Measuring change in farmers’ self-efficacy within the context of managing perennial summer forage crops

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Abstract

There is a continual need to consider ways of improving agricultural extension as concern is expressed with the slow farmer uptake of complex new agricultural technologies. Existing agricultural extension research suggests psychological drivers, such as farmers' self-efficacy beliefs, may be a key variable influencing farmers' adoption of new technologies. The focus of this study was to firstly measure change in farmers' self-efficacy as they participated in an innovative agricultural extension programme designed to support learning about the management of perennial summer forage crops (PSF). The second aim was to identify factors that may have enhanced or undermined changes in the farmers' efficacy beliefs in this domain. Finally, this study aimed to explore how changes in farmers' self-efficacy might influence their future practice. The participants in this study were thirty-five sheep and beef farmers from the Hawkes Bay, Manawatū and Wairarapa regions of New Zealand. The Riverside Farmer Learning Project (RFLP) provided the platform on which to measure change in farmers' self-efficacy.

A multiphase mixed methods research approach was adopted for this study. A Farmer Self-Efficacy Measurement survey (FSEM) was developed to measure change in farmers' self-efficacy within the domain of managing PSF. Semi-structured interviews, focus group discussions and field observations provided the opportunity to identify factors that enhanced or undermined changes in farmers' self-efficacy to manage these forage crops.

This study found that farmers' self-efficacy increased during their 18-month involvement in the RFLP. The project's collaborative style of knowledge sharing, as well as the opportunity to observe and share experiences with valued peers served to enhance the farmers' self-efficacy and facilitated new learning about managing PSF. A lack of easily sourced, scientifically robust information concerning the economic effect of PSF weed and plant health management served to undermine the farmers' self-efficacy within this domain. These new understandings and increased self-efficacy beliefs supported improved practices that lead to the potential to increase farm production. The results of the study suggest that a farmer's belief in their ability to initiate change in the future is reliant on past successes that employed practices based on scientific evidence. The study also suggests that vicarious experiences are important for farmers where they can observe and talk about the practices of other farmers who have successfully made changes within their farm system, and engage in dialogue with scientists whose research interests focus on the domain of farmer learning. Considering how farmers' new understandings and self-efficacy beliefs may shape future changes in farm practices, this study provides evidence regarding future development in the design of agricultural extension programmes.

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Chapter 1 Introduction

1.1 Introduction

This chapter introduces a study that measures change in farmers' self-efficacy and their understanding of managing perennial summer forage crops (PSF). The study explores how these changes affect the farmers' future use of PSF crops within their farm systems. A brief introduction to self-efficacy and agricultural extension follows to provide the context for this study. Finally, the researcher presents a personal context and an outline of the thesis.

1.2 Background

The demands of a growing global population continue to place pressure on pastoral farmers to improve their farms' productivity of fibre and protein (Grafton & Yule, 2015). Increased dairy farm conversions, forestry development and urban sprawl have prompted a decline in sheep and beef farming in New Zealand. Land used for sheep and beef farming between 2003 and 2016 has decreased from 10.7 million hectares to 8.5 million hectares (Ministry for the Environment, 2018). Pastoral farmers in New Zealand face increasing pressure to produce more from less effective grazing land. This study explores the impact self-efficacy beliefs have on their ability to perform the complex changes required to meet these challenges.

The 35 core farmers taking part in this study farmed in the Hawkes Bay, Manawatū and Wairarapa regions of New Zealand. All took part in the Riverside Farmer Learning Project (RFLP), which focused on sheep trials with PSF crops at Riverside Farm, a Massey University farm in the eastern lower North Island. The agricultural scientists involved with the project believed, based on scientific evidence, that farmers adopting and successfully managing PSF crops in these regions could add economic value to their overall farm productivity. The RFLP was an innovative agricultural extension programme and it is important to consider the cognitive and social aspects of learning that it drew on and that distinguish it from more traditional extension approaches.

Farmers' roles are becoming more complex, demanding and strategic (Morris & Kenyon, 2014). This growing complexity challenges the linear view of knowledge transfer, where information flows from consultant or extension agent to farmer. The linear model is still the main approach to agricultural extension in New Zealand (Moschitz et al., 2015). This model can lead to the successful adoption of new technologies. However, Beers et al. (2014) argue that it does not support the complex social and cultural processes that form an essential part of self-efficacy improvement and system innovation. Psychological drivers, such as farmers' self-efficacy beliefs, may be a key variable influencing their adoption of new technologies.

1.3 Rationale for the study

Research is needed to identify how farmers' self-efficacy beliefs inform their decisions to adopt new agricultural technologies (e.g. Nuthall, 2010; Sewell et al., 2017; Turner et al., 2014; Wilson et al., 2015). The primary aim of this study is to measure change in farmers' self-efficacy. Measuring these changes within the domain of managing PSF crops may provide useful insights for future agricultural extension development. Exploring the link between change in farmers' self-efficacy and their participation in an innovative extension project will provide a deeper understanding of the support that farmers need when introducing new technologies into their farm systems.

1.3.1 Farmers' self-efficacy

Recently, self-efficacy has become a point of discussion in agricultural extension research (e.g. Leeuwis & van den Ban, 2004; McGinty et al., 2008; Niles et al., 2016; Sewell et al., 2017; Stantiall, 1999; Wilson et al., 2015; Wuepper & Sauer, 2016; Yeuh & Liu, 2010). To date such research is rare. Notable examples include Roy (2009), who developed a questionnaire to assess the self-efficacy of jute and paddy farmers in India, and Duranovich (2015), who investigated its contribution to dairy farmers' resilience. More recently, Lind et al. (2019) developed and confirmed a measurement scale for self-efficacy within the domain of mastitis prevention in dairy cows.

As a concept, self-efficacy can explain why some approaches are more helpful than others in assisting people to overcome their domain-specific fears (Bandura, 2019). Self-efficacy is defined as a person's belief in their ability to produce potential levels of performance that may influence future events that may affect their lives (Bandura, 2000). According to Telch et al. (1982), change in self-efficacy requires adjustment of cognitive, social, verbal, or physical skills through enactive/mastery experiences, vicarious experiences and social persuasion. Individuals appraise their perceived ability to complete a task before choosing a course of action (Bandura & Cervone, 1986). If this appraisal is low, then the course of action is unlikely to be followed.

1.3.2 Agricultural extension

The purpose of agricultural extension is to support farmers to reflect on their practice, to learn about new technologies and to build capacity to adopt them into their farm systems (Hunt et al., 2011). Agricultural extension is commonly understood to be a service that aims "to extend research based knowledge to the rural sector to improve the lives of farmers" (Rivera, 2011, p. 165). Farmers require new knowledge and skills when introducing change into existing farm systems. In this sense, agricultural extension has become both an organisational and educational contributor to the rural knowledge economy (Rivera, 2011). Understanding how extension programmes build farmer capacity to do things differently is an important problem that this thesis approaches by defining and developing a measure for farmer self-efficacy. Alongside this primary goal, a subsidiary objective is to consider factors that increase or undermine farmers' self-efficacy to manage PSF crops in particular.

Agricultural extension available to New Zealand pastoral sheep and beef farmers has traditionally comprised a mix of technology transfer, education and consultancy. Farmers use knowledge gained from agricultural extension to gauge their own ability to adopt an innovative technology or change existing farm systems. The traditional extension view of knowledge transfer, from consultant or extension agent to farmer, is still the main approach used in helping farmers consider and change the way they farm (Moschitz et al., 2015). While this linear model can lead to the successful adoption of new technologies, its effectiveness has been strongly criticised. Approaches to agricultural extension have changed over time, moving away from the linear approach (Beers et al., 2014; Sewell, Gray, et al., 2014; Sol et al., 2013). A growing trend in agricultural extension is to emphasise making connections with specific farming interests and to provide relevant solutions for farmers' specific environments (Tisenkopfs et al., 2015).

Beers et al. (2014) argue that the linear model does not support the social and cultural processes that are essential for enhancing innovation in farm systems. This turn towards social and cultural processes can draw on educational theory and practice, such as that of Vygotsky (1978), who held that learning takes place through social interaction and shared culture. Recently, Sewell et al. (2017) have outlined the advantages of using a sociocultural approach to support the adoption of new technologies by farmers. The importance of interaction is also evident in work showing that partnerships between tertiary providers, private industry and farming groups support innovation in the agricultural community (Hermans et al., 2015; Kalule et al., 2019; Tisenkopfs et al., 2015).

Agricultural extension using non-linear forms of communication between industry, agency and community have been shown to support farmers seeking to make changes in their farming practice. Researchers (Gray et al., 2003; Nettle et al., 2015; Sewell et al., 2017) argue that when agricultural extension programmes are responsive to farmers' interests and ideas, they can improve the adoption of new technologies. The RFLP, with its focus on the performance and management of PSF crops, is a case whose analysis can assist the development of innovative agricultural extension programmes informed by these sociocultural principles.

1.4 A personal context

During my career as a primary school teacher and principal, I have lived and taught in several rural New Zealand communities. During this time, I developed an interest in how farmers gain new knowledge to help them to introduce new technologies into their complex farm systems. Coming from an educational background, and having an interest in rural communities, meant that exploring how farmers' perceptions of their abilities to introduce innovation into their farming became a topic of interest. My links to sheep and beef farming communities in the Hawke's Bay, Manawatū, Rangitikei and Wairarapa developed as I led and taught in rural schools in these regions. New Zealand's primary school education system is based on recent educational theory and principles. The importance of considering these theories when designing agricultural extension has become increasingly obvious to me.

1.5 Structure of the thesis

This thesis is written in a standard monograph format. The thesis comprises eight chapters, including this first chapter that has introduced the background, aims and reason for the study. The foci of the following chapters are summarised as follows.

- Chapter Two presents a review of the literature on social cognitive theory, self-efficacy theory and agricultural extension. This review identifies a lack of understanding of how effective agricultural extension can be informed by educational theory, in particular by work on social cognition and self-efficacy. Addressing this gap, this study seeks to measure farmers' self-efficacy, identify factors that enhance or undermine it and explore how these factors impact on farmers' future use of PSF crops.
- Chapter Three outlines and discusses the theory behind the mixed methods paradigm and principles applied in this study.
- Chapter Four describes how data collection and analysis procedures were actioned to satisfy the mixed methods approach described in the previous chapter. The role of the researcher in managing the quality of the study and ethical issues are also discussed.
- Chapter Five presents the quantitative results gained from analysing the Farmer Self-Efficacy Measurement survey (FSEM) data. Statistical significance is explored and cluster analysis is undertaken using factor analysis and k-means clustering.
- Chapter Six presents the qualitative data gained through analysis of interviews and focus discussion group transcripts supported with field observations and photographs.
- Chapter Seven integrates the quantitative and qualitative findings and discusses their significance with reference to the relevant literature.
- Chapter Eight completes the thesis by providing key conclusions to the research question. It summarises the implications of this study for theory and practice. Limitations of the study and some recommendations for further research are also identified.

Chapter 2 Literature Review

The purpose of this review is to position this study within the relevant existing literatures that intersect psychological theory and agricultural extension. This thesis explores the relationship between farmers' self-efficacy and their learning in the context of using PSF crops within their farm systems. Social cognitive theory (Bandura, 1986b) and self-efficacy theory (Bandura, 1977b) are highlighted as they provide the theoretical framework underpinning this research.

Theories of learning explain how people acquire new competencies, attitudes and behaviour, as well as how they motivate and regulate their level of functioning (Bandura, 1986b). Social cognitive theory is examined in detail because it helps to explain the concepts embedded in self-efficacy. Social cognitive theory, introduced in the first section, emphasises the idea of self-regulation and argues that learning occurs through observing others in social environments. The second section reviews self-efficacy theory, including the analysis of its sources and the factors that either enhance or undermine it. Following this, empirical investigations from the agricultural, business, education and health sectors are examined. As there is limited literature on self-efficacy within agricultural contexts, these other disciplines are reviewed and literature relevant to the study explored. Following this conceptual overview, the chapter turns to consider how self-efficacy has been measured, with this review informing the thesis' development of a quantitative instrument to measure longitudinal changes in farmer self-efficacy. The final sections of the chapter briefly assess the current global state of agricultural extension and farmer learning. The chapter concludes by postulating how farmers' self-efficacy and their learning may influence the management of new farm practices.

2.1 Social cognitive theory of learning

2.1.1 Introduction

Social cognitive theory (Bandura, 2001) emphasises the influence of observational learning and modelling. It thus provides the basis for arguments about the impact of self-efficacy on the construction of behaviour. Social cognitive theory strives to "develop and bring the best in others at both the individual and social system levels" (Bandura, 2019, p. 15). This section provides an overview of work on social cognition and establishes its relevance to this research.

2.1.2 Overview of Social cognitive theory

Social cognitive theory (Bandura, 1986b) argues that learners do not passively absorb knowledge from external sources; rather, they actively pursue and process information to build new understandings. Learners assemble knowledge, skills, strategies and beliefs through vicarious experiences (observations) and social interactions, within the context of various environmental factors that influence future events and the directions that the learners' lives follow (Schunk, 2012).

> Social cognitive theory embraces an interactional model of causation in which environmental events, personal factors and behaviour all operate as interaction determinants of each other. Reciprocal causation provides people with opportunities to exercise some control over their destinies as well as sets limits of self-direction (Bandura, 1986b, p. xi).

According to this "interactional model", the capacity to learn through observing and communicating with others has developed because the human mind is "generative, creative, proactive and reflective" *(*Bandura, 2001, p. 4). Humans engage in cognitive functions enabling them to formulate strategies for future use based on their past and present experiences (Bandura, 2006c, 2018). The capability to construct, evaluate and implement alternative strategies to address unplanned environmental variables assists people to achieve their goals.

Bandura (1986b, 2018) argues that human behaviour is motivated by reciprocal interactions between personal (i.e. beliefs, skills and affects), behavioural and social/environmental factors. This triad of interactions determines behaviour (see Figure 2.1). According to Bandura (1977a), the patterns of human behaviour are acquired and regulated by a continuous interplay between these three factors. This is a model of reciprocal determination in which behaviour both influences and is influenced by one's personality and environment (Bandura, 1977b).

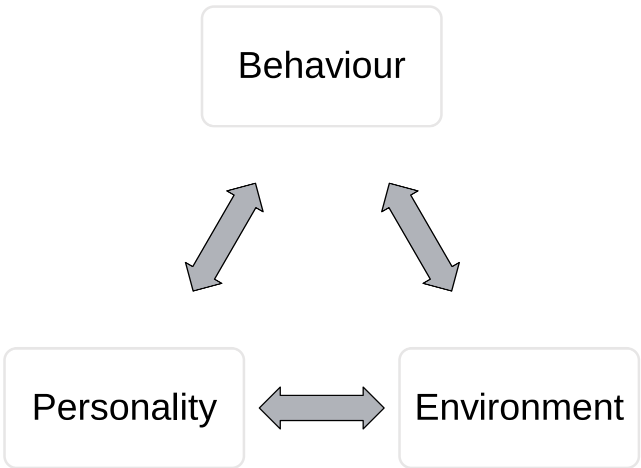

Figure 2.1. The relationship between behaviour, personality and environmental factors (Source: Bandura, 1986b)

The very name of the theory indicates its characteristic approach to understanding human behaviour. Bandura (1986b) uses the words '*social'* to acknowledge the interactive origin of human thought and action, while the term '*cognitive*' acknowledges the casual contribution of thought processes to human motivation. Social theorists argue that the ways in which we act and the beliefs that we hold are generated partly by social structure, but also in communication between individuals and in social groups (Vygotsky, 2012). Cognitive theorists argue that how individuals think, their cognitive processes, plays a dominant role in the development and retention of their behavioural patterns (e.g. Bandura, 1986b; Bandura & Walters, 1963; Berry, 1989; Schunk, 2012; Wood & Bandura, 1989). Social cognitive theory is thus founded on an agentic perspective. Human self-development, adaptation and change are brought about by human agency rather than by some sort of external determinism (Bandura (2001).

Social cognitive theory (Bandura, 1986b) emphasises the power of symbolic representations (e.g. words, diagrams) as mediators of thought. It also emphasises the utility of vicarious experiences and modelling as facilitators of learning. The theory highlights both the prevalence and variety of self-regulatory processes that shape human thought and behaviour. Bandura and Locke (2003) argue that people aspire to achieve future goals and anticipate actions to guide and motivate progress. They also reflect on their ability to achieve these goals, their belief in their personal efficacy. In sum then, from a social cognitive perspective, people adopt, monitor and regulate their actions through self-reflective processes that inform future learning.

Bandura (2018) argues that agentic action, such as exploring, manipulating and influencing environments, facilitates belief in one's ability to initiate future changes in behaviour. The core conviction of human agency is belief in one's personal efficacy, in one's capability to achieve a desired outcome by personal and collective action (Bandura, 2006a). Belief in self-efficacy is belief in "the ability to intentionally direct a course of events and circumstances in one's life, and choose one's reaction to them" (Usher & Schunk, 2018, p. 20). Within the context of social cognitive theory, individuals are agents of experiences rather than the recipients of external stimuli. Individuals are agentic in the sense that they implement intentional actions to initiate change (Bandura, 2001, 2018). Bandura identifies three distinct modes of agency: personal, proxy and collective (Bandura, 1977b, 2001). The distinction between these three modes is relevant for the research undertaken in this thesis.

Personal agency

According to Bandura (2001), being intentional, having forethought, reacting and reflecting, are the core features of personal agency. Firstly, individuals deliberately follow proactively planned future courses of action and show commitment in bringing planned action to reality. Secondly, humans display forethought when setting goals, anticipating challenges and the consequences of prospective outcomes when planning an appropriate course of action. Bandura's (2001) third core feature of personal agency, self-reactiveness, considers one's ability to shape an appropriate course of action to motivate and regulate progress towards an intended goal. Lastly, Bandura (2001) suggests that humans use self-reflectiveness to judge the correctness of predictive and operative thinking against the outcomes of their own actions and those of others. Taken together, these four core features of personal agency lead to one's future actions. For example, farmers follow a planned course of action when introducing change to an existing farm management system. They develop strategies to manage challenges and reflect on progress during its implementation. Finally, the farmer will reflect on the outcome to validate success or the need for future modification to reach the intended outcome.

Proxy Agency

Bandura (2001) recognises that people do not have a direct influence over all the social and institutional conditions that influence their lives. At times people enlist the help of others who have access to resources, expertise or influential power to act for them to attain a desired outcome. Bandura (2001) refers to this process as proxy agency. People turn to proxy control, argues Bandura (2001), when they have not developed the personal agency to directly undertake the desired actions. For example, a farmer may believe that an agricultural contractor or rural professional can do a specific task better than they can, such as cultivating and sowing pasture or identifying and managing plant health issues. Bandura (1997) argues that the use of proxy agency may limit the opportunity for mastery experiences, in which individuals respond successfully to a new challenge themselves. Acting by proxy may therefore impede the development of the self-regulatory skills necessary for moving away from reliance on the expertise, resources or influential power provided by others.

Collective agency

The idea of collective agency recognises the power of shared intentions, knowledge and skills that come with group membership. Individuals in groups have interactive and co-ordinated effects on each other that significantly influence the attainment of members' goals. Group membership thus creates collective agency, defined as "the belief by individuals in their collective power to produce a desired result" (Bandura, 2001, p. 14). Overemphasising the personal agency of individuals risks downplaying this collective power. Otsuki et al. (2018), for example, argue that farmers individually take adaptive actions and reflect on these actions. However, such an approach leaves farmers with little opportunity to systematically communicate experiences and to learn from each other, encourage collective agency and in so doing enhance community resilience. Bandura (2018) argues that many of the goals people seek are achievable only when they pool their knowledge, skills and resources. Individuals are empowered when they act in concert to shape their future by utilising a collective effort to achieve a shared goal.

2.1.3 Enactive and vicarious learning

Social cognitive theory (1986b) maintains that learning occurs through active participation (enactive learning) and by observing modelled performances by others (vicarious learning). The theory recognises that people do not live in social isolation; rather, they address increasing numbers of tasks and goals in collaboration with others to reach successful outcomes (Bandura, 2000). For example, as students apply new skills, their teachers provide feedback and on-going instruction. Research has shown that farmers highly value learning from the shared ideas and experiences of their peers (Franz et al., 2010). When incorporating a new technology into their existing farm systems, they compare the outcomes with previous experiences and observe farmers using a similar technology to gauge the successfulness of the change. This feed-back provides the farmer with crucial information about their ability to implement new skills in a practical situation. Such cases show how people use the capabilities within their social environments to influence their own personal development (Bandura, 2016).

Schunk (2012) argues that people base the expected outcomes of actions on their observations of others completing similar tasks in conjunction with their own previous experiences. For example, a farmer observing a trusted peer successfully complete a task may convey to them that they too have the capability to achieve a similar result. Schunk (2012) argues that it is through active participation, observation, practice and feedback that students learn and experience greater success. As Bandura (2019) points out, vicarious learning provides the learner an opportunity to select environmental features most relevant to their own situation.

Bandura (1986b) recognises people’s ability to use symbolic processes to interpret actions and outcomes in their life and to use such interpretations as a guide for future actions. Rather than simply reacting to a current situation, a learner can process language or mathematical notation to solve problems and create new ways doing things. Such representational processes can empower agency (Schunk, 2012). Farmers, for example, gather and process information from written sources, conversations with other farmers and rural professionals, as well as observing what is happening around them, and on this basis are able to assess the viability of introducing change to an existing farm system. As Bandura (1986b) argues, this symbolic capability allows people to adapt to and alter their environment.

Bandura (1986b) refers to a third capability, the self-regulatory process where people regulate their behaviours to conform to their internal expectations. Self-regulation is defined by Zimmerman and Schunk (2004) as “self-generated thoughts, feelings and actions which learners use to attain their goals” (Zimmerman & Schunk, 2004, p. 323). While completing a task, people reflect on their performance against these goals and alter strategies if required. Moreover, upon task completion they reflect on the experience, seek to make sense of the task and identify the next steps. After implementing a change to an existing farm management system, farmers can review the success or otherwise of the change to inform their future direction.

Usher and Schunk (2018) agree with Bandura (2016), contending that, as self-regulatory processes enable people to shape their own life outcomes, they may be one of the most vital and influential components of our humanity. Whatever other factors serve as guides and motivators, they are rooted in the core belief that one has the power to produce desired effects by one's actions; otherwise one has little incentive to act or to persevere in the face of difficulties.

2.1.4 Summary

This section has presented an overview of social cognitive theory which highlights how human functioning is an interplay of interpersonal factors, behaviour and environmental forces. Social cognitive theory provides a lens through which the findings in this thesis can be explained. Compared to more passive models of learning, this theory offers a better understanding of how farmers utilise their social environments and other factors to support their learning of new knowledge that is likely to influence future behaviour. Farmers' adoption of future actions, such as the use of PSF crops, in order to produce desired outcomes, such as increased farm productivity, is a consequence of the interaction between their previous experiences (e.g. crop innovation and management), environmental factors (e.g. climatic conditions, soil properties, topographical factors) and observations of similar farmers growing similar crops. In particular, social cognitive theory emphasises the key role played by belief in the ability to undertake such new actions successfully. The character and importance of this sense of self-efficacy is outlined in more detail in the following section.

2.2 Self-efficacy

2.2.1 Introduction

The concept of self-efficacy was developed in the 1970s (Bandura, 1977b) and has been tested in numerous pedagogic and therapeutic settings (Bandura, 1980; Bandura & Adams, 1977; Pajares, 1996; Settle et al., 2012; Usher, Li, et al., 2018). According to Bandura (2019), self-efficacy is a differentiated set of self-beliefs linked to distinct realms of functioning, such as the various agricultural activities investigated in this thesis. The previous section highlighted the important link between social cognitive theory and the concept of self-efficacy. In the following sections, the four sources of self-efficacy are introduced and explained. This is followed by a review of literature from the agricultural, business, adult education and health sectors to highlight convergence, divergence and gaps within the context of the research undertaken in this thesis. Understanding the importance and relevance of self-efficacy is crucial for agricultural extension developers if their designs for learning are to lead to farmer behaviour change, such as their future use of new forage crops.

2.2.2 Self-efficacy defined

Bandura (1977b) distinguishes between having the skills to perform a task, which he calls "outcome expectancy", and believing that these perceived skills can be used to master a set of future tasks, which he calls "self-efficacy outcomes". His definition of self-efficacy that follows is used in this study:

> People's judgments of their capabilities to organise and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has, but with judgments of what one can do with whatever skills they have. (Bandura, 1986b, p. 392)

These judgements provide the basis for an individual's self-efficacy, or belief in their present capability (i.e. knowledge and skills) to engage in future courses of action. Self-efficacy beliefs therefore provide insight to understanding the choices people make, their actions, the way they approach challenging situations, and the level of success they strive toward (Bandura, 1997). Furthermore, Bandura (1997) argues that an individual's efficacy levels are not consistent under all conditions, but rather are a differentiated set of beliefs according to a specific context. For example, a farmer may possess a high level of self-efficacy to manage traditional ryegrass/clover mix pasture, yet have a low level of self-efficacy to manage PSF crops. Consequently these are important insights for agricultural erxtension design.

As Morony et al. (2013) comment, the word 'confidence' is often used and confused with the idea of self-efficacy. For the sake of conceptual precision, it is useful to distinguish between the two terms on the basis of their place in the timing of action. Confidence refers to an attribute of an individual's character and so lacks a specifically action orientation. Rather than a character trait, self-efficacy is a cognitive process involving reciprocal interactions through which one appraises personal, environmental and behavioural factors in relation to a specific task and domain of functioning (Bandura, 1986a). Self-efficacy influences motivation by validating individuals' belief in their ability to achieve future goals and to persist at tasks during learning processes (Bandura, 1977b). People consider information from a combination of sources to inform their self-efficacy (Schunk, 2012). For the purpose of this study, then, self-efficacy is a farmer's judgement of their capability to manage PSF crops in the future using current knowledge and skills.

2.2.3 Factors influencing self-efficacy

Given that this study explores the relationship between farmers' self-efficacy, their learning and their future use of PSF crops, it is important to review the literature concerning the factors that influence these self-beliefs. The self-efficacy literature suggests that these beliefs regulate human functioning through cognitive, motivational, affective, and decision-making processes. In these various ways, self-efficacy affects whether people think in self-enhancing (enabling) or self-debilitating (undermining) ways when facing future challenges (e.g. Bandura, 1977b; Bandura, 1997, 2018; Bandura & Locke, 2003; Cervone et al., 2006; Schunk & Pajares, 2002). Welsh (2014) points out that self-efficacy beliefs are not uniform but vary across activities and fluctuate across changing circumstances. When people do not believe their actions will produce desired effects, they have little incentive to act. Self-efficacy beliefs therefore can impact motivation and perseverance in completing tasks (Bandura, 1993; Hammond & Feinstein, 2005; Usher, Li, et al., 2018). The findings from several authors (Bandura, 1993; Hammond & Feinstein, 2005; Usher, Li, et al., 2018) suggest that self-efficacy affects an individual's motivation, perseverance, emotional well-being, vulnerability to stress and depression, along with the choices they will make at important future decision points. Usher, Li, et al. (2018) argue that the strongest influential factor enhancing self-efficacy is that learners are engaged in direct experiences of mastery in which individuals experience positive or negative outcomes. Experiencing success will build self-belief in ones' ability to adopt a change whereas a failure will undermine it.

A key factor impacting self-efficacy beliefs is the learning environment. Learning environments are interpersonal; everyone's constructions are mediated by the actions of others in the social setting and by the inherent characteristics of the culture in which learning is situated (Vygotsky, 2012). In Bandura's words*,* people act in these environments "to develop their knowledge and capabilities to exercise some measure of control over their everyday lives" (Bandura & Locke, 2003, p. 92). While previous experiences of success and failure may inform one's belief in the ability to perform future tasks, Bandura (1997) argues that self-efficacy is enhanced through multiple opportunities to participate in relevant learning experiences. Self-efficacy is thus both a personal and social construct (Cervone et al., 2006; Schunk & Pajares, 2005). It is "built from a complex array of efficacy-relevant experiences that occur through enactive (e.g. grades, scores), vicarious (e.g. social comparison, social modelling), and social (e.g. encouragement, help, scaffolded instruction) means" (Usher, Li, et al., 2018, p. 16). Self-efficacy facilitates learning as it encourages perseverance and provides the sense that one has the ability to try different strategies (Lorsbach & Jinks, 1999; Wuepper & Sauer, 2016). As learners become more efficacious, they become aware of how their new knowledge is constructed based on their existing understandings (Schunk & Meece, 2006; Wuepper & Drosten, 2015). Education programmes, such as those of agricultural extension, thus have the potential to provide learners with new knowledge to enhance self-efficacy when they are engaged in enactive, vicarious and social experiences (Usher, Li, et al., 2018).

Bandura (1997) introduces the term ‘collective efficacy’ to describe a group of individuals forming to strengthen their capability to organise and carry out a specific course of action. He argues that a robust sense of efficacy develops when a strong collective focus encourages individuals to draw on the wider skill set within the group. Moreover, groups with high levels of collective efficacy attempt more challenging tasks and show higher levels of perseverance when confronting challenging situations (Bandura, 1986b, 2000, 2019). Bandura (2006a) argues that making progress to achieve significant goals requires the pooling of knowledge and innovative expertise. He defines group efficacy as "a group's shared belief in its conjoint capability to organize and execute the courses of action required to produce given levels of attainment" (Bandura, 1997, p. 477). This shared belief influences what members choose to do as a group, how much effort they put in and their staying power when group efforts fail to produce results. Research has shown, for example, that when a group of educators believed in their combined ability to influence student outcomes, there were significantly higher levels of academic achievement (Bandura, 1993).

2.2.4 Sources of self-efficacy

People assess their self-efficacy by using four main sources of information (see Table 2.1 below). This information comes from their actual performance (enactive/mastery experiences), from their observations of others (vicarious experiences), through verbal/social persuasion and, finally, through physiological indicators (Bandura, 1977b). Empirical research has identified the importance of these four sources, showing how an individual’s beliefs are developed via the cognitive processing of information relating to them(Bandura (1977b); Schunk (1996). Each of these sources and how they enhance or undermine self-efficacy are considered in more detail below.

Table 2.1. Sources of information used by individuals when gauging their perceived level of self-efficacy

Sources of Self-Efficacy information	Description
Enactive experiences (Success and failure)	The impact of previous experiences and outcomes of successes or failures when adopting new behaviours and cognitive learning.
Vicarious experiences (Social modelling)	Watching or observing others before deciding “I can do it as well”.
Verbal persuasion (Social persuasion)	Verbal affirmation from peers and other sources building a sense of “I have been told I can do it”.
Physiological arousal (Physical and emotional)	Experiencing a supportive, trustworthy atmosphere is more likely to strengthen an individual’s self-efficacy than if strong negative arousal situations are experienced.

Source: Bandura (1989b)

Enactive (Mastery) experiences

Bandura (1977b) argues that efficacy expectations influence the initiation of and persistence with future tasks. Enactive experiences, which can be either negative or positive, are considered to be the strongest source of self-efficacy as they lead the individual to expect similar future results (Bandura, 1977b, 1997, 2018; Usher & Pajares, 2009). Enactive experiences are defined as previous experiences and outcomes that enable individuals to adopt new behaviours and cognitive learning (Bandura, 2019). The experience of mastery can be achieved by learning the knowledge and skills required to successfully perform the task, by setting goals and reflecting on feedback in a range of previous diverse settings or situations (Bandura, 2019; Jansen et al., 2015; Usher & Pajares, 2009). Adding to this, Tschannen-Moran et al. (1998) suggest that repeated successes enhance individuals’ belief in their ability to master future challenges within similar domains.

Individuals who doubt their capability within a specific field will avoid difficult tasks and give up quickly when they experience challenges (Bandura, 1977b, 2018; Pajares, 1996). Usher, Li, et al. (2018) have shown that student failures, setbacks and low grades undermine their self-efficacy, arguing that “a negative experience appears to be as potent as a positive one in terms of its effect on students’ confidence” (Usher, Li, et al., 2018, p. 12). For example, students who experience repeated strong negative encounters during primary and secondary schooling exhibit low self-efficacy when attempting tertiary education (van Dinther et al., 2011). People with low self-efficacy experiencing repeated negative experiences may feel depressed and lack the motivation required to complete future tasks (Bandura & Locke, 2003).

Such negative experiences can lead them to dwell on personal deficiencies, task difficulty, and the consequences of failure (Schunk, 2012; Welsh, 2014). These arguments and findings suggest that failing to set farmers up for the successful implementation of a new farm practice or technology may have a negative long-term impact on their belief in their ability implement future innovations.

Vicarious experiences

Vicarious experience is another important source of self-efficacy information (Bandura, 1977b). Vicarious experiences are defined as the social comparisons made by individuals while observing others successfully mastering challenging situations (Bandura et al., 1977). Vicarious experiences also occur when people observe someone fail while attempting similar tasks (Bandura, 1997, 2019; Mintzes et al., 2013; Schunk & Meece, 2006). People acquire considerable information about their capability vicariously through the knowledge of how others perform similar tasks (Bandura, 2000; Mintzes et al., 2013).

Mintzes et al. (2013) argue that vicarious experiences are enhanced by learning environments made up of small groups using inquiry-style investigations. Bandura (1997) comments that vicarious experiences are typically used by individuals who observe others perceived to be similar to themselves. However, Usher, Li, et al. (2018) point out that when observing others complete a task, a full understanding of the required competencies may not be achieved because important pieces of information may be missed or misunderstood by the observer. This missing information may then contribute to an undermining of self-efficacy (Hoy & Woolfolk, 1993), discouraging future attempts at the task. The general point, however, is that the impact of vicarious experiences depends on how closely the observer identifies with task or person he or she is observing (Bandura, 1977b).

Verbal persuasion or social persuasion

A third source of self-efficacy is verbal or social persuasion (Bandura (1977b). Verbal or social persuasion refers to specific verbal and social feedback received from credible influential friends, colleagues or experts (Bandura, 1977b, 2019; Schunk, 2012). Usher (2016) argues, individuals who are socially persuaded that they hold the competences to achieve a specific task exert greater effort in achieving that task. Bandura similarly concludes that these people persist longer to ensure task completion than do those who dwell on self-doubts and personal deficiencies when challenging situations arise.

The opportunity to socially confirm or restructure new knowledge and experience is critical in enhancing one’s self-efficacy (Usher, Li, et al., 2018). Effective social persuaders do more than communicate confidence in people’s capabilities; they also facilitate success by arranging things in ways that avoid premature challenging situations which could lead to failure (Bandura, 2000). Social persuasion, Schunk and DiBenedetto (2014) point out, must be credible (i.e. objective and trustworthy) because an individual's confidence in their future abilities is influenced by the encouragement or discouragement of those whose opinion they respect.

Physiological/emotional state

The physical and emotional reactions associated with anticipated success or failure may also affect individuals' self-efficacy (Bandura, 1997). Experiencing a supportive, trustworthy atmosphere is more likely to strengthen self-efficacy than are experiences of strongly negative arousal situations (Bandura et al., 1977). For example, excitement, enthusiasm and joy may indicate a positive belief in ones' ability to achieve future success, while anxiety and stress towards the same task may signal the negative belief that a satisfactory outcome cannot be achieved. People's belief in their ability to implement a given practice is influenced by their perception of factors likely to enable or undermine the realisation of practice change (Ajzen, 1991). Subsequent success or failure at a task can therefore strongly influence an individual's sense of self-efficacy (Bandura, 1977b). Strong emotional reactions provide cues about anticipated success or failure. Affective reactions to negative thoughts regarding personal future capability may lower self-efficacy (Schunk, 2012). Conversely, when an individual becomes less stressed over a task, is anxious or afraid a higher level of self-efficacy enhances belief that they are performing the activity well (Schunk, 2012; Schunk & DiBenedetto, 2014). Highly efficacious people, therefore, exhibit more certainty and less anxiety about their ability to master future outcomes and performance levels.

2.2.5 Self-efficacy and farmer learning

Although Sewell et al. (2017) and Wilson et al. (2015) suggested that self-efficacy may significantly influence farmer adoption of new technologies, research is this area is minimal (see Table 2.2 below). There is, however, a growing interest in trying to understand and explain the way in which farmers behave when implementing change to existing farm systems, such as the use of new forage crops investigated in this thesis. Yeuh and Liu (2010) have explored the influence of farmers' self-efficacy on their use of farm management information systems (FMIS). Six instruments were developed to evaluate the computer ability, self-efficacy, performance, acceptance and attitude of 23 farmers enrolled in a farmer training workshop on the use of FMIS. The research found that the involvement of subject-matter experts and the experience of sharing activities and peer modelling strategies enhanced farmers' self-efficacy and suggests that these factors should be further investigated in future studies.

Table 2.2. Self-efficacy studies within the domain of agriculture

Context	Research studies	Topic addressed
Agriculture	Yeuh and Liu (2010)	Effects of farmer's computer abilities and self-efficacy on their learning performance and adoption intention regarding the farming management information system.
	Niles et al. (2016)	Farmers' adapting behaviours to mitigate future climate change
	Wuepper and Sauer (2016)	Explaining the performance of contract farming in Ghana: The role of self-efficacy and social capital.

Research by Wuepper and Sauer (2016) in Ghana found that self-efficacy is an important behavioural determinant, worthy of consideration by those seeking to introduce changes to agricultural practices. They suggested that improving both farmers' self-efficacy and commitment to innovative farm practice would have a greater effect than focusing on technical skills, inputs, and infrastructure. They estimated, for example, that a pineapple farmer in Ghana with high self-efficacy was more than twice as likely to adopt mulching (an innovative technology) in response to drought than a farmer with low self-efficacy. Wuepper and Sauer (2016) noted, however, that farmers most in need of support to build their self-efficacy were in fact those often neglected by extension workers.

Niles et al. (2016) suggested, there are "different drivers of intended and actual adoption of change to climate change practice" (Niles et al., 2016, p. 277). These authors argued that farmers' perceived beliefs about their capacity to change is an important predictor of both intended and actual adoption of new farm practices. However, they point out that there may be a disconnect between a farmer's intended and actual behaviour change because of factors outside his or her control (e.g. seed availability, weather conditions, or a change in the economic viability of introducing the planned change).

Although research focusing specifically on farmer-self-efficacy is minimal, the studies summarised above do indicate its importance as a contributor to agricultural change. Such claims are supported by recent research by Sewell et al. (2017), which suggests that farmers participating in sustained participatory extension practices, informed by social psychological principles, may improve their self-efficacy beliefs about the use of new technologies. However, given the paucity of research in agricultural contexts, the following sections review self-efficacy studies from a range of disciplines including business management, adult education and health, where considerably more research has been done to date. Table 2.3 below summarises this work, identifying a range of factors as predictors of self-efficacy within various specific contexts. All these studies have identified self-efficacy as a vital factor for the success of future actions.

Table 2.3. Self-efficacy studies completed within the adult education, business and health sectors

Context	Authors	Self-efficacy studies
Adult Learning	Cervone et al. (2006),	Self-efficacy and adult development.
	Hammond and Feinstein (2005)	The effects of adult learning on self-efficacy.
	Hoy and Woolfolk (1993)	Teachers' sense of efficacy and the organizational health of schools.
	Pajares and Miller (1995)	Mathematics self-efficacy and mathematics performances: The need for specificity of assessment.
	Tschannen-Moran and Hoy (2001)	Teacher efficacy: Capturing an elusive construct.
	Usher, Li, et al. (2018)	Sources of math and science self-efficacy in rural Appalachia: A convergent mixed methods study.
Business	Barakat et al. (2014)	Measuring entrepreneurial self-efficacy to understand the impact of creative activities for learning innovation
	Boyd and Vozikis (1994)	The influence of self-efficacy on the development of entrepreneurial intentions and actions.
	Carter et al. (2016)	The effects of employee engagement and self-efficacy on job performance: a longitudinal field study.
	Gist (1989)	The influence of training method on self-efficacy and idea generation among managers.
	Hoover et al. (2012)	Eyes on, hands on: Vicarious observational learning as an enhancement of direct experience.
	Judge et al. (2007)	Self-efficacy and work-related performance: The integral role of individual differences
	Sequeira et al. (2007)	The influence of social ties and self-efficacy in forming entrepreneurial intentions and motivating nascent behavior.
	Van Vianen (1999)	Managerial self-efficacy, outcome expectancies, and work-role salience as determinants of ambition for a managerial position.

Health	Persson et al. (2014)	The relationship between self-efficacy and help evasion.
	Selzler et al. (2019)	Coping versus mastery modelling intervention to enhance self-efficacy for exercise in patients with copd.
	Shields and Brawley (2006)	Preferring proxy-agency: Impact on self-efficacy for exercise.
	Strecher et al. (1986)	The role of self-efficacy in achieving health behavior change.
	Welsh (2014)	Self-efficacy measurement and enhancement strategies for medical-surgical clinical nurses.
	Williams et al. (2014)	Relationship among practice change, motivation, and self-efficacy.

Business management

There is a reasonably substantial body of work in the field of business management that is relevant to the current study. Machida and Schaubroeck (2011) explored self-efficacy within the context of business leadership development, concluding that it plays a more complex role than previously acknowledged. They suggested that developmental experiences (feedback, challenge, and support) and learning orientation are two key factors influencing business leaders' self-efficacy. Learning orientation emphasizes learning, mastery, and increasing competence. Here, Machida and Schaubroeck (2011) emphasise the importance of an individual's belief in their ability to learn a skill and to accomplish a task.

Moen and Federici (2012), in a study of executives and middle managers, have identified the need to build strong beliefs in the capabilities required for future success (i.e. self-efficacy) among these business groups. Empowering others using a coaching-based leadership model was found to be widespread. However, they argued that the business sector lacks reliable or valid instruments with which to quantify leaders' perceived capabilities in their coaching of employees. Developing and validating a multidimensional, coaching-based leadership self-efficacy survey, (Moen & Federici, 2012) provide a useful example of the measurement of self-efficacy to be further developed in this thesis.

Laura and Stephen (2002) suggested that existing leaders within an organisation may require training on how their self-efficacy influences their subordinates. Research by Schyns (2004) shows that employees with high self-efficacy are more willing to engage in change and thus may serve as future change agents for the organisation. It is, therefore, important she concludes, to give "particular attention to employees' self-efficacy" (p. 258). Research on the importance of employee self-efficacy is relevant to agricultural contexts, given for example that farm owners often rely on staff to implement new practices in the field. Carter et al. (2016) called on human resource managers to address both self-efficacy and employee engagement in order to increase employee job performance. However, an earlier paper by Judge et al. (2007) cautions that the predictive validity of self-efficacy may be reduced as a result of individual differences between employees, suggesting on this basis that the contribution of self-efficacy to work-related performance is, at times, rather small. While such claims may be true in particular cases, more generally it should be acknowledged that self-efficacy theory not only incorporates but also highlights the importance of personal and contextual variation, as the review presented above clearly shows.

Business management literature has provided some insights into the influence of vicarious learning on individual self-efficacy. Hoover et al. (2012), for example, concluded that while previous performance, physiological arousal and verbal persuasion are significant, vicarious (observational) learning is an important source of self-efficacy. Based on research involving 448 graduates completing a university business leadership course, they suggested that vicarious experiences followed by enactive experiences may in some situations provide a more realistic process to influence efficacy beliefs. For example, in situations that involve changes to intricate or high-risk patterns of behaviours (e.g. surgery skills, airline pilots), it would be unacceptable to rely solely on previous mastery experiences. If vicarious experience needs to be incorporated, then so too do the conditions that enhance its effectiveness. In this regard, Van Vianen (1999) argues that the influence of vicarious experience depends on the relevance of the task to the business managers' role. Any behaviour that is observed will only be an important source of efficacy information if the learner can personally relate to the task within the context in which it is being used.

The relationship between self-efficacy and entrepreneurial intention has also been investigated in ways that are relevant to the current study. Entrepreneurial intention is the process of creating something new with value by devoting the necessary time and effort, resulting in financial reward and personal satisfaction (Barakat et al., 2014). The introduction of PSF crops into a farming system clearly has many of the characteristics of entrepreneurial intention. Barakat et al. (2014) argued that self-efficacy plays an important role in the development of entrepreneurial intentions and actions as it influences the complex process of new venture creation. A number of recent studies (e.g. Hao et al., 2005; Kautonen et al., 2013; Sequeira et al., 2007; Zulhaidir et al., 2015) have found that strong supportive personal networks coupled with high self-efficacy increase the likelihood of future entrepreneurial intentions. Such studies confirm earlier work suggesting that the concept of self-efficacy is integrated with the development of entrepreneurial intentions and behaviour, such as that of Boyd and Vozikis (1994), who found that when mentor support within the network is a trusted and successful role model for the individual, verbal persuasion may exert a profound influence on their development of entrepreneurial self-efficacy.

Education

A substantial body of self-efficacy research has been undertaken in a wide variety of educational contexts (e.g. Bandura, 1997, 2019; Cerit, 2013; Hammond & Feinstein, 2005; Hoy & Woolfolk, 1993; Maclellan, 2016; Pajares, 1996; Tschannen-Moran & Gareis, 2007; Tschannen-Moran et al., 1998; Usher, Li, et al., 2018; Zimmerman, 2000). This work identifies self-efficacy as a powerful predictor of student achievement when they confront challenging situations.

When studying self-regulation and motivation in academic settings, Pajares (1996) established a significant relationship between self-efficacy, motivation constructs and academic performance. He suggested that self-efficacy surveys that correspond to the specific context in which they are developed provide stronger explanations and predictions than do more global surveys based on measurements that are not domain specific. Similarly, Usher, Li, et al. (2018) suggest that within a classroom teaching context, analytical capacities are increased when self-efficacy measures correspond specifically to the outcomes against which they are being compared. Because self-efficacy is context specific, it can be expected that a learner with high science efficacy is more likely to persevere at mastering challenging scientific problems than someone with low efficacy in this field (Usher, Li, et al., 2018). These arguments suggest that a significant problem with much previous agricultural research is its focus on generic capabilities (e.g. farmer resilience) rather than on capabilities that are domain specific.

Self-efficacy is important not only for students but also for their teachers. Maclellan (2016) argues that teachers' self-efficacy influences their focus on the complexities of teaching and the exploration of alternative instructional practices to facilitate student learning. Teacher self-efficacy comprises classroom management, instructional strategies, student engagement and emotional support (as cited in Maclellan, 2016, p. 83). According to Maclellan, teachers with high self-efficacy sustain an internal dialogue that allows them to clarify their thinking and act based on their reasoning. This internal dialogue involves thinking about some question or problem to be solved and comparing different solutions, in effect mentally staging a conversation with yourself to figure out the best answer. Cerit (2013) investigated the relationship between Turkish teachers' self-efficacy beliefs and their willingness to implement state introduced curriculum reform. In order to improve the quality of education in Turkey, the reform required teachers to change their role from *"agents of knowledge transmission to the facilitators of student knowledge acquisition"* (Cerit, 2013, p. 257). Cerit's tested the effect of teachers' perceptions of their own self-efficacy on their willingness to implement the reforms, which required teachers to gain new skills and change existing teaching practices. Not all Turkish teachers accepted this new role enthusiastically. Cerit (2013) established that teachers with high self-efficacy beliefs were more accepting of change and more willing to implement new practices.

Maclellan (2016) argues that teachers base their efficacy beliefs on their personal interpretation of information gained from a variety of sources including students' task completion and the perception of their own abilities in relation to those of their peers. For example, judgements of equivalent or superior ability to those of peers add value to one's own performance. Other self-efficacy sources are feedback from respected peers (encouraging or otherwise) and the level or nature of success or anxiety experienced during activities. Maclellan (2016) claims that once the a teacher's self-efficacy profile is established, they are in a better position to determine how to extend their capability. (Maclellan, 2016) argues that teachers often draw on interpretations of their performance compared with others of similar status, while (Hoy & Woolfolk, 1993) add that a principal (school leader) who is prepared to use their influence over superiors on behalf of teachers is conducive to the development of teachers' personal efficacy. Hoy and Woolfolk (1993) also emphasise the importance of a supportive school climate with a strong academic emphasis and sense of community can stimulate teachers' confidence in their ability to influence students learning.

Educational research about the importance of self-efficacy for both students and teachers has considerable general relevance for the field of agricultural learning. More specifically, agricultural extension typically involves adult participants and such contexts have also been investigated by educational researchers. Hammond and Feinstein (2005) suggest that success in formal adult learning may contribute to positive changes in self-efficacy in adulthood. Adult learning is defined as "any learning during adulthood that is taught by instructors or self-taught, but which is intentional" (Hammond & Feinstein, 2005, p. 266). In their analysis of data produced by the United Kingdom's National Child Development Study, Hammond and Feinstein (2005) found significant links between participation in adult learning and improved self-efficacy, particularly for women with low levels of achievement at school. Women with poor school attainment are at risk of social exclusion and depression, but success as adult learners enhances their self-efficacy. According to Hammond and Feinstein (2005) this enhanced self-efficacy may protect these women from future risks and help progress their personal development and occupational opportunities, as well as their family and social relationships. As self-efficacy increases, so does the motivation to take on new challenges, including participation in more challenging courses. Little has been written in the agricultural literature about the impact of increasing self-efficacy on farmers' motivation to take on new challenges. This understanding could prove to be an important driver in designing new agricultural extension programmes.

Health

Looking beyond business management and teacher education to the health sector provides further insights into self-efficacy. The health sector is particularly significant as research has been undertaken on the relationship between self-efficacy changes, in both patient and health professionals' behaviour, which resulted from planned interventions. This thesis is similarly concerned with change over time in response to interventions. Self-efficacy is considered a key construct in many health behaviour change theories, including the transtheoretical model (Prochaska & Velicer, 1997) and the Health Belief Model (Rosenstock et al., 1988) developed in the early 1950s by social scientists at the United States Public Health Service. Welsh (2014) argues that the community has a right to expect competency from all those delivering health care and that this means self-efficacy should underpin all aspects of health professional education and practice. Welsh (2014) believes that assessing nurses' self-efficacy will provide valuable information for the development of the educational programs. Cox and Simpson (2016) position nurses' clinical practice at the intersection of their self-efficacy and knowledge of core clinical concepts. Williams et al. (2014) similarly argue that more consideration should be given to the pervasive influence of student self-efficacy when considering curriculum development to encourage nurse practice change.

While Welsh (2014) argues that low efficacy beliefs for specific health-related dimensions hinder professional performance, being aware of these low levels can be used to guide the development of interventions and strategies enhancing nurses' sense of their clinical capability (Cox & Simpson, 2016). For example, enhancing nursing students' self-efficacy and understanding of microbiology may be pivotal in ensuring that nursing graduates are confident and skilled in their ability to consistently apply appropriate actions in a variety of clinical contexts (Cox & Simpson, 2016). Just like the research on school teachers reviewed above, health sector work on the value of self-efficacy for nurse education is clearly relevant to the agricultural extension issues considered in this thesis. Moreover, just as education research showed the importance of self-efficacy for students, there is a body of health research arguing that it is important for patients too. Research has demonstrated that patient self-efficacy, in conjunction with illness perceptions, is a factor that mediates the association between ones' belief in disease severity and future health fulfilment. Wilski and Tasiemski (2016), for example, found that sufferers of multiple sclerosis who presented with higher general self-efficacy and a perception that treatment could control the progression of the disease tended to have higher self-management levels. Tsay and Chao (2002) suggested that nursing interventions can be developed for patients who are at risk of low perceived self-efficacy and depression if identified early in their treatment.

A substantial body of health research has shown that high patient self-efficacy is an important component leading to successful long-term behavioural change and the adoption of complex actions (e.g. Cervone et al., 2006; Clark & Nothwehr, 1999; Persson et al., 2014; Rosenstock et al., 1988; Selzler et al., 2019; Shields & Brawley, 2006; Strecher et al., 1986; Welsh, 2014). Strecher et al. (1986), for example, investigated whether self-efficacy could be modified and enhanced to facilitate change in weight control, contraception, alcohol abuse and exercise behaviours. A programme was developed to identify specific manageable and achievable component skills required to achieve change to an existing target behaviour. Analysis of the programme showed that there was a consistent, positive relationship between patient self-efficacy, behaviour change and health status. Strecher et al. (1986) found that sequential tasks composed according to attributes identified from an individual's previous successes provided patients with a useful relative measure of progress towards the new target, a point also made by (Bandura, 1977b, 2004; Strecher et al., 1986).

Cervone et al. (2006) contend that highly efficacious adults are more likely to apply the effort essential to maintain and adhere to important health outcomes than are those with low efficacy, leading for example to increased duration and intensity of exercise regimes (Clark & Nothwehr, 1999). Selzler et al. (2019) found that self-efficacy affected the extent to which a participant engaged in physical activity and the management of chronic obstructive pulmonary disease. Their work also showed the significance of vicarious experience as enabling the initiation of new behaviours when individuals are unsure of how to begin a task, the task is complex, or when support from an expert is absent. Although this body of health sector research clearly establishes the importance of self-efficacy, it also shows that self-efficacy levels need to be appropriate. According to Persson et al. (2014), exaggerated belief in one's own efficacy may lead to the rejection or avoidance of offers of help or assistance.

2.2.6 Summary

Self-efficacy was originally developed in psychology to explain why some treatments are more helpful than others in assisting individuals with overcoming domain-specific fears (Bandura, 1977). Self-efficacy has since been used to explain a wide range of more common behaviours, such as athletic capability and performance, entrepreneurship, student attainment, teacher performance and patient recovery. The above examination of empirical self-efficacy studies from a range of disciplines provides further justification and guidance for the research undertaken in this thesis. Taken as a whole, these studies have established that self-efficacy beliefs influence the courses of action that people pursue, the effort asserted and their perseverance and resilience to adversity when planning future change.

The studies reviewed above show that self-efficacy increases personal aspirations and can motivate individuals involved in the business, education and health sectors. Previous research has established a significant link between self-efficacy, learning and an individual's ability to complete a domain-specific task. However, relatively little work of this kind has been done on agricultural topics. The literature reviewed above gives us good reason to think that enhancing farmers' self-efficacy beliefs will help to improve the uptake of agricultural innovations. Such claims about the significance of lower or higher levels of self-efficacy imply that these levels can be somehow measured. Accordingly, the following section reviews literature on the measurement of self-efficacy, in order to guide the development of an instrument able to gauge changes in farmers' self-efficacy within a specific agricultural context.

2.2.7 Measuring farmers' self-efficacy

Given that the research undertaken in this study requires the measurement of farmers' self-efficacy beliefs, it is important to review the literature about the different instruments that have been used to measure this construct. While several existing instruments are available within the health, education and business sectors, few tools have been designed to measure self-efficacy in specific agricultural contexts.

Self-efficacy instruments have been used previously to provide knowledge about the agricultural practices of efficacious farmers (Roy, 2009) and to measure farmer resilience (Duranovich, 2015). However, the concept of self-efficacy is sometimes poorly understood and treated as a domain independent rather than domain specific concept. Self-efficacy is task and context specific and this means that the assessment of someone's beliefs to be successful varies across different domains (Bandura, 1977b). Wuepper and Drosten (2015) illustrated how different levels of individual self-efficacy can evolve as a reaction to environmental demands and rewards to human intervention. Recently Lind et al. (2019) developed the domain-specific Mastitis Prevention Self-Efficacy survey (MPSES) enabling an easy and accessible way of quickly measuring farmer's beliefs in their ability to act toward future animal health.

Bandura (2006b) states that "there is no all-purpose measure of perceived self-efficacy" (Bandura, 2006b, p. 307). Similarly, Pajares (1996) argues that self-efficacy instruments need to be designed so that they are domain specific and that they relate to an individual's belief in their capability to achieve a specific future action. The general terms used in constructing "one measure fits all" (Bandura, 2006b, p. 307) measurement surveys are often divorced from specific situational demands and circumstances, which unfortunately results in ambiguity about the domain being measured (Pajares, 1996). Highly generic measures risk downplaying the challenges an activity involves. And as Bandura (2006b) comments, that if there are no challenges to overcome, or an activity is too easily achievable within the measurement process, everyone will score as highly efficacious.

The statements used in self-efficacy instruments should challenge the research participants' knowledge and efficacy within the context being measured (Bandura, 2006b). Specific measures have been developed by researchers following Bandura's (2006b) guiding principles to measure a variety of specific domains. Measures have been developed for entrepreneurial self-efficacy in order to understand the impact of creative activities for learning innovation (Barakat et al., 2014). Consumer educators and counsellors have developed measures to gain insights into some of the psychological processes that affect ones' ability to accomplish financial goals (Lown, 2011). Nurses' beliefs about their professional skills have been assessed to provide a platform for creating individualized plans for skill development in clinical practice (Welsh, 2014). Others have similarly studied the contribution of social work students' sense of efficacy to their professional development (Tompsett et al., 2017), while the efficacy beliefs of teachers have been measured to determine their persistence, enthusiasm, commitment and instructional behaviour, as have those of students in terms of their achievement and motivation (e.g. Gibson & Dembo, 1984; Hoy & Woolfolk, 1993).

According to Bandura's (2006b) guidelines, measurement using 0–100 interval scales is more sensitive and more reliable than a narrower scale because respondents tend to avoid extreme positions. A narrow scale also restricts the ability of the researcher to gather differentiating information (Betz, 2013). A broader scale provides more scope for respondents to use intermediate steps when considering their answer to the measurement tool's statements. However, several researchers, including Pajares (1996), Usher and Pajares (2009), De Vellis (2012) and Betz (2013), have tested the reliability of results across a range of Likert scale intervals and argue that smaller scales also provide reliable data. De Vellis (2012) suggests there is a trade-off between brevity and reliability because shorter scales are more respondent friendly.

2.2.8 Factors enhancing or undermining farmers' self-efficacy

Any measurement instrument for use with farmers must be relevant to farming situations and these are now highly dynamic. Farmers are increasingly being exposed to conditions they have not previously experienced in their farming career. Farmers constantly engage in experiential learning when they adopt a new management practice (Lubell et al., 2014). The knowledge gained from such trial-and-error decisions is then shared within the actors' various peer networks. These learning processes also often involve other sorts of actors, such as when farmers and scientists share their knowledge to introduce new technologies effectively into existing farm systems (Anil et al., 2015; Eastwood et al., 2017; Klerkx et al., 2012).

Farming is an activity made up of many different domains. Grazing management is the area of primary interest in this thesis, so a measurement instrument needs to be developed that is specific to this domain. Developing such an instrument requires an appropriate understanding of grazing management strategies; without this understanding, subtle but important pieces of information may be missed such that the research outcome is misleading. The general point here is critical. Agricultural extension organisations should aim to set farmers up so that they can effectively implement a specific sort of change into their system. If the set-up is too generalised to support this change then innovation may falter due to the resulting negative impacts on farmers' self-efficacy.

2.3 An overview of agricultural extension theory

The current study was initiated because there was little research into the role of self-efficacy in agricultural extension. It was proposed that self-efficacy was important for farmer learning and practice change and that an understanding of this concept would be important in the design of effective extension programmes. However, to understand the relevance of self-efficacy to agricultural extension, it is important to understand extension theory. This section provides an overview of extension theory by briefly reviewing the evolution of extension over time. Because the self-efficacy of an individual is importantly influenced by their social interactions with others, this section will also consider how actors in the extension system were viewed to interact under the different theoretical perspectives.

Swanson and Sofranko (1997) suggested that the purpose of agricultural extension had been to improve the ability of agriculturalists to adopt new practices and adjust to changing conditions and societal needs. Interventions are essential for building capacity and fostering the learning that enable a sector to respond to continuous competitive challenges (Hall, Janssen, Pehu, & Rajalahti, 2006). Agricultural extension was originally perceived as a service “to extend research based knowledge to the rural sector to improve the lives of farmers” (Rivera, 2011, p. 165). Traditional extension systems focused on increasing agricultural productivity, and tended to use an approach that focused on the transfer of technology (Röling, 1992). Agricultural extension has become both an organisational and educational contributor to the rural knowledge economy (Rivera (2011). There is a growing trend in agricultural extension acknowledging the value of knowledge exchange and collaborative partnerships between farmers and scientists that focus on evidence-based extension and co-innovation (Eastwood, Chapman, & Paine, 2012; Franz, Piercy, Donaldson, Richard, & Westbrook, 2010; Gray et al., 2016). Klerkx, van Mierlo, and Leeuwis (2012) argue that agricultural extension systems have evolved during the past four decades allowing a wider diversity of actors to be involved, recognising innovation as a co-development process and acknowledging it as a complex non-linear process. The following section briefly explores the evolution of extension theory.

Single discipline or transfer of technology (TOT) approach (1960s)

The single discipline approach (Klerkx et al., 2012; Maru, 2018) to agricultural extension, central since the 1960’s, aimed to increase farm production by transferring technology developed through research without farmers’ input (Rolling and Pretty (1997). As such, a key driver of agricultural innovation was the “supply push” from research with little input from farmers (Hall et al., 2006). In this approach, the intended outcome from the TOT approach was technology adoption and uptake with scientists seen as the innovators and farmers were viewed as the passive recipients of technology (Klerkx et al., 2012).

In the TOT approach, science and technology were viewed as relatively independent of political and other social partners (Turner, Klerkx, Rijswijk, Williams, & Barnard, 2016). As such, according to Klerkx et al. (2012), institutional factors were viewed as “external conditioners” of the adoption process. This approach sought to change farmer behaviour in order to increase farm productivity using technology packages developed from research (e.g. “supply push from research”).

The TOT approach had a number of limitations and these have been criticised by extension researchers. For example, Röling and Pretty (1997) argued that the problem with the traditional approach to agricultural extension, the TOT approach, is that technologies are developed without farmer input. Röling (1992) suggested that the transfer of technology approach did not acknowledge feedback paths, anticipate future technology needs or consider farmers as experimenters and technology developers and therefore this approach has resulted in little change on-farm. Edwards et al. (2013) argued that traditional extension methods such as the TOT approach often neglected to factor in the complexity of farm systems or explain famer behaviour (Packham, 2010). Röling and de Jong (1998) argued that problematic agricultural issues tend to be complex and require the adoption of systems thinking supported with whole farm planning through a cumulative learning process.

Early farming systems research (1970s and 1980s)

With the emergence of a market-orientated environment in agriculture and criticisms of the TOT approach, during the 1970s and 80s, early farming systems research adopted a multidisciplinary approach where scientists’ worked with extension agents to design agricultural extension programmes (Klerkx et al., 2012). Scientists and extension designers conducted surveys in order to diagnose farmers’ constraints and needs. Analysis of the data provided direction for the development of extension programmes to improve farm efficiency. “Fit for purpose”, programmes were designed and presented to farmers to improve farm efficiency. Importantly, this approach considers farmers as a valuable source of information and this information provided the drivers for innovation.

As with the TOT approach, the early farming systems research approach viewed science and technology as relatively independent of political and other social partners (Tisenkopfs et al., 2015). However, Klerkx et al. (2012) argued that the early farming systems approach introduced an agro-ecological and farm economic context in an integrated way to agricultural extension. In terms of roles, farmers were viewed as sources of information, and scientists were considered experts (Klerkx et al., 2012). The innovators in the system were now scientists and extension designers. In this approach, the key changes that were sought were the removal of farmers’ constraints so that they could improve their efficiency. The intended outcome from the early farming systems research approach was a farming system fit where technologies better fitted the needs and constraints of the existing farming systems (Kilelu, Klerkx, & Leeuwis, 2014).

Partnerships between tertiary education providers, private industry and farming groups have been identified as a useful strategy to cater for the changing roles of agricultural extension

(Klerkx & Leeuwis, 2009). When adopting innovative technologies, farmers have to adapt their existing farm systems to enable its introduction. Hence, effective agricultural extension needs to be designed with this complexity and experimentation in mind (Röling, 2009). Norton and Alwang (2020) argued that rigid recommendations without the possibility of substitution and adaptation are likely to be rejected; and extension activities developed with insufficient understanding of how farmers learn do not successfully build farmer capacity. Farm system innovation requires farmers to experiment and explore the potential of new technologies, new ways of doing things and new product market opportunities (Beers, Hermans,

Veldkamp, & Hinssen, 2014). Nettle et al. (2015) stated that providing information in this manner will not on its own lead to behaviour change because people differ in their ability to seek appropriate information, ask questions and draw on a range of information from different sources and networks.

Agricultural Knowledge and Information Systems (AKIS) (from the 1990s)

Röling and van de Fliert (1994) argued that agricultural extension needed to change from being centred on the adoption of external innovations by farmers, to one where they were empowered through active participation. The agricultural knowledge and information systems (AKIS) (Röling, 2009) approach to extension emerged in response to criticism of the earlier linear models of agricultural extension, acknowledging the importance of transferring information from farmers to research systems (Hall et al., 2006). Hall et al. (2006) argued that, innovation can be based on different kinds of knowledge possessed by different actors. For example, knowledge held by the farmers and other users of technology and generic knowledge which scientists and other producers of technology typically possess. The 1990s saw farmers, agricultural extension designers and scientists combining to produce knowledge and technologies from various sources for the betterment of farm-based livelihoods (Klerkx & Leeuwis, 2009).

The AKIS approach to extension recognises the importance of farmer involvement in setting priorities for research and development (Packham, 2010). Although it recognised that research was not the only means of generating or gaining access to knowledge, it still focused on research supply (Hall et al., 2006). Klerkx et al. (2012) argued that the collaborative production of knowledge and technologies involving scientists and farmer experts would develop technologies that were better fitted to existing farm livelihood systems. The AKIS concept recognizes that multiple sources of knowledge contribute to agricultural innovation and it focuses attention on developing channels of communication between them (Klerkx & Leeuwis, 2009). The emphasis on innovation as a social process of learning broadens the scope of agricultural research and extension to include developing local capacities (Wood et al., 2014). The addition of educators to the AKIS approach is notable. The AKIS framework clearly recognizes that education improves farmers' ability to engage in innovation processes.

Science and technology developed using the AKIS approach were embedded within a historically defined social, political, economic and agro-ecological content. The value in making connections to specific farming situations and the use of the 'social systems' approach was becoming recognised in agricultural extension in the 1990s (Sol, Beers, & Wals, 2013). Through this approach, agricultural extension activities have endeavoured to build farmer capacity and resilience through empowerment (Hunt et al., 2011). While the AKIS framework recognises the importance of transferring information from farmers to research systems, Hall et al. (2006) suggested that most technologies will be transferred from researchers down to farmers. However, the focus of the AKIS approach is restricted to actors and processes in the rural environment, and the framework pays limited attention to the role of markets (especially input and output markets), the private sector, the enabling policy environment, and other disciplines/sectors (Hall et al., 2006).

Agricultural innovation systems (AIS) (from the 1990s)

Emerging in parallel with the AKIS approach, the agricultural innovation systems AIS approach considers innovation to be the result of a process of networking and interactive learning among a heterogeneous set of actors, such as farmers, input industries, processors, traders and researchers (Botha, Small, Turner, & Klerkx, 2014). The AIS approach acknowledges the importance of co-developing innovation through the involvement of multi-actor processes and partnerships leading to building future capacity to innovate, learn and change in response to changing contexts and patterns of interaction with value chains or other institutional change (Efrén, Cesar Darío, & Hugo Ernesto, 2020). This new thinking focuses on innovation as a continuous process of social, technical and scientific collaboration between regional and higher level systems that impact on productivity and innovation performance (Hall et al., 2006). Within AIS, farmers participate as equal partners, entrepreneurs, and innovators with the intended outcomes of increasing all partners "capacities to innovate, learn and change" (Klerkx et al., 2012, p. 461). The AIS approach has a more explicit focus on institutions than AKIS, with institutional change being recognised as an essential factor or condition for innovation (Maru, 2018). AIS recognises the complex interactions between the multitude of actors and sub-systems that make up an agricultural innovation system. On these terms, then, developing a deeper understanding of the part self-efficacy and learning play in farmers'decision-making processes should usefully inform the design of agricultural extension acticities (Wilson et al., 2015). While the need to develop a deeper understanding of farmer self-efficacy is increasingly acknowledged, extension practioners lack tools capable of measuring self-efficacy changes within particular agricultural contexts.

2.4 Research questions

It is clear from the above review that a gap exists in our understanding of the relationship between psychological drivers, farmers' behavioural characteristics and the conditions in which New Zealand farmers' learning and practice change can best be facilitated. An awareness of this gap and its significance drives the research questions that guide this thesis.

Sewell et al. (2014) argue that agricultural extension can be improved by aligning with effective pedagogies drawn from evidence-based research about what supports learning. Such alignment will make for more effective support for farmers seeking to adopt innovative technologies. This thesis works towards that goal by exploring the relationship between the psychological construct of farmers' self-efficacy and their future management of PSF crops, focusing in particular on a group of farmers participating in an 18-month agricultural extension project. The thesis seeks to measure differences between and changes in these farmers' self-efficacy over time. It seeks to understand what factors account for such longitudinal variation. Accordingly, the following four research questions have been developed. Given that self-efficacy is domain specific, these questions focus in particular on the measurement and significance of self-efficacy for farmer understanding and future use of PSF crops.

1. How can farmers' self-efficacy be measured within the domain of managing PSF crops?
2. How does farmers' self-efficacy to manage PSF crops change in response to engagement in a group-based longitudinal extension programme?
3. What factors enhance or undermine changes in farmers' self-efficacy?
4. In what ways do farmers' understandings of PSF crop management change having engaged in a group-based longitudinal agricultural extension programme?

2.5 Chapter Summary

This literature review has provided a foundation for understanding how self-efficacy theory and research may inform farmer learning and future practice change. The chapter opened by providing some general conceptual background in Bandura's social cognitive theory. The influential sources of self-efficacy were then introduced, followed by discussion of the range of factors that either enable or undermine these self-beliefs. Literature pertaining to the development of self-efficacy measurement tools was introduced, an important task given that this thesis aims to measure change in farmers' self-efficacy within the domain of their future use of PSF crops.

The impact of self-efficacy in the agriculture, business, education and health sectors has been outlined and connections made to the concerns of this thesis. Self-efficacy theory was shown to be highly relevant to studies of agricultural extension, despite the relative lack of such work in this field. Finally, the chapter has concluded by outlining the four questions that frame this research. The following chapter introduces the methodology used to respond to these questions.

Chapter 3 Research Methodology

3.1 Introduction

The purpose of this chapter is to introduce the research paradigms and the philosophical position adopted for this study. The multiphase mixed methods research design is introduced and discussed. A theoretical description of the data collection methods is provided to illustrate why qualitative and quantitative analysis and interpretation were used to answer the research questions outlined in the previous chapter. Finally, ethical principles concerning data collection and methodology to ensure validity, trustworthiness and dependability are considered.

3.2 Philosophical rationale

As an underlying philosophy, pragmatism supports researchers in choosing between different models of inquiry, as certain research questions are best addressed using qualitative analysis while others suit the use of quantitative methods (Creswell & Creswell, 2018). A pragmatic researcher believes that reality is constantly renegotiated and therefore holds that the best method to use is the one that solves the problem (Weaver, 2018). According to Feilzer (2010), pragmatism accepts that multiple realities are open to empirical inquiry when solving practical real-world problems. The use of a pragmatic philosophical view recognises the value of considering “social contexts for inquiry as a social action, rather than abstract philosophical systems” (Morgan, 2014, p. 1049). Pragmatism, is often associated with mixed methods (see Creswell, 2014; Saldaña, 2016), where the emphasis falls in the first instance on the research questions and consequences rather than on methods.

Applying a pragmatic approach allowed the use of multiple sources of data to identify factors that enhanced or undermined change in farmers’ self-efficacy and their understandings of managing PSF. As a pragmatic researcher, I have used the subjective views of farmers (qualitative data) to understand changes in their perceptions of self-efficacy as identified during analysis of the FSEM survey results (quantitative data). The use of a mixed methods design allows for the merging and integration of the quantitative and qualitative data collected so as to gain a deeper understanding of the research questions (Creswell & Plano Clark, 2011).

3.3 Design rationale

Research methods are based on assumptions about the nature of the reality being researched, what constitutes knowledge and the most appropriate means of building knowledge. Methods thus draw on paradigms, defined by Kuhn (1970) as a set of assumptions and practice exemplars shared by a research community and used to generate knowledge.

Mills et al. (2006) argue that ensuring a strong research design means that researchers must choose a paradigm that is consistent with their beliefs about the nature of reality. The paradigm adopted here must be capable of exploring and providing a deeper understanding of the complex and context specific behavioural questions presented in the previous chapter.

Research methods provide opportunities for data to be used both deductively, as in quantitative tests to validate a hypothesis, or inductively, as in qualitative research to explain an emerging idea or pattern of events (Creswell & Creswell, 2018). Quantitative data is based on measured values and can be checked by others, meaning that the results are less open to interpretive ambiguities than are more informal approaches (Carr, 1994). However, poor knowledge of the application of statistical analysis may negatively affect analysis and subsequent interpretations (Black, 1999). While a quantitative design provides the validity that comes with closed data sets, a qualitative design provides for a more iterative trustworthiness based on opportunities to collect open-ended data sets. Given that the development of a farmer self-efficacy measure is a crucial objective for the current study, it could be argued that a quantitative approach is the preferable research design. Bandura (2006b) highlights the strength of quantitative approaches when measuring self-efficacy. However, in order to deepen our understanding of self-efficacy, the thesis supplements such quantitative data by collecting and analysing the subjective beliefs of the research participants.

For the qualitative researcher, there is no single reality. Reality is subjective and exists only in reference to the observer. The contexts of inquiry are natural, not contrived and predefined or taken for granted (Levers, 2013). Johnson and Christensen (2014) suggest the researcher enters “the inner world of participants to understand their perspective and experiences” (Johnson & Christensen, 2014, p. 49). While qualitative studies cannot be easily replicated and their results are difficult to generalise, this approach suits some aspects of the questions posed by this research. Collecting qualitative data using semi-structured interviews, focus group discussions and field observations provided clarification of farmers’ perceptions of their beliefs in their ability to manage PSF during the 18-month extension project.

Seeking to integrate qualitative and quantitative data is the defining characteristic of mixed methods designs, a major research paradigm developed during the 20th and early 21st centuries (Johnson et al. (2007). Mixed methods research has been defined as a philosophically underpinned model of inquiry that combines the strengths of qualitative and quantitative models while minimising their weaknesses (Creswell, 2014; Johnson & Christensen, 2014; Plano Clark et al., 2015). The complementary strengths provided by a mixed method approach means that “the whole of the research is greater than the sum of the parts” (Johnson & Christensen, 2014, p. 53). By allowing for the integration of the quantitative and qualitative data collected, a mixed methods design permits more comprehensive and in-depth answers to the research questions guiding this study.

3.3.1 Multiphase mixed methods research design

This thesis aims to measure change in farmers' self-efficacy for managing perennial summer forage crops (PSF) and to identify the factors that may have either enhanced or undermined these changes and influenced the future use of PSF within their farm systems. The concern with change over time means that the mixed methods approach adopted needs to be multiphase rather than a single snapshot.

A multiphase design acknowledges that some projects require multiple phases of concurrent and sequential activity to answer the research questions advanced. This design allows for sequences of data collection and analysis. study opens with a quantitative phase, followed by a qualitative phase concluding with an integration phase of the combined results (Creswell & Plano Clark, 2011). These phases extend over the 18-month period in which the farmer participants were involved in the PSF extension project. While the design is relatively straightforward in that it involves only one point of data integration, it is complex in the sense of involving multiple levels. The staging of quantitative and qualitative data analysis is summarised in Figure 3.1. Given that both data streams are regarded as of equal value, the design follows what Johnson and Christensen (2014) call the QUAN + QUAL mixed methods model. The following section considers the general nature of the data gathering methods used in this multiphase study.

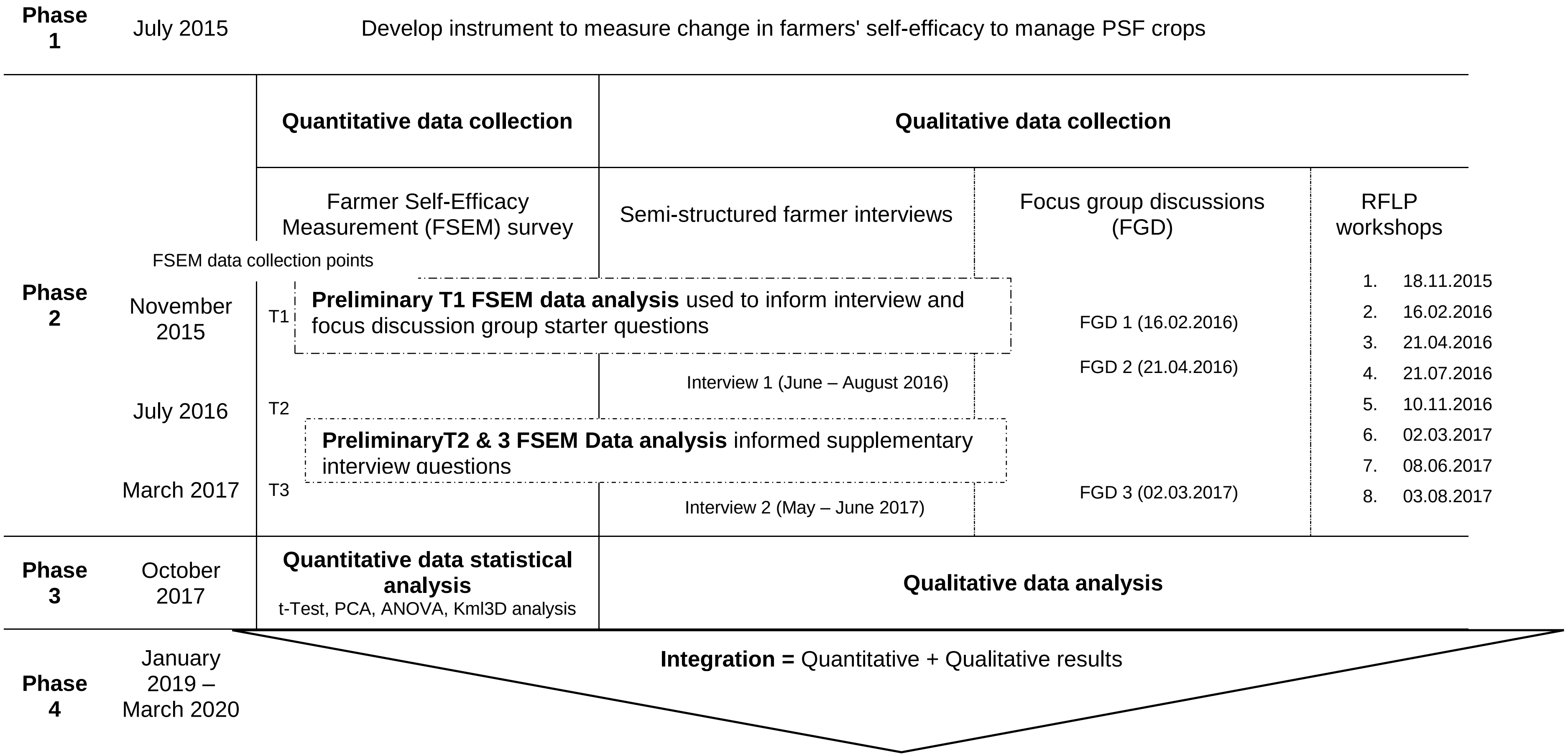

Figure 3.1. Sequence and relationship of qualitative and quantitative research phases designed to measure change in farmers' self-efficacy and understandings of managing PSF having engaged in a group-based longitudinal agricultural extension programme.

3.4 Data collection

3.4.1 Quantitative data generation

Quantitative research is considered to be a formal, objective and systematic process designed to obtain quantifiable information about the world using numbers and statistical methods (Johnson & Christensen, 2014). Structured research instruments such as questionnaires are used to collect numerical data that is analysed to generalise concepts, predict future results or investigate causal relationships (Creswell, 2014). Surveys provide the researcher with "a range of quantitative, qualitative or mixed data" (Johnson & Christensen, 2014, p. 191). While there is an abundance of benefits to using surveys to collect quantitative data, including a wide range of available software and the ability to research numerous participants. However, there are also disadvantages. For example, participants may find the survey too time consuming or the questions incomprehensible. According to Allen (2017), respondents may misunderstand questions, skip questions they find vague or answer inaccurately if the question is misunderstood. Some respondents may not give much thought when answering survey questions and provide random answers which could produce inaccurate findings during data analysis.

These disadvantages can be mitigated. Respondents exposed to the same statements and the same system of coding responses provides a standardised result for the researcher to analyse (Bazeley, 2013). Helpfully, Bandura (2006b) provides guidelines to develop tools that assess self-efficacy within specific domains. The farmer self-efficacy measure (FSEM) developed in this thesis was specifically designed using Bandura's guidelines to provide a reliable quantitative measure across a series of points in time.

3.4.2 Qualitative data generation

The qualitative data in this study primarily originates from interviews with farmers. It also draws from observations of them discussing their experiences of both successes and challenges faced while managing PSF with their peers and the agricultural scientists participating in the extension programme. The various qualitative methods used to collect this data are outlined in the following sections.

Participant interviews

Interviews were employed to provide a rich source of qualitative data. When done appropriately, interviews allow the researcher to enter the inner world of another person to gain an understanding of that person's perspective, their thoughts, beliefs, knowledge, reasoning and motivation (Creswell, 2014). Developing trust and rapport with the interviewee establishes a relationship conducive to their providing information about their inner world (Johnson & Christensen, 2014). The semi-structured interview approach allows the researcher to phrase and rephrase questions as necessary to seek clarity or deeper understanding of interviewee responses. Interviews, however, can be time consuming to organise and costly to transcribe. Their results can also be interpreted differently by others, given that the researcher co-constructs data with the participants from the questions asked and the social interaction in which they participate (Glesne, 2016). The researcher and interviewee use conversations around the questions asked to develop a deeper understanding of the topic under discussion. Semi-structured interviews are therefore an appropriate method for collecting farmers' perspectives on their multiple beliefs in their ability to manage future PSF within their farm systems.

Focus Group Discussion

Focus group discussion (FGD) provides an opportunity to explore and to clarify participants' perceptions and opinions relative to the research questions within a small group situation (Morgan, 1997). A FGD involves a small number of participants (ideally 4-12) who meet as a group with a 'moderator' to discuss a specific topic (Browne, 2016; Onwuegbuzie et al., 2010). The moderator facilitates discussion using open-ended questions, collecting qualitative data from the responses provided by the participants. Meetings are often facilitated in a non-threatening environment, allowing all participants to share their perceptions, attitudes, feelings and ideas around a central theme. While such meetings provide an opportunity to gather data from a larger cohort of farmers than do individual interviews, they require careful management to limit irrelevant discussion between participants and prevent stronger group members from monopolising the discussion. FGD was used in this thesis for a specific purpose - to gain insights from farmers not involved in the semi-structured interviews regarding the challenges and changed understandings about PSF on their farms.

Field Observations

Data captured using field notes (including descriptive and analytical notations) and digital images and recordings of discussions in the field, turn a passing event into an account of possible interest for further consideration at a later phase in the research (Bazeley, 2013). Field observations provide the opportunity to capture supplementary data that cannot be gained in other ways (Glesne, 2016; Punch & Oancea, 2014). For the purposes of this thesis, field notes and digital recordings and images were collected during the sequence of workshops held during the 18-month extension project. Although not treated as a primary data source, these methods provided the opportunity to understand more about how the participants increased their understanding of managing PSF crops from their interactions with trusted peers and scientists.

3.5 Data analysis

Two crucial tasks require completion to quantitatively measure farmers' self-efficacy. First, an instrument must be designed to measure farmer self-efficacy and, secondly, this measure's suitability must be tested. As argued in Chapter 2, measures of self-efficacy must be domain specific rather than generic. Accordingly, the FSEM developed in this thesis has been designed to assess the farmers' beliefs in their ability to adopt or manage PSF crops more efficiently within their farm system. The complete set of FSEM data and the procedures used to collect these are described in Chapter 4 (Section 4.3.1).

The qualitative interview data were examined using constant comparison analysis (Leech & Onwuegbuzie, 2011) This is the method of choice when research questions are general and overarching (Bazeley & Jackson, 2013). In constant comparison analysis, aspects of responses are categorised (coded) and the codes are then grouped into themes (Leech & Onwuegbuzie, 2007). An inductive approach allowed the generation of additional patterns and themes to emerge from the data during analysis. NVivo software (Qualitative Solutions and Research, 2016) was used to enable the complex, iterative process of analysing of the qualitative data collected from the farmers' semi-structured interviews and focus group transcripts. The qualitative analysis was used to explain and clarify the results obtained with the FSEM survey. How this process worked is detailed in Chapter 4 (Section 4.5.3).

In Chapter 7, the results of both the quantitative and qualitative data streams are integrated and analysed further to answer the research questions addressed by this thesis. Integrating the two streams of data develops an understanding of the farming culture and environment to support the findings of the study. It permits a more comprehensive and in-depth analysis than can be provided by either the quantitative or qualitative data taken alone.

3.6 Legitimation

Legitimation directly engages with the mixed methods challenge of integrating data and interpretations from very different frameworks, samples and analyses. Onwuegbuzie and Johnson (2004) discuss the concept of legitimation as a conceptual framework for providing validity to mixed methods research. The appropriateness of the researcher's interpretations influences the quality of research. Combining qualitative and quantitative approaches with differing strengths, as is the case in this current study, compensates for the weaknesses of either approach taken singly by providing *weakness minimization validity* (Johnson & Christensen, 2014). Integration of quantitative and qualitative data is achieved by merging and embedding both forms of data to achieve a valid research outcome.

3.7 Validity, trustworthiness and dependability

The validity and trustworthiness of this study were ensured through the integration of qualitative and quantitative data from multiple sources. Moving between the FSEM survey, farmer interview and FGD data allowed the researcher to develop understanding of the factors that enhanced or undermined changes in farmers' self-efficacy as measured with the FSEM survey. Rigorous checking and discussing methods and data analysis with PhD supervisors, experienced farmers outside the study population and university academics also provided validity to the findings presented in this study.

3.8 Triangulation

Triangulation, according to Tashakkori and Teddlie (2010), can be defined as the combination and comparison of multiple data sources, data collection and analytic procedures and inferences that may occur at the conclusion of a research project. Triangulation allows researchers to utilise methods in a flexible and systematic way, ensuring that they are appropriate for what is being studied (Flick, 2018). Triangulation requires the researcher to explore alternative perspectives in answering research questions. These perspectives may be validated using numerous methods and theoretical approaches to combine different sources of data against the background of the theoretical perspectives that inform the study. Flick (2018) suggests that these perspectives should be treated and applied on an equal footing.

Methodological triangulation, the use of more than one method to gather data (interviews, observations, questionnaires, etc.) broadens the researcher's insight into the different issues underlying the phenomena being studied (Allen, 2017). In this study, qualitative data (such as observations of farmer participation at workshops) were compared to the results of the quantitative phase to explain and deepen understanding of the changes in self-efficacy identified in the FSEM analysis. Triangulation used in this manner substantially improves the credibility of research (Allen, 2017; Johnson & Christensen, 2014).

In this study, all audio recordings of farmer interviews and FGD activities were transcribed verbatim. The dependability of data was also strengthened by the use of respondent validation (Bazeley, 2013). Interview transcripts were returned to participants for validation and the FSEM results were made available for viewing if requested by a participant. The FSEM results, interview and FDG transcripts are available for external referencing if required. An audit trail was created for the study by saving and organising all documentation related to the research, such as field notes, a research journal and coding schemes. This thorough record was used to check issues as they arose later in the analysis and write-up stages.

Creswell (2010) argues that a significant issue for mixed methods researchers is the ability to identify what can be generalised from one context to another. It is typically assumed that most research has relevance in a wider or alternative setting or time. Research without such transferability is of little interest to the wider scholarly community. The mixed method approach used in this thesis, with the rigorous internal checks outlined above, provides credible results that are transferable to other agricultural extension scenarios. Readers will need to judge this study's transferability to their own contexts by carefully considering the specific character of the setting and participants, as described in detail in the following chapter.

3.9 Ethical considerations

The key ethical principles for research are to minimise harm and maximise the benefit for participants (Gibbs, 2007). Informed consent, privacy, confidentiality and anonymity reinforce these key principles (Hammersley & Traianou, 2012). Moreover, as Punch and Oancea (2014) comment, ethical challenges will arise in any study and they raise the following challenge to researchers.

> The researcher must identify the ethically salient aspects of a situation and connect them, as appropriate, with principles, rules, outcomes and other cases, in order to act ethically throughout the life span of the research project (Punch & Oancea, 2014, p. 74).

Johnson and Christensen (2014) argue that the researcher has the responsibility to provide prospective participants with "a description of all features of the study that might reasonably influence their willingness to participate" (Johnson & Christensen, 2014, p. 134). In order for participants to make an informed decision to participate in this study, all farmers in the extension project were provided clear, easily understood information regarding the purpose, procedures, risks and benefits of the study. Opportunity was provided for discussion with both the researcher and principal PhD supervisor before data collection proceeded.

Collecting and analysing data in the form of photographs allows researchers to capture aspects of reality without some of the distorting effects of other methods (e.g. recall bias) and at times words alone are inadequate to capture the field experience (Harper, 1994). Photographs can be used to retrieve key moments in time and stimulate later discussion about the interactions that occurred around them. Clark (2020) debates the effectiveness and ethics of using photography in research, but concedes that it allows the researcher to add value to data without becoming entangled in the situation.

Maintaining anonymity and confidentiality is often considered central to conducting ethical research. Participants should and indeed often want to remain anonymous in any research that has been subject to much debate (Clark, 2020). In this study, the researcher endeavoured to ensure participants' anonymity by removing any informative detail which may have made them traceable or identifiable. Where digital images are used, the researcher blurred faces and attempted to photograph the backs of individuals to reduce the possibility of facial recognition. Codes, numerical numbers or pseudonyms have been employed to ensure further protection of participant anonymity. Once assigned, the same numerical identifier was used to code all the data, including semi-structured interviews and FGD transcripts.

3.10 Chapter summary

This chapter has introduced and defended the research methodology best suited to measure and analyse farmers' self-efficacy. The mixed methods design and the methods used to generate the quantitative and qualitative data used to answer the research questions have been outlined, along with their underpinning by a pragmatic philosophical approach. Finally, the importance and means of engaging sound ethical principles throughout the study has been discussed. The following chapter describes the research procedures in more detail, focusing on the specifics of this study rather than its general character.

Chapter 4 Research Procedures

4.1 Introduction

This chapter discusses how the methodology described in the previous chapter was actioned in this research. The chapter begins with a discussion of the ethical considerations followed in order to ensure that the rights of the farmers involved in this study are respected. The research setting and procedure for selecting the study participants are then introduced, followed by a description of data collection methods, including the Farmer Self-Efficacy Measurement (FSEM) design and piloting. The processes followed during focus group discussions (FGD) and the protocols for semi-structured interviewing are also considered. The chapter concludes by detailing the procedures used for quantitative and qualitative data analysis, setting the scene for the results reported in the following chapter.

4.2 Ethical procedures

As research involves investigation into people's lives and experiences, it is important to show respect to participants and to minimise harm (Denzin & Lincoln, 2000). Permission to conduct the research was received from Massey University's Human Ethics committee prior to the start of data collection (Application 4000015030, included as Appendix 10.1. This section provides an overview of the ethical procedures observed before and during the data collection phases.

4.2.1 Informed consent

Tashakkori and Teddlie (2010) emphasise the importance of gaining informed consent from all participants before collecting any form of quantitative or qualitative data. The privilege to observe and interview farmers in their natural setting is acknowledged by the researcher. The purpose of this study and expectations of participants were verbally explained by the researcher at the first of the RFLP workshops. Data collection and analysis procedures, including the anticipated time commitment for completion of the FSEM survey, semi-structured interviews and FGD, were also explained. An opportunity for asking questions was given at this initial meeting, as well as reassurance that the farmers could talk with the researcher about any concerns they might have at any time throughout the study. Participants' questions were answered honestly and promptly.

Before the FSEM data were collected at RFLP workshops 1, 4 and 6, and prior to each of the FGD and semi-structured interviews, information regarding the purpose, procedures, risks and benefits of the study were clearly presented to the farmer participants in an Information Sheet (see Appendix 10.2). The rights of participating farmers were documented on this Information Sheet, which was first circulated to the participants at RFLP Workshop 1. Written informed consent was obtained (see Appendix 10.4) and permission to record the interviewees was gained prior to the commencement of all individual interviews. All the farmers who were approached consented to participate in the study.

The researcher contacted farmers who did not attend RFLP workshops 4 and 6 via phone or email, inviting them to participate in the second and third FSEM surveys. Participants completing the FSEM survey via email were reminded of their rights to withdraw from the study at any stage. Participants were also reminded that the researcher was available to discuss all aspects of the study if required.

4.2.2 Privacy

Privacy relates to controlling the access of others to oneself, including maintaining the freedom to decide when and to what extent one's actions and perspectives might be shared with others. At the start of each data collection phase, farmers were reminded that participation in this study was voluntary and that they had the right to decline to answer any question or withdraw from the study at any point until analysis of the data was undertaken. Prior to the semi-structured interviews, the farmers were informed that they could ask the researcher to turn off the audio-recorder and finish the interview at any stage. Farmers were provided with the opportunity after reading the relevant transcripts to decide if the content could be used for analysed in this thesis.

4.2.3 Anonymity

Anonymity separates the identity of an individual or institution from information they share by using pseudonyms so that they cannot be recognized. The coding procedure shown in Table 4.1 was developed to ensure that farmers, or their farming operations, could not be identified by information that they provided during the interviews and FGD activities. This coding system provided an accurate reference to participants during the integration and reporting of results. For example, F1 (I1) refers to a comment or statement made by Farmer 1 during the first semi-structured interview. F23 (RFLW3) refers to comment made by Farmer 23 at RFLP Workshop 3. Further examples are provided in Table 4.1.

Table 4.1. Examples of codes used to ensure participant anonymity

Participant	Code used in thesis
Farmer 1	F1
Massey University agricultural scientist 1	AgS1
Data source	
Interview 1	I1
Interview 2	I2
FGD 2	FGD2
Examples	
Farmer 9 Interview 1	F9 (I1)
Farmer 23 FGD 1	F23 (FDG1)
Massey University agricultural scientist 4	AgS4

Note: This table informs the way in which the qualitative results are presented.

The transcriber used for the interview recordings signed a confidentiality agreement Appendix 10.10. After transcription, the transcripts were returned to participants, who had the right to amend or edit any part, and they signed an authority to release the transcript once they had done so Appendix 10.5. All interview recordings, transcripts, and other data were securely stored in a password protected computer and will be held for five years from the date of collection.

4.2.4 Confidentiality

Confidentiality ensures that the information participants provide will only be known to the researcher and not made public. An assurance was given by the researcher that any information provided during interviews would remain confidential. FGD participants were told that the researcher could not assure confidentiality because other members of the group heard what others had said. The researcher asked that what was shared stayed within the group. An offer to arrange support from a health professional was provided was given to all respondents if they felt their self-efficacy had been eroded in the data collection process, an offer that was not taken up. Finally, a promise was given that any published works would not identify them.

4.2.5 Social and cultural sensitivity

Respect of ethical principles associated with social and cultural sensitivity, such as the age, gender, culture, religion and social class of the participants, was considered when constructing the interview groups and FGDs. Two female and one Māori farmer are included among the participants. While this study was not categorised as highly culturally sensitive, the researcher acknowledged previous collaborations between the farmers and scientists by respecting existing networks and views. Sensitivity was observed by responding appropriately to the unique characteristics of farming culture. For instance, the researcher understood the need to make last minute changes because of on-farm situations such as shearing, crutching and cultivation work.

4.2.6 Conflict of interest

The researcher had no prior relationship with any of the participants prior to this study commencing and therefore there was no potential for a conflict of interest to occur. The collaborative partnership formed as the project progressed illustrates the appropriateness of the population to the study topic.

4.3 Research setting: Riverside Farmer Learning Project

The Riverside Farmer Learning Project (RFLP) focused on sheep trials with PSF crops (e.g. chicory, lucerne, plantain and red clover) at Riverside farm, a Massey University managed farm in the eastern lower North Island. Introducing PSF crops into an exisiting farm system could be argued as an example of a complex, as opposed to a simple technology, because of the complexity of factors within and outside a farmers control. The justification for these trials was evidence that farmers successfully adopting and managing PSF crops in this 'summer dry' region could add economic value to their overall farm productivity. The University's science team consisted of five animal scientists, two educational researchers, one agronomist, one farm management researcher, one agricultural economist, one sociologist, one Research Officer, one PhD student (the author) and the general manager of the University's farms. This team met with the 35 core farmer participants in this study every 2-3 months over an 18-month period.

Eight workshops were held between November 2015 and March 2017, with most of them taking place at the University's farm (see Table 4.2 for dates and venues). Each workshop was facilitated by the science team and had a primary focus on the ongoing PSF crop management field trials. Various learning activities were undertaken aimed at sharing and building on both the scientists' research-based knowledge and the farmers' experiential knowledge. These activities are illustrated in Image 4.1 and Table 4.3. They were explicitly designed to encourage interaction between and within these two groups in order to enhance the contribution of science to successful farming.

The eight workshops were designed at regular meetings of the science team over the term of the project. The workshops were subject to continuous review at these meetings to ensure that the farmers' learning experiences were active, dialogic and collaborative. Additional scientists from the University and from Crown Research Institutes were invited to facilitate sessions that matched their expertise with areas of interest identified from farmer feedback and post-workshop science team reflections (e.g. animal nutrition, weed control, managing plant health and sheep autopsies). At every workshop, provisional results from the PSF crop trials and grazing management decisions were discussed honestly between the science team and farmer participants.

Table 4.2. Data collection points for this study

QUAN data collection		QUAL data collection						
Farmer Self-Efficacy Measurement survey		Semi-structured interviews		Focus discussion groups		RFLP workshops		
No.	Date	No.	Date			No	Date	Venue
T1	18.11.2015	1	July/August 2016	1	16.02.2016	1	18.11.2015	Riverside Farm
						2	16.02.2016	Riverside Farm
				2	21.04.2016	3	21.04.2016	Riverside Farm
T2	21.07.2016					4	21.07.2016	Massey University
						5	10.11.2016	Riverside Farm
T3	02.03.2017	2	May/June 2017	3	02.03.2017	6	02.03.2017	Riverside Farm
						7	08.06.2017	Hawkes Bay farm
						8	03.08.2017	Massey University

Close up observations

Group discussions

Drawing in experience from other farmers

Conversations with scientists

Conversations over food

Observing In the field

Image 4.1. RFLP workshop activities

Table 4.3. A typical RFLP workshop programme

RFLP **Workshop 6 Programme**

1000 - 1030	Arrive, morning tea	AgS1 introduced day and guests
1030-1145	Red clover discussion	Farmer F23 shared his experiences of establishing and maintaining red clover on his farm. (Challenging and positive experiences) Interactive session with plant breeding scientist who elaborated on breeding red clover and related research on a King Country monitor farm. Scientists input as relevant.
1145 - 1200	FSEM (T3)	Farmers completed FSEM for researcher
1200 - 1245	Lunch	Catered for at Riverside farm woolshed Farmers involved in informal discussion and questioning with other farmers and agricultural scientists about what they had observed during the morning and how it related to their farm systems.
1245 - 1430	Visit to plantain paddock (Mikimiki block)	AgS2 facilitated discussion between farmers and scientists regarding plant health and weed management prior to visiting the plantain clover paddock on the Riverside farm Mikimiki Hill block. AgS2 facilitated discussion at the Hill block focussed on issues specific to managing plantain/clover before extending other PSF crops.
1430 – 1445	Research update	Pasture management and animal trial update provided by AgS3 and AgS4 back at the woolshed. AgS1 facilitated question and answer session between the scientists and farmers.
1445 – 1500	Afternoon tea	Farmers continued discussion over afternoon tea
1500 – 1530	FGD 3	Researcher facilitates final FGD in smoko room.

4.3.1 Participant selection

Purposeful sampling was used to populate this study. This sampling method involves identifying and selecting individuals or groups of individuals that are especially knowledgeable about or experienced with a phenomenon of interest (Creswell & Plano Clark, 2011). Farmers involved in an earlier learning project based in the Manawatū region (Sewell, Blair, et al., 2014) provided names of their farming peers whom they thought might be interested in participating in the RFLP. Selection criteria included geographic region, type of farm operation, farm experience, farm position and interest in using PSF crops in their farm system. A group of 43 farmers located mainly in the Manawatū and Hawkes Bay–Wairarapa regions of New Zealand were invited to participate by the project's management group (see Table 4.4).

Table 4.4. Location of RFLP participants' farms

Region	Farmers	% of total farmers
Hawkes Bay	11	26
Manawatū	8	18
Wairarapa	24	56
Total	**43**	**100**

The farmers invited to attend the RFLP were all operating sheep and beef breeding or finishing farms (see Table 4.5). Most farmers (91%) were operating breeding farms with varying levels of stock finishing. Only 9% (4) were operating intensive stock finishing operations. All farmers were using a species of PSF and had expressed a strong interest in extending this use in the future to improve the productivity of their farm systems.

Table 4.5. Farming systems used by the farmers invited to participate in the RFLP

Region	Breeding (with some finishing)	Breeding/ Finishing	Breeding/ Intensive finishing	Intensive Finishing	Total
Hawkes Bay	0	11	0	0	11
Manawatū	0	6	0	2	8
Wairarapa	3	17	2	2	24
Total	**3**	**34**	**2**	**4**	**43**

Table 4.6, below, outlines the composition of the RFLP farmer population. Twenty of them, are referred to as "original farmers", because they had been members of an earlier pilot study funded by Gravida (a government-financed Centre of Research Excellence) and Massey University's International Sheep Research Centre. These 20 original farmers knew the science team and were conversant with the farmer learning model of agricultural extension used in this study. The focus of this previous pilot study was a lamb finishing trial using herb pastures (plantain/chicory/clover), and so the original farmers brought their previous experience of growing and managing herb pastures to this study. The remaining 23 farmers involved in the RFLP had not participated in the earlier pilot, and therefore had not worked with the science team, nor had they engaged in agricultural extension about herb pastures.

Table 4.6. Composition of RFLP population

Farmer Learning Group	Farmers	% of total farmers
New	23	54
Original	20	46
RFLP Total number of farmer participants	**43**	**100**

4.3.2 Missing data from Farmer Self-Efficacy Measurement survey

As the RFLP progressed, less farmers completed the FSEM survey, such that 57% completed surveys at all three data collection points and by the end of the study the number of full datasets available for analysis was 24 (see Table 4.7; see also Appendix 10.7). In longitudinal studies, it is inevitable that participants will withdraw or be unavailable during one or more sessions. Missing data occurred in this study because of an unwillingness of some farmers to respond to specific items of a survey or they were absent from one or more data collection points. These types of missing data were unintended and unable to be controlled by the researcher (McNeish, 2017). As Schafer and Graham (2002) comment, “missingness is a nuisance because managing it in a principled manner raises conceptual difficulties and computational challenges” (Schafer & Graham, 2002, p. 147).

Table 4.7. FSEM survey completed at the data collection points

	November 2015		July 2016		March 2017	
	n	%	n	%	n	%
FSEM completed	41	95	34	80	25	58
FSEM not completed	2	5	9	20	18	43
Total	**43**	**100**	**43**	**100**	**43**	**100**

Analysis of the FSEM data using the Little’s Missing Completely at Random (MCAR) test provided a *p* value greater than 0.05 and on this basis the hypothesis that the data were ‘missing at random’ was accepted. Deleting all incomplete datasets in this study would have reduced the sample population to 25 meaning only 58% of all the RFLP farmer participants would be part of the statistical analysis. Participants who completed only one FSEM survey of the three were removed totally from the imputation data set used in the statistical analysis phase of this study, while those who completed two of the three were retained.

As missing data was a factor requiring attention, the Multiple Imputation (MI) technique (Rubin, 1987) was used because it solves this problem in a statistically robust manner. MI is an intuitive technique designed to take advantage of the flexibility of modern computing software (e.g. SPSS 25) to handle missing data. This technique allowed for further analysis using the more advanced statistical methods introduced below. Managing missing FSEM data using the MI technique identified 35 farmers' results as suitable for further statistical analysis. These 35 farmers were selected to become the core subjects of this study. Restricting data analysis to these selected farmers allowed rigorous matching of the quantitative and qualitative results.

4.3.3 Study population

The 35 selected core farmers represent a cross-regional spread similar to that of the RFLP population as a whole. Most of the farmers (74%) with complete sets of data were operating breeding farms with varying levels of stock finishing. Only 17% (6) were operating intensive stock finishing operations.

4.4 Data collection methods

This study explores the extent to which participation in the RFLP enabled or undermined changes in farmers' self-efficacy and seeks to understand the reasons for any such change. Two types of data were collected using a multiphase mixed method research design. A robust quantitative measure of farmer self-efficacy, the FSEM, was developed to collect quantitative data at three points in time to measure changes in farmers' self-efficacy in relation to managing PSF crops (see Table 4.2. p. 65) Qualitative data were collected through semi-structured individual interviews, FGD activities and field observations at the eight RFLP workshops, with this data thematically analysed to shed light on changes revealed by the FSEM. A full description of these various data collections is provided below.

4.4.1 Quantitative data collection tools

FSEM design and piloting

The FSEM was constructed after consulting a range of existing validated and published instruments, notably including those listed in Table 4.8. An initial collection of 50 statements was carefully grouped, regrouped, reworded and categorised using an iterative process by the researcher and a panel of five experts from Massey University's School of Agriculture and Environment and the Institute of Education.

The survey statements were phrased in terms of 'I am confident I can ….'. They were designed to measure the challenge to self-efficacy perceived by farmers while adopting or managing PSF crops in their farm system. The statements represented a variety of relevant challenges that farmers face, such as pasture establishment and renewal, weed management, plant health and grazing strategies.

Table 4.8. Existing Self-Efficacy Surveys

Self-efficacy context	Research (in date order)
Agriculture	Willock et al. (1999); Roy (2009); Turner et al. (2014); Graymore et al. (2015); Lind et al. (2019)
Adult learning.	Hammond and Feinstein (2005), Welsh (2014)
Entrepreneurship	Barakat et al. (2014)
Finance	Lown (2011)
Nursing students	Rowbotham and Schmitz (2013)

The statements were randomly distributed in the survey to minimise any clustering of responses by the respondents. This initial process resulted in 26 FSEM statements (see Table 4.9). Farmers were asked to rate their self-efficacy on each statement according to a quantitative scale. The FSEM uses a unipolar interval scale to prompt respondents to think of the presence or absence of the identified quality or attribute. The respondent's self-scoring for each statement could range between 0 – 10 (0 = not at all certain, 5 = moderately and 10 = highly certain), as endorsed by Bandura (1997).

A formal piloting of the FSEM was undertaken outside the RFLP, using Beef+LambNZ's electronic diary portal to test the statement's reliability and to refine them. Thirty farmers ranging from South Island high country to hill country breeding, breeding/finishing and intensive finishing farms from across New Zealand responded to this pilot test request. These farmers responded to an online version of the FSEM using the Survey Monkey website within a 21-day period from October 2015 to November 2015. Once closed, the FSEM data were downloaded into SPSS 25 (IBM Corporation, 2017), cleaned and tested for outliers and errors.

Analysis of the pilot's descriptive statistics identified that 23 of the 30 farmers fully completed the survey. Twenty-four (86%) of the respondents were male and four (14%) female. Two respondents did not proceed past the consent stage and five respondents did not complete all the statements. Cultural diversity was not reflected within the pilot, with 100% of the respondents identifying themselves as New Zealanders or NZ European. Their age range was relatively evenly distributed within the 30–70 years' age band, with the largest group (29%) being 40–49 years old. Most farms appeared to be in 'family' control, with 60% of respondents farming in a family trust, family partnership or owner-operated situation. Just more than a half of the pilot farmers (57%) worked in a breeding/finishing environment. Plantain was grown and grazed by 63% of them, while approximately 40% were using lucerne, chicory and red clover. Of the 30 respondents, 90% were currently using forages, 7% were considering using one or more PSF crops in the future and one was not interested in introducing PSF crops into his system at any time in the future.

Pilot farmer feedback on the readability and flow of the statements provided further guidance to the researcher in developing a more user-friendly measurement instrument. Closer examination identified some replication within the intent of the statements. After thoughtful consideration, six repetative statements (shaded in Table 4.9) were removed to produce the final version of the FSEM (attached as Appendix 10.6).

Table 4.9. FSEM (Pilot)

I am confident I can….	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
select the best species of perennial summer forages for my farm's local climate and soil conditions.	.749	.968
select the best species of perennial summer forages for my animal feed requirements.	.731	.968
manage the costs that may be required to introduce perennial summer forages.	.731	.968
implement strategies that manage the risks associated with changing from my current pasture species to perennial summer forages.	.735	.968
find science-based research that identifies the potential risks of introducing perennial summer forages onto my farm.	.752	.968
make an informed judgement using knowledge provided by farmers who have used perennial summer forages on their farms.	.746	.968
make an informed judgement about using perennial summer forages from information provided by commercial sources.	.769	.968
give useful advice to neighbouring farmers who want to use perennial summer forages on their farms.	.868	.967
defend my decisions when talking with other farmers about the management of perennial summer forages on my farm.	.884	.967
use perennial summer forages to improve my grazing options during drought events.	.720	.968
introduce perennial summer forages on my farm with minimal outside support.	.422	.971
use perennial summer forages to improve my farm productivity.	.755	.968
identify solutions to control weed problems when using perennial summer forages.	.667	.969
identify solutions to control plant health issues when using perennial summer forages.	.823	.967
focus on positive aspects of farming when management issues arise.	.887	.967
persevere if challenging situations arise when using perennial summer forages on my farm.	.895	.967
agree to decisions made by others on the use of perennial summer forages.	.542	.970
help other farmers achieve their goal to use perennial summer forages on their farms.	.873	.967
accept the group's suggestions about the species of perennial summer forage to use on my farm when they have more expertise than me	.714	.968
cooperate within a group environment to improve my own knowledge of perennial summer forages.	.810	.968
work with research scientists to improve the management of perennial summer forages on my farm.	.705	.968
express my views on important issues regarding perennial summer forages.	.719	.968
ask questions to help make my decision to change to perennial summer forages on my farm.	.733	.969
increase my personal knowledge of perennial summer forages by talking with other farmers.	.800	.968
share my enthusiasm for using perennial summer forages.	.667	.969
handle unwanted pressure regarding the use of perennial summer forages.	.604	.969

Studies based on measurement must be concerned with the accuracy and reliability of the results produced during data collection and analysis. Internal consistency reliabilities of self-efficacy measurement tools should be computed using Cronbach's Alpha (Bandura, 2006b). According to Cronbach (1951), a reliability coefficient demonstrates whether the test designer was correct in expecting a certain collection of items to yield interpretable statements about individual differences. A reliability coefficient of 0.8 or higher is considered acceptable in most social science research situations (Field, 2013). Cronbach's Alpha was used to calculate the FSEM's internal consistency. The Cronbach's Alpha reliability value for the items in the FSEM scale was 0.96, indicating that these items are acceptable for statistical purposes.

As Table 4.9 shows, most FSEM statements had a Corrected Item-Total Correlation value of greater than 0.60. Three statements scored <0.60. However, removing them made little difference to the overall FSEM correlation and they were therefore retained. All statements showed a 'Cronbach's Alpha if item deleted' value of between 0.967 - 0.971. As stated above, the FSEM survey was presented to farmer participants at three time points: (1) T1 November 2015, (2) T2 July 2016 and (3) T3 March 2018. Farmers completed the finalised version of FSEM as part of the workshop activities (see Table 4.10), with those not in attendance offered an opportunity to complete a digital version using the Survey Monkey platform.

Table 4.10. FSEM responses

FSEM data collection event		**Completed at RFLP workshop**	**Web version completed**	**FSEM completed**	**No FSEM returned**	**Total farmer participants**
T1	November 2015	29	14	43	1	43
T2	July 2016	18	17	35	8	43
T3	March 2017	20	5	25	18	43

Complete sets of 3 FSEM data were received from 25 farmers (see Table 4.11). Eleven provided two of the three, giving 35 farmers who completed at least two surveys and, as explained above, this 35 have been taken as the core farmers for this study.

Table 4.11. FSEM presented for statistical analysis

	Farmers
No FSEM surveys completed	2
One FSEM survey completed	6
Two FSEM surveys completed	10
Three FSEM surveys completed	25
Total	**43**

Cronbach's Alpha was used to calculate FSEM internal consistency and reliability across the 3 time periods. Cronbach's Alpha reliability ranged between 0.86 and 0.95 (see Table 4.12). Being above 0.80, the FSEM is therefore deemed acceptable for use at all three points in this study.

Table 4.12. Cronbach's alpha FSEM

N=35	Data collection point	Cronbach's Alpha
T1	November 2015	0.954
T2	July 2016	0.859
T3	March 2017	0.930

4.4.2 Qualitative data collection

Qualitative data were collected to further understand the quantitative data collected via the FSEM. The researcher attempted to gain an insight into each farmer's world by using semi-structured interviews and focus group discussions with the 35 farmers who were the focus of this analysis. These methods enabled the researcher to describe the farmers' understandings and challenges in managing PSF crops, as well as to better understand how changes in farmers' self-efficacy informed their future PSF management practices.

Semi-structured interviews

Interviewing is a qualitative method for finding out about people's experiences, thoughts and feelings. As mentioned in the previous chapter, interviewing enables the researcher to learn about people on their own terms, as well as in the context in which the study is taken (Check & Schutt, 2011). Semi-structured individual interviews with twelve farmers were undertaken for this thesis. The data collected from these interviews were analysed to explore factors that contributed to or constrained change in farmers' self-efficacy and their future management strategies of PSF.

The 12 interviewees were selected using a stratified sampling process. Stratified sampling considers individual subgroups in proportion to their presence within the population of interest and aims for a proportional representation of these subgroups. The most relevant subgroupings in the RFLP population are formed by the distinction between those who did and those who did not participate in the earlier learning project run in the Manawatū, recorded as the "new" and the "original" in Table 4.13.

Table 4.13. RFLP subgroup populations

Farmer Learning Group	N	Hawkes Bay	Manawatū	Wairarapa
New	23	5	1	17
Original	20	4	9	7
Total	**43**	**9**	**10**	**25**

The 43 farmers who attended and completed the FSEM at RFLP Workshop 1 were divided into these two subgroups. The farmers' T1 FESM mean scores were ranked as high, mid and low, and the proportions of these score categories were calculated for each subgroup (see Table 4.14). The mean and standard deviation of each group were used to a confirm realistic representation of the total RFLP cohort by the farmers selected for in-depth interviewing. The 12 farmer interviewees derived from the 35 core farmers, allowing for the integration of their interviews with the FSEM data.

Table 4.14. Semi-structured interview selection procedure

RFLP participants	**N**=43	Low	Mid	High
Original	20	n=7 (35%)	n=7 (35%)	n=6 (30%)
FSEM mean range		5.15 - 6.0	7.10 – 7.90	8.00 – 8.75
New	23	n=9 (43%)	n=5 (24%)	n=7 (33%)
FSEM mean range		3.20 – 5.20	5.40 – 6.20	6.65 – 8.84

Semi-structured interview groups	N (12)			
Original	6	n=2 (33%)	n=2 (33%)	n=2 (33%)
FSEM mean range		5.15 – 5.30	6.80 – 7.10	8.50 – 8.75
New	6	n=2 (33%)	n=2 (33%)	n=2 (33%)
FSEM mean range		3.20 – 3.75	5.95 – 6.15	7.95 – 8.84

Using T1 (November 2015) FSEM data, the researcher designed interview questions to explore changes in farmers' interpretations and experiences of managing or adopting PSF crops, as well as to explore factors that contributed or constrained their self-efficacy. The 12 farmers were interviewed between July/August 2016 and April/May 2017. Each interview lasted between 45-60 minutes at a venue acceptable to both interviewee and researcher. On one occasion, the farmer arranged to meet at a café in a local town.

Pre-set questions were used by the researcher to initiate the interview (see Appendix 10.8). Interviewee's responses were then probed for clarification or explanation. Responses were recorded using a digital audio-recorder, accompanied by short supporting handwritten notes to remind the researcher to pick up on ideas later in the interview. At the completion of the interview, key descriptors such as interview venue, time, participant's name, tone of interview, points to follow up and reflective comments were noted. Interviews were transcribed by both the researcher and a professional transcriber. Each transcript was checked for inconsistencies by the researcher before being sent to the interviewee for verification. The data were then stored in NVivo 12 (Qualitative Solutions and Research, 2016) for coding and thematic analysis, as detailed further below.

Focus group discussions

Focus group discussions (FGD) provided the farmer participants with an opportunity to discuss the benefits and challenges associated with adopting and managing PSF crops within their existing farm systems. Twenty-five (72%) of the 35 core farmers contributed to the qualitative data collection phase through either interview or FGD (see Table 4.15). Six-to-eight farmers not selected for individual interviewing were invited to participate in each of the three FGDs, with a different set of farmers invited each time. The decision was made to involve different individuals each time in order to increase farmer voice in the overall qualitative data set. These discussions occurred at the conclusion of Workshop 2 (November 2015), Workshop 3 (July 2016) and Workshop 7 (March 2017). Each FGD lasted for between 45 and 60 minutes. Table 4.15 identifies a 'low attendance group' – this is comprised farmers who only attended three or less of the RFLP workshops. While not actively engaged in the interview or FGD phase of data collection, some of these farmers contributed to the study through their completion of FSEM surveys.

Table 4.15. Semi-structured interview and FGD participants

FGD or semi-structured interview	Participants (N)	% of RFLP group
Interview group	12	34
FGD 1	3	9
FGD 2	3	9
FGD 3	7	20
Low attendance group	10	28
Total	**35**	**100.0**

The FGD explored the nature of what farmers were learning in the workshop activities that had been designed specifically to help them to efficiently manage PSF crops on their farms. The farmers' insights provided valuable feedback to the science team which helped the planning of future workshops. FGD members were contacted prior to each workshop via email or phone to remind them of the coming small-group discussion. A set of open-ended questions was prepared as discussion starters and made available to farmer participants prior to the discussion (see Appendix 10.9). Each FGD was audio-recorded with the prior permission of all participants and transcribed by the researcher for later analysis using NVivo.

Field Observations

Field observations of participation at the workshops were used to understand the nature of the farmers' interaction, the questions they asked and, to some extent, what information they might have been gathering about managing PSF crops. These observations, taken in field notes and photographs, enabled the researcher to prepare specific questions for later discussion during the interviews or FGDs. For example, during the first workshop, one farmer was observed discussing the possible use of lucerne on his farm with one of the scientists. The researcher used this field note to ask the farmer in a later interview about the observed conversation and whether this conversation had made him more confident to introduce the crops into his farm system. Observations were recorded using written notes and both digital sound and photographs for later analysis.

4.5 Data Analysis

The multiphase mixed method design used for this study required the quantitative and qualitative data to be analysed at multiple, sequential stages. The analysis of FSEM quantitative data gained at T1 informed the content of the subsequent semi-structured interviews and the FGD starter questions. Once T1, T2 & T3 FSEM data were available, statistical analysis using SPSS explored its statistical significance, identifying domains worthy of further investigation within the qualitative interviews, focus groups and field observations.

4.5.1 Mixed methods research data analysis

In mixed methods research, the analysis of quantitative and qualitative data is reliant on a design that facilitates appropriate data preparation, exploration, analysis and validation (Creswell, 2014). Without such a design, the two sorts of data cannot be integrated to inform a more comprehensive set of results. Analysis of the two data sets collected in this study followed the process suggested by Creswell and Plano Clark (2011), as summarised in Table 4.16. Sequential and concurrent data analysis was employed initially, followed by a final stage of data integration.

Table 4.16. Summary of data analysis procedures

	Data Analysis procedures	Quantitative	Qualitative
Methods in action	Preparing data for analysis	• Code data by assigning numeric values. • Prepare data for analysis with IBM SPSS Version 25 IBM Corporation (2017). • Clean database. • Recode or compute new variables for computer analysis. • Establish code book.	• Organise documents and visual data. • Transcribe interviews, FGD record and field observation notes. • Prepare data for analysis with NVivo ™ Version 11 Qualitative Solutions and Research (2016).
	Exploring data	• Visually inspect the data • Conduct descriptive analysis. • Check for trends and distributions	• Read through data. • Write memos. • Develop qualitative code book.
Results	Finding themes	• Choose appropriate statistical tests. • Report inferential tests, effect sizes and confidence levels. • Use IBM SPSS Version 25 (IBM Corporation, 2017) to analyse data sets.	• Code the data. • Assign labels to the codes. • Group coded into themes/categories. • Interrelate themes/categories or abstract to smaller subsets. • Use NVivo ™ Version 12 (Qualitative Solutions and Research, 2016) to analyse data
	Representing data	• Represent findings in statements of results. • Provide findings in figures and tables.	• Represent findings in discussions of themes/categories. • Present visual models, figures and tables.
Discussion	Interpreting data	• Explain how the findings address the research questions. • Compare findings with past literature theory or prior explanations.	• Assess how the research questions were answered. • Compare the findings with the literature. • Reflect on the meaning of the findings. State new questions based on the findings.
Linking back to the literature	Validating the data and results	• Use external standards. • Validate and check reliability of scores from previous use of Farmer Self-Efficacy measurement tool. • Establish validity and reliability of current data. Access the internal and external validity results.	• Use validation standards such as triangulation, participant validation, disconfirming evidence and external reviewers. • Check accuracy of transcripts and field notes. • Check for reliability.

Validity and reliability

Initial analysis of the two data bases was completed separately. As the study progressed, the data bases were compared and then merged during the final phase to give study validity and integrity. The key driver during analysis of the combined data was an attempt to determine actual changes in farmer self-efficacy. Changes in individual self-efficacy scores were identified and discussed during the individual semi-structured interview phase in order to identify relationships between a farmer’s self-efficacy and their future management of PSF crops. Analysis of the interview data provided for a deeper understanding of what contributed to shifts in self-efficacy.

The analysis relied on a mix of inductive and deductive techniques. While induction is useful for the identifying regularities, deduction is necessary to validate any theory generated in response to the research questions. The researcher employed induction to systematically examine the qualitative data for common themes. During this phase, the researcher moved from an initial descriptive understanding of the data to a more theoretical stance. Comparisons were drawn across the data sets to identify more detailed implications of individual responses to specific questions or statements. Analysis using SPSS 25 and NVivo 12 enabled the quantitative and qualitative data to be managed and patterns identified to inform integration across both data sources.

4.5.2 Quantitative data analysis

Quantitative researchers rely on the collection of numerical data to test a hypothesis or theory, often using a 'narrow-angle lens' that focuses on a limited number of causal factors at any one time (Johnson & Christensen, 2014). A number of statistical techniques were used to analyse these quantitative data. Factor analysis, 2-Factor Repeated Measures Analysis (ANOVA) and a K-Means for Joint Longitudinal Data trajectory algorithm (Kml3D) were used to group and identify statistically significant change in farmers' self-efficacy during the 18-month period covered by this study. Descriptive statistics, standard deviation and mean score values for the FSEM data (Appendix 10.12) were used to develop summaries and enhance initial understanding (Onwuegbuzie & Combs, 2010). For the purpose of this study, it was important to establish statistical significance regarding the FSEM mean results obtained at T1, T2 and T3. Implementing a paired sample t-test enabled the researcher to compare changes in farmers' self-efficacy by pairing their FSEM mean results at T1-T2, T1-T3 and T2-T3. A Kml3D analysis was used to explore changes in farmer self-efficacy across time and within the identified subgroups

Factor analysis

Factor analysis is a multivariate statistical approach used in psychology and education to develop, refine and evaluate tests, scales and reduce large data sets. Although sample size is important in FA, there are varying opinions with several guiding suggestions in the literature (Hogarty et al., 2005). In this study, however, FA was used not to reduce the data but rather to calculate the most important FSEM statements based on participant responses.

Kml3d algorithm

Given the interest in detecting subgroups of individuals with a simiar pattern in their joint trajectories regarding several longitudinal variables a longitudinal non-parametric analsysis was employed. Longitudinal data are "data in which each variable is measured repeatedly over time" (Genolini et al., 2016, p. 1). Such data are essential in research concerned with the temporal evolution of variables (Jacques & Preda, 2014). In this study, investigating quantitative changes in farmer self-efficacy required a robust statistical algorithm capable of clustering a small non-parametric data set. How to cluster data trajectories is considered a major issue in longitudinal statistical analysis (Genolini et al., 2013). The Kml3d algorithm has been selected to identify distinct, homogeneous clusters of outcome trajectories over 3 points in time (baseline, 9 months and 18 months). K means clustering was performed over 3 time points, enabling analysis of the joint evolution of complex interactions between variables over the period of the study The algorithm considered the interactions across all variables, forming clusters across time for each FSEM statement. In doing this, the algorithm considers interactions that may have taken place while the respondent was completing the survey.

The traditional method of working with variable trajectories is to cluster them using a single variable trajectory in order to identify the presence of homogeneous subgroups (Genolini et al., 2013). According to Genolini et al. (2015), however, "it is reasonable to present the average trajectory of a group of three or four individuals" (Genolini et al., 2015, p. 21). This *k-means* approach has clear advantages over mixture models when working with small data sets (Hall et al., 2019; Kramer & Golam, 2019), as is the case here.

4.5.3 Qualitative data analysis

During the qualitative data collection phase, initial analysis was carried out so that findings could be used to inform the next phase of the study. The qualitative analysis commenced with the loading and organisation of the relevant transcripts, notes, audio files and images into NVivo 12. As mentioned in the previous chapter, constant comparative analysis was used to explore the semi-structured interviews and FGD transcripts (Leech & Onwuegbuzie, 2007). Initially, the researcher read and re-read the transcripts to become familiar with the data. Interesting excerpts were identified and coded to 'free nodes'. These 'free nodes' were used to construct four tree nodes that addressed the thesis research questions - self-efficacy, enhancing factors, undermining factors and adopting new understandings of PSF management. As coding proceeded, further sub-nodes were inductively developed and progressively organised. Additional categories were identified, and new nodes created as each interview and FGD transcript was analysed. The nodes were fleshed out as data were extracted from each source referring to the same category. The resulting node structure is given in Appendix 10.15**.**

When the coding process was completed, NVivo's model explorer tool was used to map themes emerging from analysis of the farmers' interview and the FGD transcripts (see Appendix 10.15). For example, "enhancing factors" (see Appendix 10.16) was identified as a high-level node that related to a specific research question listed earlier in this thesis. This category was further divided into sub-nodes such as; new information gained at workshops, seeing and hearing others experiences with PSF, dialogue with farmers, scientists, rural professionals and own on-farm experiences to generate coding reports and visual maps for that high-level node (see Appendix 10.18). During this process, relationships between them were discovered and added to or discarded. The sub-node of "dialogue with farmers, scientists and rural professionals”, was identified from these reports. The nature of this node was further developed as more data was coded to this particular node. Nodes within this coding map were checked using the matrix function within NVivo to make sure that the various labels were sufficiently different from each other and that there was no duplication. Key pieces of the farmer interview and FGD texts linked to a common context were then inductively sorted into groups (nodes) relevant to the research questions, as shown Appendix 10.17. Descriptive information about how often a node was attributed to a farmer’s response was assembled for further investigation along with the quantitative data.

4.6 Chapter summary

This chapter has provided an overview of the procedures employed to collect and analyse the data generated from quantitative and qualitative sources. The application of ethical principles has been discussed and the participants introduced, along with an explanation of how they were selected. A range of analytical techniques as well as their integration within the overall research design have been outlined. The remainder of the thesis is concerned with the results returned by the application of these techniques and with the significance of these results for our understanding of the part played by farmer self-efficacy in the adoption of PSF crops. Chapter Five begins this task by presenting the results of the quantitative analysis.

Chapter 5 Quantitative Results

5.1 Introduction

This chapter presents the findings for the primary research question that seeks to develop a deeper understanding of the relationship between farmers' self-efficacy, their learning, and future decision-making when considering the use of up-to-date agricultural technologies, in this case, managing PSFs. The quantitative results collected from 35 farmers participating in the RFLP showed changes in their perceived self-efficacy scores for managing PSFs between their initial responses at November 2015 (T1) to the follow-up responses collected at July 2016 (T2) and March 2017 (T3). In addition, this chapter presents an analysis of the statistically significant change in the farmers' self-efficacy between T1 and T3. The outcome of the Factor Analysis (FA) used to cluster the 20 Farmer Self-Efficacy Measurement (FSEM) statements into themes for further analysis is also described. The results of two factor repeated ANOVA analysis of the four key statements identified in the factor analysis are introduced. Finally, the findings of the K-Means for Joint Longitudinal Data (KmL3D) trajectory algorithm, used to confirm the result of the 2-factor repeated measures ANOVA are also reported.

5.2 Farmer Self-Efficacy Measure (FSEM) analysis

The aim of the second research question was to explore how farmers self-efficacy beliefs changed while they were participating in an eighteen-month farmer learning project at Riverside farm. In order to investigate any difference between the level of farmers' self-efficacy at the beginning and end of the eighteen-month period, the FSEM scores of each of the 35 participants were calculated for November 2015, July 2016 and March 2017. The FSEM (Drysdale et al., 2017) was designed to measure change in farmers' self-efficacy within the domain of managing PSF. Initial analysis using SPSS version 25 (IBM Corporation, 2017) identified an increase in the overall group mean in farmer's perceived self-efficacy as shown in Figure 5.1.

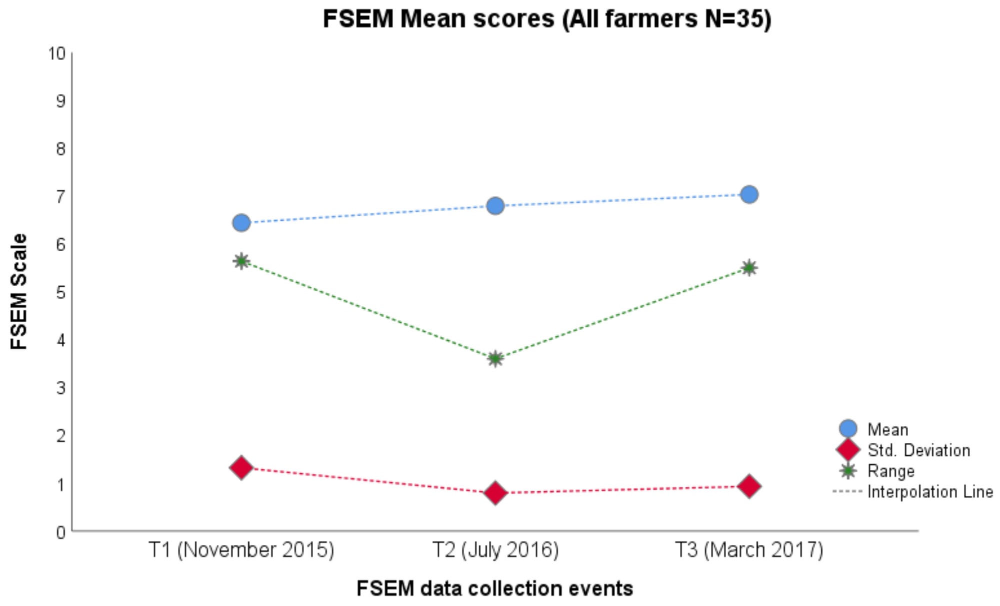

Figure 5.1. Change in farmers' self-efficacy (November 2015-March 2017)

As discussed previously, the FSEM consisted of 20 statements for which the farmers scored their perceived ability using a 10-point Likert scale (0 = not at all confident I can…. through to 9 = highly certain I can…). The RFLP group's FSEM Mean increased from 6.44 to 7.03, an increase of 0.59, between November 2015 and March 2017 (see Table 5.1). With a statistically significant change in self-efficacy of the total group established, it was decided to investigate if there was a difference between the farmers who were new to the learning group and those who had been involved with the earlier group (the "originals") that had been run at Massey between 2011 and 2015.

Table 5.1. FESM Mean scores

		November 2015	July 2016	March 2017
New (n=17)	Mean	5.98	6.48	6.96
	Std. Deviation	1.45	0.68	0.69
	Range	5.64	2.40	2.79
	Variance	2.11	0.47	0.47
Originals (n=18)	Mean	6.87	7.09	7.10
	Std. Deviation	1.05	0.80	1.14
	Range	3.60	3.29	5.50
	Variance	1.11	0.63	1.29
RFLP (N=35)	Mean	6.44	6.79	7.03
	Std. Deviation	1.32	0.79	0.93
	Range	5.64	3.60	5.50
	Variance	1.75	0.63	0.87

Table 5.1 above shows that the new group of farmers' FSEM mean within the domain of managing PSFs increased from 5.98 to 6.98, an overall increase of 0.98. The original farmer learning group's FSEM mean showed a more modest increase from 6.87 – 7.10, an increase of 0.22. Analysis also identified that while the difference between the two groups was 0.89 at November 2015, it had reduced to 0.14 by March 2017. The standard deviation (SD) of FSEM responses decreased between November 2015 and March 2017 (see Table 5.1). The SD between highest and lowest scores moved from 1.32 at November 2015 to 0.93 at July 2016, showing that the range in farmers' self-efficacy became more aligned. Further SD analysis showed that the new farmer learning group had moved closer together (T1 1.45 – T3 0.69), while the original group members moved apart from each other (1.05 – 1.14).

These results establish that there was a difference between the new and original farmer learning groups' belief in their ability to manage PSFs. The new farmer group showed an increase in their judgement of their self-efficacy of 0.98 while the original farmer learning group showed a smaller gain of 0.22. The FSEM results show that self-efficacy changes had occurred in both groups of farmers while they had participated in the RFLP (see Figure 5.2 below). Moreover, the mean scores of the two farmer groups showed a convergence as they progressed from November 2015 through to March 2017.

As the same participants completed the FSEM on three occasions between November 2015 and March 2017, a paired-samples t-test was conducted to answer this question. The results show that there is a significant difference in the farmers' self-efficacy scores for T1 [November 2015] (M=-0.3336, SD=1.1042) and T3 [March 2017] (M=0.2708, SD 0.7758); t (34) =-3.413, p = 0.002.

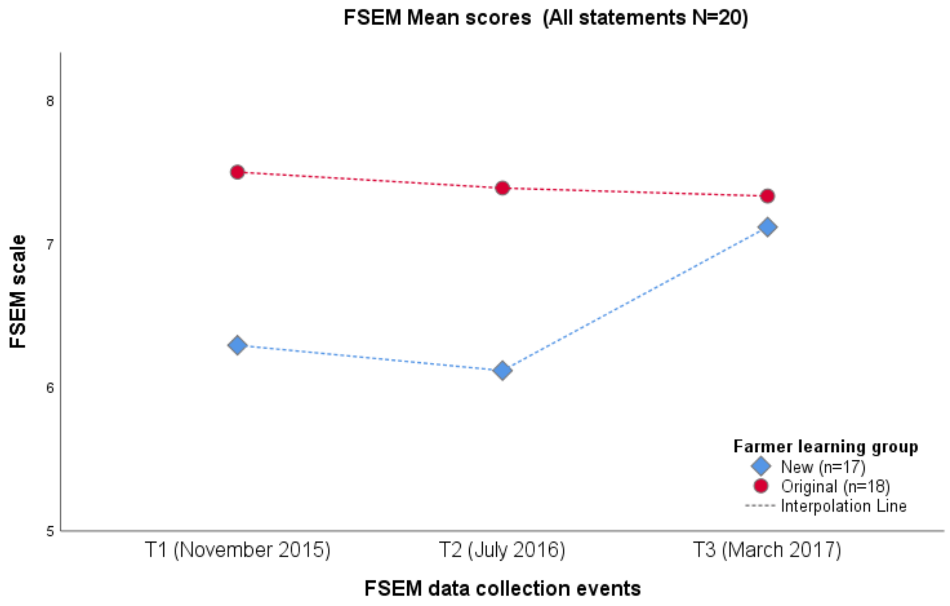

Figure 5.2. Comparing change in farmer's self-efficacy between learning groups

5.3 Factor Analysis (FA)

Factor analysis (Spearman, 1904) was used to explore the farmers' responses to the FSEM statements. Factor analysis is commonly used in the fields of psychology and education and considered an appropriate method of interpreting self-reporting questionnaires (Hogarty et al., 2005) Factor analysis revealed that four FSEM statements (Statements 7, 8, 14 and 15; shown in Table 5.2) with eigenvalues above Kaiser's criteria of 1 and accounting for 67% of the variance (see Table 5.4) were consistently significant factors for the farmers. FSEM statement 14 (*Persevere if challenging situations arise when using perennial summer forages on my farm*) accounted for 47% of the total variance, indicating the possibility of further cluster analysis. The second highest factor was the farmers' belief that they could *defend my decisions when talking with other farmers about the management of perennial summer forages on my farm (S8).* The next highest factor was the farmers' belief in their ability to *help other farmers to achieve their goals to use perennial summer forages on their farms* (S15) and followed lastly by the belief that the farmers *could give useful advice to neighbouring farmers* (S7). The Kaiser-Meyer-Olkin test was used to assess the appropriateness of using factor analysis on the FSEM data. All Kaiser-Meyer-Olkin values for the individual FSEM items were above the acceptable level of 0.5, (see Table 5.2), as suggested by Field (2013).

Table 5.2. Factor analysis matrix of key FSEM statements

FSEM statement		Factor 1	2	3	4
S8	Defend my decisions when talking with other farmers about the management of perennial summer forages on my farm.	0.794			
S14	Persevere if challenging situations arise when using perennial summer forages on my farm.	0.791			
S7	Give useful advice to neighbouring farmers who want to use perennial summer forages on their farms.	0.787			
S15	Help other farmers achieve their goal to use perennial summer forages on their farms.	0.775			

Extraction Method: Principal Axis Factoring

Analysis of the FSEM summation, averaged and pooled data confirmed the reliability of the above results. The consistency of the factor loadings across all three sets of FA data, as shown in Table 5.3, confirmed that it was acceptable to use the pooled data for further statistical analysis of the four key FSEM statements that had been identified.

Table 5.3. Total variance loadings using summation, average and pooled FSEM data.

	Summation		Average		Pooled	
S8	0.873	1	0.85	1	0.794	1
S14	0.834	2	0.806	2	0.791	2
S7	0.801	3	0.779	5	0.787	4
S15	0.807	4	0.799	3	0.775	3
S10	0.762	10	0.783	4	0.663	5

Table 5.4. FSEM total variance

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.892	44.460	44.460	8.504	42.520	42.520	3.944	19.718	19.718
2	2.302	11.510	55.970	1.906	9.528	52.048	3.323	16.616	36.335
3	1.228	6.140	62.110	0.880	4.402	56.450	2.939	14.696	51.031
4	1.119	5.595	67.705	0.703	3.514	59.964	1.787	8.934	59.964
5	0.871	4.355	72.059						
6	0.821	4.106	76.166						
7	0.675	3.374	79.539						
8	0.590	2.948	82.488						
9	0.521	2.603	85.090						
10	0.508	2.542	87.632						
11	0.423	2.115	89.748						
12	0.350	1.748	91.495						
13	0.320	1.599	93.094						
14	0.284	1.419	94.513						
15	0.258	1.290	95.803						
16	0.208	1.042	96.845						
17	0.188	0.939	97.784						
18	0.162	0.809	98.593						
19	0.152	0.761	99.353						
20	0.129	0.647	100.000						

Extraction Method: Principal Axis Factoring.

5.4 2-Factor Repeated Measures ANOVA

With a statistical significance within the FSEM results identified between November 2015 and March 2017, further analysis was initiated. The next stage of the research was to explore the famers' responses to the four key FSEM statements (S7, S8, S14 and S15) identified previously from the FA analysis. These four statements were analysed individually in the order of their F loadings. When analysed, the S8 results for both the original and new farmer learning groups followed a positive trajectory from November 2015 to March 2017. It can therefore be assumed that the farmers' self-efficacy to defend their decisions when talking with their peers about the management of PSF crops on their farm improved over time (see Figure 5.3).

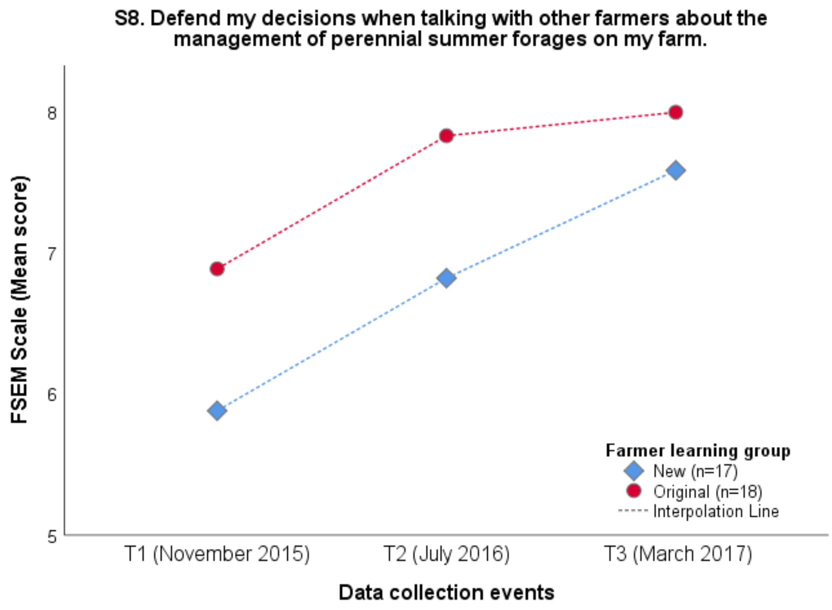

Figure 5.3. Change in farmers' self-efficacy to defend their PSF management decisions with other farmers.

The original farmer learning group's FSEM mean score to defend their decisions when talking with peers about the management of PSF crops (S8) increased steadily by 0.94 from November 2015 to July 2016 (6.89 – 8.00) as shown in Table 5.5. However, between July 2016 and March 2017, the original farmer learning group trajectory shows only a small increase of 0.17, suggesting a slowdown in their perceived ability within this context. The original farmer learning groups' mean increased 1.11 units during the entire 18-month period of the RFLP.

The new farmer learning group's perceived efficacy to defend their PSF management decisions on their farms shows a slightly different pattern over time. Their FSEM scores on S8 increased by 0.94 between November 2015 and July 2016 (6.82 – 5.88). At July 2016, the new group had almost attained the starting point of the original farmer learning group. From July 2016 to March 2017, the new farmer learning group continued to increase their self-efficacy, rising by 0.77. The new group's FSEM mean increased by 1.71 during the 18 months of the RFLP.

Table 5.5. FSEM Mean and Standard Deviation values. Statement 8.

FSEM statement	Farmer Learning Group	N	November 2015		July 2016		March 2017	
			Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
S8.	New	17	5.88	1.73	6.82	1.38	7.59	0.87
	Original	18	6.89	1.81	7.83	1.30	8.00	1.28
	RFLP	35	6.40	1.82	7.34	1.41	7.80	1.11

The difference between the two farmer groups' perceived self-efficacy to defend their decisions in November 2015 was 1.01. The trajectories of both groups from November 2015 to July 2016 follow similar rates of positive growth, with a 1.01 difference in July 2016. However, the July 2016 to March 2017 trajectory of the two groups differed, with the original farmer learning group showing only a slight increase (0.17) in their S8 efficacy compared to the more substantial 0.77 mean increase of the new learning group. In March 2017, the difference between the two groups had declined to 0.41.

These results indicate that farmers considered that their efficacy to defend their management decisions around PSF crops with other farmers had continued to improve throughout the RFLP for both the new and original groups. The new group's efficacy showed a steady positive trajectory from November 2015 to March 2017, nearly converging with the original farmer learning group by March 2017. Data obtained from the semi-structured interviews and focus discussion groups will be analysed in the following chapter to provide further explanation of this result.

The farmers' responses to S14, the self-efficacy to persevere if challenging situations arose on their farms while using PSFs, showed a decrease in both the new and original groups of farmers from November 2015 to July 2016 (see Figure 5.4). The decline continued from July 2016 to March 2017 for the original group, while the new group's perceived efficacy increased and moved towards convergence with the original group by March 2017.

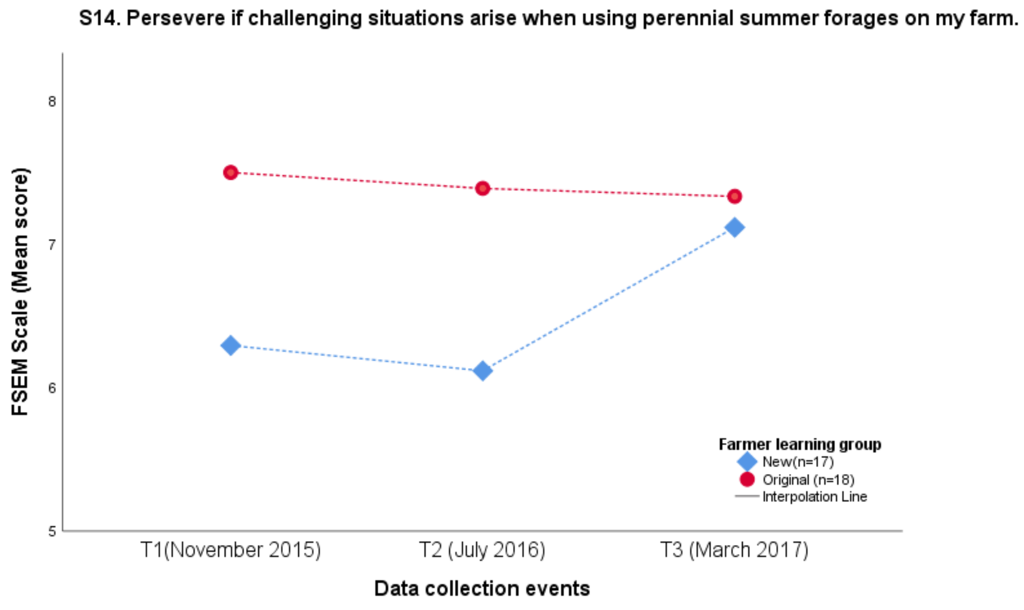

Figure 5.4. Change in farmers' belief in their future ability to persevere when challenging situations arise with managing PSF crops on their farm.

As Table 5.6 shows, the original farmer learning group's perceived self-efficacy to persevere with PSF crops in challenging situations decreased from November 2015 to July 2016 by -0.11, and this negative trajectory continued from July 2016 to March 2017 (-0.06). Over the course of the RFLP, the original group became less efficacious on S14, with the group mean declining by -0.17. The new farmer learning groups' self-efficacy on this statement initially followed a similar trajectory to that of the original group, with their mean decreasing slightly by -0.17 from November 2015 to July 2016. However, after their RFLP involvement between July 2016 and March 2017 the new group's trajectory followed a stronger positive gradient, with their mean increasing by 1. This strong growth meant that their perceived self-efficacy to manage PSF crops through challenging situations had roughly converged with the original group by the end of the RFLP.

Table 5.6. FSEM Mean and Standard Deviation values. Statement 14.

FSEM statement	Farmer Learning Group	N	Nov-15		Jul-16		Mar-17	
			Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
S14.	New	17	6.29	2.29	6.12	1.22	7.12	1.05
	Original	18	7.5	1.62	7.39	1.5	7.33	1.78
	RFLP	35	6.91	2.04	6.77	1.5	7.23	1.46

The perceived self-efficacy to help other farmers achieve their goal to use summer PSFs on their farms (S15) increased for both groups of farmers during their participation in the RFLP (see Figure 5.5). The original farmer group's S15 mean increased by 0.11 from November 2015 to July 2016, while their SD decreased -0.51 (see Table 5.7). The group's mean slightly increased from July 2016 to March 2017 (0.28), such that over the entire period of the RFLP their S15 self-efficacy had grown by 0.39. The new farmer groups' score on this statement also increased over time, but considerably more strongly than is the case with the original group. Their belief in their ability to help neighbouring farmers rose by 0.88 from T1 to T2 and by 0.41 from T2 to T3, a 1.29 increase over the entire course of the project.

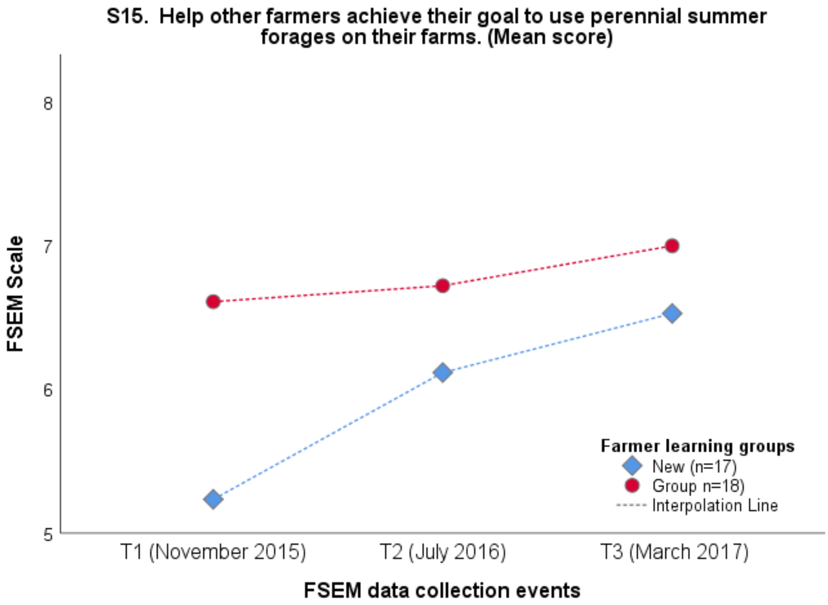

Figure 5.5. Change in farmers' self-efficacy to help other farmers achieve their goal to use PSF crops.

Table 5.7. FSEM Mean and Standard Deviation values. Statement 15.

FSEM statement	Farmer Learning Group	N	Nov-15		Jul-16		Mar-17	
			Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
S15.	New	17	5.24	1.79	6.12	1.62	6.53	1.33
	Original	18	6.61	2	6.72	1.49	7	1.53
	RFLP	35	5.94	2	6.43	1.56	6.77	1.44

S7 refers to the farmers' belief that they *could give useful advice to neighbouring farmers*. As Figure 5.6 shows, the first nine months of the RFLP had the most impact on both groups' self-efficacy in this regard. An overall pattern of an increasing efficacy is evident, but there is considerable difference between the trajectories of the original and new farmer groups.

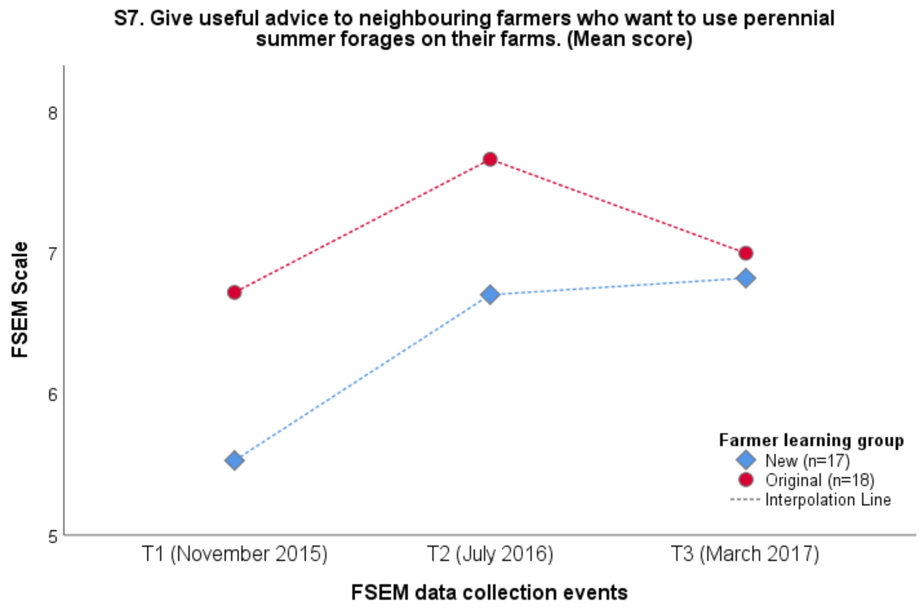

Figure 5.6. Change in farmers' self-efficacy to provide useful advice to neighbouring farmer wanting to use PSF crops.

The original farmer learning groups' S7 mean efficacy increased by 0.95 from November 2015 to July 2016 but declined by -0.67 from July 2016 to March 2017, such that their score on this statement increased by 0.28 over the course of the RFLP (see Table 5.8). The new groups' belief in their ability to give useful advice to neighbouring farmers' also increased strongly by 1.18 from T1 to T2, taking their score to the starting level of the original group, and by T3 it had grown by a further 0.11, taking them to roughly on a par with the original group. The difference between the two group's trajectories is striking and will be explored further in the following chapter using the results of qualitative analysis.

Table 5.8. FSEM Mean and Standard Deviation values. Statement 7.

FSEM statement	Farmer Learning Group	N	Nov-15		Jul-16		Mar-17	
			Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
S7.	New	17	5.53	1.91	6.71	1.11	6.82	1.24
	Original	18	6.72	1.74	7.67	1.28	7	1.33
	RFLP	35	6.14	1.9	7.2	1.28	6.91	1.27

5.5 KmL3D Analysis

The results presented to this point have focused on comparing changes in self-efficacy between the new and original farmer learning groups. This analysis has been undertaken to explore whether the length of time involved with the farmer learning model of agricultural extension had any impact on the extent of these changes. Although a number of interesting differences have been uncovered, more detailed analysis is required to understand how the farmers cluster in terms of these changes in self-efficacy. FA was used above to identify the key statements for further analysis. The FA also clustered the farmers' responses to the 20 FSEM statements, but it did not consider changes in the scores on these statements. The KMO testing reported above validated the FSEM data as suitable for further cluster analysis. As explained in the previous chapter, the K-Means for Joint Longitudinal Data (KmL3D) trajectory algorithm (Genolini et al., 2013) has been selected to explore the overall changes in the farmers' self-efficacy.

Kml3D clustering has been undertaken based on the farmers' responses to FSEM statements at the three time points, focusing in particular on those statements that loaded strongly on component 1 of the FA analysis. (RC1, 47% of the total variation; see Table 5.4). These statements have been collectively categorised as S*elf-Efficacy* to manage PSF within the farmer's existing farm system. In contrast to 2-factor repeated measures ANOVA, the KmL3D algorithm clusters the farmers into two groups based on their responses to the FSEM statements at all three data collection points. Rather than combining farmers based on the length of time they had been involved in the farmer learning model of agricultural extension, the algorithm groups participants who responded to the FSEM statements in a similar manner.

The KmL3D algorithm produced two clusters whose membership cut across the distinction between original and new farmers. Cluster A (49%) comprised 17 farmers, 10 new and 7 original, while Group B (51%) comprised 18 farmers, 11 original and 7 new. The population of each group remained constant when completing the Kml3D analysis of the Self-Efficacy (RC1) FA component. Moreover, as shown in Figure 5.7, these two clusters have distinct longitudinal trajectories during the RFLP. Cluster A followed a steady positive trajectory while Cluster B followed a more pronounced positive trajectory between T1 and T2 before levelling out between T2 and T3.

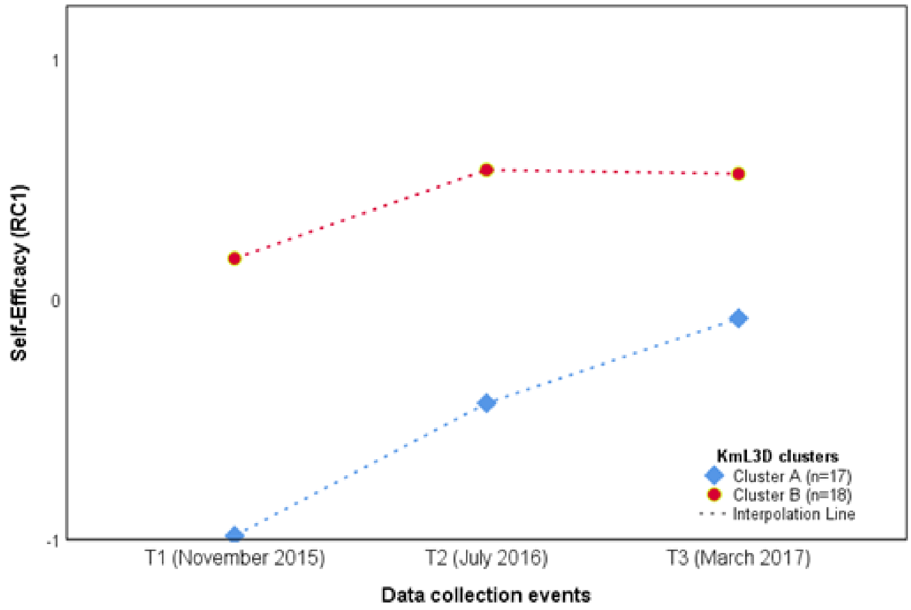

Figure 5.7. Km3D trajectories of change in farmers' self-efficacy T1, T2 and T3

In order to further explore statistical differences between the original and new farmer groups' self-efficacy, a column was added to the KmL3D data to identify the group to which each individual belonged. The trajectories of the two sub-groups (original and new) within the two cluster groupings then became visible, as shown in Figure 5.8.

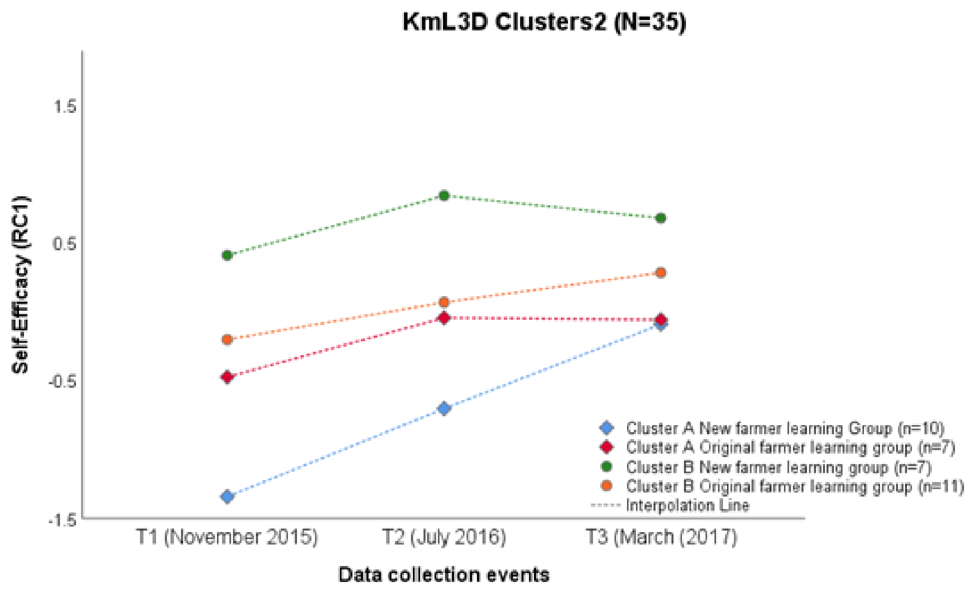

Figure 5.8. KmL3D trajectories of farmer's perceived self-efficacy (RC1)

The original farmer group members within Cluster A showed a modest positive gain in their perceived self-efficacy between T1 and T2 and remained static between T2 and T3. The new group members of Cluster A, however, showed a more consistent and significantly steeper increase. Importantly, both groups in cluster A ended up at the same point, despite the new members starting with a considerably lower FESM score.

The original group members of Cluster B steadily increased their self-efficacy at all data collection points. The new farmer learning group members tracked in a positive manner between T1 and T2 but declined between T2 and T3. However, unlike Cluster B, the new and original farmer learning groups did not converge at T3. Taken together, these results suggest the convergence of each cluster may be driven by differing drivers. Cluster A may be driven by the drop in original group members and Cluster B's result driven by the reduction in new group members. The situation is more complex than initially thought and therefore a potential problem to be explored further in the future. An explanation for this trend will be explored within the analysis of the qualitative data presented in the following chapter.

5.6 Chapter Summary

In summary, the quantitative results comprising 35 farmers participating in the RFLP showed that there was a positive change in their perceived self-efficacy scores from their initial responses at T1 to the follow-up responses collected at T2 and T3. A Paired-samples test indicated a statistically significant change occurred in farmers' self-efficacy between T1 and T3. KmL3D analysis confirmed farmers' self-efficacy did change during between T1, T2 and

T3. KmL3D analysis confirmed the original farmer group cohort were more efficacious about managing PSF within their farm system the new group members. The new farmer group however reported a greater difference between their initial perception and final perceptions of self-efficacy within the domain of managing PSF's. The quantitative results indicate that, while positive overall, these self-efficacy changes are dynamic and complex rather a matter of straightforwardly linear growth through time. The following chapter unpacks some of the drivers of this complexity by analysing the qualitative data collected during the course of the RFLP. The following chapter will also consider how the development of self-efficacy is linked to changes in the farmers' beliefs about their future management strategies.

Chapter 6 Qualitative findings

6.1 Introduction

The previous chapter provided evidence of change in the farmers' self-efficacy using the quantitative results from the Farmer Self-Efficacy Measurement survey (FSEM). The current chapter reports the findings collected from: pre-post interviews with twelve farmers, approximately twelve months apart, three focus group discussions (FGD) and field notes written at eight RFLP workshops. Initially presented, are three examples of change in the farmers' self-efficacy to manage PSF. Secondly, enabling and undermining factors impacting the farmers' self-efficacy beliefs are presented. The final section presents the findings about how changes in the farmers' self-efficacy and understandings of managing PSF crops served to inform their thinking about the place PSF crops within their farm systems.

6.2 Change in farmers' self-efficacy to manage PSF crops having engaged in a longitudinal agricultural extension programme.

The following section highlights the different responses of three farmers who engaged in the interview and FGD phases of this study to explain changes in their self-efficacy to manage PSF crops. These three farmers were chosen because they experienced similar challenges in managing PSF crops within their farm systems as the remaining twenty-five farmers taking part in this phase of the study, yet they showed quite different self-efficacy changes. Their responses suggest that both positive and negative factors influenced increases and decreases in their self-efficacy during their participation in the RFLP. The positive factors include the importance of understanding the science behind growing and grazing these PSF crops efficiently, being able to adapt to changing environmental factors and experiencing success from the adopting of new technologies into existing farm systems. The key positive factor was increasing farm productivity leading to an improved financial position. The negative factors include challenges in accessing information guiding the establishment and management of PSF crops in the early stages of their adoption, experiencing on-going issues with managing PSF crops and experiencing falling farm production.

The farmers' responses provided during interviews and FGDs align to changes noted in the Farmer Self-Efficacy Measurement survey (FSEM) analysis. The farmers' understandings of managing PSF crops also changed during their participation in the RFPL. They developed deeper understandings about the science of plant growth and the importance of managing the plant with optimal numbers of stock grazing to gain maximum potential. This increased understanding had a positive impact on their self-efficacy to manage PSF crops.

The first example is taken from farmer 7, a member of the original farmer learning group, whose FSEM survey data showed that his judgement in his ability to manage PSF crops more efficiently in the future remained constant throughout his participation in the RFLP. When he first introduced PSF crops into his system he was unsure how to manage the faster animal growth rates of the lambs grazing PSF to ensure a regular cut of lambs each week to supply his contract with a meat processor,

> We used to put the smaller lambs on there [plantain] first. We thought they would grow faster, but all that did was create us a 'bottle neck' of lambs. The better lambs that were left on the grass, for instance, were growing at 250g per day. The ones on the plantain were doing 350 g per day. However, the system was not allowing us to get a 'flow' of lambs going out every week. We were getting to a point where we were not killing any lambs and suddenly, we had 1000's. (I1)

The flow of lambs through his PSF crop and traditional grass system did not match his expectations and could have had a negative effect on his future use of PSF crops. However, he explained that after joining the earlier Farmer Learning group he realised that he did not understand how to best manage his stock to gain maximum results from his PSF crops.

Farmer 7 also noted that in the early autumn while his plantain/clover "looks really good, the lambs just do not grow on it" (I1). He was disappointed in the stock live weight gains during the autumn period. The lack of stock (lambs) live weight gain during autumn could have had a negative impact on his belief in his management of PSF crops. However, annual on-farm data collected (weighing animals on to and then off PSF crops to calculate animal live weight gain) showed that he had still produced an annual 1500 kg of animal live weight gain per hectare. This production was "head and shoulders above [what he could achieve using] grass" (I1). The resulting annual animal live weight gain per hectare restored his belief in his PSF crop management abilities. When questioned further, farmer 7 shared that as "the growth rates [annual animal live weight gains] off the plantain have been excellent" (I2) and his efficacy in his original decision to adopt plantain/clover into his farm system increased.

It appears that farmer 7's increased efficacy came from his previous successful experiences using PSF crops, his on-farm observation of his stock and an improvement in overall farm productivity. This farmer reflected on what was occurring on his farm, processing that information to generate new understandings of how to manage PSF crops more efficiently.

A second exemplar demonstrates how farmer 11's, a member of the new farmer learning group, FSEM survey result decreased drastically at T2 before returning to its starting level at T3. Farming in the Wairarapa, she knew she needed to develop strategies to cope with the climatic conditions. She believed that they were "able to better manage the grazing of PSF crops in certain climatic situations" (I1). From her observations, while farmers understood the impact of overgrazing their PSF crops, they still overgrazed it because they were short of feed and desperate to look after their animals, especially breeding stock. In this situation, farmers are forced to make a trade-off between feeding stock now because of the ongoing drought against the longer-term consequences on the PSF crops yield. Farmer 11 believed the technical or scientific results about the quality of these forages and the stock live weight gain one can get from PSF crops was valid. However, she questioned whether using these forages on her farm was profitable for the following reasons. During 2016 the farm management team had noted that even though PSF crops had been introduced into their farm system, both stock live weights and lambing percentages were decreasing. Farmer 11's concerns about decreasing animal live weights and lambing percentage are evident from her following comment.

> Two-tooth weights were not right, and our lambing percentage was down. It was a combination of the climate [for example, no winter recharging rain and very dry years] and management within our farm system. Our stocking rate was dropping, our income was dropping, and our livestock performance was dropping. (I2)

These decreasing farm performance indicators alerted farmer 11 to problems within their farm system. A detailed analysis of expenditure against income in late 2016 did not justify the inclusion of the PSF crops within her farm system. This financial analysis had a negative impact on her belief in her ability to manage PSF crops because "it is harder to take risks when you are up against it" (I2). The following assessment of the situation shows that she believed the under-performance of the PSF crops within the existing farm system was due to not understanding the strategies required to manage PSF crops efficiently. She discussed the situation with her farm management team, comprised of the farm owners, farm manager and farm consultant, concluding that:

> We never went to the end game and said all right, in order to achieve this, we need to have this much feed on hand performing at these times [of year]. I honestly do not know why it took us so long to get to the point where we looked at it**.** (I2)

Participating in the RFLP provided farmer 11 an opportunity to reflect on the systems and strategies she had traditionally used. The result of farmer 11's reflection suggested that she believed it was no longer acceptable for the management team to make 'hit and miss', short-term decisions that did not make full use of all the available information. The management team now use 'the science' to back up management decisions. For example, "We are not just saying oh well they [PSF crops] look pretty good. We are saying, okay we know what their metabolisable energy is or what the…" (I2). 'The science' knowledge was gained from participating in the field trials at Riverside farm, supported by dialogue with other farmers and agricultural scientists during the RFLP. Understanding the consequences of their short-term decisions on the longer-term performance of their system enhanced farmer 11's judgement of her ability to improve her underperforming farm system. She stated that "the whole reason for PSF crops is to have that higher quality feed over the summer when you need to be growing them [stock]" (I2). The following excerpt illustrates a positive emotional response – another cue that her self-efficacy was increasing.

> I am really looking forward to scanning this year because everything we put in place should translate at scanning. (I2)

Improvement in farmer 11's self-efficacy relied on her getting quantitative data that would confirm her beliefs. However, farmer 11 expressed caution about the changes she had made to manage her PSF crops, stating that "I will feel a lot more confident when we get the 'runs on the board' (improved hogget weights and number of lambs born) (I2). She believed that the expected success (i.e. increased lambing percentage) would improve economic returns for the farm and her efficiency to manage PSF crops in the future.

The third farmer exemplar who demonstrated a steep increase in his FSEM data during the study is farmer 14, another member of the new farmer learning group. During his first interview, farmer 14 alluded to the fact that when he introduced PSF crops, he "just did not have enough data around what was going on and coming off them. Information such as stock growth weights and kilograms of dry matter growth" (I1). Without measuring the live weight of stock going on and coming off the PSF crops, he could not calculate the economic benefit gained from adopting plantain/clover into his farm system. During his first interview, farmer 14 explained that his early attempt to manage his PSF crops had failed, a conclusion that aligned with his low FSEM score. He explained his failure as being due to "thistles and grass grub [that] demolish the plantain/clover crops [and] led to me questioning my ability to manage these particular crops within this farm system" (I1). Using the information received from rural professionals and industry representatives, he believed that PSF crops did have a place in his farm system. Observing neighbouring farmers moving away from plantain/clover crops after experiencing similar problems worried him. Farmer 14 describes the importance of listening and talking with others to inform his decision using PSF crops.

> There are a lot of guys [neighbouring farmers] around that do not see those figures [results of the Riverside Farm trials]. … I listen to everyone, reserve my comments, listen to other people and talk to other guys. At some stage you have got to make your own informed decision. (I1)

The influence of disillusioned neighbouring farmers deciding that "it [PSF crops] was not for them" did not have a negative effect on farmer 14's judgement of his ability to use PSF crops. Farmer 14's point of difference was that he talked with others, gathering his data from a range of evidence-informed sources. Farmer 14 believed that to manage PSF crops successfully in his farm system he needed to develop his understanding of the science behind growing and grazing these PSF crops more efficiently. Farmer 14's certainty in plantain/clover herb mixes provided him the opportunity to increase his farm production, as the following excerpt explains.

> We make our money in the spring. There are a whole lot of factors that go into it. …. We have a small window in the spring to get these animals out the other end as fast as we can. Without that plantain, we cannot do that. (I1)

After attending the initial RFLP workshop, farmer 14 realised that he was only touching on the potential of these crops. Hearing the agricultural scientists' results from the Riverside farm field trials, farmer 14 believed he now understood the benefits of introducing PSF crops within his farm system, as the following excerpt shows.

> We are starting to see the benefits coming through from all this stuff [PSF crops] that is growing. The perennial and legume-based forages can handle the dry [summer dry conditions] better by getting the stock off the property before Christmas when it has gone dry without looking at it through rose tinted glasses. (I2)

PSF enabled farmer 14 to wean his lambs early and leave them on the forage crop where they would continue to grow. After weaning the lambs, he planned to place the ewes on poorer quality feed, allowing more high-quality feed for lamb finishing. Farmer 14 describes below how he believed an opportunity existed to use PSF crops to increase his farm production.

> … ewes and lambs on clovers, perennial forages. The ewes are fat as mud, you can afford to take them off. You can afford to wean them [ewes and lambs] and take them [ewes] off that PSF crop and put them back on to the brown top. The rubbish grass and they [ewes] stay happy. We have the opportunity to increase our yield. I am only touching on it at the moment. Now I have some confidence in going and giving a bigger try. (I2)

Farmer 14s self-efficacy increased in the FSEM data from 5 (November 2015) to 8 (March 2017). Self-efficacy theory enables us to see that his success, seen in his increased production using PSF crops, contributed to his heightened self-efficacy. Farmer 14 now believed he was making evidence-informed decisions to continue introducing PSF crops into his farm system.

Summary

While all three farmers experienced differing challenges, they all needed the science data on PSF performance to understand how to manage PSF crops efficiently. Factors that influenced change in the farmers' self-efficacy are described in Section 6.3. Enabling and undermining factors are drawn from the 28 farmers who were interviewed or engaged in the FGDs.

6.3 Factors enhancing or undermining farmers' self-efficacy

This section reports factors that enhanced or undermined farmers' self-efficacy to manage PSF crops. Analysis of the qualitative data identified that farmers' previous experiences, both positive and negative, influenced their beliefs in their ability to manage PSF crops. Positive and negative mastery experiences, vicarious experiences and physiological cues that influenced change in farmers' self-efficacy are noted in Sections 6.3.1 and 6.3.2. Justification is provided to explain why verbal persuasion, a source of self-efficacy, was not observed in this study.

6.3.1 Enhancing factors

Three themes that support and add to the FSEM scale results emerged during analysis of the semi-structured interview and FGD transcripts. Firstly, all twelve farmers interviewed alluded to the collegial style of knowledge sharing between the agricultural scientists and farmers as an important factor to enhance their self-efficacy to manage PSF crops. Secondly, the opportunity to follow the results of ongoing, scientifically robust trials at RFLP workshops gave all twenty-eight farmers contributing to this phase of the study confidence to use knowledge shared by the agricultural scientists and other farmers. Finally, the importance of farmers' positive beliefs in their ability to maximising farm productivity is addressed.

Positive mastery experiences

Collegial knowledge sharing

All twelve farmers introduced in this section identified the important role the learning experiences within RFLP had on improving their beliefs in their capacity to adopt new or manage existing PSF crops. The twelve interviewed farmers reported that the collegial style of knowledge sharing between the agricultural scientists and farmers throughout the RFLP increased their understanding of how to manage PSF crops more efficiently.

Farmer 3 for example, explained how he had observed during the RFLP workshop activities that it was not just the farmers asking the questions; the scientists were also asking questions to the farmers and everyone was learning from this interchange, which he believed "had been quite special, that relationship" (I2).

Furthermore, farmer 33 describes how new knowledge gained while participating in the RFLP enhanced his self-efficacy enabling him to engage novel ways to manage his pasture.

> New learning from AgS1 and AgS3 [agricultural scientists] is building my confidence to try something outside the square. It is a matter of managing my pasture to suit my winter finishing farm system. A window of opportunity exists

> and if I am to take advantage of it, I need to think differently about pasture management. (FGD1)

Farmer 33 believed that the knowledge shared throughout RFLP workshops increased his self-efficacy to finish lambs during the autumn and winter. His participation in the RFLP had helped him to “understand how to use it [plantain/clover]” more efficiently. His enhanced self-efficacy through collegial knowledge sharing is noted in his comment, ‘I can see how that works now, so I will go give it a shot” (I1).

Similarly, farmer 24 mentioned that being part of the RFLP workshops with its collegial knowledge sharing had encouraged him to consider adopting alternative systems for their farm.

> There are formulas out there for growing it [PSF crops]. Being at those discussion groups and being at those days enabled us to reflect on our own on-farm experiences thus developing confidence to adopt new features into existing farm systems. (I2)

Farmer 24 recognised that his enhanced efficacy to better manage PSF crops had grown from knowledge gained during his joint participation in the RFLP.

Finally, farmer 14 identified that his biggest learning up until June 2016 had been the “real collaborative approach to learning for both parties [farmers and the science team]” (I1). He was impressed to see “how comfortable farmers were to ask the Massey University agricultural scientists’ and the more experienced farmers’ questions”. By ‘more experienced farmers’, he meant those who had been involved in the earlier 2011-2015 farmer learning project. Farmer 14’s emphasis on the ‘comfort’ of RFLP exchanges was echoed by most of the participating farmers, who all placed a high learning value on the collaborative approach to sharing their unique expertise sets.

The opportunity to learn through collegial knowledge sharing at the RFLP was a critical factor to enable farmers’ success and to enhance their self-efficacy. The following section reports how the opportunity to observe and dialogue about these observations with trusted peers was another important enabling factor.

Improved farmer knowledge

The honest, open approach of the agricultural science team to sharing their expertise served to improve farmer knowledge about how to manage their on-farm challenges. For example, farmer 27 shared that he believed ‘listening to them [scientists] talking, that is valuable information…. Getting the science behind … what we should do’ (I1). The honesty of the scientists in their reporting of field trial results resonated with his personal on-farm experiences.

Another way in which farmer knowledge was improved, leading to increased self-efficacy beliefs to manage PSF, was the scientists' practical suggestions for handling potential problems. The practical aspect of this advice provided farmer 27 greater confidence to "have a crack at it" (I1). This farmer later stated, "I am more confident now of my ability to bring in more red clover" (I2).

A third way in which farmer knowledge was improved was by sharing their own positive and negative experiences with the scientists and other farmers. Farmer 33 commented that "there are farmers who are trying new things and others who have been there and done that. However, when you go to Riverside [farm] and you look at that paddock of plantain (shown in Image 6.1 below), you think, ahh that is what you do not do." (I1)

Image 6.1. Farmers listening to the agricultural scientists describe problems that they experienced during a plantain trial at Riverside farm.

Eight of the 12 interviewed farmers identified the importance of understanding the biophysical requirements of plants. They believed that understanding the plant's climatic and physical soil requirements improved their ability to succeed in managing PSF crops. Farmer 33, for example, stated that "he was starting to understand why things last and why they do not" (I1), understanding for the first time that he needed to totally take the pressure off his PSF crops, resulting in improved plant growth, longevity and health. This increase in grazing potential enhanced his belief in his ability to manage his future PSF crops.

Another factor that supported farmer knowledge was the balance between theoretical and practical discussions, "getting that mixture of ideas from the scientists and the farmers" F7(FGD1). Five participants in the second FGD acknowledged that farmers depend on groups like the RFLP to improve their understanding of managing PSF crops, groups where they could freely interact and talk with other farmers and agricultural scientists. These farmers used their co-constructed knowledge to create original management strategies, strengthening their belief in their ability to increase farm production using PSF crops.

Improved farm productivity

All the twelve farmers who were interviewed believed that with their improved understandings of managing PSF crops they could grow more feed, especially in the summer dry conditions. The capacity to have more feed available for these conditions would potentially provide the opportunity to increase stock units and therefore improve farm productivity. As mentioned above, the RFLP provided farmers with the opportunity to enter robust dialogue with other farmers and scientists which supported learning about a range of evidence-based grazing options. The following experiences shared by the farmers provide evidence of how their self-efficacy was enhanced by the knowledge they had co-constructed in bringing their previous on-farm experiences to bear with their RFLP participation.

Some farmers compared their farm's performance using the new technology to that of their old ways. Other farmers measured stock performance on and off PSF crops, while some based their comparisons on visual clues such as stock condition. Three farmers visually compared their stock on the new PSF crops to their neighbours' stock that were grazed on ryegrass/clover pasture. There appears to be a link between farmers' measurement of their productivity and change of self-efficacy beliefs. Farmers could see how their new farm systems had improved productivity and this success contributed to enhanced self-efficacy beliefs.

This link between experiencing their own successful PSF management and enhanced self-efficacy is exemplified by farmer 6. From the start, he was confident in his ability to manage PSF crops because of the "noticeable difference in animal live weight gain, our trading lambs smoke along, it is great [for] lamb finishing" (I1). Moreover, during the RFLP, this farmer's belief in his ability to manage his plantain/clover crops continued to increase when he began comparing the weights of his hoggets with two neighbouring farms, finding out that "our hoggets [live weights] were miles ahead of anybody else's because they had been living on the plantain" (I2). This success served to increase his efficacy beliefs to manage PSF crops.

A similar experience was described by farmer 7, who was impressed by the improved live weight gains experienced when he lambed his hoggets on PSF crops, knowledge learned while participating in the RFLP. Farmer 7 shares the result improvements in his farm production below.

> The lambs did 301 grams a day through to weaning. Then we weaned them reasonably early, put the lambs back on there [plantain/clover] and they did keep going [increasing in weight]. When we weighed them next time, they had done about 320 grams, so they have done well. (I2)

The weight gain data collected by farmer 7, bolstered his self-efficacy to graze plantain/clover in new ways.

Success, contributing to enhanced self-efficacy beliefs to manage PSF, was also experienced in increased lambing percentages. For instance, farmer 26 explained that after introducing plantain/clover into his system, not only did his lambing percentages increase, but he also reached target weights in a shorter time and weaned his lambs earlier (between 90 – 100 days), which reduced animal feed demand. This series of successes confirmed his belief that he was an effective manager of PSF and that it would continue to be an important part of his farming system.

Farmer 26 used his increased self-efficacy beliefs, based on these prior successful experiences combined with knowledge gathered from RFLP workshops. He believed that introducing red clover might give him a wider range of alternatives to control weeds. In this case, the interaction between a negative experience (weed infestation in plantain) and his improved understanding of PSF crop management learned while engaging in the RFLP workshops, resulted in enhanced self-efficacy for growing red clover. He was adamant that he had "gained massively" through his previous success with PSF crops and that he would like to have more PSF because "it offers enormous advantages" (I2). Farmer 26's experiences suggest that for the farmers, "the proof is in the eating" F4 (I1**).** All twelve interviewed farmers agreed that the key to success, and therefore raised self-efficacy beliefs, was understanding how to manage the PSF crop.

Positive vicarious experiences

This section explores the noticeable impact of farmers' vicarious experiences through observations of scientifically robust on-farm trials, as well as listening to other farmers' successes, as means to improve their efficacy beliefs. Stated simply, farmers considered that 'If they can do it, I should be able to as well'. In this study, vicarious experiences with other farmers and scientists is an important cue to shape the farmers' belief in their ability to adopt and manage PSF crops for the following two reasons. Firstly, vicarious experiences helped the farmers to decide if PSF crops might be of use in their own farm system. Secondly, vicarious experiences help farmers understand how they might introduce these crops into their farm.

All twelve farmers interviewed identified the benefit of their observations, and the multiple opportunities for dialogue with other farmers and scientists. The combination of observations, for example about early weaning and an opportunity to talk about them enabled the farmers to learn about and consider new management strategies for their farm systems.

The RFLP workshop activities provided multiple activities for vicarious experiences that enhanced efficacy beliefs to manage PSF crops. The second interview phase of this study revealed that all twelve farmers recognised the value of the observations they made at the workshops. For example, farmer 26 stated that he was “really pleased to become part of the group and to get the opportunity to see what they [scientists and other farmers] are doing” (I2). Similarly, farmer 27 stated that, “seeing what is happening on other farms is bloody invaluable” (I2). He explained that it gave him confidence to try new grazing strategies because he was able to observe scientifically robust farm-scale trials. The twelve interviewed farmers agreed that observing field-based trials facilitated by agricultural scientists followed by discussing their observations contributes to feeling more efficacious to try PSF themselves.

Observations made by farmer 27 during the RFLP enabled him to develop a more drought tolerant strategy for his farm by trying out PSF crops using his existing irrigation system. Farmer 27’s following statement illustrates the power of observations to improve one’s self-efficacy.

> Yes, I am more confident in managing PSF crops [red clover, chicory]. While you read about things and you see things like seeing what farmer 7 was doing. You think well, if they can make it work, yeah, you know you are not going to go too far wrong. (I1)

Farmer 27 credited his enhanced beliefs to successfully adopt and manage his new farm system, “putting 12 hectares of spring sown red clover under irrigation”, to the information that he gained through observations at the RFLP workshops. These observations had led to successful practice, as indicated by his comment “that had been a brilliant move” (I2).

The RFLP enabled the farmers to observe how the scientists dealt with the real issues in their trials, such as drought, insect and weed infestations (see Image 6.2 below). Observing how the scientists responded to these challenges added credibility not only to the trial results but also to the farmers’ interpretation or take-home messages about PSF management. All twelve interviewed farmers recognised the need to develop efficient systems capable of maximising the full potential of PSF crops with appropriate management strategies. Farmer 6 added that he “had learned a lot about managing pests within PSF crops from his conversations with agricultural scientist AgS 2 and the other farmers” (I2). In his opinion, these conversations reaffirmed his self-efficacy, leading him to persevere with his PSF crops through the challenging situations he had experienced. Questions originating from the farmers’ observations fuelled these conversations and contributed to their improved understanding and skills to manage PSF crops more efficiently.

Image 6.2. Farmers investigating grass grub damage to plantain roots in drought conditions (RFLP workshop 3).

Farmer 7 introduced early lamb weaning on PSF crops into his farm system. His following comment shows the importance of knowledge sourced from vicarious experiences while attending the RFLP.

> It has been good finding out what the other guys [talking to trusted farmers and scientists] have been doing with it [plantain and lucerne]. It was the data, weights and stuff coming out of that [Riverside farm trials] and about management of it. We did not know what the timing of the weaning [early lamb weaning] and stuff like that off the plantain. That came from the RFLP workshops. (I1)

Prior to his RFLP involvement, farmer 7 had a limited understanding of how to manage his PSF crops. Observing the results of the Riverside farm trials contributed to this farmer's self-efficacy to manage them more efficiently within his current farm system.

A second example is evidenced by farmer 14 who believed that, through his observations of the Riverside trials, he had learned new ways to wean the lambs grazed on PSF crops earlier than he had done previously. He now understood the importance of "having the right [most valuable] stock on those plantain/clover mixes" (I1), a stock management efficiency that contributed to his enhanced his efficacy beliefs, reflected in his FSEM survey result.

These two cases demonstrate how vicarious experiences through observations of others using PSF crops convinced farmers 7 and 14 that they had the ability to manage these crops more efficiently. Changing a stock management system realised the potential of being able to finish more stock and sell them on the 'prime lamb market', rather than selling on the 'store market' as had been done in previous years. The ‘prime lamb market’ provides a premium and in dry years the store market prices are often discounted, so the gains possible through early weaning are substantial and attracted the interest of a number of the participating farmers.

The following conversation about early lamb weaning between two of the participating farmers demonstrates how observing and hearing the results of the trials at the RFLP influenced their beliefs in their abilities to change their farming systems.

> **Farmer 23:** That [early weaning lambs] is something I am intending to bring into our system. But knowing how you integrate it with the plantain etc. We could all benefit from it. Thinking outside the square a bit and getting out of the 100-day weaning mind-set. Seeing the figures [Riverside farm trial data] proves it can be done and it produces a different result.
>
> **Farmer 8:** … After observing AgS3’s trials we [farmers] can trust that it [early lamb weaning on plantain/clover] can work. We tried it this year and it worked but it is always nice to see the hard data from scientific trials.
>
> **Researcher:** So, you are comparing what you are hearing from other farmers with what you are seeing and hearing from the scientists at Riverside farm
>
> **Farmer 8**: Yeah, yeah, but we are seeing hard data.
>
> **Farmer 23:** It is not just anecdotal data. There is some actual science behind the trials and the data presented to us.

Farmers 8 and 23 were clarifying their thinking by highlighting the importance of seeing the data provided by scientists who had made their own independent observations. These farmers suggest that hearing about the scientists’ observations rates more highly than the anecdotal information provided by industry representatives who have less independent scientific research behind their advice. Farmer 14’s comment below attributes his growing efficacy to better manage PSF crops to the scientists’ research which erased his earlier doubts:

> I found [the different forages] interesting because I had doubts about the comparison in yields with lambs straight off their mums compared to the early weaned lambs off the forage crops. Now I have confidence in going and giving a bigger try. (FGD1)

Similar vicarious experiences occurred when farmers who had met at the RFLP decided to visit other farmers’ farms. For example, farmer 3 joined four other farmers to travel to the Marlborough region to observe the use of lucerne, red clover and sub-clovers within their dryland pastoral farming systems. Farmer 4 commented about the contribution of these observations to building his efficacy beliefs:

> This group of farmers now want to replicate it here [southern Wairarapa]. You look at someone who is doing it [using lucerne and clovers successfully] and think to yourself, if they can do it, we should be able to as well. (I1*)*

Farmer 4's comment above shows the power of farmers' observing another farmer's farming operations as an enabling factor that strengthens their efficacy beliefs to incorporate PSF into their existing farm system. The following section explores how verbal and social encouragement is another significant enabler.

Positive verbal persuasion

Verbal encouragement received from significant people such as respected farmers, business partners, and reputable agricultural scientists, can serve to encourage individual farmers to exert more effort and help them to overcome self-doubts and ultimately enhance self-efficacy. Conversations with other farmers and the scientists in this persuasive or encouraging form were not evident during the interviews, FGD or the observations made in the field during the RFLP. However, this finding is likely to be due to not being in a position to capture these types of verbal interactions, which may have occurred as participants walked between field activities, drove between venues or travelled to the RFLP workshops in paired or small group situations.

Positive physiological/affective state

Experiencing a supportive, trusting atmosphere is more likely to strengthen an individual's self-efficacy than if negative emotional situations are experienced, such as those that create high levels of anxiety within participants. All twenty-eight farmers involved in this phase of the study valued the collegial learning environment within the RFLP. Farmers' belief in their ability to manage PSF crops was influenced by their perception of their physiological responses within this environment. The twelve farmers who were interviewed all believed that the warmth and camaraderie of the collegial environment made them feel safe and confident about their ability to manage their PSF crops. These positive emotional sensations contributed towards their improving self-efficacy to manage PSF crops. Farmer 3 is representative of the participating farmers in this respect. He stated that the scientists created this sense of community by "not fobbing off things that challenged their results" (I2). Scientists encouraged farmers to question their research methods and results regularly and wanted to know how the results of their research fitted with what was happening on their farms.

Farmer 10 reported his feelings of excitement at the prospect of using PSF for the first time "to see if there is somewhere, I can fit it into my system" (FGD3). His enthusiasm and eagerness suggested a heightened positive psychological response influencing his sense of self-efficacy. Farmer 29, on the other hand, shared that he nervous about using PSF crops after experiencing a decline in stock live weights for lambs grazing plantain/clover pasture. He had had nothing to do with PSF crops before taking up his position as manager on the current farm. Other farmers and industry reps had told him that plantain was the “super food” (I1). However, he was observing the lambs grazing on plantain clover getting worse and worse, with their live weights decreasing. On further questioning, he alluded to the fact that he now knew that the lambs were eating the red clover in preference to the plantain. It was at a RFLP workshop when talking with other farmers that he realised this was the case.

> I was looking at the plantain and not anything else. The lambs were starving because there was no red clover there. They had eaten it all and when they were eating the plantain they were not doing as well. (I2)

Understanding how to manage plantain/clover differently in the future reversed farmer 29’s nervous approach to using PSF crops. He became confident in managing PSF crops because of what he had learned from other farmers and the scientists at RFLP workshops. He felt assured that he was with the “right group to be putting your practice out there” (I2).

Farmers 3, 10 and 29 believed that the scientists’ can-do’ attitudes, honesty and objective approach meant that the farmers could trust them and feel safe about sharing their own mistakes and challenges. This honest sharing by the farmers indicated that despite failing in a challenge they could open up about it and learn from the experience.

Summary

The findings presented above have noted many positive changes in the farmers’ self-efficacy. Their self-efficacy improved because they experienced success and vicarious experiences of success as part of the RFLP. These mastery and vicarious experiences were found to be the most important sources of farmers’ belief in their ability to manage PSF crops. Their mastery experiences were enhanced by collegial sharing of knowledge between farmers and scientists. The farmers’ vicarious experiences were also important, such as the opportunity to observe scientific farm trials which provided the much-needed knowledge about PSF crop management. Farmers observed how the scientists and other farmers introduced alternative grazing and pasture management strategies to use PSF crops more efficiently. Trust in the certainty of this new knowledge contributed to increases in self-efficacy.

Although verbal encouragement was not observed, it is acknowledged as a likely source of self-efficacy as it may encourage individual farmers to exert more effort and help them to overcome self-doubts. Finally, the importance of an emotionally positive and non-threatening atmosphere within the RFLP was shown to be a significant enabler of farmers’ self-efficacy to manage PSF crops.

6.3.2 Undermining factors

Factors that enable self-efficacy are important, but so too are factors that undermine it. This section identifies the challenges or barriers that played a part in undermining the farmers’ self-efficacy for managing PSF crops. Three key undermining factors are identified from twenty-eight farmers. The first factor is economic in nature. The second challenge is the scarcity of accessible information about how to manage PSF crops. The third undermining factor relates to the challenge of selecting species of PSF crops that are suitable for specific soil types, farm topography and climatic conditions.

Negative experiences

Uncertainty of economic potential

All twenty-eight farmers participating in the interviews and FGDs had invested significant capital to establish a variety of PSF crops (chicory, lucerne, plantain or red clover). Typically, the initial high financial cost of establishing and managing these crops was a risk many farmers were wary of taking, suggesting that this was an undermining factor for their self-efficacy. All twenty-eight farmers agreed that they intended to ‘get the most’ out of their PSF crop. The farmers were challenged by uncertainty that the money they had invested to establish and maintain the crops might not provide a reasonable economic return. For instance, farmer 11 believed there was “no question to the science [of adopting PSF crops], the question was however, is it cost effective?” (I2). Similarly, farmer 12’s concern was with “falling or static prices for some products that we are producing from that [PSF crop] growth” (I1). Furthermore, farmer 14 expressed concern about the length of time land was unable to be grazed with stock while he renewed his PSF crops.

Challenges such as these threatened to become a “tipping point”, the point where the PSF crop was going to cost more to maintain than the return it produced within their farm system. Farmer 26 provided the following commentary on how he mitigated some of the uncertainty described above through policy development and careful financial and pasture management planning.

> We do a budget, work out what it [plant health and weed management] is going to cost. We work out how spring [growth is progressing], look at our stock policy, and look at what the market [stock prices] are doing. (I2)

Farmer 26 identified ongoing crop maintenance costs as a factor that undermined his self-efficacy to manage plantain/clover on his farm. He stated that “the financial costs are significant”, however, he was confident that out of that financial cost “will come a higher revenue cash flow and hopefully higher profit” (I2). This qualitative finding showing that costs initially undermined his SE was confirmed in the FSEM data which showed a decline in his self-efficacy at T2 (July 2016) and it increased again at T3 (March 2017).

Scarcity of accessible information.

All 28 farmers who participated in the interviews and FGDs expressed frustrations about the challenges involved in using PSF crops. Farmer 17 reminisced about adopting plantain in the

1970s without being fully informed of the challenges that they were likely to experience. Eight farmers identified how they had had trouble locating accurate information based on objective research. In some cases, this lack of information led them to make poor decisions on what crops were best suited to their environmental conditions and farm systems. For example, farmer 4 remembered that when he first introduced chicory into his system in earlier years, he did not know anything about it. He described how his ignorance about plantain and chicory had undermined his belief in the crops.

> We did not know a damn thing a few years ago. We were into plantain, chicory I suppose about 8 years ago or even 10 years ago. We tried chicory about 30 years ago. Stuffed up completely. We had one paddock of 3 ha, cut it into four, tried to do a rotation on it and got pissed off with it**.** (I2)

These farmers had struggled to manage their PSF crops through these earlier periods. Without knowing the challenges and how to overcome them, farmers' self-efficacy to manage PSF crops would have been undermined. The following section explores how farmers' lack of understanding about how to manage PSF crops undermined their belief in their ability to use these crops on their farms.

Farmers' knowledge deficit

Farmers introducing PSF crops into their existing farm systems are confronted with a range of decisions. A key decision is to find a strategy to effectively graze the new crop. Fourteen of the 28 farmers identified difficulty in understanding information available detailing how to graze PSF crops in particular. This lack of understanding was a contributing factor that undermined their belief in their ability to manage them successfully. This section reports five areas where knowledge was lacking: pasture management, weed management, plant health, plant selection and adaptation to climatic conditions.

All five participants of the second FGD agreed that the pasture management required for PSF crops differed from traditional ryegrass/clover pastures. For example, farmer 15 acknowledged that participating in the RFLP project alerted him to the value of adapting his system to take taking advantage of it.

> The biggest thing with forages is the system you form around it. Particularly lucerne, because you cannot grow or graze it for 4 months of the year. That is where for me the biggest disadvantage is. Therefore, I have to learn to maximise our systems to take advantage of it. (FGD2)

The lack of an initial understanding of lucerne's grazing requirements compromised his farm system and therefore undermined his initial belief in his ability to manage his system efficiently. This missing knowledge may have contributed to his low FSEM result at the beginning of the RFLP.

FSEM survey data revealed that all thirty-five farmers in this study struggled to manage weed infestations in PSF crops. Similarly, the 28 farmers who were interviewed and participated in the FGDs experienced weed infestations in their PSF pastures. These farmers consistently referred to the management of weeds as “a constant challenge, expensive and a juggling act” (F 26 I2). Farmer 33 shared that “it is not the performance of the plant that undermined my confidence, but rather understanding how to manage weeds issues effectively” (I1).

However, as the RFLP progressed all of the farmers learned about new strategies needed for managing weeds in PSF crops. A critical component identified by two interviewees was the timing of weed spray applications. Farmer 17 describes below how at times farmers make judgments that can have negative consequences:

> Last year [2015] was a bit of a cock-up. I sprayed thistles and there was a lot that came back. I thought I have spent all this money. I did not want to go back and do it again but now know I should have just done it. (I1)

The result for farmer 17 was an underperforming crop, a failure that undermined his PSF efficacy beliefs. Farmer 26 similarly commented that he had “gone through periods of time when it [crop spraying] had been incredibly frustrating because … [he had] not been able to access the contractor services at the right time to do things in terms of pest or weed control” (I2). His FSEM survey results also showed a decrease during this period. He had known that something had to be done to manage an issue but had not been able to act at the “right time to do things”, something which “knocks your confidence to manage those [PSF] crops” (I2).

All 28 farmers also identified the management of pests and disease as contributing to undermining their self-efficacy to manage PSF crops. These farmers identified their need to access easily understood information about how to manage plant health. For example, farmer 17 explained that “We did not know about the pitfalls of using plantain. The plantain moth appeared in the middle of it [introducing plantain]” (FGD2). From his comments, managing plantain moth and grass grub appears to have been a prevalent factor undermining farmer 17’s perceived ability to manage PSF crops resulting in a decline in his self-efficacy. However, the FSEM data shows a slight increase in his self-efficacy between November 2015 and March 2017.

Another example can be seen in farmer 29, who shares his dismay when he sprayed his crop only to find that plantain moths had re-established a couple of weeks later.

> It hit quite hard, because I thought that I had buggered it up through something that I had done. If I had known more about the plantain moth, I could have jumped on or done something earlier (I2).

Farmer 29 described how he had done everything possible to eradicate the plantain moth by applying spray, but this did not provide a definitive solution. The costly management solutions affected both the economic viability of adopting PSF crops and his belief in his ability to manage them in the future. Managing plantain moth was a prevalent factor contributing to his declining FSEM data between November 2015 and March 2017. Participation in the RFLP learning activities allowed him and other farmers closer contact with the expertise needed to explore novel methods to improve their management of plant health issues. The farmers believed the knowledge shared by the agricultural scientists and other trusted farmers during the RFLP reduced the negative affect of this undermining factor.

Inaccurate advice from trusted sources

Eight of the 28 interviewed farmers identified that they had made inappropriate PSF crop selections. They attributed this to the trouble they experienced finding accurate research to inform their integration of PSF crops into their farm systems. In some cases, the lack of research-based information led farmers to make poor decisions on what crops were best suited for their system and environmental conditions. For example, farmer 6 explains below how he had observed farmers making questionable decisions about using PSF crops to address stock feed shortages in drought conditions:

> In the early stages, a lot of people thought that they [PSF crops] were going to be the answer to drought, but they are not. They help but they are not the answer to drought. (I1)

The following quote describes farmer 4's early experience of introducing chicory into his system as a drought-proofing strategy:

> We went through some real stink of droughts … There were drought meetings to help all the farmers who were going broke. … Someone [seed representative] did come up with chicory. We went and put in one paddock of chicory. …we gave it a go, but it was a joke. We discarded that [chicory], believing that stuff's useless. (I1)

Farmer 4 had tried to integrate chicory into his existing system. However, being a new crop, there was a lack of sound information based on evidence alerting them they had to plant enough to sustain an effective grazing rotation. The result experienced resulted in a decline in their self-efficacy to manage chicory within their farm system, especially under drought conditions.

Farmer 15 described a similar situation when introducing plantain.

> We [farmers] thought it [plantain] was a wonder weed … Lack of growth in the summer, lack of growth in the winter, reinforced that there is no silver bullet in farming. (FGD2)

Farmer’s 4, 6, and 15 integrated PSF crops into their existing farm system based on questionable advice provided by their industry representatives and advertising material. These farmers became sceptical and believed that PSF crops were not as good as portrayed because of the issues they subsequently experienced. The challenges experienced by these farmers undermined their self-efficacy.

Adapting to changing climatic conditions

Prolonged drought conditions may undermine farmers’ belief in their ability to manage PSF crops. Farmer 11, for instance, asserted that “farmers' confidence in managing PSF crops was dependent on the rainfall” (I1), which suggests a link between farmers’ self-efficacy and climatic conditions. Similarly, all 20 Wairarapa farmers participating in the interviews and FGDs agreed that the driver behind adopting PSF crops was the increasingly dry summer weather patterns, where it “just blew a howling gale with no rain” (F14, I1). While farm systems and climatic conditions vary across seasons and regions, all farmers involved in the RFLP had experienced the effect of prolonged dry periods which contributed to undermining their self-efficacy to manage PSF crops.

Negative vicarious experiences

In this study, negative vicarious experiences with other farmers and scientists appear to be an undermining influence shaping self-efficacy. While farmers discussed many challenging situations concerning their managing of PSF crops during interviews and FGDs, the effect on their self-efficacy to persevere with PSF appears insignificant according to the overall FSEM survey results. However, during the interviews, one farmer discussed how observing neighbouring farmers removing PSF crops gave him less confidence in adopting plantain on his farm. Farmer 29 observed that “in the Wairarapa there are a lot of people who lost their plantain and are going out of it” (I2). He had also experienced problems with managing plant health and weed infestations. FSEM data for farmer 14 showed a sharp decrease between November 2015 and March 2017.

Negative verbal persuasion

Negative verbal comment received from significant people such as respected farmers, business partners, and agricultural scientists can serve to lead farmers to doubt their abilities and ultimately weaken their self-efficacy beliefs. Such negativity with other farmers and the scientists was not evident during the interviews and FGDs. However, as noted in the discussion of positive verbal persuasion above, it is possible these types of negative verbal interactions may have occurred beyond the reach of the data collection strategies used in this thesis.

Negative physiological/affective experiences

Experiencing strong negative emotional states are likely to weaken an individual's self-efficacy. All 28 farmers involved in the interviews and FGDs experienced emotional challenges as they attempted to establish and manage PSF crops. The FSEM survey results showed a decrease in self-efficacy for five farmers over the duration of the RFLP.

The seven participants in the third FGD talked of previous negative emotional experiences when introducing new pasture species into their farms. They shared how previously they had relied on ad hoc on-farms trials to develop their knowledge and understanding when adopting new technologies. These farmers felt hesitant about the robustness of their findings. Collectively they expressed trepidation and uncertainty when introducing PSF crops because of their lack of knowledge pertaining to their establishment and on-going maintenance.

Summary

The findings presented above have identified a number of negative factors that undermined farmers' self-efficacy. Farmers' self-efficacy decreased because they experienced challenges and negative vicarious experiences either before or during the RFLP. Negative experiences included uncertainty about the cost of establishing and maintaining PSF crops and the scarcity of scientifically robust information, which created deficit in farmers' knowledge about how to successfully manage on-going plant health and weed infestations in PSF crops.

For some, negative vicarious experiences, such as the observing neighbouring farmers removing PSF crops, created uncertainty about their ability to persevere with managing PSF crops in future challenging situations. Acting on the basis of inaccurate information provided by rural professionals and other farmers also undermined self-efficacy. While undermining by negative verbal persuasion is another possible factor, it was not observed directly in this study. However, the influence experience of emotionally negative situations clearly has a negative impact and seems to be especially significant during the initial stages of establishing PSF crops on the farm.

While the negative factors identified above were present, both the FSEM results and the general tenor of the qualitative data show that their influence was slight for most participants in the RFLP. Participating in the RFLP enabled most of the farmers to persevere when managing the challenge of making on-farm changes. The following section briefly reports on how farmers' understandings of PSF crop management changed due to their RFLP involvement.

6.4 Change in farmers' understandings of PSF crop management having engaged in a longitudinal agricultural extension programme

The twelve farmers interviewed agreed that on-farm results, observations they made during the RFLP and knowledge they gained from the scientists and other farmers at RFLP workshops changed their understandings of how to manage their PSF crops more efficiently. However, farmer 27 believed that his previous experiences with managing PSF crops on his hill country farm were equally important (I2). He was adamant the combination of all these sources of knowledge provided his new understanding of how to use PSF crops to take advantage of finishing more stock in his current farm system. This emphasis on the multiple sources of self-efficacy is also reflected in the results presented above.

The farmers emphasised in particular the importance of understanding post-grazing residuals, the impact on stock intakes and the level of animal live weight gain as factors that facilitated improvement in their farm systems. The use of PSF crops to move lamb weaning rates earlier than current practice is an example that attracted considerable interest from the participating farmers. For farmer 27, the opportunity to increase farm production through adopting early lamb weaning really "gave the kick" (I1), to consider further change in his use of PSF crops. They had been "semi doing it, but that hearing the results from the scientists gave us understanding and therefore the confidence to get right into it" (I1). Such quotes abound in the qualitative data; they show how self-efficacy increases can encourage not only specific innovations but also the ability to innovate across the farm system more generally. As self-efficacy theory suggests, improvements in farmers' understandings of managing PSF crops increased their self-efficacy to trial new strategies on their own farms. Table 6.1 summarises a range of farmer-initiated PSF management changes that farmers introduced on their farms because of the improved understanding and self-efficacy that they gained from participating in the RFLP.

Farmer Learning group	Change in pasture management	Lambing hoggets on PSF	Weaning lambs earlier	Introduce chicory	Introduce lucerne	Introduce red clover
New	8	2	8	2	2	2
Original	7	5	6	5	5	2
Total	**15**	**7**	**14**	**7**	**7**	**4**

Table 6.1. Farmer initiated PSF management change on-farm because of their improved understanding gained from participating in RFLP

6.5 Chapter Summary

This chapter has reported the findings from 28 farmers who participated in the 12 interviews and three FGDs from which qualitative data were collected. While the sample size (28) was small, their voices captured in the qualitative data, contribute to valid conclusions. The first section of this chapter reported a key finding of this study. Scientifically robust on-farm field trials and collaborative dialogue between farmers and scientists throughout their duration increased farmers' self-efficacy to manage PSF crops more efficiently. Most farmers believed that the knowledge gained from RFLP had served to increase their self-efficacy to manage PSF crops. The farmers' observations made during the RFLP and successes experienced in increased farm productivity contributed to significant increases in the strength of the farmers' self-efficacy beliefs.

This chapter has identified the factors that either enhanced or undermined the farmers' self-efficacy to manage PSF crops. As noted above, positive factors notably include building farmers' knowledge through conversations between the science and other farmer participants, improved farm production resulting from successful PSF crop management and observations of on-farm trials. The findings suggest that mastery and vicarious experiences in particular have substantially contributed to improving farmers' self-efficacy to manage PSF crops, underpinning the efficacy increases indicated by the FSEM findings previously presented. Moreover, this chapter has shown the significant adoption and innovative use of PSF crops on the farms of those who participated in the RFLP. Self-efficacy beliefs are important not only for personal well-being but also for the fostering of changes in farming practices.

Chapter 7 Discussion

7.1 Introduction

This chapter discusses the main findings presented in the results chapters, with reference to the literature. This study sought to understand changes in farmers' self-efficacy beliefs as they learned about how to manage a complex technology with multiple dimensions that had implications for their broader farm systems. Interview and focus group discussion (FGD)findings helped to explain these changes in farmers' self-efficacy that had been identified through the Farmer Self-Efficacy Measurement (FSEM) survey results (see Chapter 5). Integrating these two sets of findings provides important insight into how change in farmers' self-efficacy and understandings of managing PSF crops can influence their future use of these crops. The chapter begins by discussing the design and testing of the FSEM survey (Drysdale et al., 2017). This is followed by a discussion of changes found in the farmers' self-efficacy to manage PSF crops in relation to their participation in the RFLP. Section three discusses the factors identified that enhanced and undermined farmers' self-efficacy and the final section discusses how changes in self-efficacy gained during the RFLP influenced farmers' future management of PSF crops.

7.2 Measuring change in farmers' self-efficacy within the domain of managing PSF crops

Self-efficacy, an element of social cognitive theory, is the key focus in this thesis. Agricultural extension activities are an important vehicle to help farmers to learn about and adopt innovative technologies (Takoutsing et al., 2014), and this thesis maintains that such adoption is informed by farmers' efficacy judgments of their ability to effectively use these technologies. These mixed methods measure change in farmers' self-efficacy within the specific domain of adopting or managing PSF crops into an existing farm system. No instrument previously existed to measure efficacy change within the PSF domain, so the FSEM was developed for this purpose. Two crucial components were required to measure changes in the farmers' self efficacy. The first is the development of an instrument to accurately measure farmers' self-efficacy in this particular agricultural domain. The second component is to test this instrument's suitability to measure changes in farmer self-efficacy.

Bandura (2006b) argues that "there is no all-purpose measure of perceived self-efficacy" (Bandura, 2006b, p. 307). Self-efficacy measurement instruments need to be domain-specific; they need to relate to an individual's present perceived efficacy to carry out a specific future function. Studies have reported high predictability when using domain-specific self-efficacy measures, whereas for more general measures a similar result could not be identified (Pajares, 1996). Many researchers (e.g. Niles et al., 2016; Pickering et al., 2018; Sewell et al., 2017; Wilson et al., 2015) have discussed possible links between self-efficacy and adoption of new agricultural technologies. While several measurement instruments exist within the health and education sectors (e.g. Bandura, 2006b; Strecher et al., 1986), few instruments have been designed to measure self-efficacy in an agricultural context (e.g. Lind et al., 2019; Roy, 2009).

7.2.1 Farmer Self-Efficacy Measurement survey

The FSEM was designed to measure farmers' self-efficacy to organise and execute future courses of action in relation to the adoption and management of PSF into their farm system. Studies based on measurement must be concerned with the accuracy and reliability of the results. The Mastitis prevention self-efficacy scale developed by (Lind et al., 2019) produced high internal reliability, with a Cronbach's alpha of 0.90, while the alpha score for Roy's (2009) scale used with Bengali farmers was 0.75. The Cronbach's alpha value for the reliability of items in the FSEM scale was 0.96. Given that validation of reliability is an ongoing process, accumulating as research studies increase (Rust & Golombok, 1989), these results lend further support to the idea that self-efficacy in the domain of managing PSF crops can be quantitatively measured. The FSEM provides future researchers with a robust means of measuring change in self-efficacy beliefs to manage PSF crops. It thus provides a strong basis for identifying the impact of the 18-month RFLP. The FSEM supports learning in the broader agricultural domain just as there are tools available in health and education to support learning wiothin these domains. The following section discusses how the core farmers' self-efficacy changed in response to their engagement with this group-based agricultural extension programme.

7.3 Change in farmers' self-efficacy to manage PSF having engaged in a group-based longitudinal agricultural extension programme

This section discusses how farmers' self-efficacy to manage PSF crops changed in response to their participation in the RFLP. These findings are the product of the FSEM survey, farmer interviews and FGD activities.

7.3.1 Farmer Self-Efficacy Measure (FSEM) analysis

The FSEM results show that the self-efficacy of 54% of the RFLP farmers increased, 29% remained constant and 17% showed a decrease. The largest individual increase in self-efficacy was 71%, with this farmer being new to the learning project, while among the farmers who had belonged to an earlier pilot for the programme, the "originals", the largest individual increase was 39%. Thirty-nine percent of the original farmer learning group remained static throughout the duration of the RFLP. FSEM analysis established that the difference in original and new farmer groups' perception of their self-efficacy to manage PSF crops converged towards the end of the project in November 2017.

All farmers participating in the RFLP received diverse forms of guidance on how to manage PSF crops efficiently and this guidance supported change in their self-efficacy. Farmers with low levels of self-efficacy (e.g. Farmer 11) were more likely to require extra support to achieve successful adoption and management of these pastures. Usher, Ford, et al. (2018) argue that negative experiences have more effect on one's self-efficacy than positive encounters. However, this study shows that highly efficacious farmers (e.g. Farmers 7 and 14) were more likely to persevere and succeed when confronted with challenges, going on to develop strategies to manage future system changes. For example, the influence of watching disillusioned neighbouring farmers who had decided that PSF crops were "not for them", did not have a negative effect on these farmers' resolve to learn about and adopt them. Although this thesis has shown the influence of this sort of negative experiences highlighted by Usher (2016), it has also demonstrated the importance of enhancing self-efficacy to counter such negativity.

7.3.2 Understanding PSF crops

Understanding information about the suitability and profitability of PSF crops played an important role in the farmers' decisions to adopt PSF crops into their existing farm systems. One of the original group farmers believed that many good ideas foundered because of a lack of sufficient knowledge. Similarly, during a FGD three of the 28 farmers alluded to the fact that the results of their on-farm trials influenced their efficacy to adopt new technologies. Receiving information in an accessible form assists understanding. Similar to the finding of Chavas and Nauges (2020), this research found that farmers, therefore, highly value information on the suitability of new technologies that they gather from their own experiences, from their peers through social networks and by observing early adopters.

The qualitative findings gained from farmer interviews and FGD activities showed that farmers constantly assessed the performance of PSF crops on their farms and were well aware of the importance of understanding the strategies needed to manage these crops efficiently. Three members of the original farmer learning group reiterated that they did not have a background in developing scientifically robust on-farm trials. The 28 farmers highly valued the opportunity to access scientific knowledge by observing the ongoing field trials at Riverside farm, especially when this access was supported by collaborative dialogue with other farmers and agricultural scientists. The results of this opening to science were significant, as is shown in particular by the performance of those farmers who were new to the learning programme. Seventy-six percent (13) of the new farmers showed an increase in their efficacy over the 18 months of the RFLP. Participating in the RFLP provided these farmers with a better understanding of the consequences of their short-term decisions on the longer-term performance of their farm system. During their interviews, the six new farmers explicitly identified the knowledge gained from the agricultural scientists and from the original farmer group members as something that contributed to the increase in their efficacy to the performance of their farm systems.

Like Kalule et al. (2019), this study found that farmers used group settings, such as the RFLP, to ask questions to increase their understanding of how to manage new technologies more efficiently. Fifty-three percent (9) of the new farmer learning group showed an increase in self-efficacy to work with the agricultural scientists to improve their management of PSF crops. These six new farmers who were interviewed said that the non-threatening and colleagial environment of RFLP workshops gave them confidence to seek advice from the scientists and from members of the original farmer group. Responses to their questions provided them with increased confidence to “set the wheel in motion”. This finding is in line with Bennett (2015), who found that farmers became more empowered to change a farm system when legitimate information sources endorsed their implicit knowledge. Implicit knowledge consists of know-how that is difficult to transfer to another person in written or verbal form; the openness of RFLP participants to question each other and the science team helped to surface this sort of knowledge and make it more accessible to others.

Managing plant health and weed infestations in PSF crops

All thirty-five core farmers expressed frustration over managing weed infestations and plant health in PSF crops. However, they believed that persevering with these issues had allowed them to finish more stock on-farm. The ability to finish increased numbers of stock on-farm created a higher cash flow and therefore increased farm profit. These financial successes influenced farmers’ self-efficacy. FSEM analysis showed that 40% (14) of the core farmers believed their ability to persevere in challenging situations increased as they took part in the RFLP. Ten of those farmers were from the new farmer group.

7.3.3 Increased personal belief in ability to defend their use of PSF crops

Sixty percent (21) of the core farmers who completed the FSEM survey showed an increase in their efficacy to defend their decision to adopt PSF crops over the 18-month duration of the RFLP. Four of the farmers interviewed stated that the RFLP workshops and the visits to Massey University and members’ farms provided forums in which they felt confident to share their successes and challenges. This increase in farmers’ self-efficacy to defend their decisions to adopt PSF and share their experiences is consistent with research conducted by Mintzes et al. (2013), who observed an increase in teachers’ self-efficacy while they participated in a group-based longitudinal professional development programme. The teachers reported that the programme had increased their belief in their ability to teach science in the classroom and to defend their pedagogical decisions. The importance of social interactions between the farmers and agricultural scientists has been explored previously

(Eastwood et al., 2012; Hermans et al., 2015; Sewell, Gray, et al., 2014; Sol et al., 2013), but there have been no measures of self-efficacy in longitudinal agricultural extension programmes. The results from this study suggest that a collaborative extension model supports substantial increases in farmers' belief in their own ability to make changes.

7.3.4 Persevering with managing PSF crops

The farmers experienced successes and coped with challenges when adopting new management strategies for their PSF crops. By project end, all the farmers interviewed felt more confident to implement these strategies. Seventy-six percent (13) of the new farmer members' FSEM results showed an improvement in their efficacy to manage change within their own system while they participated in the RFLP. Two farmers participating in FGDs shared how they had tried weaning lambs early previously with mixed success. However, seeing the positive Riverside trial outcomes increased their belief in their ability to improve something that had already been trialled inconclusively within their farm own systems. Observing other farmers' success in using PSF crops in a similar way also appears to have played a role in shaping a positive outcome expectation for these farmers. This finding reinforces Bandura (1997) argument that vicarious experiences gained by observing others, perceived to be similar, is a powerful source of self-efficacy.

7.3.5 Help other farmers to introduce PSF

The FSEM findings showed that 57% (20) of the core farmers believed that after their participation in the RFLP they were in a better position to provide support to other farmers, enabling them to persevere when faced with challenges in managing PSF crops. This judgement in their ability to help others is assisted by belief in the crop's economic value. Of the 12 farmers who completed both interviews and all FSEM responses, four with the highest levels of self-efficacy also displayed more conviction in the economic potential of PSF crops compared with the four farmers with the lowest levels of self-efficacy.

The increase in farmers' efficacy to share their successes and challenges increased their ability to give useful advice to neighbours who were considering the use of PSF crops. The FSEM findings showed that, over the course of the RFLP, belief in the ability to give useful advice to neighbours increased for 76 % (13) of the new farmer members. The six new members interviewed attributed their increased efficacy to the successful results they had experienced on their farms after implementing strategies observed during the RFLP workshops. These personal achievements to manage PSF crops provided the confidence to give advice to other farmers. Similarly, Perry and Davenport (2020) report that farmers' personal achievements through mastery and building resilience, have significant effects on their self-efficacy. All twelve farmers interviewed declared that the RFLP had helped them to feel more confident to advise other farmers about alternative PSF management strategies.

7.3.6 Summary

The discussion above that integrates survey and FGD data noted how farmers' self-efficacy to manage PSF crops changed in response to their engagement in a group-based longitudinal agricultural extension programme. FSEM results found that the farmers' self-efficacy increased over the 18-month course of the programme. The 17 new members of the learning group showed a greater increase in self-efficacy from participating in the RFLP than the 18 members of the original group. Existing relationships between the members of this study might have influenced the differences between the new and original farmer groups, Findings from farmer interview and FGD activities were introduced to support the discussion of the FSEM survey findings in the key areas identified where self-efficacy had increased their understandings of how to manage PSF crops, confidence in defending their own use these crops, perseverance with challenges and confidence that they could help other farmers introduce the crops to their farms.

Personal achievement outcomes have been cited as important sources of these changes in self-efficacy. As Bandura (1997) argues, previous experiences of success and failure inform an individual's belief in their ability to perform future tasks. It appears that the farmers' self-efficacy changed because they experienced mastery on their own farms and had positive vicarious experiences while participating in the RFLP. Detailed discussion of the factors that enhance and undermined the change in farmers' self-efficacy are introduced in the following section.

7.4 Factors enhancing or undermining farmers' self-efficacy

The longitudinal nature of the RFLP allowed farmers and scientists to draw on each other's previous and ongoing experiences. The social focus of the RFLP workshops provided a continuum for learning opportunities and support for the differing levels of expertise of the participating farmers. The following sections open by discussing the factors that enabled the growth of farmer self-efficacy in this context, after which consideration is given to the factors that undermine these self-beliefs.

7.4.1 Enhancing factors

Positive mastery experiences

This study found that farmers' self-efficacy beliefs to manage PSF crops were enhanced through collegial knowledge sharing, improved farm productivity and greater knowledge about how to manage PSF crops efficiently – all factors that suported mastery on-farm. These factors are discussed in the following sections.

Collegial knowledge sharing

All core farmers identified the RFLP as an important factor in strengthening their self-efficacy. The RFLP workshops were designed to promote a collaborative learning environment. Participants continued to share successes and address persistent challenges collaboratively throughout the duration of the project. The interviewed farmers and FGD participants all alluded to the collegial style of knowledge sharing between the agricultural scientists and farmers as an important factor that supported their sense of being able to manage PSF crops.

The RFLP routinely provided farmers with opportunities for robust dialogue with the scientists and with each other. Grazing options proved to be a recurrent theme in these conversations, which were intentionally designed as a mix of formal and informal occasions in which the scientists and farmers took part as equals. As the RFLP progressed, the scientists and farmers moved from working separately towards a collaborative problem-solving approach based on sharing ideas openly at the bi-monthly workshops. The FSEM results show that 34% of the core farmers believed that their efficacy improved because of working co-operatively within a group environment.

The workshop learning activities promoted knowledge sharing. The farmers took the opportunity to enter into discussion with the scientists and their peers to clarify thoughts regarding the impact of factors influencing PSF crop growth. The lack of division between the scientists and the core farmers created a situation conducive to forming a “community of practice” (Lave & Wenger, 1991). Farmers and scientists shared experiences about a wide range of topics, such as setting up red clover on a farm, the frustration of managing devastation caused by plantain moth and a lack of animal live weight gain during autumn – this knowledge sharing supported their learning, and contributed to mastery experiences leading to enhanced self efficacy (Bandura, 1997). The twelve farmers who were interviewed reported that hearing that other farmers had experienced similar PSF crop management issues to their own, increased their self-efficacy to manage PSF crops differently in the future.

Sharing experiences facilitated ongoing knowledge development in both the science and agricultural communities. Open discussions between the scientists and farmers enabled individual farmers to gauge if PSF crops were likely to fit into their own current systems. The collegial sharing of problems and finding solutions developed their sense of belonging to a community of learners, which helped to support increases in farmer self-efficacy. This finding was also reported in Sewell et al’s (2017) study.

Improved farm productivity

Observation of the Riverside on-farm trials enhanced farmers’ self-efficacy to manage PSF crops because they could envisage succsesful ways to incorporate what they had learned from Riverside into their existing farm system. The farmers interviewed believed that their improved understanding of how to manage PSF crops would increase their farms' productivity, for example, by allowing them to sell more animals the lucrative 'prime market' rather than relying on the 'store market'. The farmers also saw the possibility of substantial productivity gains in being able to address plant health and weed management issues.

Sixty-five percent of the new group members showed an increase in their efficacy beliefs to improve farm productivity using PSF crops, compared with 17% of the original members. The farmers adopt new technology if they sense an opportunity for positive net benefit (Chavas & Nauges, 2020). Adopting PSF grazing and stock management strategies learned from the RFLP workshops allowed core farmers the ability to 'finish' more lambs more quickly than on traditional ryegrass/clover pasture. Knowing that they could achieve these productivity gains, enhanced farmers' self-efficacy to continue looking for new and evidence-based ways to use these crops on their farms.

Improved farmer knowledge

The findings of this study correspond with previous research (Klerkx & Leeuwis, 2008; Sewell et al., 2017; Wood et al., 2014) which highlights the importance of social inclusiveness and collaborative engagement for the knowledge gains sought by agricultural extension. While some researchers (Bawden et al., 1984; Klerkx et al., 2010; Leeuwis & Aarts, 2011; Pant, 2012; Price, 2008) draw on branches of systems thinking, agricultural extension typically remains interventionist and top-down rather than collaborative and dialogic. Farmers are regarded as the users of knowledge rather than as the producers of innovation (Nicholson et al., 2003; Pannell et al., 2006).

Bandura (1989a), argues that "self-belief systems are affected by the authenticity of the efficacy information on which they are based" (Bandura, 1989a, p. 1179). Four of the interviewed farmers specifically identified the authenticity of the information provided during the RFLP as the strongest contributor to their increased belief in their ability to manage PSF crops. The collegial environment outlined above contributed to this sense of information authenticity. A rich mix of information moved in dialogic forms throughout the course of the RFLP.

Discussions held while standing together in the field, in vehicles and during meal breaks provided a unique opportunity for the core farmers to extract information directly from the scientists and subject matter experts attending workshops. Farmers taking part in the RFLP were presented with unbiased information provided by the scientists and by other trusted farmers. Several farmers noted that interpersonal interactions within the RFLP workshops were highly valued. Farmers became aware of new ways to manage PSF crops from a science team that did not "just fob things over" F4 (I2). The science was ongoing rather than a matter of established results simply to be received. Farmers acknowledged that the opportunity to challenge the scientists on field trial methods contributed to the growth in their belief that they could manage PSF successfully in the future. Three of the core farmers explicitly highlighted the importance of “getting the science” directly. For example F17 during in FGD 1 shared how, “new learning from AgS1 and AgS3 [agricultural scientists] is building my belief in my ability to try something ‘outside the square’. It is a matter of managing my pasture to suit my winter finishing farm system”.

Involving farmers collaboratively in the conduct of ongoing scientific trials, made the RFLP an innovative form of agricultural extension and the farmers highly valued this innovation. The farmers believed that the strength of the RFLP was its creation of a social learning environment in which they could observe and model the behaviours, attitudes and emotional reactions of others. The interviewed farmers willingly shared stories of how knowledge generated at the RFLP workshops had been an important contributing factor to their improved understandings of how to manage PSF crops more effectively. As Vygotsky (2012) argues, developing new knowledge is impacted by the actions of others in the social learning setting and by the inherent characteristics of the culture in which that learning is situated. More specifically, Sewell et al.’s (2017) study found that collaborative actions involving all affected agents and using shared, collaborative learning approaches encourages learning which serves to increase farmers’ beliefs in their ability to adopt innovative technologies (see also Franz et al. (2010).

As the farmers experienced the successes and challenges of adopting PSF into their farm systems, they had to make judgments about their capabilities and anticipate the possible effects of different farming practices or courses of action. The interviewed farmers and FGD participants recognised the value of the agronomy and animal science theory that was shared alongside practical on-farm content. Given that the ongoing trials were at farm scale, they helped to mediate a connection between these theories and the everyday farming practices. A number of the farmers highlighted the value of being able to observe the trial results in person and hear about them from the scientists in the presence of other farmers. In effect, the trials could be treated as an example of what Bandura (2006c) calls “a working model of the world that enables people to achieve desired futures and avoid untoward ones” (Bandura, 2006c, p. 168).

The FSEM findings indicate that ninety percent of the core farmers believed their understanding of the PSF plants’ physiological requirements increased or remained stable during the RFLP. Acquiring new knowledge and confirming the soundness of what is already taken as known requires sustained effort in the face of challenges and setbacks. The resilience of efficacy beliefs is therefore a critical factor to consider for learners challenged with introduvcing change (Bandura, 1989b). This resilience, through enhanced self-efficacy for managing PSF, impacts future farming actions as this study has reported. The farmers increasingly believed that: they could adopt new grazing management strategies that were appropriate for PSF crops, they could match crop species to suitable environments, and manage future challenges involving plant health and pests.

Positive vicarious experiences

While Bandura (1977b) argues mastery experiences are the strongest source of self-efficacy, Selzler et al. (2019) highlight the importance of vicarious experiences or observing social models of success. Vicarious experiences were also important sources of efficacy in my study. Bandura (1997) reports that vicarious experiences are used by individuals who observe others, perceived to be similar to themselves, as a source of information about their future capabilities. Before adopting new technologies, farmers learn how they have worked for others in similar situations as their own (Perry & Davenport, 2020). Social models of success in my study where the farmers observed the agricultural scientists and other farmers, played an important role in enhancing farmers' self-efficacy to manage PSF crops.

All 28 farmers interviewed or participating in FGD reported that being able to observe the Riverside on-farm trials, hear and talk with the agricultural scientists and other farmers had helped to increase their self-efficacy to manage PSF crops. For example, farmer 2, a member of the original learning group, explained how he believed the successes and challenges that he had observed while participating in the RFLP had "filled a gap in the knowledge that [he] had gained from various sources," giving him confidence in his ability to make PSF crops work in his own system. Perry and Davenport (2020) describe how farmers observing the success of like-minded farmers or subject matter experts served to increase their efficacy to complete a similar task. One of the interviewed farmers was adamant that hearing on-farm trial results from scientists rated more highly than anecdotal information provided by industry representatives, who have less independent scientific research behind their advice. Observing the work of the agricultural scientists and visiting other farms provided an additional source on which RFLP participants could judge their ability to manage future PSF crops.

The scientists' responses to the questions posed by farmers as part of the RFLP workshops served to improve the farmers' understanding of and skills to manage PSF crops more efficiently. These conversations increased the farmers' self-efficacy to persist with PSF crops through challenging situations such as weed and plantain moth infestations. Further questioning during the farmer interviews clarified that observing the trials enhanced their sense of efficacy because they could envisage how to incorporate new PSF management strategies learned from RFLP workshops into their existing farm system. This finding is consistent with Bandura (1989a), who argues that the characteristics of a, "self-belief system are affected by the authenticity of the efficacy information on which they are based" (p. 1179). The opportunity to follow the results of scientifically robust trials presented at RFLP workshops provided farmers the knowledge and confidence they needed to believe that they could manage PSF crops.

Verbal persuasion

Verbal persuasion, while not observed in this study, was another possible factor enhancing farmers' self-efficacy during the course of the RFLP. Verbal or social persuasion refers to specific verbal and social feedback received from credible influential friends, colleagues or experts. Persuasion received from other trusted farmers, business partners or reputable agricultural scientists may have enhanced the farmers' self-efficacy. As mentioned above, the discussions held while standing together in the field, in vehicles and during meal breaks provided an opportunity for verbal persuasion to occur. However, because the researcher was not privy to these conversations, no data were collected about their nature. It is important to note that these informal interpersonal interactions can provide valuable opportunities for verbal persuasion, in the form of praise or encouragment, to confirm or restructure knowledge to further enhance self-efficacy (Usher, Li, et al., 2018).

Positive physiological/affective state

The importance of an emotionally positive and non-threatening atmosphere within the RFLP was shown to contribute to improved self-efficacy to manage PSF crops. The RFLP provided an atmosphere where farmers became confident to share their personal beliefs about their PSF crop management with fellow RFLP participants. The interviews and FGDs pointed to the pleasure gained by farmers of learning from the scientists, and these positive affective states empowered them and contributed to increased self-efficacy. The farmers and scientists also shared challenging and stressful experiences as they learned to manage the challenges of growing PSF crops. The honest disclosure of these positive and negative physchological states was helpful to enhance self-efficacy. Farmers also believed the scientists "can-do" attitudes, honesty and objective approach meant they could trust them and they felt 'safe' to share their own mistakes and challenges. This honest sharing by the farmers and scientists showed that despite failing in a challenge they could still speak freely about it and learn from it. Hermans et al. (2015) argue that this shared emotional expression can support learning that leads to future agricultural innovation. As Bandura et al. (1977) note, such emotionally positive and non-threatening experiences are known to strengthen an individual's self-efficacy.

Summary

The section above has discussed factors that enhanced changes in farmers' self-efficacy. Building on the knowledge shared by other farmers and agricultural scientists led to new management practices that improved farm productivity. These mastery experiences enhanced the farmers' self-efficacy in the domain of managing PSF. Vicarious experiences, such as the opportunity to observe the science trials, provided farmers with deeper knowledge to understand how to manage PSF more efficiently. Scientists' reporting on-farm trial results and sharing their own challenges was also rated highly compared to anecdotal information provided by industry representatives. Finally, the emotionally positive and supportive atmosphere within the RFLP influenced a positive change in farmers' self-efficacy to manage PSF crops efficiently in future. These three self-efficacy cues discussed above not only increased farmers' self-efficacy but encouraged them to persevere when managing the challenges associated with adopting on-farm changes.

7.4.2 Undermining factors

Unsuccessful experiences

The results have identified a number of factors that undermine self-efficacy. When people do not believe their actions will produce desired effects, they have little incentive to act (Bandura, 1982). Self-efficacy beliefs impact individual motivation and perseverance to complete tasks (Bandura, 1993; Hammond & Feinstein, 2005; Usher, Li, et al., 2018). Negative experiences, argue Usher, Ford, et al. (2018), can have more influence than positive experiences on ones' efficacy beliefs to complete new challenges. Without a full understanding of grazing management strategies, some farmers missed crucial pieces of information which led to disappointment of failed outcomes. This study found that farmers' self-efficacy beliefs to manage PSF crops were constrained by economic uncertainty, scarce access to information and plant maintenance factors, inaccurate advice, difficulty adating to climatic chanages and negative vicarious experiences. These factors are discussed in the following sections.

Uncertainty of economic potential

The high financial cost of establishing and managing PSF crops was a risk many farmers were wary of taking. The farmers were challenged by the uncertainty that the money invested to establish the crop might not provide a reasonable economic return. Moreover, ongoing maintenance costs also undermined belief in their ability to continue with the crops. Doubts about crop establishment, maintenance and longevity undermined the self-efficacy of all core farmers. Four farmers were disappointed with their early economic return gained from introducing a crop such as chicory or plantain into their farm system. The self-efficacy of these farmers declined between November 2015 and July 2016 because of the high cost of setting up and managing these crops. When considering a new technologies, farmers weigh up both the expected return of the new technology, as well as the likely variability in returns over the longevity of the crop (Chavas & Nauges, 2020). Access to information about the suitability and profitability of the new technology would likely influence farmers' belief in their ability to manage PSF crops in the future. Farmers in this study believed a way to address such uncertainties about the crops' economic potential would be to develop a model that allowed them to explore their predicted economic values if adopted. The core farmers suggested that the ability to explore possible economic models before adopting new pasture species, such as PSF, would help to lift initial low self-efficacy. After experiencing an improvement in farm production between July 2016 and March 2017, 89% of the core farmers' FSEM survey results increased. This result confirms Wuepper and Drosten (2015) suggestion that farmers' self-efficacy increases as they become aware of how new technology works and how uncertainties can be overcome and risks mitigated.

Scarcity of accessible information

The core farmers participating in this study expressed frustration about the challenges to manage PSF crops. These farmers identified the trouble they experienced to find accurate information based on objective research, and this scarcity undermined their self-efficacy. The scarcity of information may have contributed to farmers making poor decisions on what crops were best suited to their environmental conditions and farm systems. Scarcity of information meant farmers adopted PSF crops without being fully informed of the future management challenges that they were likely to experience.

Disappointment was expressed by two members of the original learning group with the results gained from introducing PSF crops into their farm systems. These farmers did not realise these crops required specific grazing strategies. The resulting poor crop performance contributed to a decline in their self-efficacy to manage PSF crops, especially under drought conditions. The knowledge and understandings of crop requirements they had gained was inadequate. Not knowing the importance of growing enough PSF crop to continue a practical grazing rotation undermined these farmers' early assessment of their ability to manage the crop. Similarly, students experiencing challenges, setbacks and low grades undermine their self-efficacy (Usher, Ford, et al., 2018). This finding highlights the importance of farmers being aware of challenges associated with adopting PSF crops. Without knowing about these challenges, farmers' self-efficacy to manage these crops was in danger of being undermined from the very beginning.

The farmers in this study identified the need to seek easily understood, authentic information from multiple sources when trying to successfully manage PSF crops. Learning about and understanding the challenges associated with these crops increased their belief that they could introduce new strategies allowing for more efficient use. Similarly, when planning health education programmes, health educators found it useful to ascertain how many and which members of their target population felt susceptible to serious health issues and believed that the threat could be addressed by an action on their part (Rosenstock et al., 1988). Incorporating features of this Health Belief Model (1988), including ideas of aligning programme content with the prevailing issues and challenges facing farmers, would help to increase farmers' belief in their ability to manage PSF crops efficiently in the future.

Farmers' knowledge deficit

This study found that gaps in farmers' knowledge about managing plant health and weeds undermined their belief in their ability to manage PSF crops. The core farmers in this study recognised managing plant health and weeds was an expensive challenge and constant juggling act. The interviewed farmers and FGD participants accepted that addressing these issues required more specialised knowledge than was needed to manage traditional pastures. Many described that they felt as though they had little or no control over plantain moth or weed infestations and that scientifically robust knowledge was not available. Farmers interviewed reiterated that not understanding how to manage plant health and weed issues effectively resulted in a decline in their self-efficacy.

The FSEM survey results revealed that all thirty-five farmers in this study struggled, at first, to manage weed infestations in PSF crops. The interviewed farmers consistently referred to weed management as challenging and expensive. FSEM results showed that the sense of being able to meet this challenge improved during the RFLP for 59% of the new farmer members and 28% of the original members. During the same period, however, 39% of the original group and 18% of the new group showed a decrease in their self-efficacy to identify solutions to control weed problems in their PSF crops. Both these groups had access to the same workshops and information; however, attendance at the workshops varied (see Table 4.7 page 52). RFLP workshop 6 focussed on managing the challenges of weed infestation and, interestingly, 53% of the new members attended this workshop compared with 38% of the original members. Not receiving the information shared by the weed management specialist and other farmers at workshop 6 may have contributed to their lack of understanding about how to manage these challenges and undermined self-efficacy.

Inaccurate advice

One third of the farmers interviewed identified that they had previously made inappropriate PSF crop selections based on innacurate advice from industry representatives. For example, farmers had planted plantain into unsuitable soil types and experienced problems with successfully grazing it. Another farmer reported observing neighbouring farmers making uninformed decisions related to PSF crops as a security against drought. One of the new group members shared how he had also been advised by an industry representative that plantain was a “drought buster”. While farmers are happy to give new technologies a trial, according to farmer 33, they must work. Inaccurate advice from a rural professional led to crop failure for him because environmental conditions were not suitable to produce expected outcomes. Other farmers shared how such previous experiences had led them to question their belief in their ability to manage PSF crops. However, as Schunk and DiBenedetto (2014) point out, occasional negative experiences after many successes have little or no effect on ones' self-efficacy, as the findings given in the previous chapter also show.

Adapting to changing climatic conditions

All the farmers participating from one region agreed that a key driver behind them adopting PSF crops was the increasingly dry summer weather patterns they were experiencing. Over the 18-months of the RFLP, one-third of the participants showed an increase in their self-efficacy to improve their grazing choices during future drought events. The remaining 66% were evenly spread between registering a decline or no change to their self-efficacy in this regard. These findings align with Niles et al. (2016) who suggest farmers'beliefs of their capacity to adopt climate change practice is an important predictor of both intended and actual adoption of new farm practices. While farm systems and climatic conditions vary across seasons and regions, all farmers involved in the RFLP had experienced the effect of prolonged dry periods and these were something that may have contributed to undermining their self-efficacy to manage PSF crops.

Negative vicarious experiences

Two farmers shared how they had observed disillusioned neighbours who had lost their PSF crops and were therefore looking for new options. In this study, negative vicarious experiences with other farmers and scientists appear to be a minimal influence on farmers' self-efficacy for the following two reasons. Firstly, the FSEM results suggest that their self-efficacy was sufficiently robust to persevere with the PSF crops. Secondly, during the interviews and FGDs farmers told how experiencing challenges improved their understanding of how they might manage PSF crops differently in the future. These findings align with the theories espoused by Bandura and Cervone (1986); people with high self-efficacy more readily overcome challenges, striving instead to achieve higher future standards for themselves.

Negative verbal persuasion

Negative verbal feedback can undermine self-efficacy (Schunk and DiBenedetto (2014). Negative responses received from significant people such as respected farmers, business partners and agricultural scientists could lead farmers to doubt their own abilities to manage PSF crops. While the presence of such negative persuasion was not evident in this study, it is possible that it occurred beyond the scope of the data collection used here.

Negative physiological/affective state

According to Bandura (1997), negative physical and emotional reactions associated with failure can weaken self-efficacy. All 28 farmers involved in the interviews and FGDs had experienced emotional challenges, such as trepidation, anxiety and uncertainty, when they were establishing and managing PSF crops. The farmers shared how they had previously relied on ad-hoc on-farm trials to develop their knowledge and understanding when adopting new technologies into their farm systems. Lack of success with such an approach indicates an important learning for the design of agricultural extension programmes. Failure to support farmers for the successful implementation of a new farm practice or technology may have a negative impact on their effiacy beliefs to adopt future innovations.

Summary

This section has discussed factors that undermined changes in farmers' self-efficacy. Farmers difficulty in understanding PSF crops' economic potential, especially prior to adopting them, emerged as an important undermining factor. The scarcity of appropriate information also hampered farmers' ability to manage the crops efficiently. The resulting challenges of selecting suitable PSF crops for specific climatic and environmental conditions and managing weed infestations also undermined their self-efficacy. While farmers acknowledged observing negative vicarious experiences, it appears that these had little impact. Negative verbal persuasion was not observed in this study, but the significance of negative emotional states is clearly a factor. While the key self-efficacy cues discussed in the section above undermined farmers' self-efficacy, being aware of them provides useful guidance for extension programmes seeking to improve farmers' beliefs in their own abilities.

7.5 Improved farmers' understandings of PSF crop management having engaged in a longitudinal agricultural extension programme.

This study found that over time that farmers' understandings of managing PSF crops developed in complexity and that these gains impacted on improved profitability. Individually, the farmers employed differing strategies to increase farm production. All the farmers interviewed shared that they had changed the way they managed PSF crops on their farms. The most common change made to current grazing rotations and stock management strategies was weaning lambs earlier than was typical. Other farmers intended to lamb hoggets and wean lambs on PSF in the future to replicate the results observed at the Riverside on-farm trial.

All the interviewed farmers recounted how their understandings of managing PSF crops had improved. Ingram (2010) argues that adopting new practices relies on the willingness and capacity of farmers to experiment, innovate and learn at the farm level. The RFLP helped most farmers to improve their belief in their own ability to experiment and innovate. After participating in the RFLP, the farmers understood the importance of grazing residuals and the impact that overgrazing PSF crops has on crop longevity and future plant growth rates. Farmers were also able to introduce different stock classes to grazing their PSF crops because of the results shared by the scientists and other farmers throughout the RFLP.

Farmers based their PSF management decisions on new knowedge co-constructed in their previous experiences, their dialogue with scientists and farming peers and observations of the trials at the RFLP. The integration of FSEM results, interview and FGD data indicate significant improvements in both the original and new farmers' self-efficacy in this domain, and its is argued that these efficacy gains can be partly attributed to improved understandings of PSF crop management. This study has also shown that the inclusive and supportive environment of the RFLP was a pivotal factor driving these improved knowledge and on-farm innovation.

7.6 Chapter Summary

This chapter has discussed the findings for each research question with reference to literature on self-efficacy theory and agricultural extension. The main concern has been to explore the factors that enabled or undermined farmers' beliefs in their future ability to manage PSF crops on their own farms. In general, the RFLP had a highly positive impact for most farmer participants, and the reasons for this suggest important lessons for the design of successful agricultural extension programmes.

Four specific themes identified using FA analysis of the FSEM results have been discussed in some detail, showing how farmers' understandings of PSF crops improved as did their personal beliefs in their ability to manage these crops, persevere with them in challenging situations and help other farmers introduce them into their own farms. The key factors enhancing these self-efficacy improvements were collegial knowledge sharing and the mastery experiences that came with improved farm production. Positive vicarious experiences and physiological and emotional responses also played an important part. Farmers' self-efficacy was undermined as they became aware of the cost of establishing and managing PSF crops. They believed these costs compromised the crops' economic potential. Scarcity of information readily available to farmers also undermined their self-efficacy, especially when challenged with managing weed infestations and matching PSF crops to specific environmental conditions. The influence of negative physiological and emotional experiences on self-efficacy has also been discussed.

The final section of this chapter discussed the way farmers' understandings of managing PSF crops changed having engaged in a group-based longitudinal agricultural extension programme. Participating in the RFLP empowered farmers to believe in their ability to introduce change into their farm systems. Observing other farmers, similar to themselves, succeeding in the management of PSF crops instilled belief in their own ability to achieve similar results. Understanding the physiology of PSF plants allowed for better grazing strategies. Experiencing the success of these new management strategies learned through participation in the RFLP workshops increased farmers' self-efficacy to manage PSF crops.

The findings of this study suggest that mastery experiences, positive vicarious experiences and the colleagial and positive culture of the RFLP workshops contributed to enhanced self-efficacy to manage PSF crops. The following chapter concludes this study, presenting the overall contribution made to research, its implications for future planning of agricultural extension activities and some limitations to be considered when generalising findings to other contexts.

Chapter 8 Conclusion

8.1 Introduction

This thesis has investigated the value and means of measuring changes in farmers' self-efficacy, focusing specifically on their efficacy beliefs to manage perennial summer forage crops (PSF). The first objective of this study was to develop a valid quantitative measure for farmer self-efficacy in this domain. The second objective sought to explore how farmers' self-efficacy to manage PSF crops change in response to engagement in a group-based sustained extension programme. The final objective was to develop a deeper understanding of the circumstances that supported or undermined these farmer efficay beliefs while taking part in agricultural extension. The influence of changes in farmers' self-efficacy and understandings on their future use of PSF crops was also investigated. This chapter briefly reviews the contribution of this thesis to existing research and considers its practical implications for future agricultural extension. Research limitations and future research are discussed, concluding with some final thoughts resulting from the study.

8.2 Research contribution

A major contribution made by this thesis to existing research is the development of a robust method to measure farmers' self-efficacy. Secondly, this study also usefully identifies a range of factors that support or undermine self-beliefs mainly through mastery and vicarious experiences. Finally, the value of paying careful attention to self-efficacy has been clearly demonstrated through farmer participation in an innovative agricultural extension project. Their participation was shown to have had substantial impact on improving farmers' understandings of and efficacy beliefs to manage PSF crops. These findings have implications for designers of agricultural extension as well as policy makers.

8.2.1 Measuring change in farmer self-efficacy

This study developed a survey instrument capable of measuring self-efficacy within the domain of managing PSF crops. There are very few studies that can serve as useful models to guide this task. A rare study was conducted by Roy (2009), who developed a tool to measure the self-efficacy of jute and paddy farmers in India. As Bandura (2006) argues, instruments used to measure self-efficacy need to be domain specific; they must relate to ones' present perceived ability to embrace a specific future function. Previous studies investigating change in farmers' self-efficacy (Duranovich, 2015; Lind et al., 2019; Roy, 2009) have used a range of surveys but none focused on the domain of managing PSF crops. The FSEM survey (Drysdale et al., 2017) developed during this study addresses this gap, but it also provides a model for researchers seeking to develop a reliable tool capable of measuring changes in farmer self-efficacy within a range of agricultural domains.

8.2.2 Change in farmers' self-efficacy to manage PSF crops having engaged in a longitudinal agricultural extension programme

A second major contribution made by this study was the role self-efficacy plays in farmers' learning about new technologies. Previous research (Burton & Wilson, 2006; Nuthall, 2010; Turner et al., 2014) has considered the role of psychological attributes in farmers' uptake of new technologies. More recently, some agricultural research (e.g. Pickering et al., 2018; Sewell et al., 2017; Wilson et al., 2015) has investigated the importance of the role played by self-efficacy in farmers' learning, but prior to their research, no research has been conducted bringing together the theory of self efficacy for farmers' learning in the specific domain of PSF crops. The results of the current study revealed that change in farmers' self-efficacy occurred during the 18-month long RFLP. Significantly, the participating farmers' efficacy beliefs to manage PSF crops increased. Their belief in their ability to share their new knowledge to help other farmers wanting to introduce PSF crops into their farm system also grew. The farmers also showed that they were able to persevere when challenging situations arose, and that they were willing to defend the use of PSF crops as an added value in their farm system.

8.2.3 Factors enhancing or undermining farmers' self-efficacy

A third major contribution made by this study was the determination of factors that enhanced or undermined farmers' self-efficacy. This research found that self-efficacy beliefs were important not only for personal well-being but also for the fostering of changes in farming practices. If farmers' self-efficacy matters for agricultural innovation, then it is important to understand what factors either contribute to or undermine such self-beliefs. The farmers involved in this study identified three factors that increased self-efficacy.

Firstly, mastery experiences enhanced the farmers' self-efficacy in the domain of managing PSF.The participating farmers had the opportunity to gain new knowledge through their involvement in practical RFLP workshop activities. This research found that the involvement of subject-matter experts and the experience of sharing activities and peer modelling strategies enhanced farmers' self-efficacy. Exercises such as the digging up and examination of plants helped farmers become aware that managing the root system was as important as paying attention to the plants' leaves. Knowledge gained from this activity provided the group with guidance to solve future problems. This knowledge was not simply passively received but was constructed in the numerous activities that occurred routinely throughout the RFLP. Building on the knowledge shared by other farmers and agricultural scientists led to new management practices that improved farm productivity.

Secondly, vicarious experiences, a known source of information on which self-efficacy judgements are made (Bandura, 1989b), provided through opportunities to observe scientifically robust on-farm trials increased the self-efficacy of the farmers. Farmers observed improved animal weight gains on PSF crops over a relatively short time frame during the 18 months of the RFLP. They also vicariously experienced scientists managing similar crop challenges to their own, observations that strengthened their efficacy beliefs to adopt PSF crops. Bandura and Walters (1963) suggest that practically all learning occurrences resulting from direct encounters can also occur vicariously. The actions of the agricultural scientists and other farmers clearly had this sort of positive effect. The farmers' observations confirmed beliefs that, if managed in a comparable way, they could also achieve similar results on their farms.

Finally, the emotionally positive and supportive atmosphere within the RFLP influenced a positive change in farmers' self-efficacy to manage PSF crops efficiently in future.The farmers participating in the project acknowledged the value of their social interactions with both the scientists and other farmers.They highlighted the RFLP's collaborative approach as providing valuable opportunities to share their knowledge while contributing to research by helping the scientists solve issues that challenged the on-farm trials. The resulting sense of community provided a foundation for open dialogue, the sharing of power and the development of trusting relationships. The farmers pinpointed the importance of the face-to-face dialogue with the scientists as something that increased their knowledge and enabled a greater belief in their abilities to manage PSF crops. This direct personal dialogue was important for the communication of both scientific expertise and farmer experience. Sharing knowledge with farmers from other regions experiencing similar challenges was identified as another factor that impacted on individuals' self-efficacy. These three self-efficacy cues discussed above not only increased farmers' self-efficacy but encouraged them to persevere when managing the challenges associated with adopting on-farm changes.

Belief in one's own judgement of abilities can be eroded through negative experiences (Schunk, 1996). The farmers involved in this study identified a number of challenges that undermined their self-efficacy to adopt or manage PSF crops in the future. Firstly, farmers not being able to calculate accurately the economic potential of introducing a PSF crop into an existing farm system was one such factor. Self-efficacy beliefs were undermined by the perceived difficulty of integrating PSF crops into an already existing farm system and by the challenge matching the types of PSF crops to the specifics of farm soil type, topography and climatic conditions. It was perceived by the farmers as difficult to commit to PSF crops when they were unsure whether they were going to cost them more than the return received.

Secondly, the farmers lack of access to evidence about ways to manage weed infestations within PSF crops undermined their perception of their ability to manage PSF crops. While the farmers referred to weed management as challenging and expensive, they nevertheless persisted with PSF crops when they were convinced that they would add value to their farms in the future. Much the same can be said about the challenges associated with plant health and especially with plantain moths in plantain or clover crops. Here too, the social interactions of the RFLP helped farmers' understand how to address those challenges, which in turn supported their beliefs in their ability to be successful.

Finally, the scarcity of information in 'farmer speak' was identified by participating farmers as an undermining factor. Farmers introducing PSF crops into an existing system are confronted with a range of decisions, especially regarding the most effective grazing strategy. As above, these undermining factors were mitigated by the ways in which the RFLP operated. Dialogue with the agricultural scientists and other farmers, for example, alerted individuals to a range of practical options and so enhanced their sense that they were able to respond to these challenges.

8.3 Limitations of the study

The study has provided insights into how farmers' self-efficacy can be increased while participating in an agricultural extension project. However, it is acknowledged that the study draws on the experiences and analysis of only one specific case and therefore necessarily has limitations. The main limitations are as follows.

The core 35 farmers who contributed to the study represent a very small and regionally specific sample of New Zealand's sheep and beef farmers. This small sample limits the transferability of the findings to other types of farmers and to sheep and beef farmers generally. Similarly, the study population is predominantly made up of New Zealand European males, therefore no conclusions can be drawn about possible cultural and gender trends. This study took place within what can be regarded as a relatively short time frame when working in an agricultural setting. It often takes farmers three to four years to introduce a change in pasture or forage type into an existing farm system.

If this study were to be repeated in different regions of New Zealand or using other forms of agricultural extension, the results may be different. The findings of this study therefore cannot be easily generalised to other contexts. However, the findings are clearly significant in principle, and the context is richly described and thus can be used to inform similar initiatives.

The study focussed on one form of agricultural extension and is notable for its inclusion of research scientists. While this study shows the value of including research scientists, it may also limit the transferability of findings to other forms of agriculture extension where access to research scientists is difficult.

8.4 Implications for agricultural extension design

The need to develop a deeper understanding of farmer self-efficacy has been increasingly acknowledged in agricultural extension literature (Wilson et al., 2015). However, extension practioners have lacked instruments capable of measuring self-efficacy changes within particular agricultural contexts. The FSEM, developed specifically for this study, provided the opportunity to explore the relationship between change in farmers' self-efficacy and their management of PSF crops while they were involved in the RFLP. Given the unique context provided through analysis of FSEM data and the RFLP, this thesis has three implications for the design of successful agricultural extension programmes.

Firstly,self-efficacy is an important concept for designers to consider when designing extension programmes aimed at supportimg farmers to learn about and adopt complex new technologies. Farmers' faced with adopting new policy or complex technologies make a judgment of their capability to achieve a successful outcome based on their present knowledge and skills. This study contributes to agricultural extension research by identifying the practical significance of self-efficacy and showing how it can be enhanced in agricultural extension programmes that are intentionally informed by social cognitive learning theory.

The second implication for agricultural extension is the importance of designing collaborative learning-focused activities where farmers have diverse opportunities to engage in dialogue with others to co-construct new understandings. This new and evidence informed knowledge is key to ensuring mastery, which in turn is fundamental to enhancing self efficacy. The RFLP enabled each member to bring their own expertise to the learning process; the farmers brought their farm environment and practical system knowledge and the scientists brought their knowledge of agronomy, plant physiology, animal production and welfare. Opportunities need to be provided for farmers to develop respectful and trusting relationships with others whose expertise they want to engage with in the extension activities. Future agricultural extension can be designed with the intention to increase both the scientists' knowledge and the farmers' knowledge.

The third implication concerns the importance of providing an environment that facilitates collegial sharing of problems and finding solutions. Farmers' self-efficacy was enhanced in this study through observations of trusted others, and access to accurate, easily understood unbiased research publications that define the nature of knowledge required for reaching a successful on-farm result. The RFLP was developed using a social constructivist learning philosophy where farmers and scientists collaborated in devising not only the accepted means of extension, but also by better defining the nature of the knowledge required for a successful result. The farmer's in this study acknowledged the significance of observing and discussing successes and challenges with other farmers as a key action that they undertake when considering changes to their farm systems. Central government policy guidelines and/or agricultural extensions programmes designed to acknowledge and support farmers' self-efficacy may achieve a greater rate of adoption of complex technologies.

The value of information generated collectively by farmers and scientists, as used in AKIS and AIS agricultural extension, was found to be a significant enhancing factor of farmers'self-efficacy in this study. Farmers and scientists should be encouraged by central government agencies to identify effective strategies to make changes through pooling of resources and acting collectively when designing future research and extension programmes. The RFLP's agronomists and animal scientists were experienced university teachers with considerable experience about how to talk with farmers. They facilitated the RFLP workshops and made extensive use of their ongoing PSF trials at Riverside farm. Discussion and practical activities were planned for each workshop to build on both the scientists' research-based knowledge and the farmers' experiential knowledge. These sessions increased farmer knowledge and self-efficacy and so provide useful exemplars for extension programmes more generally.

8.5 Suggestions for future research

The sample population of this study consisted of sheep and beef farmers from the Central Hawkes Bay, Manawatū and Wairarapa regions of New Zealand. Future research could be replicated in other regions across the country, especially the regions that have a high proportion of sheep and beef farming operations. The study also focused on measuring change in farmers' self-efficacy within the domain of managing PSF crops in particular. Further research could be conducted to assess if similar factors enhance or undermine self-efficacy in other agricultural domains such as precision agriculture or making adaptations in response to climate change. Future research could also investigate the use of different agricultural extension designs, such as reflected in the RFLP to widen understanding of the relationship between farmers' self-efficacy and their future use of innovative agricultural technologies.

8.6 Concluding thoughts

I had a number of personal aims for this research, many of which have been met. I aimed to measure change in farmers' self-efficacy to identify its enabling and constraining factors and to explore how these changes in farmers' self-beliefs had learning and on-farm consequences. In completing this study, I have gained a deeper understanding of the significance of farmers' perceptions of their ability to initiate future change. Farmers faced with the decision of adopting a new technology or modifying an existing farm system need to believe that they can successfully action that change. A farmer's efficacy beliefs to initiate future change is reliant on evidence obtained through previous mastery experiences and vicarious experiences. These two key affordances for farmers' self efficacy were provided through an innovative agricultural extemsion programme. I feel privileged to have been accepted into this unique farmer learning environment. I hope that the results of this research provide valuable evidence for the future development of agricultural extension designs to promote farmers' efficacy beliefs and learning.

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10. Appendices

Appendix 10.1. Ethics approval

humanethics@massey.ac.nz

to Doug.Drysdale.1, P.Kemp

HoU Review Group

Ethics Notification Number: 4000015030
Title: Farmer self-efficacy and adoption of innovative perennial summer forages.

Thank you for your notification which you have assessed as Low Risk.

Your project has been recorded in our system which is reported in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

If situations subsequently occur which cause you to reconsider your ethical analysis, please log on to http://rims.massey.ac.nz and register the changes in order that they be assessed as safe to proceed.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.
If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Dr Brian Finch, Director (Research Ethics), email humanethics@massey.ac.nz. "

Please note that if a sponsoring organisation, funding authority or a journal in which you wish to publish require evidence of committee approval (with an approval number), you will have to complete the application form again answering yes to the publication question to provide more information to go before one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

You are reminded that staff researchers and supervisors are fully responsible for ensuring that the information in the low risk notification has met the requirements and guidelines for submission of a low risk notification.

If you wish to print an official copy of this letter, please login to the RIMS system, and under the Reporting section, View Reports you will find a link to run the LR Report.

Yours sincerely

Dr Brian Finch
Chair, Human Ethics Chairs' Committee and
Director (Research Ethics

Appendix 10.2. Farmers'demographic information

Research Id.	Farmer Learning Group	Region	Position on Farm	Farming operation	Focus Group or Interview
1	New	Wairarapa	Co-owner/partner	Breeding/Finishing	FGD 3
2	Original	Wairarapa	Owner-operator	Breeding/Intensive finishing	FGD 2
3	Original	Wairarapa	Owner-operator	Breeding/Finishing	Interview
4	Original	Wairarapa	Owner-operator	Breeding/Finishing	Interview
5	New	Wairarapa	Owner-operator	Intensive Finishing	FGD 3
6	New	Manawatū	Manager	Breeding/Finishing	Interview
7	Original	Manawatū	Manager	Intensive Finishing	Interview
8	New	Wairarapa	Manager	Breeding/Finishing	FGD 1
9	Original	Manawatū	Co-owner	Breeding/Finishing	Attended <3 workshops
10	Original	Hawkes Bay	Owner-operator	Breeding/Finishing	FGD 3
11	New	Wairarapa	Owner-operator	Breeding (with a little finishing)	Interview
12	Original	Wairarapa	Co-owner/partner	Breeding/Finishing	FGD 1
13	Original	Wairarapa	Co-owner/partner	Breeding/Finishing	Attended <3 workshops
14	New	Wairarapa	Owner-operator	Breeding (with a little finishing)	Interview
15	New	Wairarapa	Manager	Breeding/Finishing	FGD 2
16	Original	Manawatū	Owner-operator	Breeding/Finishing	Attended <3 workshops
17	Original	Manawatū	Owner-operator	Intensive Finishing	FGD 2
18	Original	Hawkes Bay	Co-owner/partner	Breeding/Finishing	Interview
19	Original	Hawkes Bay	Owner-operator	Breeding/Finishing	FGD 3
20	New	Wairarapa	Owner-operator	Breeding/Finishing	Attended <3 workshops
21	New	Wairarapa	Manager	Breeding/Finishing	Attended <3 workshops
22	New	Hawkes Bay	Co-owner/partner	Breeding/Finishing	FGD 3
23	New	Wairarapa	Manager	Breeding/Finishing	FGD 1
24	Original	Manawatū	Co-owner/partner	Breeding/Finishing	Interview
25	Original	Manawatū	Co-owner/partner	Breeding/Finishing	FGD 3
26	New	Wairarapa	Owner-operator	Breeding/Finishing	Interview
27	Original	Wairarapa	Co-owner/partner	Breeding (with a little finishing)	Interview
28	Original	Wairarapa	Co-owner/partner	Breeding/Intensive finishing	Attended <3 workshops
29	New	Wairarapa	Manager	Intensive Finishing	Interview
30	New	Wairarapa	Owner-operator	Breeding/Finishing	Attended <3 workshops
31	Original	Hawkes Bay	Owner operator	Breeding/Finishing	FGD 3
32	New	Hawkes Bay	Co-owner/partner	Breeding/Finishing	Attended <3 workshops
33	New	Wairarapa	Owner-operator	Breeding/Finishing	Interview
34	New	Hawkes Bay	Owner-operator	Breeding/Finishing	FGD 3
35	Original	Manawatū	Owner-operator	Breeding/Finishing	Attended <3 workshops

Appendix 10.3. Information and invitation to participate in research

MASSEY UNIVERSITY

COLLEGE OF SCIENCES

TE WĀHANGA PŪTAIAO

Farmers' efficacy, learning and practice change in an agricultural extension context

My name is Doug Drysdale and I am undertaking a PhD of an innovative agricultural extension programme on farmers' self-efficacy, learning and practice changes in relation to using perennial summer forages. Self-efficacy refers to one's beliefs about capability to reach certain outcomes. Perennial summer forages include Lucerne, Plantain, Chicory and Red Clover. I would like to invite you to be a participant in my research.
Effective agricultural extension is central to farmers' learning. Considerable literature points to the importance of investigating innovative forms of agricultural extension that will lead to learning and practice change.

For the purpose of my PhD I would like to:

- invite you to fill out the farmer efficacy questionnaire at three points over the next 18 months of this 3-year project. This will take approximately 10 minutes at three workshops. Completion and return of the questionnaire imply consent. You have the right to decline to answer any particular question.
- interview you twice on your farm at a time suitable to you. This will take approximately 1 hour each time.
- observe your interactions as part of the group when you come to workshops. I will have a camera and make some short video recordings of certain interactions.
- use focus group discussion to clarify some observations and to identify potential foci for future workshops. Only 8 randomly selected participants will be required for this 30-minute discussion.
- provide a summary of my findings to all participants at the end of my research.

Your involvement in this project is entirely voluntary. Confidentiality will be respected at all times and you will not be referred to by name in any situation including future conference presentations or publications. You have the right to withdraw from this research at any time during the data collection phase without explanation. You have the right to not answer any questions.

My supervisors are Prof Peter Kemp, Dr Alison Sewell, Dr Maggie Hartnett, Dr Brennon Wood and Dr Dave Gray of Massey University.

If you would like further clarification, please contact me at:

Institute of Agriculture and Environment

Massey University

Private Bag 11 222

Palmerston North 4442

Email: d.drysdale@massey.ac.nz.

You may also contact my chief supervisor:

Prof Peter Kemp

Head of Institute

Institute of Agriculture and Environment

Massey University

Telephone: +64 (06) 356 9099 ext. 84845

Email: P.Kemp@massey.ac.nz

Thank you for considering my request to participate in this research.

Regards

Doug Drysdale

PhD Candidate

Note: This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Dr Brian Finch, Director (Research Ethics), email humanethics@massey.ac.nz.

Appendix 10.4. RFLP Participant consent form - Individual

MASSEY UNIVERSITY

COLLEGE OF SCIENCES

TE WĀHANGA PŪTAIAO

Farmers' efficacy, learning and practice change in an agricultural extension context

PARTICIPANT CONSENT FORM - INDIVIDUAL

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree/do not agree to the interview being sound recorded.

I agree/do not agree to the interview being image recorded.

I wish/do not wish to have my recordings returned to me.

I wish/do not wish to have data placed in an official archive.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature: .... **Date:** ....

Full Name (Printed) ....

Appendix 10.5. Authority for the release of transcripts

MASSEY UNIVERSITY

COLLEGE OF SCIENCES

TE WĀHANGA PŪTAIAO

31.08.2016

Dear «GreetingLine»

Please find enclosed:

1. A copy of the transcript of the Farmer Learning Interview that I conducted with you recently.
2. Two copies of the 'Authority for the Release of Transcripts' form which I need you to complete. (One copy for you and one to be returned to me please.)
3. A stamped addressed envelope in which to place the signed copy of the 'Authority for the Release of Transcripts' form to be returned to me.

The copy of the transcript is yours to keep. If you do have any amendments to the transcript please let me know.

Please remember that:

- Confidentiality will be respected at all times.
- You will not be referred to by name in any situation including future conference presentations or publications.
- You have the right to withdraw from this research at any time without explanation.
- Any personal information will be securely stored separately from the data.

Thank you for making time available and allowing me to interview you for this phase of my data collection.

Regards

Doug Drysdale

(PhD Candidate)

MASSEY UNIVERSITY

COLLEGE OF SCIENCES

TE WĀHANGA PŪTAIAO

Farmers' efficacy, learning and practice change in an agricultural extension context

AUTHORITY FOR THE RELEASE OF TRANSCRIPTS

I confirm that I have had the opportunity to read and amend the transcript of the interview(s) conducted with me.

I agree that the edited transcript and extracts from this may be used in reports and publications arising from the research.

Signature: .... **Date:** ....

Full Name

(Printed) ....

Appendix 10.6. FSEM survey

Farmer Efficacy Questionnaire for Riverside Farmer Learning Project: Workshop 6 (02.03.2017)

Project: Farmers' self-efficacy, learning and practice change in an agricultural extension context.

1. Name:

2. I am confident I can.......

	Not at all				Moderately					Highly certain
select the best species of perennial summer forages for my farm's local climate and soil conditions.	○	○	○	○	○	○	○	○	○	○

3. I am confident I can.......

	Not at all				Moderately					Highly certain
select the best species of perennial summer forages for my animal feed requirements.	○	○	○	○	○	○	○	○	○	○

4. I am confident I can.......

	Not at all				Moderately					Highly certain
manage the costs that may be required to introduce perennial summer forages.	○	○	○	○	○	○	○	○	○	○

5. I am confident I can.......

	Not at all				Moderately					Highly certain
implement strategies that manage the risks associated with changing from my current pasture species to perennial summer forages.	○	○	○	○	○	○	○	○	○	○

1

6. I am confident I can.......

	Not at all				Moderately					Highly certain
find science-based research that identifies the potential risks of introducing perennial summer forages onto my farm.	○	○	○	○	○	○	○	○	○	○

7. I am confident I can.......

	Not at all				Moderately					Highly certain
make an informed judgement about using perennial summer forages from information provided by commercial sources.	○	○	○	○	○	○	○	○	○	○

8. I am confident I can.......

	Not at all				Moderately					Highly certain
give useful advice to neighbouring farmers who want to use perennial summer forages on their farms.	○	○	○	○	○	○	○	○	○	○

9. I am confident I can.......

	Not at all				Moderately					Highly certain
defend my decisions when talking with other farmers about the management of perennial summer forages on my farm.	○	○	○	○	○	○	○	○	○	○

10. I am confident I can.......

	Not at all				Moderately					Highly certain
use perennial summer forages to improve my grazing options during drought events.	○	○	○	○	○	○	○	○	○	○

11. I am confident I can.......

	Not at all				Moderately					Highly certain
introduce perennial summer forages on my farm with minimal outside support.	○	○	○	○	○	○	○	○	○	○

12. I am confident I can.......

	Not at all				Moderately					Highly certain
use perennial summer forages to improve my farm productivity.	○	○	○	○	○	○	○	○	○	○

13. I am confident I can.......

	Not at all				Moderately					Highly certain
identify solutions to control weed problems when using perennial summer forages.	○	○	○	○	○	○	○	○	○	○

14. I am confident I can.......

	Not at all				Moderately					Highly certain
identify solutions to control plant health issues when using perennial summer forages.	○	○	○	○	○	○	○	○	○	○

15. I am confident I can.......

	Not at all				Moderately					Highly certain
persevere if challenging situations arise when using perennial summer forages on my farm.	○	○	○	○	○	○	○	○	○	○

16. I am confident I can.......

	Not at all				Moderately					Highly certain
help other farmers achieve their goal to use perennial summer forages on their farms.	○	○	○	○	○	○	○	○	○	○

17. I am confident I can.......

	Not at all				Moderately					Highly certain
cooperate within a group environment to improve my own knowledge of perennial summer forages.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

18. I am confident I can.......

	Not at all				Moderately					Highly certain
accept the group's suggestions about species of perennial summer forage to use on my farm when they have more expertise than me.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

19. I am confident I can.......

	Not at all				Moderately					Highly certain
work with research scientists to improve the management of perennial summer forages on my farm.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

20. I am confident I can.......

	Not at all				Moderately					Highly certain
express my views on important issues regarding perennial summer forages.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

21. I am confident I can.......

	Not at all				Moderately					Highly certain
increase my personal knowledge of perennial summer forages by talking with other farmers.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Appendix 10.7. FSEM available for analysis at T1, T2 and T3

Farmer participant	Individual FSEM mean		
	November 2015	July 2016	March 2017
1	5.95	6.85	7.95
2	8	7.4	7.55
3	5.15	7.65	7.5
4	7.6	7.6	6.8
5	7.95	6.6	0
6	3.2	6.3	7.8
7	8.45	0	8.05
8	4.7	6.55	0
9	6.8	7.5	6.8
10	7.9	8.85	7.55
11	8.84	7.4	8.7
12	6	6.9	7.55
13	8.15	7.85	0
14	5.4	6.7	8.15
15	6.75	7.1	0
16	6.5	6.3	7.9
17	7.1	7.05	0
18	5.3	6.05	6.5
19	8.5	7.75	8.7
20	7.6	6.3	6.95
21	6.65	8.5	0
22	7.25	7.4	7.85
23	5.45	7.6	6.55
24	8.75	9.15	9.05
25	7.9	7.65	8.2
26	5.85	7.5	6.6
27	7.65	7.45	8.6
28	6.05	6.6	3.8
29	8.3	6.05	6.8
30	6.2	5.95	0
31	8.35	8	7.9
32	5.1	6.45	6.4
33	5.2	6	5.95
34	6.15	6.2	0
35	6.4	7.3	0
36	6.15	0	0
37	0	0	0
38	4.85	0	0
39	4.8	0	0
40	7.1	0	0
41	0	0	0
42	5.95	0	0

43	3.75	0	0

Key	FSEM surveys completed (N=44)	
(green)	3	n=25
(blue)	2	n=10
(yellow)	1	n=6
(white)	0	n=2

Appendix 10.8. Farmer Interview question bank (14.06.2016)

<table>
<tr><td colspan="4">Contextual Information:</td></tr>
<tr><td colspan="2">Region
Hawkes Bay Wairarapa Manawatū</td><td colspan="2">Type of Farm
Breeding, Breeding and Finishing
Intensive finishing</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>Perennial Summer Forages used:</td><td>Approx. area</td><td>Other forages used:</td><td>Approx. area</td></tr>
<tr><td>Chicory</td><td></td><td></td><td></td></tr>
<tr><td>Lucerne</td><td></td><td></td><td></td></tr>
<tr><td>Plantain</td><td></td><td></td><td></td></tr>
<tr><td>Red Clover</td><td></td><td></td><td></td></tr>
<tr><td>Other</td><td>Approx. area</td><td colspan="2" rowspan="3">Length of time forages have been part of the farm system:</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

What are some of the important things you have come away from the Riverside workshops with so far?	
*New **experiences** regarding the management of perennial summer forages.*	
*New **knowledge** regarding the management of perennial summer forages*	
New connections.	
*Networking or conversations with **scientists** linked to the Riverside Project.*	
*Networking or conversations with **farmers** linked to the Riverside Project.*	

Prompt & question to get a better insight into their learning but allow the farmers tell their story.	
Tell me more about…… Why do you think……...? What did you mean by…? Could this have happened…? How do you feel about……? Can you provide an example of that…? What lead you to that…..?	

Within the Domain of Perennial Summer Forages		
Research Question 2*:* ***How does a farmer's self-efficacy for the management of perennial summer forages change over time?***		
Self-efficacy		
a) Enactive Mastery Experiences i. Out of all of those things you have just talked about what are the ones that you have been most successful with.	***Some Prompt phrases to choose from:*** Tell me more about…… Why do you think……...? What did you mean by….? Could this have happened….? How do you feel about…….? Can you provide an example of that…? What lead you to that…...?	
b) Social Modelling, vicarious experiences and Verbal persuasion and feedback i. Can you identify the people at the workshop who have had the most impact on your confidence to use perennial summer forages?	***Some Prompt phrases to choose from:*** Tell me more about the support you have gained from the Riverside Project. What sorts of helpful advice are you getting? Are there any RFLP members that you learn from more than others? How have their comments help you feel confident about using PSF in your farm system?	

ii. Have these observations and opportunities influenced your decision-making? If so in what ways?	Has your confidence for managing perennial summer forages changed? Why do you think you are more confident in your decisions relating to managing perennial summer forages on your farm? What has led you to being more confident in your decisions?	
iii. How confident are you to share your new learning with other at the workshop? Why is that?	How do you feel about sharing your knowledge about perennial summer forages with other farmers and the science team? Can you provide an example of some ideas you have been able to share with others about perennial summer forages? Could this have happened without your participation in the Riverside project? Why?	
c) Safe low-anxiety environment: Has your involvement in the workshops been predominantly positive?	Can you talk about why that is? Why has this been so? Can you give some examples?	

Research Question 3: ***What are the changes in farmer understanding of the management of perennial summer forages?***		
Learning:		
1. What do you know now that you didn't know before about?	Initial pasture establishment. Grazing management for lucerne and plantain. Early weaning of lambs. (60-day weaning) Plant physiology of lucerne and plantain. Weed and pest control in plantain and lucerne. Managing overgrazing situation. Options for improving pasture. Flushing ewes/hoggets' on lucerne prior to tupping	
2. Are there any areas you are still unsure about? If so, what are they?		

4. Research Question: ***How do these changes in self-efficacy and understanding inform farmers' thinking about the management of Perennial Summer Forages?***

Decision Making: *(about understanding the complexity of the farm system?*

1. What is your current thinking about the management of Perennial Summer Forages on your farm?
2. What is your thinking now about the role perennial summer forages might play in your farm system? Can you explain why you think this?

Appendix 10.9. Focus group discussion starters

Welcome to this focus group discussion. Thank you for agreeing to be involved. 30 min max!!

Let's start by going around the group to introduce ourselves, say where you farm and a couple of sentences about your farm?

Today you have been involved in some diverse learning experiences to do with managing perennial summer forages. Some of these may have got you thinking about your current pasture or animal management strategies.

What learning experiences today really challenged your thinking about perennial summer forage pasture?

Allow farmers to 'tell their stories' while also probing for clarification and extending.

1. *I am interested in **changes** in your thinking, how it was **validated** or how you realised you had **misconceptions** about managing perennial summer forages.*
   (Prompt for contributions if necessary)

So what new ideas are you going away with today?

2. *How do you plan to use your learning from today's workshop activities back on your farm?*

(Prompt for contributions if necessary)

(How do you go about this:
- by talking to others
- doing a trial on the farm, or
- some other way?

3. *Have any of today's activities got you thinking – "I must find out more about that?"*
   a. Can you tell me a bit more about what you are thinking about and how you might do this?

(Prompt for contributions if necessary)

Thank you for participating in this group discussion. There has been good discussion and I appreciate your contribution.

Thank you for your time and contributions this afternoon. Travel safely. Thank you

Appendix 10.10. Transcriber's confidentiality agreement

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
TE WĀHANGA PŪTAIAO

Farmers' efficacy, learning and practice change in an agricultural extension context

CONFIDENTIALITY AGREEMENT

I .... (Full Name - printed) agree to keep confidential all information concerning the project
....
....
....
.... (Title of Project).

I will not retain or copy any information involving the project.

Signature: .... **Date:** ....

Appendix 10.11. Riverside Farmer Learning Project FSEM Base data

Research ID	Farmer Learning Group	Region	Focus Group or Interview		Individual FSEM mean		
					Nov-15	Jul-16	Mar-17
1	New	Wairarapa	FGD 3		5.55	6.41	7.32
2	Original	Manawatū	FGD 2		7.41	6.86	7.05
3	Original	Wairarapa	Interview		5.15	7.65	7.50
4	Original	Wairarapa	Interview		7.60	7.60	6.80
5	New	Wairarapa	FGD 3		7.36	6.14	6.91
6	New	Manawatū	Interview		3.20	6.30	7.80
7	Original	Manawatū	Interview		7.82	6.68	7.50
8	New	Wairarapa	FGD 1		4.41	6.14	6.82
9	Original	Manawatū	Attended workshops	<3	6.36	7.05	6.45
10	Original	Hawkes Bay	FGD 3		7.32	8.18	7.05
11	New	Wairarapa	Interview		8.84	7.40	8.70
12	Original	Manawatū	FGD 1		5.59	6.45	6.95
13	Original	Wairarapa	Attended workshops	<3	7.55	7.27	6.91
14	New	Wairarapa	Interview		5.05	6.27	7.50
15	New	Wairarapa	FGD 2		6.32	6.68	7.00
16	Original	Manawatū	Attended workshops	<3	6.05	5.86	7.27
17	Original	Manawatū	FGD 2		6.64	6.64	6.50
18	Original	Hawkes Bay	Interview		5.30	6.05	6.50
19	Original	Hawkes Bay	FGD 3		7.86	7.32	8.23
20	New	Wairarapa	Attended workshops	<3	7.60	6.30	6.95
21	New	Wairarapa	Attended workshops	<3	6.23	7.95	7.00
22	New	Hawkes Bay	FGD 3		6.77	6.95	7.41
23	New	Wairarapa	FGD 1		5.09	7.09	6.05
24	Original	Manawatū	Interview		8.75	9.15	9.05
25	Original	Manawatū	FGD 3		7.32	7.09	7.64
26	New	Wairarapa	Interview		5.85	7.50	6.60
27	Original	Wairarapa	Interview		7.65	7.45	8.60
28	Original	Wairarapa	Attended workshops	<3	5.64	6.14	3.55
29	New	Wairarapa	Interview		8.30	6.05	6.80
30	New	Wairarapa	Attended workshops	<3	5.77	5.55	6.86
31	Original	Hawkes Bay	FGD 3		7.73	7.41	7.36
32	New	Hawkes Bay	Attended workshops	<3	4.77	6.05	5.91
33	New	Wairarapa	Interview		4.86	5.64	5.95
34	New	Hawkes Bay	FGD 3		5.73	5.77	6.82
35	Original	Manawatū	Attended workshops	<3	5.95	6.77	6.82

Appendix 10.12. Riverside Farmer Learning Project descriptive statistics

Case Processing Summary

	Cases					
	Valid		**Missing**		**Total**	
	N	**Percent**	**N**	**Percent**	**N**	**Percent**
November 2015	35	100%	0	0%	35	100%
July 2016	35	100%	0	0%	35	100%
March 2016	35	100%	0	0%	35	100%

Descriptives

FSEM mean score		**Statistic**	**Std. Error**
November 2015	Mean	6.4397	0.22370
	Std. Deviation	1.32341	
	Minimum	3.20	
	Maximum	8.84	
	Range	5.64	
	Interquartile Range	2.05	
	Skewness	-0.175	0.398
	Kurtosis	-0.434	0.778
July 2016	Mean	6.7946	0.13429
	Std. Deviation	0.79449	
	Minimum	5.55	
	Maximum	9.15	
	Range	3.60	
	Interquartile Range	1.26	
	Skewness	0.740	0.398
	Kurtosis	0.751	0.778
March 2017	Mean	7.0323	0.15793
	Std. Deviation	0.93435	
	Minimum	3.55	
	Maximum	9.05	
	Range	5.50	
	Interquartile Range	0.70	
	Skewness	-1.031	0.398
	Kurtosis	5.204	0.778

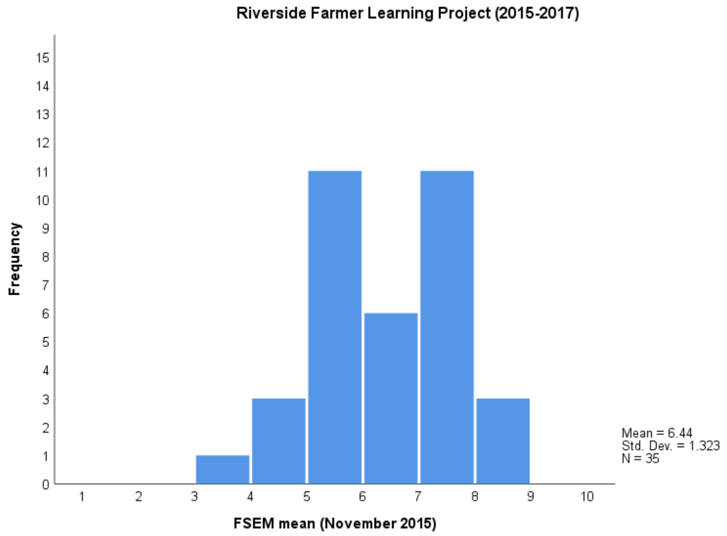
Tests of Normality

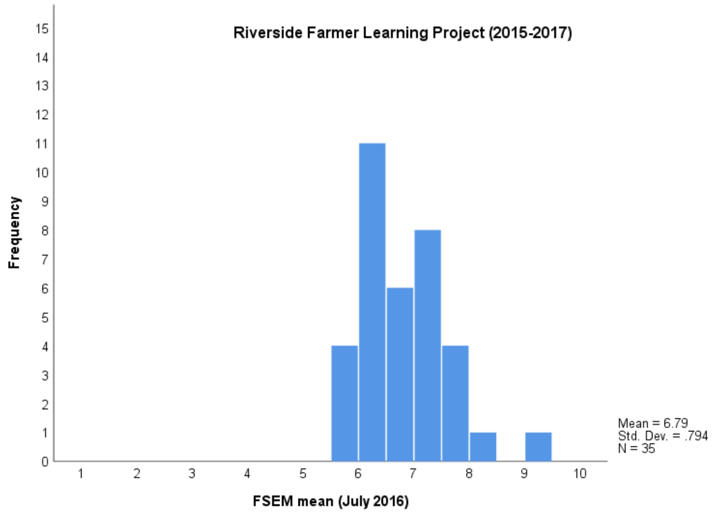
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
November 2015	0.147	35	0.053	0.971	35	0.475
July 2016	0.105	35	.200*	0.956	35	0.174
March 2017	0.173	35	0.009	0.879	35	0.001

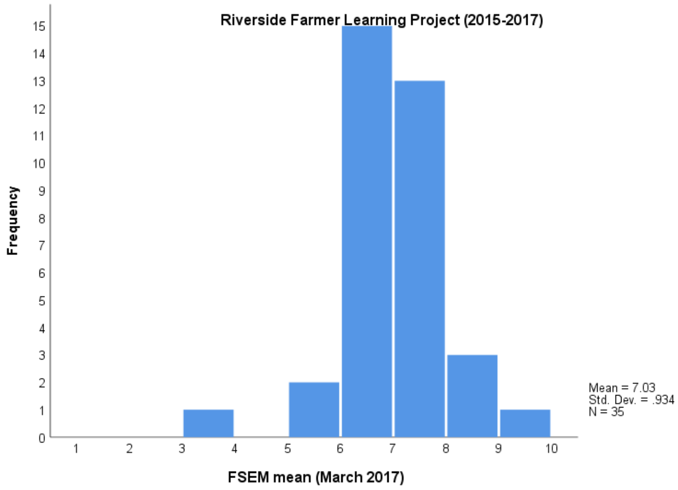
*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Appendix 10.13. Distribution graphs







Descriptive statistics for 'new' and 'original' group FSEM analysis

Case Processing Summary

	Farmer Learning Group	Cases Valid N	Valid Percent	Missing N	Missing Percent	Total N	Total Percent
November 2015	New	17	100%	0	0%	17	100%
	Original	18	100%	0	0%	18	100%
July 2016	New	17	100%	0	0%	17	100%
	Original	18	100%	0	0%	18	100%
March 2017	New	17	100%	0	0%	17	100%
	Original	18	100%	0	0%	18	100%

Descriptives

	Farmer Learning Group		Statistic	Std. Error
November 2015	New	Mean	5.9824	0.35236
		Std. Deviation	1.45280	
		Minimum	3.20	
		Maximum	8.84	
		Range	5.64	
		Interquartile Range	2.11	
		Skewness	0.299	0.550
		Kurtosis	-0.026	1.063
	Original	Mean	6.8717	0.24828
		Std. Deviation	1.05338	
		Minimum	5.15	
		Maximum	8.75	
		Range	3.60	
		Interquartile Range	1.80	
		Skewness	-0.219	0.536
		Kurtosis	-1.099	1.038
July 2016	New	Mean	6.4818	0.16572
		Std. Deviation	0.68328	
		Minimum	5.55	
		Maximum	7.95	
		Range	2.40	
		Interquartile Range	0.97	
		Skewness	0.733	0.550
		Kurtosis	-0.217	1.063
	Original	Mean	7.0900	0.18749
		Std. Deviation	0.79546	
		Minimum	5.86	
		Maximum	9.15	
		Range	3.29	
		Interquartile Range	0.90	
		Skewness	0.806	0.536
		Kurtosis	1.442	1.038
March 2017	New	Mean	6.9647	0.16625
		Std. Deviation	0.68545	
		Minimum	5.91	
		Maximum	8.70	
		Range	2.79	
		Interquartile Range	0.67	
		Skewness	0.671	0.550
		Kurtosis	1.586	1.063
	Original	Mean	7.0961	0.26822
		Std. Deviation	1.13796	
		Minimum	3.55	
		Maximum	9.05	
		Range	5.50	
		Interquartile Range	0.81	
		Skewness	-1.469	0.536
		Kurtosis	5.388	1.038

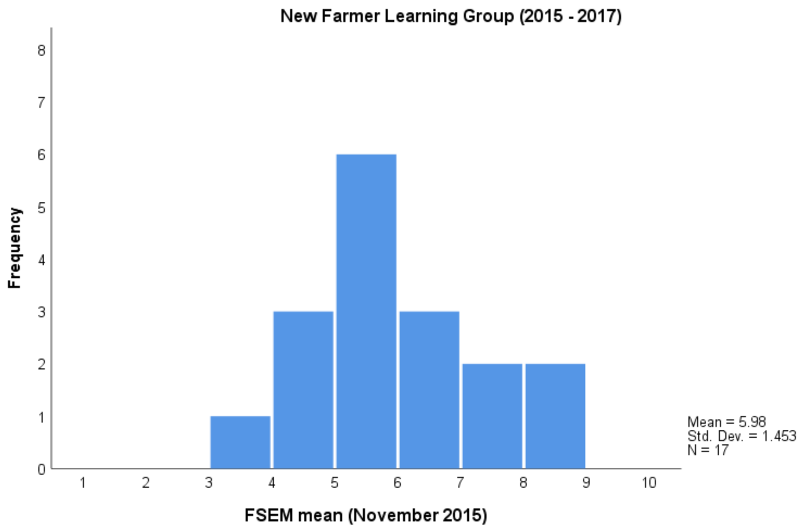
Tests of Normality

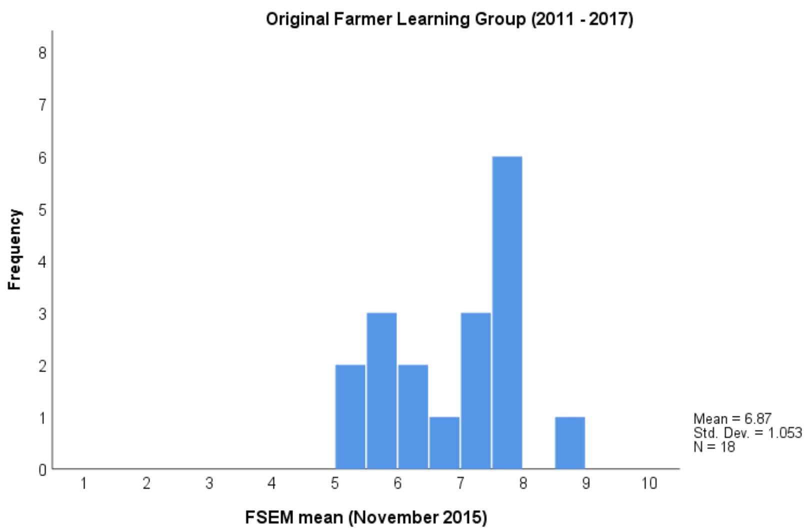
Group Numeric		Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
November 2015	New	0.125	17	.200*	0.977	17	0.920
	Original	0.220	18	0.021	0.925	18	0.160
July 2016	New	0.193	17	0.092	0.932	17	0.239
	Original	0.130	18	.200*	0.953	18	0.475
March 2017	New	0.185	17	0.124	0.924	17	0.175
	Original	0.230	18	0.013	0.842	18	0.006

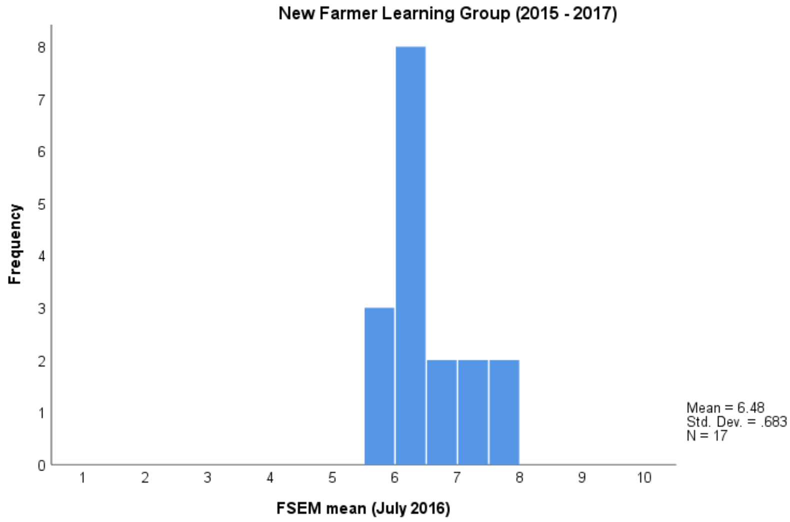
*. This is a lower bound of the true significance.

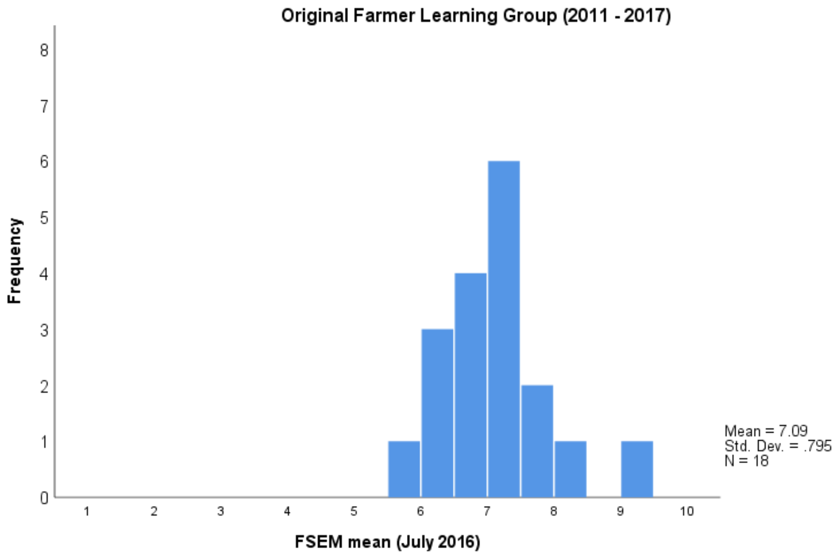
a. Lilliefors Significance Correction

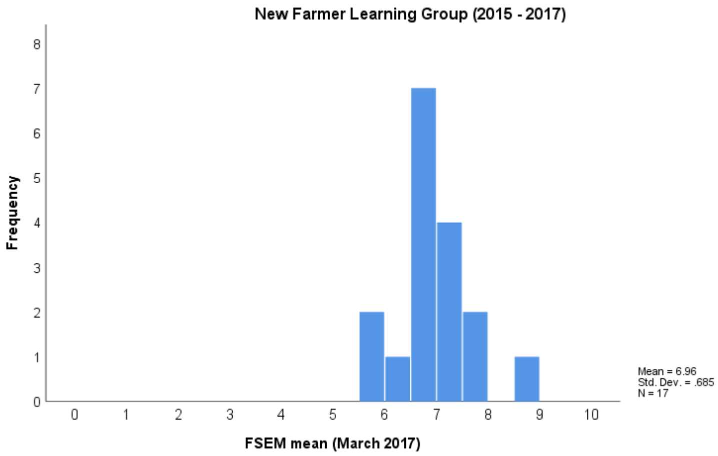
Distribution graphs

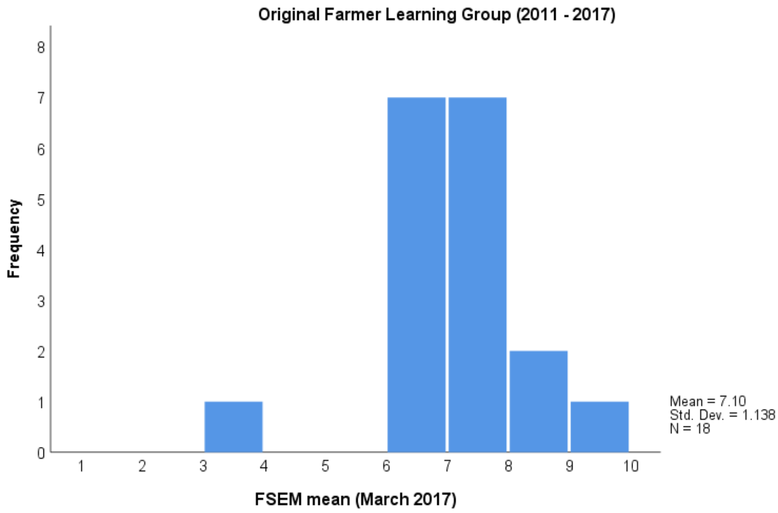





New Farmer Learning Group (2015 - 2017)
Frequency
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
FSEM mean (July 2016)
Mean = 6.48
Std. Dev. = .683
N = 17


Original Farmer Learning Group (2011 - 2017)
Frequency
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
FSEM mean (July 2016)
Mean = 7.09
Std. Dev. = .795
N = 18


New Farmer Learning Group (2015 - 2017)
Frequency
FSEM mean (March 2017)
Mean = 6.96
Std. Dev. = .685
N = 17

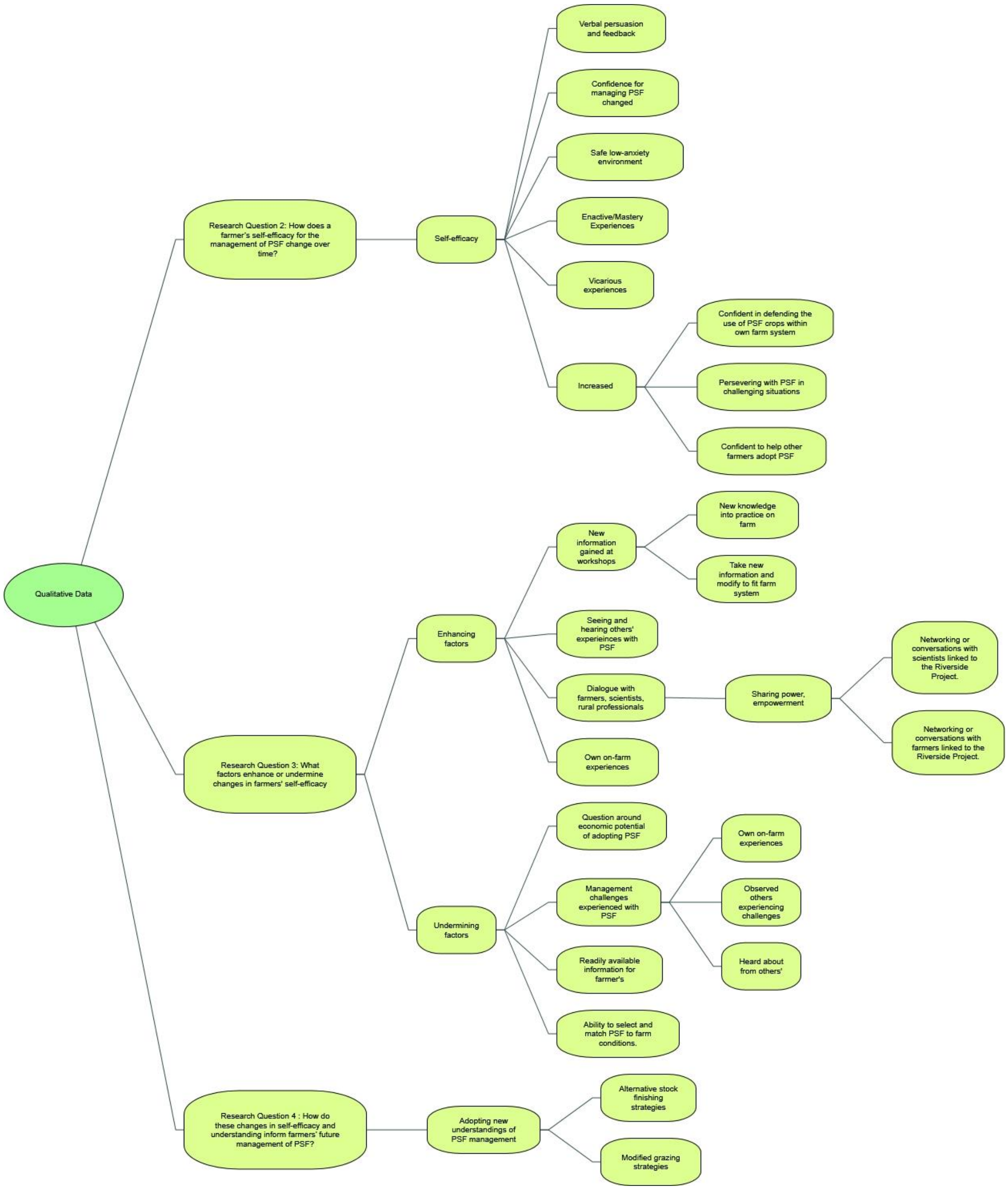

Original Farmer Learning Group (2011 - 2017)
Frequency
FSEM mean (March 2017)
Mean = 7.10
Std. Dev. = 1.138
N = 18

Appendix 10.14. FSEM surveys available for analysis at T1, T2 and T3

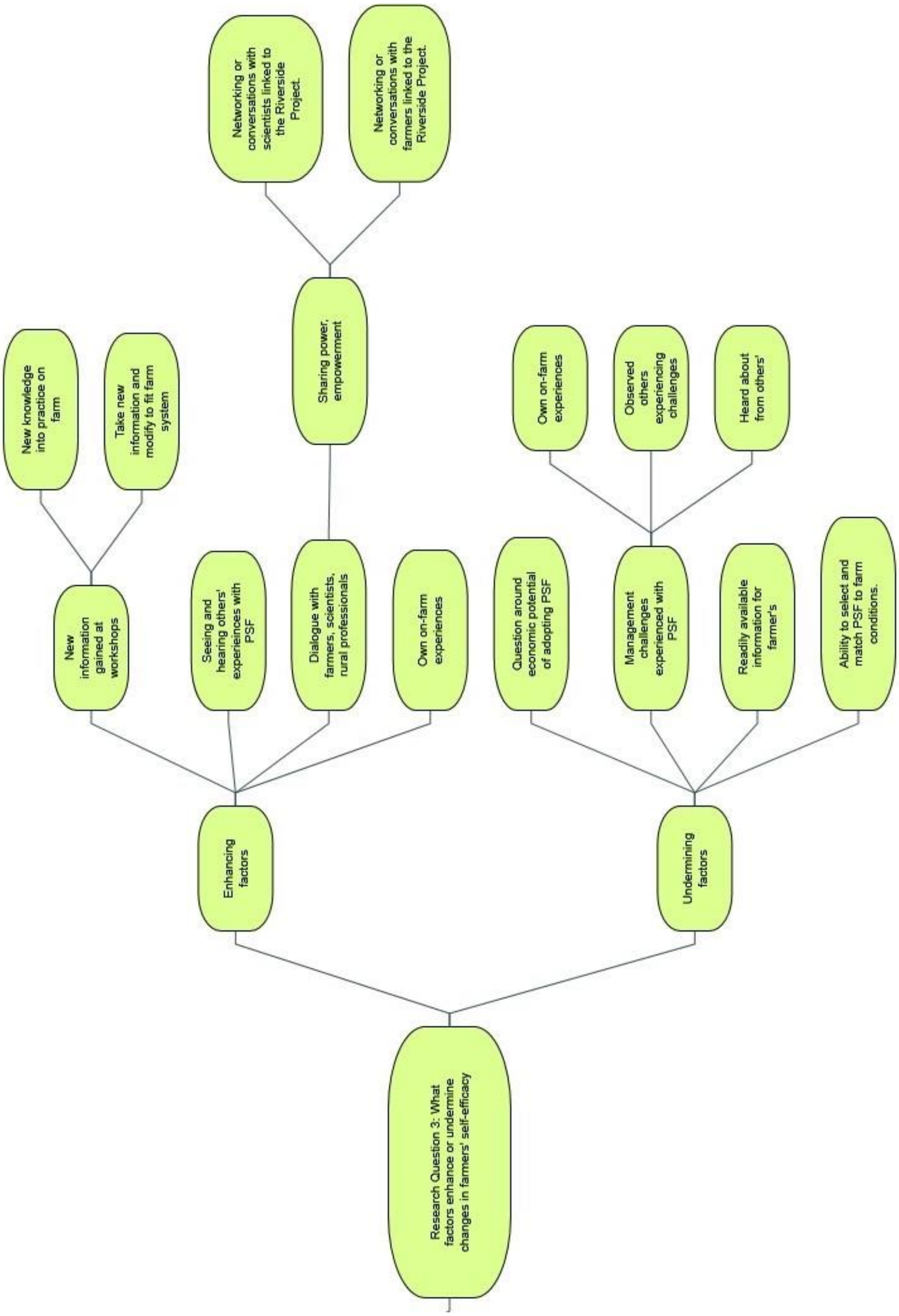
Farmer	FSEM	Qualitative results (Semi-structured interview and focus group discussion)						RFLP Workshop attendance
1	√							4 (Missed (FGD3)
2	√							7 (FGD 2)
3	√	x	x	x				5
4	√	x	x	x	x			5
5	√							1 (Missed FGD 3)
6	√	x	x	x				7
7	√	x	x	x				3 (FGD 2)
8	√	x						2
9	√							1 (FGD 1)
10	√	x						8 (FGD 3)
11	√	x	x	x				7 (FGD 2)
12	√							9 (FGD 1)
13	√							2
14	√	x	x	x	x	x	x	8 (FGD 1)
15	√	x						3 (FGD 1)
16	√							3
17	√	x	x	x				1 (FGD 2)
18	√	x	x					5
19	√							4
20	√							4
21	√							1
22	√	x						8 (FGD 3)
23	√	x						4(FGD 1)
24	√	x						6 (Joined all FGD's)
25	√							6 (Missed FGD 3)
26	√	x	x	x	x	x		9
27	√	x	x	x				2
28	√							2
29	√	x	x	x				7
30	√							2
31	√	x						4 (FGD 3)
32	√							1
33	√	x	x	x	x			8 (FGD 1)
34	√							7 (Missed FGD 3)
35	√							1

Key		Number of famers who contributed
(green)	Semi-structured interview	N=12
(yellow)	Focus group discussion	N=14
	Attended 4 or less RFLP workshops	N=10
FGD	Focus group discussion activity	3

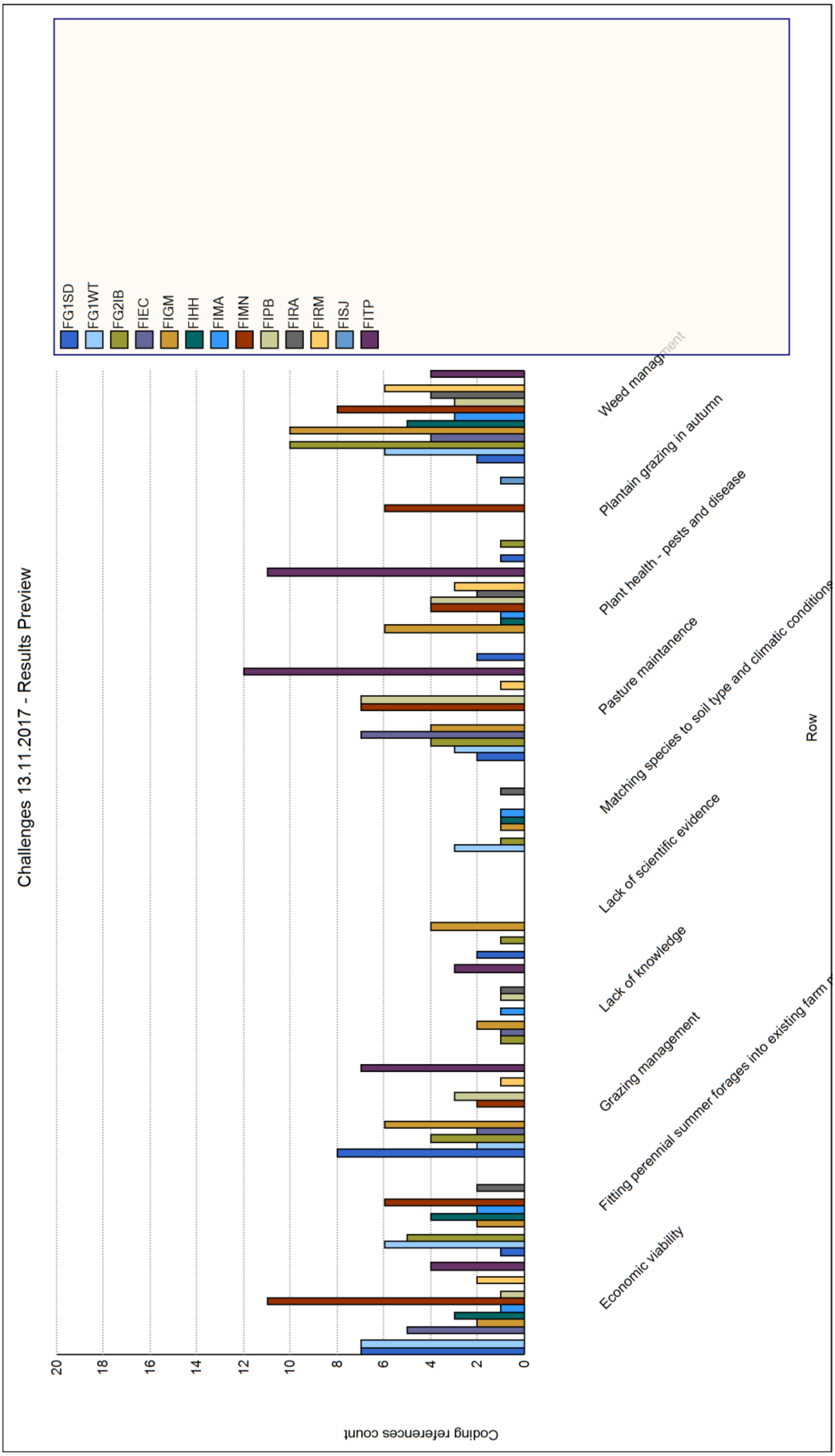
Appendix 10.15. An example of coding themes from NVivo



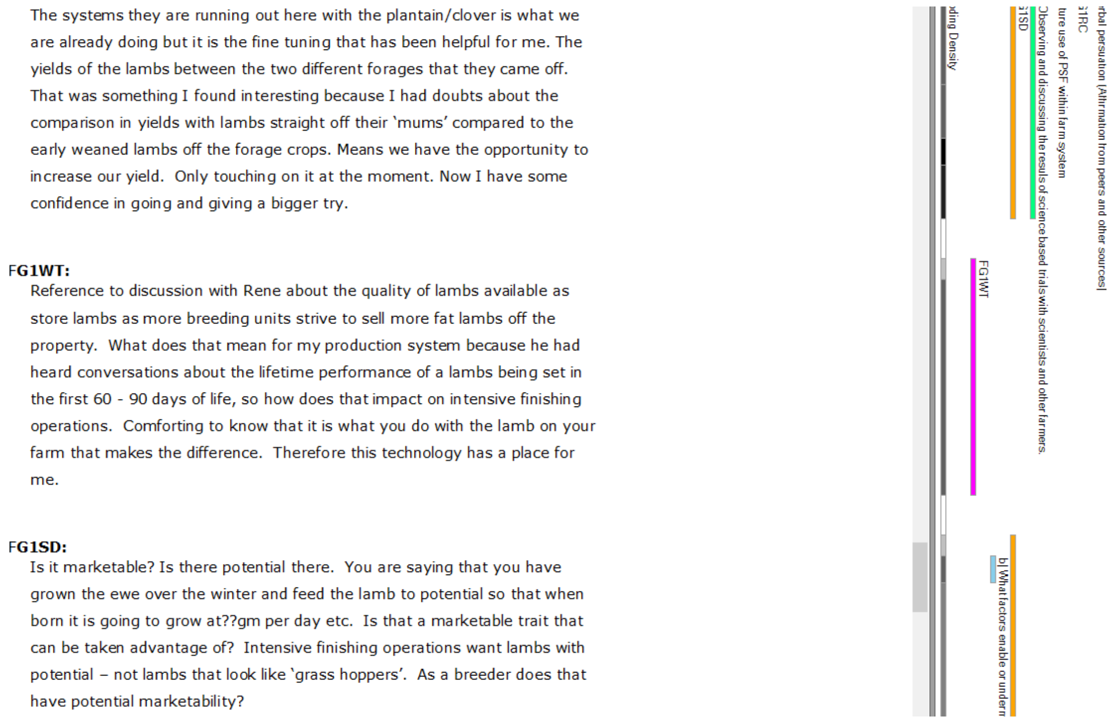
Appendix 10.16. Factors enhancing or undermining change in farmers' self-efficacy (NVivo map)



Appendix 10.17. Sample nodes arising from NVivo coding



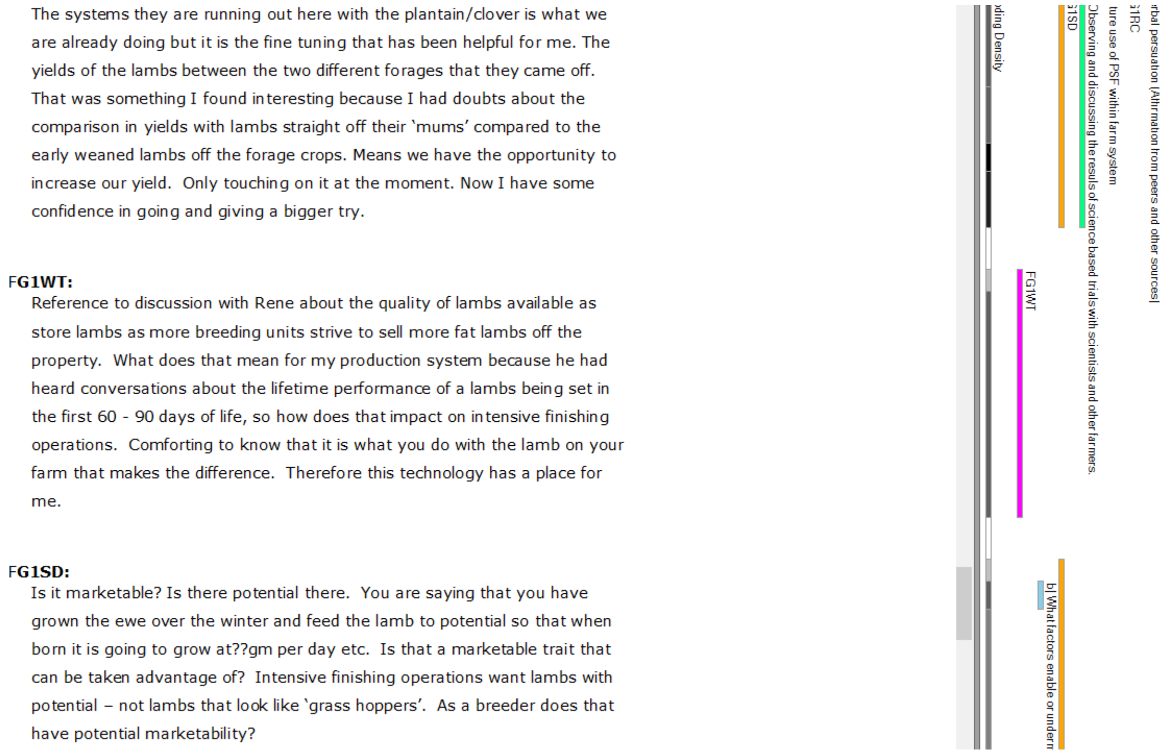
Appendix 10.18. A visual impression taken from NVivo coding book



The systems they are running out here with the plantain/clover is what we are already doing but it is the fine tuning that has been helpful for me. The yields of the lambs between the two different forages that they came off. That was something I found interesting because I had doubts about the comparison in yields with lambs straight off their 'mums' compared to the early weaned lambs off the forage crops. Means we have the opportunity to increase our yield. Only touching on it at the moment. Now I have some confidence in going and giving a bigger try.

FG1WT:
Reference to discussion with Rene about the quality of lambs available as store lambs as more breeding units strive to sell more fat lambs off the property. What does that mean for my production system because he had heard conversations about the lifetime performance of a lambs being set in the first 60 - 90 days of life, so how does that impact on intensive finishing operations. Comforting to know that it is what you do with the lamb on your farm that makes the difference. Therefore this technology has a place for me.

FG1SD:
Is it marketable? Is there potential there. You are saying that you have grown the ewe over the winter and feed the lamb to potential so that when born it is going to grow at??gm per day etc. Is that a marketable trait that can be taken advantage of? Intensive finishing operations want lambs with potential – not lambs that look like 'grass hoppers'. As a breeder does that have potential marketability?



The systems they are running out here with the plantain/clover is what we are already doing but it is the fine tuning that has been helpful for me. The yields of the lambs between the two different forages that they came off. That was something I found interesting because I had doubts about the comparison in yields with lambs straight off their 'mums' compared to the early weaned lambs off the forage crops. Means we have the opportunity to increase our yield. Only touching on it at the moment. Now I have some confidence in going and giving a bigger try.

FG1WT:
Reference to discussion with Rene about the quality of lambs available as store lambs as more breeding units strive to sell more fat lambs off the property. What does that mean for my production system because he had heard conversations about the lifetime performance of a lambs being set in the first 60 - 90 days of life, so how does that impact on intensive finishing operations. Comforting to know that it is what you do with the lamb on your farm that makes the difference. Therefore this technology has a place for me.

FG1SD:
Is it marketable? Is there potential there. You are saying that you have grown the ewe over the winter and feed the lamb to potential so that when born it is going to grow at??gm per day etc. Is that a marketable trait that can be taken advantage of? Intensive finishing operations want lambs with potential – not lambs that look like 'grass hoppers'. As a breeder does that have potential marketability?

Appendix 10.19. Overview of data generation and collection sources.

Method	Data Type	Details of procedure	Rationale
Farmer Self-Efficacy measurement survey	QUAN	To be completed at three points in time during the Riverside Farmer Learning Project. (3 survey points (Workshops 1, 4 & 7)	To measure any change in farmer Self-Efficacy during the 15 months of this research that might be a result of involvement in this agricultural extension context.
Field observations (supplementary data collection)	QUAN & QUAL	Observations of workshops and field activities took place at all 8 Riverside Farmer Learning Project workshops.	To learn about the 'farmers' world' and get to a level enabling me to enter meaningful discussion. To learn about the farmers and how they interact, share knowledge, gather knowledge with their peers and the scientists. To collect qualitative & quantitative data (Inter/Intra) over the 18 months to compare, support and merge with other data bases.
Farmer Interviews	QUAL	2 formal semi-structured interviews with 12 farmer participants preferably at least 12 months apart. (12 farmers x 2 on farm interviews)	To gain an understanding of individual perceptions of any relationship between farmer learning, self-efficacy and management of perennial summer forages because of participating in an agricultural extension context.
Focus group Informal discussion with scientists/researchers	QUAL	Focus group sessions will be held after all Riverside Farmer Learning Project Workshops.	To gain further insights of issues farmers face on farm, adoption and adaptation of learning gained through participation in the Riverside Farmer Learning project
	QUAL	Conversations with scientists throughout the research period.	To learn about perennial summer forages, farmer learning and agricultural extension.
Photographs	QUAN & QUAL	Photographs of farmers and scientists taking part in the workshop activities and farm walks. (farmer/farmer, farmer/scientist, farmer (original group)/farmer (new group).	To provide a record of events. Use for data analysis (participant involvement, behaviours, trends) Recall of prior events, topics, themes, situations and conditions.
Workshop hand-outs		Documents that inform farmers in more detail about relevant 'farmer learning; themes discussed or introduced as part of the workshop programme	To provide background information for my understanding of the management of perennial summer forages. May also provide a useful source of data for consideration as an example of supporting farmer learning.
Planning and Reflection meetings	QUAL		To develop deeper understanding of the Farmer Learning concept and its place as an innovative form of agricultural extension. Make links to farmers' needs and scientist's responses to these.
Anecdotal Field notes	QUAL & QUAN	Written throughout research period. Especially during data generation stages	To capture thoughts, ideas and interesting bits and pieces that 'might be useful' at a later stage. Provides a record of my journey.