermore, a participatory approach utilised in HCD, improves quality and the extent of commitment and acceptance (Pannell et al. 2011; Rogers 2003). Other benefits of a participatory approach highlighted by several researchers (Bell 2015; Hall et al. 2013; Leeuwis & Aarts 2016; Pannell et al. 2011) include:

- recognition by developers that their goals may be different to farmers’ goals;
- less risk of making incorrect assumptions;
- appreciation and application of farmers’ indigenous knowledge;
- promotion of understanding, trust and credibility within the collaborative network;
- participants demonstrate increased accountability and responsibility for decisions; and
- farmers involved in the development process are more likely to adopt the innovation and make it more observable to their farming community.

Applying the modelling outcomes of O’Grady’s and O’Hare’s (2017) smart farm research to IBE tools highlights the integral role that should be played by farmers in the design, development and evaluation of IBE tools. Furthermore, Rodríguez, Acuña and Juristo (2015) confirm the importance of adopting an overall HCD approach, emphasising the core functionality shortcomings that may result if usability issues are not included in the early development process. The ISO (2010, p. 5) standard 92410-210 also confirms the importance of user-involvement in a HCD approach advocating six principles that should be followed:

- the design is based upon an explicit understanding of users, tasks and environments;
- users are involved throughout design and development;
• the design is driven and refined by user-centred evaluation;
• the process is iterative;
• the design addresses the whole user experience; and
• the design team includes multidisciplinary skills and perspectives.

A HCD approach can be integrated with modern adaptive or agile systems development methodologies. These methodologies are based on iterative development and the flexibility to adapt to required changes as development proceeds. Users should generally be considered important throughout the overall development processes within these methodologies. HCD, however, emphasises a stronger focus on users and usability as promoted in ISO’s (2010) six HCD principles listed previously. Furthermore, the ISO standards for HCD of interactive systems described in ISO 9241-210 (ISO 2010), state that the objective of a HCD approach is to develop usable and useful systems by focusing on human factors, and users’ needs and requirements. Therefore, designers of IBE tools need to understand and incorporate the farmers’ perspectives, needs and goals in their design and development approach in order for IBE tools to be successful and therefore increase adoption and usage.

While this may be challenging in practice, O’Grady and O’Hare (2017) suggest that failure to adopt this approach can result in needs not being satisfied, and technologies that may be deficient in usability and functionality. Similarly, Pearrow (2007) suggests that often a gap exists between users and designers or there is a lack of interaction between designers and users which commonly results in an unusable design. Caron, Biénabe and Hainzelin (2014) also emphasise the critical role of farmers’ knowledge and expertise in the design of new agricultural technologies and practices.

More specifically, ISO (2010) attributes one of the main causes of systems failure to an inadequate understanding of users’ needs. Through an apparent lack of understanding of farmers’ perspectives, needs and goals, the farmers’ overall experience with IBE tools has led to their perception that IBE tools are deficient in usability and functionality. Hence, the failure of current IBE tools is attributed to the absence of implementing HCD principles.
The implementation of a HCD approach requires the integration of various HCD methods and activities into the overall systems design project plan as shown in the HCD process map Figure 7.3 published by DHHS (2018e).

Figure 7.3: Human-centred design process map
*Source: DHHS (2018e)*

While some process steps in the model (Figure 7.3) do not explicitly state the user focus, exploration of the associated guidelines (DHHS 2018a) clearly identifies and emphasises that focus. For example, in the planning phase it is recommended that time and resources be included in the project plan to enable usability activities to be undertaken (DHHS 2018e). Therefore, in the design of IBE tools, time and resources should be allocated in the plan to identify the target audience, that is, whether the target audience is all farmers or perhaps those in a specific industry group. Time and resources should also be allowed in developing the plan to ascertain the user goals. In the design of IBE tools, time and resources should be allocated to explore what farmers hope to achieve when using proposed IBE tools. Furthermore, usability measures should be developed within a set of measurable objectives to determine the level of effectiveness, efficiency and satisfaction of the farmers’ experience. These objectives would be evaluated in the test and refine phase (DHHS 2018e).
According to ISO (2010), four specific HCD design activities should be undertaken in the HCD approach to any interactive system. These interactive design activities illustrated in Figure 7.4 are not designed as a linear process but instead, each activity uses outputs from other activities.

**Figure 7.4:** Human-centred design activities  
*Source: Hennigs (2014) and ISO (2010)*

ISO’s model of human-centred design activities and adaptations of this model, are applied by various authors (Farinango et al. 2018; König, Hofmann & Bruder 2012; Mirnig et al. 2015). For example, König, Hofmann and Bruder (2012) evaluate ISO’s HCD process model in the design of an air traffic control interface emphasising the need for iterative adaptation of requirements and usability criteria but also highlighting the benefits of adopting the process.

The findings of this thesis suggest that HCD strategies need to be developed and strengthened in the agricultural industry to increase the usability of IBE tools and generally improve extension services that rely on the effectiveness of IBE tools. Goodman, Kuniavsky and Moed (2012) state that ‘ultimately, usability is good design’ and that UX is the cornerstone to a successful technology product. Similarly, Huang and Benyoucef (2014) advocate that in order to increase user satisfaction it is essential for developers of e-government websites to regularly analyse and enhance usability. Thus,
user interface principles and guidelines should be integral to the development of these HCD strategies to facilitate the design of usable and functional IBE tools.

7.6.2 Design standards, principles and guidelines

Extensive research literature regarding usability features of human computer interfaces has resulted in the establishment of numerous sets of user interface standards, principles, guidelines, checklists, quality attributes and evaluation heuristics, to facilitate the design of more usable, functional and successful websites (Goodman, Kuniavsky & Moed 2012; ISO 2008; Molich & Nielsen 1990; Shneiderman & Plaisant 2005; User Experience Professionals’ Association 2012). Similarly, there are numerous authoritative books written on human computer interaction, web usability and designing the user interface. Much research is also based on established sets of guidelines. For example, in their evaluation of the usability of open course ware websites, Rodríguez, Acuña and Juristo (2015) use the ISO 9241 series of design standards for ergonomics of human-system interaction. Similarly, Venkatesh, Hoehle and Aljafari (2017) base their usability study of the Obamacare website on the usability.gov guidelines established by the US Department of Health and Human Services (DHHS 2018a).

However, Adams, Lunt and Cairns (2008) suggest that usability is not intrinsically objective and that designers require an understanding of the subjective nature of usability issues experienced by users. No doubt the designers of IBE tools have agricultural expertise and knowledge and realise the potential value in sharing their information, but it is apparent from farmers’ negative responses to IBE tools, that the subjective nature of usability and the human factors pertaining to farmers, has been overlooked. While it is essential to include human factors in the design process, this also adds to the complexity and yet also the comprehensiveness of the design because human factors include perceptions and judgement which are subjective. This suggests that further subjectivity will evolve through designers’ and evaluators’ interpretations of the users’ perspective further contributing to the challenge of developing usable and functional IBE tools.

Nonetheless, Agarwal and Venkatesh (2002) consider that usability evaluations start with the basic assumption that fundamental usability features can be identified. For example, if the design of IBE tools was based on farmers’ perspectives, some of the fundamental usability features would include simple and more direct navigation, relevant
information and up-to-date content. In their analysis of critical website characteristics, Tarafdar and Zhang (2006) confirm that relevant and current information content, as well as navigation design are essential for effective usability of websites. While these fundamental usability features could be interpreted as subjective from a designer’s perspective, there would be little chance of misinterpreting these fundamental features if the farmers’ perspectives, needs and goals were the driving force behind the design.

Some of the established sets of guidelines and standards are exceedingly long and technically centred with a target audience, such as software engineers, requiring familiarity with advanced technical concepts. For example, Zeldman and Marcotte (2010, p. 53) discuss web standards using the ‘Trinity of Web Standards’ which breaks the web page into three components: structure, presentation and behaviour. From a non-technical perspective, this component breakdown might suggest the delivery of principles or guidelines relating to the arrangement or location of information on a website, the colour scheme and navigation management. On the contrary, Zeldman and Marcotte (2010) explain how to control the three components using technical methods and techniques:

- Using extensible markup language to control the structure of headings and paragraphs;
- Using presentation languages such as CSS to control features such as colour, typography and margins; and
- Using ActiveX and JavaScript to control website behaviours and effects across different platforms.

Likewise, the broad scope of the Usability Body of Knowledge (User Experience Professionals’ Association 2012) refers to eight principles for usable design as shown in Table 7.1, but expands this to include various technical and project based elements such as hierarchical and cognitive task modelling, parallel design, and platform and domain specific design issues. Similarly, ISO (2008) guidance on HCD of World Wide Web user interfaces is based on five dimensions as shown in Table 7.1 but designates a checklist with over one hundred and eighty specific standards or subclauses.
While various user interface standards and guidelines would facilitate the design of IBE tools, many of these are outside the realms of farmers’ perspectives and criticisms of IBE tools. For example, farmers did not comment on interface components such as privacy, credibility, search provisions, acceptable download times, feedback availability, text design, or colour schemes. While these components contribute to the usability of an interface and should not be overlooked by designers, they are not perceived by the farmers as deficiencies in IBE tools. Therefore, this thesis does not extend to those highly technical elements; nor does it propose that the extensive lists of best practice elements and features researched and published by organisations such as ISO and DHHS (usability.gov) are all relevant to the discussion pertaining to farmers’ perspectives and experience with IBE tools. Instead, this discussion targets the usability features that are perceived by farmers’ in this research study to be deficient and identifies HCD and usability principles and guidelines that address these deficiencies.
7.6.3 Identification of IBE tool usability issues

To further clarify the approach taken in this research study, rather than limiting the discussion to one set of established principles and guidelines, the researcher has used a combination of guidelines, principles and standards from the following HCD and usability sources:

- ISO 9241-151 Guidance on World Wide Web user interfaces (ISO 2008);
- UK Government design principles (GOV.UK 2012);
- Usability Body of Knowledge Principles for Usable Design (User Experience Professionals’ Association 2012); and
- Usability.gov (DHHS 2018a) guidelines and standards.

Therefore, farmers’ perceived usability deficiencies in IBE tools will be addressed in the following sub-section in the context of these four sets of established principles and guidelines according to their relevance.

This is a valid approach which specifically identifies and highlights usability dimensions applicable to the local context and is similar to methods adopted by other researchers in this domain (Huang & Benyoucef 2014; King & Youngblood 2016; Sá et al. 2017). For example, King and Youngblood (2016) adopted a similar approach of establishing their evaluation criteria based on various sources of best-practice guidelines in their assessment of the functionality and usability of e-government voting websites in Alabama. Similarly, Sá et al. (2017) analysed various approaches in the literature to measure the quality of local government online services. Likewise, Huang and Benyoucef (2014) in their evaluation of usability and credibility, tailored their set of heuristics from already established guidelines to align with the specific needs of e-government websites.

While only a subset of principles, guidelines and standards will be used in the following sub-section to address farmers’ perceived usability deficiencies of IBE tools, it is still essential to adopt an overall HCD development approach to IBE tools. The HCD standards already applied in the development and delivery of IBE tools should be maintained and monitored for continued usability and UX. Furthermore, applying a full
set of standards through the adoption of HCD principles and design activities discussed previously, should drive the design and development of any new IBE tools.

Analysing various published sets of user interface principles, guidelines and standards informed the development of the following actionable components perceived by the researcher as being directly relevant to the usability deficiencies encountered by farmers when using IBE tools (DHHS 2018a; GOV.UK 2012; ISO 2008; Shneiderman & Plaisant 2005; User Experience Professionals’ Association 2012). Overall, farmers’ perceptions of IBE tools identified the following issues that lower the usability of IBE tools and negatively impact the farmers’ UX:

- Information is not useful;
- Information/tools are not relevant,
- Information is not current;
- Navigation issues
- Not easy to use

Commonly identified in the literature (Hernández, Jiménez & Martín 2009; Venkatesh, Hoehle & Aljafari 2017), these user interface design issues are fundamental to users’ perceptions of usability and functionality. For example, Hernández, Jiménez and Martín (2009) research on key website factors in e-business strategy, suggest that significant weaknesses with websites could be avoided if the information content was accurate, useful, current, and relevant to the users’ requirements. Kumar, Sachan and Mukherjee (2017) recommended that e-government websites be more user-friendly, fast, and up-to-date with current and complete information to enable a more satisfactory UX. Likewise, Venkatesh, Hoehle and Aljafari (2017) found that interface design issues affecting various usability issues, such as UX, navigation and content, largely contribute to poor performance of websites.

### 7.6.4 Addressing IBE tool deficiencies with HCD standards

The main goal of a HCD approach is to make user interfaces and supporting systems usable and useful for users. To achieve this goal with IBE tools, systems analysts and designers must focus on farmers’ needs and requirements and integrate the four HCD
design activities advocated by the ISO 9241-210 (ISO 2010) standards for HCD interactive systems. These design activities (ISO 2010, p. 11), depicted in Figure 7.4, include the following:

- understand and specify the context of use;
- specify the user requirements;
- produce design solutions to meet user requirements; and
- evaluate the designs against requirements.

Several user research methods can be used to facilitate the implementation of these design activities. Like the design activities, user research methods should be used iteratively throughout the overall HCD process. User research methods enable a better understanding of users’ needs, expectations and behaviours (DHHS 2018d), thus improving usability and functionality. Therefore, the usability and functionality of IBE tools could be improved by integrating user research methods into the four design activities advocated by ISO (2010). In particular, usability.gov (DHHS 2018d) recommends the user research methods presented in Table 7.2 should be used by systems analysts and designers of IBE tools throughout the HCD process.

The perceived usability deficiencies of IBE tools identified in sub-section 7.3.3 Identification of IBE tool usability issues (usefulness, relevance, currency, navigation, and ease of use) are addressed here in the context of usability, HCD standards and guidelines, and the user research methods listed in Table 7.2.

• **Usefulness**

The Usability Body of Knowledge (User Experience Professionals’ Association 2012) specify that a well-designed user interface must be useful and provide value by addressing users’ needs. Similarly, ISO (2008) guidelines on content design, stipulate that content should be suitable for the target audience’s tasks. The farmers’ perspectives of the Agbiz farm budgeting tools (Business Queensland 2016a) indicate that farmers’ needs have not been satisfactorily addressed and the content is not suitable for their farming tasks. Hence these IBE tools are not perceived to be useful by those farmers interviewed in this research study.
<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus group</td>
<td>Facilitates learning about users’ requirements, goals, desires, attitudes and general ideas through moderated discussions with a group of users.</td>
</tr>
<tr>
<td>Individual interview</td>
<td>One-on-one discussions with users to obtain detailed information about individual users’ ideas, requirements, goals, attitudes and experiences.</td>
</tr>
<tr>
<td>Contextual interview</td>
<td>Observation of users in their natural environment, providing an effective understanding of the way they work.</td>
</tr>
<tr>
<td>Survey</td>
<td>A series of questions to acquire information about multiple users and their requirements, perceptions and attitudes of an existing or proposed user interface.</td>
</tr>
<tr>
<td>Task analysis</td>
<td>Involves learning about user goals, including what users want to do on your website, and helps you understand the tasks that users will perform on your site.</td>
</tr>
<tr>
<td>Personas</td>
<td>Representations of key user groups clearly identifying users’ needs, expectations and how they will use the site; ascertains required features and functions.</td>
</tr>
<tr>
<td>Card sorting</td>
<td>Facilitates design and evaluation of the information architecture by allowing users to group the site’s information which results in matching the site structure to the way users think.</td>
</tr>
<tr>
<td>Use cases</td>
<td>Describes a sequence of simple steps representing how users will accomplish a task and explains the system’s behaviour as it responds to the user’s request.</td>
</tr>
<tr>
<td>Prototyping</td>
<td>Allows designers to create a mock-up of the site in the planning and designing phases to gather users’ feedback and make changes early in the development process.</td>
</tr>
<tr>
<td>Parallel design</td>
<td>Several designers work independently to create an initial design; the best aspects from each design are integrated into the final solution.</td>
</tr>
<tr>
<td>First click testing</td>
<td>Examines the effectiveness of the linking structure and ease of navigation by tracking the clicks or navigation path used by a test participant to complete an intended task.</td>
</tr>
<tr>
<td>Usability testing</td>
<td>Identifies users’ frustrations, problems and/or satisfaction when users try to complete typical tasks on the site interface.</td>
</tr>
<tr>
<td>Heuristic evaluation</td>
<td>Usability experts evaluate the site’s interface against a list of accepted usability principles and established guidelines.</td>
</tr>
<tr>
<td>System usability</td>
<td>Effectively differentiates between usable and unusable systems. This tool is a subjective usability evaluation completed by users rating ten questions about their use of a site interface from Strongly Agree to Strongly Disagree.</td>
</tr>
</tbody>
</table>

Table 7.2: User research methods  
Source: DHHS (2018d)
The designer of these IBE tools may argue with this research finding based on the webpage analytics displaying recent and total views including over three hundred total views for one of the gross margin assessment tools. This indicates the number of times the links have been clicked but is not an established indicator of the value or usefulness of these tools. While these analytics are likely to be of interest to the developers of these IBE tools, they provide no value to the farmers and are perhaps better explored through the website log. While Venkatesh, Hoehle and Aljafari (2017) recommend using analytics in future research to predict usability of e-government websites, leveraging constructive and meaningful usability analytics about the Agbiz farm budgeting tools requires more extensive data than tracking total visits. Tracking inbound website traffic may provide some insight to the effectiveness of inbound strategies or growth driven design but it is not an indicator of usefulness or usability which are both subjective and qualitative in nature.

Further issues with the usefulness of IBE tools were highlighted with several farmers suggesting that video clips on industry websites are not useful. These IBE tools tend to reinforce current practice but do not offer new and innovative practices. Nonetheless, many farmers in this research study believed that some of their farming activities were particularly suited to the application of IBE tools. The researcher conducted individual and contextual interviews revealing farmers’ perceptions that IBE tools facilitating the following would be useful:

- An online spray diary or the ability to download a template (given the requirement to maintain accurate documentation of chemical application procedures and practices);
- Pineapple farmers suggested that results of trial work would be useful but an IBE tool of this nature is likely to be useful for each of the industry groups;
- Video clips demonstrating new or innovative techniques;
- Blogs that enable farmers to upload photos and seek expert advice;
- Discussion forums enabling collaboration, information sharing and ad-hoc queries would be useful, particularly for farmers seeking feedback on similar situation-specific complexities as suggested by Starasts (2015). However,
evidence of credibility and reliability would be necessary to gain farmers’ trust possibly through professional monitoring; and

- Some farmers consider an electronic version of their industry pocket guide would be a useful IBE tool e.g. the Pineapple Best Practice Manual which was distributed to all pineapple growers as hardcopy consisting of thirty-eight chapters and over three hundred and sixty pages Newett (2016).

Thus, individual and context interviews should be conducted with prospective users of new IBE tools to understand and learn more about the individual users and their requirements for the development of useful IBE tools. Prior to these interviews, focus group interviews and surveys could be conducted with farmers and other stakeholders from specific industry groups to gather users’ requirements, goals, desires, attitudes and general ideas about potential IBE tools to ensure that these tools would be useful. Task analysis and card sorting could also be undertaken in the early stages of developing new IBE tools to further understand and specify the context of use and confirm that IBE tools will be useful. Similarly, personas may be created in the early stages of developing new IBE tools to facilitate in understanding site functionality, identifying gaps, or highlighting opportunities (DHHS 2018d). Later in the design and development of IBE tools, prototyping should be introduced to gauge farmers’ attitudes and obtain their feedback. Farmers should also be involved in testing IBE tools and evaluating the usability and usefulness throughout the development of these tools.

- **Relevance**

ISO (2008) guidelines on content design also state that information content should be relevant to the users’ information requirements and their particular tasks. The Usability Body of Knowledge (User Experience Professionals’ Association 2012) also states that the information should be relevant to the users’ context. Farmers’ responses from each of the four industry groups suggest that IBE tools are not relevant to their farming activities. For example, several of the strawberry and pineapple farmers interviewed expressed negative views regarding the relevance of information on the Growcom (2016b) and Hort Innovation (HIA n.d.) websites. These farmers perceive relevant content must be specific to their industry group and specific to their farming activities. Therefore, the previously listed IBE tools perceived as being useful (under the heading ‘Usefulness’), should also be designed to satisfy the relevance criteria. Using a HCD approach, this could be achieved by designing these IBE tools for each specific industry
group and then locating them on the relevant industry group webpage and/or on the relevant industry webpage on the DAF website.

Scientific research articles are another example of IBE tools that are perceived by farmers as irrelevant. Published research resources are available on the DAF website within each of the respective industry webpages via a link to DAF’s eResearch Archive. First, the name of the link is possibly misleading with ‘archive’ commonly interpreted as historical storage rather than current. Second, several of the articles are freely available only to members of the International Society for Horticultural Science or through licensed access to electronic databases. Third, several articles available via these industry specific links are discernibly not relevant to the respective industry group. For example, on DAF’s (DAF 2014b) eResearch Archive for macadamias, the word ‘macadamia’ appears twice in over three hundred and fifty pages of the three most recent research resources. Last, information presented in scientific research articles does not align with the needs of those farmers interviewed in this research study.

Farmers are certainly amenable to exploring innovative techniques and recognise the potential of research outcomes but they need access to relevant information that is in a format that they can readily understand and utilise. Farmers consider it challenging to extricate the practical implications from scientific research perceived to be written in recondite language and jargon and largely directed at an academic audience interested in literature reviews, research methods, hypotheses as well as the scientific results. A large proportion of any research article is therefore perceived to be irrelevant to farmers; they are only interested in the results and how they can be applied on-farm.

Starasts (2015) confirms this mismatch between scientific research information compared to the practical and usable information that farmers need, in her research on the challenges of accessing digital information with the capacity to improve farmers’ decision-making and contribute to productivity improvements. Likewise, Kiem and Austin (2013) highlight the gap between scientific information providers and end-users’ needs, further suggesting that a ‘knowledge broker’ is required to translate the scientific information into usable information more suited to the end-users. Including a knowledge broker for the development of IBE tools would be an ideal method to facilitate the transformation of scientific research information into practical and relevant information. The role of knowledge broker here may be undertaken by an extension agent or possibly
a business analyst with an in-depth understanding of the science of agriculture, farming and farmers. A suitable method of delivering this information to farmers may be in the form of fact sheets and/or video-clips posted on agricultural based websites, clearly and simply describing or demonstrating how the research outcomes can be utilised by farmers. A similar view is presented by Caron, Biénabe and Hainzelin (2014) in their research on ecological intensification of agriculture. They discussed the arrangements through which scientific knowledge is produced and shared and suggested that perhaps researchers play the role of intermediary in addition to being the broker of scientific knowledge (Caron, Biénabe & Hainzelin 2014). The research outcomes from both Kiem and Austin (2013) and Caron, Biénabe and Hainzelin (2014) suggest that scientific knowledge has no value to farmers unless it is translated into language that they understand and reduced to the level where it can be applied in the local context. Once it is in this format, it can be delivered to farmers as a relevant and usable IBE tool.

In order to design IBE tools that are perceived by farmers to be relevant to their farming industry and activities, systems analysts and designers must focus on farmers’ needs and requirements. This can be achieved by integrating user research methods listed in Table 7.2 into the HCD process activities, particularly in the early phases of understanding and specifying the context of use, specifying the user requirements, and producing design solutions to meet farmers’ requirements. Throughout the HCD process activities, user research methods would need to specifically address the relevance of potential IBE tools. As previously discussed, the farmers and any other stakeholders would need to participate in these activities so that their needs, tasks, and objectives are the primary focus of the design process.

Ideally, elicitation of requirements could be customised for individual industry groups by recruiting industry group members for separate industry based focus groups. For this purpose, a practical way to access industry group members would be to attend one of their regular industry group meetings, best practice meetings or study group meetings. Farmers and other stakeholders could be recruited from these meetings to participate in further user research methods to ensure the users’ perspectives are ascertained and that relevant IBE tools are developed. In addition to focus groups, user research methods enlisting the active involvement of farmers would include individual and context interviews, surveys, task analysis, card sorting and prototyping. It is also advised that
farmers and other stakeholders participate in activities aimed at testing and evaluating the design of potential IBE tools in terms of overall usability including relevance.

• **Currency**

The currency of a web user interface is particularised in the ISO (2008) guidelines on content functionality where it stipulates that out-of-date content should not be shown to the user. From the farmers’ perspective it was established that access to up-to-date information is an essential usability feature in IBE tools. The usability.gov (DHHS 2018a) guidelines and standards state that maintaining up-to-date website content increases website credibility. Huang and Benyoucef (2014) also discovered that a lack of information currency was one of the most severe problems affecting e-government website credibility. Many farmers’ claimed that information and photographic content was too old on some agricultural websites and this forced them to investigate other information sources. Similarly, there is a lack of currency evident on many DAF webpages with some showing the latest update dating back to 2010.

Given that farmers perceive currency of information available from IBE tools as an essential feature of usability and functionality, the developers of these tools need to be mindful of this criterion. Essentially, this highlights the need for systems analysts and designers to be cognisant of the importance in understanding and learning about the users, their requirements, goals, desires, attitudes and general ideas about potential IBE tools. Developers of IBE tools can only know what is important to the farmers by asking the right questions, listening, understanding and empathising. Recognising the critical nature of currency from the farmers’ perspective is an essential usability feature of IBE tools and will be reflected in the overall success and quality of those IBE tools.

Certainly, it is fundamental for IBE developers to ascertain essential usability criteria from farmers throughout the HCD process activities by applying the various user research methods described in Table 7.2. However, another requisite characteristic of currency that needs to be addressed by developers is its enduring nature. The ISO (2008) standards for World Wide Web user interfaces state specifically that content should be kept up to date and that the date of the last update should be available for users to judge the relevancy and quality of the information. Therefore, not only is it essential for IBE tools to be current when they are first implemented, but their currency needs to be maintained, thus implying the need for ownership and responsibility of IBE tools.
Anecdotal evidence suggests that ownership and responsibility is often attached to a specific person in an organisation and with staff turnover, these responsibilities can be overlooked. In practice these potential workplace changes need to be addressed and appropriate procedures put in place so that long-term currency of IBE tools is maintained. This could be achieved by allocating the ownership and responsibility to a specific work area or job role in an organisation rather than to a specific staff member.

**Navigation**

Research conducted by Venkatesh, Hoehle and Aljafari (2017) showed that interface design issues included poor navigation where users had to click several times to locate the required information. This confirms the research findings of this thesis where excessive clicking of links on agricultural webpages was also a navigation issue identified by several farmers. For example, a farmer may have to navigate through more than ten links on the Business Queensland website (Business Queensland 2016b) to locate comprehensive guidance and information on the application of agricultural chemicals. The excessive clicking of links was perceived by farmers as a negative characteristic contributing to poor usability.

King and Youngblood (2016) found that e-government voting websites displayed navigational shortcomings with large navigational groupings which hampered users’ ability to traverse the web pages. The research findings of this thesis identify a similar navigational issue experienced by horticultural farmers attempting to locate specific information on the DAF website. In particular, farmers criticised the need for numerous menus with numerous links to webpages with further menus thus requiring excessive clicking of links. To resolve this navigational issue, usability.gov guidelines (DHHS 2018b) suggest that ‘Anchors’ provide a preview of content with a clickable list of sections and also enable fast access to information. Cascading menus would also reduce excessive navigational links. ISO (2008) also recommend that navigation effort should be minimised and that displaying several links on one page through broad navigation structures is preferred over deep structures with several navigation steps.

Farmers also identified various links that do not work on the DAF website. ISO (2008) recommend that links leading to pages that do not exist or are not functional should be avoided. Furthermore, ISO (2008) recommend that usable navigation structures can be achieved if they are based on content structure that reflects the users’ tasks and
information requirements. Various user research methods described in Table 7.2 can be adopted by designers of IBE tools to create usable navigation structures that avoid farmers’ perceived navigational issues. The content structure of IBE tools should be designed by focussing on farmers’ task requirements and matching the site structure to their preferences. For example, designers could identify the intuitive sequence of steps representing how farmers will accomplish a task and then represent this workflow with use cases (DHHS 2018d). Card sorting (DHHS 2018d) is another user research method that could be adopted to facilitate the design of the information architecture by allowing farmers to group the site’s information thereby matching the site structure to the way farmers think. Prototyping methods (DHHS 2018d) could also be used to create a mock-up of the IBE tool in the planning and designing phases to gather farmers’ feedback and make changes early in the development process. Other user research methods could also be adopted to identify navigational issues in the linking structure of IBE tools effectively differentiating between usable and unusable IBE tools from a farmer’s perspective. These user research methods must involve farmer participation to specifically test and evaluate IBE tools including first click testing, usability testing, and system usability scale.

• Easy to use
Research evaluating usability, UX and the success of e-government websites commonly identifies the perceived ease of use as a factor influencing the use and acceptance of e-government services (Al-Hujran et al. 2015; King & Youngblood 2016; Venkatesh, Hoehle & Aljafari 2017). For example, Venkatesh, Hoehle and Aljafari (2017) reported UX issues including poor streamlining of content and difficulty finding information. King and Youngblood (2016) established that website usability is directly linked to how easy a website is to use.

Based on the Technology Acceptance Model (Davis 1989) results from Al-Hujran et al. (2015) research determined that users’ attitudes toward using e-government services are determined by their perceived ease of use as well as perceived value of the website. They also established that attitude is the most significant determinant of intention to adopt e-government services (Al-Hujran et al. 2015). Similarly, Dwivedi et al. (2017) validated their research model ‘unified model of electronic government adoption’ confirming that performance expectancy and effort expectancy have a significant impact on attitude. In terms of e-government usability Dwivedi et al. (2017) also confirmed that
a user’s attitude will be determined by the extent to which an e-government service may prove useful and beneficial combined with the extent to which it may be easy to use. In part, this explains the poor adoption of IBE tools because farmers perceive IBE tools to be difficult to use and have no relative advantage or perceived value, thus contributing to farmers’ negative attitude to IBE tools.

The findings of this thesis established that several factors contribute to the difficulties experienced by farmers using IBE tools. These factors were analysed and discussed in terms of complexity and Rogers’ (2003) Diffusion of Innovations theory and include issues relating to usefulness, relevance, currency, and navigation. While these issues have already been discussed in this sub-section, each of these issues contributes to farmers’ perceptions that IBE tools are not user friendly and overall, they are not easy to use. Farmers also raised further issues that contribute to their perceptions that IBE tools are difficult to use or understand including findability, cluttered webpage structure and authentication issues. These issues could be addressed and resolved by designers of IBE tools through better understanding usability and functionality concepts and the adoption of HCD standards and user research methods.

King and Youngblood (2016, p. 721) established that many e-government websites ‘fail in findability and overload navigation’ and as a consequence, users have difficulty locating e-government services and further difficulty finding specific information. The Agbiz farm budgeting tools (Business Queensland 2016a) also fail in findability as they are not logically or intuitively located. ‘Build digital services, not websites’ is a design principle used by the UK Government (GOV.UK 2012) and the Australian Government (DTA 2015) which advocates that putting anything online that the audience cannot find is futile. While this appears to be stating the obvious, it requires developers of IBE tools to empathise with the target audience and acknowledge that they have different perspectives. Thus, building digital services for farmers requires a real connection with them to enable the development of usable and functional IBE tools. Designers of IBE tools could achieve this fundamental guideline by adopting user research methods described in Table 7.2. For example, involving farmers in user research methods such as card sorting, use cases, prototyping, first click testing, usability testing, and the system usability scale would establish that the Agbiz farm budgeting tools would be more appropriately located on the main DAF website thus eliminating the findability issue.
Another issue addressed by the UK Government (GOV.UK 2012) design principles advocates the structure of a website should be meaningful for the user although this may not align with the information providers’ perspective. This is demonstrated on DAF’s homepage that farmers consider to be cluttered and the structure not intuitive and yet there are features on the homepage that would require input from a technically skilled designer. From the farmers’ perspective, however, the structure of this website is not streamlined and not easy to use. Similarly, Venkatesh, Hoehle and Aljafari (2017) identified UX issues including difficulties using e-government websites which arise because the content is inadequately streamlined and further difficulties arise in trying to find information.

Venkatesh, Hoehle and Aljafari (2017) also highlight the UX issue relating to logins. Issues with mandatory registration on websites is not unique to farmers but the requirement to create usernames and passwords for various agricultural websites including the farmers’ industry website, Growcom and Freshcare, in addition to several other accounts required for websites such as banking, health, internet, utilities and e-government services, is an issue that several farmers raised in the context of difficulties using IBE tools. Belk et al. (2015) suggest that as well as security aspects, the authentication process should also embrace usability and transparency for users. Kumar, Sachan and Mukherjee (2017) propose that usability and the UX will be improved with the integration of e-services through a portal using a single sign-on to access the portal. While usability is an essential design component that should not be compromised, Alsaiari et al. (2016) maintain that a balance between usability and security is required for a successful authentication mechanism. Nonetheless, research conducted by Ruoti, Roberts and Seamons (2015) indicates that authentication mechanisms are still dominated by passwords despite numerous attempts to replace them with more usable alternatives.

The difficulty of remembering usernames and passwords is further exacerbated for farmers using small screens such as mobile phones or even tablets. Preuveneers and Joosen (2015) confirm that the requirement for strong passwords on mobile devices produces a low usability rating. While this may not appear to be a serious problem directly related to the design of IBE tools, difficulties remembering numerous usernames and passwords commonly results in farmers being unable to access online services or being frustrated. The outcome of this UX is the perception that IBE tools are difficult to
use. Therefore, designers of IBE tools need to address this authentication issue in terms of usability and security and discuss the alternatives with farmers and other stakeholders to determine the best option.

One alternative would be to eliminate the authentication process altogether given that farmers believe the authentication measures are unwarranted for accessing what they perceive to be non-sensitive data. Conversely, if security needs to be maintained, there are several other options that might be considered (Alsaiari et al. 2016; Belk et al. 2015; Ruoti, Roberts & Seamons 2015) including the following:

- Passphrases (replaces a password with a phrase that is more easily remembered by the user);
- Federated single sign-on (e.g. through Facebook, Google or LinkedIn);
- Email-based single sign-on (users choose which email provider to use);
- Graphical passwords (based on user selected pictures stored as the authentication key);
- QR codes (user’s credentials are encoded in a QR code); and
- Biometric authentication (using fingerprints, retina scans, facial recognition, voice recognition).

Addressing the farmers’ authentication issues would require designers of IBE tools to research and evaluate various authentication alternatives and also ascertain essential usability criteria from the farmers. Exploring farmers’ views, discussing and testing alternatives, gathering feedback and deciding on the best authentication option could be achieved through various user research methods described in Table 7.2 such as focus groups, interviews, task analysis, prototyping and usability testing. Resolving farmers’ perceived authentication issues would thereby contribute to the design and development of easy to use IBE tools.

Adoption of a HCD approach and user research methods as discussed in this section and the previous section of this chapter, would facilitate inclusiveness and engagement of stakeholders early in the process of developing IBE tools. Therefore, this approach
has the potential to address farmers’ information needs and positively change the development, design and overall usability of IBE tools.

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<th>Promotion strategy</th>
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<tr>
<td>Target and tailor robust communication</td>
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<td>Facilitate effective communication and interaction with farmers</td>
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<tr>
<td>Customise according to characteristics and needs of the target audience</td>
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<tr>
<td>Use a variety of communication methods or channels</td>
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<tr>
<td>Generate and reinforce farmers’ knowledge and awareness (awareness knowledge) of IBE tools</td>
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<td>Generate and reinforce farmers’ knowledge of the functionality, relevance and benefits (principles knowledge)</td>
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<th>Training and support strategy</th>
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<td>Enhance the capacity for farmers to adapt and change</td>
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<td>Increase confidence and self-efficacy</td>
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<td>Establish farmers’ awareness knowledge and principles knowledge prior to training</td>
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<tr>
<td>Analyse learning needs</td>
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<tr>
<td>Increase digital ability through basic skills development</td>
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<tr>
<td>Offer training targeted at specific IBE tools</td>
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<tr>
<td>Deliver a variety of training and support methods</td>
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<td>Provide supplementary training materials</td>
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<tr>
<th>Design and development strategy</th>
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<tr>
<td>Adopt a human-centred iterative design approach (end-users are the driving force)</td>
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<tr>
<td>• understand and specify the context of use</td>
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<tr>
<td>• specify the user requirements</td>
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<tr>
<td>• produce design solutions to meet user requirements</td>
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<tr>
<td>• evaluate the designs against requirements</td>
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<tr>
<td>Focus on achieving usability and user experience</td>
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<tr>
<td>Satisfy requirements for usefulness, relevance, currency, navigation, and ease of use</td>
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<tr>
<td>Incorporate User Research Methods including:</td>
</tr>
<tr>
<td>• Focus group, individual interview, contextual interview, survey, task analysis, personas, card sorting, use cases, prototyping, parallel design, first click testing, usability testing, heuristic evaluation, system usability scale</td>
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Table 7.3: Guidelines for promotion, support and design of IBE tools
7.7 **Guidelines for promotion, support and design of IBE tools**

The previous sections have discussed various approaches and strategies for better promotion, support and design of IBE tools. By integrating the main elements of these approaches and strategies, a set of guidelines or design principles has been established (Table 7.3). This comprehensive set of guidelines specifically addresses the fourth research question:

- How can IBE tools be tailored to enable Queensland horticultural farmers to more readily adopt these tools?

While the guidelines in Table 7.3 have been established, implementation of the guidelines is also an important aspect of the process of effectively promoting, supporting and designing IBE tools. As discussed in the Literature Review chapter of this thesis, consideration of change management principles may be appropriate for the implementation of the recommended guidelines. The application of change management principles facilitates a planned, managed, and systematic approach applied to the integration of change (Waddell et al. 2017). There are five main activities in the change management process including motivating change, creating a vision, developing political support, managing the transition and sustaining momentum (Waddell et al. 2017).

Change management recognises the environment in which the changes will occur, the factors that will be influenced by the change, and the elements that will need to change (Johnson 2001). It also enables those elements to be changed by ensuring that the processes are put in place to cater for the changes (Abusamhadana & Elias 2018). From the perspectives of both the farmers and extension agents, the changing environment includes strategic, cultural, technological and behavioural factors, together with the farmers’ goals and perceptions. These elements need to be linked to form a synergy where all stakeholders strive to achieve the same objectives. This comprehensive approach to promoting, supporting and designing IBE tools has the potential to dramatically change the perceptions of Queensland horticultural farmers and increase adoption and their effective use of IBE tools.

7.8 **Synthesis**

As discussed in the Literature Review chapter of this thesis, there is an abundance of research exploring the diffusion and adoption of innovations specifically within the
agricultural context (Briggeman & Whitacre 2010; Carrer, de Souza Filho & Batalha 2017; Charatsari & Lioutas 2013; Llewellyn, D’Emden & Kuehne 2012; Sewell et al. 2017) and also within a broad range of other disciplines (Barrette 2015; Isfandyari-Moghaddam & Hosseini-Shoar 2014; Melville & Ramirez 2008). The literature has established various factors (depending on the research constructs) that may affect the adoption of an innovation including those factors listed at each level of the pyramid in Figure 7.5.

In order to investigate the research questions in this thesis, the research study focused on the five constructs from Rogers’ (2003) DOI Theory including: relative advantage, compatibility, complexity, trialability and observability. These constructs alone were insufficient to capture all of the factors that affect Queensland horticultural farmers’ use of IBE tools. Thus, the main adoption factors established through the findings of this research study include those listed at the top of the pyramid in Figure 7.5. The findings of this research study identified additional factors that also have some effect on farmers’ effective use of IBE tools as listed at the second level of the pyramid in Figure 7.5, but these factors had less impact on farmers’ deciding to use IBE tools although they contributed to how effectively farmers used IBE tools.

![Figure 7.5: Factors that can affect innovation adoption](source)

*Figure 7.5: Factors that can affect innovation adoption*

Factors affecting farmers’ use of IBE tools were analysed and discussed in terms of the main reasons why farmers don’t adopt IBE tools. The main argument is that farmers will continue using their traditional methods until IBE tools are better promoted, supported and designed. Hence, a communications strategy was recommended to deliver awareness knowledge and principles knowledge to farmers. Strategies to deliver training and support programmes was also discussed. To facilitate the better design of IBE tools, usability and UX were emphasised as important aspects design and integrating a HCD was also emphasised.

A set of guidelines has been established to achieve these necessary improvements to IBE tools (Table 7.3). As discussed, change management principles have also been recommended as an effective approach to implementing the guidelines but Design Science is a potential approach for the evaluation of these guidelines.

- **Design science**

At this stage of the research journey, the research is complete and the findings have been discussed extensively. In addition, the researcher has generated a comprehensive set of guidelines for the promotion, support and design of IBE tools as identified in Table 7.3. These guidelines have been established based on the findings of this research study and current professional standards and principles as well as relevant scholarly literature. The researcher recommends the adoption of these guidelines to implement processes for addressing the main factors that compromise the effective use of IBE tools by Queensland horticultural farmers. The researcher has also outlined a set of change management principles that further guide the process of implementing the guidelines for promotion, support and design of IBE tools. Furthermore, extensive research of scholarly literature justifies and supports the credibility of the content of the guidelines which, in turn, are based on the valid, credible and rigorous research study described in this thesis. Based on the rigor and outcomes of this research study, the researcher has reflected on the contribution to knowledge made by this research study. Design Science research has been considered albeit with much perplexity and questioning.

The ‘Incommensurability in Design Science: which comes first – theory or artefact?’ (Davern & Parkes 2010) is the title of a paper in a book on the foundations of information systems and the role of Design Science (Hart & Gregor 2010). The title of the paper aptly
Chapter 7 – Discussion

describes the conundrum raised in the final part of this thesis whereby the researcher believes the contribution made by her research belongs on the Design Science continuum but questions the actual placement. Gregor and Hevner (2013) also confirm that confusion is common because knowledge contributions from Design Science research may also be perceived as a Design Science artefact.

Simon (1988, p. 69) suggests that ‘design is concerned with how things ought to be, designing artefacts to attain goals’. Venable, Pries-Heje and Baskerville (2016) suggest that Design Science research highlights the development of new knowledge as the outcome of the design and evaluation of artefacts. Gregor and Hevner (2013, p. 341) describe an artefact as something that can be converted into a process or a ‘material existence as an artificially made object’. Hevner et al. (2004) state that an IT artefact is a construct, model, method or instantiation and that Design Science creates and evaluates IT artefacts which are designed to solve an existing organisational problem.

Essentially, the researcher has undertaken a rigorous and extensive investigation of IBE tools that has enabled the design and development of guidelines which articulate an implementation process or method. This is intended to resolve the issues raised by farmers and enable extension organisations to offer better products and services. By designing the guidelines, the researcher has not only addressed the field problem but has also developed a solution to the field problem by designing and creating the guidelines. This is consistent with van Aken’s (2007) description of a Design Science solution. It is also consistent with Heinrich and Schwabe’s (2014) description of nascent design theories and their framework for the inclusion of artefacts in Design Science research. Similarly, Gregor and Hevner (2013) state that nascent design theory is a valid contribution to Design Science research and affirm that a set of design principles is a Design Science artefact.

To create a design artefact Hevner et al. (2004), suggest that a process of expert activities must be undertaken and then feedback is developed from evaluating the artefact, thus developing a better understanding of the problem necessary to improve the design process and the quality of the artefact. In this thesis, the artefact has been created through an iterative process of analysing and interpreting the research data and iteratively developing comprehensive guidelines and implementation procedures.
Valid contributions to Design Science research can be contributions to theory or to knowledge (Baskerville et al. 2018). Gregor and Hevner (2013) identify three types of knowledge that can be contributed to design science research including:

- knowledge relating to the implementation of an artefact such as instantiations of software products;
- operational or principles knowledge such as methods, models, design principles;
- robust design theory incorporating embedded phenomena such as mid-range or grand theories.

The development of guidelines or design principles in this research study therefore contributes to the operational or principles knowledge of Design Science research.
Chapter 8 — Conclusion

8.1 Introduction

Notwithstanding the availability of various IBE tools in the form of rural-focused websites and Web 2.0 technologies, not enough was known about the uptake and effectiveness of these tools. Hence, the overall objective of this research study was to better understand key factors influencing Queensland horticultural farmers’ effective use of IBE tools. This was achieved through qualitative research exploring factors affecting the adoption and effective use of IBE tools using constructs from Rogers’ (2003) DOI Theory. The overall perceived usability of various rural-focused websites was also examined in the context of usability and UX principles and guidelines.

This research study was approached using a collective case study comprising four cases based on avocado, macadamia, pineapple and strawberry industry groups within Queensland horticulture. The case study research methodology was applied within an interpretivist paradigm and included semi-structured interviews as the main data collection method which were further supplemented by focus groups, observation and document analysis.

Based on the findings of the research study, this thesis argues that IBE tools are too difficult for farmers to use effectively and they will continue using their current methods unless IBE tools are better promoted, supported and designed. An extensive discussion on these research findings was presented in terms of Rogers’ (2003) DOI Theory, agricultural models of engagement and communication strategies. The research findings were further discussed in the context of improving the usability and design of IBE tools, as well as the support and training needed for farmers’ effective use of IBE tools. In this context, a set of guidelines has been established to facilitate the implementation processes and activities recommended to address the research findings and increase the adoption and effective use of IBE tools by Queensland horticultural farmers.
8.2 Research questions

The objective of this research study was addressed through four research questions. The main findings of the research study are discussed in terms of these research questions, as follows:

• How do Queensland horticultural farmers perceive IBE tools?

In particular, farmers in this research study perceive a relative advantage to using online weather sites. This is also confirmed by Taragola and Van Lierde (2010) in their findings with horticultural farmers in Belgium where one the most important areas of Internet use pertains to weather forecasting data. Similarly, Wright et al. (2018) recently collected survey data from the Australian grains industry showing that weather apps such as the BOM Weather, Weatherzone, AccuWeather, WillyWeather, and Elders Weather are the most popular apps used by growers and agronomists.

With the exception of weather sites, most farmers in this research study have negative perceptions about IBE tools. In terms of Rogers’ (2003) DOI Theory farmers from each of the four industry groups perceive IBE tools to have little or no relative advantage, poor compatibility and a high degree of complexity. Perceptions of farmers in this research study indicate that IBE tools are not useful, relevant or current. These farmers do not see other farmers using IBE tools, they don’t hear about them, and they are generally unaware of their existence which contributes to farmers’ negative perceptions about the trialability and observability of IBE tools.

The avocado, macadamia and strawberry farmers in this research study perceive their industry websites to be lacking in useful and relevant information although the macadamia farmers were more positive in their perceptions about the usefulness of some of the video clips and fact sheets. The pineapple farmers’ peak industry body is Hort Australia and their website is also perceived by these farmers to be lacking in useful and relevant information.

The research study also analysed farmers’ perceptions of IBE tools accessible from government websites such as DAF (2018b) and Business Queensland (2018a). Again, the farmers in this research study expressed negative perceptions of these IBE tools indicating that IBE tools are not useful, relevant or current. Furthermore, perceptions of farmers in this research study also indicated that some agricultural based websites are
complex to use because they are cluttered, not intuitive, difficult to navigate and some links do not work.

- **Why do Queensland horticultural farmers use IBE tools?**

  This research study found that most of the farmers from each of the four industry groups routinely access the Internet for a variety of online activities including weather, news, email, banking, bill paying, online shopping, payroll and to a certain extent, social networking. Internet weather sites are particularly important to operational farm activities. Farmers perceive the benefits of accessing this real-time data online and taking advantage of the functionality of these websites, as more efficient and effective than maintaining manual records. In particular, Internet weather sites provide an extensive range of data enabling farmers to analyse local and more widespread weather forecasts and historical data used for predicting short and long term weather patterns.

  While most farmers in this research study are not averse to using the Internet and ICTs, with the exception of weather sites, these farmers do not use IBE tools extensively. Before an innovation can be evaluated or considered for adoption, knowledge of its existence is essential. The farmers in this research study had little knowledge or awareness of the existence or benefits of IBE tools and how they could easily be applied to their farming activities. Their knowledge of IBE tools is limited due to a lack of promotion and communication enabling knowledge awareness, principles knowledge and how-to knowledge (Rogers 2003). Furthermore, the IBE tools that had been used were perceived to be lacking relative advantage, compatibility, trialability and observability and they were complex to use.

- **How can IBE tools better satisfy Queensland horticultural farmers’ information requirements?**

  Starasts (2015) found that the complex nature of seeking new information combined with farmers’ on-farm commitments, appeared to override the original need for seeking the information. Similarly, this research study found that horticultural farmers prefer to look at their hardcopy reference books, consult with industry experts or speak directly to other growers. This is due to their current methods being perceived by farmers as easier, more convenient and more reliable than using IBE tools.
Farmers in this research study indicated that they are interested in current agricultural research information but require practical knowledge that they can apply to their farming activities. These farmers perceived that acquiring practical knowledge from scientific research articles available through some IBE tools is near impossible. Starasts (2015) suggests there is a misalignment between the science-based information available to farmers and the usable practical information that farmers can apply to their farming activities. Similarly, Formiga et al. (2014) in their evaluation of the eOrganic Webinar Program in the USA, preferred research based webinars offering practical recommendations.

Better designed IBE tools have the potential to address farmers’ information requirements. Consultation with farmers should take place to establish farmers’ information requirements. At the very least, however, IBE tools should deliver information that is useful, relevant and current; they should also be easy to use. This would create a relative advantage where the benefits of using IBE tools would outweigh the cost in terms of time, effort, comfort or convenience, usefulness, immediacy and level of reward (Rogers 2003).

- **How can IBE tools be tailored to enable Queensland horticultural farmers to more readily adopt these tools?**

The findings of this research study indicate that IBE tools would be more readily adopted by Queensland horticultural farmers if they were better promoted, supported and designed.

An effective communications strategy should be targeted and tailored around farmers needs to achieve the successful promotion of IBE tools. Better promotion of IBE tools using a mixed method of delivery may provide farmers with knowledge of the existence of IBE tools and the benefits they offer. For example, farmers could be informed of IBE tools via industry magazines, newsletters, emails and website news. Industry group meetings and field days would also be the ideal forum for IBE tools to be promoted thereby increasing farmers’ awareness and possibly providing some level of motivation if the IBE tool is visible.

However, knowledge of how to use IBE tools is also crucial and a professional training and support strategy should be developed. Part of the learning process is developing the
capacity, or skills and ability to use IBE tools effectively and efficiently (Pannell et al. 2011). The farmers in this research study have basic computer skills but most of them were not confident technology users. Basic computer training could be offered to farmers to increase their confidence and self-efficacy and also increase their ability to use IBE tools effectively. Training and support should also be delivered to teach farmers how to use specific IBE tools. Different formats of training and support for IBE tools could be in the form of workshops (face-to-face or online video clips), demonstrations at industry group meetings and field days and training booklets or fact-sheets (hardcopy or online). Online help facilities and a help-line would also provide benefits to the farmers.

Various shortcomings of IBE tools perceived by farmers in this research study should be addressed through professional design principles and guidelines. Designers of IBE tools need to understand and incorporate the farmers’ perspectives, needs and goals in their design and development approach in order for IBE tools to be successful. Integral to the better design of IBE tools is the adoption of a human-centred design approach that focuses on human factors and users’ needs and requirements (ISO 2010). Better design would increase the usability of IBE tools and enhance the farmers’ overall UX with these tools.

8.3 Significance of the research

The significance of this research study rests largely on the potential impact on farmers’ use of the Internet. In this digital era, it seems almost absurd that farmers are, to a certain extent, precluded from fully participating in the digital world. In a report on Australia’s digital divide, Thomas et al. (2017) advocate that digital inclusion is increasingly integral to daily life activities and Internet access is becoming a necessity. Knowledge and effective use of IBE tools has the potential to provide farmers with methods that may be better than their trusted and proven traditional methods. If farmers were able to effectively use better designed IBE tools the basic advantages would include fast and easy access to current, relevant and useful information that could improve the operational aspects of farming. By delivering online supporting mechanisms to Queensland farmers they would also be able to harness knowledge and information from various sources locally and globally. Thomas et al. (2017) claim that greater digital engagement in regional Australia will impact significantly on Australia’s productivity, global competitiveness and improved social wellbeing.
The significance of this research study also impacts DAF and other agricultural industry organisations providing IBE tools to farmers. Currently, DAFs knowledge of farmers’ use of these technologies and their perceptions is limited to anecdotal evidence and is sketchy at best. This research study has collected reliable data that will better inform extension organisations and enable increased adoption of rural based websites and IBE tools. This research will, therefore, enable the enhanced ability to provide better extension services to farmers.

8.4 Contribution to knowledge
This research study has created new knowledge on a topic that has not specifically been addressed in research literature. Therefore, this research study provides new knowledge about Queensland horticultural farmers’ perceptions of IBE tools, their dissatisfaction with these tools and how better promotion, support and design can mitigate those shortcomings. Hence, this research contributes to the scholarly knowledge in the research domain of Information Systems particularly in the rural environment. The research also adds to the body of knowledge on usability of user interfaces and user experience including e-government websites.

This research study has also demonstrated that the five key attributes of relative advantage, compatibility, complexity, trialability and observability in Rogers’ (2003) DOI Theory were insufficient to address the adoption of IBE tools. These constructs alone, did not provide a sufficient mechanism for understanding and explaining factors affecting Queensland horticultural farmers’ use of IBE tools. Therefore, this research adds to the body of knowledge specifically on the diffusion and adoption of innovations.

Further contribution to knowledge has been achieved by applying Design Science Theory to the problem of effective IBE tools and establishing guidelines or design principles to resolve these issues. In effect, this approach has created an artefact that aligns with the practical dimension of Design Science. Hence, this research contributes to the scholarly knowledge of Design Science in the Information Systems research domain.

8.5 Implications for policy and practice
This research study also makes contributions to policy and practice. In a practical sense, the new knowledge may be applied to the future design, development and delivery of
Internet based tools and this should increase the adoption rate and effectiveness of IBE tools. Australian farmers should be able to collaborate with other farmers online and integrate national and international data into a local context. Sewell et al. (2017) suggest that farmers’ adoption of agricultural innovations is important for increasing productivity. Therefore, the effective use of IBE tools and farmers’ collective intelligence within their rural information systems, provides potential benefits in terms of cost and time savings and productivity gains. If productivity can be increased, then further growth in agriculture may also be achieved.

The research study has also identified the importance of an effective communications strategy to better promote IBE tools. In addition, the research study has highlighted the importance of implementing design and development guidelines established in this thesis. The essential nature of training and support has also been discussed as well as the benefits that will change farmers’ perceptions of IBE tools and ICTs in general. Establishing policy planning that incorporates these three essential strategies will enable the generation of improvements in extension services. Therefore, improving the promotion, training and support, and design of IBE tools should be an important focus area for policy makers in agricultural organisations.

8.6 Limitations of the study

This research study has contributed insights into farmers’ use of IBE tools by increasing the depth of knowledge and understanding relating to the factors that affect their use of these tools. However, it is important that the reader of these research findings appreciates the boundaries of the research study. In this context, the research study focused on the farmers’ perceptions of IBE tools not the perspectives of extension agents or other agribusiness stakeholders. It is also essential to acknowledge that the findings of this research study are not a criticism of the organisations that develop or disseminate IBE tools who funded this research in order to implement more effective IBE tools. Indeed, the research findings are largely aimed at increasing the usability of IBE tools and enabling a better service to be offered to farmers. This should be interpreted as a positive outcome for farmers and agricultural organisations.

The research study has limitations that need to be acknowledged when interpreting the findings of this research. Primarily, these limitations relate to the size and location of the study. The collective case study was limited to four cases within Queensland’s
horticultural industry and further limited to the Wide Bay-Burnett and South-east Queensland regions.

8.7 Future research

One of the outcomes of this research study is the establishment of a set of guidelines for the promotion, support and design of IBE tools. While this is a comprehensive set of guidelines, it has not been applied and tested in a real-life setting. The value of these guidelines could be strengthened with future research targeting the evaluation of these guidelines to test and confirm the process and potential benefits. Ideally, this evaluation would be conducted using a Design Science approach.

The potential for future research on this topic also includes expanding the research across other geographical locations, industry groups and agricultural industries. This would further strengthen the external validity of the research findings. For example, additional cases could be researched by investigating other horticultural industry groups within the main horticultural categories such as:

- Vegetables - potatoes, tomatoes, mushrooms;
- Fruit - grapes, bananas, apples;
- Nuts - almonds, walnuts, pistachios; and
- Other – nursery plants, cut flowers, turf.

Selection of these industry groups could be based on the value or volume of production, export, or import of the same goods.

Similarly, future research could extend the scope beyond the Wide Bay-Burnett and South East Queensland regions. This could be undertaken in other regions of Queensland or further extended into other Australian states and territories. For example, the Victorian strawberry industry could be studied and compared to the Queensland strawberry industry.

Future research on IBE tools could also be undertaken within other agricultural industries such as crops or livestock within Queensland or across Australia. Research on IBE tools could also be undertaken internationally with the same industry groups, across other industry groups and with other agricultural industries.
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## Appendix 1 – Social Principles for Agricultural Extension

<table>
<thead>
<tr>
<th>Principle</th>
<th>Rural sociological perspective</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Farming is a socio-cultural practice</td>
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<tr>
<td>2</td>
<td>Farmers are not all the same</td>
</tr>
<tr>
<td>3</td>
<td>Adoption is a socio-cultural process</td>
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<tr>
<td>4</td>
<td>Profit is not the main driving force of farmers</td>
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<tr>
<td>5</td>
<td>It is hard to be green when you are in the red</td>
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<td>6</td>
<td>“Doing the right thing” is a strong motivational factor</td>
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<td>7</td>
<td>Farmers don’t distinguish environmental issues from other farm management issues</td>
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<td>8</td>
<td>There is a strong desire to hand the farm on to one's children</td>
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<td>9</td>
<td>Sustainability means staying on the farm</td>
</tr>
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<td>10</td>
<td>Women are an integral part of the farm</td>
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<tr>
<td>11</td>
<td>Stage in the lifecycle of a farming family and family composition are significant factors</td>
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<tr>
<td>12</td>
<td>Non-adoption is not the cause of land degradation, rather practices actively promoted by extension in the past have significantly contributed to degradation</td>
</tr>
<tr>
<td>13</td>
<td>Marginal farmers are not marginal because of their management ability but rather because of their structural location</td>
</tr>
<tr>
<td>14</td>
<td>Farmers’ attitudes are not the problem</td>
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<tr>
<td>Principle</td>
<td>Rural sociological perspective</td>
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<tr>
<td>15</td>
<td>Farmers construct their own knowledge</td>
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<tr>
<td>16</td>
<td>Effective extension requires more than the transfer of technology, it requires an understanding of the world views of farmers</td>
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<td>17</td>
<td>Farmers have legitimate reasons for non-adoption</td>
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<td>18</td>
<td>Top-down extension is inappropriate</td>
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<tr>
<td>19</td>
<td>The 80–20 rule is a self-serving delusion</td>
</tr>
<tr>
<td>20</td>
<td>Science and extension do not have automatic legitimacy and credibility</td>
</tr>
<tr>
<td>21</td>
<td>Representation is not participation</td>
</tr>
<tr>
<td>22</td>
<td>Promotion of awareness through the use of dramatic images is counterproductive</td>
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<tr>
<td>23</td>
<td>Put degradation into perspective</td>
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<tr>
<td>24</td>
<td>The best method of extension is multiple methods</td>
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<tr>
<td>25</td>
<td>Group extension is not a panacea</td>
</tr>
<tr>
<td>26</td>
<td>Extension is likely to have only a small impact</td>
</tr>
<tr>
<td>27</td>
<td>Farmers need to feel valued</td>
</tr>
</tbody>
</table>

Source: Vanclay 2011
Appendix 2 – Focus Group Questionnaire

1. Are you male or female?
2. What is your age?
3. What is your highest level of education?
4. Are Macadamia nuts your primary source of income?
5. Do you want to increase your productivity?
6. Where do you live?
7. Do you or another member of your household/farm use the Internet?
8. If you do access the Internet from your farm, what is your connection?
9. Where do you use the Internet? (You may select more than one option)
10. How do you access the Internet? (You may select more than one option)
11. What do you access on the Internet? (You may select more than one option)
12. What else do you access on the Internet? (You may select more than one option)
13. Do you find agricultural websites easy to use?
14. Do you find agricultural websites useful?
15. How do you prefer to receive regular industry news?
Appendix 3 – Interview Guide

1. **Personal characteristics:**
   - Age, education, family

2. **General farm attributes:**
   - Farm size, length of time farming,
   - People/family working on farm
   - Proportion of income from farming
   - Other sources of income

3. **Innovation communication channels:**
   - How do you find out about new farm equipment, tools etc.?
   - How do you find out about new IBE tools/websites (e.g. family, friends, neighbours, extension agents, field days, industry body, community groups)?

4. **Decision process**
   - Who/what influences your decisions to adopt a new technology e.g. tractor, website, blog?
   - How do you determine advantages/disadvantages, usefulness, consequences etc. (e.g. family, friends, neighbours, extension agents, field days, industry body, community groups)?
   - What other resources are used to make an informed decision e.g. newsletters, factsheets, Internet?

5. **Social system**
   - When thinking about using a new IBE tool or website, are you influenced by your family, friends, neighbours, extension agents, industry body, community groups? If so, in what way?
   - If a neighbour or a group of farmers use a particular tool would you also use it based on their recommendation or would you spend time evaluating it yourself?
6. **Change agent**
   - If an extension agent strongly recommended the use of a particular website or IBE tool would that be enough to convince you to use it?

7. **Adopter categories**
   - Innovator or early adopter of new technologies or more cautious and wait to see how other farmers go?

8. **Internet access/use**
   - How do you access the Internet on your farm (e.g. on PC at home, using laptop in the paddock, using a Smartphone)?
   - What do you use the Internet for (e.g. email, banking, online shopping, weather, other)?

9. **Specific agricultural/industry based websites** *(rel. advantage, compatibility, complexity, trialability, observability)*
   - **Uptake & effectiveness**
     - What agricultural or industry based websites do you use?
     - What do you use them for?
     - How useful are they?
     - What features do you like about these websites and why?
     - What don’t you like and why?
     - Have you had any problems using these sites (e.g. difficult, not compatible with your way of doing things)?
     - What other information would you like to access from this website?
     - Are there other websites that offer the same tools or information? Perhaps you’ve tried other websites and don’t like them?
     - What does your family/friends/neighbours think of you using these sites?

10. **Specific IBE tools e.g. agbiz decision toolkit, blogs, video clips** *(rel. advantage, compatibility, complexity, trialability, observability)*
    - Same questions as above
11. Skills
- How easy is it to learn to use these sites?
- Are you confident/competent using these sites?
- Have you undertaken any training (formal/informal)?
- How do you learn to use these sites?
- How would you like to learn to use these sites?

12. Other agricultural software or IT tools used?
- Have you used other tools that do the same thing (names of these tools)?
- If so, why choose one over the other?
- Why do you use these tools (e.g. easy to use, provide essential information, easy to access)?
- What features do you particularly like/dislike about these tools?