Pasture measurement technology in Tasmanian dairy farming: Exploring and optimising its role and adoption for improved pasture management

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Declaration of Originality

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Publications

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Abstract

Improving pasture utilisation on dairy farms remains a key focus of research, development and extension in the Tasmanian dairy industry, as it is positively related to farm profitability in pasture based systems. Biophysical research has typically focused on exploring and increasing the theoretical upper limits of pasture utilisation that can be achieved. However, on-farm improvement relies on farmer adoption of emerging research findings and proven pasture management practices. Proven and recommended pasture management practices include measuring and monitoring pasture biomass with a tool; providing farmers with objective information from which they can combine with observations to make grazing management decisions. Developing effective extension activities that engage a wide range of farmers in pasture management training and leads to greater practice change must be informed by an increased understanding of farmer decision making in relation to engagement and adoption behaviours. The aim of the research reported in this thesis was therefore to explore the role and uptake of pasture measurement technology for improved pasture management in the Tasmanian dairy industry.

The literature review introduces the value of pasture based systems that form a key component in supporting the efficiency, competitiveness and profitability of Tasmanian dairy farms. Factors influencing farmer decision making and adoption behaviour are discussed, including a critique of several adoption models. Farmers learning preferences and the role of extension in facilitating farmer learning is also discussed. In the context of the Tasmanian dairy industry, a gap exists in understanding not only what factors influence farmer decision making in relation to pasture management, but how and why these factors influence behaviour. Use of the Theory of Planned Behaviour theoretical framework and the Competency Learning Model in the research design allowed exploration of these influential factors and identification of potential extension interventions to support farmers to form positive intentions and progress to engaging and adopting improved practices.

Mixed methods were used to investigate the adoption of recommended pasture management practices on Tasmanian dairy farms (with a focus on pasture measurement tools), and farmer engagement with extension activities. Findings of a quantitative survey and qualitative, semi-structured interviews led to development of recommendations for future extension activities and pasture management training, that were refined and prioritised by farmers using a second, quantitative survey.

The survey of 162 farmers (representing 38% of the Tasmanian dairy industry) identified past and current use of pasture measurement tools, in addition to their extent of engagement with extension activities. While many farmers indicated positive intention to measure pasture, evidenced by tool ownership and trialling of measurement tools (64% of respondent farmers), fewer farmers are currently using a pasture measurement tool (48% of farmers). Only 43% of farmers had been through an intensive and extended period of measuring pasture with a tool, with past intensive use of a tool having a significant positive relationship with current use. Regular measurement of pasture for a period of at least 12 months is recognised to be an important component in the pasture management learning process and developing competency in allocating optimum quantities of high-quality feed to cows. Such a period of intensive measuring is also recognised as important in increasing farmers knowledge and confidence, as they are able to make decisions based on objective information while also developing their own skills and experience.

Several additional factors were identified to have a significant positive relationship with current tool use, including farm size (herd size and land area), level of formal education received, and attendance at extension activities. A large proportion of farmers were found to attend extension activities (86%), with significantly less attending on a regular basis (only 20% attending four times a year or more). Regular, ongoing supported learning has been shown to be more successful than a one-off learning activity when developing knowledge and skills associated with intensive practices, with a goal of extension being to support a larger number of farmers through a pasture management learning process that leads to farmer adoption and/or adaption of proven practices.

Qualitative interviews with 30 farmers therefore explored factors influencing farmers' intention to use a tool to measure pasture, in addition to factors influencing both ongoing adoption, adaption and dis-adoption of proven pasture management practices. Farmers were categorised into three sub-groups, based on the extent of use of pasture measurement tools (past and current use), and extent of extension engagement. The Non-users sub-group consisted of farmers who have never measured pasture or have only trialled a tool, and do not engage with extension. Farmers in the Triallers sub-group have trialled or used a tool on a non-intensive basis and are currently engaged with extension. Farmers in the Adapters sub-group have measured pasture on an intensive basis (with some continuing to do so,) and were currently engaged with extension. Factors that influence use of pasture measurement tools and adoption of recommended management practices, along with farmer engagement, were explored within these sub-groups. The influence of social factors within the following TPB constructs were explored in relation to the intentions of farmers to attend extension activities and adopt pasture management practices, and their current behaviours: attitudes, social norms, perceived control and actual control.

The overall attitude of farmers across the three sub-groups was positive towards measuring pasture and attending extension activities – with the majority recognising the important of effective pasture management and the role of extension in farmer learning. However, the perception of limited facilitator experience and lack of topic specificity to their own farm negatively influenced the attitudes of Non-user, Trialler and Adapter farmers with respect to attending extension activities. Another widespread view was that extension activities, particularly those focused on pasture management, are designed and targeted for younger and/or less experienced farmers. This negative social norm limited the continued engagement of many Triallers in extension activities, as they viewed themselves as experienced farmers despite not having developed advanced pasture management knowledge and skills. An additional negative social norm influencing non-engagement of one third of Triallers is that extension activities are repetitive, particularly those focused on pasture management. Further development of extension content, marketing, targeting and delivery is required to re-engage this sub-group. The perception of the risks of needing to share farm information or being asked challenging questions limited the engagement of Non-users and Triallers farmers in extension activities, and was therefore identified as a significant perceived control factor. A lack of existing knowledge around applying and implementing pasture measurement data into farm decision making (another negative perceived control factor) also prevented Non-users and Triallers farmers who initially intended to measure pasture, from progressing to adopting and adapting the related pasture management practices. Some farmers had attended an extension activity that had introduced them to pasture measurement and management practices (forming a positive intention to adopt), but without ongoing support in learning how to apply them, the practice change was not possible.

This research has confirmed the need for dairy farmers in pasture based systems to be supported through a learning process that includes an intensive period of measuring and monitoring pasture with a tool. The identification and exploration of factors influencing farmer engagement with extension activities and adoption of pasture management practices has led to the development of preliminary recommendations for the design of content, marketing, targeting and delivery of future extension activities. Farmers helped to refine and prioritise these recommendations, leading to recommendations for different sub-groups of farmers to assist in increasing farmer engagement for future activities. Extension programs that contain content based on foundational practices, yet are tailored to farmer sub-group characteristics, will continue improving pasture management and utilisation in the Tasmanian dairy industry.

This thesis contains four peer reviewed and published journal papers, and one peer reviewed and published conference paper. Together they form the five research chapters of this thesis.

Chapter 1 – Introduction

The Tasmanian dairy industry is primarily comprised of pasture based systems, with pasture forming a major component of dairy cows' diets. Pasture based systems form a key component in supporting the sustainable and competitive nature of dairy production in Tasmania, with maximised pasture utilisation (the amount of pasture grown and harvested directly by cows, while also maximising total pasture produced per hectare) being linked with farm efficiency and profitability (Dillon et al. 2005; Lane 2014).

Pasture management practices that maximise pasture utilisation therefore form a key component of development and extension (D&E) programs in the Tasmanian dairy industry. These programs have largely focused on increasing the knowledge and understanding of recommended pasture management principles and the adoption of associated practices to improve production and utilisation of home-grown pasture by dairy cows (Mann 2006; Irvine 2013). Grazing management decisions impact on animal and pasture performance in terms of quality and quantity of pasture, feed intake per cow, milk production, pasture regrowth, and supplement feed required (Lee et al. 2008; Beukes et al. 2018).

Recommended grazing management practices are knowledge intensive and require an understanding of the biological principles underlying pasture management, and how pasture measurement data can be incorporated into the farm business and grazing management decision making. The biological principles that underpin recommended management practices include the seasonal effects on growth and leaf emergence rate (Donaghy & Fulkerson 2001), and the impacts of grazing management on pasture productivity, persistence and quality (Fulkerson et al. 2005; Lee et al. 2008). Farmers also need to develop the practical skills of assessing pasture biomass in a paddock and leaf stage, in order to accurately calculate where, when and how long cows should be grazing pasture (Macdonald et al. 2010). Recommended pasture management practices include the use of tools and technologies that have been developed to assist in measuring and monitoring pasture growth and biomass, such as the rising plate meter and CDAX bike reader. Using these tools provides farmers with objective information from which they can make decisions, giving increased control and flexibility around grazing decisions on feed allocation (O'Donovan et al. 2002). Improving grazing management practices is key factor in increasing pasture consumption and business potential in pasture based dairy systems (Maher & Bogue 2018). Incorporating pasture growth data in grazing management decisions can assist in substantially increasing farm income (Beukes et al. 2018; Turner et al. 2019).

Using pasture measurement tools offers farmers a more reliable and accurate means of collecting pasture information than visual assessment (Stockdale 1984; Scrivner et al. 1986; O'Donovan et al. 2002). As farmers develop an understanding of the biological principles underpinning pasture management and increase their knowledge and understanding of pasture management practices, their reliance on using a tool may decrease. However, the process of measuring pasture growth and biomass intensively for an extended period has been found to contribute to a more confident and accurate approach to pasture management compared with farmers who have not been through this process (Turner et al. 2019).

Despite focused research, development and extension (RD&E) efforts, there is still opportunity to increase pasture utilisation (Ashton et al. 2014; Dairy Australia 2015; Tasmanian Institute of Agriculture 2017) through further uptake of recommended pasture management practices and associated tools and technologies. For further adoption and adaptation of tools, technology and practices on-farm, there is a need to understand what factors have influenced current practices, and farmer engagement with extension activities is an important step in the learning and adoption process. Identifying farmers' current pasture management practices, past and current pasture measurement tool use, and current engagement with extension activities provides a baseline to explore both demographic (for example, age, gender, education) and social factors

(factors that influence individuals' personality, attitude and beliefs) influencing decision making and adoption. Developing a greater understanding of influential factors can inform the design and marketing of content and delivery of future pasture management extension programs to support a wider range of farmers through the change process and assist in improving on-farm pasture utilisation.

Thesis Aims

The research in this thesis aimed to explore past and current pasture management and extension practices and use of pasture measurement tools and technology in the Tasmanian dairy industry. To develop a greater understanding of the factors influencing past and current pasture management practices, and farmer engagement with extension, it was necessary to quantify current practices and engagement.

The research in this thesis set out to address four key research questions:

- What are the current pasture management practices and associated tools and technology being used on Tasmanian dairy farms?
- What is the current extent of farmer engagement with extension activities?
- What social and demographic factors have influenced the decision making behind adoption and implementation of pasture management practices, tools and technology?
- What social and demographic factors influence farmer decision making about choosing to, or not to, engage with extension activities?

Thesis Structure

This thesis is structured as a 'thesis by publication' according to the guidelines provided by the University of Tasmania. It contains a literature review, followed by a methodology chapter that describes and justifies the methods chosen for the following research. This is followed by five experimental chapters, which address the preceding research questions. These chapters have been formatted as journal manuscripts for various journals and are either published or in press.

- Chapter 4 has been published in the *Rural Extension and Innovation Systems Journal* (2017, 13(2)).
- Chapter 5 has been published as a conference paper in the proceedings of the 22nd International Farm Management Congress (2019).
- Chapter 6 has been accepted for publication in *Animal Production Science* and is In Press.
- Chapter 7 has been published in the *Journal of Agricultural Education and Extension* (2019, 25(1)).
- Chapter 8 has been published in the *Rural Extension and Innovation Systems Journal* (2018, 14(2)).

For consistency, each journal manuscript has been formatted into the same style (font, layout and heading style) throughout this thesis, however have retained original reference formatting. As the experimental chapters have been published with their associated reference lists, each additional chapter of this thesis also has its own reference list included at the end of each chapter. The manuscripts that have been accepted for publication have the associated abstract included at the beginning of each chapter.

Conclusion

This research provides a greater understanding of the underlying factors influencing farmer decision making regarding adoption of recommended pasture management practices, use of associated tools and technology, and engagement with extension activities. In combination with identification of past and current pasture management practices and engagement behaviour, these insights have led to developing recommendations for future D&E programs. These recommendations have the aim of engaging a wider range of farmers with extension activities and increased pasture utilisation on Tasmanian dairy farms through improved pasture management.

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Chapter 2 – Literature Review

The Tasmanian Dairy Industry – A Pasture Based System

Tasmania is the third largest dairy producing state in Australia, producing 913 million litres of milk in the 2017-18 financial year, accounting for 9.8% of Australia's total milk output (Dairy Australia 2019). Dairy is Tasmania's largest agricultural industry, with an estimated farm gate value of milk production of $326 million, and a processed value of $474 million (Department of Primary Industries 2017). Milk production has continued to grow over the last 10 years at approximately 5% per annum, with a total increase of 43% in production compared with the national average of -4% (Newman et al. 2016).

The three major dairying regions of Tasmania are located across the north of the state, with farms also located in the midlands and southern regions. Investment and development has continued at a local, national and international level, with the addition of new, and expansion of existing, milk processors (Dairy Australia 2015), which has seen continued competition and demand for milk. Despite the decline in total number of dairy farms, milk production, farm size and herd size have continued to increase in Tasmania (Tasmanian Institute of Agriculture 2017). The average milking herd size in Tasmania is currently the largest nationally, with an average herd size of approximately 424 cows (Dairy Australia 2018).

The majority of Tasmania's milk production is manufactured for the export market and used in products such as butter, cheese, and milk powders. Milk prices are consequently driven primarily by international commodity prices and competition for milk supply, whether exported or consumed locally (Dairy Australia 2015; Dairy Australia 2018). Farm-gate milk prices have observed a long term downward trend over the last 10 years, and combined with constant price volatility (Dairy Australia 2015; Dairy Australia 2018), illustrates the need for constant improvements in productivity and efficiencies throughout the dairy industry.

Tasmanian dairy farms are primarily pasture based systems, composed typically of perennial ryegrasses or a perennial ryegrass and clover mix. Tasmania's temperate climate, relatively reliable rainfall and fertile soils means it is well suited to ryegrass productivity and persistence when well managed (French et al. 2015). Pasture based systems form a key component in supporting the economically sustainable and competitive nature of dairy production in Tasmania. Pasture is invaluable as a farm resource as it is the cheapest available feed that is suitable for meeting the majority of a dairy cows' nutritional requirements (Chapman et al. 2009; Rawnsley et al. 2012). However, dairy farmers have a constant challenge to maintain steady production and profit as they are faced with constant fluctuations in market demand for milk and milk products, volatility in milk price, changing seasonal conditions and rising input costs. Increased production and utilisation of pasture grown on-farm is essential to maintain efficiencies and ensure future growth within the Tasmanian dairy industry (Rawnsley et al. 2012; Farina et al. 2013).

Increased pasture utilisation is positively associated with dairy farm efficiency and profitability in temperate climates (Dillon et al. 2005; Lane 2014; Beukes et al. 2018). Data from analysis of the Victorian dairy industry, which also has a high reliance on pasture as the main feed source for dairy cows, has demonstrated a correlation between pasture utilisation and dairy farm profitability, with farms that have a high percentage of grazed pasture in the diet having a lower cost of production (Lane 2014). A study conducted by Dillon et al. (2005) in Ireland showed that increasing the proportion of grazed pasture in the diet of dairy cows reduced the cost of milk production. The correlation between pasture utilisation and profitability has been further supported by data analysis from an Irish benchmarking dataset, with approximately 44% of the difference in net profit per hectare among farms being explained by pasture utilisation per hectare (Dillon et al. 2005). Maximising pasture utilisation relies on optimising levels of inputs (including water and fertiliser) and accurate and timely grazing management. French et al. (2015) stated that 'if profitability of grazing systems is driven by the degree of grass utilisation, which is in turn a function of both increased growth and optimum utilisation of that growth, the accurate and timely measurement of pasture is integral to effecting grazing management practice'. Fulkerson et al. (2005) have also reported that dairy farmers can achieve approximately 10% higher milk yield through allocating an appropriate and constant amount of pasture and, when appropriate, supplements, on a daily basis.

Recommended pasture management practices include the accurate assessment of pasture availability for cows, which has a significant influence on how much supplement feed (such as grain and concentrates) will be required (Macdonald et al. 2010). Accurate assessment and allocation of pasture and supplement are important for optimising pasture utilisation (Fulkerson et al. 2005). This information informs key grazing management decisions and practices, including grazing interval (when to graze a paddock), grazing intensity (measured by post-grazing residual length; a high residual suggests cows are not eating very much, a low residual suggests cows are not receiving enough feed), and rotation length (grazing duration) (Macdonald et al. 2010). These management principles and associated decisions have significant impacts on animal and pasture utilisation and performance (Lee et al. 2008; Beukes et al. 2018).

Consequently, a major priority of RD&E in the Tasmanian dairy industry has been to promote and increase the knowledge, awareness and understanding of best practice pasture management principles and practices to improve the consumption of home-grown forage by dairy cows (Mann 2006; Irvine 2013). This has included the use of tools and technologies that have been developed to assist in pasture management, such as pasture estimation and feed budgeting, that gives farmers objective information from which they can make decisions, gives increased control and flexibility around grazing decisions, and can assist in increasing productivity (O'Donovan et al. 2002; Turner & Irvine 2017). In general, using a tool such as a rising pate meter to measure pasture has been proven to be a quick and effective way of assessing total forage growth and yield, with a greater level of accuracy than visual assessment (Stockdale 1984; Scrivner et al. 1986). Van Bysterveldt and Christie (2007, as cited in Romera et al. 2013) note that there are clear advantages in regularly measuring pasture, and tools for doing so have been the focus of research, development and extension (Eastwood et al. 2017).

As farmers learn about biological principles underlying recommended practices, using pasture measurement tools can train their eye to visually assess pasture growth and quantity with increased accuracy (Stockdale 1984; Scrivner et al. 1986). When these skills are combined with experience and existing farm knowledge, the need to continue using a pasture measurement tool may decrease (Turner & Irvine 2017). Anecdotal evidence suggests that uptake of the tools and technologies that have been developed to assist farmers in managing and improving pasture consumption has been slow. Reasons for their lack of use on a widespread basis include a lack of confidence in their accuracy (Reeves et al. 1996), high labour demand (Dobos & Fulkerson 2004), and difficulty in operation and cost (Lile et al. 2001).

In a study conducted by Craigie (2013) a high proportion (90%) of Tasmanian dairy farmers identified that grazing management was important to their farm business, in addition to the majority agreeing that grazing management plays a strong role in shaping animal nutrition, farm profits and smooth farm operation. Despite these results, only just over half (52%) of the respondents strongly agreed that allocating time to grazing management was of high importance (Craigie 2013). These findings suggest that there exists an opportunity to further improve on-farm practices, as the high level of awareness does not necessarily translate into practices being adopted on-farm. Indeed, despite the focus of extension on building capacity of Tasmanian dairy farmers in relation to pasture management practices, on-farm pasture consumption is still well below potential (Dairy Australia 2015; Tasmanian Institute of Agriculture 2017).

Extension in the Tasmanian dairy industry

In the Tasmanian dairy industry, publicly funded extension (through government and the national dairy research and development corporation) still forms a large component of information delivery and industry activities. The last decade has seen the continued provision of extension services, supported by government and industry bodies, with work in pasture management forming a core area of focus (Mann 2006; Donaghy et al. 2008; Rawnsley et al. 2012; Tasmanian Institute of Agriculture 2019).

What has the focus been?

Increasing farmers' awareness and knowledge of pasture management practices has been a core focus of extension programs and activities in the Tasmanian dairy industry. These programs have included the Pasture Management for Tasmanian Dairy Farmers, reproduced as part of the Pasture Plus program run by the national dairy research and development corporation, Dairy Australia (Pasture Plus 2006). This program continues to run in the format of a two day pasture management workshop, communicating the fundamentals of pasture growth and management and associated grazing principles (Tasmanian Institute of Agriculture 2019). An intensive pasture coaching program, the 20/12 Pasture Biomass Project was run from 2005 to 2007 and was developed in response to industry agreement that feedbase management was the highest priority for dairy extension in Tasmania (Mann 2006). This program centred on practical on-farm coaching sessions that aimed to provide the 'first step' towards challenging the way farmers manage their feedbase and to achieve on farm practice change and increased pasture utilisation. Participants undertook regular coaching sessions over an 18 month period, involving one on one sessions with consultants and coaching for group participants, which enabled the implementation of learnings on participants own farms with one on one support to put learning into practice, increase understanding and skills, and address any challenges or difficulties.

The 20/12 program resulted in the development of extension capacity in the Tasmanian dairy industry through involvement of both government and non-government sectors (Mann 2006). However, though this program was particularly effective there has not since been provision of pasture management focused extension programs at the same whole of industry level, involving input, support and coordination of all industry bodies, with follow up one on one supported learning.

The major government funded extension programs over the next decade included Beyond 20/12 (2007-2010), and Dairy Smart Phase 1 and 2 (2010-2015), along with consistent state-wide delivery of two day pasture management workshops, and general regional farmer discussion groups that meet eight to ten times a year. The Dairy on PAR program (2015-2018) varied in approach with combined RD&E and included the reintroduction of pasture coaching. The coaching involved continued, on-farm group sessions over a 12 month period, and on farm follow up from an extension officer (Tasmanian Institute of Agriculture 2019). However, difficulties with ongoing participant and group consistency, and a move away from government funded one on one support, resulted in challenges in ensuring participants continued through an extended, supported learning process that has been shown to be central in developing the knowledge, skills and confidence necessary for improved pasture production and management (Turner & Irvine 2017). The reintroduction of coaching is likely to play a valuable role in the overall approach taken by extension in developing farmers' pasture management knowledge and skills. However, not all farmers will choose to engage with this process, and while supported group learning may suit some farmers, others may find one on one support to be more effective in learning and implementing change (Kilpatrick & Johns 1999).

While RD&E have consistently focused on pasture management, there remains a diverse range in on-farm pasture consumption, level of adoption and implementation of pasture management practices and principles, and engagement of farmers with extension activities. There is therefore an opportunity to explore in more depth why greater farmer engagement and adoption are not occurring. Understanding how social factors influence the adoption process can assist in informing the development of future extension activities focused on improving farmers' pasture management practices and skills, leading to increased pasture utilisation.

Extension, Education and Farmer Learning

What is extension?

Extension is a process of enabling change through building capability and capacity in people and, for agriculture, to enable change in a way so that farming practices become more sustainable and profitable (Fulton et al. 2003; La Grange et al. 2010; Australasia Pacific Extension Network 2012). La Grange et al. (2010) also suggest that a definition of extension should include the involvement of exposure to information through facilitation that can aid in informing decisions on change to an individual's farm business.

Extension programs frequently aim to speed up the rate of adoption, or diffusion, of an idea or practice (Barr & Cary 2000). Extension services are traditionally responsible for effectively communicating research information to the agricultural sector, in order to help bridge the gap between science and practice (Folorunso & Ogunseye 2008). Traditionally, these efforts have been based on communicating with people who are considered innovators and early adopters of practices or technology, through field demonstrations, workshops, and group meetings, assuming that this information will diffuse through communication channels to the population of later adopters (Rogers 1995; Wauters & Mathijs 2010). La Grange et al. (2010) argued that farmers who gave up their time to attend extension workshops and activities did so on the assumption that they were motivated to gain a better understanding of what the workshop was delivering. He went on to argue that there was then a high likelihood that these motivated participants will then implement practice change. However, a study by Wauters and Mathijs (2010) found that diffusion of information about soil conservation practices through engaged early adopters was not as effective as expected, with diffusion occurring at a very low rate, or not at all. Without knowing who the population of likely adopters of an innovation is, there is no basis for making sound judgements on rates of adoption, nor the success of extension programs (Kaine 2004). Vanclay and Lawrence (1994) further emphasised the shortfalls of such a technology transfer approach, and that a top-down approach fails to consider the social factors that influence adoption and implementation. Morse et al. (2006) also suggested that farmers need to have more control over the information they require, driving demand for research and extension, which does not effectively occur in a top-down approach.

New approaches to extension

In the context of adoption, assessing and understanding how farmers are making decisions and how extension providers can work within this process is likely to be more useful than attempting to mould or change farmers' processes to one of our own design (Thompson 2009). Incorporating both informal and intuitive, and more formal and quantitative, approaches to decision making, coupled with the basic tools for doing so, could make for a more effective extension approach (Thompson 2009). Creighton et al. (2011) further supported the need for a new approach to technology transfer, and a need for a greater focus on farmer participation and involvement. Similar to anecdotal evidence from the Tasmanian dairy industry, a survey on pasture management practices used on Irish dairy farms found adoption of recommended grazing management practices was low. Creighton et al. (2011) concluded that a change to the traditional approach of technology transfer was needed, with a greater focus on increasing farmer participation in extension, and farmer to farmer learning and support. These findings support the need for a greater understanding of the drivers of adoption and engagement decision making, and the role of extension, with participation only not being an adequate reflection of the likelihood of practice and behaviour change occurring.

Consequently, there has been a shift in agricultural extension away from knowledge transfer to knowledge exchange (Blackstock et al. 2010), and a move to co-creating and facilitating learning in action (McCown 2002). Traditional extension approaches focused on knowledge transfer assume dissemination of information occurs where innovations and knowledge are transferred to farmers who adopt them in a one-way, sequential path (Rogers 1995; Black 2000; Rogers 2003). The shift to knowledge exchange takes a human development approach where individuals develop their own solutions to challenges, and the role of extension is in facilitating interaction, learning and innovation, rather than persuasion, and providing a source of knowledge and an environment for doing so (Blackstock et al. 2010). Extension providers can recommend practices and innovations to assist farmers with addressing challenges. However, as the focus is on individuals developing their own solutions to challenges, based on both formal and informal approaches, their solution may well differ from those recommended but may achieve the same outcome. These approaches add to the findings of Kilpatrick and Johns (2003) which promote that value should be given to non-traditional and non-expert forms of knowledge, such as local farmer knowledge and prior experience, in addition to the significance of social interaction and farmer to farmer learning (Kilpatrick & Johns 2003; Blackstock et al. 2010). These elements have been recognised as an important component of agricultural extension for a number of years (Blackstock et al. 2010). More recently, further insights into the diversity of farmers and their social culture has led to an increased interest in using market segmentation approaches, and targeting of key messages and information, with the possibility of increased effectiveness within agricultural extension programs (Garforth & Rehman 2006).

Extension has seen the introduction of knowledge and information systems, decision support tools, intermediaries (technology and human based) and innovation systems. While some approaches have been more successful at achieving behavioural and practice change, others have often been based on knowledge hierarchies that give preference to scientific evidence (Addom 2015), with less value placed on farmers and farmer knowledge, and poor links between both formal and informal knowledge and information (Sumane et al. 2018). For extension to be effective, valuing both formal, science based knowledge and informal, farmer based knowledge based on experience is necessary (Kilpatrick & Johns 2003; Sumane et al. 2018). In addition, new approaches have often been focused on providing uniform solutions based on scientific knowledge and aimed at addressing production challenges (Lyon et al. 2011). These findings support earlier studies such as that of McGown (2002), who found that for extension approaches (particularly those such as decision support tools and information systems) to be effective, there is a need to move away from prescribing solutions to encouraging and facilitating learning.

As outlined by Turner and Irvine (2017), pasture management practices and decision making are complex, and there is a need for farmers to develop their own skills and knowledge through a supported learning process. This supports the findings of Nuthall (2012), who interviewed a number of grazing farmers in New Zealand and concluded that grazing and feeding decision making and management was constantly changing. With each farmer's situation being unique, a uniform or standard approach was unlikely to be successful (Nuthall 2012).

There is increasing understanding of the importance of more participatory and inclusive approaches to extension, involving multiple actors and closer collaboration with farmers (Sumane et al. 2018). For example, such system based, multi actor approaches are being focused on in Europe as part of their strategic approach to agricultural research and innovation (European

Commission 2016). However, Sumane et al. (2018) argue that more support is needed to integrate farmers' knowledge and other informal knowledge and learning sources with existing formal approaches, and that both are integral for modern agriculture to be sustainable in the future. Innovation systems approaches that combine multiple sources of knowledge, incorporate multiple strategies, and place farmers, their social networks and interactions, and knowledge exchange at the centre have been shown to be more effective at achieving adoption and practice change (McKenzie 2013). Such an approach was demonstrated to be more effective in achieving farmer driven adoption of practices to mitigate land degradation in New South Wales, Australia (McKenzie 2013). Such an approach recognises that each farmer has a unique combination of conditions and influences, and a range of management strategies is required (McKenzie 2013).

Similar to programs that have been run in Tasmania, a bottom-up approach placing farmers at the centre of practice based innovation in Ireland involved regular measuring of pasture and follow up through farmer to farmer networking and intensive interactions (Brocard et al. 2018). Further supporting the findings of Turner and Irvine (2017), this study highlighted the importance of on farm learning, with follow up support and peer to peer learning when adopting and utilising pasture measurement and management practices. Incorporating formal knowledge in the form of pasture measurements gives farmers objective data from which they can be confident in their decision making, while they develop the skills and knowledge necessary to adapt practices that incorporate their own observations, informal knowledge and experience (Nuthall 2012; Turner & Irvine 2017).

For extension, it is also important to understand farmers' existing 'network of practices' (Eastwood et al. 2017). The network of practices includes the people farmers associate with, along with each farmer's complex mix of goals, expectations, and on and off farm support (Eastwood et al. 2006). In a study on integrating formal and informal knowledge, Sumane et al. (2018)

demonstrated that farmers operate in networks with multiple actors and social networks or influences, consisting of formal institutes (research institutes, advisory services, universities etc.) and informal networks (for example, peer and farmer groups). Such networks are often the first channels for farmers when exchanging ideas, knowledge and practices (Sumane et al. 2018).

Farmer to farmer learning, such as that which occurs in extension group settings and facilitation of social learning, generates social capital which can influence individual behaviour (Schusler et al. 2003; Minato et al. 2012). Social capital is thus strongly linked with the concept of social norms or influences, or a shared understanding of how to behave in social situations (Minato et al. 2010; Minato et al. 2012) which can impact on individual behaviour. Minato et al. (2012) reinforced the need for incorporating an understanding of social influence and its impact on individual behaviour, particularly when it comes to improving natural resource and environment management programs and practices. The role and importance of social influences is discussed in further detail on pages 28 to 30.

Though approaches to extension have continued to evolve, there is still the element of top-down approaches in designs, with many still falling short of achieving widespread adoption of practices. As concluded by Nuthall (2012), one uniform approach to extension is unlikely to be successful. Further work needs to be done to encourage farmer driven approaches that foster long term solutions to adoption challenges (McKenzie 2013). This supports the need to understand farmer adoption decision making and the factors influencing this process for particular farming contexts (such as pasture management). There is a need to understand the social context of farming and the social factors likely to influence both adoption and farmer engagement with extension.

Extension design

How extension programs are designed needs to be considered in order to achieve an outcome of adoption or behaviour change. For instance, Greene et al. (1995) found that programs with a specific recommendation were more persuasive and thus effective than those with general recommendations. In addition, Pornpitakpan (2004) found that approaches that are more targeted towards an individual with elements of personal factors can also increase the persuasiveness and effectiveness of programs and associated recommendations.

Understanding what factors can influence an individuals' behaviour and how to influence farmer group dynamics is crucial in situations such as the Tasmanian dairy industry where a large component of extension is focused on group delivery. Effective extension programs recognise that advice needs to be provided and used within a network of human relationships, and those human relationships play a role and can be used to influence behaviour (Blackstock et al. 2010). Fulton et al. (2003) promotes that understanding the social context within which farming occurs, and within which individuals operate, is essential if research and extension programs are to be successful.

However, even with improvements in extension design and delivery, on-farm practice change does not always occur, and adoption of new tools or practices can remain low. The challenge exists for extension to identify and understand the complex mix of personal and individual factors that influence individual farmers' behaviour, and the influence of farmers' social networks, in order to design effective extension programs that can address challenges and achieve an outcome.

Sources of information are rapidly growing and becoming increasingly available and accessible through online web platforms, highlighting the need for extension services to focus on credibility, legitimacy and farmers' decision making process. It is only through a greater understanding of both the physical and social factors that drive decision making processes, and how this varies between individuals, that extension services can adequately cater for individuals needs in an increasingly competitive information and knowledge delivery market.

However, Pannell et al. (2006) suggests that future extension is unlikely to play a large role in practice change on-farm, rather the role for extension will be in raising awareness of and, to an extent, changing perceptions of, new innovations, technologies and practices. McKenzie (2013) also suggests a new approach to extension design is needed, and one that builds in farmer engagement and capacity. With increasing sources of knowledge through online platforms, extension professionals are more likely to become network facilitators and knowledge brokers, as access to formal information and science is becoming more readily and easily available (McKenzie 2013).

Identifying and understanding key perceptions influencing adoption is important if extension programs are likely to be successful in the long term, as it is unrealistic to expect all potential adopters to have completed an extended learning process required for building competency, knowledge and skills necessary to adapt recommended practices to individual farming contexts within a given time frame (e.g. length of extension program) (Llewellyn et al. 2005; Turner & Irvine 2017). Developing a greater, in depth understanding of the social context and the perceptions of farmers that influence adoption means these factors can be incorporated into longer term or subsequent programs to ensure more effective behaviour change. Offering such a program on a once-off basis is unlikely to be successful, as not all farmers have been able to develop the necessary knowledge, skills and confidence to achieve long term adoption, adaptation of practices and behaviour change.

The future of extension

There are advantages to both group and individual based approaches to extension, suggesting that neither should be regarded as the only strategy for extension and influencing behaviour. Top down knowledge transfer and bottom up knowledge exchange can be viewed as two ends of a spectrum, with some middle ground that incorporates social factors likely to provide the most flexibility for future extension programs and approaches (Black 2000; Baumgart-Getz et al. 2012). Increasingly, extension professionals are dealing with the complex relationships among science, technology, individuals life experiences, social influences, values, attitudes and beliefs (Morse et al. 2006). Dealing with groups of individuals with varying and often conflicting views, interests and values, poses a constant challenge for those working in extension. At the same time, extension professionals need to encourage and facilitate peer to peer learning in order for individuals to gather enough information to make informed decisions. Group based extension does have its advantages, as it emphasises adult learning principles and encourages greater input and ownership of problems and solutions (Marsh & Pannell 2000). However, not all individuals are going to be attracted to this type of learning and extension activity, and the challenge remains of how to engage this section of the farming population. This further supports the findings of Vanclay (2004) that farmers are non-homogenous, and that a broad view of agricultural extension, knowledge and learning is essential for understanding farmer decision making and facilitating behaviour change.

While more recent approaches to extension have been more effective at achieving adoption and practice change, such as innovation systems that enable farmer driven knowledge exchange (McKenzie 2013), one approach is unlikely to be effective (Sumane et al. 2018). There remains a need to understand what factors are influencing adoption behaviour from occurring in order to develop approaches that will work in different farming contexts. New methods of engaging with farmers is required, and development of new methods requires an understanding of what factors are influencing farmer engagement (McKenzie 2013).

Farmer Education and Learning

Farmer education and adoption

Farming operations and businesses are becoming increasingly complex, with many farmers moving towards viewing themselves as managers and less as traditional farmers, requiring the same skill set and responsibilities as any other business manager (Cary et al. 2002). This shift has led to an increasing number of farmers and primary producers now pursuing formal education qualifications, with the Australian Bureau of Statistics (ABS) reporting that from 1980 to 2011, the number of farmers with a university bachelor degree or higher increased six-fold (Australian Bureau of Statistics 2012). It is also worth noting that during this same time period the number of farmers in Australia declined by 40%, with small farmers selling to larger scale operations, and fewer young people taking over family farms (Productivity Commission 2005; Australian Bureau of Statistics 2012). While there has been an increase in formal education, it is not known whether a large component of informal learning is also occurring in addition to an increase in formal learning. There may be a change in attitude and characteristics of farmers to more knowledge seeking, with an openness to learning influencing the adoption process by reducing uncertainty and improving knowledge of the potential benefits of technologies or practices.

Education and training has been shown to assist farmers in making changes to their farming practices (Kilpatrick 1996). Several studies have demonstrated a positive relationship between farmer education and adoption, such as the adoption of sustainable farming practices (Reeve & Black 1998), and the adoption of technology in the beef industry (Quinn, 1999, as cited in Fulton et al. 2003). Additional studies have found that farmers with higher education are likely to be more innovative and flexible in responding to internal and external changes that impact on the farming business, and be more likely to adopt new technologies and management practices (Kilpatrick 1997; Kilpatrick 2000; Fulton et al. 2003; Yu 2014; Bravo-Monroy et al. 2016). Studies have also found that farmers who have received a higher level of education are more likely to seek out and participate in further learning opportunities than farmers who have received lower levels of education (Kilpatrick 1996; Kilpatrick & Johns 1999; Fulton et al. 2003). Yu (2014) found that farmers with a higher level of education were more likely to be either an initial adopter of a technology or practice, or more likely to copy that innovation first, thereby enhancing its diffusion. This supported previous studies, such as that of Mues (1998), who found that training was the characteristic most frequently linked to practice adoption. Education level and training are considered an indicator of an individual's capacity and willingness to change, with more frequent involvement in training courses (such as those offered through industry) being positively associated with adoption and practice change (Cary et al. 2001; Aytülkasapoğlu & Ecevit 2002). A study by McKenzie (2013) investigating innovation of New South Wales farmers found that farmers with a proactive approach to seeking and understanding new information was positively associated with increased innovativeness and adopting new practices.

In a study on adoption of natural resource management practices, insufficient information and technical resources to address challenges were found to negatively impact adoption, but can be addressed through the extension programs providing information and knowledge development that can increase an individual's capacity to implement a practice (Cary et al. 2001). The view that a farmer has inadequate resources to address a problem can be indicative of the complexity involved in adoption of agricultural innovations and decision making. There is an ongoing need to recognise and understand the complexity of performing a behaviour or integrating an innovation into a farming system if they are to be addressed or overcome. As is the case with most agricultural groupings, there exists a wide range of knowledge and abilities among farmers, including both formal and informal education. In order to encourage a greater understanding and implementation of agricultural practices, Cary et al. (2001) suggested that it was more important to focus on how farmers might learn about using a practice instead of relying on pre-existing levels of formal education.

Farmer learning

An understanding of how farmers learn is essential if farmer learning and practice change is to be promoted and fostered (Sewell et al. 2014). Learning, in the context of agricultural extension as described by Fulton et al. (2003), includes learning what, how and why. Understanding how farmers learn and what factors influence this process is important in informing and developing agricultural extension programs (Sewell et al. 2014). The technology adoption process is one of information acquisition, where farmers collect information through a range of different learning approaches (Yu 2014). Kilpatrick and Johns (1999) have defined farmer learning into two separate categories; informal learning, such as learning from experience, observation and other people; and education and training, or organised, formal learning. As such, extension is a form of adult education, and the principles of adult education aid in forming a framework within which extension operates (La Grange et al. 2010). This becomes increasingly complex when groups of farmers are involved, as not all farmers or indeed adults learn the same way (Long 2004). A number of factors impact on an individuals' learning, including personal characteristics such as race, gender and personal experiences (Wang 2010). Motivation is also a key driver of participation in adult learning, with activities needing to engage adults as willing participants (La Grange et al. 2010).

Role of informal learning

Farmers' learning occurs through a wide range of methods, including reading, learning from other farmers, learning from experts, learning from their own experience and observation, groups, field days, organised education and training, or a combination of these (Bamberry et al. 1997; Wake et al. 1988; Kilpatrick & Johns 1999; Kilpatrick & Johns 2003; Franz et al. 2010; Sumane et al. 2018). Farmers will select particular learning sources and methods depending on their needs (Kilpatrick 1996). Despite the range of learning methods used, studies have found that farmers prefer more informal, non-organised learning such as learning from peers, fellow farmers, one on one with industry experts and learning from their own experience and observations (Bamberry et al. 1997; Kilpatrick & Johns 1999; Black 2000; Cockfield & Doran-Browne 2018). Kilpatrick and Rosenblatt (1998) summarised the reasons as to why farmers prefer to learn from informal sources as they have a preference for independence and gaining information from known sources, it is a more contextual mode of learning, and many farmers have an uncertainty or fear of being exposed to new knowledge or skills. For example, other farmers and peers are more likely to be used as a source of background information prior to making a decision and for practical issues (Fulton et al. 2003; Kilpatrick & Johns 2003).

More recent studies have supported the importance and role of informal, peer to peer learning. McKenzie (2013) found that farmers placed high value on the advice and experiences of other farmers, with farmer groups considered an important source of information and peer support. Sumane et al. (2018) found that farmers' knowledge was the most prominent and trusted knowledge source, due to the farmers practical experience and local relevance. In comparison, extension officers and private consultants tend to be used a source of technical advice (Fulton et al. 2003). Characteristics of farmers themselves, such as skill level, years of experience and business goals will also impact on the learning source farmers select (Kilpatrick 2000). However, the increase that has been observed in the number of farmers receiving higher levels of education and more formal education qualifications, and the lack of more recent research into the learning sources of farmers, suggest that a shift may be occurring in farmers' preferred methods of learning and learning sources.

New sources of information – online and internet

The introduction and rise of the internet, online web pages and applications has increased the availability of information to farmers (Jain et al. 2015). There has been a shift in recent decades in the way farmers access information, along with a diversification in the way information is received (Hall et al. 2003). The internet is increasingly being used for activities such as accessing weather information, market and price tracking, accessing technical information, accessing agricultural services and online record keeping (Simpson 1999; Easdown & Starasts 2004; Abdon & Raab 2005). It offers advantages over more traditional information and knowledge dissemination as it is quick, continually accessible, allows interaction, and offers a vast amount of information (Abdon & Raab 2005).

Though the internet offers an alternative means of information and communication, it is not without its limitations. Challenges with internet accessibility in rural areas and cost can be a barrier to use and reduce its effectiveness (Easdown & Starasts 2004). Farmers also need to have the necessary skills and support in learning how to use the internet and contextualise its information (Easdown & Starasts 2004).

Despite the increase in internet use, several studies have suggested that the internet needs to be integrated with more traditional learning sources, and used to complement rather than replace these, due to the ongoing preference of many farmers to learn in a contextualised setting (Gloy et al. 2000; Easdown & Starasts 2004; Howell & Habron 2004). Kutter et al. (2011) found that despite internet use in the form of email being widely established in the agricultural sector, and could substitute letter and post, farmers still preferred phone calls due to being able to immediately obtain information. Findings of Brocard et al (2018) also support the role and importance of new forms of communication such as internet and social media in farmer to farmer learning. However, other studies have found that use of the internet and associated applications has increased with increased farm size and higher operator education, while decreases with operator age (Gloy et al. 2000; Hall et al. 2003; Howell & Habron 2004; Abdon & Raab 2005). Along with the trend of increasing levels of formal education among farmers, these findings suggest that use of the internet as a source of information and learning is likely to continue to increase.

Farmers are problem oriented

Many farmers are 'problem oriented', in that they recognise that their current knowledge is insufficient in solving a particular problem they are faced with, and this knowledge gap drives them to find a solution (Long 2004). Rogers (2003) proposed that messages will be effective if they can convince individuals that the problem is serious and one they are susceptible to, that recommendations will alleviate the problem, and that they are capable of performing the recommendations. In a review of the persuasiveness and effect of source credibility, Pornpitakpan (2004) found that for individuals with a higher level of uncertainty, a high level of personal relevance resulted in a higher level of persuasiveness. This supports earlier findings in that individuals are more likely to respond when they recognise it is their behaviour being targeted (Petty et al. 1991). However, if farmers do not recognise or accept that they have a problem, are performing poorly, and consequently could improve, a particular area of their business, they are unlikely to pay much attention to information about potential solutions (Pornpitakpan 2004; Blackstock et al. 2010).

The challenge for extension services is to be able to identify these problems or problem areas and to provide an adequate and ideal learning environment to assist farmers in finding solutions (La Grange et al. 2010). Pannell et al. (2006) supported findings of Marsh (1998), suggesting that extension should encourage a participatory process, working with farmers so that research and extension staff recognise that their goals may not align with the challenges farmers are facing. A participatory process reduces the risk of incorrect assumptions, increases farmer knowledge and ownership of research, as well as farmer confidence in the results (Marsh 1998; Pannell et al. 2006).

Role of farmer groups and social networks

Kilpatrick and Johns (2003) emphasise learning as a social process, with people the most frequently cited source for farmers when it came it ongoing learning and making a change to farming practice, as learning was able to occur within their specific farming context. Farmers rely on both social and business networks, with family, co-workers, peers, and industry experts are all considered important sources of learning (Kilpatrick 1996; Bamberry et al. 1997; Kilpatrick & Johns 2003; Eastwood et al. 2017). In addition to an important source for farmer knowledge and learning, social networks also provide support when implementing change, and can assist farmers in working through barriers to implementation of new ideas within a local context (Kilpatrick & Johns 2003).

The social interaction that comes with group learning can be a factor in increasing motivation for individuals to participate in the learning process (Kilpatrick 1996). Innovative and successful farmers tend to be more proactive in gathering information (Sloane, Cook and King, 1995, as cited in Kilpatrick & Johns 1999; McKenzie 2013). Farmers are more likely to adopt a practice or technology if it conforms to the norms or expectations of their farming and social community, and if they think their neighbours would approve of their decision (Vanclay & Lawrence 1994; Moser & Barrett 2006; Wauters & Mathijs 2010; Läpple & Kelley 2013; Wollni & Andersson 2014). However, some farmers are self-reliant with regards to information seeking and acceptance (Waters et al. 2009). This was supported by Cockfield and Doran-Browne (2018) who found in a study of Victorian dairy farmers that some were satisfied with their own skills and information sources, and didn't want to share farm information with others. In addition, Cockfield and Doran-Browne (2018) also found that some farmers may have social and learning preferences that don't align with industry activities and programs.

While some farmers are more self-reliant when it comes to information seeking, others prefer group and peer to peer learning (Kilpatrick & Johns 2003). Therefore, social networks and interactions are important to consider when designing extension and other support tools and services (Eastwood et al. 2017). However, credibility (a product of expertise and trust) and the source of information are important components in facilitating and achieving behavioural change (Blackstock et al. 2010). Sources that have a higher level of credibility have a greater likelihood of influencing behaviour, and play an important role when decisions or behaviours are more complex, have a higher level of risk, or there is a low level of existing experience (O'Keefe 2002). Particularly in agriculture, experience and occupation are key factors when it comes to farmers determining the reliability of a source. Those from trusted networks, such as research and extension organisations (Lankford et al. 2004; Blackstock et al. 2010), peers viewed to have a high level of experience, and people from farming backgrounds (Robinson 2006) are more likely to influence behaviour (Blackstock et al. 2010).

A paper by Sewell et al. (2014) outlined five critical success factors in supporting farmer learning, including community, connection, interest, alignment, and inquiry. The most critical was community, regarding developing an inclusive community between farmers and scientists where learning occurred in both directions. This involves both farmers and scientists being jointly engaged in the learning process, generating and exchanging new ideas as a collaborative process (Sewell et al. 2014). Aligning learning with farmer interest and context was also outlined as a valuable experience, with in field observations allowing a firsthand experience of results and being better able to contextualise these to farmers' own situations (Sewell et al. 2014). This also brings variety in to the learning environment that helps to stimulate interest and enhance engagement and motivation in farmers (Brophy 2013; Sewell et al. 2014).

Membership in farmer groups, such as industry discussion groups, in addition to the amount of information available in their social and community network, can increase the likelihood of adoption due to better access to information and technical assistance (Wollni & Andersson 2014; Bravo-Monroy et al. 2016). These results further support studies that have found informal information and knowledge exchange, such as that occurring between farmers and neighbours, to be an important source of learning and factor in adoption and technology diffusion (Kilpatrick & Johns 1999; Nuthall 2012; Wollni & Andersson 2014; Sumane et al. 2018). Combining both informal and formal knowledge and information exchange that complement each other will be more effective in achieving goals of practice and behaviour change (Ingram 2008; Lyon et al. 2011; McKenzie 2013; Sumane et al. 2018).

Barriers to learning and extension

Given the range of social and physical factors that influence decision making, adoption and on-farm change, there also exists a range of barriers to participation in extension activities. These may include factors related to the individual, their family, characteristics of their farm or business, in addition to rural community and peer groups (Fulton et al. 2003). Fulton et al. (2003) identified barriers to participation in the form of farmer education and training, but also reported that little research has been conducted on identifying barriers to informal training, and further information on the extent of farmer participation in learning activities would be beneficial in understanding what these barriers are and how they could be overcome. Additional barriers to learning or making a change also exist, and revolve around the activity itself, the nature of the change, and the learning environment. Therefore, any change in attitudes of farmers with the advent of more participatory methods is likely to be slow, and any flow on to engagement with research and extension will take time.

As concluded by Kilpatrick (1996), there is not one best way of delivering education and training, and that a variety of methods and programs should be available. Farmers' learning occurs in a complex social learning system, influenced by a range of actors and networks through informal and formal learning (Oreszczyn et al. 2010), This reinforces the need for a greater understanding of farmer attitudes towards a technology or innovation, and what social and other additional factors influence the adoption and decision making process, for extension to be successful in achieving greater adoption and practice change.

Extension and learning - developing farmer competency and adoption

Learning activities in the form of extension can assist in farmer adoption and adaptation of new technologies and knowledge intensive practices (Cliffe et al. 2016). It has been suggested that such a learning process should develop farmers competency, or capability and capacity (Robinson 1974; Karbasioun 2007). Such a learning process, as suggested by Robinson (1974), develops competency from that of 'unconscious incompetence' where an individual is not aware they lack a skill or ability; to 'conscious incompetence' where an individual becomes aware there is a need for knowledge and skill development; to 'conscious competence' where an individual knows how to do something but have to consciously think about how they carry it out, and then 'unconscious incompetence' where individuals have the capacity to carry out and adapt a skill or practice independently and without conscious awareness.

These various stages of competency can be associated and align with farmer decision making and adoption, involving both informal, heuristic based and more formal, quantitative approaches (Öhlmér et al. 1998; Eastwood & Kenny 2009). Conscious decision making involves rationality, intentionality and is more rule based with deliberative analysis (Nuthall 2012). Non-conscious, or unconscious, decision making involves learning from experience and developing of knowledge and intuitive judgement (Nuthall 2012). Such processes require years of experience and foundational learning (Khatri & Ng 2000). Formal, deliberate practice (such as using pasture measurements in decision making), that involves repetition and refinement assists farmers in developing their competency (Dane & Pratt 2007; Nuthall 2012). These studies align with and support the idea of a learning competency model, an progression through competency that comes with learning, as proposed by Robinson (1974). These stages resonate with farmers using a variety of approaches to decision making, including both informal and more formal, quantitative approaches (Ohlmer et al. 1998; Turner et al. 2019).

As described by Wilkinson (2011), adoption is a continuous, step-by-step process, involving learning, knowledge and skill development. The adoption of recommended pasture management practices and associated tools and technology can be considered the same way, an ongoing process that involves farmers identifying and recognising that there is a gap in their management knowledge and skills, then developing that knowledge, skills and experience over time to a point they can adapt recommended practices to suit their farming situation (Turner & Irvine 2017; Turner et al. 2019). This process assists farmers in developing their competency until they reach unconscious competence. Further research is required to understand where within this process extension can have the greatest impact for individuals and groups of farmers, and where farmers are encountering the greatest challenges that can negatively impact adoption. Identifying how and why social factors impact adoption of pasture management practices, and where they occur within the pasture management learning process, is necessary to inform the design of future extension activities.

Adoption in Agriculture

What is adoption?

Adoption has been defined by Ghadim and Pannell (1999) as a dynamic and multi-stage decision making process, involving information seeking and learning by doing. The adoption of an agricultural practice or technology is typically thought of in discrete measures, that is, it either occurs or it doesn't (Barr & Cary 2000). In reality, adoption is a more complex and continuous process, often being reassessed by individuals (Barr & Cary 2000; Wilkinson 2011).

Traditional approaches to adoption

The concept of categorisation of individuals on a spectrum of adoption, or adoption curve, is well documented and long-standing (Rogers 2003; Pannell et al. 2006). Rogers (2003) diffusion of innovations theory has formed a central component of much of the literature on adoption and diffusion of innovations, and is commonly used when categorising individuals, ranging from innovators to laggards based on their innovativeness, or the degree to which an individual is relatively earlier in the adoption of new ideas or practices than others (Rogers 2003). This theory was based on the belief that poor agricultural performance was due to technological reasons, and could be solved by developing and delivering technology (Guerin & Guerin 1994). These views essentially reflect the technology transfer model, that studies have shown to be ineffective in resulting in adoption (McKenzie 2011).

Characteristics such as beliefs, values and attitudes as described by Guerin and Guerin (1994) and Pannell et al. (2006), among others, also influence where individuals are categorised on the adoption spectrum. More recent studies have moved away from categorising where individuals are on an adoption spectrum, focusing on what factors are likely to influence adoption occurring. Individual farmers' characteristics, including attitudes, perceptions and values have been found to strongly influence the process of adoption with regards to voluntary land conservation (Burton et al. 2008), improving water quality (Blackstock et al. 2010), and uptake of biomass energy crops (Warren et al. 2016). Understanding of motives and perceptions of farmers is therefore key in developing effective programs with the aim of achieving adoption. Understanding how these beliefs, attitudes and values, combined with social influences, impact the process of adoption and how they vary for certain practices and contexts is necessary for the design of future programs that aim to achieve adoption and behaviour change.

There have been numerous adoption studies of agricultural innovations and technology worldwide, from studies conducted in developing countries to non-adoption specifically in Australian agriculture (Guerin & Guerin 1994; Marsh et al. 1995; Donnelly et al. 2002; Kuehne et al. 2017). The adoption of new innovations and technology in agriculture has been an area of significant study for a number of years, but yet predicting the likelihood of adoption remains a challenge (Marsh et al. 1995; Ekboir 2003). These studies have centred on answering questions around what determines whether or not an innovation is adopted, characteristics of adopters versus non-adopters, and, if adoption occurs, what determines diffusion of the innovation through a population (Marsh et al. 1995; Ghadim & Pannell 1999; Barr & Cary 2000; Rogers 2003; Wauters & Mathjis 2010). In this context, technology adoption is the implementation of knowledge into practice, and is the end product of the process of technology transfer as described by Rogers (2003). Technology transfer is the process of transferring knowledge, products or practice from development to operation (Guerin & Guerin 1994; Rogers 1995; Rogers 2003).

Though more recent studies have moved towards understanding characteristics of farmers that influence adoption, fewer studies have approached the challenge of adoption through understanding the farmer decision making process, and what social and individual characteristics are likely to impact this. Adoption of practices or technology, and progression from knowledge to implementation, involves a number of stages and a range of factors influencing adoption and practice implementation (Wilkinson 2011).

Barriers to adoption

Barriers to adoption can take numerous forms with multiple factors involved, and will vary for different businesses, individuals, technologies or innovations (Guerin & Guerin 1994). Farmers will gather information on a technology and innovation and select those which are consistent with their needs and attitudes (Chamala 1987). The decision process around adoption can be quite complex, with various factors that will be taken into consideration. There are many factors that can impact on and influence adoption on-farm, in addition to those of individual attitudes towards adoption and change, previous experience, and level of education and training.

Additional factors that influence adoption that fall into the broad category concerning the farmer or individual include family and social connections, farm structure and financial situation (Fenton et al 2000, as cited in Conte et al. 2010); farmers characteristics and attitudes (Burton et al. 2008); perceptions, including those of what constitutes 'good farming' (Burton et al. 2008; Rodriguez et al. 2009); in addition to social norms and influences, personal values, and social and individual beliefs (Edwards-Jones 2006; Rodriguez et al. 2009; Cope et al. 2011). Characteristics of the technology itself can also play a role in influencing farmers' attitudes towards the technology, and also influence adoption (Guerin & Guerin 1994). These include characteristics such as ease of use and implementation (Guerin & Guerin 1994), accuracy and quality of the technology, and also trust in the technology (Eastwood & Kenny 2009). The challenge of adoption is not limited to biophysical characteristics or issues, but is a broader challenge that encompasses and involves economic, social and psychological issues (Marsh 1998; Pannell et al. 2006). To be effective, adoption studies should consider these factors along with the characteristics of individual farmers and their social networks and influences (White et al. 2009; Sattler & Nagel 2010; Ma et al. 2012). Bravo-Monroy et al. (2016) also emphasise the importance of understanding social, political, economic, demographic, technological, cultural and biophysical factors, as they are all drivers of adoption. Understanding the social factors at the farm level is central to this and can provide a better insight into what processes are occurring, and what processes and factors play an important role in adoption (Bravo-Monroy et al. 2016).

Farmer Characteristics and Attributes that Impact Adoption

Individual and Social Characteristics

Adoption is increasingly being viewed as a social process, in which adoption behaviour is influenced by social factors such as attributes and characteristics of the individual making the decision, their social networks, and family members (Fujisaka 1994; Pannell et al. 2006; Sattler & Nagel 2010; Warren et al. 2016). An individual's initial knowledge and assessment of an innovation is reliant on a combination of information from others, and their own perception of the innovation (Ghadim & Pannell 1999). Sources of information can come from personal and social networks, and these will often have a large impact on the initial assessment and decision making process regarding an innovation.

In a study on social networks and learning about agricultural innovations in the United Kingdom, Oreszczyn et al. (2010) concluded that farmers learn about new technologies and practices in a complex social learning system, placing value on their own experience but also on other farmers and experts. In a study on natural resource management in Australia, Minato et al. (2012) highlighted the importance of the influence of social norms or influences on behaviour, through impacts on individuals thinking, behaviour and facilitation of social learning.

Understanding this process involves understanding people and their social networks, and 'to understand people, one needs to understand what leads them to act as they do, how they act is influenced by their goals' (D'Andrade and Strauss, 1992, pp. 31, as cited in Manjala 2009). Failure to take into account how this process and the actors within it influence farmer behaviour can impact negatively on innovation adoption (White et al. 2009; Sattler & Nagel 2010; Ma et al. 2012; Warren et al. 2016). Further research into understanding the role of social influences on farmers adoption decision making in specific contexts is necessary if they are to be addressed in order to facilitate behaviour change.

Individual and Personal Characteristics

Personality characteristics have the potential to play a large role in impacting adoption decisions, however they can be very complex and thus hard to measure (Ghadim & Pannell 1999). Adoption studies have included characteristics such as perceived behavioural control, which is an individual's perception of the ease or difficulty of performing a behaviour; and locus of control or actual control, or the degree to which an individual believes they have control over outcomes of events, as has been included in the Theory of Planned Behaviour and related studies (Ajzen 1991; Sideridis et al. 1998; Conte et al. 2010). Many characteristics of individuals have been shown to impact on adoption decisions, such as attitude toward risk (Ghadim & Pannell 1999; Kaine 2004), attitude towards change (Chamala 1987, as cited in Guerin & Guerin 1994) beliefs and values (Guerin & Guerin 1994), and their social situation and social norms (Pannell et al. 2006; Bravo-Monroy et al. 2016). Studies have also shown that farmers have a strong motivation to conform to the idea of upholding good farm management, including aspects of farming practice and environmental management, but that ideas of what constitutes good farm management will vary between individuals (Vanclay 2004).

Prior research that has focused on socio demographic factors and the relationship with attitudes and behaviours in regards to environmental management has shown conflicting results (Tarrant & Cordell 1997; Cary et al. 2001). Farmers' age is often considered an important factor impacting the likelihood of adoption (Stanley et al. 2006; Yu 2014). However, studies have produced conflicting results on this relationship (Pierpaoli et al. 2013). Some studies have found that older farmers are more likely to adopt new technologies, as they are more experienced, able to assess the information more readily, and have a better understanding of their farm and what the outcomes of adopting a new technology are likely to mean for their business (Payne et al. 2003; Mignouna et al. 2011; Kariyasa & Dewi 2013). However, other studies have found that younger farmers are more likely to adopt new technologies as they tend to have a higher level of formal education which can reduce their uncertainty about new innovations, and they have a longer remaining lifespan to implement changes and see the benefits (Warner 1981; Chi & Yamada 2002; Adesope et al. 2012; Howley et al. 2012). While there have been conflicting results on whether younger or older farmers are more likely to adopt new technology, other studies have found that no significant relationship between age and likelihood of adoption (Guerin & Guerin 1994; Cary et al. 2001; Curtis et al. 2001; Cary et al. 2002). These mixed results suggest that age may play a role in adoption of new technologies and may be a factor that needs to be considered for individual innovations, but the influence of age is most likely to be in combination with other factors and variables, and the relationship will not be linear (Cary et al. 2002).

The stage in the lifecycle of a farming family and the composition of the family may also impact on what and how decisions are made. The stage in the family lifecycle may affect the farm finances available for purposes such as adopting a new technology, innovation, or practice, in addition to affecting commitment to the future, typically with younger farmers being more committed to a longer term future on the farm (Vanclay 2004). A study conduct by Byron et al. (2006) found that stages of life were mostly likely to constrain adoption in those under 30 years old, due to a higher likelihood of emerging family commitments, savings and debt.

The perceptions and expectations of farmers also influence adoption, with adoption depending on whether farmers believe that a particular technology or innovation will achieve a goal (Pannell et al. 2006). Access to and quality of information, financial capacity and being connected with local networks of farmer groups have also been found to play a role in adoption (Norris & Batie 1987; Baumgart-Getz et al. 2012). Perceptions largely depend on the farmers learning process and prior experience; the farmer's social environment and associated characteristics and circumstances; and the characteristics of the technology (Pannell et al. 2006). The goals of farmers are varied, and can include social, family, environmental, business, and personal goals. Non-adoption or dis-adoption is due in part to a technology, practice or innovation not progressing or achieving the farmers' goals (Thompson 2009).

Attitude

Individuals are more likely to follow through with a particular action or behaviour if they have a positive attitude towards that action or behaviour (Ajzen & Fishbein 1970). An individuals' attitude towards a behaviour is largely determined by that individuals assessment of whether the outcomes of that behaviour are negative or positive (Ajzen 1991; Fishbein & Ajzen 2011). Beliefs, values and fears are all factors that affect famer's attitudes, and are inherently individual characteristics (Guerin & Guerin 1994). As such, particular practices can be quite difficult to change as a persons' beliefs underlie their attitudes (Guerin & Guerin 1994).

In a study designed to explain farmers' soil conservation decisions, Wauters and Mathijs (2010) concluded that identification of beliefs that form the basis of farmers' attitudes would assist in targeting information and communication to farmers. Wauters & Mathijs (2010) also concluded that further analysis of those beliefs, particularly those behind farmers' negative attitude, would be valuable in targeting information in a way that would increase the cost-effectiveness of extension programs. This supports the suggestion that a greater understanding of the factors that drive decision making is necessary to further develop and enhance extension programs. Characteristics of farmers such as attitudes, however, cannot always be considered in isolation. For instance, outlining only the role of farmer perceptions of a problem in adoption decisions tends to take the technology designed to solve the problem as appropriate in meeting the needs of farmers (Adesina & Zinnah 1993), which other studies have outlined is not always the case (Komoda 1986; Fujisaka 1994; Pierpaoli et al. 2013). In a review of the drivers of adoption of precision agricultural technologies, Pierpaoli et al. (2013) found that perceptions of farmers around usefulness and ease of use of a technology can impact adoption, regardless of whether the technology is appropriate.

Attitudinal constraints have been cited as one of the most significant barriers to widespread adoption of changed practices on-farm (Stanley et al. 2006). Individuals form attitudes towards an 'attitude-object', which can be a person, idea, concept, or physical object, based on what they perceive to be true about that object (Willock et al. 1999a). These perceptions can be formed based on information or knowledge learnt or gathered about the object, or may be based on an emotional response (Willock et al. 1999a). Past experience can also influence adoption or non-adoption, with past negative experiences potentially causing indiscriminate rejection of new technologies or innovations, without trialling, testing or viewing any demonstration of the innovation (Guerin & Guerin 1994). As noted by Ibrahim (1985), resistance to change presented a problem in dissemination of technology, and if attitude to change wasn't managed, it could lead to eventual frustration with the technology and a reduction in, or complete lack of, adoption. In addition, Pannell et al. (2006) found that farmers' perceptions of how well an innovation helps them achieve their goals are critical in their decision to adopt. Despite attitudinal constraints now being recognised as a significant barrier to adoption, attitudes also represent one of the most challenging social factors to interpret, and how they can affect change (Stanley et al. 2006).

Attitudes can be influenced by a range of factors, such as family situation, type of farm, and the farmer's goals (Willock et al. 1999a). This is supported by findings of Lawrence et al. (2004) who suggested that a particular attitude, such as positive attitude towards an innovation or practice, may be a necessary condition for change, but is not likely a sufficient factor on its own. Attitudes about particular management practices can demonstrate certain traits or factors about a farm or farmer that is then likely to influence decision making (Bravo-Monroy et al. 2016). This supports conclusions of Barr and Cary (2000) who stated that the view that changing attitudes would lead to a direct change in behaviour is too simplistic.

Attitudes toward risk

Attitudes to risk describes an individual's tendency to take or avoid risk in their decision making process (Pannell et al. 2006). Individuals vary in their perception and attitudes towards risk, which can lead to a range of adoption outcomes based on how the individual views the adoption outcome for them and their business. Personal experience and risk perception are important factors when it comes to making decisions on-farm, with a farmers' attitude to risk an important factor influencing farmers' adoption decisions, and the rate at which adoption occurs (Barrett et al. 2004; Gillespie et al. 2004; Annou et al. 2005; Yu 2014).

A number of studies have found that farmers often tend to be risk averse (Guerin & Guerin 1994; Willock et al. 1999b; Sulewski & Kłoczko-Gajewska 2014), with their attitudes towards risk closely related to their attitudes towards innovations. If the details of an innovation are not able to be explained to farmers, such as how much it will cost, how to use it, and what benefits can be expected, generally the more conservative attitudes of individuals will predominate and adoption will not occur in order to avoid risk, and they will be more resistant to change (Guerin 1999).

Measurement of a farmers' attitude towards risk is an important component in understanding farmer behaviour (Cao et al. 2011). However, other studies into the impact of attitude to risk and the likelihood of adoption have produced conflicting results. A number of studies have found that risk averse farmers are more likely to adopt a new technology as the technology reduces the risk of a loss in production (Shapiro et al. 1992; Gillespie et al. 2004; Annou et al. 2005). Conversely, studies have found that farmers who are risk averse are less likely to adopt a new technology, due to the inherent uncertainty involved in implementing something new (Knight et al. 2003; Ghadim et al. 2005; Cole 2007). Yu (2014) has suggested that a reason for these conflicting results is that farmers may perceive new technologies to be more risky due to a lack of knowledge and increased uncertainty, which discourages their early adoption and use.

These conflicting findings of attitude towards risk and likelihood of adoption have implications for companies and organisations that are concerned with developing new technologies or associated technology adoption. The development of both new and existing agricultural technologies presents the potential to enhance agricultural production (Yu 2014). Despite the studies that have been conducted into understanding how attitudes to risk and social interaction impact on or influence adoption, empirical evidence shows that adoption rates of new technologies remains low (Yu 2014). This suggests that there may be confounding factors involved in adoption of technology, and when combined with conflicting results from studies around risk and adoption, suggests that attitude to risk is not universal in its impact on adoption. Assessments of risk are influenced by a farmers values and motivations (Greiner et al. 2009), emphasising the importance of exploring values and motivations, what impacts them, and their role in adoption behaviour and decision making.

Vanclay (2004) proposes that attitudes are not the primary problem when it comes to adoption of environmental management programs or practices. Rather, Vanclay (2004) believes that farmers may have different views about what adoption of a technology or practice means for them and their farm, and uncertainty about how to implement that practice. Uncertainty about a new technology and its reliability and performance poses a significant challenge to adoption. In some cases, farmers may have a positive attitude of a technology or practice, but may be lacking the knowledge, skills or support to adopt a technology or practice and make associated changes to their farm business. Social interaction among farmers, such as that which occurs through group based learning activities provided by an extension service, can facilitate farmer learning and knowledge development about a technology or practice, its benefits, and how to adopt and/or adapt it to suit their farm (Yu 2014;

Kilpatrick & Johns 2003). Decisions that are being influenced through these types of social interactions and networks present an opportunity for achieving behaviour change through targeting of information and programs (Wollni & Andersson 2014).

Farmer goals

Pannell et al. (2006) concluded that personal goals form the major driver for land management decisions. Understanding the sources of motivation for individuals is therefore important in order to attempt to explain what drives adoption of farm management practices (Toma & Mathijs 2007). Hu et al. (2006) proposes that motivation of individuals cannot be considered in isolation from both internal (social and psychological) and external (situational, technological) factors. Hu et al. (2006) goes on to explain how although many studies have examined how external factors impact on motivation and use of innovations, there are a whole range of internal factors that have not been fully explored. The study by Hu et al. (2006) and conclusions drawn present a number of parallels to what is currently occurring in the Tasmanian dairy industry, in that features of the tools and technologies have changed over time, but their use has not changed to the same extent. This creates further argument for the need of an increased focus on what other factors might be affecting their use, such as perceptions, social and psychological influences, and attitudes that may be influencing farmer motivation to use these tools and associated practices. Greater understanding of these motivational factors could lead to a better understanding of farmer decision making around adoption and implementation of these tools and associated practices (Hu et al. 2006).

The challenge exists for extension providers to understand be aware of individual farmers' goals, and how best to target extension activities in order to address these goals and achieve an outcome (Pannell et al. 2006). Changing the goal of individuals poses a greater challenge and is one that cannot be addressed through extension alone, but as argued by Pannell et al. (2006) is what will result in behavioural and practice change, and thus adoption.

Decision making

Traditionally, the dominant approach when analysing farmer decision making within Australian agriculture has assumed that farmers should, or would want, to a employ a formal, quantitative decision making process, and are indeed capable of doing so (Hardaker 2004). Thompson (2009) suggested that agricultural RD&E would benefit from a greater understanding of the socio-cultural and psychological factors that influence farmer decision making. It has also been suggested that both current and previous agricultural decision analysis, particularly the associated risk and benefit with the decision making context, does not meet the needs of more informal and qualitative approaches many farmers bring to decision making (Thompson 2009). Increasingly, decision analysis needs to, and is incorporating, personal, social and cultural aspects as proposed by Marsh and Pannell (2000) and Thompson (2009). With regards to pasture management, dairy farmers have been shown to alternate between experience, heuristic based decision making and more quantitative approaches (Öhlmér et al. 1998; Gray 2001). Eastwood and Kenny (2009) found that dairy farmers prefer to use their experience and observations to self-validate more formal, quantitative approaches, particularly while developing an understanding of quantitative approaches and trust in objective data.

Not all adoption decisions are made in a universal way, nor is the same decision making process made by an individual for all adoption decisions, and thus innovativeness is not a personal characteristic that is applied equally in all situations (Pannell et al. 2006). For instance, if an individual is an early adopter of one innovation, that does not mean they are an early adoption of all innovations. Characteristics of the innovation itself will impact on the decision making process and adoption outcome (Komoda 1986; Fujisaka 1994; Pierpaoli et al. 2013).

Farmer decision making is a complex process involving multiple factors and can be strongly influenced by peers and social judgement (Burton & Wilson 2006; Blackstock et al. 2010). Additional factors may include economic and production objectives or goals, and other social factors such as personal identity and social status (Blackstock et al. 2010). To understand the adoption process for an individual, one must understand the factors that drive that individual's decision making process, and where along the process of adoption does that influence occur. This is particularly important in farming environments where decision making is not necessarily performed by a single individual, but by a team or group of people, whose individual attitudes and perceptions may influence the decision making process as described by Fulton et al. (2003) and Kilpatrick and Johns (2003).

Understanding and predicting the process and consequences of decision making among farmers has been a continued area of focus in agricultural economics (Willock et al. 1999a). This focus has largely been on developing models that can help to predict farmer behaviour, with these models being primarily based on the assumption that all farmers are driven by maximising profit (Willock et al. 1999a). However, as noted by Vanclay (2004), farmers are not homogenous and exhibit a range of diversity when it comes to attitudes and other characteristics that drive decision making, which suggests a failure to account for diversity in these behaviour or decision models. Farmer behaviour and how farmers make decisions are influenced by a range of factors and their complex interactions, such as attitudes, social influence and confidence in applying skills and knowledge as described by Cao et al. (2011) and Ajzen (1991).

Early in the adoption process an individuals' uncertainty surrounding an innovation is typically quite high, and a learning process will occur through which an individual will gather information and knowledge about the innovation before making a decision, in order to reduce uncertainty and risk (Marra et al. 2003; Pannell et al. 2006). This learning can occur through a number of forms and methods, and will often involve learning about specific aspects or characteristics of the technology or practice, its use and implementation (Bamberry et al. 1997; Kilpatrick & Johns 2003; Pannell et al. 2006).

An innovation, as defined by Rogers (1995), is a practice, idea or observation that is perceived as new by an individual. Guerin and Guerin (1994) proposed that adoption of innovations be thought about as a continual innovation-decision process, rather than a specific process that is completed once. Four stages have been identified in the innovation-decision process, as outlined in Rogers (2003). The first stage is referred to as the knowledge phase where an individual is exposed to a new idea and develops an initial understanding of it. The second is a persuasion phase where the individual is persuaded by others, or themselves, about the idea or innovation. The third stage is decision, where an individual makes a decision to accept or reject the idea or innovation. Lastly, the confirmation stage, in which an individual will review their decision once it has been made, and confirm or disagree otherwise.

Decision making around agricultural innovations can often be quite complex as they can be high involvement decisions, due to the complexity of the innovation and potential financial and physical risks of failure. These high involvement decisions may be coupled with clear chains of reasoning that guide the decision making process (Kaine 2004). Kaine (2004) suggests that when it comes to these types of decisions, that farmers gather evidence about the innovation or practice before making a decision, which is consistent with the explanation based decision theory as suggested by Pennington and Hastie (1993). This theory proposes that information or evidence about an innovation is gathered, processed to evaluate the extent to which the innovation will meet their needs, and then used to make a decision (Pennington & Hastie 1993). Kaine (2004) proposes that farm context also plays a role in defining decision making around evaluating whether to adopt an innovation or not, with producers with similar farming contexts using similar criteria when evaluating an innovation and deciding whether to adopt (Kaine 2004). Other studies have listed perceptions of risk and strategies of reducing risk as key criteria when making adoption decisions (Driver & Onwona 1986; Kaine 2004; Annou et al. 2005).

The decision making process of an individual when it comes to adopting a new practice or innovation is influenced by a range of factors, from farming practices, existing technology used, financial and physical resources available, characteristics of the individual, and the social, physical and financial risk involved (Kaine 2004). Combined with attributes of the innovation itself, these factors result in adoption decisions being both innovation and context specific, making it difficult to generalise about the likelihood of predicting adoption, and the success or failure of adoption, across innovations and contexts. The farmer decision making process also involves prior knowledge and experience regarding the innovation, including the perceived trustworthiness of the information source and the promoter of the innovation (Thompson 2009).

Technology and Innovation Characteristics that Impact Adoption

In addition to individual characteristics, there are a number of aspects and characteristics of innovations and technologies that also influence adoption. Rogers (2003) innovation diffusion theory outlines five key aspects of innovations that influence adoption, including relative advantage, compatibility, complexity, trialability and observability of a given practice or technology (Adesina & Zinnah 1993; Guerin & Guerin 1994; Batz et al. 1999; Barr & Cary 2000; Yu 2014). White et al. (2009) also added risk as a sixth factor.

Relative advantage and risk

In agriculture, one of the key aspects of an innovation that influences its adoption is whether the innovation can better meet the needs of the farmer than current innovations or practices, whether it adequately address the problem it is designed to, and under what circumstances (Komoda 1986; Fujisaka 1994; Rogers 2003; Kaine 2004). Pannell et al. (2006) reported that if a practice is not adopted in the long term, it is due to individuals believing that implementing the practice or innovation does not advance their goals sufficiently to outweigh its costs. A study by Pierpaoli et al. (2013) found that farmers have specific perceptions about both the ease of use, and usefulness, of technologies which can have a large influence on their adoption behaviour.

While Rogers (2003) outlined five key characteristics of a technology or practice, Pannell et al. (2006) categorised characteristics into two predominate categories, being its relative advantage and its trialability. Relative advantage typically refers to the financial advantage of adopting a given practice to the adopter and/or farm business, and how the new innovation is perceived to be better than the one before it.

The perceived financial advantage of an agricultural practice or innovation, and its impact on profit, can be an indicator and motivator of adoption (Barr & Cary 1992; Cary et al. 2001; Hite et al. 2002; Pannell et al. 2006; Folorunso & Ogunseye 2008; Rezaei-Moghaddam & Salehi 2010). Many farmers are motivated by the balance between the need for profit, and satisfaction with a comfortable living that minimises risk (Rendell et al. 1996; Dunn et al. 2000). Other studies have found that many farmers will trade off profit maximisation in favour of risk reduction (Reeve & Black 1993; Howden et al. 1998).

The purchase criteria used to evaluate new innovations and technologies will usually reflect the benefits the innovation offers in the context an individual is going to use it (Kaine 2004). This context is made up of a mix of individual knowledge and skills, financial and physical resources, and current practices and techniques employed on farm; they will vary across innovations and between individuals, and will impact on usage (Crouch 1981, Kaine and Lees 1994, as cited in Kaine 2004).

While some studies have found that profit and cost of an innovation influence its adoption, others, such as Annou et al. (2005) and Fielding et al. (2005), found that technology adoption appeared to be less sensitive to cost of the technology than its efficiency. In addition, the motivation behind behaviour and decision making is driven by factors other than just profit, with many farmers opting to reduce profit maximisation in favour of reducing risk (Reeve & Black 1993; Cary et al. 2001). The physical cost of an innovation can also be a barrier to adoption, regardless of intention (Fielding et al. 2005). These include direct monetary costs, and indirect costs such as the cost in the difficulty in using the technology; in addition to the benefits being overestimated and farmers not seeing the level of benefit of use that was advocated by implementing the practice or innovation (Fujisaka 1994; Pierpaoli et al. 2013).

If characteristics of new and existing technologies are not adequately recognised, demonstrated and communicated, it is difficult to emphasise why a new technology may be of use or how it may benefit its adoption, leading to a reduced level of uptake (Madu 1988). In a study centred on technology and practice adoption among coffee producers, Bravo-Monroy et al. (2016) observed that the larger farms with more capital and labour requirements were more likely to use new and more advanced technologies. They also observed that technology affected the level of crop productivity through optimising time and space, and concluded that in return, productivity also influenced the use of the technology (Bravo-Monroy et al. 2016).

In the Tasmanian dairy industry, many of the extension-recommended pasture management tools and their use on farms, are not new to farmers and do not pose a risk or large cost to farm businesses. Despite many farmers having adopted and demonstrated these practices successfully, anecdotal evidence suggests that the adoption and implementation of some recommended technologies and practices remains low among a significant proportion of the Tasmanian dairy farmer population.

Trialability and observability

Trialability of an innovation refers to how easily an individual can learn about an innovations performance and management and how to address any issues, in addition to how easy it is to set up and conduct a physical trial using the innovation (Pannell et al. 2006). Marsh (1998) suggested that technologies or practices with a high relative advantage and high trialability were more likely to be readily adopted by landholders. Trialling an innovation gives individuals an opportunity to learn the knowledge and skills needed to apply or implement the innovation, find out information to address any challenges, and can reduce the uncertainty surrounding the relative advantage of the innovation, all while on a smaller scale with lower financial risk if the innovation is unsuccessful (Pannell et al. 2006). Cary et al. (2001) found that practices or innovations that can be trialled on a small scale and the value assessed prior to implementation on a larger scale have a greater likelihood of being adopted. However, Cary et al. (2001) also notes that trialability is dependent on observability, that is that results are able to be observed in a short time period. Therefore, practices or innovations that take a long time for the results to be demonstrated are less likely to be adopted.

Complexity and compatibility

The complexity of a practice or behaviour should also be taken into account in adoption studies, as a practice or innovation that may appear simple may imply a significant or complex change to a farming system, making them less likely to be adopted (Cary et al. 2001). According to Vanclay and Lawrence (1994), greater complexity increases the risk of failure in addition to introducing increased costs (including time) in gaining knowledge to overcome and address the complexity involved.

Compatibility refers to how a practice or innovation fits within an individual's existing knowledge and current system or farming practice, in addition to the broader social system practice, or ways things are traditionally done within a farm and community (Cary et al. 2001). Compatibility can play a large role in impacting adoption and behaviour and is often included through measuring aspects such as the influence of social norms. The role of compatibility in influencing adoption of new practices has been noted by a number of previous studies (Rodriguez et al. 2009). In a study on adoption of short rotation crops, Warren et al. (2016) found a lack of compatibility of crops with farmers' socio-cultural identity acted as a significant barrier to adoption.

Additional characteristics and challenges to adoption

It is important to realise, however, that agricultural practices rarely comprise all the attributes that positively impact adoption, including being widely applicable, high relative advantage to the farmer and their business, low in complexity, high compatibility, high trialability and low risk (Rogers 1995; Cary et al. 2001; Rogers 2003). Practices that offer relative advantage in terms of finances often come at the cost of increased complexity, risk and skill demand (Barr & Cary 2000). For others, the benefit can be difficult to observe, or take a long time for the benefit or value to be measured.

In a study on use of satellite data to make grazing management decisions, Eastwood & Kenny (2009) found trust and accuracy of data played a role in influencing adoption and use of that data in farmer decision making. Use and acceptance of technology that provided objective data depended on certainty and consistency (Eastwood & Kenny 2009).

The availability of information about new technologies or practices also plays an important role in adoption decision making (Wollni & Andersson 2014). Bravo-Monroy et al. (2016) also identified availability of the technology as one of the main factors affecting adoption decisions, however it was recognised that a combination and interaction of factors act to drive the adoption decision making process, and that these factors will vary between individuals, industries and countries. This enforces the importance of understanding the factors that impact behaviour and adoption of a practice or innovation within a given context, as these factors and their influence can vary. Understanding adoption and addressing the challenge of non-adoption is not as simple as being able to demonstrate that an innovation or technology makes more money or is beneficial to the farmer or environment, as the social nature of decision making and adoption, as outlined in studies such as that by Pannell et al. (2006), Kaine (2004) and Fulton et al. (2003), is complex.

Role of Extension in Adoption

Traditionally, extension services have played a large role in the transfer of technology in Australian agriculture, and adoption of many agricultural innovations. Within this format of agricultural extension, the major role for extension officers has been in providing technological information and knowledge (Guerin & Guerin 1994). Guerin and Guerin (1994) also state that there is a role for extension officers to follow the entire adoption process to ensure that adoption is maintained by providing support and advice if problems arise, and that it is not sufficient to only supply information about an innovation or technology.

One of the criticisms of traditional extension has been that is was used as a means of effective communication, with a lack of adoption being blamed on the failure of the extension communication process (Pannell et al. 2006). Madu (1988) suggested that communication could assist in reducing the resistance to change and minimising the 'frustration gap' between farmers and a technology. Madu (1988) also suggested that the success or failure of a new technology being adopted depends on the level of participation or engagement by the person doing the adopting, with the person promoting or encouraging the technology or innovation being adopted. Prior to the advancement of the digital age, methods of communication were slow and limited in their potential reach, posing a potential barrier to adoption. With an increase in formal education attainment in the farming community (Australian Bureau of Statistics 2012), and with more sophisticated, electronic communications and access to the online web, access to information is becoming less and less of a barrier to adoption (Guerin & Guerin 1994). If, as proposed by Pannell et al. (2006), extension has failed in one or more aspects of communication, it is suggested that this failure has not been in access to information and knowledge, but perhaps in how this can be applied in individual farmers' circumstances, what benefits exist with new innovations and technologies, and what it means to their farming business. Fujisaka (1994) stated that a failure of extension could occur when the audience for an innovation or practice is incorrectly identified, or the innovation of practice is incorrectly demonstrated, leading to a loss of faith in both the innovation itself and in extension.

Group extension, such as discussion groups, present an example of how extension services can work with leading farmers to motivate others through demonstration and farmer mentoring. A study by Rhoades and Booth (1982) found that farmer participation in discussion groups and involvement in on-farm trials strengthened the relevance and acceptance of research findings on new practices at a farm level, further supporting the development and use of discussion groups as an extension method, and use of participatory methods to achieve practice change. On-farm trials of innovations, new practices or technologies can provide information to farmers that assists in reducing the uncertainty about the relative advantages or disadvantages of a practice, provides an opportunity for farmers to learn new skills that might be necessary to apply the practice or innovation, and can assist farmers in making a decision (Pannell et al. 2006).

In order to encourage adoption of new technologies or practices, researchers and extension workers must look beyond the benefits of simply increasing productivity (Muzari et al. 2012). Adoption, like learning, is a complex social process that is impacted by a range of often interrelated factors (Kilpatrick & Johns 2003). Therefore, expecting adoption and diffusion of a technology to occur because of production benefits alone is no longer a reasonable or realistic expectation. Extension services offer a source of learning that can influence and support adoption through provision of technical advice (Fulton et al. 2003), and an environment where both formal and informal learning, such as group learning, social interaction and learning from peers (Black 2000; Kilpatrick & Johns 2003). One of the challenges for extension is to find ways to meet expectations of continued success and achieving innovation adoption (Paine & Kenny 2002). A shift in extension towards promoting practice change through learning, understanding the farmer as a learner and their personal networks has seen a move to using adoption models that incorporate individuals attitudes, social influences and personal motivations and characteristics to understand decision making (Paine & Kenny 2002).

Adoption Models

Traditional approaches to studying adoption

Adoption models such as the technology transfer model (Gibson & Smilor 1991; Rogers 2003), consumer behaviour theory (Assael 1988), diffusion of innovations (Rogers 2003), and Theory of Planned Behaviour (TPB) (Ajzen 1991; Fishbein & Ajzen 2011) have been proposed to assist in explaining and predicting adoption behaviour.

Diffusion, as defined by Rogers (2003), is the process by which an innovation is communicated through channels over time. The diffusion of innovations model assumes that once innovators and early adopters change practices, diffusion and naturally occurring knowledge transfer will occur, leading to widespread adoption (Rogers 2003). This model also assumes that the innovation or technology is appropriate in addressing the problem or issue facing the end user, and that the challenge of non-adoption is in communication of information to end users (Adesina & Zinnah 1993; Rogers 2003). However, farmer to farmer knowledge transfer is limited in cases where adoption of knowledge intensive practices requires a greater degree of supported farmer learning and skill development (Ingram 2008). Criticisms of the diffusion theory include the rate of adoption of various technologies, and its relatively narrow restriction to individual farmers in a community (Jackson et al. 2006). The linear approach taken to the diffusion process has also been criticised, with arguments against diffusion and adopted as a rational, planned process (Feder & Umali 1993; Jackson et al. 2006). Vanclay and Lawrence (1994) outlined limitations to the classical diffusion model, in that adoption does not necessarily follow the stages suggested due to barriers such as the inability to trial or demonstrate a technology or innovation.

Kaine (2004) suggested using consumer behaviour theory as the starting point for determining whether an innovation can contribute to satisfying the needs of farmers and primary producers. Kaine (2004) acknowledged that the consumer behaviour theory recognised that there are a range of decision types and different processes depending on circumstances, and the consumer behaviour theory can be used to identify which process might occur in particular circumstances. Kaine (2004) also argued that this theory recognises that individuals may purchase the same product to satisfy different needs, thus taking into account differing motivations of individuals.

Technology transfer is the application of information to use (Rogers 2002). Traditional views of technology transfer saw it as a one-way approach, but most studies realise that technology transfer is a two-way approach where two or more parties participate in a series of communication exchange (Rogers 2003). Traditionally, technology transfer has involved research results being handed to commercial providers and extension organisations for adaptation and transfer to farmers (Chambers & Jiggins 1987). Studies using the technology transfer model have used a number of different approaches, such as the appropriability model, dissemination model, knowledge utilisation model and communication model (Wahab et al. 2009). More recent approaches have placed more emphasis on communication, organisational theory and knowledge in order to overcome some of the limitations of traditional technology transfer, including the one-way approach and lack of applicability to modern, high technology industries (Wahab et al. 2009).

Though there are shortfalls in each model's approach, those that take into account the greater extent of social complexity surrounding adoption decisions and predicting behaviour have received greater support. Models like the technology transfer model and diffusion of innovations have often formed a basis for agricultural extension activities (Rogers 2003). Such models of decision making typically outline or indicate the processes or stages of decision making an individual goes through when it comes to adoption, but do not generally predict the outcome of those decisions or provide insights into how to increase future adoption (Kaine 2004). The Theory of Planned Behaviour is an alternative model that has been developed over time to assist in explaining and predicting adoption behaviour, and in doing so, addresses some of the shortfalls of traditional approaches.

Theory of Planned Behaviour

The Theory of Planned Behaviour (TPB) is an extension of the Theory of Reasoned Action (TRA) and was designed to predict and explain human behaviour in specific contexts (Ajzen 1991; Fishbein & Ajzen 2011). The TPB has been used extensively to understand the context of decision making and identify the motivational factors involved in a range of disciplines, including health (Conner et al. 2003; Bränström et al. 2004; Barberia et al. 2008), marketing and consumer behaviour (Lobb et al. 2007; Arvola et al. 2008), and agriculture, natural resource management and conservation (Beedell &

Rehman 1999; Trumbo et al. 2001; Fielding et al. 2005; Fielding et al. 2008; Bond et al. 2009).

A central element in the TPB is intention to perform a behaviour (Ajzen 1991; Fishbein & Ajzen 2011). The TPB considers that intention to perform a behaviour is guided through three main areas; the individual's attitude as to the outcome of a behaviour is evaluated as positive or negative (behavioural beliefs), the perceived subjective or social norms of a behaviour (normative beliefs), and the perceived behavioural control or capability of an individual to perform the behaviour (control beliefs) (Ajzen 1991; Fishbein & Ajzen 2011) (see Figure 2.1).

The TPB proposed that if individuals have a positive attitude towards a behaviour, in addition to positive intentions, then given sufficient actual control then behaviour will occur (Ajzen 1991; Fishbein & Ajzen 2011). A study by Fielding et al. (2005) found that landholders with strong intentions to manage their land differed significantly in their beliefs when compared with landholders who had a low or weak intention. Fielding et al. (2005) also found that strong intentions of landholders to manage land were associated with benefits outweighing the costs of doing so, a perception of support for undertaking the management practice, and low perception of barriers impeding management.

The influential role of attitude in the TPB is supported in agricultural literature that acknowledges an individual's behaviour is connected to their attitudes and beliefs towards the potential outcomes of that behaviour (Guerin & Guerin 1994; Vanclay & Lawrence 1994; Blackwell et al. 2006). Bond et al. (2009) used the TPB to study the factors influencing farmers' use of pesticides and attributed behaviour to their attitudes, social pressure and perceived control. This is supported by findings of Wauters et al. (2010) in that the negative attitudes of Belgium farmers towards implementing soil conservation practices were the main reason for low adoption, and that work to increase awareness about soil erosion practices is therefore needed. These findings suggest that a greater understanding of farmer attitudes towards pasture management practices is necessary to understand why adoption or non-adoption is occurring.

Forsyth et al. (2004) found that individuals who have a greater awareness of environmental problems, and consider them severe or important, have higher levels of behavioural intentions towards doing something or changing their behaviour towards the problem. Forsyth et al. (2004) and Aytülkasapoğlu and Ecevit (2002) reported that very few individuals in their studies had knowledge about water quality and the environment, and that because of this they were unlikely to take action to change behaviour. In the context of pasture management in the Tasmanian dairy industry, if farmers are aware that they are not achieving the levels of pasture utilisation possible, and therefore not receiving the associated benefits, they are more likely to have intentions towards changing this behaviour. The low level of adoption of pasture management practices and measurement tools suggests that increasing farmer awareness about potential gains could influence adoption of recommended practices.

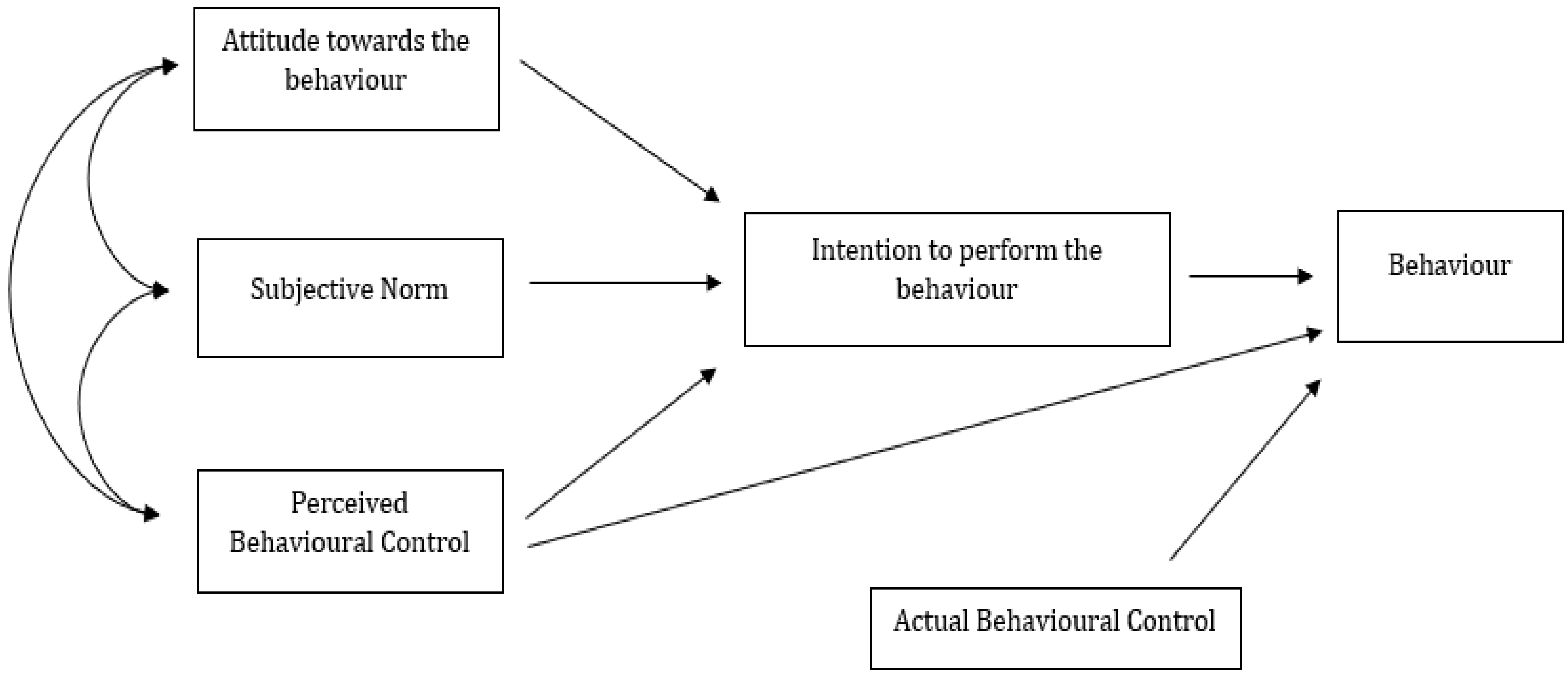

Figure 2.1. Theory of Planned Behaviour conceptual diagram (Ajzen 1991)

Attitudes

The influence of attitudes in predicting behaviour varies with the type of behaviour being predicted (Frymier & Nadler 2017). A review of studies focusing on attitudes and behaviour conducted by Wicker (1969) reported inconsistencies in attitude-behaviour relationships. Wicker (1969) found a number of studies reported a low or minimal correlation between attitudes and behaviour, such as between attitude towards employers and absences from work and work performance; attitudes and behaviours towards members of minority groups; and attitudes and behaviours toward other objects such as voting, time and money spent on activities, cheating on examinations, voting and breastfeeding. The TPB framework provides additional factors to help explain and predict adoption behaviour, including social norms, perceived control and actual control factors.

Social norms or influences

Social norms are an important construct within the TPB, particularly in agriculture. Social norms are expectations an individual feels about how they should behave or act in particular contexts (Stanley et al. 2006). Social norms or pressure apply to the adoption of new technologies or practices, with the rate of adoption linked to the degree to which the technology or practice fits with the existing social culture of how things are done (Stanley et al. 2006). A study by Rodriguez et al. (2009) found social norms to be a source of barriers to adoption of sustainable agricultural practices, including socially held beliefs and perceptions of peers, industry and community members. Blackstock et al. (2010) found that social influence through peers and networks influenced decisions on adopt practices to improve water quality. A community or group of people can therefore be used to influence or change an individual's perception about a particular behaviour, technology or practice (Finlay et al. 2005). This approach could potentially be used in extension and group-based learning to influence an individual's perceptions and attitudes, and thus behaviour, if the general consensus and behaviour of the group differs to that of individual. In contrast, when a desired behaviour is not yet present in an agricultural community (and therefore associated awareness and informal, peer-to-peer learning is lacking), greater attention must be given to demonstrating the benefits of adoption, and to the skill development required to effectively implement recommended practices.

A key element in understanding the adoption process is whether the decision is being influenced at an individual level and/or at a larger social level (Wollni & Andersson 2014). If an adoption decision is influenced at an individual level, Wollni and Andersson (2014) suggest that the decision making process is more easily influenced directly by extension agents, industry and service providers, with the aim of overcoming barriers to adoption at the individual farm level.

Perceived behavioural control

Perceived control within the TPB refers to an individuals' perception of the ease or difficulty of performing a behaviour, and is an important influence on whether or not to adopt an innovation or practice (Ajzen 1991; Fishbein & Ajzen 2011). A study by Herath (2013) found that perceived control, along with attitudes, explained intentions of farmers in the Czech Republic towards using new agricultural technologies. Price and Leviston (2014) found that perceived control, and having a sense of control of events and outcomes, was the strongest single predictor of pro-environmental land management practice. In addition, Zeweld et al. (2017) found that perceived control had a significant negative influence on farmers' intention to adopt minimum tillage practices. If negative perceived control factors can be identified and understood, they provide valuable insights into what further extension support can be designed and delivered to increase farmer knowledge and confidence around implementing new practices.

As a general rule, Ajzen (1991) proposes that the stronger an individual's intention to engage or undertake a behaviour, the more likely it is to occur.

However, the behaviour in question must be under the individual's volitional control if it is to occur. That is, if the individual can decide at their own will to perform or not perform the behaviour (Ajzen 1991). Non-motivational factors may include availability of resources such as time, money, skills and cooperation of others (Ajzen 1991). Ajzen (1991) defines these factors as actual control over a behaviour, and that if an individual has these required resources and opportunities, together with a positive intention, then they will be predicted to perform the behaviour.

Actual control

The construct of actual control is supported by Yzer (2012), who found that if individuals cannot perform a behaviour due to not having actual control, for example not having the required skills or when situational factors obstruct the behaviour, then the behaviour will not occur. The perception of behavioural control, or how easy or difficult an individual perceives a particular behaviour to be, and how it impacts on intention and action is a key component of the TPB, and its addition is what sets this theory apart from others (Ajzen 1991; Fishbein & Ajzen 2011). According to the TPB as proposed by Ajzen (1991), performance of a behaviour is a function of both intention (influenced by attitudes, social norms and perceived control) and actual control, and these can be used to predict the likelihood of a behaviour occurring.

Limitations of the Theory of Planned Behaviour

As with all behavioural theories, the TPB is not without its limitations and criticisms. For instance, Ogden (2003) argued that the constructs of the TPB were too general to be able to be tested with high precision, making it difficult to reject the theory. Additional concerns include that many studies using the TPB include self-reporting to measure behaviour rather than objective measures, thus introducing the possibility of bias (Armitage & Conner 2001; Ogden 2003). With regards to agriculture, some studies have suggested that the TPB is insufficient in accounting for the complexities of factors that influence decision making and behaviour, but does provide a solid groundwork for further investigation (Beedell & Rehman 1999; Burton 2004). Another criticism of the TPB is that it is too rational in its approach, and does not account sufficiently for cognitive and affective (feelings, emotions and responses) processes that are known to bias human judgement and behaviour (Ajzen 2011). However, the TPB does not assume that behavioural, normative and control beliefs are formed in a rational or unbiased manner, and may be based on inaccurate or incomplete information (Ajzen 2011). Regardless of how individuals arrive at their beliefs, even if they are based on inaccurate or biased information, individuals' intentions and behaviours are produced in a consistent manner with these beliefs (Geraerts et al. 2008; Ajzen 2011).

Despite criticisms of the TPB, studies have supported its use with an increasing acknowledgement that an individual's behaviour is connected to their beliefs towards that behaviour (Guerin & Guerin 1994; Vanclay & Lawrence 1994; Blackwell et al. 2006; Bond et al. 2009). Beliefs relating to attitudes, social norms and perceived control should not be considered in isolation, due to the complex nature of individuals and their adoption decision making. Identifying and understanding how these factors influence adoption decisions is necessary within the individual farmers' social context, with the innovation and/or technolgy itself, and any non-motivational and control factors that influence intention and adoption behaviours.

In Summary

A range of social and physical factors influence decision making, adoption and on-farm change, for practices such as pasture management and farmer engagement with extension activities. Previous studies have suggested that these include individual characteristics such as education, social networks, farm business characteristics, nature of the activity, and the learning environment (Fulton et al. 2003). Anecdotal evidence suggests that despite the range of activities and approaches used in extension, and the successful demonstration of pasture management and measurement practices, the level of farmer engagement with extension remains varied in the Tasmanian dairy industry, and the extent of adoption of recommended pasture management and measurement practices remains low. Analysis of pasture production and performance suggest that many farmers are not achieving the levels of pasture utilisation that are possible (Dairy Australia 2015; Tasmanian Institute of Agriculture 2017).

Pasture management practices and associated technologies are complex and knowledge intensive, requiring an understanding of the biological principles underlying recommended practices, and the development of skills and knowledge to implement recommended practices. Extension services are a means of supporting farmers in learning and developing the knowledge and skills required to adopt recommended pasture management practices, and aid in developing farmer competency and capability. To encourage increased farmer engagement with future extension, it is necessary to quantify the current extent and patterns of application of pasture management practices, and engagement in extension.

Studies on adoption and associated behaviour change have focused largely on characteristics of adopters versus non-adopters, what determines whether a practice or innovation is adopted, and what determines its diffusion through a population (Marsh et al. 1995; Ghadim & Pannell 1999). Such studies have typically employed quantitative approaches using adoption models such as the diffusion of innovations and the Theory of Planned Behaviour as a basis for predicting adoption and quantifying the relative influence of factors affecting behaviour. Few studies have used a qualitative approach which can be used to reveal unknown factors influencing behaviour, and explore how and why these factors are influential (Renzi & Klobas 2008). In light of the complexity associated with adoption and engagement decision making by farmers, using a qualitative approach in such studies can assist in interpreting results and provide a greater understanding of not only what, but how factors influence farmer behaviour (Renzi & Klobas 2008; Kauppinen et al. 2010).

The shift in agricultural extension to an approach based on knowledge transfer places greater emphasis on systems thinking and understanding the end user (Black 2000; Garforth et al. 2003). Adoption and practice change as an outcome of extension is increasingly being viewed as a social process, influenced by a combination of personal, environmental and social factors (Pannell et al. 2006; Wauters & Mathijs 2010). The majority of literature that focuses on farmer learning through extension has not been expanded on in the last decade, and along with the shift towards viewing adoption as a social process suggests there is a need for more recent studies. For extension to lead to adoption of practices or recommendations, extension providers require a greater understanding of how farmers make decisions, and what factors influence their choice to engage with extension activities. This understanding will allow extension providers to work within the context of different farming approaches in order to encourage engagement and communicate effectively to achieve greater practice change (Turner et al. 2017). Understanding farmers and their key motivators for adoption and engagement, along with the social factors that underpin associated decision making, is essential to attracting and engaging a wider range of farmers.

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Chapter 3 – Research Methodology

Introduction

This chapter outlines the research design and methodology that address the research questions of this thesis, as outlined in Chapter 1, concerning farmer decision making and behaviour relating to adoption of pasture management practices and associated tools, and engagement with extension activities.

The selection and justification of a sequential, mixed methods design incorporating quantitative and qualitative research stages is explained. The value and validity, in addition to the challenges associated and how they were addressed, are outlined.

Research Design

Research Questions

This research aimed to identify the current role and uptake of pasture management technology and tools in the Tasmanian dairy industry, and current engagement with extension activities. This study also aimed to answer the broader research questions of why some farmers adopt grazing management practices and technology and others don't, and what drives engagement with extension activities. The findings will provide insights into how service providers can develop and deliver improved extension support that encourages increased engagement with farmers and subsequently improved adoption of proven pasture management practices.

The core research questions of this study are outlined below and in Chapter 1:

- What are the current pasture management practices and associated tools and technology being used on Tasmanian dairy farms?
- What is the current extent of farmer engagement with extension activities?

- What social and demographic factors have influenced the decision making behind adoption and implementation of pasture management practices, tools and technology?
- What social and demographic factors influence farmer decision making about choosing to, or not to, engage with extension activities?

Identification of the current pasture management practices and associated tools and technology, and engagement with extension activities, also includes quantifying the social and demographic factors influencing decision making, adoption and extension engagement. Levels of engagement will also be explored to examine relationships between participation and pasture management variables.

Identification of social and demographic factors influencing adoption of pasture management practices includes exploring how and why these factors influence adoption and adaptation of practices, tools and technology. These factors are likely to include motivations, information seeking patterns, and the extent of engagement of farmers with extension activities.

To address these questions and gain insight into how to further develop extension support to positively influence farmer adoption of recommended and proven pasture management practices and technology, a mixed methods approach was used.

Methodological Influence

A range of methodologies influence choice of methods when it comes to conducting research. Methodology, as Walter (2013) describes, is the 'worldview through which the research is designed and conducted, and is comprised to a large extent of the researcher's standpoint, or how we see the world and our position in it' (p. 10). This worldview, paradigm, or researchers' standpoint is guided by a combination of what is referred to as their ontology, epistemology and axiology, their associated frameworks, and social position.

Ontology is concerned with what is considered the nature of reality (Creswell 2013), and what researchers understand to be reality (Walter 2013). As researchers, we must be aware of our own ontological position or perspective (Mason 2002). Epistemology is concerned with how knowledge is defined and what constitutes or counts as knowledge (Mason 2002; Walter 2013). Ontology is what we view as reality, epistemology is the relationship between the research and that reality, or what is being researched, and methodology is the techniques used by the researcher to discover that reality (Perry et al. 1999; Denzin & Lincoln 2011). The epistemological assumptions of the researcher underlies the research, and the theoretical and methodological approaches used (Creswell & Clark 2017).

Axiology is concerned with how researchers act based on the research they produce, and the values that inform how they view what is happening and make judgements within research (Walter 2013). Social and qualitative researchers cannot be value-free in conducting research, as they come from a worldview or standpoint (such as a constructivism) that places the research within the research process (Mason 2002). Consequently, social researchers must consider their own values and axiological position; how these form part of the research process and how they can impact outcomes. It is important to be aware of our ethics and values as researchers, and take into consideration the possible implications they may have on our research.

Methodological Approach

Quantitative and qualitative research methods have typically formed the two major research designs. Quantitative research methods are arguably the more traditional, using numbers and empirical data to quantify and explain relationships between variables (Campbell & Martin 1993; Gray 2013; Walter

2013). Qualitative research methods take a more holistic view and approach (Campbell & Martin 1993), concerned with exploring how people understand and interpret the world around them, and how they think and do what they are doing (Walter 2013). Mixed methods design combines elements of both quantitative and qualitative approaches, and has been gaining increased recognition and use (Johnson et al. 2007; Teddlie & Tashakkori 2009; Tashakkori & Teddlie 2010).

There has been ongoing debate between quantitative and qualitative researchers and subsequent research approaches, based on competing epistemological, ontological and methodological standpoints and assumptions. This has created a problem for mixed methods research, and finding rationale for combining quantitative and qualitative research and data (Hall 2013). Traditionally, a large component of agricultural research has been quantitative research, based on a positivist view of reality (Campbell & Martin 1993), which considers research to be that which can be measured and quantified, typically with numbers and cause and effect relationships (Gray 2013; Walter 2013). Though a large component of agricultural research has been based on quantitative approaches, usually concerned with answering the 'what' related questions (Carson et al. 2001; Walter 2013), there is an increasing understanding and appreciation of the importance and significance of qualitative research.

Qualitative research and researchers often take the worldview of that of constructivism, also known as interpretivism (Guba & Lincoln 1994; Perry et al. 1999), assuming that understanding, knowledge and meaning are gained by interpreting people's perceptions, relationships and interactions with each other and the world around them (Gray 2013; Walter 2013). Qualitative research has the ability to explore the significance of context, and to understand how this impacts on people, and to understand 'why' people do what they do (Mason 2002; Walter 2013).

Mixed methods research combines elements of both quantitative and qualitative research approaches, with the purpose of increasing the breadth and depth of understanding (Johnson et al. 2007). This can include using quantitative and qualitative viewpoints, and/or combining quantitative and qualitative methods of data collection and analysis (Seiber 1973; Johnson et al. 2007; Teddlie & Tashakkori 2010; Creswell 2013). A mixed methods approach can reduce the limitations of both quantitative and qualitative research techniques, while maximising their strengths, with both quantitative and qualitative data supporting the other, recognising the existence and importance of the physical, natural world as well as the importance of reality and influence of human experience (Tashakkori et al. 1998; Johnson & Onwuegbuzie 2004; Esbjörn-Hargens 2006; Denzin & Lincoln 2011). The fundamental principle of mixed methods research is that the combination of quantitative and qualitative research approaches gives a better understanding of the problem than achieved by either approach on its own (Tashakkori & Teddlie 2010; Creswell & Clark 2017). Using a mixed methods approach can help to overcome some of the weaknesses in both approaches while enabling the ability to select a method to best answer or address the research questions (Denzin & Lincoln 2011). By combining qualitative and quantitative findings, an overall or conveyed account of the findings can be forged, which is not possible by using a singular approach (Bryman 2007). Mixed methods can also help to highlight the similarities and differences between particular aspects of an issue or phenomenon under investigation (Bernadi et al. 2007).

The challenge for mixed methods research is finding a rationale for combining qualitative and quantitative research methods and data, given the two challenging and often incompatible worldviews underpinning them (Hall 2013). A number of different paradigms, or worldviews, have been suggested as possible for mixed methods research (Freshwater & Cahill 2013; Hesse-Biber & Johnson 2013; Shannon-Baker 2016; Creswell & Clark 2017). Hall (2013) suggests taking either a single paradigm or worldview stance or a multiple paradigm or worldview stance. The multiple paradigm stance claims more than one paradigm can be drawn on, and that these can be kept separate so as to draw on the strengths of each (Morse 2003). In the single paradigm approach, researchers adopt a single paradigm or worldview that encompasses both quantitative and qualitative methods (Hall 2013).

The research in this study takes a single paradigm or worldview approach in that of critical realism. Critical realism expresses a constructivist epistemology, in that the world is constructed through our individual standpoints and perceptions, and realist ontology which recognises that there is a world that exists independently of people's perceptions and constructions (Shannon-Baker 2016; Creswell & Clark 2017). In the dairy industry there are known and established pasture management practices that rely on learning processes, and that have a proven relationship with pasture utilisation and farm profitability, and that exist outside people's perceptions. Critical realism places emphasis on context, and that an individual's social and physical context will influence their beliefs and perspectives (Maxwell & Mittapalli 2010). The pasture management decision making and adoption processes of farmers rely on individual perceptions, and can and do vary. Creswell and Clark (2017) note that that use of critical realism in mixed methods research is relatively uncommon. However, critical realism has been used in social research, including program evaluation (Mark et al. 2000), accounting (Brown & Brignall 2007), operations management (Fleetwood 1999; Mingers 2000), political science (Patomäki 2003), nursing (Lipscomb 2008) and management (Modell 2007).

Mixed Methods Design

This study uses a sequential mixed methods design (see Figure 3.1), which is a multi-step process in which mixing of quantitative and qualitative methods occurs chronologically (Johnson et al. 2007; Creswell 2013). One of the most popular mixed methods designs is a sequential explanatory strategy where quantitative data collection occurs first, of which analysis and results can be used to identify participants for the qualitative data collection phase, and identify topics or issues requiring further explanation or greater understanding through ‘how’ and ‘why’ questions (Creswell 2013). In sequential mixed methods data analysis, data are analysed in a particular sequence with the purpose of informing the use of or findings from the other method(s) (Onwuegbuzie & Teddlie 2003). An example of sequential data analysis might be where quantitative findings lead to theoretical sampling in an in depth qualitative study or phase where qualitative data is used to generate items for the development of quantitative measures or phase (Ostlund et al. 2011). This study uses a similar approach but consists of three phases: a quantitative stage that assists in informing the second, qualitative stage; a qualitative stage, which assists in explaining results from the first quantitative stage, but also informs a third quantitative stage, that assists to affirm findings and conclusions drawn from the previous stage.

This research project begins with a quantitative stage involving a survey to identify the current extent of adoption of pasture measurement tools and implementation of pasture management practices, and the extent of farmer engagement with extension activities. These findings were used to guide the development of the ‘how’ and ‘why’ questions in subsequent in-depth, semi-structured, qualitative interviews; in addition to being integral to identification of interview participants. Asking questions of how and why farmers make decisions concerning adoption or non-adoption of practices and technologies are necessary to gain an in-depth understanding of what and how factors are most influential, and how and why they impact subsequent behaviour. The qualitative data helped to explain and build on the initial quantitative results, and was also used to develop the third, quantitative phase. This design can also be used to assist researchers in explaining significant, non-significant or unexpected quantitative results (Tashakkori et al. 1998).

The final component of the study was a second quantitative survey, where participants were asked to have input into prioritising recommendations for future extension programs, which had been developed from the previous stages of the research study.

It can be argued that by starting with a quantitative survey, a positivist or postpositivist worldview is being taken (Campbell & Martin 1993; Maxwell & Mittapalli 2010; Creswell & Clark 2017). The move to a qualitative phase, however, suggests a constructivist worldview and perspective (Walter 2013; Creswell & Clark 2017). Creswell and Clark (2017) suggest that if quantitative and qualitative data collection are occurring simultaneously, with merging of datasets, then a single worldview encompassing both quantitative and qualitative phases would be a reasonable and recommended approach. In this study, data collection occurred sequentially (one after that other), however analysis of the quantitative data assisted in informing the qualitative phase, which in turn informed the second quantitative stage. Due to this merging of data it is argued that one worldview or paradigm approach is warranted.

Addressing the Challenges of Mixed Methods Research

Though there are benefits in combining quantitative and qualitative methods in mixed methods research, and bringing the strengths of each approach into the one study, they also bring with them their own challenges, such as problems of representation and legitimation (Johnson et al. 2007; Denzin & Lincoln 2011). Representation is the challenge of using text or numbers to capture, communicate, and represent human experiences (Onwuegbuzie & Johnson 2006). Representational issues also involve how the researcher is presented in the research process and findings. Legitimation is the difficulty in gathering findings and making conclusions that can be confirmed, are credible and reliable, and can be transferable to a wider population (Onwuegbuzie & Johnson 2006; Teddlie & Tashakkori 2009).

These issues were taken into consideration at the beginning of the research process, to develop strategies that could mitigate such challenges throughout the research design and implementation. The researcher and research topic are known to many of the research participants, creating the potential of researcher influence and issues of power in this study. A strength of a mixed methods design is that it can assist in addressing these issues as it combines two research methods, enabling triangulation and corroboration of findings (Onwuegbuzie & Leech 2007; Walter 2013).

The use of a quantitative survey in the first stage, with the option of remaining anonymous, allowed participants the freedom of choice to respond. Providing the option for farmers to opt-in to qualitative, semi-structured interviews enabled participants to expand on questions through the opportunity for more detailed responses. Interviews also enabled the researcher to follow up responses and explore their actions and behaviour in more detail, through the natural flow of the interview and conversation. Though a qualitative approach has its strengths, the validity and reliability (or credibility, dependability, transferability and confirmability, as typically referred to in qualitative studies) of interviews are sometimes questioned. One argument against the validity of semi-structured interviews is that the participant may be untruthful, or unconsciously respond with an answer they feel the interviewer wants to hear (Tashakkori & Teddlie 2010). There are also issues such as the inability of interview transcriptions to capture the non-verbal messages contained in interviews (Walter 2013). To address this, research notes were maintained throughout the interviews that contained thoughts, feelings and emotions of the interview that could not be captured in the transcription only. In addition, 30 interviews were conducted while looking for saturation, or until recurring themes were heard, and no new themes identified. It can also be argued that semi-structured interviews have high validity as they allow the participants to talk in detail and explain meaning behind actions with little or no input from the interviewer (Tashakkori & Teddlie 2010). Using qualitative, semi-structured interviews enabled triangulation in this study, where the same question was able to be asked in multiple ways to uncover a greater representation of what was happening with individual participants and their choices, decisions, and actions. Additionally, with quantitative survey data from the same farmers to draw on, information about farmers' past and current practices helped frame interpretation of their qualitative data.

Validity and reliability do not have the same meanings in qualitative research as they do in quantitative research, which is where terms of reliability, credibility and dependability are used in reference to trustworthiness of the data (Shenton 2004; Creswell 2013). These issues of validity, reliability, credibility and dependability were taken into consideration throughout the analysis and write-up process. This included maintaining a consistent approach to methods used, including how questions were asked in the qualitative interviews, and ensuring a consistent analytical approach was taken (Shenton 2004). A well-documented method of recruitment, data collection and analysis was also maintained throughout the study (Shenton 2004). Recording and adhering to a rigorous coding process when analysing transcripts and additional data, and reviewing these with the project team, also assisted in ensuring reliability, validity and trustworthiness of data, along with representation and legitimation, in this study (Shenton 2004; Creswell 2013).

Discussions of the limitations of the findings and interpretations of this study have been included in Chapters 4, 5, 6, 7 and 8 as they formed an important part of the journal paper review and publication process. The nature of this study means that the researcher has been part of the research process, which can introduce the potential for influence in the data collection (Denzin & Lincoln 2011). The researcher was aware of this and made every effort to avoid influencing the data collection. Outlining and discussing the limitations of the findings and interpretations during the publication process helped ensure the high quality of the research. During this process researchers explain and link the choice of methods to research questions and findings in a clear way that others can follow to reach the same or similar conclusions (Denzin & Lincoln 2011; Walter 2013).

Focusing and reflecting on potential legitimation issues early in the planning stage assists in the research design as adjustments can be made early on in the process (Benge et al. 2012). Legitimation issues in this study include making generalisations from participants in a sample to a larger population, how accurately the participants view is presented, and issues of the researcher being conceived as in a position of power (Onwuegbuzie & Johnson 2006). This study was designed to address these, by oversampling in the survey phase and conducting sufficient interviews until there was saturation of themes and messages (Baker et al. 2012; Fusch & Ness 2015). However, it is important to be aware that this does not mean all participants and dairy farmers are the same, and not all findings can be generalised to the larger dairy farming population in Tasmania.

The use of a sequential mixed methods design enabled for a consistent method of procedures and analysis to be used, as each stage was conducted and analysed separately. Implementation of a rigorous coding process that was discussed and standardised with the research team, while also engaging in critical reflexivity throughout the research process also assisted in ensuring a consistent approach was taken.

Conceptual Framework

A conceptual framework is a theoretical map for how data is conceptualised, analysed and interpreted, and is based around existing theories (Walter 2013). Theory in mixed methods research studies can be used deductively, in quantitative theory testing and verification, or inductively, as in an emerging qualitative theory or pattern (Creswell 2013). Theory may also be used as a theoretical lens or perspective to guide the study (Creswell 2013). Historically, the idea of using a theoretical lens and framework in mixed methods research was suggested by Greene and Caracelli (1997). Babbie (2002) and Mertens (2003) supported this notion, in that a conceptual framework is necessary and essential in social research.

This research design uses the Theory of Planned Behaviour (TPB) to form the basis of its conceptual framework. The constructs of the TPB are used to help interpret survey data and select interview participants, in the design, analysis and interpretation of the qualitative, in-depth interviews, and in shaping future extension recommendations. Another key component of the conceptual framework was the Learning Competency Model, that was likewise conceptually drawn upon from the design of survey questions through to the framing of extension recommendations. The TPB and Learning Competency Model are discussed in the following section in more detail, and the application of them during the sequential mixed methods research design is represented in Figure 3.1.

Competence Learning Model and the Pasture Management Learning Process

The application of pasture management practices in this study involves the processes of farmer learning, adoption and adaptation. Learning, from the farmer's perspective, is key to continuous improvement in performance through adapting best practice (Parker 1999). Turner and Irvine (2017) propose that a significant period of supported learning involving knowledge and skill development is necessary before farmers can advance to adapting pasture management practices involving measuring and monitoring in their grazing management. It is proposed that as farmers move through this pasture management learning process, they also move through levels of competency, or learning (Howell 1982). This involves moving from 'unconscious incompetence', where farmers are not aware that they lack a skill or a knowledge gaps exists; to 'conscious incompetence', where farmers are aware they lack a skill or knowledge; to 'conscious competence', where farmers have the skill or knowledge but performing the skill requires concentration; through to 'unconscious competence', where farmers have advanced knowledge and skills that are used intuitively (Howell 1982; Clarkson 1994; Barrow 2011).

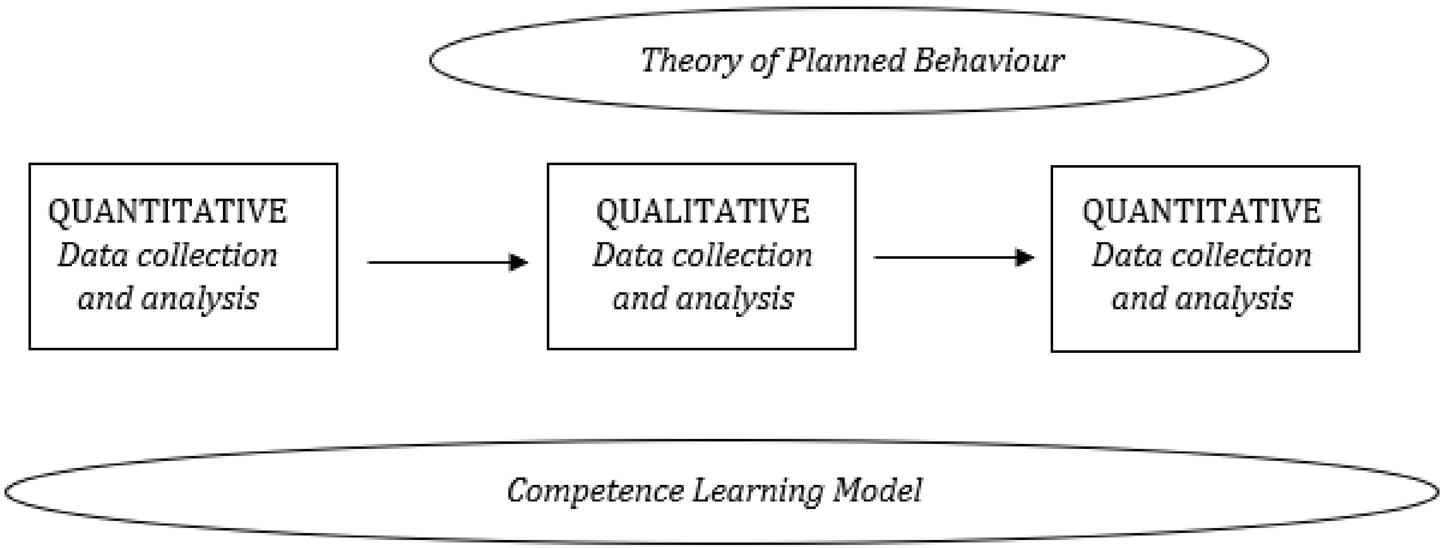

Figure 3.1. Diagrammatic representation of sequential mixed methods research design

The competency learning model was conceptually drawn upon throughout the study in terms of providing the basis for the sequential learning process required for farmers to adopt knowledge intensive practices like pasture management. The stage of competence within the context of a pasture management learning process was proposed by Turner and Irvine (2017) and provides insight into the development of knowledge and skills required for adaptive pasture management. These insights helped inform quantitative survey question design, how farmer participants were then categorised with regards to their responses, with the sub-groups based on extent of previous pasture management and measuring learning and experience. As data was collected and analysed during the first survey phase, it became apparent that farmers could be grouped according to their pasture management experience, indicating their level of learning and likely competence when it came to pasture management practices. These were explored in more depth in the qualitative, in-depth interviews. With regards to the competence learning model, it is suggested that as farmers progress through an extended, supported pasture management learning process, they move from unconscious incompetence towards conscious competence. This competency model, in the context of a pasture management learning process, was considered throughout the research process, as there is a desire to move farmers through a learning process, from unconsciously incompetent (or any starting point in competency) to unconsciously competent, as suggested by Robinson (1974).

Theory of Planned Behaviour

The TPB was employed deductively as a theoretical lens or perspective to guide the development of the qualitative interview guide and subsequent analysis. The TPB has been used extensively to understand the context of decision making and to identify motivational factors involved in a range of disciplines, including agriculture (Beedell & Rehman 1999; Trumbo et al. 2001; Fielding et al. 2005; Fielding et al. 2008; Bond et al. 2009). This research study drew on the TPB over other adoption models such as the technology transfer model and diffusion of innovations, as it focuses on intention and behaviour. other models and associated studies have been more focused on characteristics of adopters, and factors influencing diffusion through a population (Marsh et al. 1995; Ghadim & Pannell 1999). Previous studies have shown its effective use in predicting and influencing future behaviour; once key influential factors are understood they can be worked on to positively influence the desired change in behaviour (Armitage & Conner 2001; Webb & Sheeran 2006; Bond et al. 2009; Ajzen 2011; Fishbein & Ajzen 2011).

Previous studies using the TPB have typically employed a quantitative approach (Trumbo et al. 2001; Fielding et al. 2005; Lobb et al. 2007; Arvola et al. 2008; Bond et al. 2009), and have mainly been concerned with quantifying and predicting the influence of factors on behaviour. While such quantitative studies illustrate the usefulness of the TPB in predicting behaviours, such studies do not explore how and why these factors influence decision making, or assist in explaining why the behaviour has or has not occurred (Renzi & Klobas 2008). Qualitative studies that aim to better understand the underlying cultural and social beliefs associated with behaviour are equally as important as quantitative studies that aim to predict whether a behaviour is likely to occur (Ajzen 1991; Conner et al. 2005; Montano & Kasprzyk 2008; Zoellner et al. 2012). This research study applies the TPB framework in a qualitative manner, in both the design and analysis of the qualitative stage of the mixed method design. This approach was taken as the researcher was concerned with exploring how and why factors influence behaviour (Conner et al. 2005; Montano & Kasprzyk 2008; Renzi & Klobas 2008; Zoellner et al. 2012). This reflects the worldview of critical realism, encompassing a constructivist epistemology and realist ontology.

The TPB framework was used to interpret whether survey respondents intended to adopt pasture management practices or not, and those who have progressed from positive intentions to behavioural change (i.e. adoption and adaption). The framework was also used in developing the interview guide, with questions designed to explore in greater detail the attitudes, social norms, and control factors influencing pasture management and engagement behaviour. These TPB constructs were used during the analysis phase to examine their relative influence on farmer intention and behaviour. Use of the TPB as a framework for analysis was an deductive, thematic process (Punch 2005; Creswell 2013), building from the interview data to the TPB constructs. This process involved gathering detailed information through interviews, with analysis conducted by coding to broad patterns, themes or generalisations using the TPB as a guiding framework (Creswell 2013). The TPB as a conceptual theoretical lens also applies to the final stage of data collection, the second quantitative survey, as the recommendations that formed the basis for this survey are designed to target the key constructs within the TPB that may be limiting behaviour.

In terms of integrating with the TPB, the Competence Learning Model conceptually aligns with the perceived control construct, that influences both intentions and behaviour (i.e. intention to measure pasture and implement associated pasture management practices, and actual practice change). The Conceptual Framework for this research is represented in Figure 3.2.

Research Ethics

Ethical research ensures that ethical principles and values govern research involving humans (Walter 2013). The nature of social research means that individuals and groups of people are involved, requiring consideration of ethics throughout the research process. For this research in particular, as the researcher is involved throughout the data collection and research process (in particular, the qualitative interview phase), understanding and awareness of the power and/or potential influence of the researcher over the research participants is essential (Walter 2013). It is also important to consider the more traditional, competing worldviews of quantitative and qualitative research, and that elements of these may occur during the research process despite one all-encompassing approach being used. These ethical issues have to do with how the research objects (data and participants) are viewed in the research process, how they are represented, and also considers that research is not value free due to the nature of the qualitative component that places the researcher within the research process (Mingers 2009; Creswell 2013). Additional ethical issues such as providing reciprocity to participants for providing data, handling private or sensitive data, and being upfront about the purposes of the research apply to both quantitative and qualitative research (Creswell 2013; Creswell & Clark 2017).

To address potential ethics issues, it is important for the researcher to practice critical reflexivity, that is, being aware of their role and position in the research process, and how their involvement might bias data collection and results (Walter 2013; Sanjari et al. 2014). Ensuring a well outlined design to conducting the research and analysing results is used can assist in ensuring ethics and ethical issues are addressed (Walter 2013)

In addition to the ethical issues of the researcher being placed within the research process, and implication this may pose for qualitative data collection particularly, this study was subject to additional ethical issues including the provision of participants names, demographic information, and potential for identification. This minimal risk research received approval from the Tasmania Social Sciences Human Research Ethics Committee (H0015858).

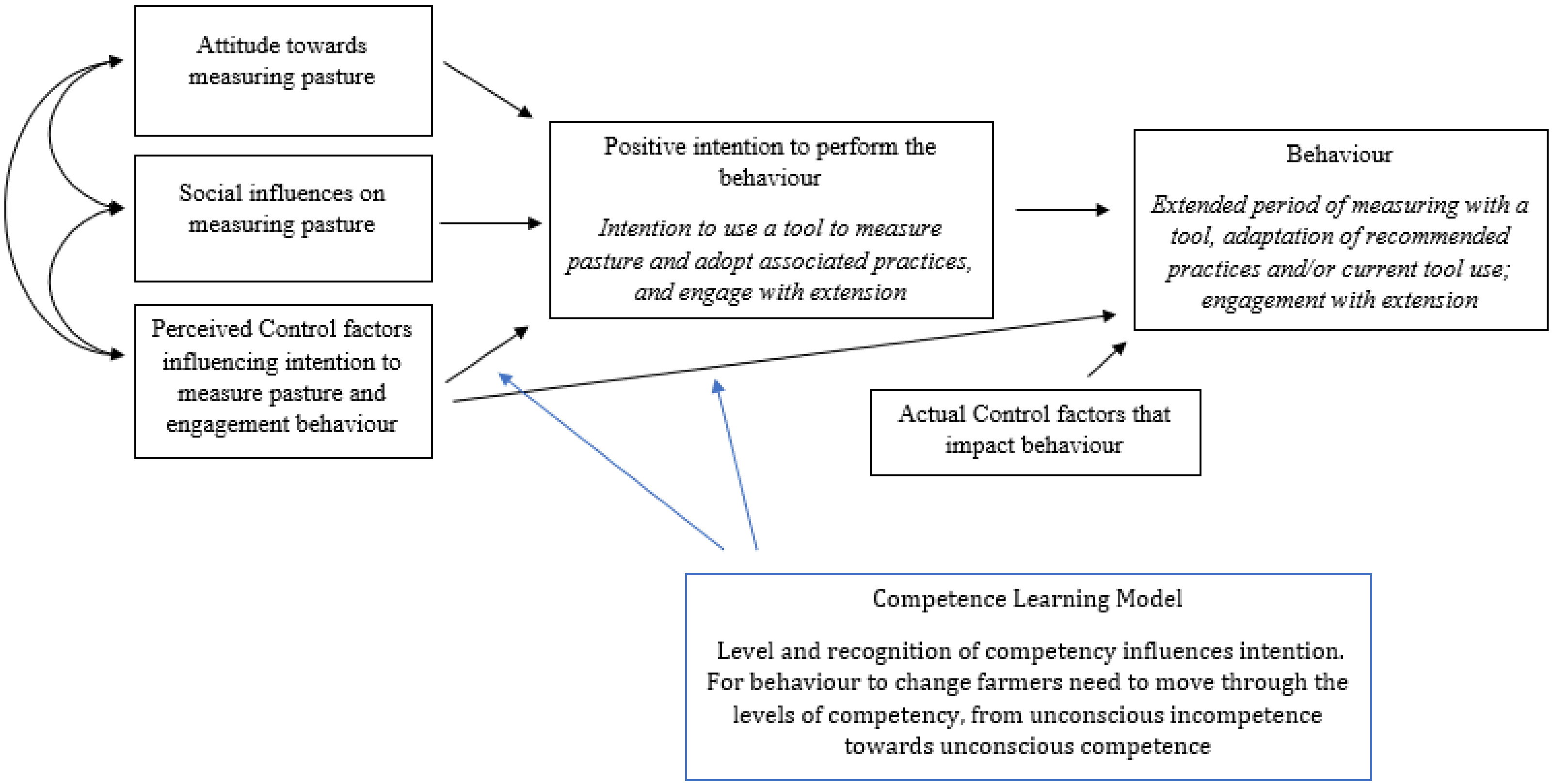

Figure 3.2. Conceptual framework

All participants were provided with an information sheet for each stage of the study, outlining the nature of the research and what they would be asked to do (see Appendices 1, 3 and 6). The aim of the information letters was to reassure participants that their research participation was voluntary, and that they were free to withdraw their data from the study within one month of participation. Participants in the interview stage of the study were asked to sign a consent form, agreeing to participate in the study and indicating then nature of the study and research outputs had been explained to them. All participants were given a number, and no individual farm information was presented in outputs of the research, minimise the risk of identification.

Research Methods

Survey 1 – Pasture Management on Tasmanian Dairy Farms, Survey 1

Design Approach, Strengths and Limitations

A quantitative survey to determine past and current pasture management practices and extent of extension engagement formed the first stage of this sequential, mixed methods study.

Appropriate use of a quantitative survey design is a means of identifying attributes and trends from a sample of individuals that can then be generalised to a larger population (Babbie 1990). Surveys are also a timely and cost effective method of collecting information from a broad population (Tharenou et al. 2007).

However, using a survey design has some limitations that should be considered. These include use of cross sectional data (all data collected at one point in time), and common method variance (extent of the inaccurate relationship that is measured between two or more variables that are measured in the same way). It is also essential that while surveys with a high response rate are representable to some extent, case must be taken to ensure the results are not inappropriately generalised beyond the sample (Mitchell 1985; Tharenou et al. 2007). To overcome these limitations, the survey in this study was followed by in-depth, qualitative interviews to check the validity of data collected from the survey, providing a second source of information. This study also employed ethical research guidelines and approach, protecting respondent anonymity to reduce evaluation apprehension, and used subjective and objective data which assists in overcoming these limitations and can increase participation (Tharenou et al. 2007).

Survey Process, Sampling and Recruitment

The survey was piloted with five Tasmanian dairy farmers before being distributed to the wider population. This enabled refining of the survey structure, response categories and questions (Babbie 1990; Creswell & Clark 2017). Piloting or pre-testing is important in survey administration to ensure validity of the survey, and to improve readability and answerability of questions, format and scales (Creswell 2013).

The survey is cross sectional in nature, with data collected at one time through a self-administered, paper-based mail survey (Dillman 2007). The survey was mailed to the vast majority of Tasmanian dairy farms – the 440 whose contact details are registered with the Tasmanian Institute of Agriculture. The person responsible for making the pasture management decisions on the farm was asked to complete the survey. The survey contained an information sheet outlining details of the study, emphasising that participation was voluntary in nature. Survey participants had the option of including their name and contact information if they consented to being contacted about participating in a follow up interview. The returned surveys were collected by the researcher for data entry, with each survey numerically coded.

The survey collected information on farmer demographics, farm information, involvement in extension activities, past and current ownership and use of pasture management tools, and how decisions were made about grazing management. Several questions included in the survey had multiple options for responses, in order to accurately reflect the respondent's situation. Numerical coding of responses was undertaken for questions where responses couldn't be grouped into 'yes' or 'no' responses, enabling further analysis.

Further details about questions included in the survey are discussed in Chapter 4, and the survey template is included in this thesis as Appendix 2.

Survey Analysis

Responses to questions were numerically coded prior to analysis. The quantitative data were analysed using the statistical program Statistical Analysis System (SAS University Edition 5.1.17). Survey results were reported using descriptive and inferential statistics, with summary statistics and correlations produced. Further details about the types of statistical analysis used and how they are reported are discussed in Chapter 4.

Qualitative Interviews

Design Approach, Strengths and Limitations

In-depth, semi-structured interviews are a data collection procedure where the researcher typically has an interview guide consisting of questions on specific issues related to the research areas. One of the main strengths of qualitative interviews is the flexibility to explore in-depth participants responses (Walter 2013). It is developed from a constructivist or interpretivist perspective that sees that social research needs to address the complexity of how people see and interpret their lives and the world around them (Walter 2013). Interviews are also advantageous in that participants can provide context and historical information, and also allows the researcher to have control over the line of questioning (Creswell 2013). Another key advantage of semi-structured interviews is that they enable reciprocity between the interviewer and participant, enabling the interviewer to improvise follow-up questions based on responses (Kallio et al. 2016).

Similar to survey research, one of the criticisms of in-depth interviews is that they only address a small population of individuals (Walter 2013). Another criticism is due to the nature of interviews, the researcher is placed within the research process, whose presence may bias responses and if undertaking the analysis can influence the results due to their individual interpretation (Creswell 2013; Walter 2013). Asking the same question in several ways (a form of triangulation), practicing critical reflexivity and maintaining research notes or a research diary throughout the process, and consulting the research team throughout analysis, can assist in addressing these limitations.

Interview Process, Sampling and Recruitment

Respondents to the initial, quantitative survey had the option of including their name and contact details if they consented to being contacted about participating in a follow up interview. Respondents who provided their contact information were categorised into farmer sub-groups based on their responses to key questions. These included questions on their level of engagement with extension activities, and their past and current use of pasture measurement tools. How this categorisation was conducted is discussed in further detail in Chapter 6 in regard to past and current use of a pasture measurement tool, and in Chapter 7 with regards to extension engagement.

The choice of key questions used to categorise respondents into sub-groups was developed from the aims and research questions of this study, drawing on the TPB constructs and framework. These questions, as outlined in Chapter 6 and 7, are concerned with the adoption and implementation of pasture measurement tools, and farmer engagement with extension activities. Combining respondents' answers to these key questions resulted in categorisation of three sub-groups, representing a range of engagement levels, past and current use of pasture measurement tools, implementation of recommended pasture management practices, and a range of practice change and adoption behaviour.

The combination of key questions and categorisation of farmer sub-groups are represented in Table 3.1. The Non-users sub-group are made up of farmers who never engage in extension activities, or engage once a year, while also never having used a pasture measurement tool or having only tried out using a tool on their farm. The Non-users sub-group don't currently use a tool to measure pasture and demonstrate no intention to adopt recommended practices or demonstrate behaviour change with regards to learning and implementing recommended practices. The Triallers sub-group is made up of farmers who predominately engage in extension two to four times a year, and a small number who engage once a year. They have either tested a pasture measurement tool, or used a tool to measure pasture non-intensively (that is, use a tool to measure pasture for a period of 6 months or less), but do not currently use a tool to measure pasture. Farmers in the Triallers sub-group demonstrated intention to adopt, by starting out on the pasture measurement and management learning process, but they did not continue, therefore not demonstrating practice change. Farmers in the Adapters sub-group have been split into temporary intensive users, and continued users. Farmers in the Adapters sub-group are regularly engaged with extension, engaging two to four times a year, and the majority engaging 4 times a year or more. They have been through an intensive period of measuring pasture, that is, using a tool to measure pasture regularly for six months or longer. Therefore they have demonstrated intention to adopt, and have demonstrated practice change as they have continued through an intensive period of measuring and monitoring, which is an important part of the pasture management learning process (Turner & Irvine 2017). The temporary intensive users, after being through an extended, intensive period of measuring and monitoring, have adapted their pasture management practices and no longer use a tool to measure regularly. The continued users have also been through an extended, intensive period of measuring and monitoring, and have adapted their pasture management practices while continuing to use a tool to measure pasture.

Respondents to the initial quantitative survey who provided their contact information were categorised into the three sub-groups of Non-users, Triallers and Adapters. This resulted in 11 Non-user farmers, 14 Triallers and 38 Adapters (six temporary intensive users and 32 continued users).

Respondents for each sub-group were randomly ordered in excel and contacted by the interviewer using random sampling to confirm further participation and organise a meeting, with the aim of 30 interviews. Eight Non-user farmers agreed to be interviewed, 12 Triallers and 10 Adapters (five temporary intensive users and five continued users). These farmers were given alpha-numerical codes according to their group and number of interviewees, so they would remain unidentifiable in research outputs. Refer to Table 3.1 for more detail on sub-groups, numbers interviewed, and their characteristics.

There are no set rules regarding how many interviews should be used in a qualitative or mixed methods research project, and the number used depends on the purpose and aim of the project (Walter 2013). For this project, the researcher endeavoured to interview equal numbers of farmers from each sub-group to ensure that each group was equally represented without significantly more participants interviewed from one group compared to another. Simultaneously, the researcher was alert for response and message saturation to guide whether the suggested 30 interviews were sufficient. The number of participants interviewed (n = 30) was based on the criterion that the sample size must be sufficient for the responses obtained to provide diversity and richness of data, and that the addition of more participants does not increase the diversity or richness of the sample, known as saturation (Robson 1993).

Thirty one-on-one interviews took place face-to-face over a four-month period from June to October 2017. All interviews were conducted by the one researcher, were 60-90 minutes in duration, and used a semi-structured interview guide that allowed for in depth discussion and freedom to explore points raised by participants in response to questions. All interviews were digitally recorded with the participants' permission, and transcribed verbatim.

Interview questions were developed within the constructs of the Theory of Planned Behaviour (TPB) to explore factors influencing adoption of pasture measurement and management practices, including intention to adopt and actual adoption, adaption and subsequent behaviour change. The constructs of the TPB were also used to develop questions to explore participants engagement with extension activities. This included questions to uncover and understand factors impacting initial and continued engagement. A deductive approach to thematic analysis was used, with a clear and concise process discussed within the research team, using constructs of the TPB guided interview schedule an a priori coding of data back to the TPB (Patton 2002; Elo & Kyngas 2008; Zoellner et al. 2012). Information on the TPB and how it is used to explore these factors in a qualitative study are discussed in more detail in subsequent chapters. Refer to Chapter 6 for use of the TPB in exploring adoption and implementation of pasture measurement tools and associated management practices, and Chapter 7 for engagement with extension activities. The interview schedule in included as Appendix 5.

Table 3.1. Interview sub-groups and their characteristics

Sub-groups	No. farmers surveyed providing contact details	No. farmers interviewed	Never attend extension activity	Engages in extension once a year	Engages in extension 2-4 times a year	Engages in extension >4 times a year	Ongoing intention to engage	Currently engaged	Tool owned	Tool trialled	Tool used intensively	Tool used currently	Intention to adopt	Practice change observed
Non-users*	11	8	4	3	1	0	✗	✗	✗(3)✓(5)	✗(3)✓(5)	✗	✗	✗	✗
Triallers	14	12	0	2	7	3	✓	✓	✗(5)✓(7)	✓	✗	✗	✓	✗
Adapters	38	10	0	0	4	6	✓							
Temporary intensive users	*6*	*5*	*0*	*0*	*2*	*3*	✓	✓	*✗(2)✓(3)*	✓	✓	✗	✓	✓
Continued users	*32*	*5*	*0*	*0*	*2*	*3*	✓	✓	✓	✓	✓	✓	✓	✓

**Non-users are also referred to as Unengaged in Chapters 7 and 8.*

Interview Analysis

The method of analysis for the qualitative interview data was thematic analysis, a method of identifying and analysing themes or patterns within data (Braun & Clarke 2006). The advantage of thematic analysis is that it is flexible in its application as it is not restricted or limited to a particular theoretical approach, and can provide more details through enabling complex analysis of data (Braun & Clarke 2006).

A deductive approach was used within the thematic analysis of qualitative data in this study. The interview schedule for this stage of the study was developed using the constructs of the TPB (discussed in more detail in Chapters 6 and 7). Responses to the open ended questions were analysed by coding the information, identifying themes, and organising information to allow for drawing of conclusions, a methodology outlined by Huberman & Miles (1994). Themes were identified in accordance with this theory, including attitudes, social norms, perceived control and actual control. During analysis the researcher was alert for additional themes that may have emerged, but none were apparent. In order to address some of the criticisms of thematic analysis, in that it lacks rigour, Reicher and Taylor (2005) state that the researcher needs to be clear and explicit about what they are doing throughout the analysis process. The use of a deductive approach to thematic analysis can assist with this process, in this case by using the constructs of a pre-existing behavioural theory to guide development of interview questions and analysis of data by providing a framework to assist in developing a rigorous analysis or coding method.

Coding and analysis of interviews was performed using NVivo 11, Computer-Assisted Qualitative Data Analysis Software. Two main activities were conducted in NVivo: set up of the node tree, and preparation of a coding framework. A node in NVivo is an object that represents an idea, theory of characteristics associated with data contained in a document. Nodes are linked in a hierarchical way to form a node tree. Nodes were established that followed the interview guide structure, and then further broken into categories under each of the interview segments. The first four interviews were coded in this manner and moderated within the research team, before the remaining interviews were coded. As nodes reflected elements included in the interview schedule in addition to the TPB, most coding involved identification of sections of text referring to these elements, and coding under respective nodes. A response or section of text may refer to one or several elements or concepts. Some nodes were broken into further segments to refine this process and reduce the number of concepts included in individual nodes.

Figure 3.3 shows the condensed node tree for all nodes developed from the interview guide. Figure 3.4 shows the node tree and sub-nodes developed using the TPB. The interview analysis is also discussed in Chapters 6 and 7.

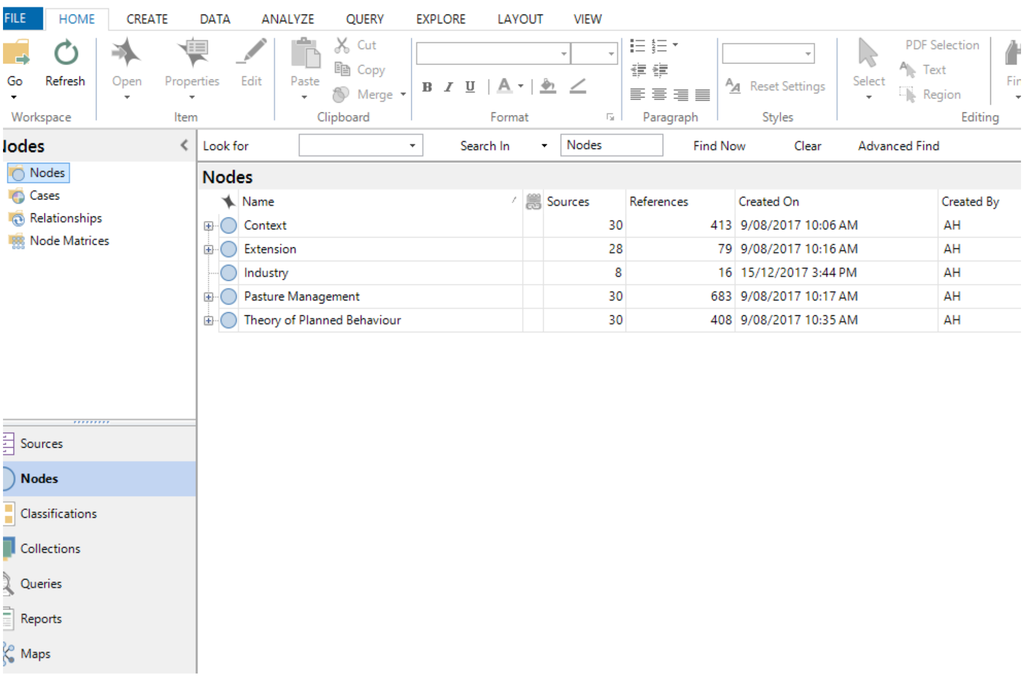

Figure 3.3. Condensed node tree for all interview data.

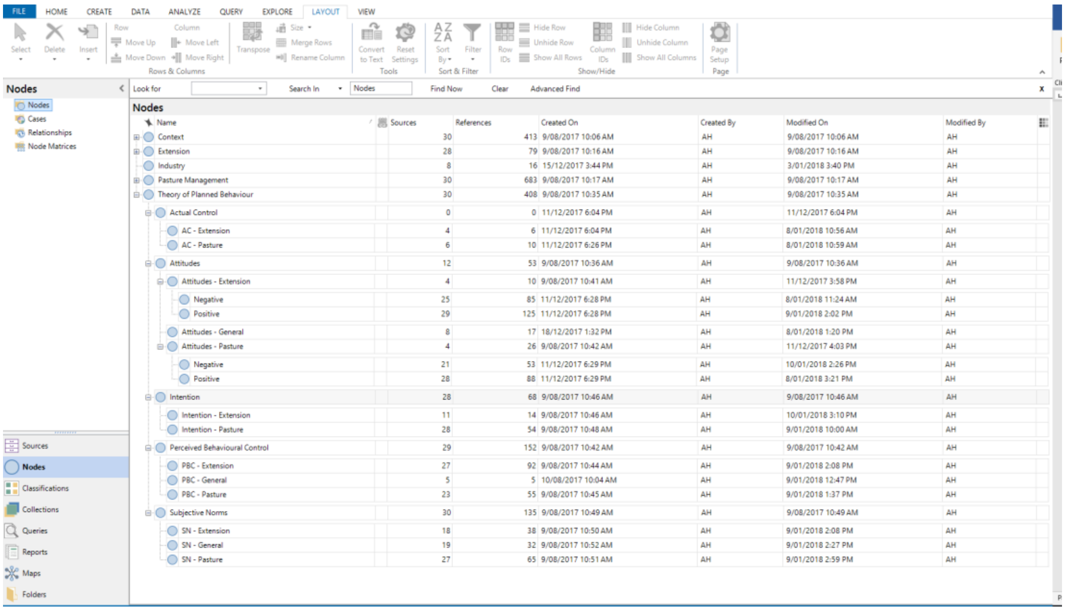

Figure 3.4. Node tree developed from the interview schedule using the TPB framework.

Survey 2 – Pasture Management on Tasmanian Dairy Farms, Survey 2

Design Approach, Strengths and Limitations

This second survey formed the final stage in this mixed methods study. Participants included those who had participated in both the first survey and also a follow up interview. A quantitative, paper-based survey was sent to these 30 farmers, asking them to prioritise recommendations developed from the previous two stages.

The benefits of a using a second quantitative survey was that it offered a time efficient means of achieving input from the 30 interviewed farmers regarding recommendations for future extension activities. However, a limitation of this approach is that it is a small population being sampled, and results can be inappropriately generalised to a larger population (Mitchell 1985; Tharenou et al. 2007). A strength of using the same population of 30 farmers that participated in the first survey and interviews was that this second survey then acted as another source of data for triangulation and validity. It should also be noted that the findings from this survey are used to support those from the previous survey and in particular the interviews, rather than generalising new findings to a broader population.

This survey was designed using a modified Delphi technique. The Delphi technique is a method designed to obtain consensus of opinions of groups of experts by using a series of questionnaires (Dalkey & Helmer 1963). The Delphi process typically includes two to three rounds of questionnaires, with the first round consisting of an open-ended questionnaire designed to solicit information on a content area (Hsu & Sandford 2007). Subsequent rounds consist of questionnaires based on the responses of the previous round (von Ruschkowski et al. 2013). Advantages of the Delphi method include the ability to maintain subject anonymity and control feedback, obtaining data without meeting physically in the same location, and reducing bias and influence of responses that can occur in a group setting (Dalkey & Helmer 1963).

A modified Delphi method was used in that the preceding survey and interviews take the place of the two questionnaires used in a traditional Delphi technique.

Survey Process, Sampling and Recruitment

The initial survey in this research project gathered information and data on pasture management practices and engagement behaviour, which then informed development of the follow up, qualitative interviews. The interview findings were developed into focus areas and preliminary recommendations for future extension activities, particularly those on pasture management. These recommendations were developed from understanding in greater detail the factors that impact adoption and implementation of pasture measurement tools and management practices, and understanding the factors impacting farmers' decision to engage or otherwise with extension activities. Based on these recommendations, 15 questions were developed into the second survey. Farmers were asked to respond on a 5-point Likert scale of 'strongly disagree' to ‘strongly agree’, following the approach used in a typical Delphi survey. The questions corresponded to recommendations, with the responses indicating the level of support for the recommendations.

The paper based, self-administered survey was mailed to the 30 farmers who had participated in the first survey, provided their contact details, and participated in a follow-up interview. An information letter was sent with each survey, outlining what the survey was going to be used for, and emphasising that participation was voluntary. Each survey included participants alpha-numerical code that had been used for both survey 1 and interview analysis, enabling responses to be grouped into the three sub-groups used throughout this study. A reply-paid envelope was also included to enable easy return of the survey. A reminder letter and second copy of the survey were mailed to those participants who hadn’t responded within the first week to increase the response rate, as recommended by Dillman (2007).

Survey Analysis

Twenty-seven of the thirty farmer surveys were returned, a response rate of 90%. Due to the small sample size, ‘strongly agree’ and ‘agree’ responses were aggregated, and ‘strongly disagree’ and ‘disagree’ were aggregated. The response ‘neither disagree’ or ‘disagree’ was left as ‘neutral’. Surveys were coded so responses could be allocated to sub-groups. Responses to questions were graphed using the statistical program R (v 3.5.0). The 15 questions were separated into three groups of five according to the group of recommendations the questions were associated with. Refer to Chapter 8 for individual questions, groupings and recommendations. While complete statistical analysis was unable to be conducted due to sample size, analysis of responses was able to produce agree, disagree or neutral trends for each question for the three farmer sub-groups. These then indicated the level of support for the associated recommendations.

In Summary

A mixed methods approach that incorporated a sequential design of quantitative and qualitative studies was an effective approach in this study. The initial quantitative survey was able to elicit information about farmers current and past behaviour in relation to pasture management and extension engagement, and was able inform the subsequent qualitative stage. The in-depth, semi-structured qualitative interviews revealed information about how and why farmers behave and make decisions, with a greater depth and breadth of understanding than would have been achieved using strictly quantitative methods. These interviews then informed the third and final quantitative stage, that invited farmers who had participated in the two preceding studies to have input into refining and prioritising recommendations for future extension activities. A mixed methods approach was able to maximise the strengths of quantitative and qualitative research techniques while overcoming weaknesses in both approaches, with each stage building on and supporting the previous.

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Chapter 4 – Pasture management and extension on Tasmanian dairy farms – who measures up?

This Chapter reports results of the first quantitative stage and Survey 1 as described in the Research Methods section of Chapter 3 – Research Methodology.

This Chapter has been published as a peer reviewed journal paper in the Rural Extension and Innovation Systems Journal (2017, 13(2)). The published abstract is included below.

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Pasture management and extension on Tasmanian dairy farms – who measures up?

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Abstract. Tasmanian dairy farmers were surveyed to identify the extent of use of pasture management tools and technology and engagement with extension activities. The survey was mailed to the 440 registered dairy farmers with a response rate of 164 (37%). Of the farmers who responded, 65% had previously used a tool such as a rising plate meter, CDAX bike reader or pasture ruler, 48% currently use a tool, and 86% had attended extension activities. Attendance at extension activities, past use of a tool, farm size and education were positively related to the current use of pasture management tools ($p < 0.05$). Farmers who have used a pasture measurement tool in the past and/or currently use a tool, ranked confidence in their pasture management ability higher ($p < 0.05$) than those who have not used a tool. Past use of a tool, herd size and farmer education were positively related to attendance at extension activities ($p < 0.05$).

Keywords: dairy farmers, engagement, extension, pasture management, technology, tools

Introduction

The Tasmanian dairy industry is comprised primarily of pasture based systems, with pasture typically being the cheapest available feed for dairy cows that meets their nutritional requirements (Chapman et al. 2009; Rawnsley et al. 2012). Dairy farmers are continually faced with the challenges of fluctuations in milk price, rising costs and seasonal conditions, which places a greater emphasis on the importance of improving farm efficiencies. Farina et al. (2013) suggests that increasing the production and utilisation of forages produced on-farm will be critical to future growth within the dairy industry. Rawnsley et al. (2012) further emphasises this, stating that in an economic environment where production costs increase faster than commodity prices, there is a need to enhance pasture production and utilisation to maintain efficiencies within the Tasmanian dairy industry.

As a consequence, a key focus of research, development and extension (RD&E) projects in the Tasmanian dairy industry has been on increasing awareness, knowledge and use of best practice pasture management principles and practices to improve the consumption of home-grown forages by dairy cows. This includes the use of tools and technologies that have been developed to assist in pasture management. In general, using a tool such as a rising plate meter to measure pasture has been proven to be a quick and effective way of assessing total forage growth and yield, with a greater level of accuracy than visual assessment (Stockdale 1984; Scrivner et al. 1986). Van Bysterveldt and Christie (2007, as cited in Romera et al. 2013) note that there are clear advantages in regularly measuring pasture, and tools for doing so have been the focus of research and development (Eastwood et al. 2017). The use of these tools gives farmers objective information from which they can make decisions on pasture management, give increased control and flexibility around grazing decisions, and can assist in increasing productivity (O'Donovan et al. 2002). Case study research by Turner and Irvine (2017) suggests that farmer confidence increases through the use of pasture measurement tools, partly due to their important role in the pasture management learning process. While farmers learn about the biological principles underlying recommended practices, the use of a pasture measurement tool assists in the training of their eye to visually assess pasture growth more accurately. As new pasture management skills are developed and combined with farmers' experience and existing farm knowledge, the need to continue using the pasture measurement tool may decrease (Turner & Irvine 2017).

Despite focused extension efforts on pasture management practices on-farm pasture consumption is still below potential (Dairy Australia 2015). Farmer engagement with extension activities varies throughout Tasmania, ranging from farmers who have never participated in extension activities to those who are regularly engaged and host events on their farm. Diversity in adoption, integration and engagement leads to a range of outcomes and impacts on-farm (Schewe & Stuart 2015). Focus groups conducted within the Tasmanian dairy industry to determine farmer attitudes towards pasture management led to the suggestion that two factors limiting use of pasture measurement tools by dairy farmers were not having the time available, and hesitation to trialling new practices on their own farm (Craigie 2013). Ghadim and Pannell (1999) also identified risk as a major factor in reducing the rate of adoption of an innovation, and given that uncertainty is a normal attribute of innovations before they have been trialled, risk aversion generally has a negative influence on rapid adoption of innovations and new technologies. However, many of the extension-recommended pasture management tools and technology, and their use on farms, are not new to dairy farmers, and despite many having adopted and demonstrated these practices successfully, anecdotal evidence suggests that the adoption and implementation of some extension-recommended technologies and practices remains low among a significant proportion of the dairy farmer population in Tasmania.

The decision-making processes around technology adoption are therefore not as straightforward as simply reducing the risk involved through demonstration and waiting for natural dissemination of information through farmer-to-farmer communication. For further adoption of pasture management recommendations to occur, RD&E providers need a deeper understanding of why many farmers are not implementing these known and proven practices. Future changes made to extension methods should therefore be based on sound social research findings. This paper reports on a survey that aimed to identify the current pasture management practices in the Tasmanian dairy industry, and potential factors related to use and non-use of tools and technology. These data are essential in informing further social research that will delve deeper into the process of decision making and adoption behind the use, or lack of, pasture management tools and management recommendations.

Methods

Survey

In 2016, a paper based, quantitative survey was mailed to all 440 dairy farmers in Tasmania using their contact details registered with the Tasmanian Institute of Agriculture. Surveys were undertaken on an opt-in basis, with a reply-paid envelope included. The survey was mailed out to each farmer once.

The person responsible for making the pasture management decisions on the farm was asked to complete the survey. The survey collected information on farmer demographics such as age, education, role in business and experience, in addition to farm characteristics such as herd size, land area operated, and location. Responses to the level of formal education respondents have achieved were numerically coded with the median level of formal education received being that of a certificate. For further analysis, the levels of qualifications included in the survey were combined to reflect the current standard levels of education and their equivalents as outlined in the Australian Qualification Framework (AQFC 2013) and Tasmanian Education Act (Tasmanian Education Act Tasmanian Education Act 2016). The six original education options were combined into three groups, Year 10 or below and Certificate, Year 11 and/or 12 and trade/apprenticeship, and Diploma and/or University (see Table 1). The survey inquired about the respondent's involvement in extension activities (including general extension activities and activities specifically focused on pasture management), and past and current ownership and use of pasture management tools. As farmers can choose to use these tools in a variety of ways, such as on a regular basis or intermittently, the survey included several options when asking about both past and current tool use. For example, have they tried out or tested a pasture measurement tool on their farm, used a tool consistently for 6 to 12 months or longer, or have they used a tool at particular times of the year. The range of options provided meant that farmers could be categorised into those that have undergone a period of intensive measuring and monitoring using a tool in the past (6 to 12 months, and 12 months or more categories as intensive monitoring), as well as those who currently use a pasture measurement tool on a regular basis or periodically. The survey continued with questions asking about how farmers make decisions about grazing management, including options related to using a pasture measurement tool or measurements taken.

When asked about tool ownership, the survey asked, 'do you own any of the following', with a selection of pasture management tools listed (including plate meter, CDAX bike reader, pasture probe, and pasture ruler), with farmers selecting one or multiple tools if they owned them, in addition to the option 'I don't own any of the above'. The survey asked if the respondent, or anyone else, currently used a tool to measure pasture on their farm, with the selection of pasture measurement tools listed identical to those included in the question about ownership, in addition to 'never use a tool to measure pasture cover'. If any of the tools were ticked, they were grouped under a 'yes' response, and 'never use a tool' was grouped as 'no'. This grouping enabled analysis of Yes/No responses to currently using a tool to measure pasture.

Respondents were asked if they had ever used, tried out or tested a pasture measurement tool on their farm, and given a yes or no option. For those who answered yes, they were asked to identify how they had used the tool in the past, with four options of increasing intensity included. Including a range of responses to choose from enabled groupings of responses into those who had previously used a tool to measure pasture intensively and those who have used a tool non-intensively.

The survey included a section on grazing and management decisions, where respondents were asked to select from a range of options on how they make decisions about feeding their cows, including allocating pasture and supplement feeding. These responses were then grouped into decisions based on using measurements or data from measuring with a tool, and other (that is, decisions not based on measuring, including visual assessment). Respondents were asked to rank their confidence in their ability to manage pasture on a scale of 1 to 10, with 1 being a very low level of confidence and 10 being a very high level of confidence. When analysing the data, a number of different groupings of confidence were analysed in comparison with demographic variables and pasture management practices. The grouping of 7 or more out of 10, and less than 7 out of 10, have been used when comparing confidence and intensive or non-intensive past use of a tool as this grouping produced a significant result. When confidence was analysed in comparison to current use of a tool, the same grouping was used in addition to 6 or more out of 10, and 5 and less out of 10, as a more representative comparison of confidence ranges.

A number of the questions included in the survey had multiple options to accurately reflect the respondents' situation. Numerical coding of responses was undertaken for questions where responses couldn't be grouped into yes or no responses, enabling further analysis. For example, education responses were coded 1 for Year 10 or below, 2 for Year 11 and/or 12, 3 for certificate, 4 for diploma, 5 for trade or apprenticeship, and 6 for university.

Questions that already had numerical responses, like those for herd size, milking area, and years' experience farming, were left in the original format. Questions that included categorical responses in a range, such as that for age and level of concentrate feeding, were also left in the original categories.

Data Analysis

Data collected from the surveys were analysed using the statistical program Statistical Analysis System (SAS University Edition 5.1.17). Survey results were reported using descriptive and inferential statistics, with summary statistics and correlations produced. The logistic procedure was primarily used to examine which demographic and farm variables were related to past and current use of pasture management tools. The logistic procedure yields odds ratio values that reflect the likelihood of a response in relation to the explanatory variable used. Comparisons were made using chi-square values, with level of significance considered at $p < 0.05$. To examine whether current use of a pasture measurement tool has impacted on farmer confidence in their ability to manage pasture, the Pearson chi-square test was used. To gain an insight into the current level of ownership, and then use, of pasture management tools among respondents, the frequency procedure in SAS was used.

Results

Table 4.1 displays summary statistics for the farmers who returned their survey (37.5% response rate). Out of the returned surveys, 162 were completed and used for analysis. The mean herd size for all respondents was 445 cows, with the mean milking area 186 hectares. The mean value for herd size for respondents of 410 cows is comparable to the estimated average herd size in Tasmania of 412 cows (Australian Bureau of Statistics 2017), which suggests that the survey population is a fair representation in terms of farm size when compared with the broader Tasmanian dairy farm population.

Sixty-four percent of respondents answered yes to owning a pasture management tool, with 65% of respondents having used a tool to measure pasture in the past. However, only 48% of respondents answered that they, or someone else, currently use a tool to measure pasture on their farm. Eighty-six percent of respondents answered that they currently attend extension events (varying from once a year to more than four times a year), with 76% of respondents having attended an activity specifically focused on pasture management.

Factors related to the current use of pasture measurement tools

Four factors were found to have a significant relationship with current use of a tool to measure pasture; past use of a pasture measurement tool, farm size (herd size and land area), level of formal education, and attendance at extension activities (general extension activities and activities specifically focused on pasture management).

The relationship between use of a tool to measure pasture in the past, and current use of a pasture measurement tool was significant (χ^2_1 = 30.6, p <0.0001). The odds ratio value of 10 indicates that respondents who currently use a tool to measure pasture are 10 times more likely to respond that yes, they have used a tool to measure pasture in the past, than no (95% confidence interval of 4 and 23).

Table 4.1. Demographics, farm characteristics and use of pasture measurement tools of survey participants

Variable	Survey Sample
Milking area, hectares*	174 (110)
Herd size, no. of cows*	410 (347)*
Education level % - Year 10 or below, and Certificate	38.5
Education level % - Year 11 and/or 12, and trade/apprenticeship	28.6
Education level % - Diploma and/or University	32.9
Past tool use, % yes	64.8
Intensive (6 months or longer)	43.0
6 to 12 months	13.1
12 months or more	32.7
Non-intensive (less than 6 months)	57.0
Less than 6 months	29.9
Particular times of the year	24.3
Tool ownership, % yes	63.7
Plate meter ownership, % yes	59.4
CDAX ownership, % yes	9.4
Pasture ruler ownership, % yes	14.4
Pasture probe ownership, % yes	0.6
Current tool use, % yes	47.8
Plate meter, % yes	42.2
CDAX, % yes	9.9
Pasture ruler, % yes	3.7
Attend general extension activities, % yes	86.3
Attended an activity specifically focused on pasture, % yes	76.4

n=162, mean values with SD in parentheses
Milking area and number of cows denoted with asterisk have been calculated from 161 respondents, with one respondent who works across multiple farms removed from the initial total of 162 respondents to give a more representative sample.

When the use of a tool in the past was separated into those who have used a tool intensively and not intensively, the relationship with current use was also significant ($\chi^2_1 = 7.2$, $p < 0.03$). Those who have used a tool to measure pasture intensively in the past are 3.4 times more likely to currently use a tool to measure pasture than those who have not used a tool intensively in the past (95% Wald confidence interval of 1.4 and 8.2). When asked to rate confidence in their ability to manage pasture, respondents who have used a tool to measure pasture intensively in the past were 4.3 times more likely to rate their confidence in their ability to manage pasture at a 7 or more out of 10, than those who haven't measured pasture intensively in the past (95% Wald confidence interval of 1.2 and 16). The relationship between current use of a tool to measure pasture and confidence was also significant. Respondents who answered no to currently using a tool to measure pasture were 2.5 times more likely to give a confidence rating of six or less out of ten ($\chi^2_1 = 5.4$, $p < 0.03$; 95% Wald confidence interval 1.1 and 5.6). When analysis was conducted with confidence groupings of five and less out of ten, and six or more out of ten, respondents that answered no to currently using a tool to measure pasture were 8.6 times more likely to give a confidence rating of five or less out of ten ($\chi^2_1 = 10.4$, $p < 0.003$; 95% Wald confidence interval 1.9 and 39).

With regards to level of formal education received, the combined levels of Year 10 and below and Certificate represented 39% of respondents; Year 11 and or 12 and the equivalent level of trade and/or apprenticeship represent 29% of respondents; those with a diploma and/or university qualification made up 33%.

A chi-square test was performed to examine the relation between level of formal education and current use of pasture management tools. The education levels of Year 11 and/or 12 and equivalent (trade and/or apprenticeship), and diploma and/or university were analysed in comparison to Year 10 or below and certificate. There was a significant relationship between use of tools and level of education for respondents with Year 11 and/or 12 and equivalent compared with Year 10 or below and certificate ($\chi^2_1 = 9.4$, $p < 0.003$). There was also a significant relationship between use of tools and level of education for respondents with qualifications of diploma and university compared with Year 10 or below and certificate ($\chi^2_1 = 19.1$, $p < 0.0001$). The odds ratio value for Year 11 and/or 12 and equivalent of 3.6 indicates that farmers with a qualification of Year 11 and/or 12 and equivalent are 3.6 times more likely to respond that yes, they currently use a tool to measure pasture than farmers with qualifications of Year 10 or below and certificate (95% Wald confidence interval of 1.6 and 8.1). For farmers with diploma and/or university qualifications, the odds ratio value of 6.1 indicates that they are 6.1 times more likely to respond that yes, they currently use a tool to measure pasture than farmers with qualifications of Year 10 or below and certificate (95% Wald confidence interval of 2.7 and 13.7).

There was a significant relationship between herd size and the current use of a tool to measure pasture ($\chi^2_1 = 19.8$, $p < 0.0001$). Further analysis produced an odds ratio of 1.5, indicating that as herd size increases by 100 cows, farms are 1.5 more likely to report that they currently use a tool to measure pasture (95% Wald confidence interval of 1.3 and 1.8). Milking area was also significantly positively related to the current use of a tool to measure pasture ($\chi^2_1 = 13.3$, $p < 0.01$). The odds ratio of 2.1 indicates that as milking area increases by 100 hectares, farms are 2.1 times more likely to report that they currently use a tool to measure pasture (95% Wald confidence interval of 1.4 and 3.1).

Attendance at general extension activities and attendance at a pasture specific activity both had a significant relationship with current use of a pasture measurement tool. Responses for attending general extension activities were grouped into yes and no categories, with those who chose once a year, two to four times a year, and more than four times a year group as 'yes', and 'never attended' as 'no'. Respondents who said they attend general extension activities were 3.44 times more likely to report that yes, they currently use a tool to measure pasture, than no ($\chi^2_1 = 5.2$, $p < 0.03$; 95% Wald confidence interval of 1.2 and 9.9).

The relationship between attendance at pasture specific activities and current use of a pasture measurement tool was significant (χ^2_1 = 7.0, p <0.03). Respondents who have attended an activity specifically focused on pasture management are 2.9 times more likely to report that yes, they currently use a tool to measure pasture, than no (95% Wald confidence intervals of 1.3 and 6.4). Forty-eight percent of total survey respondents answered that they currently use a tool to measure pasture. Of those who attend extension activities, 55% answered that they currently use a tool to measure pasture, of the respondents who currently use a tool, 43% have used a tool to measure pasture intensively in the past. Of the total survey population, 28.6% responded that they had been through a process using a tool to intensively measure pasture in the past.

Table 4.2. Explaining the current use of pasture measurement tools

Variable	**Description**	**χ^2 (P)**	**Odds Ratio**	**95% Wald Confidence Interval**
Age	Years	4.9 (0.295)		
Herd size	No. milking cows	19.8 (<0.0001)	1.5	1.3, 1.8
Milking area	Hectares	13.3 (0.003)	2.1	1.4, 3.1
Education	Year 11 and/or 12 and equivalent compared to Year 10 or below and Certificate	9.4 (0.002)	3.6	1.6, 8.1
Education	Diploma/university compared to Year 10 or below and Certificate	19.1 (<0.0001)	6.1	2.6, 13.7
Extension attendance	Yes or no	5.2 (0.022)	3.4	1.2, 9.9
Pasture specific activity	Yes or no	7.0 (0.008)	2.9	1.3, 6.4
Past tool use	Yes or no	30.6 (<0.0001)	10.1	4.4, 22.8
Past tool use	Intensive use or non-intensive use	7.2 (0.008)	3.4	1.4, 8.2

Discussion

In the past, farmers have readily adopted new technologies that have offered opportunities to increase production and income, for example biological innovations such as new seed varieties, chemical innovations including fertilisers and pesticides, animal innovations such as breeding and artificial insemination, and mechanical technology including tractors and harvesters (O'Neill 2010). Tools that have been developed to assist in measuring and managing pasture have generally not seen the same rate of adoption, with use of pasture measurement tools continuing to be limited (King et al. 2010; Eastwood et al. 2017). With the extent of information and technology available to farmers, it is plausible that technology is unlikely to be adopted of its own accord and merit, and it is important to recognise that different types of technology require more work and understanding in order to be adopted and used effectively, as they may be more complex or more knowledge intensive than other practices (Ingram 2008). There is an important role for extension and other support and information services, improved and better designed tools, in assisting in this process.

A major priority of extension in the Tasmanian dairy industry has been to promote and increase the knowledge, awareness and understanding of pasture management practices, with the aim of assisting farmers in increasing their skills and ability in pasture management and achieving a higher level of pasture consumption (Mann 2006; Irvine 2013). Various tools and technology and their application on farms have been developed with the aim of assisting farmers to improve their pasture management and pasture consumption. The use of pasture measurement tools as an important component of developing pasture management knowledge and skills has been encouraged through extension activities that include farmer discussion groups, field days, 2-day training sessions and longer-term projects involving facilitated incremental learning. The high level of engagement of Tasmanian dairy farmers in extension activities (86% in general activities and 76% in activities specifically focused on pasture management) reflects the consistent emphasis of publicly funded extension efforts on management of the pasture feedbase.

Results from this survey have found that participation in extension activities, both general extension activities and those focused specifically on pasture management, was associated with a greater likelihood of using tools to measure pasture. Fifty-one percent of farmers who had attended extension activities currently use a pasture measurement tool, compared with 23% of the farmers who have not attended extension activities. This supports findings of Rhoades and Booth (1982) who found farmer participation in extension practices such as discussion groups and on-farm trials strengthen the relevance and acceptance of research findings and their application at farm level.

Farmers who reported they had used a pasture measurement tool intensively in the past (for a period of 6 months or more) were six times more likely to have attended extension activities than to have not engaged. The relationship with past use and current use of a tool was also significant, and there was also a significant number of farmers who have used a tool intensively in the past and no longer do. A study by Turner and Irvine (2017) found that Tasmanian farmers who had been through a prior pasture management learning process, including an intensive period of measuring and monitoring pasture using a tool, developed their knowledge and skills to accurately assess pasture visually, thus reducing their reliance on the use of a tool (Turner & Irvine 2017). Eastwood and Kenny (2009) and Parker (1999) also noted this, with the use of tools by New Zealand farmers diminishing over time as farmers learn to calibrate visual assessments and outcomes with those derived from using a tool. The results of the current survey have informed farmer interviews that are exploring why some farmers have continued to use pasture measurement tools and others have not. Further study is also necessary to understand in greater depth how farmers use pasture management tools, what has facilitated the use of tools, and how these learnings and practices could be adapted and applied to others.

Despite the significant relationship observed between attending extension activities and current use of pasture measurement tools, some farmers have only 'tried them out' temporarily. While a high number of Tasmanian farmers have been motivated to buy plate meters (59%), 30% were found to use them for only a short period (6 months or less) and then discontinued use. It is important to gain a greater understanding about why some farmers intend to use a pasture management tool, often following participating in an extension activity, but do not continue using it past an initial trial. Survey results suggest that using pasture management tools more consistently (even if this has been in the past) is associated with increased confidence in decision-making (self-reported), and that the measurements assist in associated management practices like assessing pasture residuals and allocated supplements. Possible explanations for discontinued use of a tool, as proposed by Pannell et al. (2006), include challenges in applying information or data from measurements to an individual farmers' circumstances and decision making, and uncertainty about the benefits. Creighton et al. (2011) found that while farmers may be aware of research and its proposed benefits, such as the benefits of those practices promoted through extension, this does not necessarily lead to on-farm adoption. Farmers who displayed an interest in learning more about pasture management through engaging in some extension activities and purchasing or trying out a pasture measurement tool, but quickly discontinued using it, are of particular interest for further research. While it is possible that some farmers will have developed accurate visual assessments quickly, anecdotal evidence suggests that further supported learning may be required to assist farmers in gaining the full benefits of using measurement tools as well as understanding the associated biological principles underlying recommended pasture management practices. Different modes of extension delivery may well be needed to provide this supported learning, but their development must be based on sound social research that explores the how's and why's of the observed farmer behaviour.

The significant relationship identified in this survey between attending extension activities and current use of a tool suggests that farmers may have identified extension as a source of information in order to improve or enhance farm practices, such as using a tool to measure pasture to assist in improving pasture management and performance. One of the important aims of extension in the Tasmanian dairy industry has been to facilitate group learning and developing awareness, knowledge and implementation of practices. Kilpatrick and Johns (2003) reported that the social interaction such as that which occurs through group based extension and learning can assist in changing the attitudes and values of farmers, which can then present an opportunity for achieving behavioural change through targeting of information and programs (Wollni & Andersson 2014), and thus adoption. A study by Hansen (2015) found that the ability to understand and apply new knowledge and skills depends on the amount of existing related knowledge, with farmers who have received a higher level of education being more familiar with the concept and process of learning and applying that knowledge in practice. This supports the findings of this survey in that farmers with a higher level of education are more likely to attend extension activities, and were more likely to currently use a tool to measure pasture.

Level of education has been linked with knowledge seeking behaviour, with farmers who have received a higher level of education being more likely to seek out and participate in further learning opportunities than farmers who have received lower levels of education (Kilpatrick 1996; Kilpatrick & Johns 1999; Fulton et al. 2003). The significant relationship found in this survey between level of education and participation in extension activities supports these findings, suggesting that farmers with a higher level of education are more likely to seek further knowledge and development around pasture management, with extension providing an option for further learning. Education and training has been shown to assist farmers in making changes to their farming practice (Kilpatrick 1996). Several studies have demonstrated a relationship between farmer education and adoption, such as adoption of technology in the beef industry (Quinn, 1999, as cited in Fulton et al. 2003), and the increased likelihood of adoption of sustainable farming practices with increased education (Reeve & Black 1998). The significant relationship found in the current study, between the level of farmer education and participation in extension activities, and also the current use of tools to measure pasture, align with these findings. Further research is necessary, however, to explore whether there are gaps in current content and delivery of extension programs, and whether additional resources may be needed to meet the needs of farmers with a broader range of education levels and to address any possible future implications for extension such as policy and environment compliance.

Limitations

It is possible that those who completed and returned their surveys are more likely to have a positive view of TIA RD&E and represent more of the farming population that have participated in extension activities than is representative of actual engagement. This introduces a source of potential bias in the survey population, given that engagement in extension has been shown to be associated with a greater use of pasture management tools.

Conclusion

The challenge for extension providers is how to engage more farmers, and adapt extension content to a wider demographic, including those who are not currently engaged in extension. As noted by Vanclay (2004), farmers are not homogenous, and there exists a challenge for extension in not only catering for a wider demographic, but to do so in a way that caters for the application of principles to individual farmers' specific situation and needs (Wood et al. 2014; Rodriguez et al. 2009). The use of pasture measurement tools is viewed as an important component in the pasture management learning process by those in Tasmanian feedbase RD&E. This survey has identified the current and past use of pasture measurement tools, the extent of engagement of Tasmanian dairy farmers in extension activities and the farm and farmer-related factors associated with these behaviours. Further research is now being carried out to gain a greater understanding of the decision making underlying adoption and adaptation of pasture management tools in the pasture management learning process;

recognising that the consistent use of tools may not be necessary after farmers have gained new knowledge and skills that include accurate visual assessment of pasture. Farmers who have not engaged in extension activities, and those who have ‘tried out’ pasture measurement tools are of particular interest, and their stories may shed light on how the content and delivery of future extension efforts may be developed to better engage them in the pasture management learning process. As concluded by Kilpatrick (1996), there is no single way of best delivering education and training, but a variety of delivery methods and programs is required to meet different farmer needs and stages of learning. A deeper understanding of farmer attitudes towards both extension and technology, and the adoption and the decision-making processes will help inform the continued development of extension programs with the aim of achieving on-farm change.

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Chapter 5 – Understanding grazing decisions on Tasmanian dairy farms

This Chapter reports results of the first quantitative stage and Survey 1 as described in the Research Methods section of Chapter 3 – Research Methodology.

This Chapter has been published as a peer reviewed conference paper in the proceedings of the 22nd International Farm Management Congress, 2019. The published abstract is included below.

UNDERSTANDING GRAZING DECISIONS ON TASMANIAN DAIRY FARMS

Research and Extension Services

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ABSTRACT

Improving pasture utilisation on Tasmanian dairy farms is a key focus of research, development and extension programs, through increasing farmer awareness, knowledge and use of best practice pasture management practices. Recommended practices include using pasture management tools to provide objective information about pasture quantity, increasing control, flexibility and accuracy around pasture management decisions. A survey of 162 Tasmanian dairy farmers found large variation in tool use, and investigated the relationship between current tool use and key grazing management decisions. Key decisions include assessing pasture quantity (pre-grazing cover), grazing intensity (post-grazing residual), determining rotation length, and determining the level of non-pasture, supplementary feed required. There was a significant relationship between currently measuring pasture and using that information to assess pre and post-grazing cover, and decisions on rotation length ($P<0.05$). The relationship between currently measuring pasture and using that information to make decisions on supplement feeding was not significant. Using pasture measurement data can assist in increased accuracy in supplement allocation, with inaccurate allocation resulting in potential over-feeding, substitution of supplement for pasture, reduced pasture regrowth, quality and utilisation. Extension can increase farmer knowledge and understanding of how pasture measurement data can be used to make more informed grazing decisions, and subsequent increase pasture utilization, milk production and farm profitability.

Chapter 5 has been removed for copyright or proprietary reasons.

Chapter 6 – Understanding Tasmanian dairy farmer adoption of pasture management practices: A Theory of Planned Behaviour approach

This Chapter reports results of the second stage and qualitative interviews as described in the Research Methods section of Chapter 3 – Research Methodology.

This Chapter has been published online as a peer reviewed journal paper in the Animal Production Science journal (3rd May 2019). The published abstract is included below.

Understanding Tasmanian dairy farmer adoption of pasture management practices: A Theory of Planned Behaviour approach

Alison Hall , Lydia Turner , Sue Kilpatrick

Abstract

Improved pasture management and increased pasture utilisation are positively associated with dairy farm efficiency and profitability in Tasmania. Supporting dairy farmers in developing pasture management knowledge and skills has been a key priority for research, development and extension in the Tasmanian dairy industry. The role of extension has been to increase farmer awareness and knowledge of best practice pasture management and to facilitate farmer learning, focusing on training farmers to use pasture measurement tools. However, many farmers have never used a pasture measurement tool, only trialled/tested a tool, and/or do not implement recommended pasture management practices. This study aimed to identify and understand factors influencing pasture management decision making and behaviour for different farmer sub-groups. Qualitative data was obtained through semi-structured interviews with thirty Tasmanian dairy farmers. The Theory of Planned Behaviour (TPB) was used to identify and explore key factors influencing pasture management behaviour. There was a negative effect of social influence on pasture measurement tool use by experienced farmers, with many perceiving tool use to be for less experienced, younger farmers. This negative influence limited their intention to measure pasture and engage in the learning process required to overcome perceived control factors and change practices. Perceived control factors limiting behaviour change included tool data inaccuracy and challenging calculations associated with applying measurement data on-farm. This study demonstrates how the TPB can be used to identify and understand factors influencing adoption behaviour of Tasmanian dairy farmers, and assist in developing recommendations for future extension and pasture management programs.

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Introduction

Tasmanian context

Optimising pasture management and subsequent increase in pasture utilisation are positively associated with dairy farm efficiency and profitability in temperate climates (Dillon et al. 2005; Lane 2014). French et al. (2015) stated that, 'if profitability of grazing systems is driven by the degree of grass utilisation, which is in turn a function of both increased growth and optimum consumption of that growth, the accurate and timely measurement of pasture is integral to effecting grazing management practice'. Using tools such as a rising plate meter or CDAX bike reader to measure pasture provides farmers with objective information from which they can make decisions, gives increased control and flexibility around grazing decisions, and can assist in increasing pasture productivity while also increasing farmer knowledge, skills, and confidence (Turner & Irvine 2017; O'Donovan et al. 2002). As farmers learn about biological principles underlying recommended practices, using pasture measurement tools can train their eye to visually assess pasture growth and quantity with increased accuracy (Scrivner et al. 1986; Stockdale 1984). When these skills are combined with experience and existing farm knowledge, the need to continue using a pasture measurement tool may decrease (Turner & Irvine 2017). These recommended practices are knowledge intensive and require an understanding of the impacts of management practices on pasture performance, and how pasture measurement data can be incorporated into farm business and grazing management decision making. Incorporating pasture growth data in grazing management decisions can assist in substantially increasing farm income (Beukes et al. 2018).

Optimising pasture utilisation and improving pasture management practices has therefore been a key focus of research, development and extension (RD&E) programs in the Tasmanian dairy industry. Extension programs in particular have largely focused on increasing the awareness, knowledge and adoption of recommended pasture management practices, including use of pasture measurement tools (Mann 2006; Irvine 2013).

Despite focused RD&E efforts, average pasture utilisation on Australian and Tasmanian dairy farms is still well below potential (Tasmanian Institute of Agriculture 2017; Dairy Australia 2015). A study by Hall et al. (2017) found that 64% of Tasmanian dairy farmers own a pasture measurement tool, however only 48% percent currently use a tool to measure pasture, indicating significant variation exists in adoption and adaptation of these tools. Regular measuring and monitoring of pasture with a tool as part of an extended, intensive and supported learning process has been shown to be important for farmers to develop the knowledge, skills and ability to adopt and adapt practices for improved pasture management (Turner & Irvine 2017).

For further adoption and adaptation of pasture management tools and associated recommended practices, and improvement in pasture utilisation, it is necessary to understand what factors have influenced current pasture management practices on Tasmanian dairy farms. Identification and understanding of these factors and how they have influenced pasture management decision making and behaviour can then lead to the development of recommendations for future pasture management training that can assist in improving farmers pasture management knowledge, skills and ability.

Adoption and theoretical framework

Adoption is increasingly viewed as a social process, in which adoption behaviour is influenced by social factors such as characteristics of the person making the decisions (for example, attitude towards risk, attitude towards change, individual beliefs and values), and their social networks (e.g. social situation, family peers, and associated social norms) (Fujisaka 1994; Ghadim & Pannell 1999; Pannell et al. 2006). Adoption of new innovations and technology in agriculture has been a significant area of study (including, but not limited to, Marsh et al. 1995; Barr & Cary 2000; Kaine 2004; Kuehne et al. 2017; Wauters & Mathijs 2010). Studies have predominately focused on what determines whether or not an innovation is adopted, characteristics of adopters versus non-adopters, and, if adoption occurs, what determines diffusion of the innovation through a population (Ghadim &

Pannell 1999; Marsh et al. 1995; Barr & Cary 2000; Wauters & Mathijs 2010). However, there have been very few studies that have approached the issue of limited adoption of recommended practices through understanding the farmer decision making processes. Adoption of technology and progression from knowledge to implementation involves a number of stages, with a range of factors influencing adoption and practice implementation (Wilkinson 2011). In some cases, farmers may adapt how they use technology or practices to fit within their farm management. Adaptation typically follows adoption, as farmers develop knowledge and understanding of how they can adapt technology use to suit their farm.

Adoption models such as the Theory of Planned Behaviour (TPB) (Ajzen 1991; Fishbein & Ajzen 2011), technology transfer model (Gibson & Smilor 1991; Rogers 2003), consumer behaviour theory (Assael 1988), and diffusion of innovations (Rogers 2003), have been proposed to assist in explaining and predicting adoption behaviour. According to the well-known diffusion of innovations model, once innovators and early adopters change practices, diffusion (involving naturally occurring knowledge transfer) will occur, leading to widespread adoption by remaining farmer segments (Rogers 2003). However, farmer to farmer knowledge transfer is limited when innovations involve adoption of knowledge intensive practices that require a greater degree of supported farmer learning and skill development (Ingram 2008). The TPB has been used extensively to understand the context of decision making and identify motivational factors involved in a range of disciplines: health (Conner et al. 2003; Bränström et al. 2004; Barberia et al. 2008); marketing and consumer behaviour (Lobb et al. 2007; Arvola et al. 2008); and agriculture, natural resource management and conservation (Beedell & Rehman 1999; Trumbo et al. 2001; Fielding et al. 2005; Bond et al. 2009).

This qualitative study draws on the Theory of Planned Behaviour (TPB) and its constructs to explore in greater depth why adoption and non-adoption of pasture management tools and recommended practices are occurring, and what factors are influencing the adoption process. The TPB has been used to analyse what and how factors impact farmer decision making and adoption behaviour.

The TPB was designed to predict and explain human behaviour in specific contexts, and examines the relationship between an individual's attitudes (beliefs, intentions and behaviours) and their actions (Ajzen 1991; Fishbein & Ajzen 2011) (see Fig 6.1).

A central component of the TPB is intention to perform a given behaviour (Ajzen 1991; Fishbein & Ajzen 2011). The TPB integrates the role of attitudes and how they influence adoption behaviour. The TPB assumes that individuals' actions are within their own control, and are largely based on their attitudes or beliefs related to an outcome of a behaviour or goal (Fishbein & Ajzen 2011). Behaviour can be predicted through identifying knowledge, attitudes and the desired outcome (Fishbein & Ajzen 2011). The TPB was further developed with the introduction of beliefs and how they guide behaviour. Behavioural beliefs, normative beliefs and control beliefs influence intention, with actual control influencing subsequent behaviour (Ajzen 1991; Fishbein & Ajzen 2011). Behavioural beliefs are about consequence of the behaviour (positive or negative); normative beliefs are about their social norms; control beliefs are about the presence of perceived factors that may facilitate or restrict a behaviour (Ajzen 2002). It is proposed in the TPB that if individuals have a positive attitude towards a behaviour along with positive intentions, given sufficient actual control behaviour will occur (Ajzen 1991; Fishbein & Ajzen 2011).

The TPB considers that intentions to behave in a particular way (in this case, the intention to implement recommended pasture management tools and practices) is guided through three main belief areas. The first is the degree to which the outcome of a behaviour is believed to be mainly positive or negative (attitude); the second is the positive or negative influence of social pressure associated with the new behaviour (social influences); and the third is the individual's perceived capability to perform the behaviour (perceived control) (Ajzen 1991). While attitudes, social influence and perceived control factors may interact to influence intentions, actual control factors that are outside the person's control also act to support or limit subsequent behaviour change (Ajzen 1991).

There is increasing acknowledgement in agricultural literature that an individual’s behaviour is connected to their attitudes and beliefs towards that behaviour (Blackwell et al. 2006; Guerin & Guerin 1994; Vanclay & Lawrence 1994). However, the TPB is not without its criticisms or limitations. Several studies have found intention to be an inconsistent predictor of behaviour, with an increasing number of events changing or influencing individuals beliefs, attitudes, subjective norms and perceptions of control (Kor & Mullan 2011). Specific to agriculture, studies have suggested the TPB is insufficient in accounting for the complexity of factors that influence decision making and behaviour, but does provide a groundwork for further investigation (Beedell & Rehman 1999; Burton 2004). A review of the TPB by Ajzen (2011) found that studies suggested that the TPB is too rational in its approach, and doesn’t account sufficiently for cognitive and affective processes known to bias behaviour. However, the TPB does not assume that behavioural, normative or control beliefs are formed in a rational or unbiased manner, and they may be based on inaccurate or incomplete information (Ajzen 2011). Regardless of how individuals arrive at their beliefs, individuals attitudes, intention and behaviours are produced in a consistent manner with these beliefs (Geraerts et al. 2008; Ajzen 2011). Despite these criticisms, studies have supported the use of the TPB with increasing acknowledgement that an individual’s behaviour is connected to their attitudes and beliefs towards that behaviour (Guerin & Guerin 1994; Ajzen 2011; Vanclay & Lawrence 1994; Blackwell et al. 2006; Bond et al. 2009).

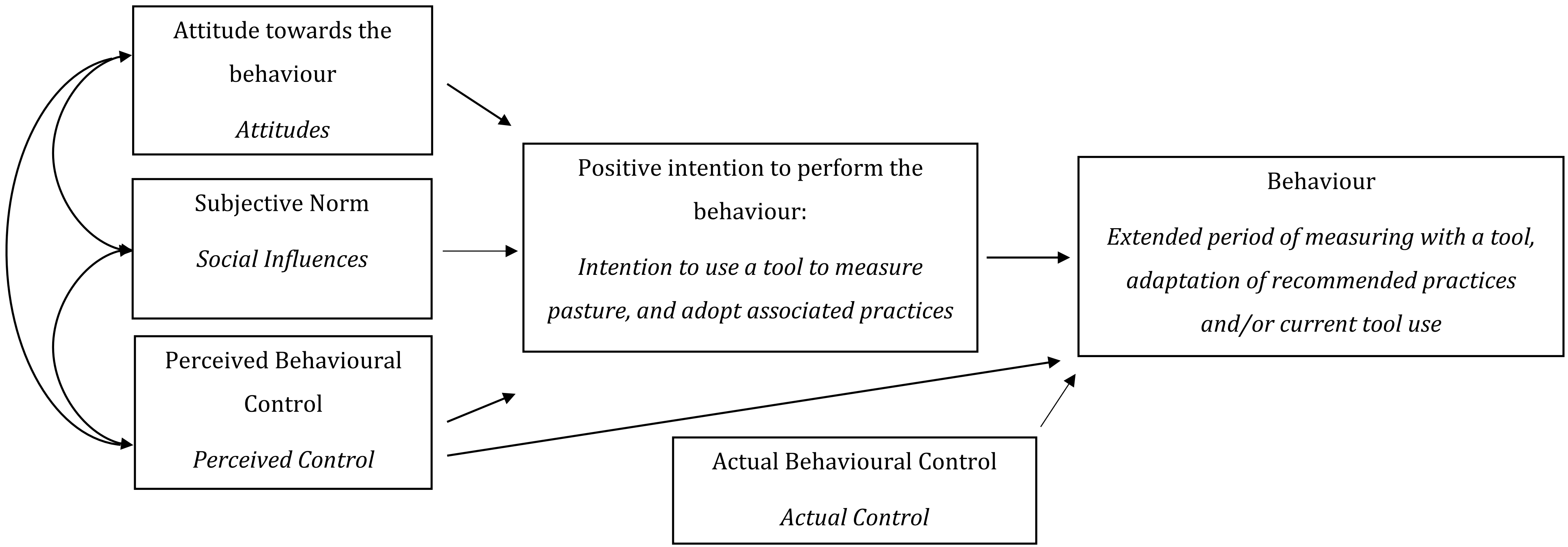

Figure 6.1. Theory of Planned Behaviour conceptual diagram, adapted from Ajzen (1991).

Previous studies using the TPB have typically employed a quantitative approach (Bond et al. 2009; Arvola et al. 2008; Lobb et al. 2007; Fielding et al. 2005; Trumbo et al. 2001), and were mainly concerned with quantifying the relative influence of known factors affecting behaviour. Such studies are concerned with identifying and quantifying factors likely to influence behaviour, and do not explore how and why these factors influence the decision making, or assist in explaining why the behaviour of interest has or has not occurred (Renzi & Klobas 2008). A qualitative approach based on the TPB can be used to reveal unknown factors influencing behaviour, and to explore how and why these factors are influential (Renzi & Klobas 2008). This qualitative application of the TPB can contribute to interpreting results and finding new and additional meanings (Kauppinen et al. 2010; Alasuutari 1995). Considering the complexity associated with pasture management adoption decision making by farmers, in-depth interviews were required to gain a greater understanding of how social factors influence behaviour. The TPB constructs were used in designing the interview framework to identify what factors influence farmer decision making and use of pasture measurement tools and practices, and understanding how attitudes, social influences and perceived control factors impact farmer behaviour.

Methods

This study aimed to identify and understand factors influencing pasture management decision making and behaviour for Tasmanian dairy farmers. This qualitative study drew on findings of a recent survey that identified past and current use of pasture measurement tools by Tasmanian dairy farmers. The paper based, quantitative survey was mailed to all 440 dairy farmers in Tasmania, with a return rate of 38%. Findings from this survey are reported in Hall et al. (2017). The current study involved semi-structured interviews with a sub selection of survey participants, which discussed pasture management (current and past), sources of information and learning, and factors influencing decision making around adoption and implementation of pasture management practices.

Some participants in the preceding survey voluntarily provided permission to be contacted about participating in follow-up interviews. These farmers were categorised into three sub-groups based on their responses to key questions about their pasture management practices, with the aim to recruit equal numbers of farmers within each sub-group for interviews. Farmers were categorised into sub-groups based on their past and current use of pasture measurement tools, which identified extent of previous use and intention to adopt, along with behaviour changed observed, In addition, level of engagement with extension activities was included due to the positive relationship between extension engagement and use of pasture measurement tools (Hall et al. 2017), and recognition of the role of extension in the pasture management learning process (Table 6.1).

Use of a pasture measurement tool by farmers was separated into four categories – non-use, where farmers had never used a tool to measure pasture; trialling, where farmers had only tested or tried out a tool on a once-off or short-term basis (that is. used for a short period of time); non-intensive-use, where farmers had used a tool to measure on a regular basis (weekly to fortnightly) for a period of six months or less, or only measured at certain times of the year (e.g. spring); and intensive use, where farmers had measured on a regular basis for an extended period, being six months or longer. Farmers were categorised based on past and current extent of use of a tool to measure pasture, according to these groupings.

Table 6.1. Sub-group categories and their characteristics

Sub-groups	No. farmers surveyed*	No. farmers interviewed	Engaged in extension	Tool owned	Tool trialled**	Tool used intensively***	Tool used currently	Intention to adopt	Practice change observed
Non-users	11	8	✗	✗(3) ✓(5)	✗(3) ✓(5)	✗	✗	✗	✗
Triallers	14	12	✓	✗(5)✓(7)	✓	✗	✗	✓	✗
Adapters	38	10							
Temporary intensive users	6	5	✓	✗(2) ✓(3)	✓	✓	✗	✓	✓
Continued users	32	5	✓	✓	✓	✓	✓	✓	✓

*No. farmers surveyed corresponds to the number of farmers who completed a survey and provided their contact details, indicating their permission to be contact regarding a follow-up interview.

**Tool trialled is testing or trialling a pasture measurement tool on a once off basis.

***Tool used intensively is using a tool to measure pasture weekly to fortnightly for a period of six months or longer.

✗ = no, ✓ = yes

The Non-users sub-group included farmers who had never used a pasture measurement tool or had only trialled a tool. The Triallers included farmers who have trialled a tool or used a tool non-intensively, indicating an intention to adopt but not the continued use required to signify practice change. To differentiate farmers who have trialled a tool as either Non-users or Triallers, engagement with extension activities was considered. Non-users are not engaged with extension, whereas Triallers are engaged, further indicating a positive intention to adopt the use of pasture measurement tools and an openness and willingness to learning new practices. Farmers in the Non-user sub-group have not started out on, or engaged with, a pasture management learning process. Farmers in the Triallers sub-group have started out on a pasture management learning process, trialling a tool or using for a short period of time but discontinuing, indicating they are unlikely to have developed their knowledge and skills to the level necessary for behaviour and practice change. In contrast, Adapters have used a tool on an intensive basis, and some continue to use this tool. Using a tool to measure pasture for an extended period indicates the Adapters have changed their behaviour so that pasture management now involves a more quantitative decision-making approach, whether they currently measure (continued intensive users sub-group, or subset) or not (temporary intensive users sub-group, or subset). Incorporating a quantitative approach and adapting pasture management practices accordingly requires a high level of understanding of the technology and/or practice, a range of additional information and knowledge, and an improvement of farmers' technical and managerial skills (Byerlee 1987). Such a level of understanding of pasture measurement tools and associated practices is most likely to come from an intensive period of using a tool to measure pasture, learning about how the tool works, what information it can provide, and how this can be implemented on-farm. Adapters who have discontinued using a pasture measurement tool have been through a sufficient period of measuring to be able to adapt principles learnt to their situation, through merging existing knowledge and experience with new knowledge (Flor et al. 2016), that has been learnt through an intensive period of measuring (Turner and Irvine, 2017).

Respondents for each sub-group were randomly ordered in Excel and contacted by the interviewer to confirm further participation. Thirty one-on-one interviews took place face-to-face over a three-month period, conducted by one interviewer. Interviews were 60-90 minutes in duration, following the same interview structure, including 'prompts' to elicit fuller responses from participants when required. The qualitative approach allowed for in depth discussion and freedom in exploring details brought up by participants in relation to questions asked. All interviews were digitally audio-recorded with participants' permission, and transcribed verbatim into word documents.

Interview questions were developed using the TPB constructs to explore factors influencing intention to adopt pasture measurement and management practices, and subsequent changes in behaviour. To explore farmer attitudes towards pasture management, participants were asked about the advantages and disadvantages of using a tool to measure pasture. Questions were aligned with perceived control factors by focusing on what made it more easy or difficult to implement recommendations, or encouraged or discouraged farmers from measuring pasture. Social influences were identified by asking questions about the role of people and institutions (family, other farmers, industry bodies and experts) in their decision making around measuring and managing pasture.

Interviews were conducted with farmers from each of the three main sub-groups. The TPB was used to identify and explore factors influencing pasture management practices of farmers in these sub-groups, to understand how factors vary between different groups of farmers. Understanding how these factors vary in their influence aids in the development of recommendations for future pasture management training provided by extension services, aimed to assist farmers in increasing their pasture utilisation and moving through these sub-groups (from Non-users towards Adapters).

Qualitative data analysis

Coding and analysis of interviews was performed using NVivo 11 Computer-Assisted Qualitative Data Analysis Software (CAQDAS) (Bazeley & Jackson 2013). Two main activities were initially conducted in NVivo: set up of the node tree, and preparation of a coding framework based on literature reviewed for the study. A node in NVivo is an object that represents an idea, theory of characteristics associated with data contained in a document. Nodes are linked in a hierarchical way to form a node tree. Initially, nodes were established that followed the structure of the interview guide, and then further broken into categories under each of the interview segments. The first four interviews were coded in this manner and discussed with the research team, before the remaining 26 interviews were coded. As the nodes reflected elements included in the interview schedule in addition to the TPB, most coding involved identification of sections of text that referred to these elements, and coding under the respective nodes. A response or section of text may refer to one or several elements or concepts. While the coder was alert for additional themes or codes that may have emerged from the data, none were apparent. Word frequency and search functions of NVivo were then used to identify common responses and themes within the participants' responses. The coding framework, themes, and identification and allocation of participants' responses was discussed with the research team to ensure a consistent approach.

Results and Discussion

Attitudes towards pasture management

In the Tasmanian dairy industry, pasture is an invaluable farm resource as it is the cheapest available feed source for dairy cows (Rawnsley et al. 2012; Chapman et al. 2009). Regardless of the extent of best practice adoption among farmers in this study, the benefits of measuring and managing pasture well were recognised across the three farmer sub-groups. Seventy-five percent of Non-users, 83% of Triallers and 100% of Adapters mentioned one or more advantages of using a tool to measure pasture, indicating a positive attitude. Benefits of using a tool to measure pasture cited included learning how to visually assess pasture quantity, and how to allocate feed to cows. A Trialler farmer noted this, commenting:

> 'It (measuring pasture) has helped me get to know the farm better…it just helps to put a more accurate figure to how much I'm feeding the cows (T12)'.

An Adapter farmer noted this, commenting:

> 'The advantage is knowing your farm. Knowing if you thought there was enough grass in there for the cows and there wasn't, or vice versa. Just getting to know your farm and how it responds at different times of the year (A28)'.

Non-user farmers recognised there was some value in measuring pasture, but the majority had not incorporated using a measurement tool into their pasture management. A Non-user demonstrated this, commenting:

> 'It gives you a better idea than what visually does…it's a bit more accurate (N5)'.

Farmers in the Triallers and Adapters sub-groups also noted the benefit of increased confidence in decision making that using a tool to measure pasture provided. An Adapter farmer noted that this confident decision making related to both pasture allocation and pasture conservation; both practices that directly influence dairy farm efficiency. The farmer describes how he:

> '(feels) more confident in knowing what is in a paddock, and what is left in a paddock…now I've got more confidence that I can drop more (paddocks) out (A21)'.

Another Adapter farmer mentioned the advantage of measuring pasture in terms of increased confidence in making important management decisions when there is surplus feed to be utilised, commenting:

> 'The biggest advantage you'll always have is to get a handle on what's coming up for the next week…in spring especially, you can make those decisions pretty quickly (A27)'.

Previous research by Turner and Irvine (2017) confirms that farmer confidence increases through the use of pasture measurement tools for an extended period of time. Using a tool to measure pasture is a quick and effective way to provide farmers with objective, quantitative data on which they can make decisions on pasture management, which has a greater level of accuracy than visual assessment (O'Donovan et al. 2002; Scrivner et al. 1986; Stockdale 1984). Dairy farmers tend to alternate between using such quantitative approaches, and more informal, experience-based approaches (Gray 2001; Öhlmér et al. 1998). They often take a quantitative approach such as measuring with a tool as a means of self-validation (Eastwood & Kenny 2009). Intensive use of pasture measurement tools through an extended learning process provided the opportunity for the Adapters in this study to make connections between evidence based ideas and their own experience, which Sewell et al. (2014) describe as the key to supporting farmer learning and adoption. Such extended learning processes focused on pasture management have recently been re-introduced through extension programs in the Tasmanian dairy industry.

Farmers in the Triallers sub-group also largely rely on visual assessment of pasture; with many feeling they have validated their approach after only a short period of measuring. However, they have not continued through a pasture management learning process involving an intensive period of measuring pasture using a tool. They are therefore unlikely to have developed their skills to visually assess pasture with a greater level of accuracy or gained an adequate understanding of the associated biological principles and calculations. They may therefore not be aware of the additional benefits of increased accuracy in pasture assessment. Farmers in the Non-users sub-group are likely to be able to make even greater improvements in their pasture management, as many have not started the pasture management learning process. These farmers are not aware they are missing out on added value and could be referred to as 'unconsciously incompetent' (Howell 1982). When individuals are unconsciously incompetent they are unaware they are not performing, or are unable to perform an activity (in this case, measuring pasture as part of advanced grazing management practices), or do not recognise there is a deficit in their management (Howell 1982; Thomson et al. 2006).

Although the Triallers have a positive attitude towards measuring pasture, it is not enough to motivate them to return to this practice as they believe that they have sufficient knowledge and experience in this area, and do not need the extra information. This was evidenced by one Trialler farmer who, despite recognising the value in measuring pasture, chose not to pursue this practice:

> 'It'd (measuring pasture) give you a more accurate knowledge of what is there. Yeah, it's probably something I should be doing, but I've chosen not to (T11)'.

This is also the case for the Non-user farmers, with many of them indicating they are aware of the benefits of using a tool to measure pasture, despite never having used a tool to measure pasture, or having tried briefly and discontinued. One Non-user who has never used a tool, when asked if there were any advantages of measuring pasture, commented:

> 'Oh definitely, on yes…they are more on top of it (N3)'.

If Non-user farmers have never used a tool to measure pasture, then they are likely to feel that they have gained these skills from elsewhere, are satisfied with their current knowledge and management ability, and have not been motivated or encouraged to look for further information or skills. Most farmers interviewed in this study believed that measuring pasture with a tool has positive benefits, and for many this translated into the intention to adopt – observed through the purchase and/or trialling of a pasture plate meter. Seventy-five percent of Non-users, 100% of Triallers and 100% of Adapters had trialled or tested a tool. With only the Adapters going on to display the related adoption behaviours, it is clear that other TPB factors strongly affected farmer decision making and behaviour beyond positive intentions.

Social Influences

A common belief and social perception held by interviewees was that younger and less experienced farmers require pasture management training, but not older or more experienced farmers. This was particularly evident among Triallers, with farmers recognising the value measuring pasture offers for less experienced, new or young farmers, but not seeing that measuring offers further value to themselves, regarding themselves as experienced farmers. Measuring pasture was an activity Triallers would only revisit if they were training a new or young person on the farm. A Trialler noted this, commenting:

> 'It is the quickest way to teach them about growing grass (T15)'.

Another commented:

> 'For somebody new it is very important…and for somebody who hasn't had the experience, if I set up a new person who didn't have experience on farm that would be one of the first things they'd have to learn (T9)'.

A farmer from the Non-users sub-group also mentioned this, commenting:

> 'Those that are share-farming or younger farmers, you know it can help, because they still haven't got the experience of knowing how many mouthfuls each of their cows is going to eat (N8)'.

This negative social influence on farmers' intention to measure pasture is reflected in the findings of Craigie (2013), who found in a previous study of Tasmanian dairy farmers that younger farmers were more likely to use a tool to measure pasture and implement best practice management recommendations. This negative social influence has implications for future pasture management training offered through extension. For those farmers who have been through an intensive period of measuring and learning about pasture management practices, they may receive little additional benefit from further training. However, there are many cases where age and experience on-farm do not reflect the depth of skills and knowledge required to apply pasture management as a knowledge intensive process, particularly if this is new to them. Future training must work within social influenced impacting farmers pasture management decision making if social acceptance of this behaviour is to be created (Klerkx et al. 2010).

Social interaction and farmer to farmer learning is important when it comes to developing knowledge about the benefits of a technology or practice, and can influence intention of farmers to adopt a technology by reducing the level of uncertainty (Yu 2014; Kilpatrick & Johns 2003). Previous studies have found that farmers prefer more informal learning, including learning from peers and other farmers, industry experience, and learning from their own experience and observations in a practical setting (Black 2000; Kilpatrick & Johns 1999; Bamberry et al. 1997). Farmers in this study reported that they generally prefer learning from other farmers in a practical, on-farm setting, in addition to learning from an expert. The majority of Triallers reported that their initial intention to measure pasture was influenced by other farmers or consultants and attending farmer discussion groups. One Trialler demonstrated this, commenting:

> 'You go out to some other farms, especially a good farm, and comparing what grass they've got, or quality, what milksolids they're doing. And you come home and think well can we do that, bring us up (T10)'.

Despite this positive influence, the knowledge intensive nature of adopting pasture management practices requires additional support, investment of time and expertise that other farmers alone can't always provide. Ongoing support such as continued pasture coaching or one-on-one advice and consulting is required to ensure sufficient, in depth knowledge and skills are developed over an extended period of time, and provide the necessary support to address challenges encountered (Turner & Irvine 2017; Ingram 2008). Despite being encouraged initially to measure pasture and not continuing, many Triallers farmers mentioned that they are no longer influenced by what other farmers do in terms of their pasture management.

Similarly, there were several Non-user farmers who noted that they were not influenced by pasture management practices of other farmers. When asked if they had been or were influenced by industry or other farmers with regards to pasture management practices, one Non-user commented:

> 'No, not really. If you're getting the best out of your ground at the cheapest price you can, that's the way of making money (N7)'.

This lack of social influence is consistent with the social perception that measuring pasture is an activity only for young or less experienced farmers. An extension strategy based on encouraging farmers in the Triallers sub-group to return to measuring pasture through demonstration of what others are doing is therefore likely to have limited impact. There is a need for farmers to realise that their pasture utilisation (and therefore farm profitability) is below potential if they are to see value in returning to measuring to improve their pasture management.

Perceived Control

Perceived control factors, or the perceived capability of an individual to measure pasture, can influence adoption at various stages. These include the intention of farmers to commence measuring pasture, continue measuring for an extended period (adoption), in addition to adapting measuring and management practices on-farm (practice change).

A previous study conducted within the Tasmanian dairy industry suggested that one factor limiting use of pasture measurement tools was lack of available time (Craigie 2013). In contrast, most farmers in this study did not discuss time as a major factor limiting use of pasture measurement tools. Just 25% of Non-users, 25% of Triallers and 30% of Adapters discussed limited time as a contributing factor to not measuring pasture, in combination with the physical effort required. A further two farmers, one each from the Triallers and Adapters, noted the effort required as a factor impacting on measuring pasture, but had adapted best practice recommendations to account for this. Their adaptations involved dividing the number of paddocks to be measured between two people, or measuring a smaller number of paddocks to give a general approximation of pasture quantity.

Fifty percent of Triallers identified lack of accuracy of pasture measurement tools as a reason they discontinued measuring pasture. These farmers intended to measure pasture (as evidenced by their acquisition of a tool and initial use) but encountered difficulties when the tool did not perform as expected. One Trialler commented:

> 'They (plate meters) aren't accurate, and actually being blindfolded you can walk over a paddock three times and take three different readings (T13)'.

While pasture measurement tools, such as the plate meter, are not completely accurate, the additional operational difficulties encountered may have been overcome with support from ongoing extension sessions, coaching or consultancy advice, until they could use the tool confidently and effectively. It is likely that the Triallers initially believed they could use pasture measurement tools successfully after engaging briefly in extension activities (e.g. a two-day course), but the challenges associated with using the pasture measurement tool as part of a more complex grazing management approach acted to reduce their perceived control, and therefore constrained practice change. One-off extension sessions can create awareness about improving pasture management, and positively influence intentions to change practices, but are unlikely to support farmers in developing sufficient knowledge and skills needed to measure and manage pasture well. In contrast, ongoing support and training allows farmers to increase their perceived control, ask questions, address challenges and solve problems over time (Turner & Irvine 2017).

Several Adapter farmers also discussed plate meter inaccuracy as a negative factor influencing other farmers' intention to measure pasture, but had continued to measure themselves. One Adapter described how he had adapted his approach, commenting:

> 'I don't use it as a hundred percent accurate figure. I just use it as a tool to manage it (pastures) (A22)'.

Unlike the Triallers, Adapters have been through an intensive learning period involving measuring with ongoing support from a consultant or coach, enabling them to develop their skills and ability in using pasture measurement tools and address challenges experienced. An Adapter farmer emphasised the importance of learning how to use a tool effectively, commenting:

> 'the disadvantage of the plate meter is how people use them. If you're not going to use it properly then don't use it at all (A29)'.

Eastwood and Kenny (2009) highlighted the importance of perception and accuracy in pasture measurement data in decision making, emphasising the role of certainty and consistency in farmer trust of data. Eastwood and Kenny (2009) went on to find a low level of trust results in farmers preferring to use their own visual assessments over data gathered using a more objective method. Consistent support and training over time assists farmers in using a tool to measure pasture with increased accuracy, with support provided to apply new knowledge and learning on an individual farm basis, for farmers to continue through the process of intention to practice change. Further education may be necessary in how pasture measurement tools and subsequent information can be used to reduce error, particularly for those who discontinued due to inaccuracies or uncertainty.

Twenty-five percent of farmers in the Triallers sub-group, and 12% in the Non-users, stated that the calculations associated with applying pasture measurement information negatively affected their intention to measure pasture, or their decision to continue measuring. For farmers with lower levels of literacy, or a disinterest in figures, undertaking the calculations associated with pasture management recommendations is particularly challenging, regardless of their positive attitude or intention to measure pasture. A previous study found a significant, positive relationship between level of formal education received and use of pasture measurement tools (Hall et al. 2017). A Trialler farmer discontinued measuring despite having positive intentions initially, due to the calculations involved, commenting:

> 'Probably the mathematics of working out was the biggest (challenge) (T12)'.

This was also the case for a Non-user farmer, whose initial positive intention to measure pasture was evident in purchase of a plate meter, but who did not continue with measuring. This farmer commented:

> 'The plate meter we have isn't an electronic one and I have to do all the sums. And math's has never been my strongest point (N6)'.

A lack of knowledge and skill development in how to use pasture measurement tools, and how to complete the necessary calculations to incorporate pasture measurements into on-farm management decisions, can block intentions leading to adoption behaviour. These findings indicate the potential for future pasture management programs to be developed to meet the needs of farmers who may not have the ability or desire to conduct calculations and use figures and objective data within the current pasture management programs.

Actual Control

Actual control factors are those factors outside an individual's control that can impact the ability to perform a behaviour, for example, if they are not in charge of decision making. Interviewed farmers were recruited based on their role as primary pasture managers, overseeing pasture management decisions. As such, no actual control factors were identified as impacting on the use of pasture measurement tools or implementation of practices. Using a tool to measure pasture involves little financial input or infrastructure development, but focuses on improving existing practices and efficiency through knowledge, skill development and implementation. The farmers interviewed were predominantly in roles where they were responsible for pasture management, and therefore had the ability to make changes and implement new, recommended practices. Regardless of intention to implement pasture management practices, practice change may be limited for those farmers who were not in a management role on-farm, if the support to do so did not exist, or they were not in charge of the pasture management decision making.

Conclusions and Recommendations

This study identified factors influencing Tasmanian dairy farmers' adoption and use of pasture measurement tools and associated management practices, and factors supporting or limiting subsequent practice change.

Based on results of a preceding survey on past and current practices, farmers were categorised into three sub-groups based on the previous and current extent of their pasture measurement and management practices and experiences. Understanding how factors influencing pasture management behaviour and decision making vary for different groups of farmers has significant implications for future pasture management training design and delivery.

Attitudes towards pasture measurement were predominately positive across the farmer sub-groups. Whether farmers were measuring pasture and implementing associated recommended management practices or not, they discussed wide-ranging benefits of measuring pasture. These include the ability to forward plan feed surpluses and deficits, increased confidence in pasture management and decision making, being able to make management decisions earlier, learning how to visually assess pasture quantity, assisting farmers new to the industry when initially learning about pasture management, and for training staff. This positive attitude towards measuring pasture was also represented in many farmers demonstrating a positive intention towards using a tool to measure pasture, especially evidenced in the Trialler and Adapter sub-groups through purchasing and/or trialling a tool. However, only the Adapter farmers who had been supported through an intensive period of using a pasture measurement tool and learning the underlying pasture management principles, had progressed from a positive intention to adoption, improved pasture management, and practice change.

The Triallers initially intended to measure pasture, but many discontinued when they experienced negative perceived control factors. These factors included perceived inaccuracies in plate meter measurements, and challenging calculations and interpretation of measurement data that form an important part of recommended practices. In addition, there was a strong perception that experienced farmers do not necessarily need to measure pasture or extension activities. This negative social norm limited Trialler farmers continued use of pasture measurement tools, and their re-engagement with extension activities focused on pasture management that could support them in continuing through the pasture management learning process.

However, it is also noted that there has been a widespread shift in the provision of government funding of Australian extension services, resulting in an absence of one-on-one extension provided through public agricultural extension. The provision of continued support necessary for farmers to develops knowledge intensive skills necessary for improved pasture management has not always been available through public extension services but provided through private consultants. Farmers who were motivated to start measuring pasture as a result of attending a pasture management course (e.g. a two-day workshop), have not necessarily had the option of participating in ongoing pasture management training or coaching through public extension services, limiting farmer options for participating in an extended pasture management learning process. Specific targeting and marketing of future pasture management training activities to farmers who see themselves as experienced, such as the Triallers, is required if they are to experience the benefits and value from re-engaging in an extended pasture management learning process involving additional measuring, ongoing support and training. Though there is a widespread recognition of the benefits of measuring pasture, ongoing support and training on-farm is needed to reap the additional value that revisiting measuring and monitoring pasture can offer. For

Non-users and Trialler farmers, this may require removing some of the focus on calculations for those who are discouraged by the calculations or literacy required, for those farmers lacking an educational component that may assist with this.

Understanding the factors that influence and/or limit the use of pasture measurement tools on-farm is required to design pasture management extension programs targeted towards farmers who are motivated by different sets of attitudes, social influences and capabilities. Identification and understanding of these motivating values, particularly for Non-user and Trialler farmers, is necessary if they are to be re-engaged in a pasture management learning process. Specific design and targeting of extension activities to address these influences, combined with the provision of ongoing support and training, are an important step towards further practice change and improving pasture management and utilisation on Tasmanian dairy farms.

Using the TPB in a qualitative interview design and analysis was an effective approach to identifying attitudes, social and control factors influencing Tasmanian dairy farmers' adoption of pasture measuring and management practices. Typically, studies using the TPB have taken a quantitative approach to predict the likelihood of a behaviour occurring. Using the TPB in a qualitative manner enabled a greater focus on understanding why factors influence behaviour, and how these may be addressed. Using the TPB enabled identification and greater understanding of what and why factors influenced behaviour of the three farmer sub-groups, and where these factors has the most influence. These insights play an important role in informing the design of future extension activities as a means of providing ongoing, supported pasture management training. Using the TPB enabled identification of preliminary recommendations that with further development can assist in addressing attitudinal, social and control factors limiting adoption of pasture measurement tools and management practices. However, it should be noted that a limitation of this study is that it is restricted to only thirty farmers (though a sufficient sample size), and that there may be additional groups of farmers and influencing factors that this study has not identified. There is a need for additional social research to explore these possibilities, and if these findings are to be applied to other farming populations. An additional limitation of the TPB is it may not be successful in identifying all factors that influence behaviour, such as affective processes or emotional responses experienced by farmers, and how farmers feel as a result of not performing the behaviour (in this case measuring pasture). Further social research could explore these factors to gain additional insights into how and why factors influence farmer adoption behaviour. The development of recommendations in this study have implications for developing future pasture management training activities if they are to be successful in engaging more farmers, helping move them through a pasture management learning process, and achieving a higher level of pasture utilisation.

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Chapter 7 – Using the Theory of Planned Behaviour framework to understand Tasmanian dairy farmer engagement with extension activities to inform future delivery

This Chapter reports results of the second stage and qualitative interviews as described in the Research Methods section of Chapter 3 – Research Methodology.

This Chapter has been published online as a peer reviewed journal paper in the Journal of Agricultural Education and Extension (1st February 2019). The published abstract is included below.

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Using the theory of planned behaviour framework to understand Tasmanian dairy farmer engagement with extension activities to inform future delivery

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ABSTRACT

Purpose: To identify and understand factors influencing farmers' decisions to engage with extension activities. To understand farmer segments and how these factors vary in order to develop recommendations for future extension delivery.

Methodology: Qualitative data was obtained through semi-structured interviews with 30 Tasmanian dairy farmers. The Theory of Planned Behaviour (TPB) framework was used to identify and explore factors influencing farmer engagement intentions and behaviour.

Findings: There was a negative effect of social influence on experienced farmers' intention to re-engage with extension, due to the belief extension activities were targeted to less experienced, younger farmers. Perceived control factors limiting engagement included lack of confidence about existing knowledge, resulting in farmers perceiving extension activities as confronting.

Practical implications: Key factors influencing intention to engage and continued engagement with extension were identified. These findings will inform future design and targeting of extension activities to improve initial and continued engagement. Subsequent recommendations are presented.

Theoretical implications: Previous TPB studies on adoption as an outcome of extension have typically focused on quantifying adoption predictions, rather than exploring how social factors interact and influence intentions and behaviours. This paper demonstrates how the TPB can be qualitatively applied to better understand farmer decision making, in this instance with respect to their initial and continued engagement with extension.

Originality/value: This paper demonstrates how the TPB can provide an evidence-based framework to qualitatively explore farmer intentions and behaviour. This approach has led to new insights into farmer decision making that will inform improvements in future extension development.

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Introduction

Agricultural extension enables change through building farmers' capability and capacity. Provision of information is facilitated to inform on-farm change, so practices become more sustainable and farms more profitable (Australasia Pacific Extension Network 2012; La Grange et al. 2010; Fulton et al. 2003). Extension programs frequently aim to speed up adoption rates or diffusion of ideas or practices (Barr & Cary 2000). Extension efforts have often focused on innovators and early adopters through activities such as field demonstrations and discussion groups - assuming information will diffuse through communication channels to later adopters (Wauters & Mathijs 2010; Rogers 1995). However, Wauters and Mathijs (2010) found this approach is not as effective in diffusing information as expected, with diffusion occurring at a very low rate or not at all. In addition, if adoption of new practices is limited within the group of innovators and early adopters, then the likelihood of on-farm practice change diffusing through a population is further reduced. For extension to lead to adoption of practices or recommendations, extension providers require a greater understanding of how farmers make decisions, and what factors influence their choice to engage with extension activities. This understanding will allow extension to work within the context of different farmer segments in order to encourage engagement and communicate effectively to achieve greater practice change (Turner et al. 2017).

Like learning, adoption and practice change as an outcome of extension is increasingly being viewed as a social process, influenced by a combination of personal, environmental and social factors (Wauters & Mathijs 2010; Pannell et al. 2006). Without a supported learning process, farmers are less likely to develop the knowledge and skills required to adopt knowledge-intensive practices (Turner & Irvine 2017).

Just as there are a range of social and physical factors that influence decision making, adoption and on-farm change, a range of factors impact on engagement with extension activities. Previous studies have suggested these include individual characteristics such as education, social networks, farm business characteristics, and nature of the activity and learning environment (Fulton et al. 2003). Agricultural extension uses a range of activities and approaches, as a variety of delivery methods and training programs is necessary to cater to individual preferences (Kilpatrick 1996). Wauters and Mathijs (2010) suggest that analyses of farmers' attitudes, beliefs and social environment would be valuable in targeting information and communication in order to benefit extension efforts.

Studies on adoption and associated behaviour change have focused largely on characteristics of adopters versus non-adopters, what determines whether a practice or innovation is adopted, and the factors influencing its diffusion through a population (Ghadim & Pannell 1999; Marsh et al. 1995). Such studies have used several models, such as Theory of Planned Behaviour and diffusion of innovations, as a basis for predicting adoption and outlining the stages of decision making involved. The same analysis could be applied to the decision making involved in farmers' choice to engage with extension activities, both initial engagement and continued engagement.

The Tasmanian dairy industry relies on pasture based systems, where improved pasture management and subsequent increased pasture production and utilisation are positively associated with dairy farm efficiency and profitability (Lane 2014; Dillon et al. 2005). A key focus for research, development and extension (RD&E) has therefore been to increase implementation of pasture management practices through supporting the development of farmer knowledge, skills and confidence. Pasture management practices are knowledge intensive and farmers require continued support as they learn to implement and adapt them (Turner and Irvine 2017). An extended, facilitative approach is more effective than single training sessions when learning to implement knowledge intensive practices, as it encourages farmers to work collaboratively to solve problems, address challenges, develop skills and knowledge and adapt practices to suit farm management (Turner & Irvine 2017; Ingram 2008). Ongoing farmer discussion groups are examples of facilitated extension activities that provide the supportive environment for this learning to occur. However, farmer engagement with extension activities varies throughout Tasmania. While 61% of Tasmanian dairy farmers are currently engaged with extension (Hall et al. 2017), only 20% attend extension activities on a regular (four times a year or more) basis (Hall et al. 2019). This study aimed to identify and increase understanding of what factors influence initial and continued farmer engagement with extension activities within the Tasmanian dairy industry, to inform implications and opportunities for future extension program design and delivery.

Theoretical Framework

This qualitative study draws on the Theory of Planned Behaviour (TPB) and its constructs to explore the social factors influencing farmers' decisions regarding whether to engage in extension activities.

The TPB was designed to explain and predict human behaviour in specific contexts, and examines the relationship between an individual's attitudes (beliefs, intentions and behaviours) and their actions (Ajzen 1991; Fishbein & Ajzen 2011) (see Figure 7.1). A central element in the TPB is intention to perform a given behaviour (Ajzen 1991; Fishbein & Ajzen 2011). The TPB theoretical framework also integrates the role and influence of attitudes in adoption behaviour. The TPB, along with many other behavioural theories, assumes that individuals' actions are within their control, and are largely based on their attitudes or beliefs related to a particular goal or outcome of a behaviour (Fishbein & Ajzen 2011). Through identifying knowledge, attitudes and the desired goal or outcome, behaviour can be predicted (Ajzen 1991; Fishbein & Ajzen 2011). A further development to the TPB was the introduction of beliefs and how they guide behaviour. Behavioural beliefs, normative beliefs and control beliefs influence intention, in addition to actual control influencing subsequent behaviour (Ajzen 1991; Fishbein & Ajzen 2011). As described by Ajzen (2002), behavioural beliefs are about the consequence of the behaviour (negative or positive); normative beliefs are about their social norms, and control beliefs are those about the presence of perceived factors that may impede or facilitate a behaviour. The TPB proposed that if individuals have a positive attitude towards a behaviour, in addition to positive intentions, then given sufficient actual control behaviour will occur (Ajzen 1991; Fishbein & Ajzen 2011).

The TPB considers that intentions to behave in a particular way (in this case, intention to engage with or attend extension activities) are guided through three main belief areas. First, the degree to which the outcome of a behaviour is believed to be mainly positive or negative (attitude); second, the negative or positive influence of social pressure associated with the behaviour (social influences); and third, the perceived capability of an individual to perform the behaviour (perceived control) (Ajzen 1991). While attitudes, social influence and perceived control factors may interact to influence intentions positively, actual control factors outside the person's control also act to support or limit subsequent behaviour change (Ajzen 1991).

The TPB has been used extensively to understand the context of decision making and identify motivational factors involved in a range of disciplines: health (Barberia et al. 2008; Bränström et al. 2004); marketing and consumer behaviour (Arvola et al. 2008; Lobb et al. 2007); and agriculture, natural resource management and conservation (Bond et al. 2009; Fielding et al. 2005; Trumbo et al. 2001; Beedell & Rehman 1999). There is longstanding acknowledgement in agricultural literature that an individual's behaviour is connected to their attitudes and beliefs towards that behaviour (Blackwell et al. 2006; Guerin & Guerin 1994; Vanclay & Lawrence 1994).

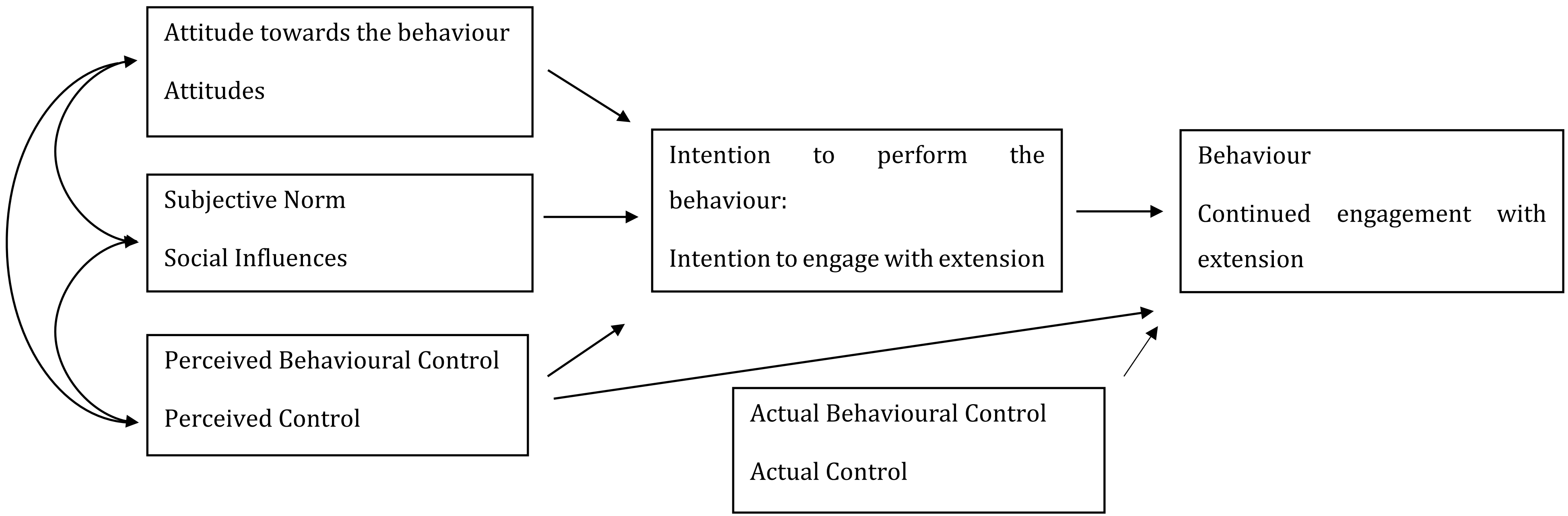

Figure 7.1. Theory of Planned Behaviour conceptual diagram, adapted from Ajzen (1991).

The TPB is not without its limitations and criticisms. Ogden (2003) argued that the TPB constructs were too general to be tested with high precision, making it difficult to reject the theory. Additional concerns include that many TPB studies use self-reporting to measure behaviour rather than objective measures, which introduces the potential of bias (Armitage & Conner 2001; Ogden 2003). Other studies have found intentions to be a poor predictor of behaviour, with an increasing number of events changing individuals beliefs, attitudes, subjective norms and perceptions of control (Ajzen 2011). In relation to agriculture, some studies have suggested that the TPB is insufficient in accounting for the complexities of factors that influence decision making and behaviour, but does provide a solid groundwork for further investigation (Beedell & Rehman 1999; Burton 2004). Another criticism of the TPB is that it is too rational in its approach, and does not account sufficiently for cognitive and affective (feelings and responses) processes that are known to bias human judgement and behaviour (Ajzen 2011). However, there is no assumption in the TPB that behavioural, normative and control beliefs are formed in a rational or unbiased manner, for example they may be based on inaccurate or incomplete information (Ajzen 2011). Regardless of how individuals arrive at their beliefs, even if they are based on inaccurate or biased information, individuals attitudes, intention and behaviours are produced from and in a consistent manner with these beliefs (Geraerts et al. 2008; Ajzen 2011). Despite criticisms of the TPB, studies have supported its use with an increasing acknowledgement that an individual's behaviour is connected to their attitudes and beliefs towards that behaviour (Guerin & Guerin 1994; Vanclay & Lawrence 1994; Blackwell et al. 2006; Bond et al. 2009).

Most previous agricultural studies using the TPB model employ a quantitative approach (Bond et al. 2009; Arvola et al. 2008; Lobb et al. 2007; Fielding et al. 2005; Trumbo et al. 2001), with few using qualitative methods that can expose why and how factors impact on behaviour (Renzi & Klobas 2008). Quantitative studies using the TPB typically predict factors likely to affect behaviour associated with attitudes towards the behaviour, social influences, and perceived control over performing the behaviour. While such studies are concerned with identifying and quantifying factors likely to influence behaviour, they do not explore in detail how and why these factors influence the decision making associated with intentions and practice change, or assist in explaining why or why not the behaviour of interest has occurred (Renzi & Klobas 2008). In light of the complexity associated with farmer engagement in extension activities, it was important to develop a more in-depth understanding of how these social factors interact to influence farmer intentions and behaviour.

Materials and Methods

This study used a qualitative approach to identify factors that impact farmer engagement with extension activities, within TPB constructs of attitudes, social influences and perceived control factors. In-depth interviews offered the flexibility needed to investigate this complex behaviour, enabling issues to be explored in greater detail as they are raised (Walter 2013).

The study drew directly on findings of a preceding survey that quantified Tasmanian dairy farmers' current engagement with extension activities, and their pasture management practices. The paper based, quantitative survey was mailed to 440 dairy farmers in Tasmania (representing the majority of the dairy farms in Tasmania), with a return rate of 38%. Findings from the survey are reported in (Hall et al. 2017). The current study involved semi-structured interviews with a sub selection of survey participants, to discuss factors influencing participants' engagement or non-engagement with extension activities, and their sources of information and learning.

Quantitative survey respondents who gave permission to be contacted for a follow-up interview were categorised into three sub-groups based primarily on their responses to key questions on their level of engagement with extension activities (Table 7.1). The characteristics of the following three sub-groups, focusing on engagement with extension, are presented in Table 1: Unengaged, Triallers and Adapters. The Unengaged sub-group were not currently engaged with extension, either never participating or participating once a year. The majority of the Triallers sub-group were actively engaged with extension, most attending two to four times a year. The Adapters sub-group were actively engaged with extension, the majority attending four times a year or more. The secondary factor for categorisation and naming of sub-groups was participants' past and current use of pasture measurement tools and practices, discussed in more detail in Hall et al. (in press). The approaches ranged from non-use or very limited use of tools and associated recommended practices by the Unengaged; tools trialled for a short period by the Triallers; and tools used for an extended period of time and confidently applied by the Adapters.

Potential interviewees for each sub-group were randomly ordered in Excel and contacted to confirm further participation and organise a meeting. One interviewer conducted 30 one-on-one face-to-face interviews over a four-month period from June to October 2017. Interviews were 60-90 minutes long, using a semi-structured interview guide that allowed for in depth discussion and freedom to explore points raised by participants in response to questions. Interviews were digitally audio-recorded with participants' permission and transcribed verbatim.

Interview questions were developed within the constructs of TPB to explore factors influencing both intention to engage in extension activities and continued engagement. To explore farmer attitudes towards extension, participants were asked about advantages and disadvantages of attending extension activities. Social influences were identified through questions about the role of people and institutions (family, other farmers, industry bodies and experts) in their decision or not to attend. Questions were aligned with perceived control factors by focusing on what made it easier or more difficult for participants, or what encouraged or discouraged them, from engaging with extension activities.

Table 7.1. Sub-groups categories and categorisations.

Sub-groups	No. farmers surveyed	No. farmers interviewed	Never attend extension activity	Engages in extension once a year	Engages in extension 2-4 times a year	Engages in extension >4 times a year	Ongoing intention to engage	Use of recommended pasture management practices
Unengaged	11	8	4	3	1	0	✗	✗
Triallers	14	12	0	2	7	3	✓	✗
Adapters	38	10	0	0	4	6	✓	✓

*No. farmers surveyed corresponds to the number of farmers who completed a survey and provided their contact details, indicating their permission to be contact regarding a follow-up interview.

✗ = no, ✓ = yes

Qualitative Data Analysis

Coding and analysis of interviews were performed using NVivo 11, Computer-Assisted Qualitative Data Analysis Software using a deductive, thematic approach (Bazeley & Jackson 2013; Walter 2013). The main activities initially conducted in NVivo were setting up a node tree, and preparing a coding framework, based on themes from the literature reviewed for the study. A node in NVivo is an object that represents an idea, theory or characteristics associated with data contained in a document. Nodes are linked in a hierarchical way to form a node tree. Nodes were established that followed the interview guide structure, and then further broken into categories under each of the interview segments. To address the criticism that thematic analysis can lack rigour, the first four interviews were coded in this manner and moderated within the research team, before the remaining interviews were coded. A deductive approach to thematic analysis, with a clear and concise process discussed within the research team, using constructs of a pre-existing behavioural theory assisted in developing a rigorous analysis and coding method. As nodes reflected elements included in the interview schedule in addition to the TPB, most coding involved identification of sections of text referring to these elements, and coding under respective nodes. A response or section of text may refer to one or several elements or concepts. While the coder was alert for additional themes or codes that may have emerged from the data, none were apparent. Word frequency and search functions of NVivo were used to identify common responses and themes within participants' responses. The coding framework, themes, identification and allocation of participants' responses were discussed within the research team to ensure a consistent approach. Results are presented in line with the TPB constructs.

The qualitative nature of this study means the researcher has been part of the research process, which can introduce potential for influence in the data collection. The researcher was aware of this, and every effort was made to avoid influencing data collection. Potential legitimation issues of making generalisations from a sample to a larger population, how accurately participants view is presented, as issues of the researcher being conceived in a position of power (Onwuegbuzie & Johnson 2006). This study was designed to address these by oversampling in the previous survey phase, and conducting sufficient interviews so similar themes and messages were being heard, and no new ones noted (Fusch & Ness 2015).

To address issues of credibility and trustworthiness, research notes were maintained throughout the interviews containing thoughts, feelings and emotions of the interview that could not be captured in the transcriptions alone. In addition, 30 interviews were conducted while looking for saturation, or until recurring themes were heard, and no new themes identified. However, the semi-structured nature of the interviews can be argued to have high validity as they allow the participants to talk in detail and explain meaning behind actions with little or no input from the interviewer (Tashakkori & Teddlie 2010). The use of qualitative, semi-structured interviews enabled triangulation, where the same question was able to be asked in multiple ways to uncover a greater representation of what is happening with individual participants and their choices, decisions and actions (Tashakkori & Teddlie 2010). Issues of validity, reliability, credibility and dependability were taken into consideration throughout data collection and analysis by maintaining a consistent approach to methods used, interview questions asked, and a consistent and detailed analytical approach (Shenton 2004).

Results

Attitudes towards engagement with extension activities

The overall attitude towards extension from farmers across all sub-groups was positive. Seventy-five percent of Unengaged, 83% of Triallers and 100% of Adapters mentioned one or several advantages of engaging with extension, indicating a positive attitude towards extension activities. Experiencing and observing what is happening on other farms in a practical setting was reported as one of the main advantages of attending extension activities by farmers in all sub-groups, including 63% of Unengaged farmers, 50% of Triallers and 30% of Adapters. This anticipated benefit was explained by farmers commenting:

> 'just getting on other people's farms…you'll pick up something good or bad (T16)' and, 'it was a lot better because it was on farm…it was more practical, because you're learning off another farmer and seeing what they're doing (T10)'.

An Adapter explained how attending extension activities had been valuable for his learning, commenting:

> 'pretty much everything I know now has been from those discussion groups and business groups, and mainly learning from other people (A21)'.

Eighty-three percent of Triallers stated there is always new knowledge to gain from attending any extension activity, if you are willing and open to learn. One believed that an individual's attitude underpinned how much they could learn from attending extension, commenting:

> 'it's all in your mindset, and my mindset…is you simply go with an open mind to learn something (T15)'. An Adapter also commented 'if you're interested you'll always learn something (A22)'.

Trialler and Adapter farmers found that learnings from attending extension went beyond the planned topic, often learning something not directly related. However, not all farmers shared this experience. While some farmers attend extension based on the assumption they learn something regardless of the planned topic, others will make the decision to attend based on consideration of the direct benefit they will gain. These farmers (50% of Unengaged, 33% of Triallers and 50% of Adapters) consider factors including whether the topic is specific to their farm, the type of activity (e.g. on or off farm), and facilitator knowledge and experience. An Unengaged farmer chose not to re-engage in extension after finding previous activities to be irrelevant to their farm, commenting:

> 'some (extension activities), it's a waste of time, I might as well be at home doing my own work (U1)'.

Perception of (limited) facilitator experience and knowledge was the most commonly mentioned factor discouraging engagement with extension by all sub-groups (25% of Unengaged, 25% of Triallers, 40% of Adapters). The facilitator must have the skills to communicate information to farmers, with one Adapter mentioning this as the reason they believed other farmers choose not to attend:

> 'I think it's the people that run them. You haven't got the quality of really good people that get the message across as well (A30)'. Other farmers placed emphasis on the facilitator needing to have practical, farming experience to be seen as credible, with one Unengaged farmer commenting 'sometimes you need farmers to talk to farmers…it's one thing to say about it but unless you're actively doing it, it doesn't encourage people (U6)'.

Social Influences

Farmers reported they prefer learning from other farmers in an on-farm environment, supplemented by an expert speaker. Sixty-three percent of Unengaged, 75% of Triallers and 100% of Adapters mentioned social interaction, farmer-to-farmer learning, and learning in a practical environment as benefits of extension, regardless of their extent of engagement. Thirteen percent of Unengaged, 42% of Triallers and 40% of Adapters farmers had been encouraged to attend extension activities, or attended, because other farmers did.

A common perception was that extension activities, particularly those focused on pasture management, are targeted at and designed for younger and less experienced farmers. Thirty-three percent of Triallers and 20% of Adapters held the belief that extension activities are not relevant for them as more experienced farmers. One Adapter commented:

> 'I noticed a lot of it is focused on younger people, and so sometimes I think it's for young people (A30)'.

One of the Triallers, after attending an activity, also felt that extension was not designed for older farmers with more experience, commenting:

> 'it was so evident that we were the old guard. Which is fine, that's how it should be. There should be young ones coming along (T15)'.

This negative social perception can result in farmers not re-engaging with extension, as they feel that socially they don't fit due to age and experience, or that they won't receive value from attending as the content is targeted towards less experienced farmers.

This negative social perception was also reflected in comments around the repetitiveness of extension activities, mentioned by 33% of Triallers and 10% of Adapters. One Trialler commented:

> 'There has to be something new for people to go, and they've got to feel like they're going to learn something from it. If it's going over the same things from year to year, and that's what the older people are probably (turned off) after a while (T13)'.

Another Trialler found extension activities on pasture management to be repetitive and not relevant to more experienced farmers, commenting:

> 'it's been done and done, overdone probably. Because a lot of them, they don't want to hear that now (T10)'.

Despite this, some farmers see value in attending for altruistic reasons, including helping those young or less experienced farmers. One Trialler summed this up, commenting:

> 'I don't get a lot of value in the general stuff. But then I do like the idea of trying to feed back into the younger people too (T13)'.

There are farmers that are not seeking to change their behaviour regardless of social influence. The Unengaged sub-group displayed these characteristics, often being satisfied with their current farming practices, not being influenced by what other farmers are doing, and therefore not seeing value in attending or engaging with extension activities. One Unengaged farmer vocalised this preference when describing himself:

> 'no, I never was somebody who went to other farms (U3)'.

Perceived Control

Farmers across the three sub-groups mentioned that attending extension activities can be confronting, finding that sharing their farm information in a group setting can be intimidating. Concern they may be asked questions they cannot answer, or not being able to provide adequate farm data, can lead to farmers believing they will be judged in extension settings, and this has a negative impact on their intention to engage. An Unengaged farmer noted how this influenced both initial intention to engage and continued engagement:

> Sometimes if they ask the figures and you don't know it…it's hard to get off farm and the days you put in an effort, you want to go, you want to see things, you want to learn things, and if somebody there makes you feel like a dill for asking a question or ridicules your idea or something like that, it gives you no desire to go back again really (U6).

However, continued, ongoing engagement can improve farmer knowledge and skills, and increase farmer confidence in managing their farm business. One Adapter had experienced this, and despite an initial perception that engaging with extension and sharing farm information was confronting, they had overcome this through continued involvement:

> I think a lot of people feel like they're going to be judged, might feel embarrassed or something…that's what I felt at first, I didn't want to say anything, I didn't want to tell them what we were doing...I was

> petrified, we had all these experienced farmers and I thought they were going to judge what we were doing (A21).

Another Adapter highlighted that confidence in attending extension activities and sharing information in extension activities increases over time and as relationships among peers are established:

> If I moved to the area and I just started working on someone's farm and I start going along to the open discussion group, I'm not going to feel comfortable in saying something…whereas now, you feel comfortable and everyone knows who you are (A24).

Actual Control

Actual control factors, as outlined in the TPB, are those factors outside an individual's control that impact on their ability to perform a behaviour, in this case whether they can attend an extension activity. Some farmers may have the positive intention to attend extension activities, but factors outside their control impact on actual engagement. One third of farmers, including the majority of Triallers, mentioned time as a major factor limiting engagement with extension. A reason for insufficient time to attend included factors such as losing a staff member, resulting in increased workload. If events are run during busy periods such as calving, farmers are likely to have conflicting commitments that impact their ability to attend extension activities.

Discussion

Using the constructs of the TPB identified a number of factors that impact both positively and negatively on farmers' engagement with extension. Through focusing on understanding attitudes, this study found that overall farmers have a positive view and attitude towards extension activities regardless of their level of engagement. Farmers believe they will learn new information through attending activities by interacting with farmers in an on-farm setting, facilitated through extension. This supports previous studies that have found farmers prefer to learn from other farmers in a contextualised, practical setting (Kilpatrick & Johns 2003; Kilpatrick & Rosenblatt 1998).

A study by Wood et al. (2014) found that many farmers prefer to learn about a practice that can be applied directly to their individual farm, and are less interested in engaging with activities focused on general information. Wood et al. (2014) reported that farmers preferred learning that was property specific, as farmers could compare and contrast examples with their own farm, especially if it was the same land type or area. This study supports these findings, with 47% of all respondents reporting that a benefit of extension is experiencing and observing what is happening in a practical, on-farm setting. Although some farmers will attend extension regardless of the planned topic, others will assess the direct relevance of the topic to their farm and consider the potential benefits before deciding to attend, regardless of a positive attitude towards extension. If these farmers consider the content or topic of extension activities is not specific to their farm, or the facilitator is lacking knowledge and experience, they can develop the belief that they will not receive value from attending. This negative attitude limits their intention to engage or re-engage in extension activities that are provided.

As described by the TPB, an individual's attitude towards a behaviour is largely determined by that individual's assessment of whether the outcome of that behaviour is negative or positive (Fishbein & Ajzen 2011). Using the TPB, this study revealed additional attitudes that can constrain farmer engagement. Despite most participants describing a positive attitude towards extension, this did not necessarily translate into an intention to engage, particularly in the case of the Unengaged farmers. Perceiving extension content to be irrelevant to their farm, or facilitator experience to be limited negatively influenced their intentions, especially when associated with a general aversion to change. Turner et al. (2017) describe these farmers as 'maintenance farmers', who display a low level of information seeking, are not wanting to change, and value maintaining the status quo. Farmers in the Unengaged sub-group displayed such characteristics, and despite describing a positive attitude towards extension, they did not intend to engage. These types of farmers who exhibit low levels of information seeking are unlikely to be motivated to engage, regardless of changes made to extension activities. These farmers do not want to make changes to their farm practices and perceive that extension activities will put pressure on them to do so.

Using the TPB to focus on social influence identified several key factors influencing farmer engagement with extension, that have direct implications for future extension design and delivery. Findings from this study supported previous research that showed many farmers prefer more informal, peer to peer learning, and learning from their own experience and observations in a practical setting (Black 2000; Kilpatrick & Johns 1999; Bamberry et al. 1997). The social interaction that comes with group and peer to peer learning can be a factor that motivates individuals to participate in a learning process, such as that offered by extension activities (Kilpatrick 1996). This study supports this finding, with farmers from all sub-groups (with the exception of some Unengaged farmers previously described) having been encouraged to attend extension activities because their peers did. This suggests an element of social influence on farmer engagement with extension; both initial motivation to attend and continued involvement.

A key finding from using the TPB to understand social influences on extension engagement was the perception that extension activities were designed for younger and less experienced farmers, and the negative influence this has on engagement with activities, particularly those focused on pasture management. Farmer-to-farmer learning, and social perceptions such as age and experience, play a role in creation of social acceptance of and engagement with extension activities. In some cases, if farmers have been through an intensive period of learning about particular management practices, they may receive little additional benefit from further training in that area. However, there are many cases where age and experience on-farm do not reflect the depth of knowledge and skills required for applying knowledge intensive processes, particularly if learning about new practices is required. Extension has the ability to play a role in supporting and facilitating the adoption of knowledge intensive processes, but must work within the social influences impacting farmer decision making to engage with extension, and create social acceptance of new behaviours (Klerkx et al. 2010).

A lack of existing knowledge and confidence can negatively influence farmer intention to engage with extension, as well as continued engagement. In the context of the TPB, this can create a perceived control barrier to engagement as farmers perceive they will not be able to answer a question or provide adequate farm information, and therefore perceive extension to be confronting. In many cases farmers are not aware that this is because they are lacking knowledge, or are 'unconsciously incompetent', or that they aren't aware that they lack a skill or that a knowledge gap exists (Thomson et al. 2006). Ongoing, continued engagement over time with supported learning can assist farmers in developing their skills and knowledge (Turner & Irvine 2017), increase confidence, and reduce the perceive control factor of extension being confronting.

Conclusion

This study has identified factors influencing Tasmanian dairy farmers' engagement with extension programs and activities. Farmer participants in the Trialler and Adapter sub-groups confirmed that continued engagement in extension can improve knowledge and confidence in managing their farm systems.

Attitudes toward extension were consistently positive across all three farmer sub-groups despite the fact the Unengaged farmers had minimal engagement. Farmers from all sub-groups appreciated learning from other farmers, and favoured extension taking place on-farm, supplemented with an expert speaker and/or knowledgeable, experienced facilitator. Some Unengaged farmers are likely to remain unwilling to engage, despite describing a positive attitude toward extension. Other farmers may be attracted to activities if social factors impacting their choice to engage are addressed. For example, addressing the perception that extension activities are designed for younger and less experienced farmers.

Specific designing and targeting of extension activities is required to encourage initial and continued engagement over time, so that farmers can overcome factors restricting or inhibiting engagement and receive the value from attending or re-engaging with extension. Future extension approaches could:

- Introduce a range of discussion groups, with some focused on individual farm data, but others that remove this requirement for those who might find it confronting
- Introduce 'master classes' or activities that have an 'advanced management' component for more experienced farmers
- Focus on the key motivators for different farmer segments and the benefits practices and activities can have for those areas. For example, for farmers motivated by animal care, focus on the benefits a practice has for cow health and welfare, rather than profitability
- Ensure facilitators have sufficient knowledge in a topic area, or have an expert speaker to deliver topic specific content

These recommendations incorporate potential changes to existing extension programs with the aim of increasing engagement with a wider range of farmers. Effective design and targeting of extension activities requires a greater understanding of farmer segments and their key motivators for engaging with extension, including what is the best season for extension, and which topics are attractive for on or off farm learning. Future research focused on understanding the key motivators for different farmer segments, and a greater understanding of the social factors that underpin farmers' decisions about participating in various extension activities is key to attracting and engaging a wide range of farmers.

Using the TPB constructs in qualitative interview design and analysis was an effective means of identifying attitudes, social and control factors influencing Tasmanian dairy farmers' intention to engage or not engage with extension activities, and factors influencing continued engagement. Typically, studies have taken a quantitative approach focused on using the TPB to predict the likelihood of an outcome or behaviour occurring. This study used the TPB in a qualitative manner in order to focus on understanding factors influencing behaviour, and how these may be addressed. Despite criticisms of the TPB, using its constructs enabled a clear, consistent and rigorous approach to analysing qualitative interview data, identifying factors influencing behaviour, and developing associated recommendations. Using the constructs of the TPB enabled specific recommendations to be developed with regards to addressing attitudinal, social and control factors limiting farmer engagement. Such recommendations can be developed into future organisational program delivery and design, in order to encourage and facilitate desired behaviour and outcomes. Using the TPB in such a way presents possibilities for its inclusion in designing future research, development and extension programs, and analysing their effectiveness, which has implications for organisations, policy and program development.

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Chapter 8 – Using a participatory approach to refining and prioritising recommendations for future extension delivery in the Tasmanian dairy industry

This Chapter reports results of the third stage and quantitative survey 2 as described in the Research Methods section of Chapter 3 – Research Methodology.

This Chapter has been published as a peer reviewed journal paper in the Rural Extension and Innovation Systems Journal (2018, 14(2)). The published abstract is included below.

Rural Extension & Innovation Systems Journal, 2018 14(2) - Research

Using a participatory approach to refining and prioritising recommendations for future extension delivery in the Tasmanian dairy industry

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Abstract. Supporting dairy farmers to develop pasture management knowledge and skills through implementation of best practice recommendations has been a priority for research, development and extension in the Tasmanian dairy industry. Many farmers have not engaged with extension, and/or have not implemented recommended pasture management practices. The purpose of this study was to refine and prioritise recommendations for future extension and pasture management activities from a survey of 162 Tasmanian dairy farmers that identified current practices and extension engagement, and in-depth, qualitative interviews with 30 of these farmers that explored factors influencing adoption and engagement behaviours. Preliminary recommendations for developing future extension activities were drafted from these studies. A modified Delphi technique and survey invited these 30 farmers to prioritise the recommendations. Highest priority recommendations include: introducing different levels of pasture management training relative to experience; identifying and targeting farmers motivating values; and their requirement for ongoing, on-farm support to apply pasture management information and principles.

Keywords: Adoption, engagement, extension, pasture management, recommendations

Introduction

Extension programs frequently aim to speed up adoption rates or diffusion of ideas or practices (Barr & Cary 2000). A key focus of extension in the Tasmanian dairy industry has been to increase implementation of pasture management practices and subsequent increase in pasture utilisation, through supporting the development of farmer knowledge, skills and confidence. Despite this focus, average pasture utilisation on Tasmanian dairy farms is still well below potential (Dairy Australia 2015; Tasmanian Institute of Agriculture 2017).

Extension efforts are often based on communicating with innovators and early adopters, assuming information will diffuse through communication channels to the population of later adopters (Rogers 2003; Wauters & Mathijs 2010). However, Wauters and Mathijs (2010) have shown that this approach is not as effective at diffusing information as expected, with diffusion occurring at a very low rate or not at all. Such an approach fails to consider a range of social and innovation factors that influence adoption and implementation of practices (Vanclay & Lawrence 1994).

Continued, ongoing support is required for farmers to learn, implement and adapt recommended pasture management practices as they are knowledge intensive in nature (Turner & Irvine 2017). An extended, facilitative approach, such as ongoing farmer discussion groups, are more effective than single training sessions, as they encourage farmers to work collaboratively to develop skills, knowledge, adapt practices and solve problems (Turner & Irvine 2017; Ingram 2008).

There exists significant variation in adoption and adaptation of pasture management practices, and in the extent that farmers engage with extension activities (Hall et al. 2017). Measuring pasture with a tool as part of an extended, supported learning process offered through extension is important in increasing farmer knowledge, understanding and adoption of recommended pasture management practices (Turner & Irvine 2017). A previous survey of Tasmanian dairy farmers found that 61% are currently engaged with extension (attending at least once a year or more) (Hall et al. 2017), but only 20% attend activities on a regular basis (attending four times a year or more). Such variation in engagement with extension, use of pasture measurement tools and implementation of recommended practices results in a large variation in pasture utilisation being achieved. If the focus of research, development and extension (RD&E) in the Tasmanian dairy industry is to continue to encourage increased pasture utilisation through adoption or adaptation of recommended practices, understanding why this variation is occurring, and trying to reduce it, will be essential.

Adoption and practice change as an outcome of extension is a social process, influenced by personal, environmental and social factors (Pannell et al. 2006; Wauters & Mathijs 2010). Individual characteristics that impact extension engagement include education, social networks, farm business characteristics, and the nature of the activity and learning environment (Fulton et al. 2003). For extension programs to be successful in achieving practice change, a variety of delivery methods and training programs is necessary to cater for individual preferences (Kilpatrick 1996). It has been suggested that extension should encourage a participatory process, including farmers as an important player in informing research design and extension methods and outcomes (Pannell et al. 2006; Bruges & Smith 2008).

Understanding farmers' attitudes, beliefs and social environment through social research is essential for effective design and targeting of extension activities. This includes understanding farmer motivators for engaging with extension, and the social factors that underpin their decision about participating in activities, and decision making around implementing recommended practices. If extension activities can be targeted towards influencing perceptions and motivating factors known to be associated with adoption, investment in these activities is more likely to lead to a change in practice or management (Llewellyn et al. 2005). Social research is important in understanding these factors and informing future extension design and delivery. A participatory approach that recognises that farmers goals may differ to that of extension will assist in encouraging farmer engagement, adoption and practice change (Rhoades & Booth 1982).

This study aimed to refine and prioritise recommendations for the development of future extension activities in the Tasmanian dairy industry, particularly those on pasture management training.

Research Aims and Methods

This study drew on the findings of two preceding studies. The first was a quantitative survey of 162 dairy farmers in Tasmania, which identified past and current use of pasture measurement tools, and extent of engagement with extension activities (refer to Chapter 4). In-depth, qualitative interviews were conducted with 30 of the surveyed farmers who voluntarily provided permission to be contacted about participating in follow-up interviews. These farmers were categorised into three sub-groups based on their past and current use of pasture measurement tools, and their level of engagement with extension activities (Table 8.1). These interviews were used to identify what and understand how factors influence the use of pasture measurement tools and practices, and farmers decision to engage or otherwise with extension activities (refer to Chapter 6 and 7 respectively). Preliminary recommendations for future extension activities were developed, including marketing, targeting, content and delivery.

Table 8.1. Sub-group characteristics and number of farmers in each group

Sub-groups	No. farmers interviewed	No. farmers surveyed	Engaged in extension	Been through intensive period of measuring pasture	Use of recommended pasture management practices
Unengaged	8	8	✗	✗	✗
Triallers	12	11	✓	✗	✗
Adapters	10	8	✓	✓	✓

Farmers who were categorised as Unengaged do not currently attend extension activities and have not been through an intensive pasture management learning process, which is an important component in adoption or adaptation of recommended pasture management practices. Trialler farmers are currently engaged with extension and have trialled a tool but not continued through an intensive learning process for pasture management. Adapter farmers are currently engaged with extension and have used a tool to measure pasture as part of an intensive learning process. Interviews with these farmers were used to identify what and explore and understand how factors influence the use of pasture measurement tools and practices, farmer involvement with a pasture management learning process, and farmers' decisions to engage or otherwise with extension activities. Identifying and understanding how attitudes, social influences and perceived control factors have influenced farmers pasture management and extension engagement decision making and behaviour enabled the development of preliminary recommendations for future extension activities, including marking, targeting, content and delivery. These recommendations were developed from in-depth analysis of interviewed farmers' responses, and improved understanding of what and how factors have influenced farmers decision making and behaviour. The aim of this study was to further develop these recommendations, inviting the same interviewed farmers to refine and prioritise recommendations for future extension and pasture management training activities.

This study was designed using a modified Delphi technique. The Delphi technique is a method designed to obtain consensus of groups of experts by using a series of questionnaires (Dalkey & Helmer 1963). The Delphi process includes at least two, and typically three, rounds of questionnaires, with the first round consisting of an open ended questionnaire designed to solicit information on a content area (Hsu & Sandford 2007). Subsequent rounds consist of questionnaires based on the responses of the previous round (von Ruschkowski et al. 2013). Advantages of the Delphi method include the ability to maintain subject anonymity and control feedback, replace the need to meet physically in the same location, and also reduces bias and influence of responses that can occur in a group setting (Dalkey & Helmer 1963).

One of the main criticisms of the Delphi technique include the introduction of potential researcher bias in development and analysis of responses (Linstone & Turoff 2002). Oversampling to ensure saturation of messages in the initial survey and the interview stages, along with using a consistent and detailed analytical approach, assisted in eliminating bias throughout this study.

Typically, designs are either 'Delphi' or 'Modified Delphi' (Avella 2016). In a modified Delphi design, answers to one of the initial phases are usually collected by some other means rather than from an expert panel, such as from interviews, review of literature, or an external group (Avella 2016).

A modified Delphi method was used in that the preceding survey and interviews take the place of the two questionnaires used in a traditional Delphi technique. The initial survey gathered information and data on pasture management practices and engagement behaviour, which then informed development of the follow up interviews. The interview findings were developed into focus areas and preliminary recommendations for future extension activities. Based on these focus areas and recommendations, 15 questions were developed into a survey, with farmers asked to respond on a 5-point Likert scale of 'strongly disagree' to ‘strongly agree’. The questions corresponded to recommendations, with the responses indicating the level of support for the recommendations. Responses to questions were graphed using the statistical program R (v 3.5.0), organised by sub-group, with the 15 questions separated into three main groups of five according to the recommendation topic. The survey was mailed to the 30 farmers who had participated in the preceding interviews, with a response rate of 90%. Surveys were coded so responses could be allocated to sub-groups.

Due to the small sample size, ‘strongly agree’ and ‘agree’ responses were aggregated, and ‘strongly disagree’ and ‘disagree’ were aggregated. The response ‘neither disagree or agree’ was left as ‘neutral’. While complete statistical analysis was unable to be conducted due to sample size, analysis of responses was able to produce agree, disagree or neutral trends for each question for the three farmer sub-groups. These then indicated the level of support for the associated recommendations.

Results and Discussion

Figures 8.1, 8.2 and 8.3 are a graphical representation of the aggregated responses, showing the level of support according to the response trends. Most farmers see themselves as experienced in pasture management, with 90% of Unengaged, 64% of Triallers and 90% of Adapters agreeing with this statement (Figure 8.1, Question 2). Seventy-five percent of Unengaged, 73% of Triallers and 63% of Adapters agreed that they could benefit from additional pasture management training (Figure 8.1, Question 1). Fifty percent of Unengaged, 54% of Triallers and 63% of Adapters agreed that they thought the current pasture management training offered was better suited to younger or less experienced farmers (Figure 8.1, Question 4).

These trends support the recommendation that there is a need for different levels of pasture management training, along with the need for pasture management training to be developed for and targeted to experienced farmers. This is further supported by 55% of Triallers and 75% of Adapters indicating that they would be interested in advanced pasture management training or 'master class' (Figure 8.1, Question 5).

However, there is a need for different levels of pasture management training for these sub-groups. Unlike the Adapters, the Triallers have not continued through a pasture management learning process involving an intensive period of measuring and monitoring pasture using a tool. Continuing through a supported pasture management learning process, involving measuring and monitoring, enables farmers to develop their skills and knowledge to be able to visually assess pasture with increased accuracy (Stockdale 1984). As these skills are developed and combined with experience and existing farm knowledge, the need to continue using a pasture measurement tool may decrease (Turner & Irvine 2017).

As Triallers have not continued through such an intensive learning process, they are unlikely to have developed the same level of knowledge, skills and experience as the Adapter farmers, though they both consider themselves experienced in pasture management. While it is possible that some farmers have developed accurate visual assessment quickly, anecdotal evidence suggests that further supported learning may be necessary for farmers to gain full benefit from using pasture measurement tools along with understanding the associated biological principles underlying recommended management practices. There is a requirement for different levels of training for these sub-groups to address the gaps in knowledge and skills, based on their past involvement with a pasture management learning process. Targeting these activities to the different sub-groups, and marketing them as for experienced farmers, is important to encourage Triallers to re-engage with the pasture management learning process.

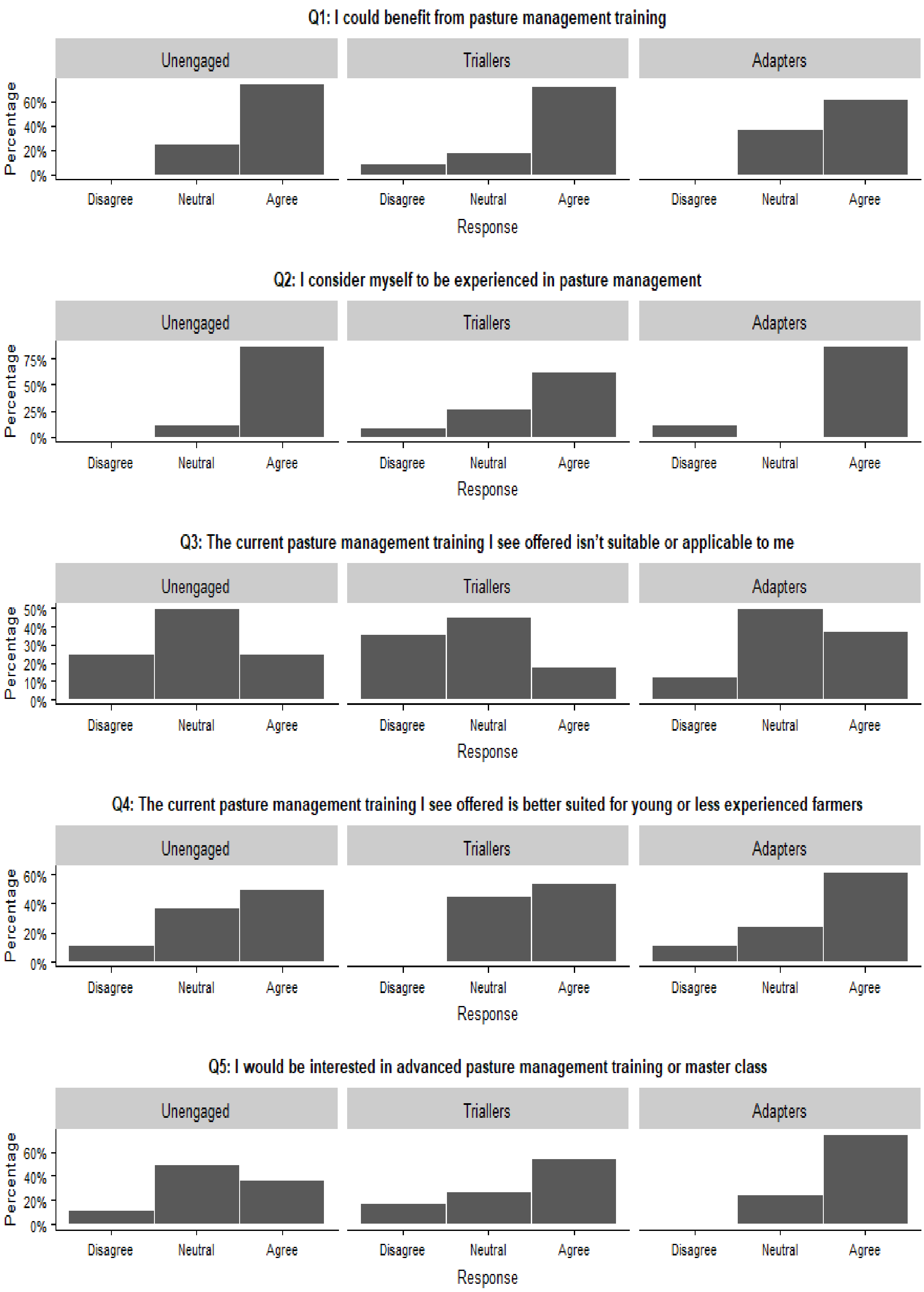

Figure 8.1. Questions 1 to 5 on pasture management experience and training, with proportion of survey respondents agreeing, disagreeing or neutral for each sub-group.

Regardless of the extent they measured pasture previously, 63% of Unengaged, 100% of Triallers, and 90% of Adapters agreed that it is important to understand how to do pasture management calculations rather than just being provided with the data (Figure 8.2, Question 6). However, 100% of Unengaged and 82% of Triallers agreed that they were more likely to visually assess pasture than use figures or calculations (Figure 8.2, Question 7). Seventy-five percent of Adapters tended to disagree or remain neutral. These trends support the suggestion of Hall et al. (in press-a) that the Unengaged and Triallers are 'unconsciously incompetent' (Burch 1970; Howell 1982), in that they are unaware they lack knowledge or skills, in this case in pasture management. They see themselves as experienced, but they have not been through a period of intensive pasture measurement and learning, and therefore are unlikely to have gained an in-depth knowledge of pasture calculations and be able to apply the associated principles to the same extent and thus receive the same benefit as the Adapters. The Unengaged and Triallers also indicated that the current pasture management training is not suitable for them, supporting the recommendation that a variety of approaches is needed if they are to re-engage with extension activities focused on pasture management. Such approaches may include focusing on or targeting motivating values through different topics, and different levels of pasture management training from less advanced to more advanced. Re-engaging these farmers and encouraging them to continue through a pasture management learning process is important if they are to gain the knowledge and skills required to improve pasture management and production.

Thirty-seven percent of Unengaged and 37% of Triallers agreed that they were more likely to attend an activity on pasture management if it did not involve calculations (Figure 8.2, Question 8). However, 50% of the Unengaged and 27% of the Triallers also gave a neutral response. In comparison, the Adapters had a strong disagree trend. Though removing the focus on calculations, and adding a more practical component, is likely attract some farmers in the Unengaged and Triallers sub-groups, the overall neutral trend indicates that introducing activities with this reduced focus is not a high priority for future extension.

Thirty-eight percent of Unengaged and 45% of Triallers agreed that they were more likely to attend an activity on feeding their cows better than an activity focused on pasture management, with the overall trend being neutral (Figure 8.2, Question 9). However, 100% of Unengaged and 55% of Triallers agreed that feeding their cows well was more important than achieving a grazing residual (Figure 8.2, Question 10). The Adapters were less supportive of this statement, with 50% agreeing. This suggests that as farmers become more experienced in pasture management, they develop a greater understanding of the link between improved pasture management and cow production. This strong agree trend for the Unengaged indicates that a key recommendation to encourage the Unengaged sub-group to participate in extension is identifying and targeting their motivating values, such as focusing on the benefits of improved pasture management on cow health and performance. Designing, targeting and marketing activities accordingly is important if extension is to be more effective at engaging these farmers. These farmers have indicated they would benefit from additional pasture management training, but do not engage with the training options currently offered. Further social research to increase understanding of these values that influence farmer decision making would provide valuable information to guide this extension development. These trends support the suggestion that Unengaged and Triallers would gain additional benefit from re-engaging with the pasture management learning process, and revisit measuring pastures for an extended period (Hall et al. in press-a).

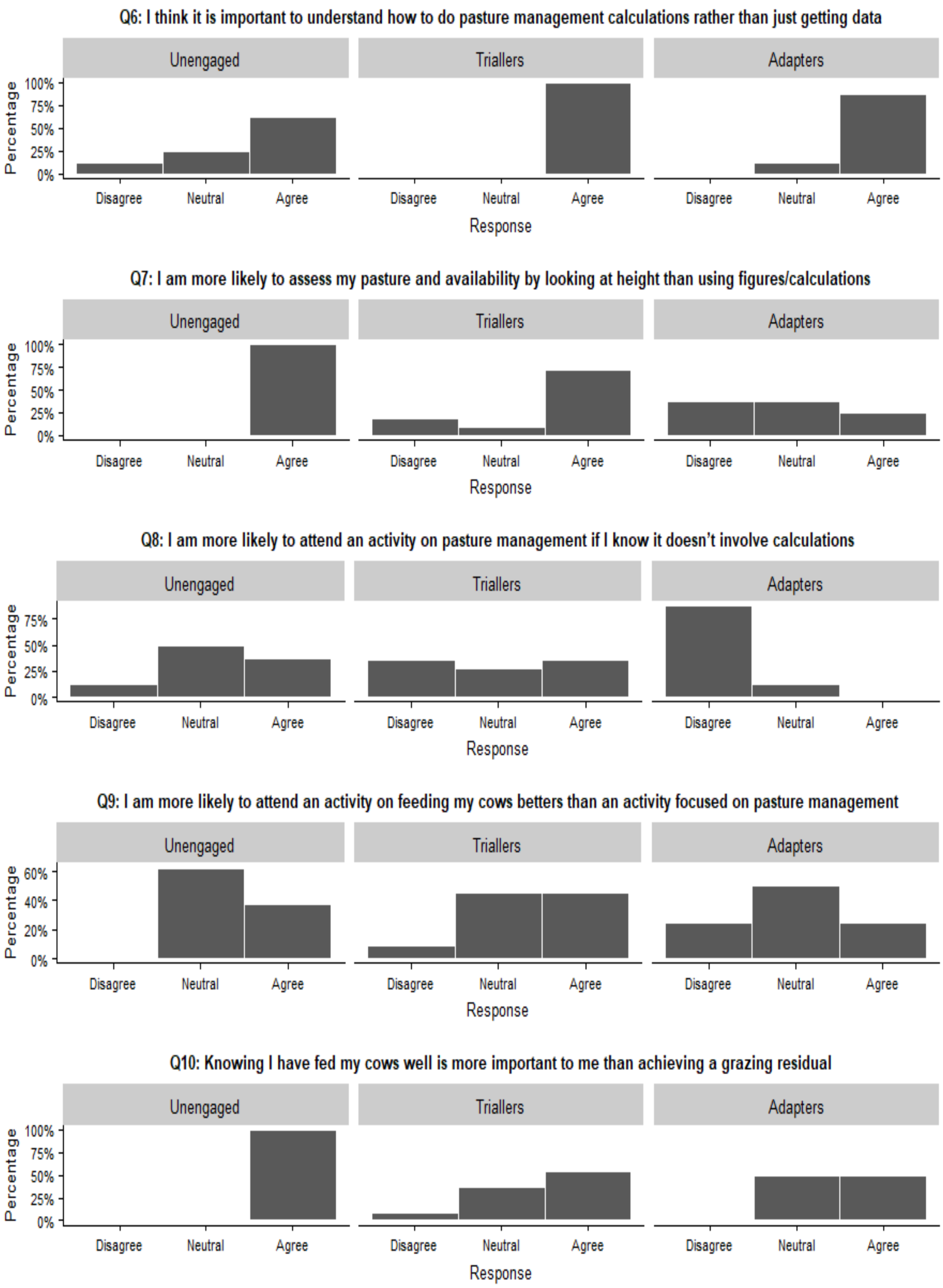

Figure 8.2. Questions 6 to 10 on content of pasture management activities and motivating values, with proportion of survey respondents agreeing, disagreeing or neutral for each sub-group.

Fifty percent of Unengaged and 36% of Triallers agreed that they would be more likely to attend an extension activity if it is with people they know (Figure 8.3, Question 11). Sixty-three percent of Adapters had a neutral response. Thirty-eight percent of Unengaged, 36% of Triallers and 63% of Adapters agreed with the statement that they were more likely to attend an extension activity if it was with people who had a similar level of experience to them (Figure 8.3, Question 12). Farmers vary in the ways they prefer to learn, including one-on-one learning and learning from peers (Kilpatrick & Johns 2003). Less experienced farmers, or farmers with less knowledge or skills, can benefit from learning from more experienced peers, and how they have implemented practices (Kilpatrick & Johns 1999; Kilpatrick & Johns 2003). For this to occur, some of the more experienced farmers, such as the Adapters, need to be motivated to attend for altruistic reasons as they have potentially less to gain, but rather are sharing their knowledge with less experienced farmers. A study by Hall et al. (in press-b) found this to be the case for some Adapters, in that they choose to attend extension activities to help less experienced farmers. Though introducing a range of group options that cater for individual preferences may be effective in encouraging some farmers to engage with extension, the overall neutral trend indicates that this is a lower priority recommendation for future extension. However, The Adapters are more likely to engage with extension if it is with farmers of a similar experience level, suggesting that this recommendation would be beneficial for activities targeted to this sub-group.

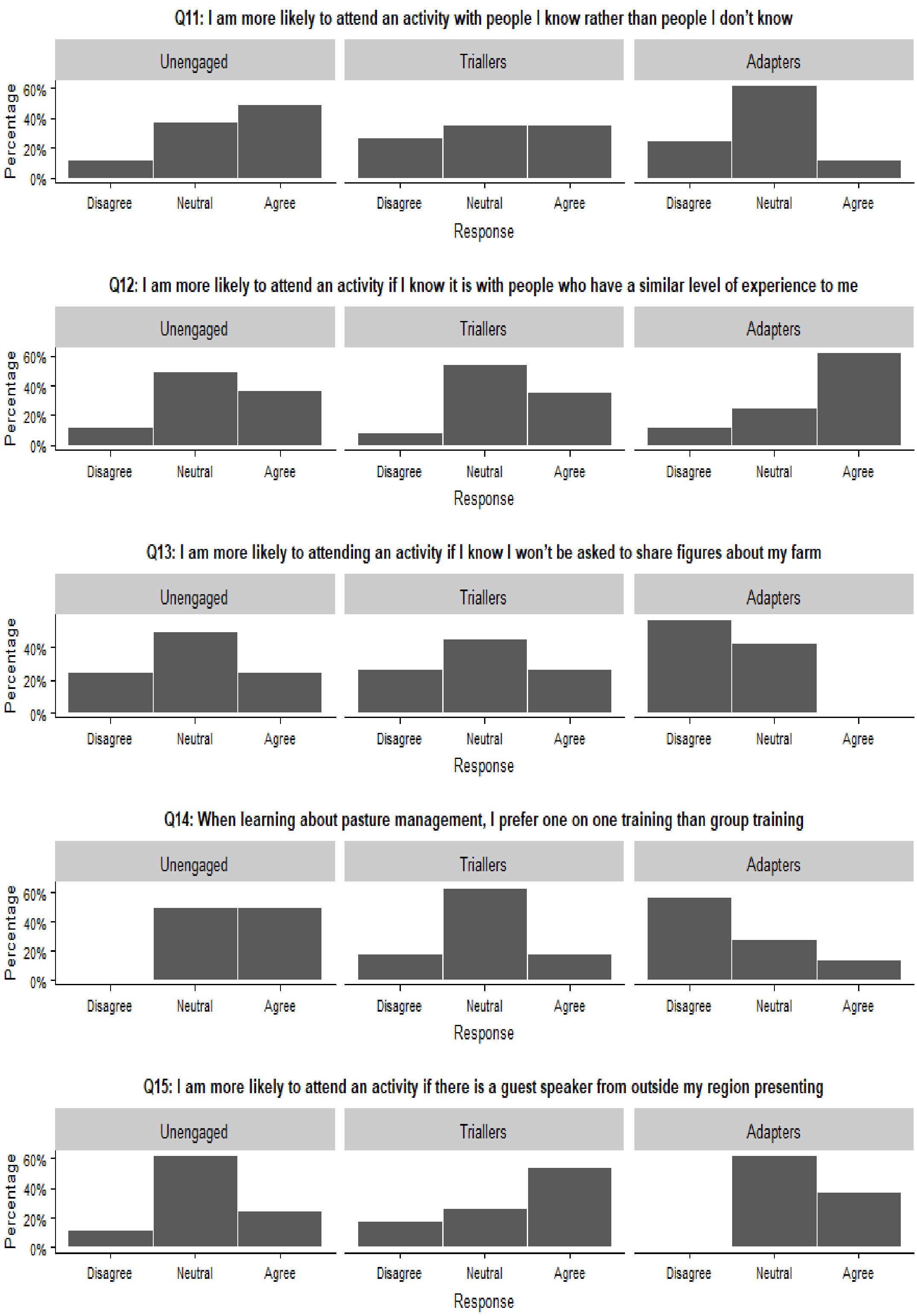

Figure 8.3. Questions 11 to 15 on general extension activity design, with proportion of survey respondents agreeing, disagreeing or neutral for each sub-group.

In addition, the range of responses when farmers were asked if they preferred one-on-one training when learning about pasture management supports the recommendation for the provision of a variety of training options (particularly for pasture management specific activities). Fifty percent of Unengaged farmers agreed that they prefer learning about pasture management one-on-one, with 45% of Triallers responding neutral. Fifty percent of the Adapters did not agree with this statement, indicating they prefer learning about pasture management in a group setting (Figure 8.3, Question 14). One-on-one learning through coaching, particularly when learning about pasture management, has been shown to be the most effective model for many farmers, particularly those with low levels of existing knowledge (Davey & Maynard 2007; Turner & Irvine 2017). These farmers are likely to include the Unengaged and Triallers who have not previously been through an extended pasture management learning process involving measuring pasture with a tool. Continued, one-on-one, supported learning is also more effective when it comes to implementing knowledge intensive practices, as farmers can work through challenges and adapt practices to their farm (Turner & Irvine 2017). However, one-on-one is resource intensive, and its use is often limited for public extension due to both time and resource constraints.

When asked if they were more likely to attend an activity where they would not be asked to share farm figures, 50% of Unengaged and 45% of Triallers were neutral (Figure 8.3, Question 13). Fifty percent of Adapters did not support this statement. It is likely that the Adapter farmers have been involved to some extent with benchmarking programs and associated business management groups offered through extension, as they have indicated a higher incidence of measuring and monitoring and extension engagement as reported in (Hall et al. in press-a). Fifty-five percent of Triallers agreed they were more likely to attend an activity with a guest speaker from outside their region, while 63% of Unengaged and 64% of Adapters were neutral (Figure 8.3, Question 15). This suggests that the recommendation of using an expert guest speaker should be a lower priority for future extension targeting a wide range of farmers, as while it might encourage farmers in the Triallers sub-group to engage with extension, it is less likely to encourage others.

The Adapters' general neutral response to questions focused on extension activity design (except for preferring to attend activities with farmers of similar experience), indicates that they are more flexible regarding activity type and content. These farmers are currently engaged with extension, indicating that less focus is required on changing current activities to suit their needs. Adapters are likely to remain engaged with extension activities, as they currently engage and many see value in continuing to do so (Hall et al. in press-b). These farmers are likely to be more confident in their knowledge and skills, particularly those relating to pasture management, as they have been through an intensive pasture management learning process where focus is placed on understanding and applying figures and calculations. A previous study found that farmers who have been through such a process are more confident in their management ability (Turner & Irvine 2017). Hall et al. (2017) also reported that farmers who had been through an intensive period of measuring and monitoring pasture with a tool were more confident in their pasture management ability. Activities with specific recommendations are often more effective in encouraging farmer engagement (Greene et al. 1995), particularly for farmers such as the Adapters who may have a greater level of existing knowledge and skills.

Conclusion and Recommendations

For future extension activities to facilitate greater adoption and practice change, it is essential to understand the social factors influencing farmer engagement. Using a modified Delphi technique that builds on previous social research is an effective method to assist in the development of successful research and extension programs as it places emphasis on developing an understanding of the social factors that influence behaviour and decision making and understanding the social context within which farming occurs. Time pressures of planning RD&E programs can be challenging for building in such participatory approaches.

However, it is important for RD&E experts to plan and use participatory approaches where possible, as they allow projects to connect with and build on existing farmer knowledge, leading to improved adoption outcomes.

Using a modified Delphi technique in this study enabled identification of key recommendations for each farmer sub-group, and was an effective means of validating and prioritising recommendations for future extension design by inviting farmers to have input, supporting previous studies that have found it a useful and valuable method of reaching group consensus on recommendations (Hsu & Sandford 2007). Using this type of approach over others, such as focus groups, was more effective as it enabled open and unbiased input from each farmer participant. This technique enabled farmers equal opportunity and ability to voluntarily provide input, with independent and unbiased views, and equal representation and weighting of responses.

The modified Delphi survey built on the previous rounds consisting of an initial survey and in-depth follow up interviews. Each round built on the farmers responses to the previous, leading to development of recommendations for future extension and pasture management training activities. By inviting the same farmers to respond to a final survey enabled further development, refinement and prioritisation of these recommendations. A summary of these recommendations and level of priority are as follow:

- Introducing different levels of pasture management training that caters for experience level and past training – high priority
- Introducing ‘master classes’ or activities with an advanced management component for farmers who consider themselves as experienced – high priority
- Requirement for ongoing, on-farm support to understand and apply pasture measurement information, and not just providing data – high priority

- Identify and target motivating values to engage the Unengaged sub-group – high priority
- Introduce a range of extension activities and group types, including some with a reduced focus on farm data and calculations – low priority
- Using an expert speaker from outside the region – low priority

Prioritising recommendations for sub-groups enables more specific design and targeting of activities for farmers, increasing the likelihood of influencing adoption and practice change outcomes. Motivating and influencing factors for sub-groups can be identified, which assists in targeting, designing and marketing of extension activities. Using a participatory approach enables farmers to have input into informing design of future extension content and delivery that will attract and engage a wider range of farmers.

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Chapter 9 – Discussion and Conclusion

The research described in this thesis explores past and current pasture management practices and use of pasture measurement technology in the Tasmanian dairy industry, providing insights into the factors that have influenced adoption and use. In combination with exploring factors influencing farmer engagement with extension activities, these insights and understanding can assist in optimising the role and use of recommended practices and engagement behaviour in order to improve pasture management on Tasmanian dairy farms.

This research provides a deeper understanding of the underlying factors influencing farmer decision making regarding implementation of recommended pasture management practices, use of associated tools and technology, and engagement or otherwise with extension activities. Social research mixed methods explored how these factors influence adoption behaviour, and aided in the development of recommendations to inform future extension activities.

Optimising pasture management and performance have been a key focus of RD&E in the Tasmanian dairy industry. The focus of these programs has been on increasing farmer knowledge and understanding of recommended practices, in order to develop the skills necessary for improving pasture management and consumption, and subsequently profitability (Mann 2006; Irvine 2013). The advantages of doing so have been well documented, including more accurate daily allocation of feed and optimised pasture utilisation (Dalley et al. 1999; Fulkerson et al. 2005), pasture growth and quality (Lee et al. 2008; Fulkerson et al. 2005), improved farmer confidence in making grazing management decisions (Turner & Irvine 2017), and increased profit through application of recommended pasture management practices (Beukes et al. 2018). However, anecdotal and benchmarking data show that many farmers are not achieving the levels of pasture performance and utilisation that are possible in the Tasmanian temperate dairying environment (Dairy Australia 2015; Tasmanian Institute of Agriculture 2017; Dairy Australia 2018). Below average pasture utilisation has implications for dairy farm efficiency and profitability (Dillon et al. 2005; Lane 2014). While biophysical research has focused on pushing the upper limits of what can be achieved in terms of pasture and farm production, industry recognise that there remain considerable improvements that can be gained through adoption of proven recommended practices, particularly by farmers who are achieving below average levels of pasture utilisation.

To develop a greater understanding of why many farms are not achieving possible levels of pasture production and utilisation, it was necessary to understand what practices are currently implemented on farms, and what factors have influenced those practices. This led to the development of the four following key research questions that this thesis addressed:

1. What are the current pasture management practices and associated tools and technology being used on Tasmanian dairy farms?
2. What is the current extent of farmer engagement with extension activities?
3. What social and demographic factors have influenced the decision making behind adoption and implementation of pasture management practices, tools and technology?
4. What social and demographic factors influence farmer decision making about choosing to, or not to, engage with extension activities?

To investigate the factors influencing farmers decision making around pasture management practices (Research Question 1: What are the current pasture management practices and associated tools and technology being used on Tasmanian dairy farms?), and extension engagement (Research Question 2: What is the current extent of farmer engagement with extension activities?) current practices were identified through a quantitative survey. Relationships between past and current pasture management practices were quantified, including demographic factors such as level of formal education, previous experience, and attendance at extension activities. This survey built on the foundations of a pasture management learning process, as proposed by Turner and Irvine (2017).

This process involves an ongoing, supported learning environment where farmers measure and monitor pasture with a tool, incrementally building pasture management knowledge and skills, and can then apply and adapt pasture management principles to their individual farm (Turner & Irvine 2017). It is also proposed that as farmers move through this pasture management learning process, they also move through levels of competency (Howell 1982). This involves moving from 'unconscious incompetence', where farmers are not aware that they lack a skill or a knowledge gaps exists, through to 'unconscious competence', where farmers have advanced knowledge and skills that are used intuitively (Howell 1982; Clarkson 1994; Barrow 2011). Measuring and monitoring of pasture with a tool is considered an important part of developing competent pasture management practices, providing farmers with objective information from which they can make decisions as they learn about the underlying biological principles. After this intensive, supported learning process, the extent that farmers continue to use pasture measurement tools varies, as farmers adapt practices to suit their farming practices. As reported by Eastwood & Kenny (2009), many farmers prefer to use their experience and observations to self-validate more formal, quantitative approaches. However, developing farmer competence is required for well informed, informal and intuitive decision making. As discussed by Thompson (2009), incorporating both informal and intuitive, and more formal and quantitative approaches, could make for a more effective extension design and method.

Pasture measurement tool ownership and use – 64% of survey participants own a pasture measurement tool, yet 24% of these farmers are not currently using that tool to measure pasture

The state-wide survey demonstrated large variation in the extent of pasture measurement tool ownership and in farmers' use of tools to measure pasture. Sixty-four percent of farmers own a pasture measurement tool, indicating the positive intention to adopt recommended pasture management practices through purchase of a tool. Of these, 76% are currently using that tool to measure pasture. The remaining 24% intended to measure pasture as demonstrated through tool ownership, but are not currently doing so. Of the 64% of farmers who own a pasture measurement tool, the vast majority owned a plate meter (59%) and the remainder a CDAX bike reader.

The survey was designed to investigate whether farmers had been through a period of intensive measuring in the past, as well as current practices and their relationship with decision making. The survey found that 65% of farmers had used a tool to measure pasture to some extent and that 35% of farmers have never measured pasture growth using a tool. While some of these farmers have been through a period of intensively measuring pasture with a tool (43%), others have started to measure and discontinued after only trialling for a short period (57%). Intensive use of a pasture measurement tool, involving measuring and monitoring of pasture for an extended period of time (12 months or longer) was positively linked with increased confidence in pasture management decision making. Farmers who currently use a tool to measure pasture are significantly more likely to have used a tool to measure pasture in the past, particularly if they have used that tool on an intensive basis.

There was no existing literature or knowledge around the extent of current pasture management practices and the specific use of pasture measurement tools on Tasmanian dairy farms, and how these relate to farmer demographics (such as farm size and education), and engagement with extension activities. This knowledge gap was addressed through answering Research Question 1 and using the Competence Learning Model theory to frame the survey questions, providing greater insights into the extent of pasture management practices being implemented. Farmers with formal education qualifications of Year 11 and/or 12 and equivalent (trade and/or apprenticeship), and diploma and/or university are significantly more likely to currently use a tool to measure pasture than farmers with qualifications of Year 10 or below, and certificate. As herd size and/or milking area increase, farmers are also more likely to currently use a tool to measure pasture. Farmers who attended general extension activities and/or activities specifically focused on pasture management are also significantly more likely to use a tool to measure pasture.

Extension engagement – 86% of farmers attend extension activities, but only 20% attend on a regular basis

The extent to which farmers currently engage with extension activities was also identified (Research Question 2: What is the current extent of farmer engagement with extension activities?). Despite 86% of surveyed farmers attending extension activities to some extent, only 20% indicated that they engage on a regular basis (four times a year or more). Attendance at extension activities was positively related to current use of a tool to measure pasture. This study found that 51% of farmers who had attended extension activities currently use a pasture measurement tool, compared with 23% of the farmers who have not attended extension activities. Farmers who have been through an intensive period of pasture measurement in the past (for 6 months or more) were also more likely to have attended extension activities. The use of pasture measurement tools as part of an extended, intensive learning process is an important component in developing pasture management knowledge, ability and skills (Turner & Irvine 2017), and has been a key focus of extension programs. These have included farmer discussion groups, field days, one or two day training sessions, and longer term programs (for example, pasture coaching) involving facilitated incremental learning. Current tool use and high levels of engagement with extension is likely a reflection of the emphasis of publicly funded extension efforts on management of the pasture feedbase. While previous extension projects in the Tasmanian dairy industry have reported on the numbers of farmers who have engaged with extension (e.g. Irvine (2013)), there was no data on the regularity of engagement or the relationship between engagement and pasture management practices and adoption behaviour. This information was acquired through addressing Research Question 2.

Farmers in this study were categorised into sub-groups (Non-users, Triallers and Adapters) based on their past and current use of pasture measurement tools, their involvement in an extended pasture management learning process, and the extent to which they engage with extension. The Non-users sub-group included farmers, most of who had not used a pasture measurement tool, or had only trialled a tool non-intensively (6 months or less), and who do not engage with extension. The Triallers included farmers who have trialled a tool, or used a tool non-intensively, and the majority engage with extension two to four times a year. The Adapters sub-group included farmers who have used a tool on an intensive basis, and some continue to do so, and regularly engage with extension with the majority attending four times a year or more. This research added to previous knowledge by increasing our understanding of why some farmers have continued through an extended pasture management learning process, while others have never started out, or started out and discontinued. This research further adds to knowledge by increasing our understanding of why some farmers choose to engage regularly with extension and others not at all, and to understand the factors influencing farmer decision making.

Qualitative use of the TPB can explain farmer decision making and improve future adoption outcomes

A qualitative approach using the TPB framework was therefore used to identify factors that influence pasture management (Research Question 3: What social and demographic factors have influenced the decision making behind adoption and implementation of pasture management practices, tools and technology?) and extension engagement (Research Question 4: What social and demographic factors influence farmer decision making about choosing to, or not to, engage with extension activities?). The TPB was chosen because it focuses on intentions and behaviours, whereas other models such as the technology transfer model and diffusion of innovations focus more on characteristics of adopters and factors influencing diffusion through a population (Marsh et al. 1995; Ghadim & Pannell 1999). Most previous studies using the TPB have employed a quantitative approach to predict the likelihood or outcome of adoption and decision making. This study employed a qualitative approach using the TPB as it was concerned with exploring how and why social factors influence decision making and behaviour. In-depth interviews with sub-groups of survey participants offered the flexibility needed to investigate complex behaviour and decision making, enabling issues to be explored in greater detail as they were raised (Walter 2013). Using the TPB was an effective, action-based approach to identifying and understanding the social factors that influence farmers pasture management and extension engagement behaviour, and provided answers to Research Questions 3 and 4. Qualitative interviews with the sub-groups of farmers identified a range of attitudes, social influences, perceived and actual control factors that influence pasture management and extension engagement intentions and behaviour. This approach has provided information that can inform the development of recommendations for future extension programs and activities. These recommendations include introducing different levels of pasture management training and experience, providing ongoing on-farm support, and identifying and targeting farmers motivating values, with the aim being to improve future adoption outcomes. These recommendations are outlined in more detail below, following a discussion of the influence of attitudes, social norms and control factors on farmer adoption intentions and behaviours.

ATTITUDE – Farmers have a positive attitude towards measuring pasture and attending extension, but adoption behaviour is influenced by social and perceived control factors:

In general, there was a positive attitude from most farmers towards measuring pasture and attending extension activities, regardless of the extent of best practice adoption and extension engagement. This supports findings of a previous study of Tasmanian dairy farmers conducted by Craigie (2013), that found the majority of farmers had a positive attitude towards pasture management in that they agreed with recommended pasture management practices, and that they have an important role in shaping animal nutrition, farm profitability and efficiency.

Despite this positive attitude, this study identified several factors influencing farmers' behaviour for each sub-group. These factors are identified in the following TPB diagrams for each sub-group, and whether they were found to influence intention, behaviour, or both, for adoption of pasture management tools and extension engagement. Figure 9.1, 9.2 and 9.3 identify the factors influencing intention and behaviour and at which point these factors have the greatest impact for the Non-users, Triallers and Adapters sub-groups respectively. The colour red is used to show where overall negative impact or influence is occurring, whereas green is used to show an overall positive influence or impact. These impacts have been combined for both pasture management and extension engagement, to visually represent which factors within the TPB framework are likely to impact each farmer sub-group.

While the majority of the Non-user farmers positively described pasture measurement and management, there was little indication that they intended to develop more knowledge and skills in this area, and have not invested in purchasing or trialling a pasture measurement tool. In contrast, purchasing of pasture measurement tools by Trialler and Adapter farmers indicates there has been positive intention by farmers to measure pasture, along with developing knowledge and skills in this area. However, positive intention towards measuring pasture does not always result in behaviour change. Farmers in the Triallers sub-group encountered both negative social influences and perceived control factors that prevented adoption and behaviour change from occurring, which are discussed in the following perceived control and social influence sections. Farmers in the Adapters sub-group also encountered some challenges with pasture measurement tool use, but were able to address these and adapt practices accordingly as they have developed their knowledge, skills and competence through previous participation in an extended, supported pasture management learning process.

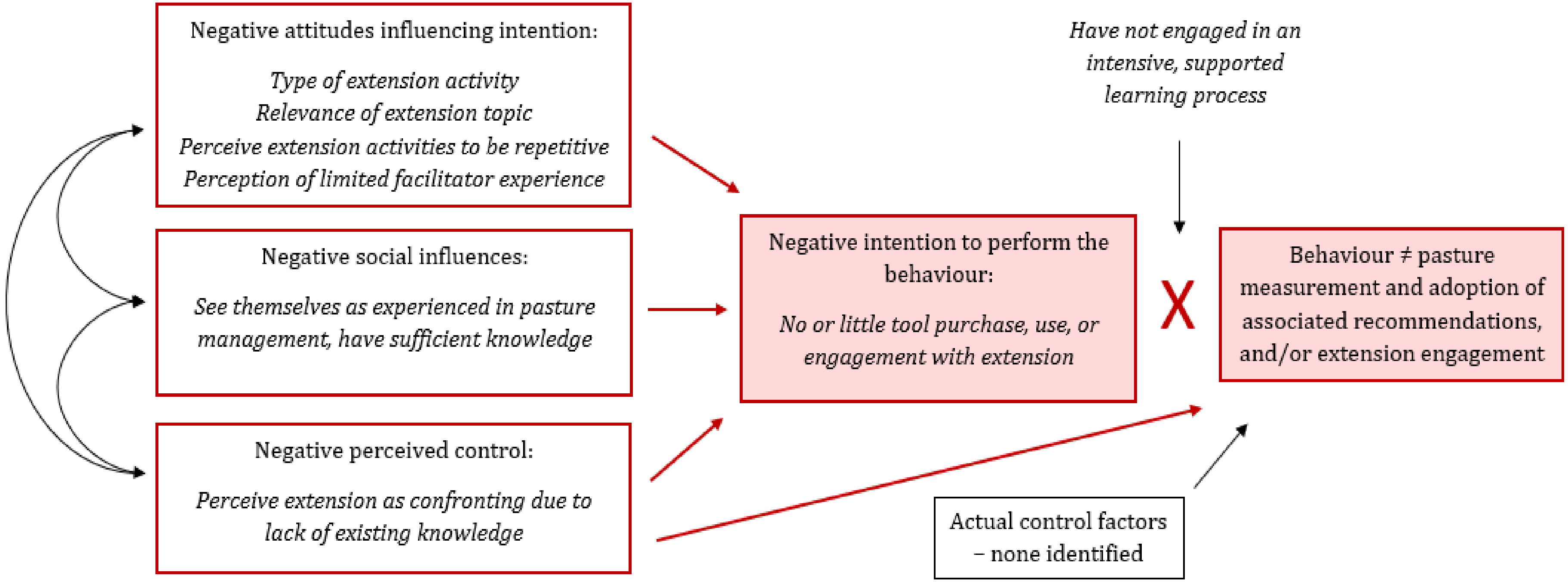

Figure 9.1. Theory of Planned Behaviour diagram for the Non-users sub-group. factors influencing intention and behaviour are shown in italics in each appropriate box, at the point they influence the intention-behaviour process.

**Refer to Chapter 3, page 116 for detailed breakdown of farmer sub-group classification based on pasture management adoption and extension engagement behaviour.*

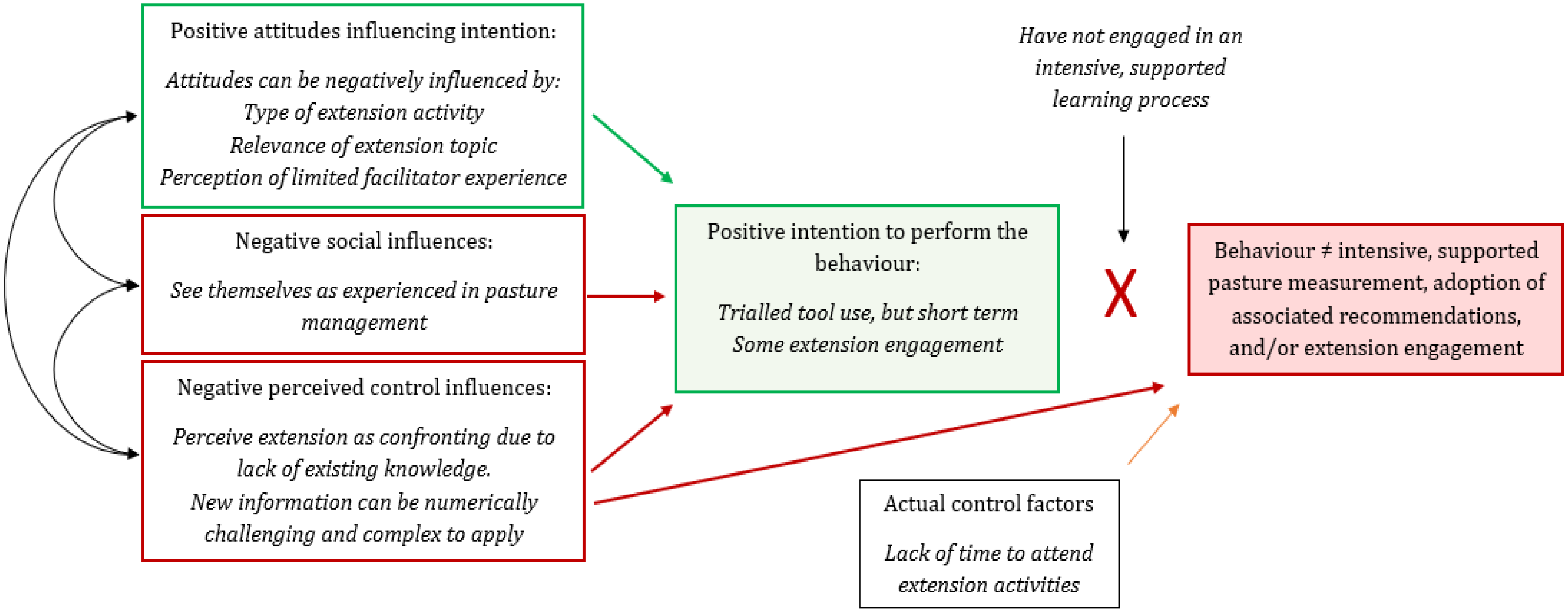

Figure 9.2. Theory of Planned Behaviour diagram for the Triallers sub-group. factors influencing intention and behaviour are shown in italics in each appropriate box, at the point they influence the intention-behaviour process.

**Refer to Chapter 3, page 116 for detailed breakdown of farmer sub-group classification based on pasture management adoption and extension engagement behaviour.*

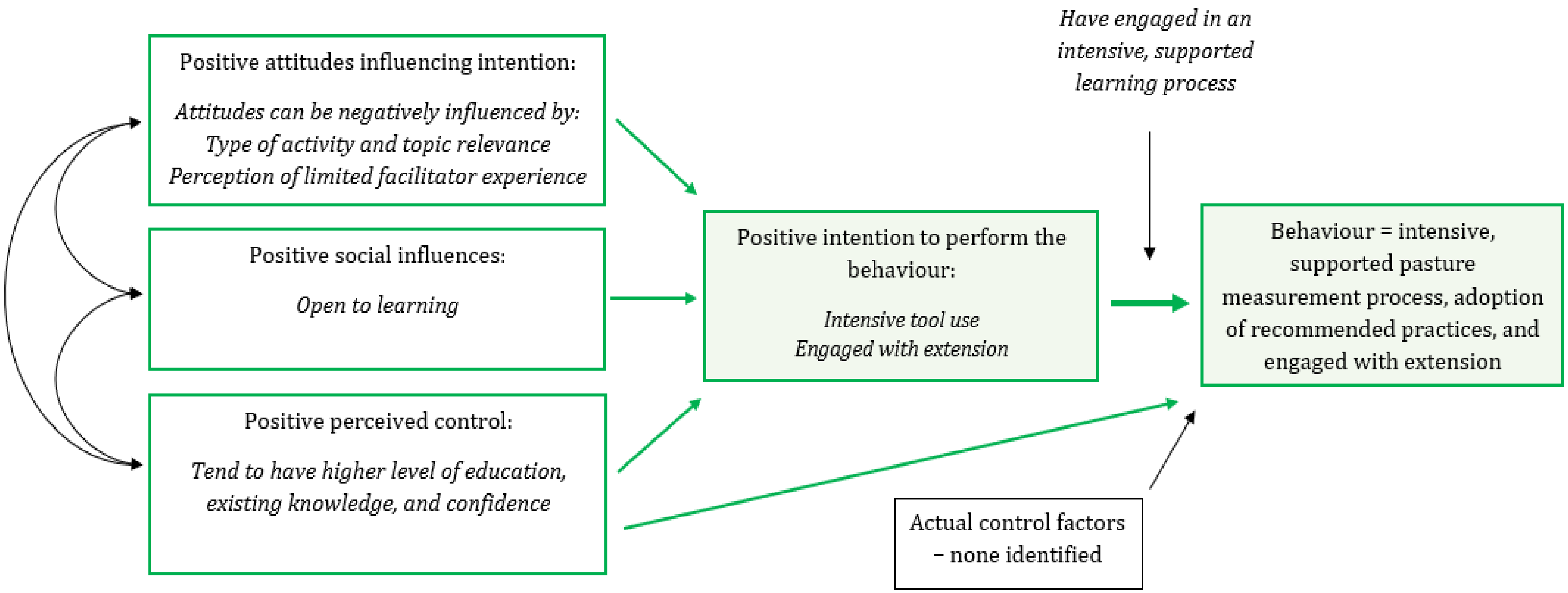

Figure 9.3. Theory of Planned Behaviour diagram for the Adapters sub-group. factors influencing intention and behaviour are shown in italics in each appropriate box, at the point they influence the intention-behaviour process.

**Refer to Chapter 3, page 116 for detailed breakdown of farmer sub-group classification based on pasture management adoption and extension engagement behaviour.*

ATTITUDE – Topic relevance, perception of limited facilitator experience, and perception of extension activities as confronting negatively impact farmer engagement with extension:

Though there are a number of studies that have investigated farmers' preferences for learning and the role of extension, many of these are over a decade old and there is little new literature that explores the role of extension in a specific learning context (i.e. pasture management). Topic relevance and the specificity to individuals farm, the type of activity and perceived facilitator knowledge and experience are factors mentioned by Non-users, Trialler and Adapter farmers that can negatively influence farmer engagement with extension, and were identified through answering Research Question 4. Interview data found that many farmers prefer to learn about a practice that can be applied directly to their individual farm and will make a decision to attend based on the consideration of the direct benefit they will gain. These findings align with those of Wood et al. (2014), who found in a study investigating farmer networks and the role of science in a lamb grazing setting, that farmers sought out and preferred particular knowledge that could be applied to their individual farm.

Perception of limited facilitator experience and knowledge was commonly mentioned by farmers in all three sub-groups as a factor that discouraged engagement by farmers in this study. Farmers placed importance on the facilitator needing to have the skills to communicate information to farmers and having practical experience to be seen as credible. Studies on the attitude of Nigerian farmers towards extension agents (Oladosu 2006), and perception of extension workers or facilitators in Bangladesh (Sarker & Itohara 2009) support these findings, in that provision of reliable information through reciprocal, regular and effective communication helped build facilitator credibility which in turn improved the effectiveness of extension programs (Oladosu 2006; Sarker & Itohara 2009).

This study found that a lack of existing farmer knowledge and confidence can also negatively influence Non-user and Trialler farmer engagement with extension, as farmers perceive extension activities to be confronting as they may be asked to provide farm information or asked a question they may not be able to answer. This supports findings of Kilpatrick and Rosenblatt (1998) in that many farmers have an uncertainty or fear of being exposed to new knowledge or skills, and a preference for more informal learning. In contrast, Adapter farmers tend to have a higher level of existing knowledge and confidence, and are more open to learning and sharing farm information and figures. These findings also support those of McKenzie (2013) who, in a study of farmer driven innovation to address land degradation in New South Wales, Australia, concluded that knowledge seeking behaviour and a proactive approach to seeing information was positively linked to increased innovation on farm. In a study of adoption of decision support tools on dairy farms in New Zealand, Eastwood et al. (2016) found that adoption was negatively impacted by farmers lack of existing knowledge, and not having the skills required to make sense of and apply data resulted in non-adoption or dis-adoption.

SOCIAL INFLUENCE – Farmers' perceptions that they are experienced in pasture management, and that current pasture management training is for less experienced, younger farmers negatively influenced measurement intention and behaviour:

A common factor that negatively influenced Non-user and Trialler farmers decision to engage with pasture management activities, and therefore measuring pasture, was the social perception that experienced farmers do not need to measure pasture, and that current pasture management training is designed and targeted for less experienced, younger farmers or those new to the industry. Many farmers see themselves as experienced in pasture management, despite not having been through an extended period of measuring pasture with a tool. However, Non-user and Trialler farmers who have not been through an extended period of measuring pasture are likely to be less advanced in their pasture management ability, and less aware that they lack knowledge and skills required to implement recommended practices, compared to more advanced farmers who have been through an extended measuring process (Turner et al. 2019).

While this study found that a large proportion (86%) of farmers have engaged with general extension activities, and 76% with an activity focused specifically on pasture management, these are most likely to have been a short, one-off training session (such as a two-day workshop), as this is what has predominately been offered and available in the Tasmanian dairy industry. Knowledge intensive practices such as those involved in pasture management require a greater degree of supported farmer learning and skill development (Ingram 2008; Turner & Irvine 2017). Farmers who were motivated to start measuring pasture as a result of attending a pasture management course have not necessarily had the option of participating in ongoing pasture management training or coaching through public extension services, limiting farmer options for participating in an extended pasture management learning process. One-off extension sessions can create awareness about improving pasture management, and positively influence intentions to change practices, but are unlikely to support farmers in developing sufficient knowledge and skills needed to measure and manage pasture well.

PERCEIVED CONTROL – Perceived lack of accuracy of pasture measurement tools and challenge in applying calculations and data negatively influence measurement intention and behaviour:

The assumed lack of accuracy of pasture measurement tools was a perceived control factor identified as negatively influencing Non-user and Trialler farmers' decisions to measure pasture, and a reason why some farmers discontinued using a tool. The calculations associated with applying pasture measurement information and interpreting the information was a factor that also negatively impacted some Non-user and Trialler farmers' intentions to measure pasture, or decision to continue measuring. For farmers with low levels of literacy, or a disinterest in figures, undertaking calculations associated with pasture management recommendations can be particularly challenging, regardless of a positive attitude and intention towards measuring. This supports findings of Vanclay (2004), in that uncertainty about how to implement a technology and/or practice, or a lack of knowledge, skills and support to make associated changes, poses a significant challenge to adoption.

Level of formal education received was found to have a significant, positive relationship with current use in the preliminary survey, with farmers who had received formal education qualifications of Year 11 and/or 12 and equivalent (trade and/or apprenticeship), and diploma and/or university significantly more likely to current use a tool to measure pasture than farmers with qualifications of Year 10 or below, and certificate. This indicates that farmers who have received a higher level of formal education may have been more able to independently address challenges experienced or lack of knowledge, to a greater extent than those with a lower level of formal education. While pasture measurement tools are not completely accurate, operational difficulties and challenges associated with using measurement information may be overcome with support from ongoing extension sessions, coaching or consultancy advice, through supporting farmers to develop sufficient knowledge and skills needed to address challenges. However, it should also be recognised that some farmers have not always had access to supporting learning through extension, other than through the use of paid consultants, as these programs have not been offered in continuity. This has been recognised by RD&E organisations, who have addressed this with the re-introduction of pasture coaching training activities within the Tasmanian dairy industry (i.e. from 2016). This move towards knowledge exchange involving social interaction and farmer to farmer learning is recognised as an important component of agricultural extension, and a more effective means of farmer learning and knowledge development (Blackstock et al. 2010).

This research has highlighted the difficulties in re-engaging such farmers (i.e. Non-users and Triallers) in the pasture management learning process, particularly if they encountered challenges in using a tool to measure pasture or in applying that information to their farm, as they do not see the value in doing so. As suggested by Barr & Cary (2000), the view that changing these farmers' attitudes towards pasture management will lead to behaviour change (e.g. re-engaging with measuring pasture and a pasture management learning process) is too simplistic. Future pasture management training needs to target and address the social norms that have been revealed through the interviews: that dairy farmers are experienced in pasture management (regardless of the extent of knowledge and skill development acquired) and that training is for farmers who are inexperienced, young farmers, or new to the industry.

From these findings, preliminary recommendations to address the factors impacting farmers' decisions to measure pasture and engage with extension were developed. These include changes to extension content, marketing and delivery that could assist in overcoming perceived control and social factors.

Key questions that arose from the survey and interview results were: how can extension re-engage farmers who had started but not continued through a pasture management learning process, and encourage them to revisit measuring pasture for an extended period?; what would encourage farmers who have never measured pasture to start out on a pasture management learning process?; what would encourage farmers who aren't currently engaged with extension to attend an activity?; and what would encourage continued engagement for farmers who currently attend extension activities?

Recommendations for future extension activities to encourage farmer engagement with extension activities, measuring pasture and the pasture management learning process:

To be more effective it has been suggested that extension takes a more participatory approach, including farmers in informing research and extension methods and outcomes (Pannell et al. 2006). A participatory approach that places farmers at the centre of developing methods to address outcomes is likely to be more effective. This study used a participatory approach modifying the Delphi technique and asking interviewed farmers to prioritise future extension recommendations.

Recommendations and associated priority include:

- Introducing different levels of pasture management training that caters for experience level and past training (particularly lowering the complexity for less literate and inexperienced farmers) – high priority
- Introducing pasture management 'master classes' or activities with an advanced management component for farmers who consider themselves as experienced – high priority
- Requirement for ongoing, on-farm support to understand pasture management information, and not just providing data – high priority
- Identify and target motivating values in order to engage the Non-users sub-group – high priority
- Introduce a range of extension activities and group types, including some with a reduced focus on farm data and calculations – lower priority
- Using an expert speaker from outside the region – lower priority

Including farmers in the process of refining and prioritising recommendations for future extension increases confidence in the recommendations developed and enabled prioritisation of recommendations for different farmer sub-groups. Investment in activities that are targeted towards influencing farmers perceptions and motivating factors is more likely to influence adoption and lead to behaviour change (Llewellyn et al. 2005).

Limitations

This thesis has identified a range of factors that can influence farmers' decision making and adoption behaviour around the use of pasture measurement tools and associated recommended practices, and farmer engagement with extension activities. Through in-depth interviews with farmers, a greater understanding of how these factors can act to influence behaviour has been developed. However, this study recognises that not all Tasmanian dairy farmers may fit within identified sub-groups, and exhibit or share the same characteristics. Though it is ideal for farmers to progress through the sub-groups outlined in this study, as they learn pasture management principles and develop competency, some farmers' traditional segment characteristics may stay the same. For instance, allocation to sub-groups may be issue or topic specific, with attitudes to adoption or change dependent on the proposed practice (Waters et al. 2009; Cockfield & Doran-Browne 2018). The range of responses identified to some of the questions in the final Delphi survey indicate this, and though some farmers within a sub-group may support a recommendation, others may not.

The design and delivery of effective extension continues to be an area of interest worldwide, it is necessary to acknowledge that some farmers will remain unwilling to engage with extension activities and will not want to change practices, regardless of activity design, marketing or delivery. Some farmers are solitary, 'maintenance farmers' (Turner et al. 2017), who exhibit low levels of information seeking and do not want to make changes to their farming practices. For others, the higher level of human interaction associated with the coaching form of extension support does not sit well with their personality, particularly in the group settings of most publicly funded services (Shrapnel & Davie 2001; Cockfield & Doran-Browne 2018).

It should also be noted that the TPB is not without its limitations and criticisms. Some studies have been concerned with the potential introduction of bias, as many TPB studies use self-reporting to measure behaviour rather than using objective measures (Armitage & Conner 2001; Ogden 2003). Other studies have found intentions to be a poor predictor of behaviour, with an increasing number of events changing individuals beliefs, attitudes, social norms, and perceptions of control (Ajzen 2011). However, this study was not focused on predicting or quantifying the likelihood or outcome of adoption and decision making behaviour, but was concerned with identifying the factors that influence behaviour, and understanding how and why this occurs. For this reason, a qualitative approach using the TPB was used to explore decision making of farmer sub-groups based on existing practices and engagement. Traditional segments as proposed by Rogers (2003) were therefore not used to categorise farmers on their adoption behaviour characteristics and rate of adoption, and attention was similarly not paid to segmentation of farmers based on values. While this type of categorisation or segmentation has its benefits in identifying individuals who are likely to adopt a technology or practice first, the approach of this study aligns with Wilkinson's (2011) description of step-by-step adoption (that involves multiple phases, trialling, adaption and dis-adoption) that relates to knowledge-intensive practices like pasture management. Acknowledging that future pasture management extension needs to connect to an existing frame of reference to be effective (i.e. knowledge builds on existing knowledge), farmers in this study were categorised into sub-groups (Non-users, Triallers and Adapters) based on their knowledge, skills, practices and engagement as identified through the initial quantitative survey.

It should also be noted that additional factors could be identified that, while not exclusively included in the TPB, can influence farmers attitude, intention and social norms and thus adoption decision making and behaviour change. Further in depth studies that investigate the role of social networks, trust and role of farmers' prior knowledge or experience could uncover in greater detail how these factors may influence farmer behaviour.

Further Research

Future pasture management training will require a greater understanding of the level of information and knowledge required for different farmer sub-groups, and what gaps there are in management skills and ability, so training can be designed and targeted accordingly. This study found that there is need to identify sub-groups based on knowledge, learning and competency within farming populations, and recognise and understand that their motivational factors and perceptions will vary. Only through understanding these factors and how they vary between sub-groups, can specific designing and targeting of activities encourage farmers to engage with extension, or start out on and/or continue through a pasture management learning process.

Further social research is necessary to explore in detail the motivating factors impacting intention to engage with pasture management and extension activities for different sub-groups, in order to understand and target these factors. Further research into how these factors vary for different topics or innovations, and how they impact intention, is also necessary to understand farmer adoption and engagement behaviour.

The advancement and increased availability of emerging technologies such as remote sensing and pasture measurement technology and decision making tools (Eastwood et al. 2009; Tasmanian Institute of Agriculture 2019) offers an alternative to traditional measurement and management practices outlined in this study. However, measuring and monitoring of pasture growth with a more traditional tool for an extended period of time is recognised as an important part of the learning process, increasing farmers' knowledge and skills so that farmers can adapt and apply learning in different ways (Turner & Irvine 2017; Tasmanian Institute of Agriculture 2019). In addition, just providing or increasing access to remotely accessed pasture measurement data will not ensure its use or understanding by dairy farmers, particularly those with less advanced pasture management skills (such as those in the Non-users and Triallers sub-groups) and therefore needs to be introduced within a supported learning process in the future (Turner et al. 2019; Tasmanian Institute of Agriculture 2019). This study also found that many farmers agreed with the need to understand pasture measurement calculations that are associated with measuring and monitoring rather than just receiving the data, reinforcing the need for a supported process to increase farmers knowledge and skills in understanding, applying and adapting this information to their farm.

Methods used within this study, such as using the TPB to understand factors influencing adoption behaviour, can be applied to other areas of agricultural adoption research to increase understanding of factors influencing or constraining adoption and practice change. Gaining a greater knowledge and in-depth understanding of these factors through social research is essential for challenges to be addressed. Using methods such as the Delphi technique can also be applied to other research areas to involve farmers in a participatory process that can assist in developing more effective extension programs. Such an approach also can be incorporated in setting future research priorities and in evaluating extension programs, so they are more effective in meeting farmers needs and achieving desired outcomes.

Conclusion

Adoption of agricultural technologies is a complex process, influenced by multiple farmer, technology and innovation related factors. How these factors influence adoption decision making and behaviour is context specific, and an understanding of how they vary for different farming contexts, different types of technology, and for individuals is necessary to further develop our understanding of adoption more broadly.

The context of the research in this thesis was that recommended pasture measurement technologies and their use on dairy farms are relatively low risk and low cost. The associated management tools and practices have been promoted for decades in the Tasmanian dairy industry through publicly funded extension, and despite some farmers implementing these practices successfully, this research confirmed that adoption remains low among a significant proportion of Tasmanian dairy farmers. Natural diffusion has not occurred throughout the industry and pasture utilisation on many farms remains well below potential. There was therefore a need to understand why greater practice change has not occurred when the financial benefits from measuring pasture and improving pasture management practices have been clearly demonstrated.

The industry-wide survey was based on competency theory and captured the trialling pattern of many farmers (that has not led to practice change) and the importance of extension support in developing competence in pasture measuring and management. A qualitative approach to using the TPB then focused on farmer intentions and behaviours in relation to engagement with extension and adoption of pasture management practices. This applied social research did not delve into individual farmer motivations or farming styles, but developed an understanding of how attitudes, social norms and control factors influenced the intentions and behaviours of farmers at different stages of developing competency.

Despite many farmers having a positive attitude and intention towards measuring pasture and adopting associated management practices, perceptions of limited accuracy of measurement tools and difficulty in applying measurement information negatively impacted continued development through the pasture management learning process. While researchers may assume it is lack of time that prevents farmers from measuring pasture with a plate meter, this research suggests that 57% Tasmanian dairy farmers have not developed the knowledge and skills (competence) to measure pasture with confidence and use the data effectively in decision making. For many farmers, advisory support is required throughout a 12 month period to answer questions and address challenges encountered as they learn how to apply best practices (moving from conscious incompetence to conscious competence). For some farmers, their trialling of pasture measurement tools occurred during periods when this ongoing support through public extension services was not available, with training being predominantly delivered in the form of one or two day workshops. In contrast, those farmers who had been through an extended period of using a pasture management tool with the support of a coach or consultant, had overcome the challenges associated with measuring pasture and applying the information on farm. Farmers then had the capacity to adapt these practices throughout the seasons and some no longer relied on regular tool use (unconscious competence).

A key finding of this research was that many farmers who have not yet developed competency view themselves as experienced pasture managers. They believe they have sufficient knowledge and skills in pasture management and perceive the associated training to be designed for less experienced farmers. Raising awareness that these farmers lack some essential knowledge and skills and re-engaging them in the pasture management learning process will be challenging (i.e. moving into conscious incompetence). This view was found to be an ingrained social norm belief across the industry, and addressing it requires further development of extension delivery and content.

This research has provided new insights into how to target Tasmanian dairy farmers and used a modified Delphi approach (that involved farmers) to refine and prioritise recommendations for future extension. Recommendations include introducing different levels of pasture management training, including activities with lower complexity of calculations as well as 'master classes' for more experienced farmers. Providing ongoing on-farm support to understand pasture measurement and how to use the associated data is essential. Further research to identify farmers' motivating values outside of profitability will help engage a wider range of farmers to develop further competence.

The aim of future extension and pasture management training in the Tasmanian dairy industry is to support all farmers who have not yet gained competence through a pasture management learning process - increasing their knowledge and skills to enable behaviour change and adaptation of practices on-farm. This research quantified the extent of adoption of pasture management practices throughout the industry using competency theory, and through use of the TPB developed insights into the targeted support needed within different farmer subgroups to further develop farmers' knowledge and skills.

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Appendices

Appendix 1 – Pasture Management on Tasmanian Dairy Farmers, Survey 1 Participant Information Sheet

TASMANIAN INSTITUTE OF AGRICULTURE

TIA Dairy Centre

University of Tasmania

PO Box 3523 Burnie Tasmania 7320

Pasture Management on Tasmanian Dairy Farms – Farmer Survey

PARTICIPANT INFORMATION SHEET

Invitation

You are invited to participate in a farmer survey that is part of a research study that will explore the role and adoption of pasture management tools and technology on Tasmanian dairy farms. The study is being conducted by PhD student Alison Hall through the Tasmanian Institute of Agriculture (TIA) Dairy Centre and is funded by Dairy Australia. This PhD project is supervised by Dr Lydia Turner (Research Fellow with TIA Dairy Centre), Professor Sue Kilpatrick (Professor of Education, University of Tasmania), and Lesley Irvine (Development and Extension Leader of the TIA Dairy Centre).

What is the purpose of this survey?

The purpose of this survey is to identify what pasture management practices have been used in the past and at present, and the extent of adoption of associated tools and technology. This survey therefore includes questions around pasture management practices, use of tools, and participation in industry training activities.

Why have I been invited to participate in this survey?

All Tasmanian dairy farmers who are mainly responsible for pasture management on their dairy farm have been invited to participate in this study.

What will I be asked to do?

You are asked to fill out the survey provided and return it in the reply paid envelope. You may also receive a link via email to complete the survey online. The survey should take around 10-15 minutes to complete. There is the option to provide your name and contact details if you are willing to be contacted about participating in a follow up interview. There is no obligation to participate in an interview if you are contacted. If you provide your contact details, you also may be one of a small number of farmers invited to join a group to trial some pasture management technology and practices. There is no obligation to participate in the group if you are contacted. There is also no obligation to provide your name or contact information on the survey.

Are there any possible benefits from participation in this survey?

This survey is part of a social research PhD study and the Dairy on PAR project, which have been designed to ensure dairy farmer levies are spent efficiently and effectively. By participating in this study your experience and knowledge will help ensure that future RD&E projects meet the needs of Tasmanian farmers and subsequently maximise the productivity and profitability of our dairy farms.

Are there any possible risks from participation in this survey?

While the information you provide does not pose any risk to you, it is important for potential participants to know that all information will be treated in a confidential manner, and your name will not be used in any publication arising out of the research.

What if I change my mind during or after the survey?

While we would be pleased to have you participate, this is a voluntary study and we respect your right to decline. There will be no consequences if you decide not to participate. If you choose to provide your name and decide to discontinue participation, you may do so within one month of participating, and you may do so without providing an explanation and your data will be withdrawn.

What will happen to the information when this survey is over?

All hardcopy research documentation will be kept in a locked cabinet and all electronic research documentation will be stored in a password protected confidential folder on the UTAS server for a duration of 5 years, after which the data will be destroyed. The survey results (not including any farmer names) will be reported to Dairy Australia to aid future decision making about RD&E project funding, may be extended to the general public if relevant, and will be written up in a thesis and the academic literature.

What if I have questions about this study?

If you would like to discuss any aspect of this study, please contact Alison Hall, by phone or email (03 6430 4525; A.F.Hall@utas.edu.au) at any time.

This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, you should contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants and you will need to quote H0015858.

Thank you for taking the time to consider this study. If you wish to take part in it, please complete and return the survey in the supplied envelope.

This information sheet is for you to keep.

Kind Regards,

Alison Hall

Appendix 2 – Pasture Management on Tasmanian Dairy Farms, Survey 1

Pasture Management on Tasmanian Dairy Farms

Hi, my name is Alison Hall, and I am studying a PhD with the Tasmanian Institute of Agriculture Dairy Centre, at the University of Tasmania. This survey forms the initial part of my PhD research project, which is investigating the use of pasture management practices, tools and technology, and engagement with industry extension and training activities.

Take a break, enjoy a Kit Kat and use the pen included to fill in this short survey.

We would like the person who is mainly responsible for, and/or makes decisions about pasture management on your dairy farm to complete this survey, which should take approximately 10 minutes. A reply paid envelope has been included so you can return your completed survey.

Section A: Demographics

A1. Are you:

- Male ☐
- Female ☐
- Other ☐

A2. Please select your age group from the following:

- Less than 20 ☐
- 20-35 ☐
- 36-50 ☐
- 51-65 ☐
- Over 65 ☐

A3. **What is your role on your farm?**

- Owner/operator ☐
- Share farmer ☐
- Manager ☐
- Assistant manager ☐
- Farm hand/employee ☐
- Other ☐

Other

A4. **What region/town is your farm located in? For example, Deloraine, Meander, Smithton.**

A5. **How many years have you been dairy farming?**

A6. **For how many years have you been responsible for and/or making decisions about pasture management?**

A7. **What is the size of your milking area? Please specify if acres or hectares.**

A8. **What was your peak number of cows milked in the 2014/15 season?**

A9. **Typically, what is your level of concentrate feeding?**

- Less than 500kg/cow/year ☐
- 500-1000kg/cow/year ☐
- 1001-2000kg/cow/year ☐
- More than 2000kg/cow/year ☐

Section B: Extension, Education & Training

B1. What level of formal education have you received?

- Year 10 or below ☐
- Year 11 and/or Year 12 ☐
- Certificate ☐
- Diploma ☐
- Trade/apprenticeship ☐
- University ☐

B2. Typically, how often would you attend a dairy industry extension activity (for example, discussion groups, workshop, field day)?

- Never ☐
- Once a year ☐
- 2-4 times a year ☐
- More than 4 times a year ☐

B3. Have you ever attended an activity that was specifically focused on learning about pasture grazing management?

- Yes ☐
- No ☐

B4. If yes, what activity was it?

Tick all that apply

- 20.12 pasture business program (with pasture coaching groups or 1:1 consultancy) ☐
- Pasture management workshop (one or two day workshop) ☐
- Other ☐

Other

B5. In the next 12 months, do you plan on attending any pasture management activities, such as a course or workshop?

- Yes ☐
- No ☐
- Maybe ☐

B6. **Have any of the pasture management activities you have attended led you to do any of the following:**

Tick all that apply

- ☐ Change the way you carry out grazing management?
- ☐ Purchase a pasture measurement tool (e.g. plate meter, CDAX bike reader)?
- ☐ Start using a tool to measure pasture dry matter?
- ☐ Other

Other

B7.

How confident are you about your pasture management skills? Rank on a scale of 1 to 10, with 1 being a very low level of confidence and 10 being very high level of confidence.

1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

B8. **Have you ever participated in a business benchmarking program?**

- ☐ Yes
- ☐ No

B9. **If yes, in which of the previous years have you participated?**

Tick all that apply

- ☐ 2014/15
- ☐ 2013/14
- ☐ 2012/13

Section C: Pasture Management

C1. **Do you own any of the following?**

Tick all that apply

- ☐ Plate meter
- ☐ CDAX bike reader
- ☐ Pasture probe
- ☐ Pasture ruler
- ☐ I don't own any of the above

C2. In the past, have you ever used, tried out or tested a pasture measurement tool (e.g. plate meter, CDAX bike reader, etc.) on your farm?

- Yes ☐
- No (go to question C4) ☐

C3. When you have used a pasture measurement tool in the past, have you:

Please select one

- Tried out a plate meter or other pasture measurement tool on your farm (e.g. tried it for a short period of time)? ☐
- Used a tool to measure pasture consistently (at least once every 14 days) for 6 to 12 months? ☐
- Used a tool to measure pasture consistently (at least once every 14 days) for 12 months or more? ☐
- Used a tool to measure pasture at particular times of the year (e.g. spring) ☐

C4. Have you ever contracted someone outside your immediate farm team to measure pasture on your farm?

- Never ☐
- Once ☐
- Occasionally ☐
- Often ☐

C5. Do you, or someone else, currently use any of these tools on your farm?

Tick all that apply

- Plate meter ☐
- CDAX bike reader ☐
- Pasture probe ☐
- Pasture ruler ☐
- Never use a tool to measure pasture cover (go to section D) ☐

C6. Do you currently use a tool (e.g. plate meter, CDAX) to measure individual paddocks to determine average pasture cover across your whole farm?

- Yes ☐
- No (go to question C10) ☐

C7. If yes, how many paddocks do you measure?

Tick all that apply

- All milking area paddocks only ☐
- All milking area and runoff paddocks ☐
- Top (pre grazing) 3-5 and bottom (just grazed) 3-5 paddocks ☐
- Other ☐

Other

C8. How often do you use a tool to measure the pasture cover of individual paddocks to work out average pasture cover across your whole farm?

Please select one

- Weekly ☐
- Fortnightly ☐
- Monthly ☐
- Particular times of the year (e.g. spring) ☐
- Other ☐

Other

C9. If you are measuring individual paddocks, what do you usually do with the data collected?

Please choose the most appropriate answer

- Nothing ☐
- Keep values in mind to help guide decisions ☐
- Write values down on paper and use them to make calculations ☐
- Put values into my own computer spreadsheet ☐
- Put values into a program or app that came with my pasture measurement tool ☐
- Put values into a freely available program or app that I sourced myself ☐
- Put values into a commercial program or app that has been purchased separately ☐
- Other ☐

Other

C10. Do you currently use a tool to measure pre grazing cover ONLY (that is, you only measure just before the cows go in to graze)?

- Yes ☐
- No (go to question C12) ☐

C11. If yes, how often do you measure pre grazing cover?

Please select one

- Always measure each paddock just prior to cows grazing ☐
- Measure the next few paddocks to be grazed ☐
- Particular times of the year ☐
- Other ☐

Other

C12. Do you currently use a tool to measure post grazing residuals ONLY (that is, you only measure after the cows have grazed a paddock)?

- Yes ☐
- No (go to C14) ☐

C13. If yes, how often do you measure post grazing residuals?

Please select one

- Always measure after cows have grazed a paddock ☐
- Measure several paddocks a week after cows have grazed them ☐
- Particular times of the year (e.g. spring) ☐
- Other ☐

Other

C14. If you measure pre and/or post grazing covers, what do you usually do with the data collected?

Please choose the most appropriate answer

- [ ] Nothing
- [ ] Keep values in mind to help guide decisions
- [ ] Write values down on a piece of paper and use them to make calculations
- [ ] Put values into my own computer spreadsheet
- [ ] Put values into a program or app that came with my pasture measurement tool
- [ ] Put values into a freely available program or app that I sourced myself
- [ ] Put values into a commercial program or app that has been purchased separately
- [ ] Other

Other

C15. To what extent have the following information sources contributed to you using a pasture management tool on your farm?

	No role	Small role	Moderate role	Large role
Talking to other farmers	☐	☐	☐	☐
Consultant/advisor	☐	☐	☐	☐
Pasture management workshop	☐	☐	☐	☐
20.12 pasture coaching program	☐	☐	☐	☐
Business benchmarking program	☐	☐	☐	☐
Field days and/or discussion groups	☐	☐	☐	☐
Internet	☐	☐	☐	☐
Newsletters, books, other publications	☐	☐	☐	☐
Other	☐	☐	☐	☐

C16. If you have selected other, please specify:

Section D: Grazing Decisions

D1. How do you usually determine how much supplement to feed?

- From measuring average pasture cover across my whole farm ☐
- From measuring pre and/or post grazing residuals ☐
- Eyeball of pre and/or post grazing cover ☐
- Dropping milk levels in vat ☐
- Observing cow behaviour ☐
- I usually feed a set amount of supplement ☐
- Other ☐

Other

D2. How do you usually make decisions about rotation length?

- My rotation length doesn't change very much, or I use a set rotation ☐
- Adjust it according to changes in seasonal conditions ☐
- Physically assess leaf stage in the paddock every 1 to 2 weeks ☐
- Use the TIA research farm report or online leaf stage calculator ☐
- Other ☐

Other

D3. How do you assess what the pre grazing cover of a paddock is (that is, how much pasture is in a paddock before the cows go in to graze)?

Please select the most appropriate answer.

- I don't assess pre grazing cover ☐
- Always measure pre grazing cover with a pasture measurement tool ☐
- Use figures from a regular farm walk ☐
- Assess pre grazing cover by eye ☐
- Assess pre grazing cover by eye and occasionally check with a pasture measurement tool ☐
- Other ☐

Other

D4. **How do you assess post grazing residual length in a paddock (cover after cows have grazed)?**

Please choose the most appropriate answer.

- I don't assess post grazing residuals ☐
- Always measure post grazing residuals with a pasture measurement tool ☐
- Use post grazing residual measurements taken from a regular farm walk ☐
- Assess post grazing residuals by eye ☐
- Assess post grazing residuals by eye and occasionally check with a pasture measurement tool ☐
- Other ☐

Other

D5. **If post grazing residuals are too high in a paddock, what immediate action do you typically take?**

Please choose the most appropriate answer

- Nothing ☐
- Put all the cows back in that paddock to graze further ☐
- Put some of the cows back in that paddock to graze further ☐
- Top that paddock using a mower or slasher ☐
- Other ☐

Other

Thank you.

Contact Information:

By providing your name and contact information, you are willing to be contacted about participation in a follow up interview. When contacted, you may accept or decline the invitation.

Your name and contact information will not be provided to anyone outside the project research team, and your personal details will be stored separately to your survey responses.

Name:

Phone number:

Email address:

Appendix 3 – Interview Information Sheet

TIA Dairy Centre

University of Tasmania

PO Box 3523 Burnie Tasmania 7320

'Technology in Tasmanian dairy farming: Exploring and optimising its role and uptake for improved pasture management'

Farmer Interviews

PARTICIPANT INFORMATION SHEET

Invitation

You are invited to participate in a research study that will explore the social processes and factors that influence the adoption and implementation of pasture management tools and technology on Tasmanian dairy farms, in addition to those factors that influence farmer engagement in industry extension activities.

This study is being conducted by Alison Hall from the Tasmanian Institute of Agriculture (TIA) Dairy Centre. This is a PhD research project that is part of the larger TIA Dairy on PAR project, funded through Dairy Australia. This PhD project is supervised by Dr Lydia Turner (Research Fellow with TIA Dairy Centre), Professor Sue Kilpatrick (Professor of Education, University of Tasmania), and Lesley Irvine (Development and Extension Leader of the TIA Dairy Centre).

What is the purpose of this study?

The purpose of this study is to gain a greater understanding of what factors influence the process of technology adoption, implementation and decision making on dairy farms with regards to pasture management, how these factors interact to influence this process; in addition to what factors influence farmer engagement and participation in industry extension activities. These interviews will build on existing farmer learning and adoption research, and provide insights into how future projects can be developed to support increased on farm change, productivity and profitability in the future.

Why have I been invited to participate in this study?

You have been invited to participate in this study because you are a Tasmanian dairy farmer, who has indicated willingness to be contacted about participating in this study by providing your name and contact information and responses to the survey that made up the initial phase of this project.

What will I be asked to do?

Participating in this phase of the study will involve you being interviewed about your past and current approach to pasture management, what factors have

influenced your pasture management practices, and how they have influenced your pasture management and decision making. In addition, the interview will cover what involvement you have had in industry extension activities and why you have or haven't participated.

The interview will take around 60-90 minutes, will be conducted one-on-one with the researcher either on your farm, or in a café conveniently located for you,

depending on your preference. The interview will be audio recorded for transcription and accuracy purposes.

Are there any possible benefits from participation in this study?

The Dairy on PAR project, including this social research PhD study, has been designed to ensure dairy farmer levies are spent efficiently and effectively. By participating in this study your experience and knowledge will help ensure that future RD&E projects meet the needs of Tasmanian farmers and subsequently maximise the productivity and profitability of our dairy farms.

Are there any possible risks from participation in this study?

It is important for potential participants to note that although all information will be treated in a confidential manner to protect privacy (i.e. your name will not be used), it is possible that some information shared could make you identifiable given the relatively small number of farmers participating in this stage of the study (20-30 Tasmanian dairy farmers). In the unlikely event of this occurring, the investigators do not foresee that this would be a cause for distress, given the non-threatening nature of the information being sought.

What if I change my mind during or after the study?

While we would be pleased to have you participate, this is a voluntary study and we respect your right to decline. There will be no consequences if you decide not to participate. If you decide to discontinue participation at any time prior to the information being published, you may do so without providing an explanation and the data you have provided will be withdrawn.

What will happen to the information when this study is over?

All information will be treated in a confidential manner, and your name will not be used in any publication arising out of the research. All hardcopy research documentation will be kept in a locked cabinet and all electronic research documentation will be stored in a password protected confidential folder on the UTAS server for a duration of 5 years, after which the data will be destroyed. The project results will be reported to Dairy Australia to aid future decision making about RD&E project funding, may be extended to the general public if relevant, and will be written up in the academic literature.

What if I have questions about this study?

If you would like to discuss any aspect of this study, please contact Alison Hall, by phone or email (03 6430 4525; A.F.Hall@utas.edu.au) at any time.

This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study you should contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants and you will need to quote H0015858.

Thank you for taking the time to consider this study. If you wish to take part in it, please sign the attached consent form.

This information sheet is for you to keep.

Appendix 4 – Interview Consent Form

TIA Dairy Centre

University of Tasmania

PO Box 3523 Burnie Tasmania 7320

'Technology in Tasmanian dairy farming: Exploring and optimising its role and uptake for improved pasture management'

Farmer Interviews

CONSENT FORM FOR PARTICIPANTS

1. I have read and understand the 'Information Sheet' for this project and agree to take part in the research study named above.
2. The nature and possible effects of the study have been explained to me.
3. I understand that if I participate in this study, it will involve one 60-90 minute meeting with a researcher to talk about my approach to decision making and adoption of technology with regards to pasture management, in addition to talking about my engagement with industry extension.
4. I understand that the interview will be audio taped for transcription purposes and to ensure accuracy.
5. I understand that all research data will be securely stored on the University of Tasmania premises for a duration of 5 years, after which the data will be destroyed.
6. I agree that any questions that I have asked have been answered to my satisfaction.
7. I understand that the results of the study will be published without naming participants, however acknowledge that due to the small number of participants there is an unlikely chance I may be identifiable by those with prior knowledge about me.
8. I understand that the risk of participation is therefore minimal. While it is possible that the information provided will make me identifiable (despite privacy and confidentiality measures being taken by the investigators), the nature of the information being provided should not pose any foreseeable risk to me.
9. I understand that participation is voluntary and that I may withdraw at any time before information is published without any effect; data I have supplied to date may be withdrawn from the research.

Name of Participant:

Signature: Date:

Statement by Investigator

☐ I have explained the project & the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation

If the Investigator has not had an opportunity to talk to participants prior to them participating, the following must be ticked.

☐ The participant has received the Information Sheet where my details have been provided so participants have the opportunity to contact me prior to consenting to participate in this project.

Name of investigator ____________________

Signature of investigator ____________________ Date ____________

Appendix 5 – Interview Schedule

TIA Dairy Centre

University of Tasmania

PO Box 3523 Burnie Tasmania 7320

'Technology in Tasmanian dairy farming: Exploring and optimising its role and uptake for improved pasture management'

INTERVIEW SCHEDULE

CONTEXTUAL:

To start with, can you please tell me a bit about your farm?

Probe: Land size, no cows, irrigation & dairy infrastructure. Any other enterprises apart from dairy?

How long have you been dairy farming? Your family/company?

Do you make decisions about farm management on your own?
If No, who helps you?

What do you find the most challenging aspect of managing your farm?

What do you enjoy most about being a dairy farmer?

If you had more time in your week, what do you think you would spend that time doing?

Where do you get advice and information from, to help you manage your farm?
Probe:
Workshop/events
On-going farmer groups
Professionals (i.e. accountant, consultant, stock agents, dairy company extension officers)
Farm management team members
Other farmers
Field trips in Australia and overseas
Written material (i.e. web/books/newsletters/journals)

PASTURE MANAGEMENT:

Can we discuss in more detail your approach to pasture management?

Thinking about the last 'typical' season on your farm, can you explain how you currently approach pasture management on your farm?
Prompt: Setting your rotation, measuring average pasture cover, measuring residuals, subdividing paddocks, feeding supplements

Do you currently measure pasture cover on your farm, using a tool such as a plate meter or CDAX?

<u>If YES:</u>

Which one?

When did you first purchase your pasture measurement tool?

What prompted you to do this?

Did you start using this tool after purchasing it?
What motivated you to start using a tool?
Why and how did this motivation occur?
Did this motivation continue?
How often to do use this tool?

When/how frequently do you use this tool?

Attitudes:

What do you see as the advantages of using a tool (plate meter/CDAX) to measure pasture?

What do you enjoy about using a tool to measure pasture?

What do you see as the disadvantages of using a tool (plate meter/CDAX) to measure pasture?

What do you dislike about using a tool to measure pasture?

What has influenced your decision to use a plate meter/CDAX?

Did anything else influence your decision to use a tool to measure pasture?

Where did you learn about using a plate meter/CDAX to measure pasture?

Subjective norms:

Are there any individuals or groups of people who have influenced your decision to measure pasture, using a plate meter/CDAX? *E.g. family, dad, employees, etc.*

To what extent have these people or groups influenced your decision to measure pasture using a tool? *Prompt: have some people or groups had greater influence compared to others?*

Do they still have an impact on the decisions you make around managing pasture? If no, why/why not, are there others?

Do you feel any social pressure to measure pasture?

Does what other farmers are doing (using, or not using, a tool to measure pasture) important to you and what you do in terms of pasture management?

Who are the individuals or groups who would approve or think you should use a tool to measure pasture?

Have the things that have influenced your decision to use a plate meter/CDAX changed from when you started using this tool?

What do you usually do with the information or data you collect?

E.g. use a computer program for feed budgeting, use paper to make calculations?

Does this information assist you with making decisions?

What sort of decisions does and doesn't it assist with?

How does it assist?

Do you keep any other pasture records?

If yes, what are they? How are they used?

Do they help in decision making and approach to pasture management?

Were there any challenges in learning how to use the tool?

Prompt: if yes, what were they and how did you resolve these?

Are you still using the tool or measuring in the same way as when you first started?

Prompt: If not, how has your use changed over time?

Do you think you will continue to measure pasture?

Why or why not?

What is likely to change this?

If you no longer use a tool, how long did you use it for and why did you stop?

Prompt: Is there anything that would have helped you continue using it after your purchase - was there information or support missing?

Perceived behavioural control:

What factors or circumstances made (or would make) it easy, enable or encourage you to use a tool to measure pasture?

What factors or circumstances make (or would make) it difficult or prevent you from using a tool to measure pasture?

Have you ever considered paying someone else to measure pasture cover for you on a regular basis?

If yes, what were the reasons for this?

Do you still pay someone to do this for you? Why/why not?

Would you consider it? Why/why not?

If you could receive weekly growth rate data and/or pasture cover for your farm for free, how do you think you might use it?

How might this information be incorporated into your management and decisions?

What kind of decisions would/might it help with?

If there was free data available to you, and/or a program on using this data, what would you want it to look like?

Are there others that you know that purchased a tool but don't use it?

Why do you think that is?

Do you think you could improve your pasture management and pasture consumption?

If yes, what would help you?

Prompts: data availability and delivery, ease of understanding, follow up support?

Are there any programs or apps that you currently use to help make pasture management decisions?

In general, what do you think is the biggest limitation to increasing pasture consumption on Tasmanian dairy farms – not just your own farm, but also other farms?

Attitudes:
Is there anything else that comes to mind when you think about using a tool to measure pasture?

If NO:

Have you ever used a tool in the past?

If yes, which one?

How did you use it?

Prompt: tried or tested it for a short period of time, used it consistently (at least once every 14 days) for 6 to 12 months, used it consistently for 12 months or more, used at specific times of the year, e.g. spring?

If you have used a tool previously to measure pasture, did you do anything with the information? E.g. keep records etc.

If yes, did this information assist your decision making?

Did you use this information in your decision making?

Do you currently keep any pasture records?

If yes, what are they? How are they used? Do they help in decision making and approach to pasture management?

Have you ever considered paying someone else to measure pasture cover for you on a regular basis?

If yes, what were the reasons for this?

Do you still pay someone to do this for you? Why/why not?

Would you consider it? Why/why not?

Attitudes:
What do you see as the advantages of using a tool to measure pasture, if any? What do you see as the disadvantages of using a tool to measure pasture?

If you could receive weekly growth rate data and/or pasture cover for your farm for free, would you be interested?

If yes, how do you think you might use it? Prompt: anything you would specifically like to do with this data, if it was available? How would you imagine incorporating it into your management and decisions?
What would you want the data and/or program on using this data to look like?

If no, any reasons why?

Subjective norms:

Are there any individuals or groups of people who have influenced your decision not to measure pasture using a plate meter/CDAX?

To what extent have these people or groups influenced your decision to use a tool? *Prompt: have some people or groups had greater influence compared to others?*

Do they still have an impact on the decisions you make around managing pasture? If yes, how? If no, why/why not, are there others?

Do you feel any social pressure to measure or not measure pasture?

Does what other farmers are doing (not using, or using, a tool) important to you and what you do in terms of pasture management?

Who are the individuals or groups who would approve of not using, or think you shouldn't use, a tool to measure pasture?

If you don't own or use a measuring tool, are there other farmers that you know of that do use a measuring tool?

Do you think it works well for them?

Are there others that you know that purchased a tool but don't use it?

Why do you think that is?

Intention:
How likely is it that you would start using a plater meter or CDAX to measure pasture in the future?

Would anything be likely to influence this decision? Why or why not?

What might motivate you to start using a tool to measure pasture?

Is it something you have thought about but not tried? Why or why not? E.g. barriers, missing information, confidence, time, couldn't see the relevance etc.

Perceived behavioural control:

What factors or circumstances make (or would make) it difficult or prevent you from using a tool to measure pasture?

What factors or circumstances made (or would make) it easy, enable or encourage you to use a tool to measure pasture?

Do you think you could improve your pasture management and pasture consumption?

If yes, what would help you?

Prompts: data availability and delivery, ease of understanding, follow up support?

Are there any programs or apps that you currently use to help make pasture management decisions?

In general, what do you think is the biggest limitation to increasing pasture consumption on Tasmanian dairy farms – not just your own farm, but also other farms?

Attitudes:
Is there anything else that comes to mind when you think about using a tool to measure pasture?

PROCESS OF CHANGE:

Let's move onto talking about how you approach making changes on your farm. Start by thinking back to when you first started managing pastures:

Can you describe what your approach was when you first began measuring pasture?

Where did you learn or pick up this knowledge and skills?

What practices have changed with your approach to pasture management since then?

What knowledge and skills have changed? Where did you pick up or learn information and skills to change what you are doing?

Can you choose one significant change to your pasture management over the last 5 to 10 years?

Prompt: Managing rotation/residuals, inputs, irrigation, supplement use

If no change – did you try something, why or why not, did something not work, did you want to try something but couldn't? Was something missing that prevented you from making the change?

Where did you get the idea that led you to make the change?

Probe: person, media, other source

Did you get any extra information or support before making the change?

How did you go about making the change?

What kind of benefits/differences do you see on your farm now as a result of the changes that have been made?

How long was it before you started seeing some results? Do you think something would have aided this?

Are there further changes in this area that you'd like to make in the future?

If yes: what, why, when, why not yet?

Was there something you would have liked to try, but didn't?

If yes: what, why, when, why not?

Was there something you have tried, and not continued with?

If yes: what, why, when?

Are you satisfied with how your pastures are performing?

Do you think you could improve?

If yes, how do you think you could improve? Are you missing something to do this, e.g. support, information?

What would motivate you to make a change, big or small?

What about your farm and business performance in general?

Do you think you could improve?

> If yes, how do you think you could improve? Are you missing something to do this, e.g. support, information?
>
> What would motivate you to make a change, big or small

EXTENSION:

Can we talk about extension activities now?

What industry extension activities do you attend, if any?

Prompts: discussion groups, field days, workshops, online training, webinars etc.

If yes to attending, what influences your decision to attend an extension activity?

> Is there something that motivates you to go?
>
> Do other people (farmers, friends, family) influence your decision to attend extension activities?
>
> To what extent do/have other people influence your decision to attend extension activities?
>
> Do you feel any social pressure to attend extension activities?

If no to attending, why not?

Prompts: delivery method, types of events, information given, etc?

Attitudes:

What do you see as the advantages of attending extension activities?

What do you see as the disadvantages of attending extension activities?

Are there other activities you prefer?

Why or why not?

Have you been to these often, had much follow up, etc?

Have you been in the past but no longer attend?

Prompts: did something change? What impacted this?

Perceived behavioural control:

What factors or circumstances make, or would make, it difficult or prevent you from attending extension activities?

What factors or circumstances would make it easy, enable or encourage you to attend?

Would you attend something different? Does something prevent you from going that could be changed? Such as?

Do you feel like you could make changes as a result of attending? Is the information relevant to you?

What has motivated or continues to motivate you to attend? Has this changed over time?

Is there a type of event you prefer?

Prompts: current events, future events, topics, speakers, locations. Mode of delivery, type of information etc.

What kind of activities have you found the most useful? What format is best for what topics?

Do or have any of these activities motivated you to go to other events? Why or why not?

What information sources have you found particularly helpful when it comes to pasture management?

Have you been to any specific pasture management courses or workshops?

Prompts: 20.12 pasture business management course, one or two day pasture management workshop. If no, is there something specific you would attend if it was offered?

Has attending extension activities changed how you manage pasture on your farm?

Yes/no; what, when, why, how? Has it had an impact?

Is there something you think would assist you to change how you manage pasture on your farm?

What would motivate you to go to something that would achieve that?

What is the biggest impact extension has had on your farm business?

How do you think extension could impact on your business?

What would encourage you to make a change? What would this take?

How do you think we can get more people involved in extension activities?

What would make you get involved?

Attitude:

Is there anything else that comes to mind when you think about extension activities and attending them?

CLOSING: What has the biggest influence on your farm business success?

Key Information Checklist:

- Do they measure pasture?
- What do they do in terms of pasture management?
- What is their attitude to pasture management?
- Who or what has impacted or influenced decision to measure and manage pasture?
- Do they engage in extension?
- What is their attitude towards extension?

Appendix 6 – Pasture Management on Tasmanian Dairy Farms, Farmer Survey 2 Participant Information Sheet

TIA Dairy Centre

University of Tasmania

PO Box 3523 Burnie Tasmania 7320

Pasture Management on Tasmanian Dairy Farms – Farmer Survey 2

PARTICIPANT INFORMATION SHEET

Dear xxx

Previously, you participated in a farmer survey and a follow up interview as part of my PhD project. This project is exploring the role and adoption of pasture management practices on Tasmanian dairy farms, what factors have impacted on this, and what factors influence farmer engagement with extension activities. Thank you for your willing involvement in my PhD study to date.

As a result of these surveys and interviews, I have developed draft recommendations for future extension activities, particularly those focused on pasture management training. Enclosed with this letter is a second survey. I would appreciate it if you could take a few minutes to complete this final survey which will help me refine and prioritise the recommendations. These will then be provided to extension providers to be implemented in future extension activities.

What is the purpose of this survey?

The survey has a series of statements based on information collected through the interviews. Each statement asks you to tick a box on a scale of 'strongly disagree' to 'strongly agree'. Your answers will help me to refine and finalise the draft recommendations.

What will I be asked to do?

You are asked to fill out the survey provided and return it in the reply-paid envelope. While your participation is valued and appreciated, this survey is voluntary. The surveys have been numbered according to codes that were attributed to each participant during data analysis. Your individual answers will remain unidentifiable in any outputs from this study.

Are there any possible benefits from participation in this survey?

This survey is part of a social research PhD study in the Dairy on PAR project. By participating in this study, your experience and knowledge will help ensure that future RD&E projects meet the needs of Tasmanian dairy farmers to help improve the productivity and profitability of dairy farms.

Are there any possible risks from participation in this survey?

While the information you provide does not pose any risk to you, it is important for potential participants to know that all information will be treated in a confidential manner, and your name will not be used in any publication arising out of the research.

What if I change my mind during or after the survey?

While I would be pleased to have you participate, this is a voluntary study and I respect your right to decline. There will be no consequences if you decide not to participate. If you choose to provide your name and decide to discontinue participation, you may do so within one month of participating, and you may do so without providing an explanation and your data will be withdrawn.

What will happen to the information when this survey is over?

All hardcopy research documentation will be kept in a locked cabinet and all electronic research documentation will be stored in a password protected confidential folder on the UTAS server for a duration of 5 years, after which the data will be destroyed. The survey results (not including any farmer names) will be reported to Dairy Australia to aid future decision making about RD&E project funding, may be extended to the general public if relevant, and will be written up in a thesis and the academic literature.

What if I have questions about this study?

If you would like to discuss any aspect of this study, please contact Alison Hall, by phone or email (03 6430 4525; A.F.Hall@utas.edu.au) at any time.

This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study you should contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants and you will need to quote H0015858.

Thank you for taking the time to consider this study. If you wish to take part in it, please complete and return the survey in the supplied envelope. Returning this survey confirms your consent for the information you have provided to be used in this research.

This information sheet is for you to keep.

Kind Regards,

Alison Hall

Appendixes 7 – Pasture Management on Tasmanian Dairy Farms, Survey 2

Pasture Management on Tasmanian Dairy Farms – Survey 2

Thank you for your participation in my PhD project to date.

This survey is a follow on from the interview you participated in last year and is the final part of my PhD. Your answers to the following survey, if you are willing to participate, will be used to refine and prioritise recommendations that will assist in developing future extension activities for the Tasmanian dairy industry.

A reply-paid envelope has been included so you can return your completed survey.

Please rate the following statements according to how strongly you disagree or agree with them by ticking the most appropriate box for you.

Questions:

1. I could benefit from additional pasture management training

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

2. I consider myself to be experienced in pasture management

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

3. The current pasture management training I see offered isn't suitable or applicable to me

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

4. The current pasture management training I see offered is better suited for young or less experienced farmers

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

5. I would be interested in advanced pasture management training, or a pasture management master class

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

6. I think it is important to understand how to do pasture management calculations rather than just getting the data from a calculator, app or program

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

7. I am more likely to assess my pasture and how much is available for my cows by looking at the height than using figures and calculations

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

8. I am more likely to attend an activity on pasture management if I know it doesn't involve calculations

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

9. I would be more likely to attend an activity on feeding my cows better than an activity focussed on pasture management

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

10. Knowing I have fed my cows well is more important to me than achieving a particular grazing residual

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

11. I am more likely to attend an activity if it is with people I know rather than people I don't know

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

12. I am more likely to attend an activity if I know it is with people who have a similar level of experience to me

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

13. I am more likely to attend an activity if I know I won't be asked to share figures about my farm

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

14. When learning about pasture management, I prefer one-on-one training (for example with a consultant or mentor) than group training

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

15. I am more likely to attend an activity if there is a guest speaker from outside my region presenting

❑ Strongly disagree	❑ Disagree	❑ Neither disagree or agree	❑ Agree	❑ Strongly agree

Returning this survey confirms your consent for the information you have provided to be used in this research.

Thank you.