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Measuring farmers' self-efficacy for managing perennial summer forages

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Abstract. Farmers' self-efficacy beliefs impact on their learning and decision-making processes, and as such provide vital information to agricultural extension providers. Self-efficacy is measured as an individual's perception of what they 'can do', rather than what they 'actually do', providing an indication of their present efficacy to carry out a specific future task. This paper reports on the design, development and pilot study of a tool to provide quantitative measures of farmers' self-efficacy when considering the introduction or management for perennial summer forages. Preliminary results indicate that this tool provides a robust means of measuring changes in self-efficacy beliefs within this specific domain of managing perennial summer forages. Understanding farmers' efficacy beliefs may guide the design of more effective agricultural extension activities to better assist farmers in their learning and decision-making when adopting innovative agricultural practices.

Keywords: measuring self-efficacy, farmer learning, practice change

Introduction

The purpose of this research was to design and test a tool capable of measuring farmers' self-efficacy specific to the management of perennial summer forages (chicory, lucerne, plantain and red clover). While many researchers discuss possible links between self-efficacy and adoption of new technologies, measurements of actual change in farmers' self-efficacy within a specific context is not well understood (Sewell et al. 2014a; Wilson, Rhodes & Dodunski 2015; Niles, Brown & Dynes 2016; Sewell et al. 2017).

Slow adoption of innovative technologies is a concern expressed by central government policy makers, technology developers and agricultural extension activity designers within the agricultural sector. Developing a deeper understanding of the part self-efficacy and learning play in farmers' decision-making processes may inform future agricultural extension activities according to Wilson, Rhodes and Dodunski (2015). Measuring and understanding self-efficacy beliefs may also assist farmers and agricultural extension agents to make individual decisions and to benefit the national economy (Lown 2011).

The influence of psychological constructs, such as self-efficacy, on farmers' decision-making processes is gaining interest in New Zealand from designers and presenters of agricultural extension (Sewell et al. 2014b; Turner, Payne & Rijswijk 2014; Wilson, Rhodes & Dodunski 2015; Niles, Brown & Dynes 2016). The influence of external variables and internal beliefs on an individual's behaviour has been discussed and debated by psychologists for decades (Beal, Rogers & Bohlen 1957; Rotter 1966; Bandura 1977a; Vygotsky 1978; Prochaska & Di Clemente 1982; Ajzen 1991; Rogers 2003). While psychological theories are valued for their ability to provide explanations and predictions of behaviour, they also provide an operational power to effect change (Bandura 2006). Bandura (2006, p. 319) argues:

> That knowing how to build a sense of efficacy, and how it works, will provide further guidelines for structuring experiences enabling people to realise desired personal and social changes.

Defined as one's belief in their ability to achieve success or not at a given future task, self-efficacy is related to self-confidence, motivation and optimism (Bandura 1977b). Bandura (1997) argued that it is this self-belief that provides an individual with the ability to navigate future challenges. For example, a farmer may possess a high level of self-efficacy in managing traditional ryegrass/clover mix pasture, yet have a low level of self-efficacy related to the introduction or management of perennial summer forages. Developing the Farmers' Self-Efficacy Measurement Tool (FSEMT) may allow both the farmer and agricultural extension providers to identify links between self-efficacy and the adoption or adaptation of innovative agricultural technologies.

Review of literature and theoretical framework

People tend to avoid tasks they believe exceed their capabilities; however, they are prepared to undertake and perform activities they judge themselves capable of managing (Bandura 1977b). Self-efficacy determines how much effort the individual is prepared to expend and their level of persistence when faced with obstacles and negative experiences. The stronger the perceived self-efficacy, the more vigorous and persistent their efforts will be according to Brown and Inouye (1978). The FSEMT may provide a robust means of measuring changes in farmers' self-efficacy within the domain of managing perennial summer forages over time.

According to Bandura (1977b) behavioural change occurs when there is an incentive to act such as a perceived threat for continuing a current behaviour, or a beneficial outcome from implementing a new behaviour. Research shows that self-efficacy influences a number of employment related behaviours including goal aspirations, commitment to tasks and performance (Gist 1987). Success or failure at a task therefore relates to an individual's sense of self-efficacy. An individual's self-efficacy beliefs are based on four sources of information (Bandura 1977b; Bandura 2004) as shown in Table 1.

Table 5: Sources of information an individual may use when gauging their perceived level of self-efficacy

Sources of Self-Efficacy information	Description
Mastery experiences	The impact of previous experiences and outcomes of successes or failures when adopting new behaviours.
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 they experience strong negative arousal situations.

A stimulus such as the realisation that change is required, a negative experience, visual on-farm evidence, unease about a current situation, media releases, climatic events or simply thinking that there must be a better way to do a task usually initiates change within existing on-farm systems. Agricultural extension programmes designed to provide tailored learning activities for farmers may be the stimulus to enhance farmers' self-efficacy and therefore, their future actions. Farmers with low levels of self-efficacy within the domain of managing perennial summer forages are more likely to require extra support to achieve successful adoption and management of these pastures (Telch et al. 1982). However, more efficacious farmers are more likely to succeed in these endeavours, even going on to develop management strategies for other new pasture species. Innovative models of agricultural extension need to arouse interest through experiences that replicate reality, enabling farmers to observe and try new things that appeal to their interest (Wilson, Rhodes & Dodunski 2015).

Wilson, Rhodes and Dodunski (2015) suggest looking beyond agriculture and towards the health sector for some insight into models of decision making and changed behaviour to inform future extension practice. A review of health related studies (Strecher et al. 1986; Rosenstock, Strecher & Becker 1988) identified self-efficacy as a consistent predictor of short and long-term practice change. Self-efficacy appears to be an important component leading to successful long-term behavioural change or the adoption of complex actions according to Strecher et al. (1986) and a predictor of health behaviour change and maintenance (Rosenstock, Strecher & Becker 1988). Strecher et al. (1986) investigated whether self-efficacy could be modified and enhanced to facilitate change in weight control, contraception, alcohol abuse and exercise behaviours within the 'Health Belief Model'. Strecher et al. (1986) identified a consistently positive relationship between self-efficacy and health behaviour change and maintenance. Strecher et al. (1986) developed a programme to identify specific manageable and achievable component skills required to achieve the overall target behaviour. Tasks provided in a sequential manner provided a relative measure of progress towards the given target as well as being attributed to the individual's previous successes (Bandura 1977b; Strecher et al. 1986; Bandura 2004). Using the experiences gained from the health sector may provide guidance for measuring farmers' self-efficacy within the dryland agricultural sector.

Features of the 'Health Belief Model' Strecher et al. (1986) that explore the link between self-efficacy and behaviour change align with the challenges faced by those working in agriculture. Wilson, Rhodes and Dodunski (2015) argue that changing farmers' behaviour towards innovative technologies requires new approaches to agricultural extension. Understanding the whole-farm system as well as all the factors associated with successful implementation of the process is required (Wilson, Rhodes & Dodunski 2015). These authors discuss a process of knowledge sharing with each person bringing their own expertise to consider innovative management practices. They argue that efficacy beliefs may be an important variable in a farmer's decision to adopt new strategies. To be able to test their hypothesis it was necessary to develop a tool capable of measuring changes in farmer self-efficacy.

Research purpose and rationale

Researchers, agricultural extension providers and agricultural technology developers have observed and discussed how farmers go about their learning, make decisions to adopt innovative technologies or other farm management system changes in a wide range of contexts (Yule & Wood 2014; Graymore, Schwarz & Brownell 2015). There was no research that explored the relationship between farmers' self-efficacy and their learning within the domain of managing perennial summer forages, or related pastoral agricultural contexts. A rare example of research on self-efficacy of farmers was by Roy (2009), who developed a questionnaire to assess the self-efficacy of jute and paddy farmers in India. Measuring change in a farmer's self-efficacy is essential when determining its role to determine their capability and capacity to adopt and manage new technologies. As no such agricultural domain specific measurement tool existed, the FSEMT was developed for this research. Two crucial components of this research were firstly design a tool to measure farmers' self-efficacy specific to their learning and management of perennial summer forages in a New Zealand dryland sheep and beef farming environment and secondly conduct initial testing of the FSEMT within a pilot study scenario.

FSEMT design

The design of the FSEMT was guided by Bandura (2006) who stated that: 'there is no all-purpose measure of perceived self-efficacy' (p. 307). Self-efficacy measurement tools need to be domain specific and relate to an individual's 'present perceived efficacy' to carry out a certain type of future function (Bandura 2006). Bandura (2006) provided guidelines to develop tools that assess self-efficacy within specific domains. The FSEMT was designed to measure how farmers perceive their efficacy to organise and execute future courses of action in relation to the adoption and management of perennial summer forages into their farm system.

Sewell et al. (2017) identify a number of variables as key determinants governing or impeding farmers' decision making when challenged to modify an aspect of their current farm system such as how they learn about new technologies (farmer learning), how they share their 'new' knowledge (sharing knowledge), how they make decisions (decision making) and how they go about adopting or adapting practice changes (practice change). Bandura (2006) argued that if there were no challenges to overcome, or the activity was too easily achievable, everyone would score as highly efficacious. Therefore, the developed statements were designed to challenge the farmers' knowledge and efficacy in managing perennial summer forages more efficiently within their farm system. Statements were generated after consulting the types of questions and statements used in a range of existing validated data collection tools used in the agriculture, education, health, business and sports management sectors (see Table 2). An initial collection of 50 statements were considered sufficient to measure the relationship between farmers' self-efficacy, knowledge and decision making relating to their management of perennial summer forages within their farm system. These statements were carefully considered, grouped, regrouped, reworded and categorised using an iterative process involving a panel of experts until 26 were selected for inclusion in the pilot study.

All statements were designed to reflect farmers' perceived capability to complete relevant tasks or challenges specific to the context of managing perennial summer forages as suggested by Bandura (2006). Therefore, statements were phrased in terms of 'I am confident I can ….' Statements varied in terms of task difficulty (for example pasture establishment and renewal, managing weeds and plant health and grazing strategies) and were distributed randomly to minimise any clustering of responses. According to Bandura's (2006) guidelines, a 0–100 interval is more sensitive and more reliable than a narrower scale. A number of researchers including Pajares (1996), Usher and Pajares (2009) and Betz (2013) discussed the merits of a range of different measurement intervals and tested the reliability of a range of Likert scales and concluded smaller scales also provide reliable data.

Given the arguments for a range of measurement intervals, a unipolar interval scale was used where the score for each statement could range between 0 – 10 (0 = not at all, 5 = moderately and 10 = highly certain) as endorsed by Bandura (1997). It was considered important by the development group that the FSEMT be completed with ease and within a reasonable timeframe, by a cohort of busy New Zealand dryland sheep and beef farmers. A further review of the FSEMT, involving a panel of five experts from Massey University's Institute of Agriculture and Environment and Institute of Education, analysed the relevance of the statements to the research focus measuring farmers' self-efficacy within the context of their learning and managing perennial summer forages within the farm system. For example, were the statements going to provide data relevant to the research focus, were they relevant to the farmer participants and was there any unnecessary duplication within the range of statements?

Table 6. Pre-existing Self-Efficacy Surveys

Measurement tool context	Research
Agricultural context	Incorporating psychological variables in models of farmer behaviour: Does it make for better predictions? (Edwards-Jones et al. 1998)
	Edinburgh farming objectives scale. (Willock et al. 1999)
	The role of attitudes and objectives in farmer decision-making: Business and environmentally-oriented behaviour in Scotland (Willock 1999)
	Self-efficacy of agricultural farmers: A case study (Roy 2009)
	Informing extension pilot project design - Final Report (Turner, Payne & Rijswijk 2014)
	Development of quick tool for farmer segmentation: Practical uses for extension work. (Graymore, Schwarz & Brownell 2015)
Guiding principles for researchers developing self-efficacy measurement tools	Guide for constructing self-efficacy scales.(Bandura 2006)
Financial efficacy	2011 Outstanding AFCPE[R] conference paper: Development and validation of a financial self-efficacy scale (Lown 2011)
Entrepreneurial efficacy	Measuring Entrepreneurial self-efficacy to understand the impact of creative activities for learning innovation (Barakat, Boddington & Vyakarnam 2014)
Measuring self-efficacy within an adult learning development context.	The effects of adult learning on self-efficacy (Hammond & Feinstein 2005)
	Development and Validation of a student self-efficacy scale (Rowbotham & Schmitz 2013),
	Self-efficacy measurement and enhancement strategies for medical-surgical clinical nurses (Welsh 2014)

A pilot study provided the opportunity to test the reliability and refine the statements of the FSEMT. The pilot study population were sheep and beef farmers from across New Zealand who had access to Beef+LambNZ's weekly e-Diary platform. Farmers were invited to complete an online version of the FSEMT. Using this platform provided access to the full range of farming operations including: South Island High country, hill country breeding, breeding and finishing, and intensive finishing farms across New Zealand. Many of these farmers were in a suitable position to consider the adoption of up-to-date agricultural technologies, including the use of perennial summer forages within their farm pasture systems.

Demographic data were gathered from the pilot study participants of this study. Data requested from participants included: farm location, types of pasture used, farming experience, farm ownership and position on farm. Participants were asked about their current use of perennial summer forages, length of use, and if not currently using them, their consideration for future use. The participants also had the opportunity to provide feedback on the readability and flow of the statements. These comments provided guidance to develop a more user-friendly tool that could be easily completed by busy farmers. Demographic data were collected because of its importance in describing the characteristics of the pilot study.

The FSEMT was set-up online using the Survey Monkey website with data collected online during October and November 2015. This research was approved by the Massey University Ethics committee and judged as 'low risk'. Once closed, FSEMT data were downloaded into SPSS (Version 24) (IBM Corporation 2015) on the researcher's computer, cleaned and tested for outliers and errors.

Thirty (30) responses were received from the farmers within the 21-day period that the survey was open. Analysis of the descriptive statistics (see Table 3) identified that twenty-three (23) farmers fully completed the FSEMT Pilot version. Two respondents did not proceed past the consent stage and five (5) respondents did not complete all statements of the tool.

Table 7. FSEMT (Pilot version) case processing statement

Cases	*n* (participants)	%
Valid	23	76.7
Excluded	7	23.3
Total	30	100.0

SPSS Version 24

The majority (86%) of respondents were male with 14% female. Cultural diversity was not reflected within the pilot result because 100% of the respondents identified themselves as New Zealanders or NZ European. Ages were relatively evenly distributed within the 30 – 70 years of age range, the largest group (29%) being between 40 – 49 years of age. Most farms appear to still be in 'family' control as 60% of respondents were farming in a family trust, family partnership or owner-operated situation. Farmers working in a breeding/finishing environment seemed most interested in completing this pilot survey (57%). Plantain was grown and grazed by 63% of the farmers with lucerne, chicory and red clover all scoring around 40%. Of those who responded, 90% were using forages, 7% were considering using one or more of them in the future and one farmer was not interested in introducing perennial summer forages into his system. Farmers not using perennial summer forages (10%) stated that they were using other options such as sub-clover, grasses other than ryegrass, or crops including summer leafy turnip or pasja.

Results of reliability testing

Research based on measurement must be concerned with the accuracy or reliability of the results produced during data collection and analysis. 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. Internal consistency reliabilities of self-efficacy measurement tools should be computed using Cronbach's Alpha (Bandura 2006). 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 tool's internal consistency reliability by calculating whether the statements measuring the same general ideas produced similar results. A test value of reliability for the items of this FSEMT was 0.97 and was considered 'acceptable' for use in this research.

Most statements had a Corrected Item-Total Correlation value of greater than 0.60 (see Table 4). Three statements scored <0.60; however, removing them made little difference to the overall FSEMT Corrected Item-total Correlation Value and internal consistency. All statements showed a 'Cronbach's Alpha if item deleted' value of between 0.967 - 0.971 (Table 4).

The result of the pilot study indicated the FSEMT was a reliable tool to measure farmers' self-efficacy in the domain of managing perennial summer forages. De Vellis (2012) suggested a trade-off between brevity and reliability because shorter scales are more respondent-friendly. After considering the useful feedback provided by pilot study participants the number of statements was reduced to 20 for the final version of the FSEMT (see Table 5). The deleted statements related to repetition within the 26 statements or measurement of contexts outside of this research.

Discussion

This paper makes explicit the process used to design a tool to measure self-efficacy within a specific domain. There is a growing interest in the role of self-efficacy within agricultural extension and farmers' adoption of innovative technologies (Wilson, Rhodes & Dodunski 2015; Niles, Brown & Dynes 2016; Sewell et al. 2017). In the health sector, self-efficacy has been identified as a consistent and reliable predictor of short and long-term practice change in patients (Rosenstock, Strecher & Becker 1988). Slow adoption of innovative technologies within the agricultural sector has been a concern expressed by New Zealand government policy makers, technology developers and agricultural extension designers. Developing a deeper understanding of the part self-efficacy plays in farmers' decision-making processes may improve the rate of adoption of innovative agricultural technologies. For example, Sewell et al. (2017) concluded that farmers' self-efficacy informs their perception of their capability to adopt and manage innovative farm technologies. Likewise, Strecher et al. (1986) noted that a better understanding of self-efficacy along with introducing strategies for enhancing efficacy in practice, can lead to more effective health programmes that lead to changed behaviours.

Table 4. FSEMT Corrected Item-Total Correction Value and internal consistency

Statement	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	N (Participants)
select the best species of perennial summer forages for my farm's local climate and soil conditions.	0.760	0.968	23
select the best species of perennial summer forages for my animal feed requirements.	0.749	0.968	23
manage the costs that may be required to introduce perennial summer forages.	0.718	0.968	23
implement strategies that manage the risks associated with changing from my current pasture species to perennial summer forages.	0.748	0.968	23
find science-based research that identifies the potential risks of introducing perennial summer forages onto my farm.	0.721	0.968	23
make an informed judgement using knowledge provided by farmers who have used perennial summer forages on their farms.	0.751	0.968	23
make an informed judgement about using perennial summer forages from information provided by commercial sources.	0.766	0.968	23
give useful advice to neighbouring farmers who want to use perennial summer forages on their farms.	0.841	0.967	23
defend my decisions when talking with other farmers about the management of perennial summer forages on my farm.	0.887	0.967	23
use perennial summer forages to improve my grazing options during drought events.	0.700	0.968	23
introduce perennial summer forages on my farm with minimal outside support.	0.440	0.971	23
use perennial summer forages to improve my farm productivity.	0.726	0.968	23
identify solutions to control weed problems when using perennial summer forages.	0.685	0.968	23
identify solutions to control plant health issues when using perennial summer forages.	0.797	0.967	23
focus on positive aspects of farming when management issues arise.	0.894	0.967	23
persevere if challenging situations arise when using perennial summer forages on my farm.	0.902	0.967	23
agree to decisions made by others on the use of perennial summer forages.	0.551	0.969	23
help other farmers achieve their goal to use perennial summer forages on their farms.	0.852	0.967	23
accept the group's suggestions about the species of perennial summer forage to use on my farm when they have more expertise than me	0.687	0.968	23
cooperate within a group environment to improve my own knowledge of perennial summer forages.	0.810	0.967	23
work with research scientists to improve the management of perennial summer forages on my farm.	0.712	0.968	23
express my views on important issues regarding perennial summer forages.	0.736	0.968	23
ask questions to help make my decision to change to perennial summer forages on my farm.	0.753	0.968	23
increase my personal knowledge of perennial summer forages by talking with other farmers.	0.801	0.968	23
share my enthusiasm of using perennial summer forages.	0.661	0.968	23
handle unwanted pressure regarding the use of perennial summer forages.	0.596	0.969	23

Table 5. The 20 statements decided on for the final version of the FSEMT.

I am confident I can.......
select the best species of perennial summer forages for my farm's local climate and soil conditions.
select the best species of perennial summer forages for my animal feed requirements.
manage the costs that may be required to introduce perennial summer forages.
implement strategies that manage the risks associated with changing from my current pasture species to perennial summer forages.
find science-based research that identifies the potential risks of introducing perennial summer forages onto my farm.
make an informed judgement about using perennial summer forages from information provided by commercial sources.
give useful advice to neighbouring farmers who want to use perennial summer forages on their farms.
defend my decisions when talking with other farmers about the management of perennial summer forages on my farm.
use perennial summer forages to improve my grazing options during drought events.
introduce perennial summer forages on my farm with minimal outside support.
use perennial summer forages to improve my farm productivity.
identify solutions to control weed problems when using perennial summer forages.
identify solutions to control plant health issues when using perennial summer forages.
persevere if challenging situations arise when using perennial summer forages on my farm.
help other farmers achieve their goal to use perennial summer forages on their farms.
cooperate within a group environment to improve my own knowledge of perennial summer forages.
accept the group's suggestions about species of perennial summer forage to use on my farm when they have more expertise than me.
work with research scientists to improve the management of perennial summer forages on my farm.
express my views on important issues regarding perennial summer forages.
increase my personal knowledge of perennial summer forages by talking with other farmers.

Early indications show that FSEMT can provide a reliable method to measure farmers' self-efficacy within a specific agricultural context. While several existing measurement tools are available within the health sector and other contexts such as education (Strecher et al. 1986; Bandura 2006), few tools have been designed to measure self-efficacy in an agricultural context. A notable exception is the study by Roy (2009) who reported on the design and use of a tool to provide some understanding of farming practices of self-efficacious farmers within a jute and paddy farming context.

Designing the FSEMT required a team of academics to create and select statements that would challenge farmers' perceived capabilities to complete specific tasks relevant to the management of perennial summer forages. In line with Bandura's (2006) advice, the process of creating the statements required the identification of specific strategies, skills and knowledge relevant to the measurement of farmers' self-efficacy in relation to the use and management of perennial summer forages. The effectiveness of this process required a team with expertise in the domains of both management of perennial summer forages and in self-efficacy.

Validation of reliability is an ongoing process, accumulating as research studies increase (Rust & Golombok 1989). Subsequent to its development, the FSEMT has been used in a longitudinal agricultural extension research study which aims to provide insights into the extent to which farmer's self-efficacy impacts on their use of perennial summer forages. Additional studies are required to provide further evidence of the construct validity of this tool. The development of the FSEMT is the first step toward providing a reliable approach for measuring the self-efficacy of farmers in specific agricultural contexts.

Limitations

No research is without limitations. Most farmers have affiliations to Beef+LambNZ through their levies, field day attendance and publications. The pilot testing of the FSEMT involved a small sample of pastoral farmers (23) from throughout New Zealand.

The FSEMT was designed to measure the self-efficacy of farmers participating in a research project centred in the Hawkes Bay - Wairarapa region of New Zealand. While the pilot group were located throughout New Zealand it was considered that this difference would have minimal impact on the research finding as the tool was constructed to measure farmers' self-efficacy within the domain of managing perennial summer forages, rather than their self-efficacy on a regional basis.

Conclusion

Self-efficacy has become a recent point of discussion in agricultural extension research (McGinty, Swisher & Alavalapati 2008; Yeuh & Liu 2010; Wilson, Rhodes & Dodunski 2015; Niles, Brown & Dynes 2016; Wuepper & Sauer 2016; Sewell et al. 2017). Collecting longitudinal quantitative data specific to farmers' self-efficacy may help develop a better understanding of how to support farmers when they are faced with the challenges of adopting or adapting innovative technologies into their farm systems. The FSEMT provides researchers with a means of measuring longitudinal change in a specific cognitive aspect of a farmer's action. If a relationship between the farmers' self-efficacy and practice change relating to adopting or managing perennial summer forages is identified, then similar tools could be designed to inform future extension aimed at other forms of agricultural innovation. Improving an understanding of how farmers' self-efficacy changes as a result of agricultural extension activities may lead to an enhanced rate of adoption of future innovative agricultural technologies. The FSEMT provided a reliable measurement of farmers' self-efficacy within a specific agricultural domain; however, future research could involve the tools use within a population sufficiently large to enable factor analysis of the results.

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