An Exploration of Collaborative Learning Spaces in the Quest for Agricultural Sustainability in New Zealand

Marie Josephine McEntee

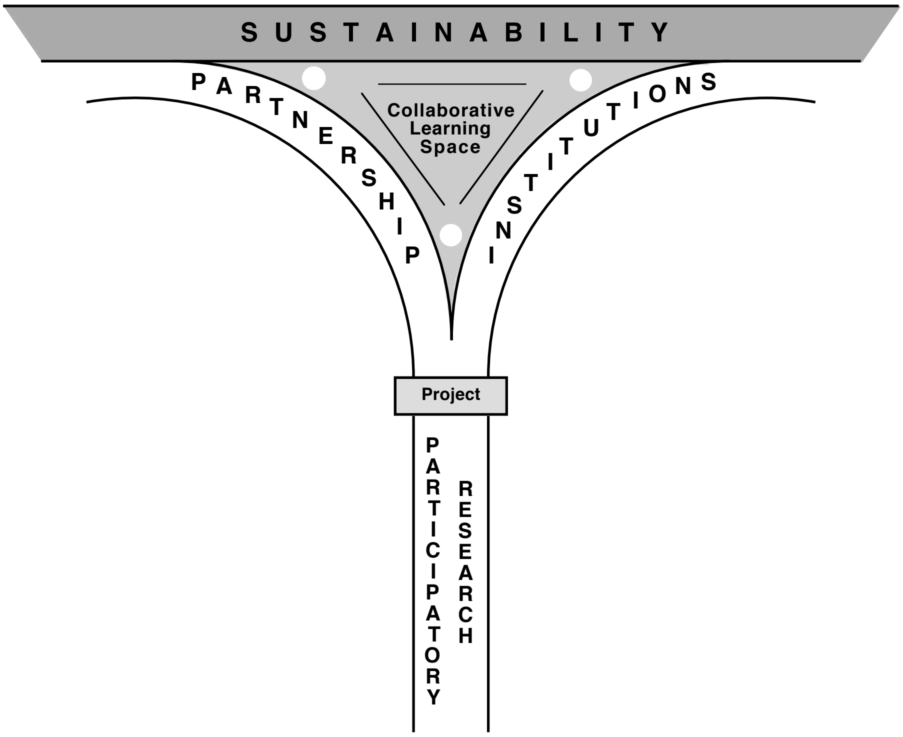
A thesis submitted in fulfillment of the requirements for the degree of
Doctor of Philosophy in Environmental Science,
the University of Auckland, 2015

Abstract

Participatory research is advocated for fostering multi-stakeholder engagement and learning towards sustainability. Using multiple sources of evidence from stakeholder interviews, participant observations and review of project documentation from six micro-level agricultural innovation projects in New Zealand, this work examines how effectively participatory research is utilised to advance agricultural sustainability.

Project partnerships are shown to be a dynamic union between farming, science and funding partners and their formal and informal institutions. The empirical evidence shows the inter-relatedness between institutions, partner relationships and collaborative learning. Institutions which shape actors' engagement in participatory research lead to wide variation between actor groups. Participatory research is undermined by formal and informal institutions that inhibit collaboration and favour prescriptive outputs. To provide an enabling environment for collaborative learning, partnerships should foster relationships to align partner priorities, engender shared visions and stimulate knowledge co-production. The research conceptualises partnership as a relationship between actors that goes beyond a principal focus on it as a contractual entity. Changes in farming practice are dependent on the depth of farming partner involvement and engagement with project design and implementation, along with the strength of feedback loops with the communities of practice and the farming group's capability to sustain learning beyond a project's funded period.

Building on these findings, a model is presented that conceptualises a variable collaborative learning space that emerges from the project partnership. Collaborative learning is shown to be influenced by the strength of partner relationships within and beyond the project partnership and institutions that together act to enlarge or constrain the collaborative learning space and enable or deter learning. The thesis concludes by reframing participatory research in production agriculture to create transdisciplinary partnerships and foster systems thinking to facilitate a questioning of the assumptions and values that drive current practice. This appropriately frames participatory research for sustainability as a means to an end and not an end in itself. Such framings recognise sustainability as a multi-dimensional, interconnected and complex concept. Conceptualising participatory research projects as a collaborative learning space provides the opportunity for knowledge to be co-developed where learning is emergent, adaptive and dynamic.


S U S T A I N A B I L I T Y
PARTNERSHIP
INSTITUTIONS
Collaborative Learning Space
Project
PARTICIPATORY RESEARCH

To Grant

Acknowledgements

There are a number of people I would like to acknowledge who have played a part in my long journey to this submission:

My research supervisors Gary Brierley, Susan Owen and Willie Smith;

Gary, we have only had a short time together but thank you for providing me a space to think creatively and for your positive encouragement. You have been a tower of strength in the final months of this work.

Sue, for your comments on my drafts. I hope my finished product reflects your advice over the five years you have been on board.

Willie, for giving me the opportunity to do this PhD. I learnt a lot about myself in writing this work but mostly I learnt what it meant to be resilient.

My research participants;

who openly and willingly shared their experiences and ideas. I have met some incredible Kiwis. You let me into your worlds and you were friendly, welcoming, honest and frank. You taught me so much about rural New Zealand. This work has been enriched by your contribution.

My departmental colleagues;

for your support and words of advice, particularly my heads of department, Glen McGregor and Paul Kench.

My friends;

Simon Wegner, Roger Baars, Vivien Wells and Gael Arnold for being my sounding board, I appreciate that you cared, and Margaret Goldstone, Bill Barton and Ivan Reilly from the University of Auckland for your gentle words of encouragement. Thank you also to Tom Phillips from Massey University for openly welcoming me into the world of agricultural extension with your infectious enthusiasm and energy and to Will Allen and Chrys Horn for your advice and conversations as I was starting out on this journey of exploration. To all of you I look forward to staying in touch and to reconnecting where I have lost touch.

My family;

Mum and Dad, I have been a little preoccupied over the past several years on what seemed to you to be an endless task. I knew you were there as you have always been supportive and proud of my efforts, whatever I turned my hand to. I owe you a lot and look forward to sharing more time together.

Grant, Hannah and Zane. What can I say, words simply will not cover this. You have been on this journey with me every step of the way.

Grant, 24 years ago we promised we would stick by each other through the good times and the bad times. I have tested that promise. You are my rock. I look forward to our new life TOGETHER.

Hannah and Zane, Mum is finally coming home.

Today as I write this it is September 1, the first day of spring. It has been a dreadfully long winter. Today is a new beginning. I can't wait.

Table of Contents

7.0 Discussion

List of Tables

List of Figures

Abbreviations

AIS	Agricultural innovation Systems
CFR	Crop and Food Research
CoP	Community of Practice
CRI	Crown Research Institute
ECOP	East Coast Organic Producers
FAR	Foundation for Arable Research
FRST	Foundation for Research Science and Technology
HortNZ	Horticulture New Zealand
IPM	Integrated Pest Management
MAF	Ministry of Agriculture and Fisheries
	(1998 became Ministry of Agriculture and Forestry)
MPI	Ministry of Primary Industries.
NZ	New Zealand
PFR	Plant and Food Research
PROCLE	Participatory Research Optimal Collaborative Learning Emergence
R&D	Research and Development
SCC	Science for Community Change programme
SFF	Sustainable Farming Fund
WCED	World Commission for Economic Development
WIG	Walnut Industry Group

CHAPTER ONE

1.0 Using Participatory Research to Advance Sustainable Agriculture

1.1 Participatory research and sustainability

Published in 1987, the United Nations World Commission on Environment and Development's (WCED) publication *Our Common Future*, widely known as the *Brundtland Report,* sought global consensus around sustainability by defining the concept of sustainable development as:

> …development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
>
> *(WCED, 1987: 23)*

However, despite nearly thirty years having passed since its release, the implementation of sustainability remains a highly fraught and contested endeavour. Within agriculture there remains an urgent need to effectively address and advance sustainability as rural communities are facing ever-increasing global and local pressure from diverse sectors of society such as markets, regulatory bodies, the public and interest groups to address the environmental impacts of agricultural practices.

The need to find effective approaches to identify, understand and address agriculture's externalities has never been more critical, since it is asserted that the agricultural sector must double food and animal feed production over the next decades to keep pace with worldwide population growth, increased per capita consumption, dietary changes and bio-energy requirements (Jones et al., 2013). Meeting these demands will require effective responses at all levels, including at the micro-level - the "multi-party collaboration processes in which representatives from different stakeholder groups interact" (Medema, Wals, & Adamowski, 2014: 27). If agriculture is to be sustainable then it must clearly find ways to grapple with the somewhat contradictory expectation of meeting current and future consumption demands without negatively impacting the environment (Bos, Smit, & Schröder, 2013; Cocklin & Dibden, 2005; Foley et al., 2011; Jones et al., 2013; New Zealand. Office of the Parliamentary Commissioner for the Environment, 2004; Pretty, 2005).

As Foley et al. (2011: 337) correctly notes,

> "Looking forward, we face one of the greatest challenges of the twenty-first century: meeting society's growing food needs while simultaneously reducing agriculture's environmental harm."

Regulatory controls implemented as a political response to societal pressures provide a minimum level of environmental protection, but they are intensely disliked by farmers (Allen, Du Plessis, Kilvington, Tipene-Matua, & Winstanley, 2003). Furthermore, as they are not designed to address the underlying approaches and perspectives that drive the agricultural practices they seek to regulate, regulation alone has only achieved limited success at advancing sustainability outcomes in agriculture (Ketterings, 2013).

Participatory approaches that encourage multi-stakeholder engagement and collaboration, learning and collective action are put forward by researchers as an effective platform for facilitating change towards sustainability (Keen, Brown, & Dyball, 2005b; Neef & Neubert, 2011; Pretty, 1995, 1998, 2006; Reed, 2008; Roling & Wagemakers, 1998b). There is also support for participatory approaches to research from policy and funding agencies as a means to both promote sustainable agriculture and increase adoption of sustainable agricultural innovations on the farm (Ison, Roling, & Watson, 2007; Pahl-Wostl, 2002; Phillips, Allen, Fenemor, Bowden, & Young, 2010; Tippett, Searle, Pahl-Wostl, & Rees, 2005; Van de Fliert & Braun, 2002; van de Fliert, Dilts, & Pontius, 2002).

Despite the wide support for participatory research as an approach to the implementation of sustainability in agriculture, there remains limited understanding of how the dynamics of participatory research projects may stimulate or impede real and lasting change towards sustainability in the rural sector. Therefore while participatory research may have both democratic and 'public' accountability appeal, the integration of scientific and local knowledge in research projects remains difficult to achieve (Allan, Nguyen, Seddaiu, Wilson, & Roggero, 2013; Hoffmann, Probst, & Christinck, 2007; Neef & Neubert, 2011). This raises questions about the effectiveness of participatory research as a means to advance sustainability.

This research investigates participatory research in an agricultural setting. The aim of this work is to better understand how participatory research enables actors from both inside and outside the science and technology system to share in a vision that enables them to be collaboratively engaged in problem identification and the co-development of solutions to those problems. To investigate this, the research focused on six micro-level horticultural and arable sector participatory research projects in New Zealand. The selected public / private partnerships involved farmers and scientists working collaboratively in efforts to use science and farming knowledge to advance sustainability.

As collaborative engagement around sustainability often involves multiple stakeholders who typically hold different perspectives about both the issue and its possible solutions, implementing sustainability in an agricultural context can be challenging. This chapter explores the concept of sustainability, and discusses characteristics of sustainability that might assist in guiding its implementation. It then uses the New Zealand agricultural context to examine the challenge of sustainability implementation by exploring how it is variably interpreted at the policy, science and farmer levels. This discussion lays the foundation for the thesis' objectives and its central and focusing questions that are outlined in the final section of the chapter.

1.2 Characterising sustainability: seeking clarity to guide implementation

1.2.1 Introduction

The *Brundtland Report* emerged out of a fractious historical context, where arguments over environmental degradation had been fervidly debated (see Commoner, 1971; Ehrlich, 1968). Although the report's definition of sustainability (Section 1.1) created an uneasy alliance between economic growth and ecological sustainability (Ratner, 2004; Robinson, 2004), it nonetheless consciously showed the interdependence of the social, environmental and economic dimensions of sustainability. In doing so it widened the concept of sustainability away from a primary and narrow environmental focus.

Brundtland's pathway forward for sustainability followed a course based on inclusion and compromise, to accommodate within it as many different perspectives as possible (Robinson, 2004). Thirty years since its release, the *Brundtland Report* still remains the primary point of reference for discussions about sustainability and it has been the catalyst for three United Nations' Earth Summits and other multi-national conferences on environment and development, along with being cited in a broad range of literatures (Schubert & Láng, 2005).

The broad reach of sustainability post-Brundtland however, has led to wide discussion and disagreement over its meaningfulness as a concept (see Franklin & Blyton, 2011; Gladwin, Kennelly, & Krause, 1995), its relevance (see Hopwood, Mellor, & O'Brien, 2005) and its usefulness for guiding policy (see Holden, Linnerud, & Banister, 2014).

The enormous breadth and diversity of opinion in these discussions creates potential dilemmas for the implementation of sustainability. Among this diversity of opinion, three characteristics of sustainability emerge which shape how sustainability might be implemented to address agricultural impacts:

- Sustainability must be viewed as multi-dimensional and interconnected
- Sustainability must be viewed as complex
- Sustainability must be viewed as having temporal and spatial dimensions

1.2.2 Sustainability must be viewed as multi-dimensional and interconnected

Sustainability is recognised to be a multi-dimensional and inter-connected concept that seeks to balance economic, environmental and social perspectives (Kates et al., 2001; Levin, 1993; Pettie, 2011; Pretty, 2006; Ratner, 2004; Redclift, 1987; Robinson, 2004; Robinson & Tinker, 1997; WCED, 1987). These dimensions have been popularised as the 'three pillars' approach to sustainability, or the triple bottom line – economic, environmental and social. Although the multidimensional aspect of sustainability is widely accepted (Aras & Crowther, 2013), the need to consider the interconnectedness of these dimensions is less understood, despite it appearing in the literature to be central to the implementation of sustainability. Robinson and Tinker (1997) argue that ignoring the interconnections between economic, environmental and social dimensions and implementing sustainability by addressing one dimension in isolation is problematic. They claim,

> Addressing any one of the three imperatives in isolation, without also satisfying the other two, virtually guarantees failure, first because each is independently crucial, second because the satisfaction of each is urgently necessary to remove elements of gross unsustainability from human society and third because the three imperatives (like the three prime systems) are intimately connected.
>
> *(Robinson & Tinker, 1997: 19)*

Similarly Pettie (2011: 21) recognises both the human focus and the multi-dimensional and interconnected nature of sustainability and argues against those who adhere to a narrow one-dimensional view. He states,

> … in reality there is no such thing as an 'environmental problem'. The environment does not have problems; it just is. It is society that has problems due to the unsustainable interactions between our social, economic and technological systems and the physical environment.

Researchers emphasise the importance of the linkages between the different dimensions of sustainability. Smith (2002) contends that sustainability implementation should ideally aim for a holistic systems-based approach that principally focuses on the linkages between its different dimensions rather than its component parts. This view seeks integration between the dimensions rather than considering each separately. Similarly Kates et al. (2001) argue that if measures to address sustainability are to be effective, there needs to be a deeper understanding of the interconnections particularly between nature and society. Furthermore, Robinson (2004) claims that sustainability requires understanding of the interactions between the environmental, social and economic systems and the natural world and that this understanding must extend to practitioners for sustainability to have a chance of being successfully implemented. Therefore what these researchers are arguing is that while considering a single dimension of sustainability is clearly inadequate, considering the three dimensions individually is equally problematic.

Discussions about how to balance the multiple dimensions of sustainability have direct application in an agricultural context. The economic viability of agriculture is recognised as being dependent on essential ecosystem services provided by the natural environment such as soil fertility, water supply and climate (Merrington, Nfa, Parkinson, Redman, & Winder, 2002; New Zealand Office of the Parliamentary Commissioner for the Environment, 2004). Smith and Montgomery (2004) claim that managing the social and environmental impacts of agriculture will always be a balancing act between appropriate environmental management and the economic viability of the sector. Their work shows that farmers continually make choices about how to best manage their land and that decisions, particularly about implementing sustainable practices, are largely values-based choices.

Pretty (2006) asserts that farmers must examine the impact of their practice on physical, natural, social, human, and financial assets. He argues that sustainable agricultural systems produce positive impacts and accumulate these five assets, while unsustainable systems produce negative impacts and deplete them. Other researchers recognise that agriculture lies at the interface of the natural and social systems (Bawden, Macdam, Packham, & Valentine, 1984; Darnhofer, Gibbon, & Dedieu, 2012; Ison, Maiteny, & Carr, 1997; Packham, 2011). They acknowledge the interconnectedness of the economic, social and environmental dimensions of agricultural practice and the need for a holistic systems-based approach to addressing sustainability in this sector.

While a balanced approach to sustainability is normally a tripartite division that focuses on environment, economy and society, a small number of researchers embrace institutions as a fourth pillar of sustainability (Pfahl, 2005; Spangenberg, Pfahl, &

Deller, 2002). The *Brundtland Report* identified the importance of institutions when it claimed,

> In essence, sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations.
>
> *(WCED, 1987: 46)*

Institutions include both formal institutions such as organisations, regimes, laws, mechanisms and rules, and informal institutions such as social norms, practices, values and customs that shape behaviour and support decision-making (Ostrom, 1990; PCE, 2004; Pfahl, 2005; Smith, 2002). Investigations of sustainability's institutional dimension, such as the United Nation's Agenda 21 (UNCED, 1992), often focus on the structures and arrangements of formal organisations, but in a critique of this narrow interpretation Pfahl (2005) identifies the critical role that informal structures play in shaping behaviour and expectations. She argues that sustainability implementation needs to recognise both formal and informal institutions. Similarly Leeuwis and Aarts (2011) look beyond institutions as formal structures and organisations and claim that communication and self-organisation can act as a form of social action that can bring significant change to formal institutional structures. These perspectives show the importance of informal arrangements as people organise themselves to bring about action.

Although institutions are often overlooked by researchers as noted by Pfahl (2005), this thesis adheres to Brundtland's balanced multi-dimensional and inter-connected approach to sustainability and views sustainability as a four-dimensional concept, which makes explicit formal and informal institutions. Understanding institutions is considered to provide an important platform to assess how participatory principles and collaborative engagement can underpin new institutional arrangements (both formal and informal) that challenge traditional power dynamics and existing ways of knowing and doing.

1.2.3 Sustainability must be viewed as complex

There is wide support in the literature for sustainability to be viewed as a complex problem (Frame, Gordon, & Mortimer, 2009; Rayner, 2006). Some authors use the term 'wicked' in preference to 'complex' (Frame et al., 2009; Rayner, 2006) and in so doing borrow from Rittel and Webber (1973: 160) who first used the term 'wicked' to describe complex problems in urban planning. It is argued that complex or 'wicked' problems are difficult to solve because proposed solutions raise new problems, which makes it difficult to gauge the effectiveness of any particular solution (Rittel & Webber, 1973). Conklin (2006) even goes so far as to suggest that complex problems can only be tamed and not solved. As a result, Rittel & Webber (1973: 163) argue that addressing complex problems is about "improving characteristics of the world". The emphasis therefore is on 'improvement'.

Authors contend that complex problems, such as sustainability should never be addressed at the symptom level (Camillus, 2008; Rittel & Webber, 1973) . Instead they recommend that a range of stakeholder perspectives must be embodied within any decision-making. On the one hand this further increases the complexity of the problem and fragments efforts to find solutions (Cocklin & Dibden, 2005; Roux, Rogers, Biggs, Ashton, & Sergeant, 2006), but on the other hand, shared concerns and ownership of issues are considered to be fundamental requirements in developing efforts to address them. Although Rittel and Webber (1973) applied the term wicked problems to social issues such as urban planning, they did not regard environmental problems as wicked, although the term has now become widely associated with socio-ecological problems such as sustainability (Frame et al, 2009). Levin et al. (2012: 123) even go so far as to characterise global environmental problems such as climate change, which have significant policy implications, as "super-wicked".

In an attempt to characterise different levels of complexity, researchers have visualised and classified 'problem types'. For example Stacey (1999), working in organisational management, classified problems as simple, complicated, complex and chaotic. He visualised a two-dimensional matrix (Figure 1.1) to understand problems. The matrix positions problems according to the degree of uncertainty of outcomes and the degree of disagreement among stakeholders. In this matrix, the complexity of the problem increases as both the level of uncertainty of outcome and the level of disagreement among stakeholders increases. Stacey (1999) further argued the classification of problems is not static but can shift between domains as new information emerges.

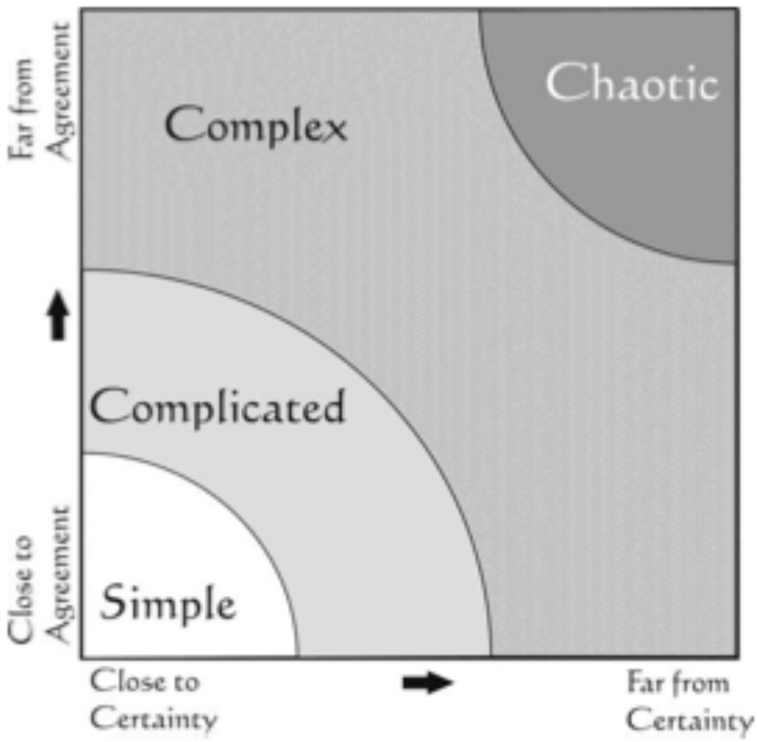


Figure 1.1: Visualisation of Stacey's (1999) Agreement and Certainty Matrix from the Canadian Centre on Substance Abuse (2012)

Allen et al. (2010) applied Stacey's matrix in an environmental context and suggested a correlation exists between the number of stakeholders and the level of difficulty encountered in managing a problem, regardless of the degree of uncertainty of outcome. They claimed that complicated problems are manageable because they generally have one principal stakeholder, while complex problems are more difficult to manage because they have multiple stakeholders. Allen, Horn & McEntee (2010 Nov) applied Stacey's matrix to biosecurity problems in New Zealand, and argued that while pest control for conservation on government controlled offshore islands is technically challenging, it is best framed in this context as a complicated problem, whereas aerial insecticide spraying over urban communities to eradicate an invasive economic pest becomes a complex problem by virtue of the massively increased numbers of stakeholders and the number of conflicting issues that are raised and require resolution.

Further visualisations of problem domains have been offered in the natural resource management literature where environmental problems are classified according to their ability to be resolved through cause and effect relationships (Snowden, 2002; Stirzaker, Biggs, Roux, & Cilliers, 2010). In this literature the four problem domains are identified as: known, knowable, complex, and chaotic (Snowden, 2002; Stirzaker et al., 2010). It is argued that deterministic cause and effect relationships are appropriate for the known and knowable problem domains but not for complex problems, which behave stochastically in an uncertain and unpredictable manner (Stirzaker et al., 2010). According to these conceptualisations of problem domains, sustainability is a complex problem by virtue of the multiple stakeholders involved and the likely disagreement among them of how to resolve an issue as well as the level of uncertainty associated with implementing any solution.

In the natural resource management literature (Stirzaker et al., 2010), the management of complex problems emerges from judgment rather than from a clearly defined set of rules. In this light adaptive management approaches are generally recommended for implementing a response. This literature acknowledges dimensions of a problem beyond the biophysical and refers to systems as socio-ecological systems, where the dynamic interactions between humans and natural systems are recognised and considered (Berkes, Colding, & Folke, 2003; Holling & Gunderson, 2002; Kates, Parris, & Leiserowitz, 2005). Humans are no longer argued to be merely managers or stressors of the system, but are actually part of the system (Berkes et al., 2003; Davidson-Hunt & Berkes, 2003).

What emerges from these literatures is that the approach needed to address complex problems such as sustainability must not rely solely on a traditional linear (cause and effect) approach to science to develop solutions. In general, such 'positivist' science seeks to eliminate complexity by simplifying problems to singular cause and effect relationships that behave deterministically, which generally leads to technological or engineered solutions being favoured (Holling & Goldberg, 1971). This approach is acknowledged to be too simplistic for the complex stochastic nature of socio-ecological systems that underlie agricultural systems (Berkes et al., 2003; Kates et al., 2001).

Furthermore, solutions to advance sustainability must equally consider social, institutional and economic dimensions (Franklin & Blyton, 2011; Robinson, 2004; Roling and Wagemakers, 1998) in addition to the environmental dimension. Each of these components or dimensions has its own inherent complexity that must be acknowledged and effectively managed. As complex interactions among these components are inevitable, approaches to address sustainability must therefore embrace its multidimensional and interconnected dimensions to provide a more holistic means to address issues, compared to a purely reductionist science-based approach that seeks to reduce complexity.

1.2.4 Sustainability must be viewed as having spatial and temporal perspectives

The *Brundtland Report* established the view that sustainable development requires that today's generation does not compromise the ability of future generations to meet their own needs. This has a strong implication that sustainability requires a long-term ongoing perspective and one that is forward-looking. Therefore, there is growing recognition in the environmental literature that a transition to sustainability is a long-term journey, and is not a destination or end-point (Robinson, 2004; Wals & Rodela, 2014).

In terms of agricultural sustainability, a long-term perspective is often entwined with broader concerns about the accumulative environmental effects of off-farm externalities. This argument centres around the contention that for agriculture to be sustainable, it needs a long-term perspective that equally considers the spatial impacts of farming practice both on the farm and beyond the farm gate (Cocklin & Dibden, 2005; Pretty, 2006; Roling & Wagemakers, 1998a). Gliessman (2005: 104) encapsulates this notion as follows:

> Agriculture is more than an economic activity designed to produce a crop or to make as large a profit as possible on the farm. A farmer can no longer pay attention to the objectives and goals for his or her farm only and expect to adequately deal with the concerns of long-term sustainability.

Taking a long-term perspective to farming challenges the dominant productivist approach to land management that Cocklin and Dibden (2005: 174) claim privileges, "short term economic returns over the maintenance of the long-term productive capacity of the land". This somewhat provocative argument is rooted in concern over agriculture's privileging of economic productivity over the ecological productivity of the land. Furthermore, there is growing recognition of the need to view the farm within the landscape system in which it is located (Fenemor et al., 2008; Mills et al., 2011; Sayer et al., 2013).

Agricultural productivity has significant effects on essential ecosystem services (Merrington et al., 2002; PCE, 2004). Indeed Pretty (2006: 9) claims that agriculture is a unique economic activity in that it directly impacts the natural assets on which it must rely for success.

Gliessman (2005) provides evidence of the effects that agriculture has on natural systems. He claims that compared to natural systems, modified and simplified agroecosystems alter energy flows that are essential for biomass production. They affect nutrient cycling, with any subsequent nutrient loss typically being replaced by high levels of inputs from agrochemicals that can leach into waterways and groundwater. Population-regulating mechanisms are also altered, reducing biodiversity and disrupting natural pest control. This, in turn, makes agroecosystems vulnerable to significant pest and disease outbreaks. With reduced ecological structural and functional diversity these systems can have little inherent resilience.

This literature recognises the complexity of ecosystems and the interconnectedness of its interlocking array of ecological feedback mechanisms (see Stirzaker et al., 2010). The conventional economic efficiency in a productivist paradigm results in the deterioration of ecological resilience, leaving the human and natural systems unable to cope with change and surprise (Berkes et al., 2003).

Alternatively, the purely economic focus of the productivist paradigm is argued to fervently adhere to the notion that human progress is inevitable and non-bounded (Glasser, 2007). While this notion is explicitly challenged in international policy documents, such as *Living Beyond Our Means* (Millenium Ecosystem Assessment, 2005), the productivist paradigm is argued to still dominate agricultural practice (Blunden, Cocklin, Smith, & Moran, 1996; Cocklin & Dibden, 2005; Jones et al., 2013; Pretty et al., 2010). Cocklin and Dibden (2005) suggest that there is a continual tension between agricultural production and the environment that acts like a tug-of-war, constantly pulling farming into a productivist paradigm. Any move towards sustainable agriculture will therefore require greater consideration of farming's place in, and its effects on the environment.

The productivist paradigm is not restricted to the expansion of agriculture but also includes its intensification. Statistical evidence shows that of the one third (38%) of the Earth's landmass occupied by agricultural production (Foley et al., 2011), the area of crop production only increased 3% between 1985-2005, while total crop yield over this period was estimated to have increased by 20% (Foley et al., 2011). Most productivity gains have therefore occurred from agricultural intensification rather than agricultural expansion (Foley et al., 2011), with increased farm inputs raising food production through the use of agrochemicals, synthetic fertilisers and pesticides, as well as through animal feedstuffs and advanced technology.

The expansion and particularly the intensification of farming in the industrialised world since the 1940s with a reliance on increased farm inputs to raise food production have exerted significant negative effects on ecosystems (PCE, 2004). In New Zealand, for example, the total area of land under irrigation has increased 400% since 1961, which has opened up marginal rainfall or even drought prone areas to more intensive agricultural production (MacLeod & Moller, 2006). Agricultural intensification and clearance have exposed watersheds to declining water quality from microbial contaminants (Sinclair et al., 2009) and increasing phosphorous levels (Hamill & McBride 2003), and has contributed to biodiversity loss (Lee, Meurk, & Clarkson, 2008; Moller et al., 2008).

The accumulative and chronic environmental effects of farming expansion and intensification present significant problems for the implementation of sustainability. In order to properly understand these impacts they must be viewed with a long-term perspective. Local effects may appear negligible when viewed within a short-term economic timeframe. However, a long-term perspective requires both an examination of their impact beyond the farm gate and the effect of cumulative impacts. Environmental impacts viewed through a short-term economic timeframe risk being seen solely as an immediate cost and meaningful attempts to address them may be reduced to limit their perceived cost.

With the source of environmental impacts being difficult to isolate, costs for mitigation are often socialised and this is seen as a market failure as the actual polluter or manufacturer does not usually incur any direct costs from their pollution (Klerkx, de Grip, & Leeuwis, 2006; Naylor et al., 2005; Pretty, 2006; Tilman, Cassman, Matson, Naylor, & Polasky, 2002). Pretty (2006) estimates that downstream costs, or externalities incurred in the USA, United Kingdom and Germany, range between £49 and £208 per hectare of agricultural land. Similarly Tegtmeier and Duffy (2005) estimated conservatively that United States' citizens collectively pay between $US5.7 billion and $US16.9 billion each year for agricultural externalities. A further $US3.7 billion was paid to regulate the agricultural sector and mitigate damage. These figures do not include publically funded subsidies or support mechanisms provided to farmers. These costs are generally paid through taxation and food manufacturers increasing prices, and through declining collective social wellbeing from diminishing environmental and public health (Pretty, 2006; Tegtmeier & Duffy, 2005; Vanclay & Lawrence, 1995).

Attempts to advance sustainability in the agricultural sector are often complicated by agricultural extension activities designed to enhance farmer learning. Such endeavours are typically directed at individual farmers to improve on-farm returns with short-term economic benefits (Klerkx et al., 2006). Learning to simply improve economic returns ignores the negative impacts of agricultural practice beyond the farm gate that result in the deterioration of public goods. In contrast, a long-term perspective would require the agricultural sector to address the negative impacts of farming practice at the landscape / catchment level (Fenemor et al., 2008; Mills et al., 2011; Sayer et al., 2013). The challenge for agricultural sustainability implementation therefore, lies in optimising farming's immediate economic benefits while simultaneously avoiding long-term environmental costs both on the farm and beyond the farm gate.

1.3 Viewing agricultural sustainability implementation through multiple spheres

1.3.1 Introduction

The implementation of sustainability in agriculture entails a continual tug-of-war between a multitude of factors (Cocklin & Dibden, 2005; Leeuwis & Aarts, 2011). This section examines how actors' interpretations of sustainability shape their understanding of sustainability as a multi-dimensional, interconnected and complex concept. To do this, the discussion focuses on the New Zealand setting to explore how sustainability is currently interpreted within the policy, science and farming spheres.

1.3.2 The policy sphere and sustainability implementation

Despite the rhetoric of policy that calls for sustainable approaches to environmental management, researchers argue that in the agricultural sector the continued pursuit of the productivist paradigm stifles meaningful discussion and effective action (Cocklin & Dibden, 2005; Jelsoe & Kjoergard, 2010; Ludwig, 1993; Pretty, 2006). Taking a somewhat dim view, Ludwig (1993: 555) lays the blame for this with policy and claims that the perceived inadequacy in sustainably managing limited natural resources is equivalent to the "miracle of the loaves and fishes" and so resembles the notion that human progress is inevitable and non-bounded (Section 1.2.4).

New Zealand was one of the first countries in the world to embed sustainability into legislation, with the enactment of the Resource Management Act (1991). This integrated previous environmental management legislation into one statute with its express purpose being the sustainable management of New Zealand's natural and physical resources. This groundbreaking legislation has been and remains today a significant force shaping the environmental landscape of New Zealand (Grundy, 2000).

However, New Zealand's focus on sustainable environmental management and in particular sustainable *land* management largely ignores the multidimensional nature of sustainability and in particular the social dimensions that have been more dominant in European interpretations of the concept (see for example, Spangenberg & Schmidt-Bleek, 1997). In fact, an amendment to the Resource Management Act in 1999 specifically removed social dimensions from the legislation's wording (Smith, Montogomery, & Rhodes, 2007). The New Zealand focus on land likely reflects the dominance of agriculture in the country's economy (PCE, 2004), with the agricultural sector contributing around 5% of GDP (Treasury, 2012), although Federated Farmers (2007) claims this increases to around 15%, when services to agriculture and the processing of agricultural products are included.

New Zealand's Ministry of Agriculture and Forestry's (MAF)[1] 1993 definition of agricultural sustainability did however refer to a need for balance, when it stated that sustainable agriculture should be environmentally sustainable, socially acceptable and economically viable (PCE, 2004). It read (quoted in PCE, 2004: 26),

> [Agricultural sustainability] is the use of farming practices, which maintain or improve the natural resource base of agriculture and any parts of the environment influenced by agriculture. Sustainability also requires that agriculture is profitable; that the quality and safety of the food, fibre and other agricultural products are maintained; and that people and communities are able to provide for their social and cultural well-being.

MAF's definition, while recognising agricultural externalities largely limited itself to the productive environment, with only minimal consideration of the non-productive environment that is impacted by agricultural production. Blunden et al. (1998) argued that in reality MAF policy linked sustainability with resource use and so actually promoted the profitability of agriculture over environmental considerations. This concern reflects wider recognition in the international literature about sustainable agriculture policy discourse, referring to the need to *control* the use of natural resources through management, so as to ensure their continued use for productive purposes, which in turn privileges the economic dimensions of sustainability (Kates et al., 2005; Onyx, 2005). Macro-level dynamics such as the recent global financial crisis also exert pressure to move towards an economic focus. When this happens, environmental concerns become marginalised as the multidimensional and interconnectedness of sustainability's dimensions (Section 1.2.2) may be overlooked in favour of a focus on immediate short-term economic gains (Cocklin & Dibden, 2005). Jelsoe and Kloergard (2010) claim the concept of managing the environment for productive purposes contrasts with the 'balanced' approach advocated in the *Brundtland Report*.

The role of policy in influencing sustainability implementation should not be under-estimated as they set the framework in which other actors, such as farmers, science institutes and scientists must operate. The New Zealand agricultural situation shows that the interpretation of sustainability by policy has implications for the way sustainability is implemented, as it gives different weightings to the different dimensions of sustainability.

[1] Now known as the Ministry of Primary Industries (MPI)

1.3.3 The science sphere and sustainability implementation

There is a long history of science innovation influencing the direction of the agricultural sector and on-farm practices in New Zealand (PCE, 2004; Star & Brooking, 2011). Science research plays a pivotal role in assisting primary industries to increase agricultural productivity. At the same time science research is being called on to advance sustainable farming practices to address negative impacts of agricultural externalities (Pretty et al., 2010). This dual role for science research Beck (1992) argues makes research organisations, along with legal and civil institutions, both the manufacturers and managers of the risks of modernity, including environmental risks.

The policy and funding framework influences how science research institutes and scientists operate (Buhler, Morse, Arthur, Bolton, & Mann, 2002; Halliwell & Smith, 2011; Hunt, 2009). In New Zealand, the science system has undergone significant changes since the 1990s with the sector becoming increasingly aligned with the political drive for a knowledge economy (Halliwell & Smith, 2011; Hunt, 2003, 2009; Leitch & Davenport, 2005; PCE, 2004). This has been led by a political desire for science to be more cost effective, transparent and client-focused (Devine, 1997, 2003; Halliwell & Smith, 2011).

Science changes in New Zealand were initially progressed through the establishment of a contestable science funding system, the creation of the government-owned Crown Research Institutes (CRIs) and the eventual dissolution of government funded agricultural extension services. These reforms significantly changed the way science is conducted in New Zealand (Devine, 1997; Easton, 1997), as the CRIs operate as businesses in competition with universities and other research agencies while seeking research funding from both public funds and through commercial ventures.

Devine (2003: 70) argued that while the 1990s science reforms raised the quality of research and enabled the CRIs to earn significant overseas revenue, the presiding economic dogma viewed growth in terms of “efficiency and good business practice”. Hunt (2009) contends that this has led to an emphasis on research that supports patented or licensed commercial products or processes, rather than directed at improving public goods (see Journeaux & Stephens, June 1997). It has also resulted in a continuing “struggle” between the CRIs and universities for limited research funding (Halliwell & Smith, 2011).

Although the science reforms sought to create a more client-focused system, the competitiveness between science providers has been argued to have “bred a culture of mistrust and competition rather than collaboration” (New Zealand Association of Scientists, 2010). It is also argued to have acted as a barrier to interdisciplinary research (Gluckman, 2009 July) and led to low job satisfaction and enthusiasm among CRI scientists, bought on by a need to comply with management requirements (Hunt, 2009). It is too early to assess the impacts of a recent change to reduce the competitiveness of the science funding system by introducing core funding for a significant portion of the CRI’s budgets (MSI, 2013). Parker (2013) suggests that although core funding has assisted in reducing the uncertainty of revenue streams, around 60% of research funds to SCION (a CRI) are still sourced through contestable funding and commercial ventures.

In evaluating New Zealand’s science sector as a driver of environmental sustainability in agriculture, the Parliamentary Commissioner for the Environment (PCE, 2004) claimed that while New Zealand’s science research was highly regarded, there were concerns over both the type of research that was being funded and how the outcomes from science research were being communicated. In a review of ‘publicly’ funded projects, the PCE (2004: 53) found significantly less research conducted “into the natural resources necessary for farming (such as water and soil)” relative to research into “the manipulation of natural resources for farming and farming management practices to improve production”. Research therefore is targeted more at increasing agricultural production than mitigating or preventing impacts of agricultural externalities, although the PCE acknowledged the significant contribution of the Sustainable Farming Fund (which supported five of the six cases in this research) towards improving land management practices to address “the health and functioning of natural resources”.

The PCE (2004: 53) further contended that the Government’s science funding agency, the Foundation for Science, Research and Technology (FRST), which was established in 1992 to largely remove government from direct involvement with science funding decisions (see Devine, 1997: 73), had undergone a revision to better reflect “Government priorities for knowledge development and wealth creation”. It can be assumed that this revision was more likely to see the Fund support research that was directed at increasing production. This highlights the impacts that changing political contexts have on research funding with flow on effects to the resourcing of sustainability projects.

In 2010 the Government made 'knowledge transfer' a core purpose of each CRI (MORST, 2010). On the surface, this can be seen as a positive move, since the demise of publicly funded extension services in the 1990s fragmented agricultural extension in New Zealand, leaving it to be serviced by an array of providers including private extension professionals, commercial companies, industry good bodies, local and regional councils and the CRIs (Neels Botha, Coutts, & Roth, 2008; Hall, Morriss, & Kuiper, 1999; Massey, Morriss, Alpass, & Flett, June 2004). A recent survey investigating technology transfer in New Zealand (Ministry of Primary Industries, 2012) casts some doubt over the CRIs effectiveness as communicators of science, with farming respondents reporting the perception of a growing disconnect between the farming and science sectors, despite increasing interest in finding ways to increase the adoption of sustainable innovations and practices on the farm.

This evidence raises concerns about the role CRIs can play in advancing agricultural sustainability. It is unclear how the increasing commercial focus of the CRIs will impact the implementation of agricultural sustainability. Indeed it is unclear whether the CRIs have both the capability and the capacity to undertake knowledge transfer to address complex problems such as sustainability. What is apparent from recent changes to the science system in New Zealand is that agricultural research and extension is once again at a crossroads and is facing an uncertain future.

1.3.4 The farming sphere and sustainability implementation

Farmers operate both as individuals serving their own interests and within a wider social network that is influenced by local, regional, national and international constraints (Barr & Carey, 2000; Oreszczyn, Lane, & Carr, 2010). These considerations are in turn influenced by political, social and economic factors (Darnhofer, Fairweather, & Moller, 2010; PCE, 2004). Worldwide, farmers face pressure from the globalisation of agriculture and food production through the growth of multi-national agrifood companies, large-scale food production, cost reduction, and market liberalisation (Cocklin & Dibden, 2005; PCE, 2004; Rivera, 2011).

Farmers in New Zealand are particularly vulnerable to international and national economic drivers such as changing global markets, world trade policies, exchange rates, oil prices, commodity prices and the requirements of overseas markets and national and international supermarket chains (PCE, 2004). For example, increases in world commodity prices particularly for milk (up to 2014) and a favourable political environment, prompted a significant increase in farm conversions to sustain growth in New Zealand's burgeoning dairy sector (Statistics NZ online). This growth has resulted in vigorous debate in the public arena about flow-on environmental effects of agriculture (Laxon, 2014).

Farming practice is also shaped by factors such as regional regulations, land value, debt servicing, water availability and pricing, and regional infrastructure. Consumer demands for safe food, source of origin labelling and concerns about agricultural pollutants can also have indirect flow-on effects to farming practice through government policy and retailer buying decisions, particularly from supermarket chains (PCE, 2004). Cocklin and Dibden (2005) argue that these contributing factors cause a constant tug-of-war between production / productivity and environmental management.

It is therefore too simplistic to assume that farmers can be induced or persuaded to simply adopt innovations that are developed to address agricultural impacts (Pretty, 1995, 1998). Although research shows that farmers may readily adopt clearly defined innovations that address single-issue innovations such as vaccinations to prevent disease (Van Den Ban & Hawkins, 1988), farmer adoption of sophisticated innovations is often low in New Zealand (Jago, Davis, Newman, & Woolford, 2006).

International innovation adoption studies show a complex mix of factors influence farmers' decisions to adopt (Barr & Carey, 2000; Kilpatrick, 2003; Welsh & Young Rivers, 2010). Rogers' (1983, 2003) seminal research into innovation adoption and diffusion showed a number of intrinsic factors of an innovation influenced farmer adoption. He claimed these were: perceived efficiency gains offered by the new innovation compared to staying with existing tools or practices; the innovation's compatibility with a farmer's socio-cultural values, beliefs and needs; its complexity and ease with which the innovation could be explained; its "trialability", with a farmer being more likely to adopt an innovation that could be trialled; and its "observability", since it was increasingly argued in both the sociology and psychology literature that people learn through imitation. Rogers and other scholars (Pannell et al., 2006; Vanclay & Lawrence, 1995) have shown that adoption of innovations is not based solely on an innovation's technical aspects.

New farming practices must align with what is deemed to be "right" by individual farmers and the networks to which they belong (Phillips, 1985). At the individual level, a farmer's willingness to implement more sustainable practices is influenced by his/her vision of 'good' land management (Vanclay, 2011; Vanclay & Lawrence, 1995). Agricultural sustainability appears to align well with farmers' land stewardship ethic, which is often cited as an integral motivator of farming practice (Barr & Carey, 2000; Federated Farmers New Zealand, 2007; Kroma, 2006). This ethic implies that a farmer, recognising his/her dependency on the land, feels ethically responsible to look after the land on which they farm. Federated Farmers in New Zealand promote this ethic on their website (Federated Farmers, 2007).

> I am confident our existing land use is sustainable. Our farm represents our family's asset and net worth – I am charged with looking after that for my family and our future. The land is our biggest asset, I take the responsibility of looking after that asset very seriously.
>
> *(Edward Aitken, NZ Federated Farmers, 2007)*

As the quote suggests, stewardship, while showing an ethical responsibility to the land, is typically viewed through an economic rather than an environmental lens. Indeed academic commentators consistently agree that rarely does a farmer's land stewardship ethic alone lead to environmental action (Barr & Carey, 2000; Smith et al., 2007). Tensions exist between a farmer's perceived conservation attitudes and sustainable land management. Typically concern for the environment and positive conservation values, do not translate effectively into more sustainable practices on the farm or adoption of sustainable innovations (Vanclay & Lawrence, 1995). Furthermore "contradictory trajectories" can co-exist with some farmers adhering to environmental best practice to secure elite markets, while others continue along a productivist pathway (Haggerty, Campbell, & Morris, 2009: 768).

Studies show that while farmers utilise the agricultural sciences and physical observation to identify and resolve farm problems, they rarely utilise or place the same credibility in the ecological or environmental sciences, associating these with 'green' and conservation agendas (Smith, Montgomery & Rhodes, 2007). This is problematic for sustainable land management, which is argued to require a more ecological approach to farmer management decisions than currently exists (Pretty, 2006).

While the productivist paradigm may be a dominant force that shapes farming practice, farmers and farming groups do actively engage in environmental initiatives, and proactively search for more sustainable approaches to land management. When present, these networks have very positive effects in stimulating farmer learning on issues including environmental matters. For example, farmers in Landcare groups in Australia have a higher adoption of best practice land management approaches, as well as greater awareness and level of knowledge about land degradation issues (Campbell, 1994, 1998; Curtis & De Lacy, 1996; Nicholson et al., 2003). Their success was dependent on a supportive policy framework of stable funding, strong linkages with outside agencies, effective facilitation, leadership, local co-ordination and flexible management that encouraged farmer experimentation (Sobels, Curtis, & Lockie, 2001). However, Wadsworth (2010: 202) reported that the conditions under which Landcare networks functioned and worked effectively have been eroded by policy changes, which has led to a decline in the number of groups.

The Australian Landcare groups indicate the importance and success of self-organised peer networks for stimulating change for sustainability, a feature also identified by Leeuwis and Aarts (2011) as critical for fostering change in agriculture. The evidence from the research of the Landcare groups also highlights the importance of a supportive institutional framework for fostering peer networks and how their effectiveness can decline if this supportive framework is eroded by policy changes.

1.4 Investigating the use of participatory research to advance sustainability

1.4.1 A new approach to addressing sustainability

There is a compelling need to develop innovations and knowledge to advance sustainability in the agricultural sector to address the environmental impacts of agriculture. Given the characteristics of sustainability outlined in Section 1.2, it is widely recognised the science that is required to address sustainability issues will be very different from a purely reductionist approach to science, despite such approaches still being able to make a valuable contribution to problem identification and solution development within a more holistic and enriched framework.

New approaches to science have therefore emerged in response to the call for science to address the socio-ecological complexity of environmental issues. 'Post Normal Science' described by Funtowitiz and Ravtez as an "enriched" systems theory (1993) that is "dynamic, systemic and pragmatic" (1994: 198), emerged in the 1990s as a direct response to calls to democratise knowledge by embodying multiple perspectives into decision-making. Extended peer communities are advocated that involve both expert and lay stakeholders engaging and collaborating through dialogue. As Funtowitz and Ravetz (1993: 73) argue,

> The reductionist, analytical worldview which divides systems into ever smaller elements, studied by ever more esoteric specialism, is being replaced by a systemic, synthetic and humanistic approach.

Post normal science, therefore directly challenges traditional notions of certainty and constancy in systems. As Funtowitz and Ravetz provocatively stated (2003: online);

> The approach used by normal science to manage complex social and biophysical systems as if they were simple scientific exercises has brought us to our present mixture of intellectual triumph and socio-ecological peril.

The new vision for science reflected wider calls for science to engage with society, what Lubchenco (1998) referred to as a "new social contract for science". This vision was reflected in Gibbons et al. (1994) Mode 2 model of science, which they described as transdisciplinary, heterogeneous and heterarchical. This mode contrasted with the more disciplinary, homogeneous and hierarchical model of traditional 'Mode 1' science. Ravetz (2006: 277) however argued that Mode 1 thinking is very different to post normal science in that it has "no discussion of quality, no hint of a social critique, and no mention of an extended peer community".

The new vision for science appeared also to be evident in a number of government and non-government organisation publications and reports (for example Royal Commission of Environmental Pollution; Wellcome Trust & Office of Science and Technology, 2000

October) and most notably the British House of Lords' Third Report titled, *Science and Society* (British House of Lords' Select Committee on Science and Technology, 2000) which signalled a need for more emphasis on engaging with society over science matters. While at first glance the report's call for engagement appeared to be a watershed in thinking, some still argue it contained implicit undertones that public criticism of technological advancement is anti-science and irrational (Allan, 2002; Dickson, 2000).

Sustainability science emerged at this time to link knowledge to action and by doing so to contribute to solutions to address the complexities of sustainability issues (Kates et al., 2001; Komiyama & Takeuchi, 2006; Wiek, Farioli, Fukushi, & Yarime, 2012). In keeping with the growing trend towards engaging society over matters that affected them, sustainability science scholars recognised that multi-stakeholder engagement was essential to ensure a wide range of perspectives were included in decision-making relating to sustainability (Wiek et al., 2012).

Participatory research is put forward as an effective approach for multi-stakeholder engagement, as it is inherently collaborative and inclusive so as to bring a wide base of expertise to both identify problems and co-develop solutions (Reed, 2008). Participatory research has long been advocated as an effective approach to research that sees farmers, scientists and other rural stakeholders engage in collaborative learning to promote rural change and facilitate a move to more sustainable agricultural practices (Leeuwis, 2004; Leeuwis & Aarts, 2011; Pretty, 1995; Pretty et al., 2010; Rolings & Wagemakers, 1998; Vanclay & Lawrence, 1995). Success of such endeavours is not measured by the number of workshops held, the number of people who attended, the number of leaflets distributed or the number of popular articles published. Such simple quantitative indicators would buy into a participatory dogma that values participation by numbers rather than real and lasting change (Vanclay, 2011; Ziegler & Ott, 2011).

Participatory approaches can foster transdisciplinary environments that enable collaborative engagement and learning with multiple stakeholders from both inside and outside the science and technology communities (Polk, 2014, online; Wiek, Farioli, et al., 2012; Wiek, Ness, Schweizer-Ries, Brand, & Farioli, 2012). These environments are widely valued because they acknowledge agriculture as a ‘human’ activity and recognise the constructed nature of agricultural knowledge.

Collaborative engagement can challenge traditional ways of how knowledge is generated and push the boundaries beyond science as the only ‘legitimate’ knowledge (Urlich, 1998). Applied to sustainability in agriculture, collaborative multi-stakeholder engagement and learning in a transdisciplinary environment will therefore likely challenge assumptions and values of both farming and science practice. Transdisciplinarity encourages partnerships between scientists and non-scientists that can encourage new ways of thinking from a process of cumulative and incremental learning (Allen, Kilvington, Nixon, & Yeabsley, 2002; Allen, Kilvington, Oliver, & Gilbert, 2001; Keen et al., 2005b; Leeuwis & Pyburn, 2002; Reed et al., 2010; Roling & Wagemakers, 1998b; Sims & Sinclair, 2008).

Arguably the suitability of participatory approaches for advancing sustainability is driven by the inclusive nature of these approaches and the potential they have for mobilising collective action in local communities, that is necessary for sustainability (Dale & Onyx, 2005; Pretty, 2003; Pretty & Ward, 2001; Robinson, 2004; WCED, 1987). Given the complexity of socio-ecological systems as discussed in Sections 1.2 and 1.3, the road forward will not be straightforward. Indeed the sustainability science literature raises concerns about both the changes in personal attitudes and institutional support that will be needed to facilitate collaborative endeavours to advance sustainability (Klerkx & Leeuwis, 2009; Wiek et al., 2012).

1.4.2 Thesis’ research scope and objectives

This thesis uses New Zealand’s farming and science landscape to provide a rich context to examine how effectively participatory research projects facilitate collaborative learning partnerships to advance agricultural sustainability. Farming remains a dominant force in New Zealand’s economy (PCE, 2004) and land-use data shows that just over 54% of New Zealand’s landmass is allocated to farming practice with the agricultural sector directly contributing to over 50% of New Zealand’s total merchandise export earnings (Statistics New Zealand, undated). New Zealand rural communities, like other countries around the world, face increasing pressure to address wide social concerns about the detrimental environmental effects of farming practices. In New Zealand there is also concern that the agricultural sector is underperforming in promoting and improving its environmental performance (PCE, 2004).

Policy and funding agencies have challenged New Zealand scientists to build greater capability for participatory approaches into science research projects. As discussed in Section 1.3.3, this call for participatory research occurs against a backdrop of significant restructuring in the science sector and the dissolution of publicly funded agricultural extension services. While the employment of participatory approaches in science research parallels trajectories in other countries, observations from its application in New Zealand agricultural projects, can inform approaches elsewhere.

Worldwide many large-scale multi-disciplinary participatory research projects have addressed sustainability issues in rural environments at regional and multi-national levels. These projects have often been long-term and supported by staggeringly large budgets and their achievements have been reported extensively (see Fenemor et al., 2008; Ison et al., 2007; Tippett et al., 2005).

Micro-level participatory research projects that address grassroots initiatives to improve agricultural sustainability receive far less funding and academic attention. Although numerous publications in technical agricultural journals outline the scientific achievements of micro-level projects (Allan et al., 2013; Turner, Rijswijk, Williams, Barnard, & Klerkx, 2013), little has been published in these journals about the employment and effectiveness of participatory research as a means to advance sustainability.

With increasing support by policy and funding agencies for participatory approaches in science research in agricultural sustainability, these micro-level projects are now scattered throughout the landscape. They are typically locally created, locally targeted and locally implemented. While participants may recognise that change in rural communities requires people to work together in collaborative partnerships, there are no guiding principles by which these collaborations should occur, nor a clear articulation of how these partnerships might best operate.

This research has two principal objectives:

- to gather and interpret empirical evidence from a range of participatory agricultural sustainability projects to enrich understanding of the theory that informs the practice of participatory research to enhance stakeholder collaboration and learning;
- to provide deeper insight and clearer guidelines for the practice of participatory research to advance sustainable agriculture in farming production systems.

The first objective has relevance beyond the agricultural context of this research, as its focus is on participatory research. The second objective however provides guiding principles for the application of participatory research to advance sustainability in an agricultural context. The dual theoretical and applied focus of this research is intentional, as participatory research practice should be informed by both theory and real world evidence.

1.4.3 Thesis central research question

Investigating six participatory agricultural research projects in New Zealand, which are outlined in Chapter 3, the thesis addresses the following central and focusing questions:

> How effectively does micro-level participatory research in the agricultural sector advance more sustainable farming practices in agricultural production systems?

Focusing questions

- How do formal and informal institutions affect project partnerships and learning outcomes?
- How are partnerships articulated, formed and fostered in projects?
- How successfully is local and scientific knowledge co-produced in projects to foster innovations that advance agricultural sustainability?
- What effect (if any) does project learning have on actor understanding of the complexity of sustainability?

1.4.4 Thesis outline

The thesis has eight chapters. The first three chapters outline the theoretical and conceptual framework and the methodological approach to the research. The first two chapters investigate the key concepts of sustainability and participatory research to build clarity around these somewhat ambiguous concepts. Chapter 3 discusses the methodology that provided a rich and large source of empirical data through investigation of six participatory research projects. Empirically-based findings presented in Chapters 4, 5 and 6 focus on institutions, partnerships and learning respectively. Chapter 7 synthesizes this empirical evidence, and develops a conceptual framework that demonstrates the research's contribution to the wider understanding of the practice of participatory research. The final chapter advances the application of participatory research for agricultural sustainability.

Chapter One

This chapter has argued that the greatest challenge for sustainability lies in its implementation and introduces participatory research as a multi-stakeholder approach for advancing sustainability. The chapter contends that to meaningfully advance sustainability in agriculture, sustainability needs to be recognised as a multi-dimensional, interconnected and complex concept.

Chapter Two

This chapter explores the path by which participatory approaches have emerged as an alternative to traditional approaches to science research in the agricultural sector. It examines and critiques the participatory literature to explore the strengths and limitations of employing participatory approaches to promote environmental change. The discussion also moves beyond the participatory literature and explores the farming systems literature and more specifically the agricultural innovation systems (AIS) literature to enhance understanding about the co-development of innovations in agriculture. Combining the participatory research and farming systems literatures provides deeper understanding about learning to enact change in agriculture, which is regarded as a key requirement for advancing sustainable agriculture.

Chapter Three

Chapter 3 outlines and discusses the case study design of the research, which has been guided by Yin's (2003, 2009) approach to case study research and Saldana's (2009) approach to the analysis of empirical social research data using coding and analysis. The chapter presents an overview of the case studies investigated in this research. A critical appraisal of the appropriateness and robustness of a multiple case study research approach for investigating sustainability as a social process is presented. The multi-method approach of this research design is outlined. This includes stakeholder interviews, field and participant observations and project documentation review. Emerging from this approach, three key themes form the foci of the empirical results Chapters 4, 5 and 6.

Chapter Four

Projects that seek to address sustainability in agricultural systems operate within complex contexts. This chapter examines the major actors in the projects and the wider institutional contexts in which they operate. Existing institutions are argued to enable or disable innovations. This chapter seeks to identify the hard and soft institutional contexts which shape actors' visions of participatory research and which may enable or disable innovation. To do this it examines policy/funding, science, and farming group actors' motivations for engaging in, and their expectations of, participatory research. Findings from this chapter provide a foundation for the subsequent analysis of project partnerships and project learning in the following two chapters.

Chapter Five

The participatory literature argues that partnerships should be based around notions of co-operation, reciprocity, equality, shared understanding, trust, conflict management, negotiation and dialogue to support the co-production of innovations. The participatory research projects in this research sought to advance sustainability by establishing partnerships between science providers and farmers. This chapter explores how effectively the projects established and maintained partnerships. A novel approach for characterising partnerships is developed. Use of this approach generates insight into the different types of partnerships that formed and how these partnerships affected project objectives and project relationships. It also identifies project dynamics that shape partnerships. Findings from this chapter extend notions of partnerships beyond them being considered solely as a contractual agreement to explore the importance of the relationships that exist within the partnership.

Chapter Six

Chapter 6 explores how effectively participatory research provides a platform for the integration of local and scientific knowledge into project decision-making. The chapter explores actor learning to identify dynamics that influence knowledge production. It compares and contrasts the effect on actor and project learning of minimal collaboration between farming and scientist partners with situations in which partners create interactive learning environments. The chapter examines the effect that learning platforms have on learning at both the individual and social levels.

Chapter Seven

This chapter synthesises the discussions from Chapters 4, 5 and 6 to integrate the previous chapters' discussions about institutions, partnerships and learning. While these have each been discussed as discrete subjects in the previous three chapters, they are recognised in this chapter to be highly inter-related dynamics of participatory research projects. This inter-relatedness underpins the thesis' contribution to the understanding of participatory research. The chapter presents a model to conceptualise how project actors and their institutional contexts create both partnerships and relationships that shape a collaborative learning space. The model is applied to the investigated projects to examine how effectively learning is realised in projects to support moves towards sustainability.

Chapter Eight

This final chapter reflects on the thesis' central and focusing questions before reflecting on participatory research as a methodological approach for developing new knowledge and practice to advance sustainability in agricultural production systems. Finally the chapter reflects on the limitations of the research and proposes areas for further investigation.

CHAPTER TWO

2.0 Participatory Research in Agricultural Contexts: A Literature Review

2.1 Introduction

Chapter 1 argued that when sustainability is viewed as a multi-dimensional, interconnected and complex concept then implementing research to advance sustainability requires collaborative engagement between a wide range of stakeholders from both inside and outside the science and technology systems to ensure multiple perspectives are included in decision-making. Participatory research provides a suitable approach to research for transdisciplinary collaboration and reflexivity (Popa, Guillermin, & Dedeurwaerdere, 2015). Indeed, scientists are now increasingly encouraged by policy and funding agencies to engage in participatory endeavours (Kerckhoffs, Bruges, & Smith, 2006; Williams, 2007).

This chapter examines the literature around the use of participatory approaches in the agricultural sector. It outlines the emergence of these approaches and explores and critiques the rationale for participatory research as a collaborative approach to multi-stakeholder engagement to advance sustainable agriculture.

The literature examining participatory research is extensive spanning all disciplines in the social sciences. This chapter's discussion is informed by research in this broad body of literature and explores three areas of focus that are dominant in the participatory literature: knowledge creation and integration, collaborative learning and power structures. Examples are largely drawn from studies in the agricultural sector. As initiatives that seek to advance agricultural sustainability are essentially agricultural innovation initiatives, the final section of the chapter engages with farming systems research and particularly Agricultural Innovation Systems (AIS) research to enhance understanding of how participatory research is applied in agricultural innovation.

2.2 Participatory approaches: an alternative to traditional agricultural research and extension

In an agricultural context participatory approaches slowly emerged in the 1970s and 1980s as an alternative to the Transfer of Technology model (TOT) where agricultural scientists determined priorities and developed technologies and then transferred the knowledge to leading farmers through extension workers (Chambers, Pacey, & Thrupp, 1993). The TOT model promoted a linear top-down approach to agricultural research and extension with information transferred one way from scientists to end-users.

The model also rather simplistically saw innovation as being inherently good for farmers (Ison, 2005), and it assumed all farmers would eventually adopt an innovation as it slowly diffused through the farming community. It was recognised that adoption would occur at different rates as predicted by Rogers (1962, 1983, 2003) Innovation Diffusion Model, and that the rate of adoption would typically follow an S shaped curve (Figure 2.1). Rogers categorised adopters along this curve depending on their speed of adoption as: innovators; early adopters; early majority; late majority; or laggards (Figure 2.2).

While the diffusion model influenced agricultural extension practice for much of the second half of 20th century, (and is still being taught to change agents, see Robinson, (2015)), scholars claim that it does not adequately reflect how farmers utilise and adopt innovations, and the subjectivity of the category labels only further reinforces this criticism. Furthermore Ison (2005) criticises the model for appearing to blame end-users for a failure to adopt (Ison, 2005; Phillips, 1985; Ruttan, 1996).

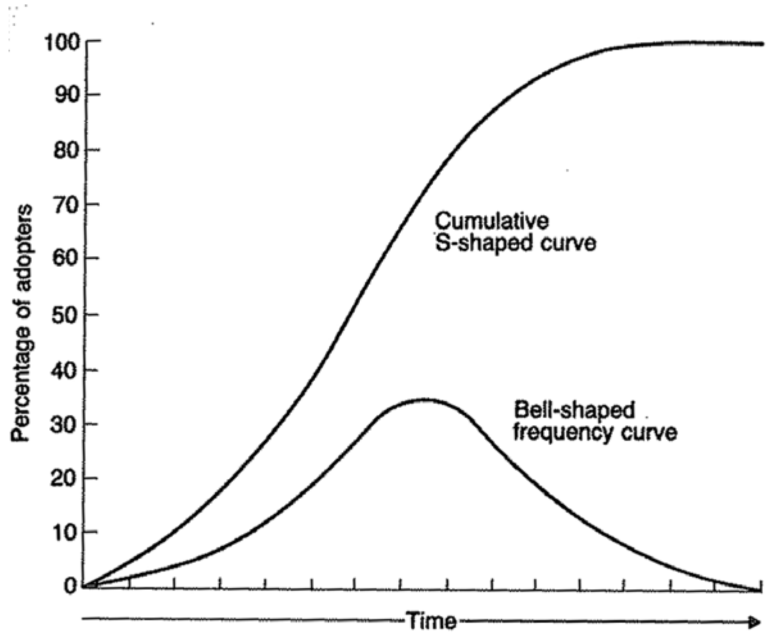


Figure 2.1: Rogers (1983: 243) S-shaped (cumulative) curve and bell-shaped (frequency) curve, showing the adoption distribution (image taken from Van Den Ban & Hawkins 1988: 105)

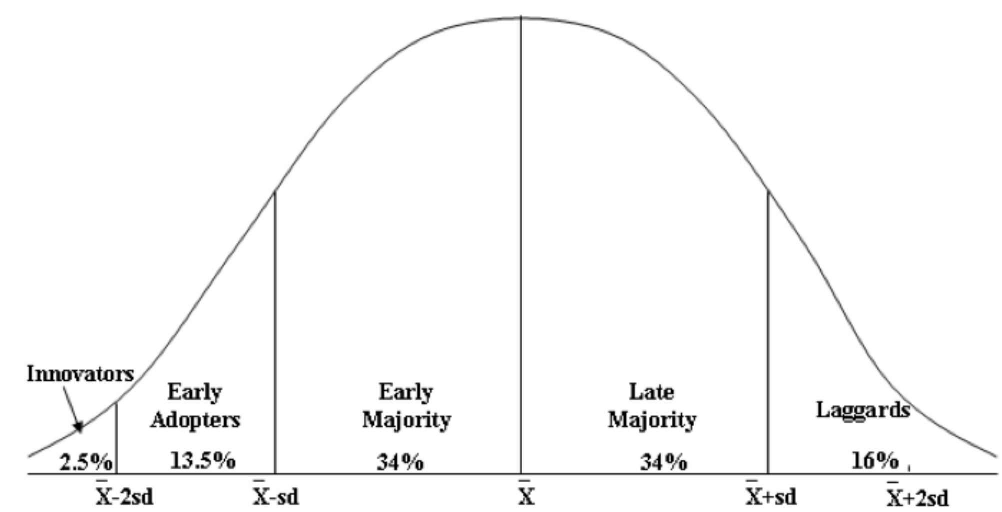


Figure 2.2: Rogers (1983: 247) adopter categories (image from Van Den Ban & Hawkins 1988: 105)

State funded extension largely adhered to the TOT model and the Innovation Diffusion Model (Leeuwis, 2004). This encouraged a linear top-down approach to research and extension and a focus on innovations that would diffuse rapidly which Van Den Ban & Hawkins (1988) claim favoured simple innovations and those that maintained the dominant thinking. Scholars contend that TOT state funded farmer extension programmes were often poorly implemented, bureaucratically inefficient and not relevant to farmers' needs (Jones & Garforth, 1997). Indeed both models are argued to largely ignore the wider social, political and economic context in which farmers, researchers and other stakeholders operate (Scoones & Thompson, 1994).

New Zealand's state funded extension service largely followed a TOT model and focused on increasing farm productivity with the overall aim of improving financial returns from agriculture (Journeaux, 2009 June). Extension officers were annually provided with a list of topics to cover with farmers by stated deadlines. Although a review of the service showed that it was "aimed at the individual farmer rather than national goals" (Gilmour & Victoria Dept of Agriculture, 1975: 2), government policy still determined which farmers would be advised and the intensity of the advice. While this reflects a top down approach to extension, the New Zealand agricultural extension service nonetheless was highly regarded by farmers and government administrators, with an Australian reviewer claiming the Victorian state of Australia would do well to emulate it (Gilmour & Victoria Dept of Agriculture, 1975).

The rise of neoliberalism and market liberalisation worldwide bought about changes to farmer extension services as the relevancy and necessity of publicly funded services came under increased scrutiny (Hall & Kuiper, 1998). Significant cuts to agricultural support in industrialised nations during the 1980s and 1990s led to increased privatisation and commercialisation of extension services and the growth of demand-driven research and extension (Hall & Kuiper, 1998; Klerkx et al., 2006). During New Zealand's neoliberal reforms in the mid 1980s, which were regarded to have gone further than most other countries (Peters, 2001), almost all agricultural subsidies (Cloke & Le Heron, 1994) and support were removed and farmer extension services were fully privatised over a nine-year period between 1986 and 1995 (Hall & Kuiper, 1998).

Participatory approaches to agricultural research, which would see farmers and scientists collaborate in research projects emerged at the same time as public agricultural extension services were in decline. While they appeared in industrialised countries in a variety of guises (see Buhler et al., 2002), they all recognised to some degree the value of local knowledge and a need to involve farmers in decision-making (Okali, Sumberg, & Farrington, 1994). In so doing, participatory research offered a more inclusive engagement of non-scientists in agricultural research and extension that had not been promoted through the TOT model.

The call for increased farmer participation in agricultural research and extension during the 1980s followed the wider employment of participatory methodologies in local community-based research which sought for communities to benefit directly from research programmes and to set research agendas (Arnstein, 1969; Freire, 1970). These methodologies were closely aligned with action-based research, which aimed to bring about positive change in local communities (Freire, 1970; Kindon, Pain, & Kesby, 2007; Wadsworth, 2010). Participation was viewed as the democratic right of all citizens and optimistically argued to lead to collective action, empowerment, institution building and better decision-making (Arnstein, 1969).

Arguably though, the employment of participatory approaches in the agricultural sector stemmed more from a school of thought that valued participatory approaches as a means to increase efficiency (Pretty, 1995). This ‘utility’ approach assumes that farmer participation in research and extension leads to greater support for services and policy. Pretty (1995) however argues this is a rather naive assumption. While this ‘utility’ perspective appears to echo a return to the TOT model, it actually aligns more with the democratic approach evident in Freire’s (1970) writing than the TOT model, as it recognises the weakness of excluding stakeholders from outside the science and technology sector from participating in research and decision-making. Indeed Pretty (1995) describes the democratic and utility schools of thought as overlapping, and so claims they are not mutually exclusive.

Participatory approaches which emerged at the same time as wider policy and scholarly discussions about the democratisation of science (Section 1.4), do not seek to gain public support for science innovation through education or public outreach, an approach to science communication known as the public understanding of science model (Burns, O'Connor, & Stocklmayer, 2003). Indeed Reed's (2008) literature review of participatory research shows that scholars visualise the application of participatory approaches well beyond a public understanding of science model. He claims that while there is wide disagreement around what was 'best practice' for stakeholder participation, there are key characteristics of a participatory approach that appear to be common across the scholarly literature that should be evident in a 'participatory' project. These include: the process must be underpinned by empowerment, equity, trust and learning; it should be considered as early as possible; stakeholders must be analysed and be representative of the community; objectives must be widely agreed at the outset; the approach must be tailored to the context and will likely require skilled facilitation; local and scientific knowledge should be integrated into decision-making; and participation should be institutionalised to ensure its long term success.

2.3 Participatory approaches in agricultural research

Despite the inclusiveness of the participatory methodology, integrating expert and local knowledge in agriculture, using a participatory approach to research is often argued to be,

> a compromise between the inclusion of farmer management and a perceived desirability for an element of experimental rigour so as to allow statistical analysis.
>
> *(Buhler et al, 2002: 100)*

Even when farmer driven participatory approaches emerged, such as *Farmer First* (Chambers et al., 1993), their effectiveness was influenced by institutional contexts within science and policy that limited acceptance of farmer participation in research (Buhler et al., 2002). As a result, many research projects in the agricultural sector are argued to have remained a hydridisation of participatory and TOT approaches. Buhler et al. (2002) suggest this is partially due to projects being managed largely by physical scientists with little experience of participatory research and a considerably different epistemology to the farmers and other non-scientists with whom they worked (Buhler et al, 2002).

Compared to the TOT model, this "compromised participation" in agriculture (Buhler et al., 2002) still better reflects how knowledge is formed and shaped in rural communities (Bruckmeier & Tovey, 2008; Roling & Wagemakers, 1998b). Prior to such framings, recognition of farmers and farm advisors as social actors, and the social dimensions of knowledge creation were never acknowledged in 'purely scientific' approaches that adhered to the TOT model of research and extension (Klerkx & Jansen, 2010; Leeuwis, 2004).

In stark contrast, participatory approaches focus on knowledge creation and integration to enable local and scientific knowledge to be embodied into decision-making (Allan et al., 2013). Through collaboration and collective learning they seek to facilitate equitable transdisciplinary partnerships that co-develop innovations in a reciprocal and reflexive approach to learning (Boon, Maryse, & Perenboom, 2014; Crawford, Nettle, Paine, & Kabore, 2007; Polk, 2014) and in the uncertain, changeable environment of agriculture participatory approaches utilise systems thinking to develop adaptive and emergent solutions to complex environments (Darnhofer et al., 2012; Klerkx, Van Mierlo, & Leeuwis, 2012; Wiek, Ness, et al., 2012). These features of participatory research are explored in more detail in the following sections.

2.3.1 Knowledge creation and integration

Agricultural research that embraces a participatory approach seeks to create a collaborative environment that fosters a joint production of knowledge, co-developed by scientists, farmers and other rural stakeholders (Leeuwis, 2004; Probst, Hagmann, Fernandez, & Ashby, 2003). This collaboration brings different knowledges together and includes them in the decision-making process (Baars, 2011; Gibbons et al., 1994; Leeuwis, 2004). Giddens (1976) contends that explicit and tacit knowledge, what Lundvall and Johnson (1994) call the "know why" and "know how" of knowledge, should be drawn on to enable actors to assign meaning to their environment. Inevitably this is an iterative and ongoing process as people continuously shape and reshape their understanding of the world and refine their perspectives based on past and present experiences along with new encounters they gain along the way.

Leeuwis (2004) argues that since the knowledge needed to address agricultural issues, particularly complex issues such as sustainability is often not readily available, it has to be developed ‘on the spot’. This often entails close interaction between farmers, scientists and other rural actors. In this engagement, he claims that researchers need to recognise that farmer awareness of local environments and dynamics must be built into decision-making. Viewed in this way, a variety of stakeholders with different knowledge bases and experiences are able to formulate the problem and relevant solutions together. Leeuwis claims that farmers need to be conversant with a broad range of knowledge and be willing to draw on scientific knowledge. For example, Ingram’s (2008) study of farmers’ knowledge of sustainable soil management shows the value of drawing on scientific knowledge. She found that while farmers were technically informed, they lacked the in-depth “know-why” of scientific understanding to implement complex practices. In this instance, they displayed weak tacit or “know-how” knowledge of soil management to assist them with observation and interpretation.

Changing existing practices in agriculture is often met with significant resistance (Allen, Kilvington, Nixon, & Yeabsley, 2002; Pahl-Wostl, 2002). Some argue that only in an effective collaborative environment can this be understood and reconciled (Hale Butler & Goldstein, 2010; Keen, Brown, & Dyball, 2005a). Raymond et al. (2010) contend that projects can achieve greater uptake amongst local community participants, when they apply processes that successfully integrate different knowledges and actively seek to facilitate collaborative knowledge sharing and engagement between farmers and scientists. An empirical study by Allan et al. (2013) examined knowledge integration and uptake by comparing two projects that sought to integrate local and scientific knowledge to address issues of environmental sustainability. They found projects that actively sought to engage in collaborative exploration were more successful at bringing about transformations in practice.

The challenge of knowledge integration

However, as discussed above, integrating local and scientific knowledge into agricultural projects is not easy. Allan et al*.* (2013) found that to stimulate significant change, project processes need to be interactive, provide opportunity for shared reflection, involve collaborative experimentation and foster discussion and joint interpretation of results. Farmers also needed to be given opportunity to link results to farming practice through careful facilitation. When traditional approaches to research and extension were employed and information was transferred in seminars, meetings and field days, transformative change was not fostered. Although farmers participated in all events, their passive contribution ensured scientists dominated project development. Experimentation was replaced by demonstrations and reflection was anticipated rather than shared. The authors concluded

> "…the benefits of knowledge integration do not necessarily occur just because multiple types of knowledge are shared in a public place…the opportunities for information sharing and creation of joint knowledge need to be developed and maintained if participants are to benefit."
>
> *(Allan et al., 2013: 115)*

Furthermore, Hoffman et al. (2007: 362) contend that projects need to pay attention to capturing the tacit knowledge of expert farmers, since this knowledge is "context-specific, based on experience, often used intuitively and unconsciously...that cannot easily be copied or automated." They argue that the "mobilisation and externalisation" of tacit knowledge, "is a key factor for creating new explicit knowledge". As a result, formal experimental research should be more open to farmers' informal experimentation. They noted,

> "…experienced farmers must clearly be seen as experts who have developed a deep situational understanding of their environment and their profession. A considerable part of their performance is intuitive and non-reflective and entails a large body of tacit knowledge."

Integrating local and scientific knowledge into agricultural projects is widely recognised to be a complex process (Bicker, Sillitoe, & Pottier, 2004; Roux et al., 2011). Raymond et al. (2010: 1769) offer an explanation for this complexity, since they claim knowledge production and interpretation are

> "heavily influenced by people's personal perspectives and ideologies which are in turn shaped by contextual factors and the values of the society in which a person is embedded".

Participants also bring to projects their underlying perspectives that shape their philosophical standpoints (Raymond et al., 2010). Raymond et al. (2010) advocate for processes that promote discussion and negotiation to provide a platform that enables epistemological beliefs that underpin knowledge claims to be expressed, while also establishing the validity and reliability of those knowledge claims. Furthermore, Neef and Neubert (2011: 191) warn against stereotyping participants' according to rigid disciplinary boundaries. They argue that social scientists' research can sometimes display no more evidence of participatory elements than their natural science counterparts. They claim the successful integration of participatory approaches into projects "depends more on the personal characteristics of researchers than on their disciplinary background and the research approach."

'Normal' scientific knowledge viewed through a 'positivist' lens is typically portrayed as being objective and value free (Funtowitz & Ravetz, 1993; Pretty, 1995; Roling & Wagemakers, 1998). However, Raymond et al. (2010) argue that an emphasis on the need to be objective denies the socially constructed nature of knowledge production and interpretation. Others also argue that it denies the embedded nature of institutionalised science that shapes how scientists behave and practise science (Klerkx & Leeuwis, 2009; Sarewitz, 2004; Ziegler & Ott, 2011).

Evidence shows farmers' knowledge, which is often categorised as implicit local knowledge, and scientists' knowledge, which is usually categorised as explicit 'objective' knowledge, cannot be simplistically categorised this way as they both typically possess a complex mix of explicit and implicit knowledge (Fazey, Fazey, & Fazey, 2005; Ingram, 2008). Fazey et al. (2006) claim that while a scientist may have both explicit and implicit knowledge, they may still lack the necessary local understanding of the context to work effectively in a project. To alleviate these concerns, Raymond et al. (2010) contend that evaluating the skills and knowledge of participants at the earliest opportunity, rather than dividing participants into simplistic knowledge categories, will assist in identifying the relevant skills and knowledge needed for projects.

Resolving divergence through negotiation and communication

As stakeholders bring multiple perspectives to the table, participatory processes must accommodate divergence among participants over both the issue being addressed and any solutions. Reconciling such divergence requires scientists and non-scientists to view communication as dialogue (Leeuwis, 2004; Leeuwis & Aarts, 2011; Weber & Word, 2001; Yankelovich, 1991, 1999). Weber and Word (2001) however contend that the increasing specialisation of science makes dialogue problematic. Addressing divergence through communication endeavours that focus primarily on educating non-scientists, what Nelkin (1987) phrased 'Selling Science,' is argued to be too simplistic for the complexity of environmental issues that typically involve risk (Hornig Priest, 2001). Hornig Priest (2001: 98) contends that it is "questionable" to assume that a "knowledge deficit" drives fear and ignorance in non-scientists and that this then leads to the rejection of science innovations. This questionable assumption is also argued to ignore the underlying drivers of divergence between participants and underestimates the complex inter-relationship between knowledge and attitude, particularly in environmental issues (Sturgis & Allum, 2004).

Webler, Tuler and Kruger (2001) contend that conflicts that develop in participatory endeavours typically result from people's different expectations of the process, and not from the process itself. Reflexivity, a process of deep self-reflection as a means to question one's expectations, assumptions and values that drive behaviours and expectations, is increasingly advocated in transdiciplinary environments (Popa et al., 2015). Bergmans (2008) offers practical advice for gaining mutual understandings between divergent participants. She recommends participants meet regularly, get to know each other in both formal and informal settings and bridge gaps and different frames as interested parties rather than defenders of a viewpoint. Rosendhal, Zanella, Rist & Weigelt (2015) however raise concerns about the effect of power imbalances in transdisciplinary environments in marginal communities where knowledge co-production is sought. They claim reflexivity alone does not address how social positions including those of the science researchers influence the process of knowledge production. Drawing on feminist traditions they rather surprisingly advocate for taking a position of 'strong objectivity', where researchers explicitly assume sides in contested environments.

Engaging in participatory research and knowledge co-production can be very unsettling as it can challenge existing ways of knowing and doing. Exploring scientists' experiences from working with non-scientists, Weber and Word (2001) show that scientific integrity is not compromised by scientists being exposed to the divergent interpretations of non-scientists or by negotiating with non-science partners to reach mutual understanding. However Webler et al. (2001) contend that managing partner divergence is likely to require skilled facilitation and needs to be reconciled at the outset in a participatory process. Relationship and trust building are regarded as essential requirements of any participatory endeavour and highly valued in environmental and agricultural projects (Allan et al., 2013; Reed, 2008).

Vanclay (2011: 69) warns that "enabling participation is more difficult than getting a few representatives on a committee". Effective participation therefore should never be quantitatively measured, an approach to participatory research that Ziegler and Ott (2011: 37) refer to as "the dogma of participation". They argue this creates a sense of obligation to participation rather than an underlying commitment to collaboration and mutual understanding.

Communication in a participatory environment is widely recognised as a complex social process involving people constructing and co-constructing solutions in a very adaptive and emergent way (Clark, 2002; Douthwaite, Kuby, van de Fliert, & Schulz, 2003; Stirzaker et al., 2010). Knowledge is not viewed as a series of facts but actively constructed through dialogue and information-sharing activities that occur during social interaction. Communication is inclusive and interactive and meaning which is created through a two way process of communication is negotiated and contextual (Burns et al., 2003; Leeuwis, 2004).

2.3.2 Collaborative learning

Participatory processes should create collaborative and collective learning environments (Blackmore 2007; Keen, et al., 2005; Roling & Wagemakers, 1998). This contrasts with the linear approach of the TOT model, which sees farmers only as adopters of knowledge rather than as originators of knowledge. The TOT model assumes scientists alone develop 'better' technological solutions without considering who participates to define what is 'better' (Ison, 2005). The notion of collective responses and a collective sense of responsibility is also not a focus of the Innovation Diffusion Model which instead focuses on individual farmers with the explicit intention of changing behaviour so innovations will be adopted (Pretty & Ward, 2001).

Participatory scholars advocate for creating shared understandings of problems and co-produced knowledge amongst divergent stakeholders in what has been variously termed, extended peer communities (Healy, 1999), communities of learners (Allen et al., 2002), and a "master-class of experienced practitioners" (Baars, 2011: 601). Participatory research typically views learning through a constructivist epistemology. For example Ison (2005) argues that when scientists collaborate with other stakeholders as active participants in the process, learning becomes an emergent property of both the collaboration and the platforms that are created. The knowledge that is obtained from practical experience and gained though collaborative experimentation is then built into the resulting solutions (Uphoff 1992, quoted in: Blackmore, 2007: 514), so decision-making is collectively framed through dialogue (Brierley, 2009; Leeuwis & Aarts, 2011).

The literature is therefore emphatic that participatory projects should focus on the capacity of actors to learn together and to develop learning systems that are based on the involvement of all stakeholders. These constructivist notions of learning are not focused on traditional models of teaching. Learning is viewed as a continuous and holistic process of adaptation to the world, rather than as an outcome or a solely cognitive process. Conversely learning is not seen simply as a means to persuade people to adopt an innovation or practice but instead seeks to bring about transformations in people's perceptions and assumptions (Keen et al., 2005a; Mezirow, 1994; Sims & Sinclair, 2008). Participatory learning is closely aligned to Kolb's (1984) theory of experiential learning and Wenger's (1998) notion of Communities of Practice, in that both Kolb and Wenger believe that knowledge is continuously created rather than transmitted and acquired as occurs in more conventional approaches to research and extension.

Constructivism also rejects the knowledge deficit model of communication as a foundation on which to build understanding, since as Ison (2005) argues this wrongly assumes that only scientists possess knowledge and only farmers need to learn. Daniels & Walker (1996: 73) argue this assumption views communication in a "narrow and unidirectional" way that fosters the misconception that scientists themselves have nothing to learn. In contrast, the constructivist epistemology views learning as a mutual and reciprocal experience. Learning is therefore not seen as a means to persuade people to adopt.

Collaborative learning processes

To be effective, it is argued collaborative learning processes must be both iterative and interactive (Keen et al., 2005b; Roling & Wagemakers, 1998b). Farmers and scientists must be jointly engaged in setting research priorities and this engagement must continue throughout the whole process, not just in the planning stage (Hoffmann et al., 2007; Mostert et al., 2007). Extensive analysis of ten case studies from the European HarmoniCOP project shows that project success requires stakeholders to be jointly engaged in both defining the problem and the process, and that this activity needs to be transparent (Mostert et al., 2007). Raymond et al. (2010: 1766) contend that processes need to be,

> "systematic, reflexive and cyclic so that multiple views and multiple methods are considered in relation to an environmental management problem."

Keen et al. (2005a) argue that learning processes should be built on three agendas. Firstly, they should foster and develop equitable partnerships between communities, professionals and government. Secondly, they should develop learning platforms to enable people involved in an issue to meet and interact to resolve conflict, collaboratively learn and make collective decisions. Finally, they should create and foster learning values and ethics that lead to a transformation in the way people think. This transformation is known as double-looped learning (Argyris & Schon, 1978). When applied effectively this leads to a questioning of existing assumptions and practices that can generate new ways of knowing and doing. (Keen et al., 2005a) Research by Argyris (1999) in organisational management shows that double-loop learning is needed to address complex issues because it questions either the "governing variables" (Argyris, 1999: 68), that need to be considered to correct an error, or the actions that need to be taken. In contrast, single-loop learning, which occurs when an error is detected and corrected without question, is shown to only be appropriate for routine and repetitive issues (Argyris, 1999). While single-loop learning asks, "Are we doing things right?" double-loop learning asks, "Are we doing the right things?" (Lachlan CMA, 2013: 227). By so doing, double-loop learning takes learning beyond skill uptake to question the underlying assumption that drives practice.

This understanding of learning drawn from research in organisational management enhances understanding of participatory research, as it shows that learning to bring about change needs to go beyond simple skill learning. It provides insight into how change may be fostered by emphasising the importance of participants reflecting on and questioning the underlying assumptions that drive current practice.

However agricultural change requires people to work collectively and constructively (Pretty et al., 2010). To foster change Leeuwis and Aarts (2011: 27) argue that people must be provided opportunities or space to manouvre and interact with others, in what they call "a space for change". This is conceptualized as a discursive space (social-institutional space and biophysical space), lying at the intersection of the mental space and inter-actional space (Figure 2.3).

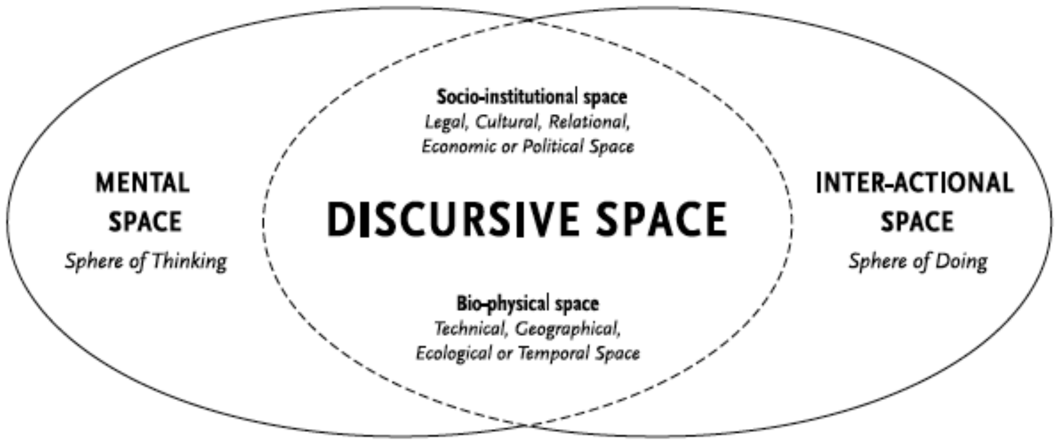


Figure 2.3: A space for change (Leeuwis & Aarts, 2011: 27)

Typically they argue the space for change will involve multiple and divergent actors interacting with each other while mobilising a variety of divergent "discourses, representations and storylines" that fluctuate between the dominant thinking and new ways of knowing and doing. To order and re-order the world, they claim people are influenced by a variety of socio-institutional and biophysical factors, such as the policy environment in which actors must operate or the physical landscape in which they must work. The resulting divergent conversations may cause conflict, however the authors claim that this should be seen as a positive element that through negotiation and communication activities (Section 2.3.1) has the potential to lead to change.

Social learning

While the extension literature most noticeably focuses on learning by individuals, particularly in relation to the adoption of innovations (Pannell et al., 2006), collective learning and action is regarded as critical for managing complex issues such as sustainability (Blackmore, 2007; Darnhofer et al., 2012; Hubert et al., 2012; Keen et al., 2005a; Leeuwis & Aarts, 2011; Muro & Jeffrey, 2008). The concept of 'social learning' has therefore emerged in the sustainability literature as it focuses on "shared learning of interdependent stakeholders as a key mechanism for arriving at more desirable futures" (Leeuwis & Pyburn, 2002: 11).

Social learning as a concept is regarded as "a bit messy" as it is argued to have no "common theoretical perspective, disciplinary heritage, or even language" (Wals & van der Leij, 2007). Despite this criticism, when employed in an agricultural context it views rural stakeholders as active, engaged and collaborative learners who collectively seek to meet the challenges they face in an uncertain and changing world (Parson & Clark, 1995: 429). Social learning is viewed as both a process and also as a mechanism or institution for change (Ison, Collins & Wallis, 2015). Projects become a space to reconstruct reality through communication, negotiation and dialogue (Kroma, 2006; Roling & Wagemakers, 1998b). Arguably, this leads to the co-production of new knowledge and new practices (Healy, 1999; Leys & Vanclay, 2011). Co-production of knowledge therefore acknowledges and seeks to capture the social dimension of knowledge creation and so moves the management of agro-ecosystems away from a purely technical focus.

Roling (2002) argues that to address complex issues such as sustainability, stakeholders must build interdependence as a means to create trust, resolve conflict, and importantly bring about social learning and concerted action. Roling uses the term 'concerted action' in preference to collective action to indicate the purposeful nature of the collaboration. This term was subsequently adopted by the European Union's SLIM project researchers who investigated social learning in the sustainable management of water at the catchment scale (Blackmore, 2007; Ison et al., 2007). Roling contends that "social learning can best be described as a move from multiple to collective or distributed cognition" (2002: 35). He claims that multiple cognition maintains the difference in actors' perspectives, collective cognition emphasises the shared attributes of stakeholders, while distributed cognition recognises the "different but complementary contributions that allow concerted action" (2002: 35). While Roling recognises that interdependence can lead to situations that result in winners and losers, he contends that when it is facilitated carefully through a process of learning, the result will move participants towards concerted action.

Research by Mills et al. (2011) that considered large-scale environmental programmes in agricultural settings in Wales showed that projects can lead to social learning and collective action. They found that by facilitating social learning at a landscape level in farming communities, groups not only acted collectively towards environmental outcomes, they also developed stronger levels of social capital through improved trust and an increased willingness to learn from each other.

Although shared interdependence is sought, there is wide acknowledgement in the literature that divergent parties will not necessarily reach consensus. While projects are seen as a space where stakeholders work together and engage in concerted action, participants can still hold different values and aspirations. As Keen et al. (2005:14) claim,

> The goal is not a single consensus, nor the lowest common denominator, but a rich tapestry that weaves together diverse ideas to reveal the nature of the complexity.

An emphasis on consensus-building is criticised for its idealism and its inadequacies in managing stakeholder conflict and divergent perspectives (Renn, 2004). Indeed, Mosse (2001) claims consensus-building minimises difference and promotes the normative view.

2.3.3 Power structures

Collaboration and spaces of interaction are however affected by power dynamics (Kindon et al., 2007; Rosendahl et al., 2015). Indeed Wildemeersch (2007: 107) contends that despite the "democratic" appeal of participatory methodologies, collaborative endeavours do not take place in a power vacuum. He contends that power relationships must be understood and that power sharing should be a fundamental principle of the participatory process. Participatory research is therefore concerned with, and how outcomes are affected by, power structures. The participatory literature often focuses on the coercion of power and the dominance of elites (Chambers et al., 1993; Cooke & Kothari, 2001; Kindon et al., 2007; Scoones & Thompson, 1994). Wildemeersch (2007) suggests to overcome power dynamics requires recognition of the capacity of local people and their values and practices. This is essential for advancing sustainability given that to address sustainability will require stakeholders with divergent perspectives to develop shared visions of the future (Section 1.2).

Kelly (2011: 168) asserts that participatory researchers must be acutely aware of power arguing that in natural resource management rarely is power directly mentioned and power struggles are often overlooked. She claims,

> Language often masks the importance of power, but the concepts relating to it often underpin how participatory programs operate.

Participatory approaches inherently require that traditional hierarchical power structures be replaced by more equitable partnerships when engaging in participatory endeavours. Arnstein (1969: 217) argues that power and participation are entwined, "…participation without redistribution of power is an empty and frustrating process for the powerless". In agricultural projects this means that multiple stakeholders, elite and community, work together as partners. This relationship replaces the more traditional role of scientists as experts giving "top-down" advice to farmers as passive recipients. Participatory approaches seek therefore to provide communities with a process that enables their aspirations, knowledge and experiences to be realised in projects. In essence the participatory process seeks to empower communities (Freire, 1970; Selener, 1997).

The challenge of working with communities

The notion of empowering communities may underestimate the challenge of working with communities and indeed rarely do participatory approaches follow the 'ideal' pathway that is implied in this approach. Implementation presents several challenges (Cornwall & Jewkes, 1995) which include control of the research rarely being devolved to the community or the community not wanting it even if it is devolved; lack of enthusiasm for the project by locals or suspicion of outsiders; demands on people's time preventing involvement; the time consuming nature of the methodology leading to exhaustion or fluctuations of interest; discrepancies over both the meaning of 'participation,' 'community' and 'learning' (Murray, 2000) stakeholder agendas or the exclusion or marginalisation of stakeholders by their community (Webber & Ison, 1995). Bradshaw (2003) even questions the credibility and capacity of communities to undertake resource management.

Furthermore researchers undertaking participatory approaches also struggle with the requirements of funding agencies, which tend to rely on evaluation measures that are more suited to the TOT model. As Webber and Ison (1995) argue, pre-determined outputs and measures undermine the essence of the participatory process. Furthermore, community reluctance or difficulty with meeting these outputs may lead to funding agencies and policy-makers perceiving participatory initiatives as vague. This leads to a preference for funding projects that are more clearly defined and monitored within a traditional TOT framework (Allen, 1998).

The effectiveness of participatory research may also be limited by scientific researchers and extension workers receiving inadequate training (Murray, 2000). Indeed, the approach may challenge the very essence of how scientists view themselves and science's role in the world (Roderiguez, Molnar, Fazio, Sydnor, & Lowe, 2008). Fergus and Romney (2005) argue that western science has historically been afforded a privileged position in agricultural research and extension.

Participation typologies

Assessing power dynamics in participatory projects can be problematic. Participation typologies have historically been used to assess the level and form of participation in research projects as a way of identifying power differentials (Biggs, 1989; Cornwall, Guijt, & Welbourn, 1994; Pretty, 1995). All typologies are concerned with who is included and who is excluded from the research process and are embedded in the belief that citizens have a democratic right to be involved in decision-making. The typologies identify differing levels of participation and are based on Arnstein's (1969) ladder of citizen participation (Figure 2.4) which described eight levels that ranged from non-participation at the bottom, through tokenism to citizen power at the top of the ladder. High levels of participation occurred when citizens were engaged in either a partnership with officials leading to a sharing of power and decision-making or at an even higher level where citizens may have power delegated to them allowing them to take complete control over decision-making. Arnstein (1969: 217) argued that power and participation were entwined, "…participation without redistribution of power is an empty and frustrating process for the powerless". It is argued that ideally participatory initiatives should seek the highest level of engagement (Cornwall & Jewkes, 1995).

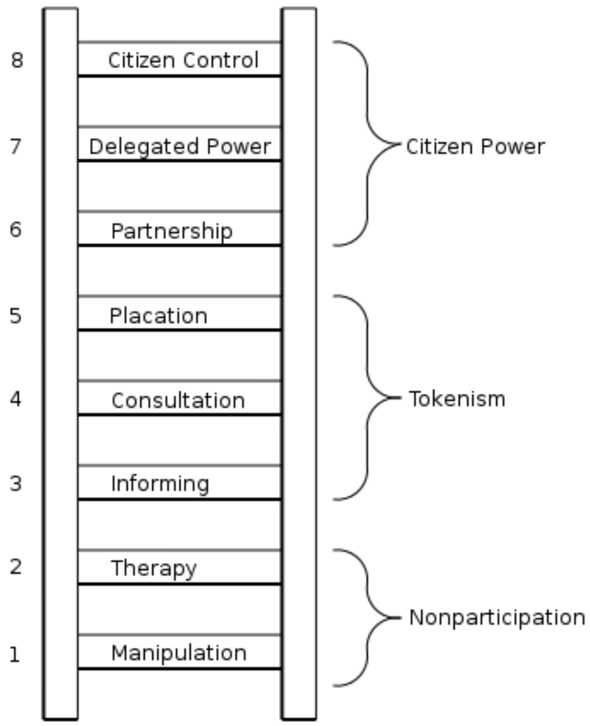


Figure 2.4: Arnstein's (1969) ladder of participation

Biggs (1989) applied this concept to agriculture in his typology of participation in the agricultural sector. He identified four levels of participation.

- Contractual: Communities are contracted to take part, but the experiments are largely designed and carried out by the researchers
- Consultative: Consultation with the 'community' occurs but the researchers remain in control of the project
- Collaborative: While the project remains largely research designed, initiated and managed, communities and researchers work together in the project
- Collegiate: Both researchers and communities have control over the process. There is co-learning. Each recognises the other's skills and incorporates these into the project.

Pretty (1995) identified seven levels of participation in his typology to describe how people participate in rural development projects. Pretty argued that community involvement leads to greater ownership of outcomes as well as continuance of practices beyond the time period of the project. Cornwall & Jewkes (1995) modelled a typology on Biggs' four levels and argued that participatory research sought to respect and understand the communities in which researchers work and recognised them as knowledgeable people who could meaningfully and jointly contribute to analysis and solutions. Probst et al. (2003: 6) modified Biggs four level typology to reflect the level of control and ownership communities had in decision-making.

Despite the prevalence of typologies in the literature throughout the 1990s, it is now recognised that classification of participation using a typology is too simplistic. Authors warn that a hierarchical ladder of participatory levels does not reflect the dynamic nature of participation and the way participatory engagement varies at different times in the life-cycle of a project (Stringer et al., 2006). Other authors rightly caution against the overly optimistic and almost romanticised view of higher levels of participation, where full control of project decision-making is devolved to communities (Balint & Mashinya, 2006; Bradshaw, 2003). They claim that without adequate support from lead agencies, projects may be doomed to fail.

Empirical evidence also shows that projects rarely reach the higher levels of participation indicated by the typologies (Cornwall & Jewkes, 1995; Pretty, 1995). Power structures in participatory endeavours can lead to competing agendas, exclusion of stakeholders or marginalisation of participants by their community. Pretty's (1995) analysis of empirical research in rural development projects undertaken by government agencies found that most agencies paid only token attention to upper levels of stakeholder engagement, some had no community involvement and in nearly all projects the funding was controlled by an outside agency. He argued that the only way to develop meaningful participatory learning processes in rural development projects was through decentralised organisations that recognised the multiple realties around issues, such that meaningful participative decision-making responded to the needs of farmers.

Recognising the limitations of participatory typologies, Neef and Neubert (2011: 192) published a more detailed framework to assist researchers undertaking participatory research. In their framework they identified six dimensions of a project: the project type; its approach; researcher characteristics; researcher/stakeholder interaction;

stakeholder characteristics and stakeholder benefits. Researchers are invited to use the framework to reflect on and plan the use of participatory approaches in agricultural research, so as to "optimize the use of participatory approaches in a given context, not to maximise the application of participatory methods in agricultural research in general". In this regard they reflect Ziegler and Ott's (2011) concern that researchers must not adhere to the participation dogma that more is better, but rather to optimise participatory endeavours that are undertaken.

While Neef and Neubert's (2011) research provides a comprehensive framework for reflecting on and planning a participatory project, the authors rightly caution against it being used as a formula or blueprint, but rather claim it provides researchers with overarching questions and areas for reflection as they embark on a participatory project. The framework makes a significant contribution to the understanding of participatory research by synthesizing the many strands in the literature to enable practitioners to reflect on their participatory endeavours.

However, as it treats the six dimensions as discrete entities, it does not explore the inter-relatedness of these entities or how different emphasis on the dimensions might affect the application of participatory research. Furthermore, although institutional contexts are acknowledged in the framework, their importance is underplayed, with the focus on the project researchers and stakeholders. Scholars of agricultural innovations systems (AIS) (see Klerkx et al., 2012) emphasise the need to understand the institutional context in a more substantive manner.

Although participatory research seeks to empower local communities, Neef and Neubert (2011) acknowledge that this should not be viewed in the emancipatory way of Freire (1970) but in a more functional way. This pragmatic approach therefore views participation as a means to an end rather than an end in itself. Even if this more pragmatic approach is taken in agricultural research, overcoming traditional power structures to advance sustainability is difficult. Integrating science and local farmer knowledge into decision-making challenges the very essence of the traditional model of science, which often relies upon an objective and reductionist methodology that some authors argue privileges western science in a 'research' environment (Fergus & Rowney, 2005; Kuhn, 1996).

Western science and traditional knowledge

The need to rebalance power structures is recognised to be most acute when participatory research is undertaken in marginalised communities. The historical relationship between western science and traditional knowledge in particular is recognised to be an uneasy one (Moody & Cordua-von Specht, 2005; Nadasdy, 1999; Walker & Ngati Porou, 2004). The challenge created by power differentials between western science and traditional knowledge communities is demonstrated in New Zealand, where Māori perspectives of being marginalised are argued to shape relationships between Māori and the Crown as exemplified by matters to do with science knowledge (Coombes & Hill, 2005; Newman & Moller, 2005). Durie (1998) argues that differences between Māori and western science worldviews have the potential to create tensions in spite of the Māori worldview appearing to be closely aligned to environmentalism and sustainability.

Despite government policy increasingly recognising the need to consult with Māori over a variety of matters including natural resource management, Māori often express concern over the sincerity of the consultation and understanding of the Māori perspective (Roberts, 2009). This is illustrated by a quote from Ngati Porou, an *iwi* (regional tribal body) on the East Coast of New Zealand, who partnered with scientists in one of the projects investigated in this research, when they stated,

> "The supremacy of Western knowledge systems, particularly science, has not only nullified Māori conceptions of the world, but further that such dominance has meant consultation has been a one-sided process with little understanding or acceptance of Māori views or processes."
>
> *(Walker and Ngati Porou (2004: 111))*

Participatory methodologies are recognised to be an appropriate platform for identifying cultural differences and building trusting relationships between scientists and indigenous communities (Nadasdy, 1999). It is suggested that rebalancing existing power structures in New Zealand will require science organisations to "acknowledge and value the kaitiakitanga roles of Māori", and Māori to "fully embrace the range of opportunities that collaborative research presents" (Bourhill et al., 2004: 6). Nadasdy (1999:15) similarly identifies both the opportunity and the challenge rebalancing power structures creates when he writes,

> "Returning decision-making power over the land to local communities, however would provide a counter-weight to the power-centralising tendencies of scientific resource management. This would not preclude scientists from engaging in their own set of socially useful practices, but they would be doing so at the request and direction of local communities".

Participatory methodologies inherently imply and require that hierarchical power structures be replaced by more equitable relationships. To achieve this, participatory research is likely to challenge existing power structures. Given the institutional changes required to create equitable partnerships, participatory research is itself a challenging endeavour.

2.3.4 Systems thinking

Participatory approaches are well suited to farming systems because they acknowledge the constructed nature of relationships and the "complexity of the farmer's position in the system" (Darnhofer et al., 2012: 7). Farmers are not seen as isolated individuals but as social actors who interact and are influenced by a variety of other actors. Indeed Phillips' (1985) analysis of dairy farmers in New Zealand found they sought information from up to 40 people. The farm is therefore viewed as part of wider cultural, economic, political, local, agro-ecological and social systems.

In the uncertain, changeable and complex environment of agriculture, participatory methodologies are encouraged to utilise systems thinking as an approach to enquiry (Darnhofer et al., 2012; Roling & Jiggins, 1998). This approach is exemplified by farming systems research, which despite its many guises has three distinct features. It relies on systems thinking; it requires interdisciplinarity (although the term transdisciplinarity is increasingly preferred); it mobilises participatory approaches as it seeks to integrate a broad range of actors into decision-making (Darnhofer et al., 2012).

As a systems approach to thinking recognises the interactions between the different components of the system, Darnhofer et al. (2012:7) claim it captures the 'logic' of farming. Farming systems research rejects a narrow view of farming seen solely through its biophysical and technological components. It therefore engages with soft systems or "the meaning that actors give to farming systems" (Darnhofer et al., 2012:

10). As soft systems thinking recognises the multiple perspectives that form around an issue it facilitates a process that leads to problem formulation rather than problem identification. This is because it enables stakeholders to become actively involved in decision-making rather than having an external agency impose the problem and solution on them (Checkland & Scholes, 1999; Ison et al., 1997).

Soft systems thinking recognises the social complexity of knowledge construction and seeks to reconcile different and often conflicting stakeholder perspectives that typically characterise issues. Bawden et al. (1984) challenged TOT approaches to research and extension by positioning farming as a human activity. They developed a model that incorporated both hard and soft systems - the hard system provided the tools for analysis, while the soft system provided the human capacity to address complexity and the wider environmental influences. This model situated agriculture at the interface of the natural and social systems (Packham, 2011). In a similar vein Pretty's (2006) 'assets-based model of agricultural systems' also conceptualised a systems approach to farming by recognising the interconnections that occur within agricultural systems and the impacts of agricultural practice.

A more recent advancement of systems thinking in agriculture is offered by an Agricultural Innovation Systems (AIS) perspective. AIS is concerned with the influences on learning and innovations such as institutions and infrastructure (Klerkx et al., 2012) and the relationships and connections between organisations and how they use knowledge (Hall, Janssen, Pehu, & Rajalahti, 2006). As it recognises that agriculture operates in complex adaptive innovation systems, it acknowledges a broader range of value chain actors and institutions than might be considered by a purely participatory approach. These include *chain actors*, such as farmers as primary actors, and others such as processors, wholesalers, retailers and consumers; *chain supporters* such as business services, advice, research; and *chain contexts* including government, laws, policies, financial services along with the effects of physical factors such as the climate (Royal Tropical Institute (KIT) & IIRR, 2010). Klerkx et al., (2012: 457) claim that AIS,

> provides a comprehensive view on actors and factors that co-determine innovation, and in this sense allows understanding of the complexity of agricultural innovation.

In an AIS perspective existing institutions are recognised to both enable and disable innovations in agricultural systems (Klerkx & Nettle, 2013; Klerkx et al., 2012; Leeuwis & Aarts, 2011; Murphy, Nettle, & Paine, 2013). Klerkx et al. (2012) list the characteristics of an agricultural innovation system that are enabling. These include: learning to innovate; building and strengthening individual capacity; science and technology that is both demand and supply driven, knowledge exchange that includes both tacit and codified forms; management that is decentralised. On the other hand innovation disablers are grouped according to failures that occur in: infrastructure; hard institutions (e.g. rules, laws, regulations and instructions); soft institutions (e.g. routines, practices, habits, traditions and customs); networks (strongly and weakly linked networks); compatibility; and market structures. AIS researchers are particularly interested in understanding how innovation support is operationalised to facilitate the engagement of multiple stakeholders in a process of co-production (Klerkx & Nettle, 2013).

Ideally participatory methodologies are recognised to provide an enabling environment for innovation in agriculture as they allow divergent actors to collectively engage, negotiate and reconcile tensions that may emerge from actors' differing perspectives and visions. Wieczorek & Hekkert (2012) argue that innovation must be seen as a largely values-based vision that is in part shaped by both the 'hard' institutions and the 'soft' institutions that shape current ways of doing and knowing. In the AIS literature knowledge production is not viewed simply as a technical endeavour, but it is argued to require "alignment of technical, social, institutional and organisational dimensions," (Kilelu, Klerkx, & Leeuwis, 2013: 65). Leeuwis and Aarts (2011) refer to this respectively as the hardware, software and orgware of innovation.

Participatory methodologies ideally allow innovations in agriculture to embody the shared perceptions and visions of stakeholders in a collaborative process of co-development. Innovation becomes an emergent property of the collaboration between stakeholders as they learn and reflect together (Botha, Klerkx, Small, & Turner, 2014; Hall, Rasheed Sulaiman, Clark, & Yoganand, 2003; Roux et al., 2011; Sumberg, 2005). As such participatory methodologies are central to AIS as Darnhofer et al. (2012: 8) contend,

> "The participatory approach … allows integrating local and farmers' knowledge with scientific knowledge, thus fuelling reciprocal learning processes".

2.4 Investigating participatory research in agriculture

The projects in this research are participatory partnerships between farmers and scientists. They are centred on multi-stakeholder learning that facilitates the co-production of knowledge that leads to innovation to advance sustainability in the agricultural sector. The farming systems and in particular agricultural innovation systems literatures therefore offer particular utility for investigating participatory research partnerships in agriculture.

Table 2.1 synthesizes key areas of consideration in the participatory, farming systems and agricultural innovation systems literatures into six themes that have informed the investigation in this research. This is largely drawn from the discussion in Chapter 2.

When working in an agricultural context the farming systems and specifically the AIS literature enhance the participatory research literature by exploring how institutions, knowledge co-production and exchange lead to innovation. Hall (2006: 26) argues that AIS as an approach to enquiry "offers a holistic way of strengthening the capacity to create, diffuse, and use knowledge." Furthermore, the AIS literature enriches inquiry of participatory research initiatives in agriculture by seeking a deeper understanding of the relationships and connections between actors, institutions and organisations.

Table 2.1: Investigating participatory research in agricultural production systems

Theme	Areas for exploration
Actors	• Actors access- inclusion / exclusion (science / non-science). • Value chain actors. • Epistemologies of actors. • Actor visions. • Actor capacity and capabilities.
Institutions & Contexts	• Soft & hard institutions that enable or disable innovation. • Institutional contexts that shape engagement and practice. • Infrastructural support
Power	• Equity of partnerships. • Partnership tensions. • Perceptions around legitimacy of knowledge. • Recognition / accommodation of divergence among participants.
Partnerships	• Partnership Agreement /contract. • 'Disciplinarity' of project environment. • Network ties – weak, strong, bridging, bonding. • Partner relationships. • Guidance of the search (see Hekkert et al., 2007). • Actor motivations / expectations. • Agenda setter. • Existing relationships between partners.
Processes	• Platforms for collaboration. • Trust building. • Formal and informal learning processes – self organisation. • Communication: negotiation, dialogue, conflict resolution and skilled facilitation. • Discursive spaces for knowledge production and exchange. • Iterative and ongoing process as people continuously shape and reshape their understanding of the world. • Facilitation of co-creative enquiry - creating shared understanding. • Co-development of innovations in a reciprocal & reflexive approach. • Opportunities for shared reflection, collaborative experimentation, discussion and joint interpretation of results. • Reflexive opportunities.
Knowledge & Learning	• Integration of local and scientific knowledge. • Knowledge (co) production / knowledge diffusion. • Utilisation of systems thinking to develop adaptive and emergent solutions to complex environments. • Scales of enquiry. • Learning by doing – learning by interacting, learning by using. • Single-loop / double-loop / multi-loop learning. • Transformations in participants' perceptions and assumptions. • Utilisation of explicit and tacit knowledge to enable actors to assign meaning to their environment. • Collective action / social learning. • Integration of diverse stakeholder viewpoints into constructive and long-term solutions. • Learning beyond the project funded period.

2.5 Summary

Chapter 1 of this thesis argued that addressing complex environmental problems such as sustainability requires input from multiple stakeholders from inside and outside the science and technology system (Gibbons, 1999; Gibbons et al., 1994; Lubchenco, 1998). Participatory approaches to research are argued to be necessary in this environment to embrace the critically important social dimensions of sustainability especially in an agricultural context. To achieve this, these approaches must seek collaborative partnerships between farmers, scientists, policy and other stakeholders in agricultural innovation systems. Addressing only the biophysical dimensions of sustainability will be insufficient for any transition to sustainable agriculture since this ignores the people within the system.

Chapter 2 has explored and critiqued the application of participatory research largely in an agricultural context. Participatory research is seen as a way for communities to embody a diverse range of perspectives into constructive solutions (Reed, 2008). Importantly it allows for collective learning and action that is argued to be essential for addressing sustainability (Dale & Onyx, 2005; Pretty, 2003; Pretty & Ward, 2001; Robinson, 2004; World Commission on Environment and Development (WCED), 1987). Critically, participatory approaches are argued to create collaborative partnerships that enable people to learn continuously and collectively about issues within their specific context. Ideally this creates a space for stakeholders to question existing practices and assumptions, which may lead to new ways of knowing and doing (Mills et al 2011; Raymond et al, 2010). Stakeholder learning that leads to the co-production of new knowledge lies at the heart of participatory research.

This research seeks to understand the dynamics of participatory research so its application may be enhanced, particularly within the context of agricultural sustainability in production systems. The following chapter outlines the methodological approach to the research undertaken in this study.

CHAPTER THREE

3.0 Methodology

3.1 Introduction: Seeking to understand social phenomena

This thesis uses a multiple case study approach to capture and unravel the complexities of participatory research by drawing on the empirical evidence of six projects (cases) that saw scientists and farmers undertake participatory research to advance sustainability in agriculture. As Chapter 2 identified, since participatory research involves multiple stakeholders often with divergent perspectives, integrating scientific and local knowledge in projects is a challenging process (Section 2.3.1). Furthermore this challenge is likely to be further enhanced if sustainability is viewed as a multi-dimensional, interconnected, and complex issue (Section 1.2).

The methodological approach employed in this research views 'reality' as subjective and the participants who engage in projects as social actors who interpret phenomena according to their own beliefs and value systems. Participants' understandings are therefore acknowledged to arise from the unique perspectives each assign to the phenomena they experience.

To capture actors' perspectives, research participants were able to tell their 'stories' as a way to reveal their construction of reality (see Berger & Luckman, 1991; Rorty, 1998). Capturing and understanding the essence of social phenomena lies at the heart of social science research, as Wadsworth (2010: xxvii) explains:

> "By taking a magnifying glass to 'the system', we begin to detect a vast web of energized micro-interactions between us (and everything else)…It is in *these* busy buzzing micro-inquiry actions that may be seen slowly, over time, to build up to comprise more (or less) viable exchanges and patterns for achieving our various desires or purposes – or not."

The methodological framework, approach and practices described in this chapter reflect what Baxter (2010: 90) calls, "a cyclical mode of exploration in case study research". Figure 3.1 adapts Baxter's conceptualisation of case study research to provide a holistic overview of how this cyclical mode of exploration was applied to the thesis to enable the development of the thesis' conceptual model (the PROCLE Model) (presented in Chapter 7). The initial literature review enabled themes and subthemes to be developed which informed the scope, focus and approach of the investigation and the methods for gathering evidence. The in-depth analysis of the collected data, which required exploration of the AIS literature, and was then informed by this literature, enabled new concepts to be developed that identified the emergence of a '*collaborative learning space'* for fostering innovation in participatory research (discussed in Chapter 7). The conceptual model enhances understanding of participatory research. While Baxter used the word 'theory' in his original diagram of a cyclical approach to case study research, Figure 3.1 prefers to use the term 'conceptual insights' as participatory research is not a theory, but a practice that is underpinned by theory, and so this work does not seek to generate 'theory'. The thesis' conceptual model therefore seeks to enrich understanding of the practice of participatory research. Baxter (2010) recognised that case study researchers often work with very under-developed 'theory'.

Each of the methodological components identified in Figure 3.1 are detailed in this chapter. The chapter starts by examining the usefulness and rigour of a case study approach and details the investigated cases. The chapter then presents and explores the triangulation of methods used for data gathering, which included stakeholder interviews, field and participant observations and review of project documentation. Working in social research demands a reflexive approach to enquiry (Bolton, 2010; Mansvelt & Berg, 2005). Hence, the chapter also describes the process of researcher positionality and reflexivity that occurred throughout the investigation. The final section details the process by which the large corpus of empirical data was analysed. These data provided the empirical evidence presented in Chapters 4, 5 and 6, which underpins the thesis' conceptual model in Chapter 7 and the reframing of participatory research practice in Chapter 8.

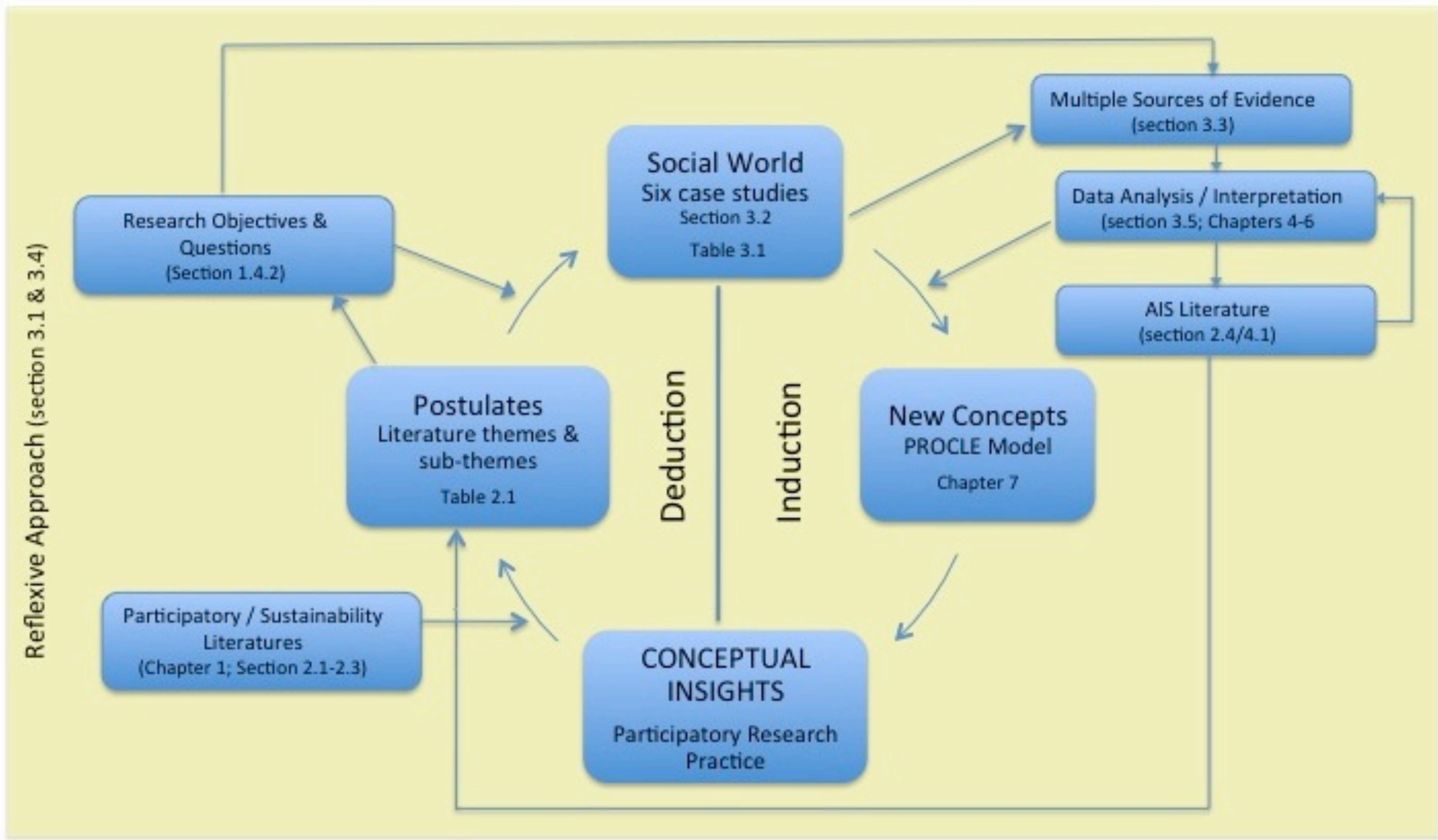
3.2 Research approach: Case study research

Case study research is described as a broad methodology or research approach and not a method (Baxter, 2010). Yin (2003:14) argues that case study research is a "distinctive empirical enquiry" arising out of "a desire to understand complex social phenomena". Similarly, Snow and Trom (2002: 151) claim that the case study approach enables the researcher to "excavate and understand" complex social phenomena. To do this, case study research investigates either a single case study, or as this research has, nuances of the phenomena across multiple cases for in-depth analysis and for understanding the influence of context on the phenomena.

This research investigates the utilisation of participatory research in micro-level agricultural projects. The discussion in Chapters 1 and 2 identified that participants' constructions of their reality are influenced by the contexts in which they operate. Case study research enables understanding of these contextual factors and allows exploration of their effect on the investigated phenomena (Baxter, 2010). Yin (2003) argues that case study research is particularly useful for revealing the boundaries between the phenomena and the context that may not always be apparent.

Utilising an approach to research that enables understanding of contexts is recognised to provide practical perspectives, as it allows a researcher to see why actions may be taken (Baxter & Jack, 2008). Richardson (2000: 933) however asserts that understanding contexts also has epistemological perspectives, since it prevents the constraining belief that social science texts are simply a means to convey

> "…facts or themes or notions existing independent of the contexts in which they were found or produced as if the story we have recorded, transcribed, edited, and written up in prose snippets is the one and only true one: a "science" story….



Adapted from Baxter, 2010:90

Figure 3.1: The methodological framework, approach and practices used in this thesis

Context is fundamental to the central question of this current research, since the thesis seeks to understand how participatory research is utilised in micro-level agricultural research to advance sustainable agriculture. While all projects in this research employed participatory approaches, the implementation of these approaches varied across the six projects. Why participatory approaches were variously applied and how this affected project outcomes and learning is of primary interest to the thesis' investigation and requires an understanding not just of the specific phenomena, but also its contexts. The multi-case study approach in this research enables in-depth or 'intensive' understanding of stakeholder engagement in participatory research (Bradshaw & Stratford, 2010; Platt, 1988). Understanding the effect of project contexts enables insights into 'why' there is variability between cases, along with identifying what is common between cases.

The use of case study research for 'how' and 'why' questions, as occurs in this research, is recognised by case study proponents. Yin (2003) argues that case study research is best suited to 'how' and 'why' research questions as these questions seek rich understandings. Methodologists contend that statistical correlations of survey results are unable to unravel and reveal the in-depth nuances that are needed to understand the how and why of social phenomena (Hancock & Algozzine, 2006; Yin, 2003). Quantitative methods of surveys are also deemed too mechanistic to provide what Weick (1989) calls the "disciplined imagination" that is required for gaining a rich understanding of complex phenomena. What appears evident in these scholarly writings is that case study research provides a means to unravel the messiness of social phenomena to enable insights to emerge.

Multiple case studies, which this research has utilised, also have particular value for developing, extending or refining conceptual and theoretical understandings (Baxter, 2010; Darke, Shanks, & Broadbent, 1998; Vissak, 2010; Yin, 2003). Yin (2003) recommends that case study researchers should begin by developing theoretical propositions based on an investigation of the literature. Yin claims that it is this early engagement with the literature, which differentiates a case study approach from ethnography or grounded theory. While it is unlikely that ethnographers or grounded theorists do not engage to some degree in the literature prior to undertaking their research (see Heath, 2006), Baxter (2010) contends that it is the more intensive degree with which case study research engages with the literature from the outset that differentiates it from these other methodological approaches.

However, a cautious approach to Yin's recommendation to create theoretical propositions was applied in this research. An investigation of the participatory literature led to the identification of themes and 'areas of consideration' acting as a guide for the research's investigation (Table 2.1), rather than a list of propositions. The themes and sub-themes assisted with developing the interview questions and served as a base on which the data analysis and interpretation were compared and contrasted to develop concepts to inform existing understandings of participatory research. This cautious approach to proposition-making is supported by Baxter (2010) who argues that the context dependent nature of case study research and its reliance often on under-developed 'theory' make proposition making unreliable and difficult. This use of themes and subthemes (Table 2.1) rather than the formal propositions recommended by Yin (2003) also provided more scope to adapt the investigation as new literature emerged. For example, Neef and Neubert's (2011) research, which arguably provides to date one of the most comprehensive frameworks of participatory research (Section 2.3.3), informed subsequent adaptations to the themes and subthemes of Table 2.1, as did the agricultural innovation systems literature (Section 2.4).

Yin (2003) claims the use of multiple cases strengthens patterns and assertions that emerge during the data analysis. Establishing patterns and linkages is argued to be too complex for methods such as surveys or experiments alone (Baxter & Jack, 2008). Baxter (2010) contends that the number of 'units' or cases is of less importance than the in-depth understanding of the phenomena and the context. Case study research does not seek to test 'direct' causal relationships, as with controlled experiments. However, the ability to undertake cross-case analysis provides opportunities for relationships and linkages to emerge. In this current research, linkages that emerged during the data analysis and interpretation phases were central to the conceptualisation of the thesis' PROCLE model, which is presented in Chapter 7 (Section 7.2).

The ability to conduct cross comparative analysis between different cases is argued to increase the robustness of the research (Herriott & Firestone, 1983). Baxter (2010: 90) claims that cross case analysis provides a broader base for 'theory-making' and for the subsequent exploration of that ‘theory’ across the different cases to enhance “the credibility and trustworthiness of the concepts and explanations”. He claims the qualitative researcher in case study research therefore uses both inductive and deductive modes of enquiry in “multiple loops of reasoning” (2010:90). This research contends that this inductive and deductive approach to enquiry increases both its internal and the external validity. The thesis acknowledges that case study research is context dependent, but does not support the contention that case study research is not generalisable (see discussion in Flyvbjerg, 2006). Certainly, conceptual understandings that are developed in this research (Chapter 7) are not generalisable in a statistical sense but rather as Yin (2003) describes, are generalisable or “transferable” (Baxter, 2010: 89) in an analytical or theoretical sense, to understand how participatory research supports change to advance sustainable agriculture.

3.2.1 Investigating participatory research: The case studies

This current research extends understanding of participatory research by combining existing theoretical understandings that inform the practice of participatory research, which were gained from the literature, with the empirical insights from six investigated studies to advance new conceptual understandings. To do this, the research focused on the utilisation of participatory research in micro-level agricultural sustainability projects in New Zealand.

Sustainability is well suited to case study research. Evans (2011: 54) argues that the empirical foundation of case study research enables a researcher to capture the plurality of the social dimensions of sustainability, while also being able to “encompass a wide variety of data from a wide variety of sources and disciplines”. He demonstrated its effectiveness in examining the social benefits of forest use in the United Kingdom (Evans & Franklin, 2008). Case studies are also argued to capture “dynamic, experiential and complex processes” in fast-changing environments (Vissak, 2010), which this thesis would argue is synonymous with the dynamic, uncertain and changing environment of the agricultural sector. Case study research has been utilised for investigating learning and social learning in agriculture (Cundill, Lotz-Sisitka, Mukute, Belay, Shackelton & Kulundu, 2014; Wals & Rodin 2014) and for understanding agricultural innovation systems (Klerkx, 2015). Indeed, the recognised contribution of a case study approach in these fields has led to calls for more empirical research in the agricultural sector (Klerkx et al., 2012; Cundill et al., 2014). This thesis responds to this call.

The six investigated cases used in this research all involved scientists and farmers engaging in agricultural production sectors to advance sustainable innovation, either through the advancement of knowledge and/or technological innovations. The cases (or projects), had been 'pre-chosen' from six cases that were part of a larger programme titled *Science for Community Change*, which was funded by the Foundation for Research, Science and Technology (FRST) from 2003-2008 and which also funded this research. As all projects in the *Science for Community Change* programme involved scientists and farmers engaging in participatory research to advance sustainability outcomes, the projects provided an ideal opportunity to undertake an in-depth investigation of the social phenomena of engaging in multi-stakeholder participatory research.

The *Science for Community Change* programme sought:

> "positive change in the capacity of agricultural industries and communities to develop and implement technological innovations in crop production systems so they are more resilient, profitable and environmentally benign"
>
> *(FRST contract documentation, 2006)*

Although the cases used in this research were pre-determined, they offered distinct advantages for the thesis' conceptual contribution, as their positioning in the horticultural sector offered a context that while variable between the different horticultural sectors, still provided consistency that would not have been possible with cases from markedly different agricultural sectors. Six cases also provided a large corpus of data, and so the consistency of the horticultural context assisted in capturing but containing the complexity of the social phenomena being investigated.

Five of the investigated projects were public/private initiatives partially funded by the central government funded Sustainable Farming Fund (SFF) and matched with in-cash or in-kind contributions from project partners. The other project was fully funded by the government's Foundation for Research Science and Technology (FRST). The Parliamentary Commissioner for the Environment has recognised SFF as an exemplar of participatory partnerships between scientists and farming groups addressing sustainable land management issues (PCE, 2004). This government fund was established in 2000 to support grassroots partnerships to "deliver economic, environmental and social benefits to New Zealand's primary industries" (Sustainability Farming Fund, 2008/2009). All SFF projects exist at the applied end of research and are required to demonstrate evidence of extension activities. A report at the 10-year celebration of the programme stated,

> "This *Ten Years of Grassroots Action* highlights why the initiative works so well – because it is a "grassroots up" fund supporting a broad range of innovative projects across our primary industries."
>
> *(Ministry of Agriculture and Forestry, 2010)*

FRST (which has been subsequently restructured and incorporated into the Ministry of Business, Employment and Innovation) is a much larger fund specifically directed towards science research. Scientists are however required to demonstrate engagement with end users and participatory approaches are encouraged (Kerckhoffs et al., 2006).

A synopsis of each project's objectives, principal partners and funding, as sourced from project documentation and promotional literature, is outlined in Table 3.1. While Table 3.1 outlines the projects' funds, objectives and time frames, the research does not seek to project 'review' these cases in regards to their use of public funds. Rather it is the participatory basis of their partnership that is of most interest to the thesis' central and focusing questions. Furthermore this research has a focus on project learning to investigate how projects advance learning in project actors and their communities of practice to support a move towards sustainability. The differences between project funds are not the focus of this thesis' exploration of collaborative learning, as it is assumed that learning should occur in projects across all funding bands. However, the expectations of funders and their motivations for funding participatory projects are relevant to this work, along with issues around access to, and control of funds, and these aspects of funding are explored in the thesis' results, which are presented in Chapters 4-6. The six investigated projects' geographical locations are identified in Figure 3.2.

Table 3.1: Synopsis of project objectives, participants and funding

Project / Participants / Funds	Project Objectives
Crop Science for Māori East Cape, North Island (5 yr project + 1 yr extension) CRI scientists & the East Coast Organic Producers (ECOP) Trust **Total funds:** $3,363,475	• Identify how Māori communities could transition from extensive agriculture to intensive organic horticulture. • This involved establishing a reciprocal learning network providing scientific, education, and extension services to enable ECOP Trust to develop and implement 'best' organic vegetable farming practices.
Squash Rot Gisborne, Manawatu, Hawkes Bay (3 year project) CRI scientists & squash industry group (Horticulture NZ), squash farmers & pack-house owners. **Total funds:** $201,265 ($121,860 cash + $79,405 in-kind)	• Assess factors that influenced the extent of storage rot in squash (buttercup) fruit lines. • Scientists aimed to develop a model of weather influences on squash growth and yield to assist with defining multi-factor influences on fruit yield and maturity.
Potato Aphid Project Canterbury (3 year project) CRI scientists & Potatoes New Zealand (Horticulture NZ) & farmers **Total funds:** $431,250 ($300,000 cash + $131,250 in-kind)	• Develop a resistance management strategy to delay or prevent aphid insecticide resistance in potatoes, with the intention of maintaining future options for pest control and potato quality. • In addition it sought to determine 'best practice' for the control of aphids and viruses in potato crops, and provide to growers up to date information on aphid flights and infestation of potato crops.
Walnut Blight Project Canterbury (3 year project) Scientists & Walnut farmers from the Walnut Industry Group **Total funds:** $635,142 ($550,767 cash + $84,375 in-kind)	• Optimise the timing of copper-based sprays and understand and transfer best practice to growers around blight management. • The overall objective was to develop an environmentally benign agent for blight control to reduce grower reliance on copper-based sprays.
The Wheat Calculator Canterbury (3 year project) CRI scientists & FAR (Foundation for Arable Research) & farmers **Total funds:** $480,875 ($418,875 cash + $62,000 in kind)	• Examine and quantify the effects of arable and vegetable growing practices on nitrate leaching. • Project participants involved in development of "user-friendly" software called the Wheat Calculator, which provided information on how different wheat cultivars respond to nitrogen loadings and irrigation. The calculator aimed to increase farmer profitability by increasing yields & reducing farm inputs & improving environmental outcomes by limiting the detrimental effects of nitrate leaching into groundwater.
Precision Agriculture Projects LandWise working with LandWise farmers, researchers, arable & vegetable industry partners. **Total funds:** $493,116 and $480,000	• To co-ordinate on-farm research & development, primarily in vegetable & arable cropping industries. • *Controlling the Strip* (2003-2006) focused on soil health, minimum tillage & irrigation efficiency. *Advanced Farming Systems* (2008-2009) investigated farmers' engagement with advanced technology (Precision Agriculture), including RTK-GPS guided mechanical weeding, GPS controlled spraying, GPS contouring, data and zonal management.

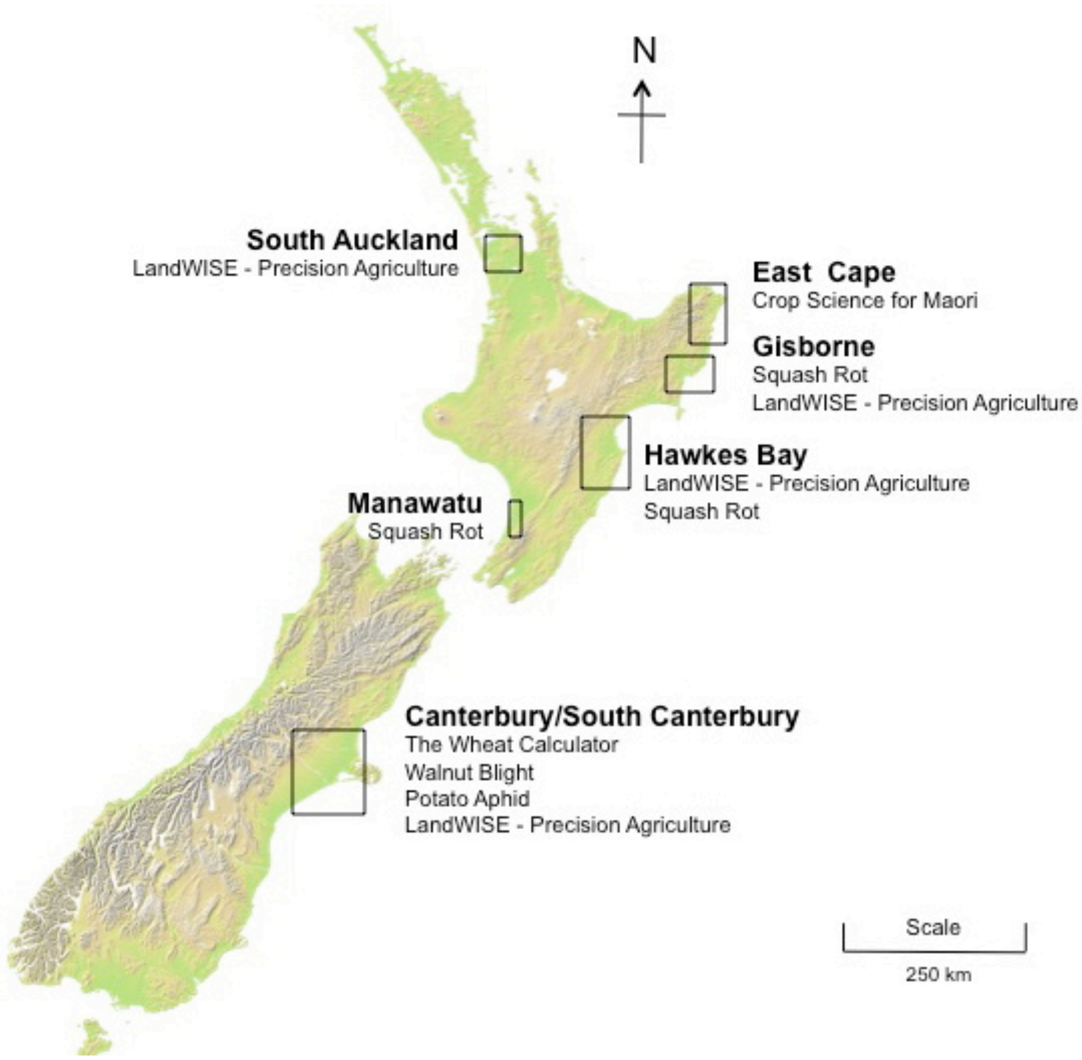


Figure 3.2: Project locations

The investigated projects come from New Zealand's horticultural and arable sectors. The horticultural sector in particular is regarded as a significant contributor to New Zealand's economy, accounting for 8% of total merchandise exports or $NZ6.7 billion in revenue in 2012 (Aitken & Hewett, 2013). The arable sector is a much smaller contributor, generating an estimated $NZ959 million to New Zealand's GDP (Sanderson, Dustow, & Dixon, 2012 August). Being largely from production agriculture, the investigated projects provide a valuable source of empirical evidence to investigate the thesis' central and focusing questions to explore how effectively micro-level participatory research projects in the agricultural sector advance more sustainable farming practices in agricultural production systems.

A synopsis of the farming group and sector characteristics, as revealed from project documentation is outlined in Table 3.2. While all projects were horticultural the distinct differences between the groups provided valuable areas of interest for comparison and more detailed exploration in Chapters 4-6. The discussion assisted with the development of the thesis' conceptual contribution – the PROCLE model where the concept of a collaborative learning emerged. This is discussed in Chapter 7. The differences between the groups provided valuable understanding around the maximisation of the collaborative learning space (Section 7.4), the effect of 'disciplinarities' on the collaborative learning space (Section 7.5) and the realisation and optimisation of learning within the collaborative learning space (Section 7.6).

Each investigated project supported engagement between science and farming actors in a research partnership, therefore they were all generally consistent with a participatory paradigm. Each project sought to mitigate the impacts of specific agricultural practices, and accordingly they are ideal cases for investigating how effectively participatory research at the micro-level can support collaboration to advance agricultural sustainability.

3.3 Research methods

3.3.1 Introduction: Multiple sources of evidence

To investigate the complexity of the phenomena of participatory research, multiple sources of evidence, or methodological triangulation (Denzin, 1970) was used to gather the empirical data. The sources of evidence were collected from stakeholder interviews, observation of project activities and a review of project documentation. These multiple sources of evidence were used to generate what Charmaz (2006: 45) calls the "bones" for the analysis which, when interpreted, forms the "skeleton" of the work where meaning is always closely linked to data. The use of multiple sources of evidence aligns well with Denzin & Lincoln's (2003: 4) concept of the researcher as an "interpretive bricoleur" piecing together the "set of representations" of a complex situation. Case study research is recognised as a suitable approach to capture multiple sources of data from complex situations (Evans, 2011).

Table 3.2: General characteristics of farming groups / sectors

Project	Farming Group and Sector/Community characteristics
Crop Science for Māori - ECOP	• East Cape Region: Economically deprived and geographically isolated. • ECOP Trust sought to improve the health, social, cultural, economic and ecological wellbeing on the East Cape by promoting cultural values. • ECOP Trust membership was very small – approximately 6-10 growers. • Communally owned land makes development capital hard to secure. • Understanding of tikanga, Māoritanga, Mātauranga Māori critical when working in Māori communities.
Squash Rot - Squash Industry group	• Group funded by grower levy administered according to an Act of Parliament, supports full time employee. • Offices in Wellington as they belong to HortNZ with strong policy focus. • Complex value chain. • 5-6 corporate growers largely control the squash value chain.
Potato Aphid Project – Potatoes NZ	• Group funded by grower levy administered according to an Act of Parliament, supports full time employee. • Offices in Wellington as they belong to HortNZ with strong policy focus. • Complex value chain divided into three sectors: seed, process, table. • In the seed sector (where the project was targeted) margins are small. • Seed potatoes are rarely grown as a sole crop. • Most farmers contract grow for seed merchants.
Walnut Blight Project - WIG	• Small emerging industry progressing towards commercial production. • Consists largely of part-time growers, many are scientists and other highly skilled professionals along with older retired couples. • Industry group formed by farmers to represent growers & access funding. • Voluntary membership, so grant success is required for group's knowledge generation – no full time staff. • Long association with Lincoln University and access to trial orchard.
The Wheat Calculator - FAR	• Group funded by grower levy administered according to an Act of Parliament, supports several full time employee. • Offices located in Lincoln next to science partners. • Complex value chain with multiple industry players. • FAR supports research and technology transfer in the arable sector. • Majority of growers are contract growers & often engaged in mixed cropping. • Farmers' incomes are influenced by the international grain price. • Imports of high quality flour supplement local produce
Precision Agriculture - LandWISE	• Farmer extension group that promotes the use of precision agriculture with strong interest in land and water sustainability primarily in the vegetable and arable sectors. • Voluntary membership - supports 1-2 part time staff. Primary income comes through research grants. • Offices Located in Hawkes Bay, with research fields • LandWISE partners with complementary organisations including CRIs. • Scientist sits on the LandWISE Board.

Triangulation enabled multiple perspectives to be gathered to capture the complexity of participatory research. It also provided rigour and credibility to the research by providing validation of perspectives across different methods of data collection. This is particularly important in this research, as the cases were largely retrospective examinations, which raised concerns of participant recall bias. Recall bias was identified as being most acute in stakeholder interviews, where participants were asked to recall and reflect on their experience in projects. Triangulation is recognised to minimise the threat of this bias (Baxter, 2010). To address this, project documentation including grant applications, meeting minutes and correspondence (Section 3.3.4) were included to validate dates and recorded events, while participant observations were undertaken as a primary source of data (Section 3.3.3) to complement the retrospective reflection of many of the stakeholder interviews (Section 3.3.2).

The use of triangulation to increase the credibility and rigour of the data is recognised by case study scholars (Baxter & Jacks, 2008; Denzin & Lincoln, 2003; Yin, 2003, 2009). They contend that multiple sources of evidence increase the credibility of the data, its subsequent interpretation, and therefore the internal validity (Yin, 2003). Barbour (2001: 1117) however prefers the term "comprehensiveness" over triangulation since he claims the former is a "more realistic goal" for social science research, as…

> "apparent contradictions (or exceptions) do not pose a threat to researchers' explanations; they merely provide further scope for refining theories."

Richardson (2000) also challenges the concept of triangulation. Her criticism is not directed at its use to enhance research rigour and credibility, but instead it is directed at the use of the concept of a triangle, preferring instead to use the metaphor of a crystal,

> Crystallization, without losing structure, deconstructs the traditional idea of "validity" …(we feel how there is no single truth, we see how texts validate themselves)… …crystallization provides us with a deepened, complex, thoroughly partial, understanding of the topic. Paradoxically, we know more and doubt what we know. Ingeniously, we know there is always more to know.
>
> *Richardson, 2000: 963*

In this research the multiple sources of evidence are used to piece together multiple representations and layers of understanding, occasionally as phenomena happened (participant observations), but mostly through a retrospective lens (stakeholder interviews and review of documentation) and always acknowledging the interpretive nature of both the data and the analysis. In doing this the research sought to capture the complexity of the cases and the social phenomena of actor engagement in participatory research.

While the interpretive 'subjectivity' of qualitative research may be seen by some as a weakness, Stake (1995: 45) argues that in case study research subjectivity should not "be seen as a failing needing to be eliminated, but as an essential element of understanding". Triangulation provided a rigorous and credible approach to enquiry that captured complexity of participatory research at the micro-level.

3.3.2 Stakeholder interviews

Semi-structured interviews were the primary source of evidence to capture participants' experiences and perspectives of micro-level engagement in participatory research. Interview participants included people who were active in the investigated projects such as farmers / growers (these terms are used interchangeably in this thesis) and research scientists and employees of farming (industry) groups. In addition, a number of sector farmers not directly engaged in the project were interviewed to examine project learning beyond actors who were actively engaged. Additionally, a range of actors from each project's wider agricultural innovation system were also interviewed, including those from policy and funding agencies, processors, seed merchants, millers and bakers.

Participant selection for interviewing was purposive (Patton, 2002) and used a variety of strategies. Project documentation identified actors who were actively engaged in projects. These active project participants were the principal source of data as the research questions sought to examine learning and engagement in projects, which required active science and farming members of project teams to be the focus of the research. However, as the research sought to explore engagement between the project and the wider communities of practice, farmers outside the project, and related agribusinesses people were included in the participant sample. Farming groups provided names of their sector members. However, as this had the risk of directing attention to the more actively connected members, farmers were also identified and approached to participate from sector events such as the LandWISE conference. Agribusiness participants were approached from publicly available records. Some further participants were identified during participant interviews and contact details were obtained from public records. All policy and funding participants were contacted from publicly available records.

The purposive approach to sampling sought to capture the diversity and complexity of perspectives across the six investigated projects. In doing so it reflects O'Reilly & Parker's (2012: 193) argument that,

> "the corpus needs to be large enough to capture a range of experiences but not so large as to be repetitious…the adequacy of the sample is not determined solely on the basis of the number of participants, but the appropriateness of the data."

The focus in this research was on the sample's adequacy to answer the research questions and to capture the diversity of perspectives in the projects to assist with developing conceptual insights. In this way the approach reflects Yin's contention that sample size should not determine sample appropriateness when the work does not aspire to be statistically generalisable and is instead directed at answering questions rather than being directed at "samples and universes" (Yin 2003: 43). Therefore while the sample size was not exhaustive or fully comprehensive, it was extensive enough to be insightful to answer the thesis' questions.

The research however does adhere to case study scholars' recommendations to carefully determine boundaries about the unit of analysis or what and who is and is not to be included (Baxter & Jack, 2008; Hancock & Algozzine, 2006; Stake, 1995; Yin, 2003, 2009). In this research, because the focus of the research questions is on participant engagement in micro-level projects, the unit of analysis was defined as the 'project'. A diverse range of actors needed to be located so their perspectives could be captured including actors who were active in the project, but also those from each farming group's community of practice, and wider members of the innovation system (value chain) in which each project was embedded, as well as actors from the wider political and economic contexts that shape the actors in projects including actors from policy, science funding and agribusiness. The principal focus, however, was the participants in projects as the research's questions sought to examine engagement and learning in participatory research. O'Reilly and Parker (2012: 194), however, rightly argue that "data are never truly saturated as there will always be new things to discover".

A total of 78 people were interviewed over the course of this research. Most provided perspectives on one project, but five participants - two farmers, one research scientist and two industry/farming group employees provided perspectives on more than one project in which they had been actively involved (these totalled seven perspectives). In addition, interviews with 12 participants from the wheat calculator, walnut blight and potato aphid projects that were undertaken by a *Science for Community Change* researcher during the early stages of these projects were included in the analysis. Six of these participants were re-interviewed during this research. When the six participants from the *Science for Community Change* researcher, who were not re-interviewed, are included in the participant total, 84 participants (Appendix 1) provided a total of 91 project perspectives for the data set for this research. Table 3.3 provides a breakdown of the participant perspectives captured for the six investigated projects.

Table 3.3: Number of participant perspectives captured by project and type

Participants / Project	*Farmers / Growers*	*CRI Scientists*	*Industry Body / Farmer Group Employees*	*Policy/ Science Manager*	TOTAL
Crop Science for Māori	10	4		4	**18**
Squash Rot	4	2	1	2	**9**
Walnut Blight	11	2			**13**
Potato Aphids	9	2	2	2	**15**
Wheat Calculator	8	3	5	2	**18**
Precision Agriculture	7	1	2		**10**
Policy/SFF/ Science admin		1		7	**8**
TOTAL	**49**	**15**	**10**	**17**	**91**

Most participants were interviewed individually but some interviews involved up to three participants. All interviews were undertaken in a place chosen by the interviewee and took place between 2007 and 2010. Two participants were interviewed twice and one was interviewed three times, as time did not allow the original interview to be completed and the participant requested more time, or a participant who had been involved in more than one project wished to talk about the different projects at different interview times. The participants in these repeat interviews therefore addressed new areas of interest rather than re-explored earlier discussions.

Semi-structured interviews were employed as these enabled some structure to the flow and scope of the interview, while also allowing the interviewees flexibility to explore and discuss avenues of personal importance. In this way, it is argued the interviewer and interviewee collaboratively engage in the examination of phenomena (Crabtree & Miller, 1992; Longhurst, 2003). No questionnaire or a formal set of questions was drawn up in advance. However, to assist with providing structure and focus to investigate engagement and learning in participatory research and to also enable cross-case analysis, there were consistent areas of enquiry as outlined in Table 3.4.

Participants from policy and funding agencies were also asked to provide perspectives relevant to their professional position. These conversations focused on the provision and delivery of agricultural research and extension in New Zealand, the science research funding system and science / industry / agribusiness connectivity.

All the interviews adhered to the ethics approval granted to this research by the University of Auckland Human Participants Ethics Committee (Ref: 2007/095), included in Appendix 3. This approval granted permission for the research interviews to be conducted between 2007 and 2010, and was extended to 2013 following the approval of an extension application in 2010. Ethical guidelines hold the research accountable to a set of externally approved rules. However this current research argues, as others have, that adherence to these protocols is more than an exercise in accountability since it articulates the research and researcher's core values (Hing, Breen, Gordon, & Russell, 2014). In this research these core values recognise and respect the fundamental importance of participants' rights in the research process.

Table 3.4: Interview areas of enquiry for project participants

Participants active in projects	Relevance and importance of the sustainability problem being investigated by the project to the interviewee
	Why the interviewee participated in the project
	Nature of his/her involvement
	Interviewees perception of project partner relationships
	Project activities interviewee engaged in
	Perception of project's achievements
	What interviewee personally learned and how they learned
	Applicability of any learning and farm application
	Interviewee/sector current use of the project's knowledge /technology
	Interviewee communication of the project learning to others
	Strengths of the project
	Weaknesses of the project
	Personal perspective on agricultural sustainability
	Personal perspective on value of science knowledge in agricultural practice
Participants not active in project	Awareness of the project, how the interviewee heard about it
	Relevance of the problem being investigated by project
	Knowledge and relevance of the project's findings
	Use (if any) of the project's finding
	Engagement in any other participatory research projects
	Sources of agricultural information
	Personal perspective on agricultural sustainability
	Personal perspective on value of science knowledge in agricultural practice

Interviewees were advised about the research when an interview was requested and participants were asked to complete a consent form prior to the interview. This consent sought interviewees' permission for the interview to be digitally recorded. It also provided the opportunity for the interviewee to approve the use of direct quotes in the reporting of the research and allowed them to determine if their identity could be revealed. In addition, interviewees could indicate whether they wished to receive a copy of a research summary at the completion of the research.

Most interviews were recorded and fully transcribed by the researcher, if the participant gave written approval for this to occur. The data were then analysed (as described in Section 3.5). To ensure what Yin describes as a necessary "Chain of Evidence" (Yin, 2003) to be maintained in case study research, all datum was coded with an individual numbering system that enabled it to be traced back to its place of origin in a transcript to prevent inaccurate representation of participants' quotes if they were extracted from their contexts. The datum code recorded the project, location of the interview, date of the interview and a unique identifier for each interviewee. A full list of interviewees' unique identifiers, and a description of each interviewee is contained in Appendix 1.

Anonymity has been maintained for all participants, although with all interviewee quotes, the interviewee unique identifier code, the occupation of the participant (e.g. farmer, scientist) and in most cases the project they were involved with has been included with the quote. A large number of interviewees were happy to be identified and for any quotes to be used without their prior approval. This may reflect the retrospective analysis of many of the projects, which provided a spatial and temporal distance that enabled interview discussions to be frank and open and for the interviewees not to feel censored by the immediacy of the events being discussed.

3.3.3 Participant and field observations

To complement participant interviews, participant observations were able to be collected, from the Crop Science for Māori and Precision Agriculture projects that were still in operation. The Precision Agriculture project provided opportunities to engage with farmers and scientists at their annual conference, on an annual fieldtrip and in local workshops. The Crop Science for Māori project provided opportunities to observe project actors engaging in workshops and larger gatherings (*hui*). In addition, the opportunity to engage in a field excursion in Gisborne allowed observation of the squash industry. This was undertaken to gain further insights about squash production and the squash value chain. Table 3.5 summarises the timing and nature of the eight project observations.

Observational data enable the researcher to observe more deeply the activities and lives of participants (Hoggart, Lees, & Davies, 2002). In this research it provided complementary evidence to the participant interviews by both enhancing and validating participants' perspectives (Kearns, 2010). Furthermore, it assisted with deepening understanding about how projects engaged with their community of practice, by observing how project findings were communicated to the wider farming sector members, who were not 'active' project participants. Participant observation was also used to observe and understand how scientific and local knowledge was integrated into project learning. It also enabled exploration of learning in projects by revealing the 'boundaries' of learning, an area of inquiry that is receiving increasing interest in recent discussions about landscape approaches to agriculture (Sayer et al., 2013).

Observational methods provided a less formalised opportunity to observe actors in their natural setting and placed participants in their own contexts. Although interviews are usually situated in a participant's own setting, they are still recognised to create an artificial structure that imposes on the naturalness of the setting, no matter what attempts are made to limit the formality of the interview (Kearns, 2010).

In all participant observations the role of the 'researcher' was known. The participation did not seek to embed the researcher in the project as with ethnographic research or action research, instead it sought to provide opportunities to participate and observe people in action in their context. Notes were made from recall following each observation as this was less intrusive. Evidence that was gathered was not analysed as occurred with the transcripts from the formal interviews, but rather the observations were used to complement and enrich the primary source of data collection from the interviews, through field experience. This field experience was particularly valuable given the largely retrospective nature of most of the investigated cases, as it provided 'real time' observations of participant engagement and learning that enriched the interpretations made from the primary data collection and analysis of the interviews.

Table 3.5: Participant and field observations undertaken in research

March 2007	**Participant Observation** **Project:** Crop Science for Māori **Venue:** Tukapa Marae (north of Ruatoria), East Cape **Activity:** Weekend workshop on Tikanga (Māori protocols) attended by scientists and community members from the Science for Community Change (SCC) Programme.
September 2007	**Participant Observation** **Project:** Crop Science for Māori **Venue:** Uawa Marae, Tolaga Bay, East Cape **Activity:** Overnight workshop run by SCC scientists with ECOP to showcase Organic Food. Presenters included SCC scientists, community participants, and an organic Māori potato grower from Taranaki. Two chefs prepared dinner from local produce. The session was also attended by participants from a local polytechnic organic crop production course.
December 2007	**Field Observation** **Project:** Squash Rot **Venue:** Gisborne **Activity:** Field excursion with a packhouse manager to observe squash production.
July 2008	**Participant Observation** **Projec**t: Crop Science for Māori **Venue:** NZGS Conference, Victoria University of Wellington, Wellington **Activity:** SCC Programme session at the conference. This included presentations from the lead crop scientist, social scientist, extensionist responsible for programme communication, one of the Māori kumara growers and an Australian researcher undertaking similar work in Aboriginal communities. The session concluded with a panel discussion.
May 2010	**Participant Observation** **Project:** Precision Agriculture **Venue:** Havelock North Community Centre, Hawkes Bay **Activity:** Observer at LandWISE Annual Conference "Know Your Farm with Precision Agriculture"
March 2011	**Participant Observation** **Project:** Precision Agriculture **Venue:** Pukekohe, South Auckland **Activity:** Observer at LandWISE field workshop to promote Precision Agriculture
May 2011	**Participant Observation** **Project:** Precision Agriculture **Venue:** Havelock North Community Centre / LandWISE Head Office, Hawkes Bay **Activity:** Observer at LandWISE Annual Conference "Precision Spending: Putting Your Dollar Where it Counts" / Field Workshop
May 2012	**Participant Observation** **Project:** Precision Agriculture **Venue:** Havelock North Community Centre / Farmer's paddock, Hawkes Bay **Activity:** Observer at LandWISE Annual Conference "Site Specific Management: Growing Within Limits" / Field Workshop

Participant observation was particularly beneficial in the Crop Science for Māori project as its less intrusive nature enabled valuable observation of two discussions (hui) and a conference workshop to explore how scientific and traditional knowledge were recognised by different actors and legitimised (or not) through project activities. This assisted with understanding critical aspects of participatory research relating to power, knowledge and legitimization (Urlich, 1998).

The value of employing less intrusive methods of enquiry is recognised by methodologists, with Crabtree and Miller (2003) claiming that participant observation is less likely to alter participants' behaviours and more likely to lead to enhanced observations that enrich researcher understanding. While Kearns (2010) agrees, he cautions researchers undertaking observation methods that observed participants may still alter their behaviour. Research integrity and researcher positionality is recommended as being particularly useful in participant observations (Section 3.4). As Kearns (2010: 257) contends, "the key to taking observation seriously is being attentive to detail as well as acknowledging our position as researchers".

3.3.4 Document and media review

To further complement the primary source of data collection from interviews a range of documents was reviewed, particularly archived project documents. Roche (2010) claims archival material is often overlooked as a valid and valuable methodology for research. While Roche's comment focuses on archival research as the primary source of data collection, he nonetheless emphasises the importance of this source as a way of capturing the voices of the past, and accessing historical records that can have significant insight for the present. Given the retrospective nature of the research, the project's archival documents were a valuable source of information.

Project documents provided background context to the cases during the early phase of this research and served as a complement to interviewees' conversations after interviews. Having no prior experience working with the projects, the review of project documentation enabled the researcher to develop greater understanding of each project. Project documents that were accessed included funding agency reports for both the Sustainable Farming Fund and the Foundation for Research Science and Technology, project meeting minutes, project correspondence, which typically related to project funding, project publications from participants and academic researchers, project and industry newsletters and project conference PowerPoint presentations. Media articles from commercial and industry media were also obtained for some of the projects.

Factual information such as activity dates and participant names, positions and contact information were extracted from the documents. Funding applications and letters provided project objectives, achievements and outreach activities, while meeting minutes and reports enabled approximate timelines to be sketched for each project. This supported efforts to build an understanding of how each project progressed and to unravel the 'messiness' of project delivery. In addition, if scientific publications were an output of a project, these were accessed from scholarly databases. Extracts from funding applications relating to project objectives and project background, project correspondence and meeting minutes were included in the data set for analysis (Section 3.5). These extracts provided valuable insights for the discussions in Chapter 4 on actors' motivations and expectations; in Chapter 5 on partnerships and relationships and in Chapter 6 on learning, particularly in relation to learning platforms and recorded learning outcomes. It was always important when working with documents to reflect on who the documents were written for, who wrote them and the year they were written to provide context to the document particularly when reviewing them prior to interviews. This reflection is encouraged by methodologists to avoid biased conclusions being reached from documents (Kitchen & Tate, 2000). These documents principally acted as a complement to the primary source of evidence through interviews.

Two Crop Science for Māori broadcast media articles provided further access to participant perspectives (TVNZ, 2005 March 11; TVNZ 2008 April 26). A story from Television New Zealand's Māori news programme, "Te Karere" (TVNZ, 2005 March 11) was particularly insightful as it captured project participants speaking about the project in their native language, Te Reo. Although the understanding of the story was taken from the accompanying English subtitles, which may not adequately translate Māori concepts particularly if words have no direct English equivalent, it gave insights to the cultural and spiritual importance of kumara to the growers that was not adequately captured from any stakeholder interviews conducted in English. Additionally, both articles enabled access to perspectives from project participants who it had not been possible to interview. Each news item was transcribed and quotes used by project participants were included in the dataset for analysis as described in Section 3.5.

Extracts from two SFF promotional publications were also included in the dataset as these provided useful insights to the agency's narrative of applied research, sustainability and communities of interest (Ministry of Agriculture and Forestry, 2010; Sustainability Farming Fund, 2008/2009). It also complemented the insights SFF personnel gave about their motivations for engaging in participatory research and their current and future expectations of the process as discussed in Section 4.2. Two draft documents about agricultural extension in New Zealand provided by policy interviewees were reviewed as these gave insights to political support for participatory research, policy's expectations of agricultural extension projects and clarification of "under-performance" in agriculture – which had featured in policy respondents' interviews (Section 4.2.2). Two additional policy reports, one about technology transfer (MAF, 2012) and a review of SFF (Kinnect Group, 2014) were reviewed in the later stages of this research to give up to date context to the research's findings that had emerged during the analysis undertaken in 2010-2011.

3.4 Research integrity: Positionality and reflexivity

Qualitative methodologists, and particularly feminist scholars, have argued that all knowledge is situated and the subjectivity of the researcher influences both the research process and its knowledge production (Kindon et al., 2007; Newton & Parfitt, 2011; Rose, 1997; Skelton, 2000). The researcher must therefore be *self-reflective* about their *position* in the research process to expose and address how their position may influence the research process and to limit bias (Hoggart et al., 2002; Longhurst, 2003; Stoecker, 2005).

This research recognises that qualitative interviewing can never be totally objective, removed, and value-free. Since meaning-making emerges from an interactive process of information sharing between interviewer and interviewee, it is important to open up the interview process, and indeed the whole research process to reflexivity – a self-critical process of reflective enquiry. As Newton and Parfitt, (2012: 80) argue,

> "the researcher is able to contextualise findings and account for how their position affects not only their experience in the field but the actual process of knowledge production".

Reflexivity was a critical consideration during the data gathering, interpretation and writing phases of this research. Sultana (2007: 376) contends that reflexivity enables the researcher to think how "one is inserted in grids of power relations and how that influences methods, interpretations, and knowledge production". In this research it was important to address issues that might influence the relationships with research participants as data gathering is recognised to be both intrusive and to create potential dilemmas between the researcher's and the participants' social identities and social situatedness (Nagar & Geiger, 2007).

As a result, issues relating to gender, urban/rural divides, age and power differentials were considered prior to undertaking the fieldwork. Methodologists encourage such reflexivity in the researcher as a means of limiting bias in the research design since it requires the researcher to think before, during and after how they may affect the process of enquiry and the process of knowledge production (Nagar & Geiger, 2007; Sultana, 2007). Reflexivity is increasingly seen as an important consideration in both sustainability research (Franklin & Blyton, 2011; Roling, 2002), farming systems research (Darnhofer et al., 2012; Elzen, Barbier, Cerf, & Grin, 2012) and social learning (Wals & Rodela, 2014).

Newton and Parfitt's (2011: 71) writing had particular appeal, since they claim the researcher must "strive for mutuality in research relationships." While others agree with this sentiment, it appears mutuality is most acute in ethnographic studies (Enticott, 2012) and participatory action research (Newton & Parfitt, 2011), where the researcher embeds themselves in communities. However, it was considered to be no less important in this research and required consideration of the interviewer / interviewee dichotomy and how a female European urban graduate student in her late 40s/early 50s might affect the research process.

Hoggart, Lees and Davies (2002: 265) argue that no matter how much researchers attempt to free themselves of preconceptions they always carry "cultural baggage". They contend that,

> Quality research calls for approaching the field with a preparedness to change and challenge your existing ideas, not to act like a supercharged zealot determined to find class conflict, difference distinction or discrimination in every setting.
>
> *(Hoggart, Lees & Davies, 2002: 277)*

Considerable self-reflection was required in the Crop Science for Māori project because of the cultural differences between the researcher and the Māori project participants. In the Māori communities on the East Cape this was compounded by lowered trust of outside researchers that had stemmed from the communities past experiences of being subjects of research rather than being viewed as genuine partners in research initiatives, and therefore not benefitting from research project outcomes (Bruges, 2006). Crop and Food Research (CFR), who were already working with the community in the *Science for Community Change Programme* and had established relationships with community members, assisted the researcher with introductions to project participants and this helped to engender trust in the research.

The researcher's participation in a collaborative workshop with the community and project scientists provided awareness and understanding of *Tikanga Māori* (protocols and perspectives), *Mātauranga Māori* (traditional Māori knowledge), *kaitiakitanga* (guardianship), *whanaungatanga* (relationship), and *whakapapa* (genealogy / heritage) concepts that were recognised as fundamental to Māori and their engagement in the Crop Science for Māori project (Bourhill, Shaw, & Kerckhoffs, 2004). This understanding reinforced respect for previously understood protocols such as *koha*, but also raised an awareness of protocols around visits to crop sites where traditional protocols guided not only crop planting and husbandry but also visitor access. The researcher's participation in workshops also provided further introductions to growers and enabled an opportunity to provide a presentation about this current research. This aided in separating this research from the field research being undertaken by the Crop Science for Māori scientists. This minimised the perception that the researcher was part of the Crop Science for Māori 'science' team, which might have affected interviewee's responses to questions in interviews. In two cases in the Crop Science for Māori project, where the interviews had been pre-arranged with community members, the interview was digitally recorded, but where the interview was spontaneously arranged, digital recording was not used to minimise the intrusive nature of recording. As discussed above, participant observation was also used as a less intrusive method of data collection since this is recognised in the literature to limit differentials between researchers and research participants when researching across cultural divides (Clancey, 2013; Nadasdy, 1999).

For the projects that focused on the commercial production sectors of squash, potatoes, wheat and Precision Agriculture (which focused on farmers in the arable and vegetable sectors), interviews were mainly with male participants. Female farmers were more common in the Crop Science for Māori and walnut projects, where they worked independently, or in partnership with their partners/husbands. The inclusion of predominately male participants in the four commercial sector projects reflects the low level of female farmers in the sectors rather than a sampling bias. In these projects, female interviewees were usually from the farming groups or were project field technicians rather than farmers.

Data gathering is recognised to not take place in a "gender vacuum" (Herod, 2005). Indeed gender differences and similarities between the interviewer and the interviewee have been shown to affect the dynamics of the social interaction that take place during an interview. Gender does not just refer to one's identity as male or female but to the way people are socialised about being male or female (Longhurst, 1999). The literature shows that gender may influence the access granted to an interviewer, shape participant behaviours, influence interviewee responses resulting in "storytelling" and lead to stereotyping (Herod, 2005; Padfield & Proctor, 1996).

In this research gender differences or similarities did not appear to influence access to participants or outwardly appear to alter their responses. No person approached to participate in this research declined to be interviewed. In all situations interviews were collegial, relaxed and free flowing. One of the female field technicians interviewed for this research did comment that being female had a positive effect on her relationship with farmers. She attributed this to her listening skills, her diplomatic approach to transferring information, and her willingness to learn from the farmers, characteristics she aligned more generally with being female. However, there appeared to be no outward indication that being a female researcher influenced the interview process in any way. Age similarities between the researcher and the interviewees may have lessened any effect caused by gender differences. Indeed, Herod (1993) notes that rarely does gender alone shape interactions, but rather these are simultaneously affected by other characteristics of the interviewer including age.

Consideration was also given to how a researcher from a large urban university may be perceived in rural New Zealand. All conversations throughout this research, whether part of an interview or not, and across all 'categories' of rural participants were robust and friendly. Some research participants even saw the rural / urban difference as an opportunity to comment about other matters, including their perceptions of a rural/urban divide, tertiary education, tertiary graduates' environmental attitudes, and attitudes of graduates in regulatory roles in regional councils.

Researcher positionality was not just considered during the data collection phase. As noted by Nagar and Geiger (2007), an awareness of positionality creates epistemological considerations relating to the 'accuracy of representation' that must be applied at all stages of the research process. Throughout the analytical phase, handwritten 'analytical' notes were kept (Saldana, 2009). Importantly these captured the researcher's thoughts, ideas and questions as the analysis of the collected data gave rise to the thesis' conceptual insights.

3.5 Data analysis

To unravel the complexity of the large body of evidence that was gathered in this research, data analysis was undertaken to code, order and structure the data. This ordering and structuring of the data reflects what Cope (2010: 282) calls partial data reduction to distil key themes, partial data organisation, and a "substantive" process of data exploration, analysis and 'theory-building'.

Rather than use commercially available analysis software (such as CAQDAS), a simple computerised system for coding was developed using PAGES word processing software for first cycle coding, and EXCEL spreadsheet software for second cycle pattern or category coding. The use of this 'personalised' data analysis system made analysis more time-consuming but increased the intimacy with the data in an attempt to capture the complexities and nuances in participants' perspectives. The advantages of having increased intimacy with the data has been recognised by Gallagher (cited in

Saldana, 2013: 26) in her study investigating youth and schooling. She found that while commercial software was effective for data management, it was

> "inadequate for the nuanced and complex work of data analysis. [The software package] gave us style, but not substance, it sacrificed the attention to, and containment of, complexity we were after… In effect we returned to a manual [coding] system that respected the sheer quantity and complexity of qualitative data and the surrounding contexts."

Interview transcripts from 68 interviews, notes from interviews that were not recorded and selected media articles and documents (Section 3.3.4) were included in the dataset for analysis. Themes from the participatory and sustainability literatures presented in Chapters 1 and 2 initially provided a valuable starting point for investigation and the initial coding sought to identify key areas of interest at the project level. These focused around the following broad areas of enquiry:

- Project Partnerships – how actors described these and the conditions that led to these descriptions; expectations of partnerships;
- Actor relationships within projects and actor type relationships in general (e.g scientist / farmer types) – how actors described these relationships and what conditions led to these descriptions;
- Power / power differentials in projects and how these were exhibited through struggles, tension, negotiation, resistance and the legitimisation (or not) of different knowledge;
- Learning processes – how actors collaborated in formal and informal ways;
- Engagement with wider communities of practice and how actors described this;
- Actor references to learning outcomes / change / paradigm shifts.

Two "cycles" of coding were applied. In the first cycle, "holistic coding" (Saldana, 2013:142) was initially undertaken as a "grand tour" (Saldana, 2013: 64) to gain a first impression of the data corpus. This coding reflects what Saldana (2013: 142) describes as a lumping rather than a splitting of the data. To capture diversity in the data a more in-depth second cycle coding followed. In this process a mixture of first cycle coding methods drawn from Saldana's in-vivo, description, values and process coding were applied. Saldana does not specifically mention this mixed method approach in his 2009 coding manual. However, in his 2013 edition he labels this approach as 'eclectic coding' (Saldana, 2013: 188).

The six cases were initially examined discretely to enable each 'story' to come through. In addition analytical notes were used to record areas of interest about similarities and differences between projects and between actor types across projects. The notes also recorded emergent areas of interest. This emergence of new areas of focus is not unusual during data analysis. Cope (2010) contends that the process of coding and theme-making is a somewhat messy process. Furthermore, Richards (2009) notes that data analysis is a very personal endeavour and cautions against the notion of themes simply emerging, as she says this evokes the mistaken belief of spontaneity. As this research found out, developing concepts (which Richards (2009: 74) rightly contends is a human construct) comes from careful data handling, which involves analysing and re-analysing the data.

As the dataset was analysed several times, the initial broad areas of enquiry revealed additional areas of interest not covered by the initial thesis' focus of enquiry. For example, the initial 'project focused' enquiry omitted 'wider contexts' and influencers. On review, additional areas of enquiry were included to examine 'institutional contexts' to identify influences that occurred from outside the project such as institutional dynamics of funding systems, CRIs or farming groups. Furthermore, while the data were initially explored case by case, it was also decided to look at the data by actor type, since the note taking indicated points of interest, with more uniformity among the scientists across projects than the farming respondents.

Reflectivity through note-taking importantly opened up the data analysis and interpretation to self-reflection, which methodologists argue is critical throughout the entire research process (Charmaz, 2006; Cope, 2010; Richards, 2009; Saldana, 2009). This reflexivity challenged the initial participatory focus at the project level and led to a review of the thesis' literature, which was initially focused on the participatory and sustainability literatures. To understand the emergent ideas about 'contexts' in the data, the agricultural innovation systems (AIS) literature was explored. This literature complemented the participatory literature since it valued participatory approaches and stakeholder learning. However, it also expanded the focus of the research's initial literature review by providing valuable insights and understandings of institutional contexts in agricultural innovation systems (Klerkx et al., 2012). Engaging in the AIS literature led to a further analysis of the data. Although this was time consuming it highlighted key issues about actors, institutions, interactions and infrastructure that enable and disable innovation (Hekkert, Suurs, Negro, Kulhlmann, & Smits, 2007; Klerkx et al., 2012; Wieczorek & Hekkert, 2012). For example, this analysis explored the dataset for differences in how actors visualised themselves in their conversations as innovators and the projects as innovation. It examined the influences on power dynamics and how they were managed. It explored how actors engaged with wider value chain actors, and how institutional dynamics sought to shape project expectations, delivery and outcomes.

Engagement with the AIS literature opened the data to a literature that enabled the projects to be viewed as participatory research in agricultural innovation systems. Importantly, this acknowledged the wider system in which the investigated projects were situated. This expansion of the project 'context' allowed for a deeper understanding of multiple actor engagement in agricultural innovation systems. For example this enabled analysis of the alignment (or not) of actors' priorities that can facilitate a shared vision, what AIS scholars refer to as guidance of the search (Hekkert et al., 2007) an exploration of inclusion (or exclusion) of actors not just those directly involved in the projects but also those from the wider value chain, and a focus on co-production to enrich understanding of knowledge integration and knowledge diffusion in multi-actor partnerships. The discussions in Chapter 4 on actors' motivations and expectations and in Chapter 5 on partnerships were informed by this engagement with the data. This exploration also contributed to the discussions on transdisciplinary partnerships in Section 7.5.

By allowing the data to highlight relevant literature that was not part of the research's initial literature focus illustrates the importance of reflexivity in the data analysis. The data were not being forced into the existing participatory literature, but rather it pointed to a need to explore a complementary and growing body of literature. In so doing this process of self-reflection follows what Heath (2006: 522) calls inductive sensitivity where she claims the approach enables "insightful identification of relevant literature." Methodologists, particularly grounded theorists (Glaser & Strauss, 1967) have long debated the arguments of forced versus emergent theory (Bendassolli, 2013). In this research this "inductive sensitivity" ensured researcher reflexivity was applied at all stages of the investigation. During the data analysis, reflexivity contributed significantly to deeper understanding and particularly to the development of the thesis' conceptual model from the data.

Investigating the effect of outside dynamics enabled a deeper understanding of the 'pre-wired' expectations that actors bring to projects, which shape project objectives, relationships and delivery, and which affect project learning. With the AIS literature informing the investigation, the data analysis of the cases became as much about what the case study data did not reveal, as what it explicitly revealed. For example, this highlighted the low level of evidence for transdisciplinary partnerships in the projects.

With the AIS and participatory research literatures both informing the analysis, the second cycle code categories organised the data to assist with developing the concepts of the model presented in Chapter 7. This reflects what Cope describes as creating larger "trends, categories and common elements that are theoretically important" (Cope, 2003: 454). When a code could not be assigned to an existing category, a new category was created. The analysis of all the coding data led to a total of 20 categories, which were then further grouped into themes or meta-categories. While Saldana (2009) argues there is no consensus in the literature about the precise definition of a theme, in this research meta-categories clustered the 20 'second-cycle' coding categories into three broad themes shown in Table 3.6. These themes form the discussions of the results in Chapters 4, 5 and 6 of this thesis. The chapters each explore one of the key themes.

Creating categories allowed patterns to be seen. For example, when the codes were grouped a category of 'project initiators' emerged. Investigating this pattern further provided insights into how project relationships, delivery and outcomes were shaped by project initiation.

The meta-categories or themes were critical for informing the conceptual development, as these themes identified institutional contexts, actor relationships, and knowledge co-production and learning as critical aspects of projects. These aspects of projects form the key attributes of the thesis' contribution – the conceptual model, referred to as the PROCLE model, that is outlined in Chapter 7. While institutions, partnerships and learning are discussed as discrete themes in Chapters 4, 5 and 6, Chapter 7 synthesises these themes as the data analysis revealed that institutional contexts

(Chapter 4), partnerships and relationships (Chapter 5), and knowledge integration and learning (Chapter 6) are highly inter-related dynamics of participatory research projects in agricultural innovation systems. The empirical evidence from this research has enabled the development of a conceptual model, which shows the inter-relatedness of project contexts, relationships and learning in participatory research.

Table 3.6: Analytical categories and themes that influenced chapter content

Categories	Theme 1
Policy/Funding Motivations	**INSTITUTIONAL CONTEXT TO SUPPORT INNOVATION** (Chapter 4)
Policy/Funding Expectations	
Institution of Science	
Scientists' Motivations	
Scientists' Expectations	
Farming Groups Motivations	
Farming Groups Expectations	
Value chain actor inclusion / exclusion	

Categories	Theme 2
Project Initiators	**PARTNERSHIP** (Chapter 5)
Project Objectives	
Actor Relationships	

Categories	Theme 3
Knowledge Production	**LEARNING** (Chapter 6)
Learning Platforms	
Learning Outcomes	
Transformation / Reflective Practice	
Resistance / Barriers To Change	
Knowledge Sharing / Diffusion	
Collaboration	
Individual learning	
Social learning	

While the discrete discussion of each theme in a chapter of this thesis is somewhat artificial, given their inter-relatedness, it allows the empirical evidence of each attribute to be fully explored to inform the conceptual contribution in Chapter 7. For example, the exploration of learning in Chapter 6 enabled ‘the space for learning’ to be identified as a critical attribute of the model presented in Chapter 7. The empirical evidence presented in Chapter 6 also identified the ‘realisation’ of learning within the learning space. Understanding the theme deeply in the results chapters gave insight into the need for a learning space and also the importance of ‘filling’ this space to optimise learning, which is central to the conceptual contribution of this thesis as discussed in Chapter 7. The in-depth exploration of each theme in the chapters also assisted with the development of the thesis’ guidelines for sustainability implementation that are presented in Chapter 8.

The results chapters begin in Chapter 4 with a discussion of the institutional contexts that actors bring to projects. These contexts take the investigation of projects beyond the boundaries that are artificially determined by the funded dates of a project, to explore the influences that shape actors’ motivations and expectations of participatory research, as these set the landscape in which participatory research operates and also shape actors’ engagement in participatory research projects.

The discussion then moves in Chapter 5 to an examination of project partnerships. As the data analysis revealed the novel patterning of projects according to the initiator of a project, the discussion uses this pattern to provide valuable insights into how partnership categories (according to who initiates the partnership) affect project objectives and partner relationships.

The final results chapter addresses the theme of learning in projects. The ordering of learning as the last results chapter is intentional, since the data analysis revealed the effect that the other attributes – contexts and partnership has on learning. Understandings gathered from the empirical evidence presented in Chapter 6 provide the foundation for the identification of a ‘collaborative learning space’ that is pivotal to the conceptual model presented in Figure 7.1.

3.6 Summary

The methodology used in this research sought to enhance understanding of participatory research by unravelling the complexities of multi-stakeholder engagement in six cases where scientists and farmers collaborated to advance sustainability in agricultural innovation systems. The multiple case study approach provided a rich corpus of empirical data from stakeholder interviews, document review and participant observations. While the case studies are not replicates in an experimental sense, they nonetheless have in common the participatory engagement of scientists, farmers and other rural stakeholders working together. Through exploration and analysis of the cases' commonalties and differences, insights have been gathered to build new understanding and develop conceptual insights. The findings, presented in the next four chapters, which are drawn out of a reflexive methodological approach using a cyclical process of deduction and induction, enrich and deepen the practice of participatory research and contribute to informing the theory which underpins this practice.

CHAPTER FOUR

4.0 Exploring Institutional Contexts that Shape Actors' Visions

4.1 Introduction

Innovation cannot be simply viewed as invention as it is a "normatively laden" process of knowledge production that emerges from people's perceptions and visions of the type of world they wish to live in (Klerkx et al., 2012: 458). Participatory research projects that seek to advance sustainability require actors to come together to create a shared vision to enable learning and the co-production of innovations, whether this be new ways of knowing (knowledge innovations) or doing (innovations in practices), or new tools (technological innovations). Innovation, particularly when progressing sustainability, is therefore a largely values-based process and is argued to be in part shaped by institutions that shape current ways of knowing and doing (Wieczorek & Hekkert, 2012). These include for example the 'formal' institutions of rules, regulations and instructions and the 'informal' institutions of routines, habits, traditions, customs and social norms (Pfahl, 2005). As Klerkx, van Mierlo and Leeuwis, (2012: 458) state,

> … production and exchange of (technical) knowledge are not the only prerequisites for innovation. Several additional factors play a key role, such as policy, legislation, infrastructure, funding, and market developments. Agricultural innovation is hence not just about adopting new technologies, it also requires a balance amongst new technical practices and alternative ways of organizing.

Existing institutions are argued to enable or disable innovations (Section 2.3.4). This chapter seeks to identify how institutions shape actors' visions of participatory research and enable or disable innovation. “Institutional contexts” was a dominant theme to emerge from the data analysis (Section 3.4 and Table 3.6). This theme was largely formed from data categories that grouped interviewees’ motivations for engaging in participatory research and their expectations of participatory research. To explore this theme, the chapter examines policy/funding, science, and farming group actors’ motivations for engaging in, and their expectations of, participatory research. Exploring why major project actors engage in participatory research and their expectations of the participatory process importantly identifies the institutional constraints that actors take to projects. These have the potential to disable the creation of a shared vision between actors that is necessary for innovation co-production. This chapter’s discussion provides a foundation for understanding how institutions might shape project partnerships and actor learning, which are discussed in Chapters 5 and 6.

4.2 Policy/funding actors’ motivations and expectations

4.2.1 Background to policy and funding actors in this research

New Zealand’s Sustainable Farming Fund (SFF) is a central government funding agency which supports the funding of private/public partnerships in agriculture. Policy recognises the Fund as an exemplar of participatory partnerships (PCE, 2004. See also Section 3.2.1). It funded five of the six projects in this research. The Crop Science for Māori project was funded through the Foundation for Research Science and Technology (FRST), a government science-funding agency. Both the SFF and FRST funding agendas reflect an increasing move worldwide by policy and funding agencies to challenge scientists to adopt more participatory approaches in their research (Bruges & Smith, 2008; Smith & Halliwell, 2011).

Six actors from SFF and policy agencies were interviewed in this research to provide insights about New Zealand’s funding and policy agencies’ support for participatory research at the micro-level. The following sections identify policy and funding agencies’ motivations for supporting, and expectations of, participatory research as articulated by individuals from these agencies. The discussion explores how agencies’ motivations and expectations may shape micro-level collaboration between farmers and scientists.

4.2.2 Policy/funding agency actors' motivations for supporting participatory research

Policy/funding actors in this research valued the move towards demand-driven extension. A policy actor described SFF's establishment as a "breath of fresh air", when he stated,

> It was initiated on Sutton's view [the Minister of Agriculture] that there had to be a better way to achieve change on the ground in rural New Zealand… There was nothing to support the producer-led, community-led approach other than the Sustainable Management Fund but that didn't tackle anything in the production field. So really [SFF] was a breath of fresh air.
>
> *Participant R26O*

This actor's comments position demand-driven research and extension as being a "better way" to "achieve change on the ground". Furthermore the focus of SFF on production agriculture clearly differentiated the fund from the purely 'environmental' funds in New Zealand, while its focus on being "producer-led" / "community-led" differentiated it from the science funds which often focused on fundamental science research. This same policy actor emphasised the fund's production agriculture focus by stating that SFF was never intended to be a science fund or "science funding in drag" (Participant R26O). In keeping with international trends, this actor reveals that SFF was established to support farmers' needs and be more responsive to the dynamic economic and social conditions of production agriculture.

SFF's documentation gives further insight to policy's motivations for supporting demand-driven initiatives. A promotional brochure (SFF, 2007) claims the fund is based around the creation of 'communities of interest', while an in-house review at the fund's 10-year anniversary claimed it is these "communities" that are the key driver of project success as SFF claim they engender greater project ownership by farming groups, "from conception through to adoption" (SFF, 2010). There is an implicit suggestion in these documents that community ownership is critical for driving "change on the ground", although the documents acknowledge that ownership must occur at all stages of a project. Both the participatory and AIS literatures recognise the connection between community ownership of a project and any subsequent ownership of the outcomes (Klerkx & Leeuwis 2009; Pretty, 1995).

The SFF documentation (SFF, 2007) describes its communities of interests as land managers, industry organisations, agribusinesses, consultants and researchers who "come together to tackle a shared problem or develop a new opportunity." Policy actors interviewed in this research valued the fund as a means to foster relationships and collaboration among potentially divergent rural stakeholders. The fund's claim to successfully foster relationships between agricultural stakeholders is supported by an independent review of SFF (Kinnect Group, 2014), which found that project partnerships enhanced relationships and networks between farmers, rural communities, scientists, local government and industry bodies.

The motivation for stimulating change on the ground is further outlined in a Ministry of Agriculture and Forestry (MAF) 2010 draft document (anonymous, undated), provided by one of the interviewees, which highlighted an urgent need to target 'underperformance' in the agricultural sector. The document's contention of underperformance in agriculture was supported by studies such as a 2006 assessment of technology uptake in the dairy sector which identified a low level of development and adoption of sophisticated new technologies, as well as poor recognition amongst farmers and rural professionals of the benefits of technologies (Jago & Ohnstad, 2006). The MAF document (anonymous, undated) states,

> "There is broad agreement among sector participants that the technology transfer system is showing symptoms of underperformance in terms of contributing to increased productivity and improved environmental performance".

This quote demonstrates a desire to address under-performance. Demand-driven applied research and extension initiatives are seen to offer an approach to agricultural research that addresses this underperformance through participatory endeavours that have direct relevance to farmers and direct application on the farm. Interviews with policy actors and review of policy documents reveal that policy and funding agencies have been motivated to support participatory research in New Zealand largely to foster and create multi-disciplinary partnerships that will work together to address a shared problem in order to improve economic and environmental performance in the agricultural sector. As a policy actor explained,

> We have got this long tail of underperformance and our current mechanisms don't kind of get that. What we know from past experience is that it is quality not quantity that counts in the engagement.
>
> *Participant R25O*

The support by policy and funding agencies for demand-driven initiatives can be viewed positively as an enabling factor to support innovation that advances sustainability. Demand-driven initiatives move research and extension away from linear approaches that are increasingly recognized as unlikely to bring about marked changes in agricultural practice and thinking that addresses the complexity of sustainability (Section 2.2). Internationally, policy agencies view the move away from a "science-push" towards a demand-driven research and extension system as a positive move (Klerkx & Leeuwis, 2009), since they claim the latter is more focused on farmers' needs and more responsive to dynamic economic and social conditions (Umali & Schwartz, 1994). On a practical level, policy agencies also appear to favour the associated reduction in the costs of research and extension from no longer having to provide a solely public extension service (Ameur, 1994).

Bruges and Smith (2008), however, raise concerns over the appropriateness of using participatory research to achieve policy goals that promote change towards sustainable agriculture. They caution that the absence of discussion by policymakers and scholars around the use of participatory research to achieve policy goals may lead to participatory research being employed simply to reduce costs and legitimize pre-determined goals.

4.2.3 Policy/funding agencies expectations of participatory research

Interviews with policy actors suggested that there was increasing political expectation for greater transparency and accountability of public funds. As a fund that encourages community-led initiatives, policy actors claimed that SFF has had to balance the need for financial accountability with management flexibility. This approach, which a policy actor called "active management" (Participant R26O) was claimed to be founded on "sensible but strong internal controls" and "flexible, friendly supportive systems" to give project teams autonomy to collaborate and engage.

> I think a big part of the reputation that the programme has is founded in that flexibility and problem solving and expecting that things could go pear-shape from time to time.
>
> *Participant R26O*

An SFF project adviser also reinforced the need for balance, "we don't want them [fund recipients] to spend all the time report writing but we need to know that they are on track" (Participant R24O). The research shows the recognition that policy actors had of creating a supportive but flexible policy framework. Empirical evidence from Landcare projects in Australia supports the need for good agency management in private/public demand-driven networks (Curtis, 1998) and the positive effects this has on sustainability outcomes (Campbell, 1994, 1998; Curtis & De Lacy, 1996; Nicholson et al., 2003).

Interviews with farming groups in this research, however, suggested that the fund's tolerance for balance was lessening. One farming group manager suggested that an increasing demand for accountability was leading to an overly bureaucratic approach to SFF fund management. His following statement suggests that the pressure for accountability was coming from forces outside the fund.

> I just worry that it is becoming bureaucratic which is a burden to those who are involved in the process - I mean themselves as well, and it is not their doing necessarily.
>
> *Participant R75Wh*

This quote suggests that political pressure may be eroding the participatory framework on which SFF's participatory research partnerships originally thrived. This concern is reinforced by a recent independent review of SFF (Kinnect 2014:14), which noted growing concern amongst project managers about increased bureaucracy and rules, which were taking precedence over effective project outcomes.

Support for participatory research brings with it clear expectations of change on the ground. However, the interviewees revealed that an increasing requirement for accountability of public funds may under-value participatory research which in turn undermines the ability to effect real change. The *Science for Community Change* (SCC) programme (Section 3.2.1), from where the six cases investigated in this research were drawn, provides evidence of the tensions that exist between motivations, expectations and funding accountability. Science interviewees from the

Science for Community Change Programme believed that their original funding proposal aligned well with the call by policy and funding agencies for research to demonstrate active engagement with end users and provide direct benefits to end users. Their original proposal fully embraced a comprehensive programme of participatory research by setting out eight objectives involving seven multi-disciplinary partnerships between physical and social scientists and farming groups in participatory learning networks in seven participatory research projects. The funders, however, rejected this extensive proposal and interviewees explained that the research institute was left to reluctantly accept a substantially reduced programme with only two objectives. The Crop Science for Māori project (Table 3.1) formed the first objective while the remainder of the original programme was reduced to a single objective examining five 'existing' public-private projects funded by the Sustainable Farming Fund (these projects are described in Table 3.1).

The substantially modified programme raises questions about whether policy and funding agencies will support an ambitious goal for science research to be client-focused, cost effective, transparent and publicly accountable while promoting agriculture change that improves economic and environmental performance in the rural sector. The reduced SCC proposal from eight to two objectives illustrates what Buhler et al. (2002: 123) suggest is "compromised participation". This has the potential to undermine the effectiveness of participatory endeavours, particularly when partners require time to develop trusting relationships.

Increasing accountability of funds was also shown to be affecting routines of SFF projects. Fund managers gave insight into how projects might be expected to articulate 'change'.

> We are now starting to ask candidates to suggest key performance indicators for their projects - very much outcome focused. So it won't be how many scientific papers have been published in peer-reviewed journals, it could be how many field days did you have, what was the attendance like and how have you since measured changes in behaviour. So I think there has been a significant change in focus and concern about not just throwing out money from the skies but really assessing what good we achieve.
>
> *Participant R29O*

The measurement of success using quantifiable outcomes has been shown to undermine the foundational base for participatory research, since many of the outcomes of participatory research, such as trust-building and collaboration, are recognised to be difficult to quantify (Murray, 2000). Measurements such as the number of field days may indicate the level of activity, but they do not indicate underlying social dimensions of projects such as collaboration leading to concerted action, which the participatory literature recognises to be essential for fostering sustainability (Franklin & Blyton, 2011; Keen et al., 2005b; Roling & Wagemakers, 1998b; Van Den Ban & Hawkins, 1988). Van den Ban and Hawkins (1988) show that a focus on quantifiable outcomes leads to a preference for innovations that diffuse rapidly, such as simple innovations or innovations that maintain the dominant thinking. Simple innovations, which do not necessarily challenge the dominant thinking will have limited effect in complex systems where changes to deeply rooted agricultural practices may instead be needed to challenge the assumptions and values that drive current thinking and practice (Keen, Dyball & Brown, 2005). A farming group respondent stated that a focus on measurable key performance indicators (KPIs) discourages aspirational research:

> The real risk of key performance indicators will be, you have science being driven by a key performance indicator instead of by innovation or getting unique outcomes. So you write in key performance indicators that you know you are going to achieve - that are a piece of cake.
>
> *Participant R75Wh*

Funding regimes may similarly be undermining participatory research. Farming groups expressed concern at the way applied research and extension was funded. They claimed that short-term funding and one-off project funding, as opposed to long-term programme funding do not drive durable change. A farming group manager explained:

> We need stable funding in extension, the same as they are trying to do with the stable funding of science - that addresses the science bit, but no one is doing anything to address the extension bit.
>
> *Participant R01L*

An SFF project officer also acknowledged that short-term funding bought with it challenges, when she openly declared that ‘change’ could take time:

> It would be very very rare that we have been able to have an uptake of anything in three years.
>
> *Participant R24O*

The interviews with policy and funding actors showed a desire to support client-focused, cost effective, transparent and publicly accountable research to promote real change that would improve economic and environmental performance in the rural sector. While there appeared to be a genuine desire to recognise the need for a balance in participatory research projects that allowed flexibility with accountability, the balance appeared to be shifting. Evidence from Landcare farmers' networks in Australia shows that when policy changes bring about a more bureaucratic approach to fund management, the conditions under which these networks operated was eroded, and this led to their decline (Wadsworth 2010 – Section 1.3.4).

4.2.4 Policy/funding agencies enabling and disabling factors for fostering innovation in participatory research

This research illustrates the critical role policy and funding agencies play in determining the framework for innovation and supporting private/public partnerships in agriculture to advance sustainability. Table 4.1 presents the findings from Section 4.2.1 and 4.2.2 and lists dynamics of policy and funding agencies' identified in this research that have the potential to enable or disable innovation. As stated earlier (Sections 2.3.4 and 4.1), existing institutions are known to both enable or disable innovations (Klerkx et al., 2012; Leeuwis & Aarts, 2011).

Table 4.1 shows that policy and funding agencies' motivations for supporting participatory research in general have an enabling effect on innovation in that their support for participatory provides opportunities and resources for these endeavours to occur. However, their expectations of participatory research have significant potential to constrain innovation in that they may both underestimate and undermine the collaborative and adaptive nature of participatory relationships and learning through increasingly bureaucratic management regimes. The research also reveals that policy agencies may set an a priori narrative of expected change that potentially underestimates and undervalues the practical realties of multi-stakeholder engagement and the dynamic and unpredictable nature of how knowledge is developed and adopted in farming communities (Section 2.3.1). These constraints have the potential to markedly compromise participatory endeavours and are addressed in Chapters 5 and 6 to examine their effect on partnerships and learning.

Table 4.1: Factors of policy/funding actors that enable and disable innovation

Policy/Funding Agencies Enabling and Disabling Factors for Innovation to Support Sustainable Agriculture
Enabling Factors Financial enablers • Financial support for demand-driven research and extension through public funding of initiatives such as SFF. • Demand-driven research and extension opens up funding avenues for non-science sectors. • Public private sector funding model provides support for natural resource management research in production agriculture. The projects in this research show funds are being directed at managing negative impacts of agricultural externalities. • SFF funds accessibility to small players such as the walnut industry group. Political enablers • Political support for demand-driven extension. • Funds actively challenge scientists to engage in participatory research / transdisciplinary partnerships Flexible Management • Active fund management – allowing a balance between flexibility and accountability.
Disabling Factors Tensions from policy goals targeting both environmental / economic underperformance • Increasing economic alignment of innovation policy with the knowledge economy may undermine initiatives directed at environmental underperformance. • Potential under-estimation of the practical difficulties of reconciling policy goals in participatory research may lead to 'compromised participation' as evidenced by modifications made to the SCC programme proposal. Prescriptive management • Accountability of public funds can limit the scope of participatory endeavours as evidenced by the SCC programme modification. This has the potential to undermine and undervalue a policy goal to bring about agricultural change. • Active 'fund' management being replaced by a more bureaucratic approach to fund management. • Fund regimes that seek quantifiable measurements and KPIs which are known to devalue non-quantifiable outcomes (Murray, 2000). • Short term and one-off project funding of applied projects potentially underestimates and undervalues the timeframes needed to bring about significant and durable change. • KPIs encourage targets that are easy to achieve and discourage aspirational research initiatives.

4.3 Science actors' motivations and expectations

4.3.1 Background to the scientists in this research

Science actors interviewed in this research were overwhelmingly government research scientists working for either Crop and Food Research (CFR) or HortResearch, one of the government-owned Crown Research Institutes (CRI). HortResearch and Crop and Food Research were merged in 2008 to form Plant and Food Research (PFR). One research scientist in the walnut project was a private scientist (although initially when contracted to the project had been working at Lincoln University) and another in the squash project was a retired government scientist who was contracted as an advisor to the squash industry group. Except for the retired scientist, all others were active researchers in their respective projects, most having direct field research roles, while a few took a research oversight role.

4.3.2 Motivations and norms that influence how scientists practise science

Interviews with scientists in this research indicated that they were motivated by both professional and personal factors. All interviewed scientists were personally motivated by a curiosity to answer questions about the world. One scientist put it rather succinctly,

> …for scientists the main driver is the question and that is why they go into science.
>
> *Participant R48L*

To answer questions, scientists overwhelmingly used experimental research in which their role as the scientist was viewed as an objective observer. Technology transfer to end-users was largely perceived to follow technology/knowledge development. In most conversations with scientists there was an implicit assumption that technology/knowledge development was to be undertaken by scientists, while in some conversations this was stated explicitly, as the following scientist explained,

> I always thought …you had to do the science first, so I tried to put as much as I could into the science to get the information out.
>
> *Participant R43P*

Scientists' personal motivations were influenced by the research environment, and in particular the contestable funding system in which they operated. For all but one of the interviewed research scientists, New Zealand's competitively funded science system, and the business structure of the CRI they worked for, was vastly different from the science system that existed in New Zealand when they began their careers. Scientists claimed their CRI rewarded them for scientific outputs from publications, citations and commercial intellectual property, a feature noted also by Hunt (2009) in her ethnographic study of a CRI. Scientists therefore valued large research grants because these enabled them to undertake long-term fundamental research that provided opportunities for publications in prestigious journals, which increased their professional reputation.

One scientist overtly claimed that the narrow focus and short-term duration of applied research typically did not meet the statistical rigor demanded by both international publications and their research institute's own biometricians. This meant applied research papers were often relegated to local rather than international journals. This scientist described the dilemma of trying to publish results from a one-year applied participatory research project:

> *The European Journal of Plant Pathology* – they can't publish that. If I had two years work I could have put it in *Plant Disease* but we only had the funding for that one year with no repeats of that. I can't publish it in *Plant Disease*, but it was a nice piece of work, beautiful results. So *NZ Plant Protection* they take it, and because I know for that work there is no other subsequent work that comes into it, it won't go anywhere else.
>
> *Participant R65Wa*

Applied research that required science to be narrowly focused and easily communicated to meet farmers' needs therefore risked being seen by scientists and their institutes as less important than fundamental research. Scientists who undertook applied research reported feeling torn between the requirements of their employer and the traditions of science to publish in prestigious research, and the needs of their farming group partners to produce practical tools or knowledge that was relevant to farmers. The previous scientist went on to explain this tension:

> As a scientist at the end of the day I don't really care about the grower, I care about my science, the grower becomes a tool for me to do my science. And that is controversial for me, because I *DO* care about my growers, but I have other interests as well, other than the grower's best interests, and for my own career interests the grower's best interest is *NOT* my best interest - from a career point of view and a publication perspective.
>
> *Participant R65Wa*

In a competitive funding environment, a significant portion of a scientist's time was spent writing applications for what many described as "over-subscribed" funding rounds. Project-based participatory research with its short-term applied focus, while described as enjoyable rarely met the criteria for access to the large fundamental science research grants. Nonetheless with larger grants often described as difficult to secure, scientists found applied research a useful means for securing funding, as one scientist explained:

> [You have to] come up with ideas and do something quickly because you are running out of funding. To be honest there has been a fair number of projects where the researchers are scratching around for money and, "oh let's put in an SFF proposal - what ideas have we got." And then they go looking for the community group. I don't want to bag that too badly because you are dealing with the everyday reality of trying to fund people that need to put bread on the table and some of those projects have worked out really very well.
>
> *Participant R14M*

This quote captures the realities of operating in a contested funding environment and identifies the risk that applied projects may not be primarily driven by an ethic that is committed to community-based research. This leads to research that is potentially retro-fitted into an applied umbrella to meet funding requirements.

4.3.3 Organisational expectations and science practice

While the contestable funding system in which scientists operated shaped how scientists practised science, it required them to be adaptable, to avoid being what one research scientist bluntly called, "cures looking for a disease". No longer could they be creatures of habit, reluctant to move out of one narrow field of research. Indeed nearly all of the scientists interviewed for this research were no longer working in the same field they worked in when they participated in the SFF projects under investigation, and for which they were interviewed. Some had become science managers, some had moved overseas to work in science organisations, one had moved to the tertiary education sector, while others were working in different research fields in New Zealand "to follow" the research funding. It was clear that the unpredictability of funding in the science system presented significant personal and professional challenges. As a scientist stated:

> So you have to change the system from time to time and that of course is an anathema to people who want stability in their jobs.
>
> *Participant R14M*

Scientists articulated in their conversations a continual struggle with meeting organisational research requirements while also being challenged to engage with end users. A scientist explained:

> When a scientist is doing research, … that is where the bulk of their time goes, they don't have time to go out and talk to this grower and that one…
>
> *Participant R48S*

Research requirements limited opportunities for relationship building with stakeholders outside the science system. While the CRIs *Statements of Core Purpose* explicitly state a need to create strong and long relationships with key stakeholders, a scientist lamented that the increasing corporatization of the CRIs bought with it a changed culture that focused on research and not relationships. In talking about being part of a CRI who had just undergone a merger he stated:

> The new institute has a different culture – it's all about the science and not about relationships and this place has become very, very quiet and dull… When the world is driven by bean counters, you lose the point of who grew the beans in the first place.
>
> *Participant R14M*

Scientists also claimed the combined business and research focus of the CRIs meant project funds were directed as much as possible towards the science investigation.

They claimed this limited availability of funds for project communication and extension. A senior research scientist who had managed many applied projects stated:

> There is always institutional pressure to keep as much of the funding within the group as you can, and that is understandable but not always the best way of getting the project done.
>
> *Participant R14M*

To meet organisational research expectations, scientists typically placed emphasis on the science research and confined project 'extension' to the final year when research results were known. This occurred in two of the projects in this research (discussed in Chapter 6). Extension, which was most commonly verbalised in this research by scientists as 'technology transfer', often consisted of a written report for the farming group partner and some research seminars. Many scientists felt inadequately equipped to engage in a meaningful way with non-science audiences, as this required a set of skills many felt they did not possess. As one scientist explained:

> Scientists do want to see [their research] make a difference but that [extension] is a whole new ball game that requires another set of skills… Scientists aren't often good people-people.
>
> *Participant R48S*

While this comment may seem to stereotype scientists, scientists acknowledged their motivations for entering science were focused on research and not communication. Project reports were typically written for science audiences. The previous scientist recalled the numerous applied project reports he had read over the years.

> I thought OK these are scientists that have written these reports and it doesn't even make sense to me, they haven't explained really well what they are doing, and why they are doing it, the relevance it has to the industry. They come up with a whole bunch of recommendations which don't really connect with where a grower might be thinking, they haven't really understood what the grower really wanted, they just have come up with some objectives and done the objectives but they haven't really understood why the grower is really interested in this or why the industry is really interested.
>
> *Participant R48S*

A science manager expressing concern at an increasing perception by some scientists that writing a report constituted project extension, bluntly stated, "[the CRIs] shouldn't be doing it." An organisational expectation that scientists should focus on research, meant project extension, a critical part of participatory research that connected projects with farming communities of practice, was left under-resourced and under-valued.

> …technology transfer is the 'D' of R and D [Research and Development]. Where New Zealand is at, maybe we do need to spend more on D than R – but at the moment we have that sitting on shelves.
>
> *Participant R27O*

A farming group manager similarly expressed concern that the competitive environment in which scientists operate, was increasingly creating a science sector that was disconnected from the farming sector, a feature also noted in a recent survey about technology transfer in New Zealand (MPI, 2012). The farming group manager stated:

> I think New Zealand science is in a terrible state at the moment because we are meant to have a whole heap of scientists that are real innovative people that are rushing to our door to say boy have I got the best idea for you, and they are not…there has always been flexibility within the funding system for a manager who is prepared to put his neck on the line to say I will give you X thousand dollars to go away and come up with something smart… But they are not prepared to put their neck on the line because it is all about these outcomes that are preconceived.
>
> *Participant R75Wh*

The interviews with scientists in this research revealed uniformity across all scientists, irrespective of the project in which they participated. Scientists' conversations were typically illustrated with wider revelations about the personal and professional factors that shape how they conduct and communicate research. These conversations overwhelmingly illustrate the tensions that exist between the demands of participatory research and the scientist's personal motivations for engaging in science. Findings also indicate how organisational expectations influence how scientists operate in a competitively funded and economically focused research environment.

4.3.4 Enabling and disabling factors that influence scientists' engagement in participatory research

The data analysis and document review conducted for this research indicated that the institutional context in which government scientists operate both enables and disables innovation in participatory research projects. Table 4.2 presents the factors that may enable and disable scientists' engagement in participatory research. These are grouped into personal, institutional, organisational and educational factors that influence the way research is conducted and communicated and affect the way scientists engage in participatory research that seeks to foster innovation to advance sustainability.

The table shows these factors can have an enabling effect on micro-level engagement. However, the empirical evidence from this research reveals that overwhelmingly they act to disable scientists' engagement in micro-level participatory endeavours that are sought to advance a move towards sustainable agriculture.

Table 4.2: Factors that may enable and disable scientists' engagement in participatory research

Scientists' Enabling and Disabling Factors for Innovation to Support Sustainable Agriculture
Enabling Factors Personal enablers • Scientists' personal curiosity, knowledge and skills to answer questions about the real world. • Personal enjoyment of applied research. Organisational enablers • Organisational infrastructure that supports scientists' engagement in projects. • Recognition of research opportunities from applied research partnerships.
Disabling Factors Personal disablers • Scientists' worldviews of science and being a scientist that may not be realised by engaging in applied research. • Scientists' perception they are ill-equipped with the skills for collaborative engagement in participatory research with non-scientists. • Career prospects and professional reputation that bias fundamental research. • Limited understanding of non-research components of projects. • Epistemology that devalues knowledge that is not derived from rigorous experimental approaches to research. Formal and informal institutional disablers • Participation in applied partnerships to satisfy job security rather than a genuine commitment to community-based research. • Traditions and methodologies that promote linear approaches to research and extension. • CRI regimes and routines that reward quantifiable outputs and make it difficult to realize partners' expectations. • Regimes and routines of publishers and biometricians that may bias fundamental research. • CRI 'research' focus that has the potential to devalue non-research components of projects and limit funds for extension. • CRI business & commercial focus that limits transdisciplinary collaboration and favours commercial ventures (see also Hunt 2006). • Funding regimes that allocate applied research to the less lucrative short-term grants. • Competitive funding creating research adaptability to secure funding, fosters instability & limits relationship building with industry Educational disablers • Education and training that may not equip scientists with the skills needed for collaborative engagement.

4.4 Farming motivations and expectations

4.4.1 Background to farming groups in this research

All farming groups were motivated to engage in participatory partnerships with the science sector. However, this section shows groups were motivated for different reasons and to differing degrees.

Farming groups were either industry-good bodies or voluntary farmer groups. The industry good bodies were the squash rot project's Squash Industry Group (formally the Kabocha Industry Group), and the potato aphid project's Potatoes NZ, (both product groups in Horticulture New Zealand (HortNZ)), and the Wheat Calculator project's Foundation for Arable Research (FAR). The voluntary farmer groups were LandWISE, which managed the precision agriculture projects, the Walnut Industry Group (WIG), which managed the walnut blight project, and the East Coast Organic Producers Trust (ECOP) from the Crop Science for Māori project.

Industry good bodies allow for sector interests to be represented in policy and in industry relevant research. They are principally funded by a compulsory levy paid by farmers in accordance with the Commodity Levies Act 1990, although they also receive money from grants, sponsorship and sales. Farmers vote on the maintenance of the levy at nominated intervals and typically they receive wide farmer support, with FAR receiving over 80% support from arable farmers during the 2011 membership vote for the continuation of the levy (FAR website, 2014). FAR's commodity levy is primarily used to maximise farmer profitability and increase productivity through investment in research, development and on-farm activities. HortNZ uses its levy to "protect growers' interests, increase fruit and vegetable consumption and improve profitability of the entire industry". They claim that for every dollar of levy money received, they return around $NZ30 in value to growers (Horticulture New Zealand, 2012). Levy funds are also used to leverage further funding from government agencies such as the Sustainable Farming Fund.

Unlike the industry good groups that have a relatively secure and known income base from the commodities levy, LandWISE and WIG are reliant on voluntary membership, sponsorship and funding grants. LandWISE, unlike WIG, is not industry specific, although the group primarily serves farmers in the arable and vegetable sectors. Both groups draw strongly on the financial and human capital of their membership. Government funding of projects assists them to further their research interests, advance crop knowledge through research, and in the case of LandWISE, to support staff. Both groups do not have a large subscribed membership base, so their long-term survival is principally dependent on their success in grant applications. Interviews indicated that this reliance on government grants makes them vulnerable to changes in the research priorities of policy and funding agencies.

The Crop Science for Māori project's ECOP (East Coast Organic Producers) Trust is a charitable trust. It was established around 2000 with the aim of improving the social and economic outlook for Māori on the East Cape. ECOP members are predominantly but not exclusively Māori from across the East Cape region. Membership of this group is difficult to quantify and while estimated to be around 50 landowners, by the start of the Crop Science for Māori project, only 5-10 ECOP landowners were able to be identified (Bruges, 2006).

4.4.2 Farming groups' motivations for engaging in participatory research

Farming groups' motivations for engaging in participatory research are not uniform. The groups could be divided into three groupings. 1) Those with a research focus, which included FAR, LandWISE and WIG who were motivated by a need for industry related research and who fostered within their sector environmental, economic and social dimensions of sustainability. 2) Those with an economic focus included the Squash Industry Group and Potatoes NZ, who fostered economic sustainability in their unpredictable and volatile sectors. 3) ECOP who had principally a cultural focus with aims and objectives that sought to advance the socio-cultural dimensions of sustainability. Motivations of each group are outlined below.

Research as a primary motivator

FAR, LandWISE and WIG have a strong research and extension focus. All three groups have a history and a group culture of being engaged in research. The structure and genesis of these groups underpins the way they consider and engage in research.

FAR was established in 1995 following significant restructuring in the wheat industry when a group of farmers proactively created a "new model" (Participant R75Wh) for sector engagement following the dissolution of New Zealand's public extension services. The FAR manager explained, "there was a vacuum, we had nothing there." (Participant R75Wh).

FAR's head office is strategically located in Lincoln next to its main science provider, Plant and Food Research (previously Crop and Food Research and HortResearch). FAR's website describes the organisation as "an applied research and information transfer organisation…" (FAR website, 2013). Levy money funds a Strategic Research Committee and six regionally based Arable Research Groups. This focus on research is evident in the 70-80% of levy funds that FAR directs into research relevant to the arable industry. Indeed FAR's reputation was claimed by interviewees to be built on its independent, unbiased and trusted arbitration of crop trials. As an arable farmer explained:

> You constantly have to stay in touch with what is happening in the industry. It is the independence of FAR's trials that is important because advertising can sell a lot these days…FAR is really the main [source of information] for arable farming… Every levy payer gets the FAR newsletter, you don't have to be a member you are a member because you are a levy payer… All the companies send newsletters out but a lot of the stuff in their newsletters is derived from FAR.
>
> *Participant R71Wh*

Like FAR, LandWISE was established by a group of proactive farmers in 1999 in partnership with other interested rural stakeholders to respond to growing concerns about the effect of wind erosion on the light soils of the Hawkes Bay region. The group undertakes its own independent research and also partners with research organisations such as Plant and Food Research, Landcare Research and Massey University. A farmer who was a foundational member explained his interest in establishing the group:

> I got a Nuffield Scholarship, so I went to the States - I looked at strip tillage or minimum till systems and irrigation management – and when we came back from that … a few of us got together and started forming the idea of some sort of sustainable cropping group. I had the ideas of the Nuffield to feed into that…
>
> *Participant R04L*

WIG similarly was motivated by a desire to develop practical and useful knowledge specific to the walnut sector. Having a number of members who were scientists or engineers, they sought a strong connection with science research and established an association with Lincoln University, where they had access to a walnut research orchard to conduct field trials. Walnut growers sought knowledge about walnut production and they made this knowledge available to current and prospective growers. The group had compiled a *Walnut Grower's Manual* that contained the collective knowledge from their research initiatives. The following sentiment from a walnut grower showed how important knowledge production was to the walnut industry's culture:

> The walnut growers … they are interested in the science and I think most of them are able to comprehend the knowledge. There is a lot of interest because there are very relevant questions. There is a high level of understanding within the industry.
>
> *Participant R54Wa*

The walnut group's commitment to research had led to the group establishing a research and development sub-committee. This committee, which consisted of many of their science members provided research direction to the wider group and oversaw all research activities. As one member who was not a scientist explained:

> There are people … who have got that scientific background. I think if they weren't there a lot of those things wouldn't happen and they have their own orchards so they have their own interest in it. Things like benchmarking – that kind of thing only happens because we have those scientific people who know from other information the value of these things.
>
> *Participant R63Wa*

The analysis of these three groups showed that their research focus provided a strong motivation to engage in participatory projects to enable their membership to connect with science to further both economic and environmental goals. They were keen to extend their membership's outlook beyond a short-term focus. A walnut grower who played an active role in the group's research and development committee explained:

> As an industry we have a narrative that says people 25 years ago bothered to think long-term - that's part of our identity. We need to be doing that as well.
>
> *Participant R56Wa*

The LandWISE manager similarly repeated this sentiment:

> What do the farmers need to know about Precision Agriculture to make better decisions to make their farming more sustainable to help them sustain the distance till next year? And if they use it for their farm can they pass it on to someone in 25 years.
>
> *Participant R01L*

The FAR manager also expressed concern about both the agricultural and science sectors short-term focus. He stated:

> I think we get really wrapped up in the current direction of whatever might be and our science is too geared to that…[The farming sector] should be saying what are the key issues around having an industry that is sustainable and we should try and figure out what the next things are. I don't think we do it.
>
> *Participant R75Wh*

The interviews show these farming groups consistently view participatory research projects as providing an enabling platform for engaging with the science sector to advance sector goals. LandWISE farmers acknowledged that science knowledge assisted them to understand the underlying reasons *why* something should be done and not just *how* it should be done. While these three groups undertook their own investigations, they also valued the scientific method and its perceived objectivity. One LandWISE farmer saw their engagement in science trials as a counter-balance to what he perceived as the subjectivity of farmer investigations, as he explained:

> Of course what [scientists] do is they get accurate results, unlike farmers trying to do research. We are looking for the answer – sorry - the one we want before we start the project.
>
> *Participant R03L*

These groups claimed they bought issues to their members' attention that would otherwise remain under the radar of individual farmers, particularly issues around sustainability. They viewed projects as an opportunity to engage as a network of learners each bringing their own expertise to the table, as the LandWISE project coordinator explained.

> [LandWISE farmers] are giving of themselves because they know that they receive by doing that and the sharing they do here of knowledge, they do without fear of commercial advantage being lost, because they know they get more from this forum than they put into it, things come back.
>
> *Participant R02L*

Group characteristics and sector dynamics of research motivated farming groups

FAR, LandWISE and WIG have either staff and/or members who have a broad understanding of science as a development tool. LandWISE's membership was described by its manager as "impetuous" and "resourced" with members who embrace technology because they are searching for solutions. He claimed they typically have had prior "experience with trials" and are prepared to be "publicly visible" and share their experiences and knowledge with other farmers. He further explained:

> They have got confidence and they have got financial capacity to make some change and they have got an interest in using science to decide if what they are doing is making a difference or not… They will be ahead of anybody anyway so they are not too afraid about secret squirrel stuff… We have got an open door policy and anyone who wants to play with us in our sandpit is welcome.
>
> *Participant R01L*

While some LandWISE farmers have agricultural degrees, many do not, but their familiarity with field trials and their interest in science allows them to combine their knowledge of science principles with their experience of working the land to address issues on the farm. As a LandWISE farmer explained:

> I did a Massey [a university in New Zealand] degree and soil science and structure was critical. When we came back here and I could tell our ground which was being ploughed in full cultivation was getting worse…so taking those first principles it didn't take a lot to work out where to change.
>
> *Participant R04L*

The Walnut Industry Group (WIG) is an atypical group in the horticultural sector in that most growers are part time, older professional people with an average age of 57 (Thompson, undated) who are generally highly educated, including a number of research scientists. Group members expressed a desire to continue the sector's legacy of contributing to improved knowledge about walnut production. Members reported to have an industry culture which valued knowledge. As a grower explained:

> I think the tree crop culture was quite formative…and so there was always this acknowledgement that we only knew so much and in the end we didn't know – that was OK not to know because if you didn't know you wouldn't ask the next question. That culture has been transferred over to the walnut industry to a large extent…
>
> *Participant R56Wa*

Similarly interviews with FAR's wheat farmers indicated that the sector is receptive to science innovations that contribute to the sector's productivity through the development of cultivars and crop management techniques. Arable farmers recognise the importance of research and in particular science research for providing this knowledge. However others in the industry's very complex value chain did not necessarily share the same research focus (Rees, undated). Interviews with other chain actors such as millers and bakers indicated a strong focus on profit maximisation, cultivar quality, principally to maximize yields, and economic sustainability - "what else is there" (miller respondent; Rees' interview undated). In addition, the demand by bakers for a regular supply of high quality product meant that New Zealand's flour market is often supplemented by imports with one baker claiming that if New Zealand's wheat industry ceased to exist, he did not perceive it would present a problem. While the baking industry conducts "appropriate industry related research", it focuses on 'lifestyle foods' that offer health benefits and export potential (BIRT, undated). A further levy also supports a grower-driven organisation *United Wheat Growers,* which manages a disaster relief fund and a quality assurance scheme.

Arable farmers typically negotiate contracts with grain merchants, although some negotiate directly with millers. Interviewees reported they were subject to wide price fluctuations in international grain markets. Most growers are also contracted to seed merchants who are reported to exert significant influence over farm management through the farm advisory role of the merchant's field representatives. One farmer indicated that these representatives influence his farming practice "probably 80%" and reported that they demand a "do this now or else" approach if a farmer strays from agreed practices.

Respondents from FAR, LandWISE and WIG indicated members had a sense of social conscience towards other 'sector' farmers, although this was more acute in the latter two groups. Two LandWISE farmers described their willingness to share information:

> We don't mind sharing because we are not going to take each other's market. We are not a threat to each other.
>
> *Participant R03L*

> You listen and you learn from others and you pass it on – it's the natural way.
>
> *Participant R05L*

Similarly a walnut farmer also expressed strong commitment to sharing information with other growers since she claimed to have already benefitted from the knowledge gathered by others. Crop knowledge had been collectively accumulated and there was no sense of personal ownership of the knowledge:

> We knew nothing when we came here and we had the knowledge of those people before us. We have all been outsiders coming in and have been able to tap into all that knowledge that is already there.
>
> *Participant R56Wa*

Engagement across all three groups was reported to be conducted collegially and cooperatively. The LandWISE board meeting was an example of this collegial spirit.

> Our board meetings could be over within about half an hour with the business, but they take most of the day and it's because they are talking and helping each other out. I just sit back and listen and love it. If someone brings up a problem, the others give them three different answers and its pretty cool.
>
> *Participant R01L*

Analysis indicated that the crowded value chain, the instability of the grain market, and the compulsory membership of FAR which leads to a more heterogeneous membership base compared to the more homogeneous membership base of the voluntary WIG and LandWISE groups, limited a sense of industry collective particularly around natural resource management. However despite this, wheat farmers generally acknowledged the need to work together. A farmer recalled a discussion amongst farmers at a FAR workshop:

> I remember in a workshop somebody said we can't compete with each other too much, we need the voice, we need to stand together to get things through.
>
> *Participant R72Wh*

Despite the differing group memberships between FAR, LandWISE and WIG and the complexity of the value chain within which FAR operated, all three groups were strongly committed to shaping the research direction in their respective sectors. They took a very proactive role in achieving this by undertaking their own research, funding engagement with Crown Research Institutes and acting as a bridge between science research and their farming communities.

Economics as a primary motivator

Analysis revealed that the squash and potato product groups of HortNZ were positioned in sectors where economic drivers dominated and farmers were price sensitive and risk-averse. These drivers caused farmers to have a short-term focus to their farming businesses. As one policy actor claimed, this encouraged a focus on issues that were critical, highly visible and offered immediate economic return (Participant R25O). This short-term focus generated strong support for market rather than science research. However, Potatoes NZ recognised that the science sector could assist their members in meeting strategic regulatory requirements, as a farming group spokesperson explained:

> So what we're encouraging our growers to do is regulate themselves so that they don't have regulation pushed on them.
>
> *Participant R40P*

A review of the squash sector's discontinued annual 'red book', which contained results from industry supported research, showed that the squash sector had historically engaged in science research. A retired DSIR scientist who had engaged with squash growers before the formation of the CRIs recalled his involvement with the emerging industry:

> The NZ Squash Council became a politically active organisation and they were able to influence funding…so the DSIR found it necessary to have their scientists go and sit on those groups once or twice a year and I ended up going to the Squash Council meetings.
>
> *Participant R47S*

The scientist claimed that what had been a collegial and cooperative relationship between science and the "self-made" squash growers substantially changed as the industry consolidated into large corporate growers who had a purely economic and competitive focus. However, one corporate grower saw the changed relationship quite differently, claiming that sector disillusionment with science had occurred following the establishment of the CRIs when he perceived scientists became interested only in "preserving their jobs", and "dreaming up projects" to secure funding (Participant R50S).

The potato and squash groups' investment in science research is modest. When interviewed in 2010, a potato group respondent stated that the sector spent only 0.2% of its levy on science research (Participant R40P). A squash group respondent claimed that no levy money was now directed into purely science investigations. He claimed growers preferred to undertake their own research with private agronomists, where they perceived they got "more bang for your buck" and could keep control of any competitive advantage this research might deliver (Participant R51S). Support for participatory research in both the potato and squash sectors was therefore more likely to occur if a project enhanced sector productivity, increased profitability and protected access to markets. A potato group respondent put it quite bluntly:

> We need the science but the bigger sustainability issue is making money. If farmers are not going to make money they are not going to invest in the outcome of the science.
>
> *Participant R40P*

With sustainability largely framed in economic terms, the research they supported was less about environmental improvement and more about efficiencies in production.

Group characteristics and sector dynamics in economically focused farming groups

The potato and squash industries have complex value chains. Both sectors are reputed to be highly competitive, with squash farming reported by interviewees across all sectors to be risky but extremely profitable, while seed potato farming is known for its small profit margins. Contract arrangements between growers and their customers drove a culture of secrecy among growers in both sectors.

The potato industry is divided into three distinct sectors – seed potato, process potato and table potato growers, although most growers engage in mixed cropping. A seed merchant stated that only two growers in the Canterbury region were solely dedicated to seed potatoes (as at 2009).

Interviews with stakeholders from the potato industry showed that a variety of chain actors influence farming practice. The seed potato sector grows potatoes as the seed source for the other industry sectors and is regarded as being most vulnerable to potato viruses. Seed growers contract grow for seed merchants. As with the wheat industry, merchants' representatives exert significant influence on farming practice, with growers reporting stringent spray regimes in contracts to prevent the spread of disease. A seed merchant even indicated financial penalties could be applied if spraying regimes were not met (Participant R36P). Chemical companies also exert influence on seed potato growers' spraying practices. In addition, farmers reported that they faced a barrage of company literature enticing them to use new sprays.

Process potato growers were contracted to large internationally owned corporations supplying the crisping or frozen food markets. These corporations complemented New Zealand's supply of potatoes with imported produce from Australia or China when needed. Interviews showed that potato processing companies built valued relationships with their growers and were keen to promote Integrated Pest Management (IPM) strategies to safeguard the quality of crop production. As a processor respondent said:

> [IPM allowed growers] to have a more sustainable and balanced approach to their programme and to go for periods without spraying to not put their crop quality at risk.
>
> *Participant R32P*

The table potato sector primarily grow for the two large supermarket chains in New Zealand. As most growers were not large enough to supply supermarkets directly, sales were negotiated through wholesalers. A table potato grower described his frustration in receiving a low price from the wholesaler for his produce:

> I don't know how to control it because they are the wholesaler and do the marketing - as long as they get their 12.5% they don't care and the price wasn't good enough. You can't go direct to the supermarkets, unless you are Wilcox. Wilcox can deal direct because they are so big. We always pride ourselves on what we bagged up, and then you go in to the supermarkets and you would see bloody rubbish being sold for dearer than what you could get.
>
> *Participant R37P*

Power structures evident in contract arrangements divided potato growers, with "one group that belongs to that lot of merchants and another group that belongs to that lot of merchants" (Participant R34P). This was reported to have eroded sector cohesion, as a farmer explained "not a lot of integration… don't like each other….not a lot of love lost there, it's crazy" (Participant R35P). A lack of trust permeated the potato sector and farmers rarely shared their knowledge, as a rural professional explained "…you don't tell anybody what you're doing, and how you're doing it" (Participant R32P). Interviews suggested that a culture of secrecy had been an historical feature of the potato industry. As a grower explained:

> I don't know why it's like that, well we're all probably for ourselves and if you give something away you – I make sure I don't give some things away either – it's been like that ever since I can remember the old man doing it… When you are talking to your neighbour about potatoes you don't tell him what you are doing, like he might say "oh that is good paddock of potatoes" and you'll just agree with it, but you won't say "I have done this, this and this"… There are no prizes for coming second.
>
> *Participant R35P*

The squash industry value chain was similarly complex, with corporate growers largely controlling the sector as the industry consolidated into fewer growers. Industry statistics of grower numbers show a steady decrease to 52 in 2011 from a high of 187 in 2006, while total hectares planted remained stable (Aitken & Hewett, 2013). As an industry respondent said:

> the big are getting bigger, there is more consolidation going on… oh yes it's still dropping - there is no doubt about that. The top are getting bigger and the grower, packer, shipper relationships - they influence that.
>
> *Participant R48S*

Unlike the other sectors investigated in this research, the squash sector is export focused on the Asian markets of Japan and Korea. Pack-houses, owned by corporate operators, negotiate contracts with international buyers. A pack-house owner indicated that buyers could be ruthless depending on the availability of squash from other international markets such as Chile, and prices could fluctuate dramatically each year. In addition, buyers rejected poor quality fruit and these "throw-aways" could significantly impact pack-house earnings. Any downturn in income from rejected fruit was passed down to squash growers. As a grower described:

> So they send you a bill for dealing with all the throwaways. Oh yeh, they sent us a bill one year for $800,000. It did not come to that in the end – we negotiated – but they did get a cheque out of me. The Japanese will never lose money.
>
> *Participant R03L*

New Zealand's clean green image was promoted but not "overplayed" in the Asian markets, to affirm standards in farming practice, fruit quality and food safety to Asian buyers who demanded stringent food safety requirements. A respondent from the Squash Industry Group stated that these markets provided no incentive to advance environmental sustainability:

> If you told your Asian customer that you have done a carbon footprint they would say "it is nice to know, here's the price". It doesn't mean anything to them at the moment. It's nice to have, not a must have in those markets.
>
> *Participant R51S*

The highly competitive nature of the corporate squash industry drove an attitude that differentiated the squash sector from the other sectors in this research. Farming and science respondents alike, from all sectors variously described the corporate squash growers as, “gamblers”, “cowboys”, rat-bags”, “boom-bust guys”, “risk-takers”, “self-interested – “not ashamed of making a buck”, “pushy individuals” with a “cut throat mentality”.

The empirical evidence indicated that the squash and potato farming groups operate within significantly different sector cultures compared to FAR, LandWISE and WIG. Their relatively short-term economic focus motivates their engagement in research to limit their vulnerability to price fluctuations and to protect their markets. Their competitive and secretive cultures significantly shape industry dynamics and limit the development of a cohesive industry with a sense of collectivity. As a vegetable industry spokesperson explained:

> If you come to the vegetable industry, nobody’s in cooperation, they’re all in competition, so trying to get farm discussion groups going is not easy.
>
> *Participant R45P*

Such competitiveness is likely to impact the collective and collegial requirements of participatory research. These issues are explored in Chapters 5 and 6.

Culture as a primary motivator

ECOP’s motivation for engaging in participatory research was significantly different to the other farming groups. ECOP’s wider goals sought to assist regional economic development through transitioning the predominantly Māori community from extensive agriculture to intensive horticulture. Cultural drivers were the primary motivators for the group’s engagement in participatory research.

Documentation (FRST application, 2006) showed the ECOP Trust sought to improve the health, social and economic wellbeing of Māori on the East Cape by promoting the values of tino rangatiratanga (independence), kaitiakitanga (guardianship) and whanaungatanga (relationship). ECOP identified the potential for organic kumara production as a way to achieve their aims. As a result they saw a need to access science knowledge and research, since ECOP recognised growers had limited understanding about the nature of science, cropping knowledge and organic farming skills (ECOP, 2002). ECOP and Crop and Food Research developed a relationship that led to the decision to apply for funding for the Crop Science for Māori project that combined agronomy, extension and social science.

Postgraduate research undertaken during 2004-2005 identified that the community wanted to generate an economic activity to attract back to the region the younger generation who had left to work in the cities (Bruges, 2006). They saw kumara production as a way to provide local employment while fostering organic practices and Māoritanga (Māori culture/traditions). The researcher's participation in a tikanga (Māori protocol) workshop (March 2007) and a review of ECOP's own strategic plan identified that this concern for economic wellbeing was integrally linked to cultural, social, spiritual and ecological wellbeing. The Trust's motivation to improve the economic position of the East Cape to attract whanau (family) home was driven by cultural values that were very different to the economic motives of farmers in the potato and most notably the squash sectors, where production and profit were significant drivers and farmers visualised their farms firstly as businesses.

A quote from a grower interviewed for a broadcast news item for the *Te Karere* Māori news programme on national television captures the cultural importance of the project when he talks about another grower's kumara produce:

> Our ancestors have passed these foods and practices down. Well done Lillian be strong. A final word from Tairawhiti and Ngati Porou, be strong – my hope is that the creator walks beside you.
>
> *(Grower, TVNZ, Te Karere, March 11, 2005)*

Although ECOP saw a need to access science knowledge and research, they sought to achieve this through collaborative engagement. For ECOP, engagement meant an equitable long-term relationship, and most critically recognition of their traditional knowledge in project decision-making. This was also recognised by social scientists from the Science for Community Change Programme, who reported that the community sought science to complement and not replace their traditional Mātauranga Māori knowledge (Bruges & Smith, 2008).

Observation at a Tikanga (Māori protocol) workshop (Table 3.5) where formal presentations by community members and scientists were observed and participation in other informal activities recorded several key differences between a Māori worldview and a Western science worldview. While there is no one Māori worldview (and indeed no one science worldview either (Section 1.3), Walker and Ngati Porou (2004) argue there are enough similarities between different hapu's worldviews to suggest key components of a Māori worldview. Insights from Walker and Ngati Porou (2004), (Ngati Porou was the iwi engaged in the Crop Science for Māori project) and Hikuroa, Morgan, Durie, Henare & Robust (2011) have been combined with data from this research to identify key aspects of both a Māori and Western science worldview, that need to be reconciled in participatory research. These are presented in Table 4.3.

Table 4.3: Māori worldview and Western science worldview

Māori worldview	Western science worldview
Holistic	Reductionist
Experientially based knowledge	Theoretically based knowledge
Embraces Subjectivity	Seeks Objectivity
Recognises the social, cultural, spiritual, economic and political dimensions	Recognises an external reality
Recognises plurality and diversity of knowledge	Universal knowledge
Communicated orally	Communicated through scientific papers
Influenced by values of ancestors	Peer assessed

Table derived from notes gathered from participant observations, data gathered from stakeholder interviews and media articles and insights presented in Walker & Ngati Porou (2004) and Hikuroa et al., (2011).

ECOP group characteristics and community dynamics

ECOP sought to assist organic producers on the East Cape, in what is recognised as one of New Zealand's most economically deprived and geographically remote regions. A government-funded report that profiled the East Cape/Gisborne community (Ministry of Social Development (MSD), 2011) found that 46% of the population were "judged to be among the 20% most socio-economically deprived in New Zealand". The East Cape communities were listed in the report as being among the poorest in the region with Māori making up approximately 46% of the population compared to a national average of 15% (Ministry of Social Development (MSD), 2011).

ECOP membership was predominantly, although not exclusively Māori, with growers located across the East Cape. Growers predominantly farmed organic kumara but also grew other vegetables, fruits and herbs mainly in small blocks or gardens. Documentation suggests that approximately 50 landowners were involved in the Trust at the time of its formation although not all were members. By the start of the project in 2003, Bruges (2006) estimated membership had fallen to around 5-10 landowners. While this raises significant concern over ECOP's capacity to support a participatory research project, ECOP's Strategic Development Plan (ECOP, 2002 October) indicates they sought to benefit the whole community, particularly the people of Ngati Porou and not just their membership.

ECOP recognised a need to address significant infrastructure weaknesses on the East Cape, particularly relating to packing and distributing produce. However, as Māori land is largely communally owned, this limits access to development capital (Kingi, 2012), which the draft development strategy states led ECOP to recognise a need to work collectively. Local protocols between marae (communal meeting places), however, present significant challenges for collaboration and consensus decision-making across whanau and hapu land (ECOP, 2002). This creates potential difficulties about regional acceptance of locally generated knowledge. Therefore, understanding tikanga and Māoritanga is essential for working in these communities.

Furthermore, the community's poor experience of past research endeavours, where they were noted to be angry about not having benefited from the research had left significant levels of mistrust among some members of the community about future consultative initiatives (Bruges, 2006; ECOP, 2002). Mistrust over engagement with the Crown is widely recognised among Māori communities, (Section 2.3.3). Māori often express doubt over both the sincerity of the consultation and understanding of the Māori perspective (Roberts, 2009). This is clearly illustrated by a quote from Walker and Ngati Porou (2004: 111):

> "The supremacy of Western knowledge systems, particularly science, has not only nullified Māori conceptions of the world, but further that such dominance has meant consultation has been a one-sided process with little understanding or acceptance of Māori views or processes."

These community dynamics present significant challenges for collaborative endeavours. As outlined in Chapter 2, participatory research inherently implies and requires that traditional hierarchical power structures be replaced by more equitable relationships that recognise and embody into decision-making the multiple knowledges of all participants. ECOP's cultural motivations seek this equality, engagement and inclusion.

4.4.3 Summary of group characteristics and sector dynamics

The six farming groups in this research each bought unique characteristics and sector dynamics to their projects. The interviews revealed that farming group motivations showed significant variation depending on the motivations for the group's formation, the group culture, which shaped group dynamics and social cohesion, their science competencies and past experiences with the science sector. The variation between the farming groups was significantly different to the scientists where there was more uniformity in their motivation to engage in participatory research. A summary of the characteristics of farming groups and their "communities" is presented in Table 4.4.

Table 4.4: Summary of farming group and sector dynamics

RESEARCH-FOCUSED GROUPS	
Walnut Blight Project Farming Group: Walnut Industry Group	• Collaborative and cohesive group with research a focal point. • Undertakes own research to develop crop management knowledge. • Established research committee consisting primarily of science members.
Precision Agriculture Projects Farming Group: LandWise	• Farmer members are generally well educated, resourced, have a strong social conscience, experience with trials and are willing to share. • The organisation has strong spirit of cooperation & collegiality. • Farmers are central to the organisation's constitution. • Group undertakes independent trials and contracts scientists who provide advice and support as needed on trial design and analysis of research data.
The Wheat Calculator Farming Group: Foundation for Arable Research	• Growers are typically passionate about arable farming and strongly support the FAR levy. • Strong research focus - levy money funds a Strategic Research Committee and six regionally based Arable Research Groups. • Many value chain actors are primarily 'economically' focused. • Grain merchant representatives are known to provide significant farm management advice.

ECONOMICALLY FOCUSED GROUPS	
Potato Aphid Project Farming Group: Potatoes New Zealand HortNZ Product Group	• Very secretive industry with growers reluctant to collaborate for fear of losing any perceived competitive advantage. • Small percentage of levy funds allocated to 'science' research. • Growers' contracts hold financial penalties for crop management breaches. • Buyers (merchants, processors, supermarkets and consumers) influence crop varieties and management practices.
Squash Rot Project Farming Group: Squash Industry Group (product group of Hort NZ)	• Highly competitive, high-risk but financially lucrative product industry. • As industry competitiveness has increased, growers have preferred to carry out their own independent research but recognise rot research needs science input. • Packhouses inflict large penalties on growers for rot.
CULTURALLY FOCUSED GROUP	
Crop Science for Māori Farming Group: ECOP Trust (East Coast Organic Producers)	• Scientists needed to be sensitive and receptive to Mātauranga Māori and tikanga. • Marginalisation of Māori perspectives in the past led to mistrust of outsiders / researchers. • Local protocols limit collaboration across different Marae. • Limited capability and capacity of ECOP.

4.4.4 Farming groups' expectations of participatory research

Motivations for farming groups entering into participatory research were influenced by each group's focus, culture and sector dynamics. These factors varied between groups. Expectations by farming groups of the participatory process, however, showed more consistency between groups.

All farming groups expected participatory research to seek outcomes that were relevant to farming practice and they expected this to be clearly evident in a project's aims and in the experimental design. Farming groups expected projects to produce knowledge or tools that could be applied on the farm and wanted the investigation to be focused at a farm or even paddock scale. As the LandWISE manager explained:

> We're interested in environmental or economic sustainability at the paddock scale.
>
> *Participant R01L*

All groups recognised the value of their local knowledge, which they claimed was gained through their experience of working or living in their local environment. They expected their local knowledge would be utilised in projects.

The research-focused groups of FAR, LandWISE and WIG expected to set the research agenda and undertake field research or engage at a strategic level in the science investigations undertaken by scientists. They rejected or challenged linear approaches to science research that marginalized them and they did not want to wait passively for scientists to deliver results in a report. Their empowered and engaged attitude around project management was influenced by their human capability and capacity to undertake applied research. The groups' expectations of being intimately engaged with the research process were more intense when they funded the research. As the FAR manager stated:

> He who has the gold calls the tune and as long as we are the ones with the gold we can call the tune and we can pull it back on track at any time when we need to.
>
> *Participant R75Wh*

The Crop Science for Māori growers, although less informed about the nature of science and its limitations than members of LandWISE, WIG and FAR, still expected knowledge that the project generated to complement not replace their traditional forms of knowledge (Bruges and Smith, 2008), as discussed in Section 4.4.2. Their cultural motivations to engage, brought with it clear expectations of how they would engage. For all farming groups, the scientist as expert giving "top-down" advice to the community as passive recipients, was expected to be replaced by a network of learners each bringing their own expertise to the table.

The economically focused squash and potato farming groups expected to take a more passive role in their project's knowledge generation than FAR, LandWISE, WIG and ECOP, although they expected to play a very active role in project extension. Interviews with potato farmers and the potato farming group manager indicated a changing attitude to the passive approach they adopted for their projects. Science projects that had significantly marginalized their involvement in the past saw them now expect a more active role in setting a project's research agenda. Overall LandWISE WIG, ECOP and FAR wanted to co-develop knowledge and tools in their projects, while the squash and potato farming groups were content to be collaborative but more passive partners with scientists.

Farming groups did not view themselves as passive recipients of the outputs from science research. They expected project innovations to have direct relevance to their members' farming practice, although the intensity of the expectation was influenced by the degree to which the sector was commercially oriented. In interviews with farmers in the commercial sectors, farms were more commonly articulated as businesses. Hunt (2013) has similarly reported increasing evidence of New Zealand farmers describing their farms as businesses, as one large commercial organic grower explained:

> We have to pay the wages each week and try and balance the books at the end of the year. We are a business and the business does not operate on environmental outcomes, it operates on economics… really you have to survive … So number one are the economic drivers and number two are the environmental ones.
>
> *Participant R05L*

In commercial sectors, being profitable was a pre-requisite for being environmental. Farmers in the arable and vegetable sectors repeatedly stated variations of the following phrase:

> You have to be in the black to be green – or you can't be green if you are in the red. And I think even environmentalists have to get that.
>
> *Participant R35P*

Interviews suggested that projects that had direct farming application and offered economic benefits were likely to generate the strongest farming group membership buy-in, particularly in the commercial production sectors. Generating membership buy-in was critical for all groups, since farmers played a central role in farming-group governance. The smaller voluntary farmer groups of ECOP and the Walnut Industry Group consisted entirely of sector growers. LandWISE farmers held at least 50% of the seats on their board. HortNZ's product groups had farmers present on their boards, while farmers played central roles in FAR's board and its Strategic Research Committee and were on all of its six regionally based Arable Research Groups.

In the industry-good bodies of FAR and HortNZ, the grassroot's representation and the vote by farmers to abolish or continue their sector levies, ensured these groups remained cognisant of their members' interests. This was illustrated by the following comment by a wheat farmer:

> [FAR] is driven by farmers, so there is always this farmer input and they do seem to listen to what the farmers say.
>
> *Participant R71Wh*

Generating membership appeal meant farming groups expected projects would engage in a significant level of 'extension' activities, to connect a project with the wider farming sector. Interviews revealed that the groups differed over how this extension might be implemented. LandWISE, FAR and WIG expected extension activities to be embedded in projects from the beginning, to enable a free flow of communication back and forth between field trials and the wider farming group membership. The LandWISE manager claimed that he refused to work in projects where science institutes only scheduled extension in the final year, since he claimed this prevented valuable feedback between the project and its end users and devalued farmers' local knowledge in the development of innovations. Furthermore he believed leaving extension to the final year was perceived to indicate both a poor understanding and a lack of commitment by scientists to extension and to the end users of innovations. FAR, WIG and LandWISE, who all had significant extension capability and capacity, wanted to oversee project extension throughout the lifespan of the project. As the LandWISE project officer explained.

> You start at the beginning and you build it through so there is no surprise at the end.
>
> *Participant R02L*

In contrast, Potatoes NZ and the Squash Industry Group viewed extension more through a technology transfer lens, where resources and information would be made available to growers in an accessible, timely and useful way once the science results were known. A Potatoes NZ spokesperson explained the process of transferring a scientist's report (manual) into accessible information for farmers:

> I don't want a manual, so we then took the manual and gave it to a [marketing] company and we talked to growers and said what do you want – they said we want a ute guide [a guide to place in a farm vehicle]. I said how about a CD-ROM, so we provided a CD-ROM and a ute guide.
>
> *Participant R40P*

All farming groups held a strong sense of ownership over any results from participatory projects, particularly when they had contributed either with financial or non-financial in-kind support, although their intensity of ownership appeared to be greatest when there was a financial commitment. The Potatoes NZ spokesperson put it quite bluntly. In recalling a conversation with a scientist who objected to changes being made to his IPM manual, which he had delivered to the farming group at the end of a project, he commented:

> I told him, "I paid $100,000 for this, it is mine and what I do with it is my bloody business and if you look at your SFF contract any bloody IP belongs to me".
>
> *Participant R40P*

Past experiences of poor delivery of project results from science teams has led farming groups to take a cautionary approach when funding science projects. FAR claimed to drip-feed funds to projects based on scientists' results at agreed milestones.

> We say "here you go, here's five grand" – only little bits – "go and see what you can do and then come back". And if they come back with a good idea we will put some more money there. But there are not very many people you can give that money to.
>
> *Participant R75Wh*

LandWISE, FAR and WIG's expectations of their involvement in participatory research led them to seek to create relationships with known scientists to avoid personality difficulties. They increasingly contracted scientists who they had previously worked with, or who had a reputation for being personable, practical, efficient, communicative, and most importantly could relate to farmers. In essence they handpicked individual scientists. The FAR manager explained this as follows:

> We don't contract research with CRIs we contract research with individuals in CRIs based on their credibility. Sometimes you have to create the credibility for somebody first and they obviously have to have some skills. They have to be able to develop a rapport with the farmers. They have to be able to have some understanding of the farming business. They have to be a communicator – particularly a verbal communicator.
>
> *Participant R75Wh*

Evidence from farming group managers' conversations indicated an increasing trend for scientists to be employed on contract by the farming sector to undertake some but not all of the research. In the research-focused farming groups, this appeared to have arisen in part to minimise the percentage of funds being absorbed by the science component of projects, given the recognised expense to do this work. These groups who had a broad understanding of science were keen to carry out some of the fieldwork themselves. It also appeared to be a response to the increasing perception by the commercial farming sectors that science research was not always good value for money particularly if it was not relevant or was not farm applicable. While a project's relevance to a farming group was dependent on the group's motivation for engaging in participatory research which influenced the weighting they gave to the three dimensions of sustainability (Section 4.4.2), increasingly farming groups expected to have more control in participatory research. By doing so they ensured the projects they funded were relevant.

4.4.5 Farming groups' enabling and disabling factors for fostering innovation in participatory research

Table 4.5 presents the factors identified from this research's empirical evidence that enable and disable farming groups' engagement in participatory research. The analysis revealed that enabling factors could be grouped into characteristics relating to a group's capacity and internal capabilities, their cohesiveness and connectedness and characteristics of the sectors in which they operated. Disabling characteristics derived from particular motivations and expectations of groups. The evidence shows LandWISE, FAR and WIG had more enabling factors, while the squash rot and potato aphid farming groups and ECOP and the sectors in which they operated, created more disabling factors.

Table 4.5: Factors that enable and disable farming group engagement in participatory research to support moves towards sustainability

Farming Groups' Enabling and Disabling Factors
Enabling Factors
<u>Dynamics relating to group capacity and internal capabilities</u>
• Strong reputable and established farming group with solid membership base (all except ECOP).
• Farming groups with a strong group focus on research (WIG, FAR, LandWISE).
• Proactive farmers and farming groups who had formed groups to address industry issues (WIG, FAR, LandWISE).
• Local tacit knowledge of farmers and farming groups (all groups).
• An understanding of science as a development tool and trial experience (WIG, FAR, LandWISE, HortNZ groups).
• Stable funding revenue such as farmer levy (HortNZ groups, FAR).
• Farming group supports staff (all except WIG and ECOP).
<u>Group cohesiveness and connectedness</u>
• Strong group cohesion (WIG, FAR, LandWISE).
• Strong group sense of empowerment and engagement (WIG, FAR, LandWISE).
• Existing relationships between farming groups and science providers (all except ECOP, particularly WIG, FAR, LandWISE).
• Willingness to collaborate in multi-disciplinary networks (WIG, FAR, LandWISE).
• Connection with research sector and significant extension capabilities and capacity (WIG, FAR, LandWISE, Potatoes NZ.
<u>Sector characteristics</u>
• Markets pay premium for 'environmental credentials' and encourage sustainability (lately ECOP).
• Strong sector cohesion that supports sustainability (LandWISE, WIG).

Farming Groups' Enabling and Disabling Factors
Disabling Factors Group Motivations • Farming groups with a strong economic focus as only a small percentage of money is typically directed towards science / sustainability research (Squash and Potatoes). • Groups with a short-term focus – focused on the immediate, and problems that could be seen, characteristics that did not readily favour environmental sustainability (Squash, Potatoes). • The potential for the levy system to strongly influence farming group priorities and limit focus on environmental issues as groups must be very responsive to members' needs and wants (FAR, Potatoes NZ, Squash Industry group). Group Expectations • The divergent expectations of scientists and farmers (all groups). • Expected scale of enquiry – paddock / farm scale focus (all). • Expectations on science research to deliver narrow outputs (Squash, Potatoes). • Narrative of the farm 'as business' – prioritises economics - restricts sector support & project buy-in (all except ECOP and WIG). Sector characteristics • Weak sector cohesion (Squash, Potatoes, ECOP). • Sector competitiveness (Squash, Potatoes). • Complex value chains, with strong economic focus (Wheat, Squash, Potatoes). • Price sensitive markets (all). • Power structures of contract arrangements (Wheat, Potatoes, Squash). • Economic deprivation (ECOP). • Historical factors (Squash) and past experiences (ECOP) that reduce trust in science.

4.5 Summary

This chapter explored actors' motivations for engaging in participatory research and their respective expectations of a participatory research process. This exploration identified the enabling and disabling factors for innovation that actors bring to projects that are likely to shape both the context in which participatory research projects operate and the way actors engage with the project and with each other.

The analysis revealed that participatory research may be undermined by a policy framework focused on tangible outcomes such as publishable outputs, commercial ventures and other easily measurable key performance indicators to satisfy demands for accountability of public funds and an a priori narrative that demands change. It may also be undermined by scientists' personal and professional drivers and regimes and routines created by the largely competitive funding system in which scientists operate. Furthermore, farming groups' motivations and expectations, which are shaped by the institutional contexts in which they operate may also influence how farming actors will engage in participatory research.

These differences between actors' motivations and expectations are likely to create challenges for participatory research project delivery. Applied research that requires science to be narrowly focused and easily communicated to meet the farming sector's need for practical tools or knowledge relevant to farmers may not meet the rigorous quantitative research standards demanded by biostatisticians and prestigious science journals.

As Chapter 2 identified, participatory research inherently implies and requires equitable relationships often between divergent partners that recognises and embodies into decision-making the multiple knowledges brought to the table by all project participants. Participatory research that fosters agricultural innovation and change requires a collaborative environment where divergent actors discuss, negotiate and work towards a shared vision (Klerkx et al., 2012). By examining the institutional contexts of the principal actors in this research, and identifying the enabling and disabling factors for fostering innovation gives insight to potential power struggles that may affect and possibly undermine the likelihood of creating a shared vision. As Buhler et al. (2002:150) contend:

> At the macro level… participation is always compromised by those in a position to do so and the outcome of these compromises is a complex interaction involving the power relationships of all those involved.

Identifying the institutional factors which shape the context for participatory research and which influence the way actors engage, gives insight to potential challenges that lie in the implementation of participatory research particularly when creating partnerships (Chapter 5) and during the production and diffusion of project knowledge (Chapter 6).

To ignore the contexts in which projects and actors must operate overlooks the social, technological, economic and institutional change that is likely to be necessary for fostering innovation and particularly sustainable innovations. A well performing, well functioning innovation system requires vision, leadership and coordinated interaction between all components of the system (Klerkx et al., 2012; Wieczorek & Hekkert, 2012) and particularly between the institutions engaged in participatory research.

CHAPTER FIVE

5.0 Exploring Participatory Research Partnerships

5.1 Introduction

The participatory research projects in this research involved an eclectic mix of participants seeking to develop sustainability innovations through project-based collaborative partnerships formed between scientists and farmers as the principal actors. As Chapter 4 illustrates, multi-stakeholder partnerships involving actors from inside and outside the science and technology sector are seen by policy and funding agencies as a way of bringing about change towards sustainability in the agricultural sector (Section 4.2). However, when multiple actors, often with divergent perspectives, converge in the complex and contestable milieu of the agricultural sector, achieving collaborative partnerships may be an ambitious undertaking.

The scholarship on the social complexity of partnerships in participatory research however is limited (Bidwell & Ryan, 2006). The analysis of data in this current research revealed the fundamental importance of partnerships in the quest for sustainability (Table 3.6). Investigation of project partnerships further revealed the critical importance of which actor type initiated the project - farming group initiators, scientist initiators, or joint actor initiators where both scientists and farming groups formed a shared partnership. Table 5.1 outlines the characteristics of the farming group, shared and science-initiated partnerships in this research.

Table 5.1: Characteristics of project partnership categories

Project Partnership Category	Characteristics
Farming group-initiated Partnership	• Farming group initiate project. • Farming group seek science partners to collaborate on some aspects of the project. • Farming group submit SFF project application and are the principal applicant. • Farming group contribute in-cash or in-kind to project funds and may seek funding from other sources. • Farming group manage project funds and ‘contract’ scientist/s to contribute expertise. • Farming group take responsibility for project reporting.
Shared Partnership	• Project collaboratively initiated (either science or farming group may start the initial conversation). • Project money managed either by farming group or science team depending on farming group’s capability. • Farming group is the principal applicant on SFF application (a requirement of SFF). Science team will be the principal applicant if seeking a ‘science’ fund. • Farming group or science team manage project depending on the type of funding received. • Farming group or science team may take responsibility for project reporting.
Science-initiated Partnership	• Science team initiate project. • Science team approach farming group to seek a farming project partner. • Farming group is the principal applicant on SFF project applications (a requirement for SFF). • Science team largely manage project funds (although partners negotiate funding allocations). • Project manager used (may not be scientist or farmer). • Project manager is responsible for project reporting.

This chapter begins by discussing the three partnership categories outlined in Table 5.1 to examine how the six investigated projects grouped according to these categories of partnership. This provides important insights into how partnership formation shapes project objectives and actor relationships within projects. Key characteristics of these three partnership categories are identified. The analysis of partnership provides the foundations for subsequent investigation of why groups form in these ways, identifying key dynamics that shape partnership formation.

5.2 Project partnership categories

5.2.1 Farming group-initiated partnerships

The Precision Agriculture and Walnut Blight projects were both farming group-initiated projects. As shown in Section 4.4.2 both these groups have a strong research focus, a broad understanding of science as a development tool, field trial experience and in WIG's case significant science research experience with members of their research committee being research scientists. These groups expect to be active participants in a project's research space. Their research capabilities and expectations give them an empowered sense of ownership and control over their research projects to ensure projects remain relevant to their farmer members. These motivations, expectations and group characteristics led to both the walnut blight and precision agriculture projects being initiated by their respective farming groups, LandWISE and WIG with each group also managing their SFF research funds (SFF, 2003a, 2004, 2008).

Both groups drove their projects from the ground up, building the project objectives and research around their specific interests. For LandWISE their projects were built around precision agriculture techniques that have direct application for cropping, while for WIG their project focused on orchard management and disease control. LandWISE partnered with science providers and sought to determine project objectives and manage and undertake farmer-led field trials. WIG's Research and Development Committee initiated, coordinated and drove the walnut blight project. As one grower commented:

> They [the leaders of the WIG Research and Development committee] were the leadership that drove getting SFF funding and designing the research. They understood the funding system enough, they were organised enough, and they were analytical enough.
>
> *Participant R56Wa*

Project objectives in farming group-initiated partnerships

By taking responsibility for managing the research agenda, LandWISE and WIG ensured that project objectives were farm or orchard focused. LandWISE required its precision agriculture projects to have direct and immediate application to their members' farms. In their 2003 *Controlling the Strip* project, farmers trialled a variety of innovative field cropping practices, particularly banded fertiliser application and controlled traffic in fields to reduce soil compaction caused by machinery. In their 2008 *Advanced Farming Systems* project*,* farmers investigated advanced technology including RTK-GPS (Real Time Kinetic – Global Positioning System) guided mechanical weeding, GPS controlled spraying, GPS contouring, data and zonal management. The LandWISE website stated that farmers undertook trials on farms across New Zealand with the objective of increasing technology uptake by farmers to increase profitability, reduce costs and "enhance economic and environmental resilience in the face of climate change" (LandWISE, undated). The LandWISE manager described the *Advanced Farming Systems* projects as a very active hands on approach to farmer engagement and learning, where the group remained in control of the project throughout the whole research process.

> We have got 12 farmers from Mangere to Dorie over 2000km from Auckland to Ashburton and six of them would be involved in some kind of soil engaged comparison and the other 6 are totally different to that, one is looking at how you shift information from your tractor to your computer without losing it and doing it faithfully and another one is looking at precision technology that lets you reduce your herbicide over-spray. So they are really different types of stories… We have a project group meeting today to see where we have got to after our first nine months. These are the case studies we've got, this is where we are at, this is what we are going to do in the next two years at these places, and these are the things we hope to learn.
>
> *Participant R01L*

Similarly the walnut blight project contained orchard-focused objectives that were of immediate relevance to growers as the project sought to inform and guide growers' management of blight in orchards. For example, a benchmarking investigation was undertaken by members of WIG's Research and Development Committee, in consultation with a scientist at Lincoln University, who the group had successfully worked with in an earlier SFF project. This investigation gathered data on orchard performance under different conditions and management approaches, so climate models could be developed to assist with spraying regimes to combat walnut blight (Thompson, undated).

The group also supported fundamental science research to develop a bacteriophage for blight biocontrol that would 'out-compete' the causal agent of walnut blight. As the research involved novel and fundamental science research, it was carried out in partnership with scientists from HortResearch and the group supported related doctoral research at Lincoln University. The inclusion of this fundamental science objective in the project reflected the atypical 'scientific' background of members of the WIG Research and Development Committee. As one member of the committee explained:

> We were always pushing – OK that's the question you can ask but can you ask this question as well, or if that is how you design the research – what about that. Even right down to the research that [the scientist] was designing, we actually got in and had conversations about how it was designed and questioned as to why it had been done that way, and not this way.
>
> *Participant R56Wa*

The LandWISE and WIG projects show that where farming groups have a strong applied research focus and are scientifically confident or experienced, the traditional research boundary between farming groups and research organisations is blurred. LandWISE and WIG eagerly moved into the research space normally dominated by science research organisations. They set the research objectives, guided project planning, led project implementation and oversaw the field research. Rather than exclude scientists both groups purposefully built a network of stakeholders in their projects that included farmers, scientists, and in the precision agriculture projects, other value chain actors such as processors and local government. Network participants were valued for the expertise they could bring to the project. As the LandWISE manager explained:

> In this project, Plant and Food Research is our lead science provider. I have just been having a discussion with them because we don't have nearly as much agronomy as we thought we would. So we had a chat with them about how we could better use them.
>
> *Participant R01L*

The farming groups stayed in close contact with all research undertaken by scientists to ensure this remained relevant and focused on agreed objectives. As a member of WIG explained, "we stayed engaged with the researchers all the way" (Participant R56Wa).

Partner relationships in farming group-initiated partnerships

Where farming groups took a lead role in projects, scientists' contributions were managed by the farming group. While science advice was sought, and scientists were engaged in the delivery of some objectives, farming members often carried out significant parts of the research, as evidenced by WIG's orchard benchmarking work and LandWISE's farm field trials by undertaking the research. This included doing the data collection and the analysis themselves or collecting the data and seeking expert science assistance with the analysis. Scientists therefore often acted as trial advisors or were contracted for specific components of the project. As a result the scientists in farming group-initiated projects often took a more passive role than their farming counterparts. A scientist who worked on LandWISE projects referred to his and other scientists' roles in the precision agriculture projects as the "reference guys" (Participant R48L), as they often advised and guided project delivery rather than being actively engaged in the fieldwork.

Farming groups moving into the research space therefore created a new power dynamic between the farming and science sectors. LandWISE and WIG established ongoing relationships with scientists who understood how these groups worked and were prepared to engage with them. LandWISE has a position on its Board for a research scientist. They contracted scientists who they had successfully worked with in the past, or who had a strong reputation for working effectively with farmers. The science / farming group relationship was established from existing relationships, developing organically as they grew to better know each other.

Similarly WIG worked with a scientist with whom they had already established a relationship in their first SFF walnut project and who understood their unique membership. He was well liked by both the science and non-science members.

> [*Scientist's name*] was very approachable you could always ask him what he was doing and he would always tell you what he was doing.
>
> *Participant R63Wa*

> Enthusiastic. He is lovely… from my perspective he is really interesting at the research level and he is funny.
>
> *Participant R54Wa*

> [*Scientist's name*] had been around the Walnut Industry anyway and we knew, liked and trusted him.
>
> *Participant R56Wa*

When specific expertise was required for the bacteriophage trials, which involved laboratory research, WIG contracted a scientist who had a history of working with small emerging industries. As such she understood the characteristics of small groups and the dynamics of these sectors. The scientist's background enabled her to act as a bridge between the science and farming sectors while also being confident through her science expertise to extend and challenge growers. As she explained:

> I come from a farming background and my first degree was agriculture and I worked as a farm manager for various years and so I understand all the other issues … I am a very honest person, I am a very direct person and I tell them things [growers] don't always like to hear… the walnut growers are a small group they all turn up, they know what they are doing and they have their field talks and that system works really really well.
>
> *Participant R65Wa*

A grower who was a member of the WIG research committee described the researchers they contracted for the bacteriophage work as "wonderfully pragmatic", who "knew this was an industry group who needed something it could use" (Participant R56Wa). However the relationship with a PhD researcher financially supported by WIG was less successful because as the same grower admitted, "[PhD's] have a different audience, you have to prove you are academically sound." The bacteriophage scientist confirmed this, "I don't think [the PhD] connected with them" (Participant R65Wa).

The Walnut and Precision Agriculture projects show that for farmer/scientist relationships to thrive in these two farming group-initiated projects, the researcher needed to be personable and understand farming practice. Relationships in these partnerships therefore often moved beyond the professional to the personal as they were central to the partnerships. As the LandWISE project coordinator said, "it is all about relationships" (Participant R02L). Phillips (1982) investigating New Zealand dairy farmers' learning environments found that those closest to farmers, what he deemed 'intimates', had the most influence on farmers' decision-making, however rarely were 'experts' in this category. The farming group-initiated partnerships indicate the effect of moving the science-farming relationship into a more ‘personal’ relationship.

The farming group conversations show that personable science/farming relationships have a profound effect on projects in the formative period of project establishment. In farming group-initiated partnerships, farming partners see partnerships as being a collegial and collaborative relationship between partners. These empowered farming groups want project objectives to be farm relevant and their leadership of the project ensures this occurs. This creates a new power dynamic which challenges traditional ways of doing research, which this research suggests may cause some unease for scientists.

5.2.2 Shared partnerships

Shared partnerships occurred when farming groups sought to work collaboratively with science partners to combine their own local knowledge with the scientists’ specialised knowledge. The partnership required an equitable relationship between the farming and science partners. While roles were not necessarily equally shared, both farming and science partners contributed to project planning with neither assuming control over the project, as occurred in the other two partnership categories. A shared partnership occurred between ECOP and Crop and Food Research (CFR) scientists in the Crop Science for Māori project, and between FAR and a CFR Lincoln based scientist and his technical team in the Wheat Calculator project.

As Chapter 4 showed, ECOP wanted science knowledge to complement and not replace their traditional knowledge. They wanted to work with scientists to enhance their traditional cropping knowledge to aid Māori growers to develop cropping potential on the East Cape with cultural values central to the project. Scientists working in this environment needed to be sensitive and receptive to local and traditional Māori knowledge or *Mātauranga Māori*. The wider scholarship shows that science researchers working in indigenous communities need to be aware of and limit power differentials (Fergus & Rowney, 2005) that afford western science significant privilege and which have been shown to undermine partnerships (Coombes & Hill, 2005; Nadasdy, 1999) as discussed in Section 2.3.3 and 4.4.2.

FAR, like ECOP also wanted to access science knowledge, in their case as a proactive response to threatened regulation from the Canterbury Regional Council (ECAN) which was concerned about the state of the region's aquifers as a result of increased nitrogen fertiliser applications and irrigation from agricultural intensification (ECAN, 2002a, 2002b). The knowledge they sought was embedded in CFR's Sirius wheat simulation model, which had been developed for research purposes for over 20 years.

FAR believed a wheat calculator, which was informed by the underlying Sirius wheat model would act as a defense against impending local government regulation by improving nitrate management on farms, while also increasing farmers' profitability by reducing costs associated with irrigation and fertiliser inputs. FAR sought to incorporate its own input into the calculator's design to ensure its ease of use by farmers, although Bruges (2006) argued farmer uptake of the calculator was a secondary consideration, as its primary goal was to increase farmer profitability while improving farmers' understanding of nitrate management, whether or not they adopted the technology.

Project objectives in shared partnerships

In shared partnerships, project objectives had direct on-farm relevance as the farming groups had input to their development. In the Crop Science for Māori project, while specifics of the wider Science for Community Change Programme were largely negotiated between CFR and FRST as the project funders (Section 4.2.3), ECOP was actively involved in defining the objectives at the project level (Bruges, 2006). Science partners recognised the need to involve growers, as a scientist who was involved in setting the original objectives explained, "the whole programme was designed around community interaction" (Participant R13M).

An interview with the lead scientist who entered the programme after the original goals were set found that community-based research in the remote Māori communities of the East Cape required flexibility in project objectives and timelines. As he explained:

> In the beginning it was very process driven – when you are contracted to do something - you tell folks we are delivering our promised four or five workshops. No criticism, but it was more administrating than really hands-on and making it work for them. I was keen for more hands-on deliverables that made it really work. You learn to be very flexible and adaptable. The [subsequent] goals – these things were not written that specifically, so there was a lot of room for going your own way. We learned very quickly that when you were discussing cropping principles for instance, we needed to get into their garden to walk the talk. We realised we needed to ask questions and to listen as well.
>
> *Participant R13M*

The project developed a strong social science and applied focus to project research, rather than a "pure" science focus. Participatory research is naturally well suited to applied or adaptive approaches (Neef & Neubert, 2011), however this approach challenged some on the science team who although familiar with applied research and working with farmers, were more used to setting science objectives to achieve science outcomes in applied projects where the outcomes were tangible and measurable. A scientist from the team explained.

> The whole project proposal was built around a participatory approach – big ideas and milestones. From a social science point of view I am sure it was totally worthwhile because [the social scientists] are learning from this. We did ok research. It was very applied which I guess is all you can expect. There was no fundamental research done… Science outcomes? I think they were pretty limited really, to be honest. We developed some – we had a better understanding of fertilizer management in their systems, we put together some nutrient management plans, that was useful.
>
> *Participant R20M*

In the Crop Science for Māori project, while some scientists embraced the project's participatory research focus in facilitating researcher/stakeholder interaction in the research, one scientist explicitly stated in his conversations that this approach was more suited for social science outcomes, rather than an integrating framework for science, social science, and local and traditional knowledge in community-based research. The challenges of integrating the social and physical sciences in interdisciplinary projects are recognised in the participatory literature (Neef & Neubert, 2011; Pettie, 2011). As discussed in Section 2.3.1, Neef and Neubert (2011) claim acceptance and utilisation of participatory research is often driven by a scientist's personal characteristics and beliefs rather than an adherence to any particular epistemology. Indeed they claim being a social scientist does not of itself guarantee understanding of participatory approaches.

The wheat calculator project took place in a more conventional science / farming relationship than the Crop Science for Māori project, with a farming group that had a broad understanding of science as a development tool (Section 4.4.2). The project objectives reflected this with a combination of science investigation followed by technology transfer. The first component of the project was largely undertaken by the scientists and was centred on a scientific investigation to examine and quantify the effects of arable and vegetable cropping practices on nitrate leaching to gain specific local data to develop a prototype wheat calculator. This component sought minimal input from farmers, other than the provision of access to farmland. The second component involved farming and science partners co-developing a user-friendly interface to ensure the end product was easy for farmers to use. A Crop and Food Research (CFR) science technician was employed to work with farmers to test the prototype calculator. Information from this testing was then to be fed back to CFR to enable changes to the software.

While the development of the calculator's interface was to be collaborative, the calculator's underlying science knowledge was already developed and the intellectual property was owned by Crop and Food Research. It had been the 'life's work' of one scientist who had spent over 20 years developing the Sirius Wheat Model that underlies the calculator. As the FAR manager explained:

> When we first became involved there was a huge amount of science that had been done and funded by someone else. There was one person who had a huge knowledge of it and who viewed it as a science tool.
>
> *Participant R75Wh*

From the scientists' perspectives, the project objectives reflected a traditional linear approach to research and extension, given the science had already been developed. As the lead scientist explained:

> The wheat calculator it was much more about extension - to try and put our knowledge in the hands of farmers who are generally extremely knowledgeable but they are not specialists, they are much more generalists.
>
> *SCC interview, Research Scientist, undated*

For the farming group, however, their collaboration and input into the design of the calculator's interface set the project apart from more traditional linear extension. FAR expected farmer feedback to be fed to the science team via a field technician during the extension component to enable changes to be made to the software design.

The objectives in shared partnerships, as evident in the Crop Science for Māori and the wheat calculator projects, reflected their different contexts and audiences and the shared nature of the partnership. In both cases partners acknowledged the need for the science and farming partners to work together and so the objectives sought to reflect each of the partners' motivations and expectations, as discussed in Sections 4.2, 4.3 and 4.4.

Partner relationships in shared partnerships

The analysis showed that shared partnerships require relationships to be equitable to facilitate both partners' engagement in collaborative research. In the participatory literature, partnerships are recognised to require shared understanding, compromise and negotiation among partners (Bayer, 2004).

To establish an equitable power dynamic in the Crop Science for Māori project, relationships needed to be built on a foundation of trust between the partners. This need for trust in relationships between scientists and first nation communities is well documented (Bourhill et al., 2004; Moody & Cordua Von-Specht, 2005; Nadasdy 1999). The Crop Science for Māori partnership emerged out of an uneasy historical context (Section 4.4.2). For the Māori community, if a trusting partnership was to be established and past experiences were not to distort this, then the community expected significant commitment by their science partners. However, the community and science stakeholders' perception of this commitment was initially misaligned. As a scientist explained:

> I think we used the word relationship "Isn't it wonderful we have got this new relationship between Crop and Food and the Māori community" – they said, "NO, it is marriage".
>
> *Participant R14M*

Trust building was essential for developing commitment, which slowed the pace at which the project could proceed. This challenged the scientists who were more familiar with traditional science/farming partnerships where relationships were pre-existing. The following members of the science team explained:

> I normally wouldn't have to put much effort in, because you make a quick phone call to a farmer – "We have a trial, we want to put in this, this is what it is about." Whereas up there it is more complicated.
>
> *Participant R20M*

> Really all we did in the beginning was go and try and prove to the people, try and get them to come across to us to tell us what they wanted. Didn't work very well… it was probably three years into the programme before we started to actually get some feedback.
>
> *Participant R10M*

In this project, the evidence shows that relationships needed to firstly develop on a personal level. To assist with connecting the community and scientists, a community member worked as a bridge in the early stages to introduce the scientists and advise on protocols. The participatory literature refers to these people who cross between two worlds as 'boundary crossers' (Veitch, Taylor, Kilpatrick, Farmer, & Chesters, 2007). Such personnel are recognised as important facilitators in building social capital in participatory projects (Bayer, 2004). Interviews with both science and community respondents in this research revealed the importance of facilitators (boundary crossers) and one to one relationship-building between partners for fostering trust. Relationship-building on a personal level required time and could not be forced. As a scientist explained:

> To break down suspicion you drink a lot of cups of tea - you must wait for people to realize that you are genuinely interested in facilitating a better future with all the respect for their current situation.
>
> *Participant R13M*

By developing personal relationships with members of the community the scientists built considerable inter-personal trust. This was recognised by an ECOP grower:

> I really like them [the CFR scientists in the project]. If it wasn't for them I wouldn't have carried on to where I am now. When they came – it's like lifting me up, pepping me up, encouraging me, "Oh you're garden's so beautiful". "Oh you've got this and got that". "Have you done this?" "Why haven't you?" I said, "Oh would you do it please". They're really good. Encourage me to try to do it myself.
>
> *Participant R11M*

Since trust building took time, scientists claimed that project timelines and budgets needed to be flexible, which they found problematic for the organisational routines and regimes in which they operated. Scholars recognise the difficulties that arise explaining intangible outcomes such as trust building to funding agencies and science organisations who seek measurable and tangible outcomes (Murray, 2000) (Section 4.2). Scientists in the Crop Science for Māori project who operated in a commercial science system, which valued measurable outputs, experienced difficulties reconciling institutional demands with participatory research.

> I can relate to a lot of the stories on the Coast. But trying to relate it into the science system … and I think I don't want to rush this programme because the system forces me to. It is a real struggle to merge – and it is something I cannot escape. I am not a Māori, I am a scientist but I am in these two worlds.
>
> *Participant R13M*

In contrast to ECOP in the Crop Science for Māori project, who had no prior experience of having worked with scientists, FAR in the wheat calculator project had pre-existing relationships with CFR, and FAR's members had a broad understanding of science as a development tool. As there was a general recognition between partners of science as a development tool, the partnership was more conventional. Despite this, significant tensions emerged in the wheat calculator project as a result of a clash between the partners' motivations and expectations. Scientists viewed the calculator as a science tool and saw the project as a linear transfer of "our" knowledge to farmers (SCC interview, Research Scientist, undated). In contrast the farming group viewed the calculator as a farming decision-support tool and expected strong feedback loops between their farmers and the science team to allow farming input into the calculator's interface design to maximise the technology's usefulness to farmers.

The initial prototype of the calculator designed by the scientists met significant farming resistance as farmers found it too complicated. A science technician who introduced the calculator to farmers recognised that the initial interface did not reflect how farmers managed their crops. While scientists had detailed understanding of wheat, the technician claimed the prototype did not reflect farming practice and how the farmers managed their wheat crop.

> Often research-grower relationships are hard to form because the two never meet … the calculator would put N [nitrogen] on when the crop ran out – but growers put it on according to a growth stage of the crop – much more practical and proven to be successful … to me the biggest problem was the interface and I didn't have much luck with getting it changed.
>
> *Participant R79Wh*

Scientists held a strong sense of ownership of the science knowledge that underlay the calculator. It was driven by the 20 years of science research that had gone into developing the Sirius wheat model. When farmers reported that they found the interface too complicated, recommendations for changes were strongly resisted by scientists. Farmers' modifications were perceived to compromise the legitimacy and integrity of the science knowledge that was incorporated within the model. The wheat calculator project shows that shared partnerships can become contested environments, as traditional power dynamics are challenged. Projects cannot proceed unless these issues are resolved through dialogue, negotiation and compromise. In the wheat calculator this was successfully achieved through the facilitation role of a science technician whose experience of working with the farmers taught her that applied projects required:

> A close connection between researchers and industry bodies so that the science people can understand how the growers operate.
>
> *Participant R79Wh*

Successful relationships in community-based research require a shared approach to problem identification, goal definition and solution development (McEntee & Mortimer, 2013). In shared projects like the wheat calculator and Crop Science for Māori project, significant tensions needed to be overcome to rebalance the power differentials. This could only be resolved through communication, negotiation and trust building between partners. For this to be achieved in the Wheat calculator project, the lead scientist had to firstly transition away from viewing the calculator as a research tool, to viewing it as a farming tool. As the FAR manager explained:

> [Scientist's name] had to realise what he had was not usable in its current form. That took a while … but once he embraced the fact that his work, his life's work and career might be of value to a whole heap of people … he was fantastic and you had that enthusiasm, you had that person who actually wanted to be delivering it to farmers.
>
> *Participant R75Wh*

The Wheat Calculator and the Crop Science for Māori projects both show that relationship building is critical in shared partnerships to ensure project partners meaningfully connect. While partners had different roles in their projects, equity came from each recognising and respecting the specialist contribution of the other. In a shared partnership, connection between partners was important even when partnerships were more 'conventional' as they were in the Wheat Calculator project.

Analysis of the shared partnerships in this research shows that relationship building in shared partnerships takes time, continual dialogue and negotiation to work through any conflicts. It took much longer to develop relationships in those instances where partners had not previously worked with each other, where farmers had only limited understanding of science and where scientists had a limited and more traditional view of applied research and extension. Without understanding the differing motivations and expectations of project partners, actors could overlook or underestimate potential incompatibilities.

5.2.3 Science-initiated partnerships

The squash rot and potato aphid projects were both science-initiated projects as evidenced by the following statements from leading project actors in both the squash and potato projects:

> I was looking for new projects and so it was kind of a scientist self-interested thing rather than an industry driven starting point.
>
> *Participant R53S*

> In those days it used to be a concept that came through from the scientists and they might think, yeh well this is pretty good for us to research, hopefully its going to be relevant to what they want. I was there as the grower to get SFF funding. It had to come from a grower, whereas in actual reality it was coming from Crop and Food, but I was put forward as the grower, it was a way around getting funding.
>
> *Participant R31P*

Although all funding applications show farmers as principal applicants, because SFF documentation requires a farmer to act as the principal applicant it is not necessarily reflective of the project's true initiator. Scientists who wish to access SFF funds must seek farming partners. As was noted by the potato aphid applicant farmer, this could lead to a "rent a farmer" approach to funding applications (Participant R31P).

Both the potato and the squash projects were supported by their respective farming industry bodies as they addressed immediate issues of concern to these sectors. In the potato aphid project the industry body Potatoes NZ, wished to protect the viability of their markets from disease transmitted by aphids or other vectors (SFF, 2002). The increased use and rates of insecticide applications by farmers to combat crop disease were recognised by both the farming and science sectors to expose the entire potato industry in New Zealand to disease through the spread of virus infected seed potato and insecticide resistant aphid vectors. Similarly in the squash sector, access to the lucrative Japanese and Korean markets was recognised to be dependent on buyers' perception of fruit quality, which was adversely impacted by squash rot (SFF, 2003b). Determining which fruits were vulnerable to squash rots was estimated to have the potential to increase annual squash export income by NZ$75 million (SFF, 2003b). Project documentation shows a narrative of economic sustainability through access to markets (squash) and security of the industry's economic future (potato) as strong motivators for project engagement by these two economically focused farmer groups (Section 4.4.2).

Project objectives in science-initiated partnerships

Objectives had a strong experimental research focus in the science-initiated projects. This was most noticeably seen in the squash rot project, which sought to undertake complicated field trials to investigate the relationship between nutrient concentrations and rot. The intensity of this science research was evident in the project documentation, which detailed protocols for sampling soil, leaf and fruit tissue and the fruit at harvest. Samples from commercial fields were to be analysed over two seasons and if a strong relationship between nutrients and rots was shown, scientists would then develop a preliminary storage rot predicator tool for chain actors - the farmers and the squash pack house operators. A second version of the tool was to be developed by the scientists for commercial release in year three of the project. Farmers in the project simply provided access to their land, while pack house operators provided access to their stores.

In the Potato Aphid project, scientists sought data from field and laboratory experiments to develop an Integrated Pest Management programme to prevent aphid resistance to any one class of insecticide. This included benchmarking aphid resistance and undertaking insecticide field trials at CFR research stations. In addition, data on the numbers of flying aphids were to be gathered from six field sites using large suction traps and from 12 smaller sites using yellow bowl traps all situated in farmers' potato fields in Canterbury.

In each project the development of a 'tool' for farmers was dependent on the availability and reliability of data from the fieldwork, which was largely undertaken by the scientists. These two projects were set up to proceed in a linear path. Scientists proposed the projects and set the objectives. Scientists would then collect the data and develop the technology. Farming groups would then transfer the technology to their farming communities who, it was assumed, would adopt it.

While the squash and potato projects addressed issues of relevance to their respective farming sectors and were supported in-kind by the squash farming group and financially by the potato farming group, these science-initiated projects did not generate wide farming sector buy-in. Interviews with potato farmers even revealed doubt over the credibility of the evidence linking potato disease prevalence with insecticide resistance. As a research scientist explained:

> Sometimes people develop conspiracy theories - you can see it in the potato industry - they really start to fester. I almost felt there was a tension between the wholesaler and the farmer - they are not too far below the surface.
>
> *Participant R33P*

In a sector where chain actors such as wholesalers exert significant influence over farming practice (Section 4.4.2), conspiracies "fester" and when they take hold they affect farmer buy-in to projects. A project where the problem is not widely recognised by the farming community or undermined by conspiracy theories generates little buy-in.

Farmer buy-in was similarly limited in the squash rot project, despite a decline in crop yield in the previous season. A scientist employed as a science consultant by the squash industry group recalled a grower's buy-in to the project:

> [*Grower's name*] might have had 10% rot where he was used to having 2%, "Oh well we better do something about it." That kind of thing - it wasn't a real buy-in.
>
> *Participant R47S*

Similarly a squash scientist stated:

> There was an obvious problem with these rots and for some reason even that didn't seem to motivate them to fund any research. The only research they ever funded was very specific crop protection things. Those I guess are a lot easier for growers to get their head around…
>
> *Participant R53S*

Another scientist stated:

> deep down there wasn't any real grower interest, grower drive or buy in, any industry push for the project, it just went along.
>
> *Participant R48S*

Intensity of farmer buy-in was affected by how important an issue was perceived by the sector's farmers and by the influence of other chain actors. Despite the immediacy of the crop management problem of these two projects, these scientist-initiated partnerships did not generate the same level of farmer group buy-in to the problem as either shared or farming group-initiated partnerships.

Partner relationships in science-initiated partnerships

Participatory engagement in the science-initiated projects was largely managed through project steering committees, which generally met twice each year. Scientists and farmers and sometimes other stakeholders from the value chain participated in the committee meetings. Farming group involvement was largely delegated to nominated farmers. Meeting minutes show one or two farmers attended some of the stakeholder meetings in the potato project, while in the squash project the farming representation was overseen by the corporate grower / packhouse operators, although one large grower nominated a cropping consultant to attend, while another had his operations manager attend. Commercial company representatives acted as project managers on both committees. The international food processor McCains provided an agronomist as the project manager for the Potato project, and Analytical Research Laboratories (ARL), a wholly owned subsidiary of the large fertiliser company Ravensdown, provided their technical manager as the project coordinator for the Squash project. Steering committees acted as a forum to discuss project achievements, to plan work for the next season and to address operational difficulties.

When compared to the naturally developed relationships in the farming group-initiated and shared partnerships, interviews indicated that relationships between partners in science-initiated projects, while generally cordial, were more distantly professional and managed largely through the formal settings of project meetings. This formal setting provided limited opportunity for informal social interaction that was evident in LandWISE and WIG's engagement with scientists. The potato farming group manager commented that there was "not enough involvement of the growers right through the whole thing" (Participant R40P).

In the squash project the steering committee meetings were the principal forum for major actors to interact. The squash project manager explained that while partners talked openly at these meetings about technical matters, their conversations were limited by industry competition between growers:

> Around the table I can remember having some pretty open discussions about some of the technical stuff of growing. I am sure if they thought they had something that gave them a market advantage well no they are not going to go out and tell everyone – and then equally you didn't get complete silence or they didn't want to talk.
>
> *Participant R52S*

In these projects the collective requirement of participatory research was undermined by sector dynamics of competitiveness among packhouses. As discussed in Section 4.2.2, a culture of secrecy in these industries drove a reluctance for farming actors to share information. The squash project manager explained the challenges of working with the squash industry:

> They are extremely competitive, so they don't trust each other, they are not a coordinated industry. They remind me of the cut flower industry … they are all trying to beat each other to the market, they are all trying to get that wee niche, get that advantage on each other, even the growing standards and those sort of husbandry practices they keep quite tight to their chest.
>
> *Participant R52S*

Although highly competitive, four competing corporate squash growers and pack house operators did participate in the squash rot project. However, a squash scientist explained that, "it was a group that didn't seem to work very well with each other" (Participant R48S). Farming partners put boundaries around the information they were willing to share, a feature not evident in the shared and farming group-initiated partnerships. One squash scientist recalling his experience claimed that projects needed more than farming group commitment or the desire to answer a research question to hold a group together. He stated:

> You actually need to generate emotional buy-in, like it's not like them saying to you – "oh go away and come back when you have finished", it's like you want to go on this thing together and learn together.
>
> *Participant R48S*

This research shows that these steering committees met project accountability requirements, but they did not provide the necessary informal opportunities to develop inter-personal relationships between partners. The formal structure and infrequency of meetings and the variation in attendees limited the ability to build relationships and therefore trust in the science-initiated partnerships.

5.2.4 Summary of partnership category effects

This comparison between the different project partner categories has identified a number of effects that partnership categories had on project objectives and project relationships in this research. These are summarised in Table 5.2. The following section examines dynamics that drive the way partnerships form and the relationships that develop between partners.

5.3 Dynamics that affect participatory research partnerships

Section 5.2 showed that the notions of partnership are a more socially complex concept than might be implied by the notion of ‘partnership’ in the funding contract that partners sign. Although findings from this research show that participatory research is being integrated into private/public partnerships, the partnerships that form are often very different, with the evidence revealing that project initiators have a significant effect on the type of partnership that is formed. These considerations affect project objectives, dynamics, partner relationships and outcomes. Analysis of the six cases revealed three suites of dynamics that affect the type of partnership, and/or the development of relationships.

- Institutional dynamics
- Alignment of partner priorities
- Power dynamics

5.3.1 Institutional dynamics

Chapter 4 identified a range of institutional dynamics that shape the major project actors’ motivations for engaging in, and expectations of, participatory research, which have the potential to affect project delivery. The empirical evidence presented in Section 5.2 reveals that these institutional dynamics have a direct effect on the way project partnerships form. This in turn, has flow-on effects to the shaping of project objectives and partners' relationships.

Table 5.2: Partnership category effects on project objectives and partner relationships

Project Partnership Category	Project Objectives / Partner Relationships
Farming group-initiated Partnership	**Objectives** • Determined largely by farming group and their members who would seek scientists' input if needed. • Farm or orchard focused. • Direct or immediate relevance to farm members. • Significant extension component built into project from start. • Partner interaction and knowledge sharing built into project objectives. • Smaller trials on a variety of issues housed within larger project. **Relationships** • Farming groups establish long-term relationships (outside the project) with partners, particularly science partners. • Informal social interaction welcomed between partners. • Farming groups utilise existing relationships in projects. • Scientists act as advisors or contractors, which creates new power dynamics compared to traditional applied projects. • Scientists have positive track record of working with farming groups, are personable and effective communicators. • Relationships between partners often on a personal level. • Relationships described as collegial and collaborative.
Shared Partnership	**Objectives** • Collaboratively negotiated between project partners. • Had direct farm relevance but combined this with science component. • Had significant extension component. **Relationships** • Relationships shaped by partners' motivations and expectations. • Requires early understanding of partners' motivations and expectations. • Farming groups insist on equity. • Mistrust between partners (if present) will erode trust building - resolved through dialogue, negotiation, conflict resolution even in conventional partnerships where partners are more familiar working with each other. • Facilitators play bridging role. • May require re-balancing of power differentials. • Relationship building can be affected past experiences. • Likelihood of contested environment. • Delivery of project unlikely to proceed without relationship building. • Early relationship set backs can be resolved.

Project Partnership Category	Project Objectives / Partner Relationships
Science-initiated Partnership	**Objectives** • Strong experimental focus to research. • Research may involve complicated and fundamental science research. • Problem is farm relevant and mutually accepted by partners but farming sector buy-in to problem and project is more limited. • Extension not specifically mentioned in objectives – accepted by partners that it will follow science research when results are known. **Relationships** • Managed through the formal structure of a project steering committee with farming, science and other stakeholder representatives. • Farming representatives may delegate their participation to others. • Farming engagement on steering committee can be variable. • Farming representatives provide logistical advice to ensure science fieldwork fits in with farm operations. • Relationships cordial and professional but with limited opportunity for informal social interaction.

Effects of institutional dynamics that scientists bring to projects

The science-initiated squash project shows that a need to secure research funds can lead to science-focused objectives being 'shoe-horned' into applied projects. When this occurs, farming partners take a more passive role in both setting the research agenda and determining the research process. In science-initiated projects, objectives have a more experimental science focus than in the partnerships in the other two categories investigated in Section 5.2. Furthermore, when farmers are largely isolated from active engagement in the planning of the research programme, even though they may engage in project administration (such as attending project meetings, as they did in the squash project) farming partner buy-in is limited.

While demand-driven research is encouraged to meet the challenges of today's agricultural environments (Klerkx et al., 2006; Klerkx & Jansen, 2010), it would be too simplistic to draw from this that applied projects should not be science-initiated. This research shows that science-initiated projects can expose farming partners to issues that might otherwise fall under their radar and extend them beyond a focus on issues that increase production and profitability. Indeed these considerations were identified as key areas of interest, particularly for the economically focused farming groups in Section 4.4.2. Sustainability, which requires understanding at spatial and temporal scales beyond the immediate and impacts beyond the farm gate, does not feature in farmers' vocabulary, even if they generally espouse to notions of sustainability (Cocklin & Dibden, 2005). The limitation of science-initiated partnerships as evidenced in this research, however, is that they start from a pre-determined science perspective rather than allowing objectives to be co-developed and research to be collaboratively designed. This leads to farming actors in science-initiated partnerships being participants in participatory science research. Notions of co-produced knowledge and applications are anathema to such framings.

Successful project partnerships in this research occurred where positive partner relationships between farmers and scientists were typically established before a project partnership was formed, as in the LandWISE and Walnut projects. When relationships were not pre-established, projects required considerable time to develop trust between the partners. This was especially critical in shared partnerships that started from a relatively low level of trust, as in the Crop Science for Māori project. The empirical evidence from Section 5.2 however, shows that relationship-building is undermined by an institutional context which focuses solely on the research, and underestimate the time needed to develop strong industry connections through networking outside the immediate project. The shorter time frames of applied research also under-estimates the time that is needed to build trust in projects. This research shows that trust-building is essential for establishing a foundation on which to develop strong partner relationships in participatory research. Trust-building, however, may be undervalued by institutional contexts that seek measurable outputs. The Crop Science for Māori scientist described the tension of working in "two worlds" – as a scientist in a corporate research environment and as a researcher working in a largely Māori community. In addition, relationship-building beyond the boundaries of projects may be further undermined by transience in the science community, as scientists need to move from project to project to secure research funds (Section 4.3.3).

The evidence from Section 4.3.2 also showed that scientists are shaped by both personal and professional drivers. The 'scientist' growers in the walnut group gained enjoyment from and had confidence engaging in science, which influenced their decision to undertake more fundamental research with their bacteriophage work. However, they balanced this experimental science component with applied orchard benchmarking work to ensure the project had immediate relevance to their wider membership to generate grower buy-in.

While all scientists in this research expressed enjoyment at engaging in applied research, participatory research built around micro-level engagement risked being seen as less important than fundamental research. This was most extreme where science outcomes were minimal, such as in the Crop Science for Māori project. Here some scientists questioned the value of engaging in participatory research, viewing it instead as a methodology for social not physical scientists, rather than a framework for applied research. Science built around a rigorous methodology that generates sound, reliable, measurable and reproducible quantitative data more easily fits scientists' perception of science, and of the scientist as an objective, unbiased observer. Funding agencies that encourage scientists to engage in participatory initiatives can act as a catalyst to extend scientists' research methodologies (Section 4.2.2). At the same time funding agencies' increasing preference for measurable outcomes may ironically promote an experimental approach to science research that favours quantitative 'science' outcomes (Section 4.2.3) to meet accountability requirements through stated key performance indicators. The influence on participatory initiatives of regimes, rules and practices such as funding agencies' demand for accountability, is also noted by others (Barr & Carey, 2000; Hartwich & Negro, 2010; Murray, 2000; Mustalahti, 2006) and the use of knowledge brokers, to act as a bridge between scientists and policy and funding agencies, is increasingly promoted to manage these types of regulatory requirements (Pennell et al., 2013).

Scientists' understanding of farming practice affected the development of strong and trusting partner relationships. Scientists who reported growing up on farms (a scientist in the Crop Science for Māori and another in the Walnut project), claimed this enabled them to develop a strong empathy with their farming partners which acted as a foundation to build trust and shared understanding. Where a scientist's empathy with farming practice was initially poor, as in the wheat calculator project, relationships were strained.

Institutional dynamics of farming groups

Positive participatory research partnerships were established where farming groups had applied research as a focus and possessed internal research knowledge. Research-focused groups saw themselves as creators of knowledge and sought external competencies to enhance their own capabilities. This was evident with

LandWISE, WIG and FAR. These groups were scientifically literate and resourceful. They built farmer awareness and acceptance of issues that were relevant to their sector, which acted to prime their membership and increase buy-in to project research. Farmer buy-in was more limited in the squash and potato projects, which were science-initiated partnerships.

Where farming groups had positive group cultures of engaging with science and a strong research focus shaped by a history of developing and sharing knowledge to improve their industry's performance both economically and environmentally, as with LandWISE and WIG, groups developed positive partner relationships and strong farmer group buy-in. Furthermore LandWISE, WIG and FAR were also able to draw on a wide base of explicit and tacit knowledge in either their staff and/or membership and FAR and LandWISE also drew on their connections with other chain actors. Research-focused farming groups actively sought to connect their farming members with the science sector. By acting as a bridge between farmers and scientists these farming groups linked their members to outside science capabilities and resources. This research reinforces the importance of social networks for fostering change (see Kroma, 2006; Phillips, 1985; Ridley, 2005; Sligo & Massey, 2007). It furthermore highlights the importance of 'loosely' tied linkages between all chain actors, which are recognised as weak ties (Granovetter, 1973) and which are shown to be critical for effective innovation development (Gielens & Steenkamp, 2003).

WIG and LandWISE's existing positive working relationships with scientists provided a foundation for their projects. These relationships were described as being between people and not between organisations. Where these relationships did not exist, or relationships were assumed, the project had to allocate considerable time to establish and develop the relationship between partners (e.g. Crop Science for Māori and the Wheat Calculator projects). Where industry cultures were competitive, as demonstrated in Section 4.4.2 for the squash and potato sectors, relationships in projects were more muted. Relationships were further compounded by sector secrecy, which limited opportunities for the relationship-building and flourishing of relationships among all partners.

5.3.2 Alignment of partner priorities

When partners' motivations for participating in projects and their expectations of the participatory process are not well aligned, the empirical evidence clearly shows that positive partner relationships are difficult to foster. Farming groups in all projects began with an expectation that the science research would deliver applied outcomes.

Where one partner took a lead role in a project, whether it was the farming group or the scientists, the project followed the lead partner's agenda. In farming group-initiated projects such as the precision agriculture and walnut blight projects, farming group expectations were clearly articulated and scientists were aware of what was expected. Potential tensions caused by the scientists taking a more passive role in project governance was mitigated by the farming group generally working with known science partners where relationships had already been established. Where new science / farming group relationships needed to be established and scientists contracted, such as in the walnut blight project, the farming group chose a scientist who understood their emerging industry and who was comfortable with the group being actively engaged in the research.

In science-initiated partnerships, where scientists largely developed the research agenda, project objectives were science focused and scientists largely designed the research. Steering committees were established to manage projects and while farming partners participated in committee meetings, their significant contribution was to align the research to field operations. Farming groups assumed a more passive role than in the farming group or shared partnerships, waiting instead for the science research to deliver relevant tools or knowledge that could then be applied in their sectors.

Shared partnerships in this research required the greatest effort to align partner priorities, since the partnership by its very nature needed to be built around shared understanding. Tensions developed when priorities were not aligned. This was evident in both shared partnerships in this research. In some instances participatory research can cause a clash between institutional frameworks, exemplified on one side by the institution of farming seeking knowledge that is relevant to farming practice, and on the other by the institution of science that values outputs of evidence-based research that are robust and statistically rigorous. These tensions may engender strained partner relationships that have the potential to derail projects. As such, they need to be addressed before the research can proceed. This was evident in the Crop Science for Māori project and most noticeably in the Wheat Calculator project.

Institutional dynamics that partners bring to projects can express themselves through a misalignment of priorities. If these issues are not reconciled they can erode the foundational requirements of effective collaboration in a project, eroding prospects for shared understanding that is necessary for successful participatory research. Effective partnerships require all partners' priorities to be closely aligned (Morriss, Massey, Flett, Alpass, & Sligo, 2006; Schensul, 2002) and partners need to understand the other partners' motivations and expectations such that they mutually understand each other's needs, wants, expectations and constraints.

Partners' priorities should not necessarily be the same. Rather, partners should understand each other to collaboratively create a shared vision. In innovation systems, *guidance of the search* which refers to activities that influence positively "the visibility and clarity of specific wants among technology users" (Hekkert et al., 2007: 423), needs to be evident for effective innovation to take place. Alignment of partner expectations assists in guidance of the search, which typically occurs from the interactions and exchange of ideas between partners. Indeed, Morriss et al. (2006) examining farmer/scientist interactions in New Zealand's dairy industry found that a misalignment of partner objectives limited knowledge exchange of new technologies. Prospects to align priorities are more effective when partners' relationships are strong and particularly when they are pre-existing. Turner et al. (2013) claim that industry groups are becoming increasingly aware of the importance of building relationships with science organisations, a feature also found in this research.

This chapter's discussion of participatory partnerships enhances understanding of the need to align partner priorities and most importantly the effect that both informal (practices, customs, traditions) and formal (regimes, laws regulation and rules) institutions have on relationship-building (Section 5.3.1) by restricting opportunities for partners to connect. A recent report from New Zealand about technology transfer (MAF, 2012), reported industry perception of a growing disconnect between science organisations and farming industry. What is surprising is this has occurred despite a policy and funding environment that encourages scientists to engage with farmers in participatory research initiatives.

5.3.3 Power dynamics

The establishment of project relationships was strained in those instances where existing power structures affected project cohesion. Within farming sectors power structures were highlighted with the Māori kumara growers and their unique culturally-based relationship, where restricted knowledge sharing between different communities on the East Cape made collaborative endeavours more complex. Distinctive power structures in the contract relationships in the squash and potato sectors also strained the development of relationships. This was very different from the more open relationships found among the small group of walnut growers and the community-focused and resourceful LandWISE membership.

The empirical evidence from this research shows that relationships between science and farming-group are more difficult to foster in competitive sectors, such as squash and potatoes. The formality of project committees is too structured to provide suitable platform for relationship building between partners. While participants in the squash project did regard it as a significant achievement to get the major industry actors to participate, and relationships were cordial, the protection of vested interests limited opportunity to meaningfully articulate the partners' expectations and motivations and address mistrust. The protection of vested interests erodes the social capital and collective requirements necessary for participatory research (Bayer, 2004).

In addition, where partners were less informed about the nature of science and its limitations, as in the Crop Science for Māori project, partners needed to be valued as equal contributors in order for relationships to flourish. Where partners' science knowledge was more equitable, with farming partners having a broad understanding of science as a methodology for developing innovations, as with the walnut growers and LandWISE farmers, relationships between science and farming groups developed organically. However, the research-focused groups created new power dynamics in projects. Scientists in partnerships with research-focused farming groups, took a more passive role in the project's research or were contracted for selected components. These groups do not see themselves as beneficiaries of science research but rather as active participants. They expected to lead or to take a prominent role in project governance. Farming group-initiated and shared partnerships challenge traditional approaches to research that Fergus and Romney (2005) argue have afforded science a privileged place in western knowledge. This research shows that farming group-initiated partnerships in particular create a new form of governance that disrupts historic power dynamics in farmer / science relationships that have traditionally seen farmers, rather than scientists take passive roles.

Carr and Wilkinson (2005) argue such forms of governance challenge power dynamics by blurring and blending the boundaries between farming and science. Farming groups like LandWISE, FAR and WIG act as boundary organisations (Cash, 2001) that bridge the gap between the farming and science sectors. Cash et al. (2003: 8086) claim that sustainability efforts are enhanced when organisations "manage the boundaries between knowledge and action in ways that simultaneously enhance the salience, credibility and legitimacy of the information they produce". To do this requires effective communication and translation of information and mediation. Farming groups in this research who acted as effective boundary organisations (LandWISE, FAR and WIG) have the human capability and the institutional capacity to take on this role. In so doing, they challenge traditional approaches to research. Participatory research provides an enabling environment for these farming groups to take an active role in challenging traditional project power dynamics.

Shared partnerships required the most negotiation and compromise to reconcile power dynamics between partners, as was evident in the wheat calculator. When there is mistrust, relationships cannot be forced. Partners need time, space and flexibility to learn to know each other and to develop shared understanding to break down mistrust. Where there are low levels of trust or significant power differentials, key local individuals, or boundary crossers (Veitch et al., 2007), can assist with reducing tensions, acting as a bridge they both expose and assist to reconcile tensions. The Crop Science for Māori project shows significant gaps are best bridged by developing positive interpersonal relationships between partners.

Trust building is also critical where relationships are more conventional and assumed, but partners have no established working relationships, such as in the wheat calculator project. Partners needed time and space to align each other's motivations for engaging in the project and their expectations of that engagement. Incompatibilities that arise between the science and farming partners' expectations cause relationship tensions and projects will not be able to proceed until these tensions have been resolved. This was noticeable in the wheat calculator which saw a clash between scientists' evidence-based findings and the lived experience of farmers. Scholars argue for effective communication strategies to overcome tensions (Section 2.3.1). Yankelovich (1999) importantly states that collaborative dialogue can only take place when there is equality, emphatic listening and when partners' assumptions are non-judgmentally evaluated. He contends this cannot take place until relationships have been humanised. Empirical evidence shows that collaborative relationships that engender trust between partners can take engagement "beyond initial responses and assumptions based on stereotypes or positions" (Fernandez-Gimenez, Ballard, & Sturtevant, 2008: online). This research shows that 'humanising' relationships is critical in participatory research partnerships.

Participatory research is rightly concerned with stakeholder representation (Reed, 2008). However, this research shows that of equal importance is the mindset of actors, which demands they seek collaboration and are willing to co-develop. Science-initiated partnerships marginalised farming partners from co-setting the research agenda while industry competitiveness eroded collaboration and partnership cohesion. Shared partnerships show that through a process of negotiation and dialogue where tensions are exposed and addressed, a productive and collaborative environment for innovation can be created and power dynamics that erode trust and the creation of a shared vision can be made more equitable. Farming group-initiated partnerships began from a position of partner equity where all knowledge was viewed as legitimate and therefore valued by participants.

5.4 Key requirements of partnerships to provide an enabling environment for participatory research

This chapter's investigation of partnership as a social process that seeks to engender collaboration, foster relationships and create shared meaning through communication and negotiation between project actors, differentiates it from the notion of partnership as a structural and contractual entity that is often implied in project contracts. Analysis of the evidence provides valuable insight into the key requirements for creating an enabling environment for participatory endeavours. These are identified in Table 5.3. The evidence in the table draws from sections in this chapter and also from Chapter 4, which shows the inter-relatedness of institutional dynamics and partnerships.

Table 5.3: Dynamics that foster positive partner relationships

Dynamic	Dynamic Characteristic	Research Evidence
Partner networking & collaboration	• Maintenance of strong relationships outside project • Positive past experiences of collaboration	Very evident in research-focused farming group partnerships – LandWISE, WIG, FAR where groups actively seek collaboration with science and other partners and begin partnerships often from existing relationships (4.4.2), (5.2.1). Historical / cultural facets in projects present challenges for establishing channels for collaboration – e.g Māori, Squash, Potato projects (4.4.2) (5.2.2) (5.2.3).
All partners are viewed as innovation / knowledge co-developers	• Partners share in programme planning • Partners co-develop objectives • Partners co-develop research design and are viewed as active partners in project research	Evident in farming group-initiated partnerships (5.2.1) Shared partnerships needed to negotiate to begin developing. Significant trust-building, negotiation and compromise required (5.2.2). In the Crop Science for Māori project, co-development emerged after the trust building period. However, in the Wheat calculator the epistemological differences between partners while aired and understood were never fully resolved and so partners co-development was more limited. Not evident in science-initiated partnerships (5.2.3) since these had a strong science focus with minimal farmer engagement in initial research planning and agenda setting. Farmers and farming groups had a passive role in project research (5.3.1). Farming groups' role was limited to advising on project logistics to enable the research to be undertaken smoothly in farmers' fields.
Partners humanise relationships	• Transcends the purely professional • Trust-building is an integral part of early relationship-building	Very evident in farming group-initiated partnerships (5.2.1), where project learning is built around collaborative peer networks. Shared partnerships needed to develop this (5.3.3). Relationships flourished when partners understood each other and interacted positively. Science-initiated partnerships provided few opportunities for informal inter-personal relationship-building since projects and relationships were managed largely through formal committee structures (5.2.3).

Dynamic	Dynamic Characteristic	Research Evidence
Partner priorities are aligned	• Understand partners' motivations and expectations. • Wide sector buy-in at start • Farm/orchard relevant objectives • Applied farm focus is evident in objectives and research design • Priorities are articulated so these can be aligned early	Very evident in farming group-initiated projects where farming groups articulated their expectations (5.2.1) and oversaw project work. Scientists in these projects faced personal challenges in working in environments that may not follow more rigid science protocols, but they enjoyed the relationships that developed. Shared partnerships needed to work through tensions to align priorities (5.2.2). Required considerable learning by scientists in particular about working in collaborative participatory relationships. Not evident in science-initiated partnerships driven by the science research (5.2.3). Resulted in minimal farmer buy-in in squash and potato projects (5.2.3).
Supportive institutions	• Wide support for knowledge sharing and engagement • Actors have a personal mindset for collaboration • Partners recognise and value input of different knowledges • Farming group has broad understanding/acceptance of science as a development tool • Scientists have a broad understanding of farming practice and how crops are managed on farms • Policy environment that provides an enabling flexible and non-prescriptive environment for stakeholder collaboration	Research-focused farming groups break down barriers that inhibit collaboration and knowledge sharing (5.3.3) (4.4.2). Scientists claimed to enjoy participatory endeavours but talked about significant institutional impediments to engagement in participatory research that under-estimate/undervalue participatory requirements (4.3) (4.3.2) (Table 4.2). Industry competitiveness in squash & potatoes made knowledge sharing difficult (5.2.3). Scientists' sense of what it meant to be a scientist created personal barriers which some felt they had to set aside to engage in research they may not 'control' (4.3.2). Difficulties doing this could create significant epistemological tensions, that became evident in projects as a clash between evidence-based science and lived experience of farmers (5.2.2). SFFs original flexible but friendly active management approach was recognised to be conducive to fostering collaboration (4.2.3). There is evidence in this research that this may be changing to a more KPI driven focus that may inadvertently undermine the participatory process as it favours quantitative evidence of collaboration and maybe less aware and accepting of the importance of trust-building and the time it takes to develop this (4.2.3).

5.5 Summary

The case studies examined in this research provide a valuable opportunity to contribute to the understanding of project partnerships. The partnership categories identified in this research grouped partnerships according to which actor group initiated the project (Section 5.2.2). This provided a novel way to investigate partnership as a social process, generating insight into how the actors who initiated the project shaped project objectives and partner relationships.

The comparative analysis of the projects shows that achieving collaborative partnerships in the complex and contestable agricultural sector can be a messy, highly variable and complex social process. The discussion enhances understanding about the social complexities of partnerships in project-based science, a recognised under-researched area of scholarship (Bidwell & Ryan, 2006). While partnership engagement in public-private partnerships is typically formalised when the partners sign a contract, the evidence from this research shows that project partnerships are affected by institutions that influence how actors engage in participatory partnerships and affect the collective and collaborative requirements of project partnerships (see Hartwich & Negro, 2010; Morriss et al., 2006). This chapter's discussion enhances understanding in this area by showing the effect these institutional contexts have on the way project partnerships form, with flow-on effects to project objectives and partner relationships.

The research extends the typical focus of scholarly research about participatory partnerships beyond a principal focus on partnership as a contractual entity. It also extends the focus beyond the bounded project timeframe of the formal start and end dates, which usually aligns with the period a project is funded. Farming group-initiated partnerships clearly illustrate the importance of relationship building outside projects, and especially beforehand. While organisational narratives such as New Zealand's CRI's *Statements of Core Purpose* (see for example Plant and Food Research, 2010) may call for greater connection between the science sector and primary industries to drive innovation and stimulate New Zealand's knowledge economy, this chapter reveals that institutional dynamics can erode the development of partnerships and partner relationships in micro-level projects.

This chapter's empirical evidence provides strong support for investing in partnership building to create trusting relationships in participatory research projects, particularly where projects seek to advance sustainability. This is because the paradigmatic changes that are required to advance sustainability in the agricultural sector (Chapter 1) depend not just on who sits around the project table, but more importantly on the partners' mindsets which recognise that shared understanding and collective visions are built on strong partner relationships and inclusion of the multiple and sometimes divergent knowledges that each partner brings to the table. Participatory partnerships demand more than just the requirement for partner participation; they demand participatory relationships.

CHAPTER SIX

6.0 Exploring Learning in Participatory Research

6.1 Introduction

In the agricultural sector it is widely argued that stakeholders must collectively develop knowledge, technologies and institutions if global agriculture is to become more equitable, sustainable and innovative (Pretty, Sutherland, Ashby et al., 2010). As Chapter 5 highlighted, participatory research in applied agricultural projects can facilitate rich partnerships. These partnerships should be fostered to enable partners to engage collectively and collaboratively in an enquiry that leads to co-produced knowledge (Hekkert et al., 2007; Klerkx et al., 2006; Turner et al., 2013). Furthermore, participatory researchers recognise that the ownership of the learning process and the knowledge that is generated should be widely and equitably distributed amongst the project partners (Cornwall et al., 1994; Neef & Neubert, 2011; Reed, 2008).

However, as Chapter 2 discussed, integrating science and farming knowledge in participatory research partnerships can be notoriously difficult (Allan et al., 2013). Given the growing interest from funding and policy agencies to seek ways to increase the adoption of sustainability innovations on the farm (Botha et al., 2014; Ministry of Primary Industries, 2012) there is a need to more closely examine learning processes and outcomes in participatory projects that seek to advance sustainability.

The six projects in this research provided ideal sites to explore knowledge production and knowledge diffusion. Turner at al. (2013) refer to this as 'knowledge exchange' in participatory research projects. Learning emerged as a dominant theme during the analysis of data collected for this research (Section 3.3). This theme was drawn from coding categories that focused on: the production and diffusion of knowledge; the space where knowledge production occurs; the knowledge that is produced; and the learning and transformation (change) that takes place.

This chapter examines communication, enquiry and learning in the six investigated projects. It begins by examining how knowledge production occurred in the projects by exploring project learning spaces to see how project actors created an enabling environment for joint knowledge production. It then explores how different learning spaces affected learning outcomes. It finally examines how project learning was diffused to farming communities to advance more sustainable practices in farming sectors.

6.2 Project knowledge production

6.2.1 Learning spaces

For people to work collectively and collaboratively they must be provided opportunities and spaces to interact with others. Leeuwis and Aarts (2011: 21) call this space of interaction "a space for change", highlighting how such spaces are necessary for stimulating innovation in complex systems. The concept of spaces for change has received wide interest in the literature (for example Chowdhury & Odame, 2013; Klerkx, Koutsouris, & Labarthe, 2013; Sewell et al., 2014; Sterk, Kobina, Gogan, Sakyi-Dawson, & Kossou, 2013). This notion has particular utility in this chapter's investigation of learning in agricultural innovation projects, as its focuses on understanding the discursive space where people engage, communicate and exchange ideas (Section 2.3.2). This section explores the development of learning spaces in the six projects in this research.

6.2.2 Linear knowledge production

Linear processes occur when knowledge production undertaken by scientists is followed by knowledge diffusion to farmers as users of the knowledge (Leeuwis, 2004). Participatory research seeks to avoid linear processes by encouraging interactive knowledge production that integrates the multiple knowledges of stakeholders into decision-making (Pretty, 1995). Although all projects in this research employed a participatory methodology, linear processes were still evident in two projects, the potato aphid and the squash rot projects. Both of these project partnerships were science-initiated (Section 5.2.3).

In the Potato Aphid project the research involved laboratory and field experimentation conducted by Crop and Food Research scientists to monitor local aphid infestations and resistance. Scientists sought to identify levels of insecticide resistance in aphids and to assess trap effectiveness for monitoring aphid numbers from yellow bowl traps and suction traps placed in seed potato farmers' fields (SFF Project documentation date 30.8.06). Farmers' spray diaries were also made available to the scientists for the assessment of crop spray routines.

Overall, interviews with farmers revealed that they were principally observers of the project's research, rather than active participants in the research, although they did report occasional talks with members of the science team when they visited their farms to monitor the yellow bowl traps. The following three quotes from seed potato growers are typical of grower comments:

> I wasn't too involved with the research side of things.
>
> *Participant R31P*

> Well [the scientist] did all of it, basically I didn't do it. I provided the place, I might have been there two times when he collected them.
>
> *Participant R37P*

> I didn't see them all that often, the guys that were doing the monitoring…they just sort of told me that they would be monitoring the traps once a week.
>
> *Participant R41P*

Similarly the Squash Rot research was carried out by Crop and Food Research scientists. In this instance determining the multi-factorial influences on Squash Rot was regarded as scientifically complicated. Pre-harvest conditions were considered a likely cause of rot, so the science team focused the research on isolating particular influences. Fruit, soil and leaf samples were collected and analysed over two seasons from field sites in Gisborne, Manawatu and Hawkes Bay. These sites were principally owned or leased by four of the major 'corporate' squash growers. At each site, field coordinators collated information on temperature, rainfall, fertiliser, irrigation and spray programmes. After harvesting, fruit were stored in pack-houses for eight weeks then evaluated by the scientists for rot. A scientist explained, "there was complexity, so we looked after all the field stuff" (Participant R48S). A squash grower whose land was used for field trials described his involvement with the project as follows:

> Can't really remember it because it was not something I actively did – they came and did it… but they did pass on the information about the results.
>
> *Participant R03S*

Project steering committees managed both the squash and Potato Aphid project, with science and farming representatives on these committees collaboratively engaging in project planning (Section 5.2.3). Farming input ensured that the field research that was undertaken largely by the scientists aligned well with farming operations. As two farming representatives on the squash project committee explained:

> You are often dealing with operational people and the growers are operational people and the packhouses are operational people and they don't like things that interfere with that. So it's got to be set up in a way that is practical for the operational side of the business.
>
> *Participant R46S*

> Sometimes when scientists are talking they don't think about the logistics of how you are going to do something, they think this is going to be the best from a scientific point of view, but if you can't do it in the field you are doomed to failure from the start.
>
> *Participant R49S*

Squash farming participants wanted the scientists to produce a Squash Rot predictor tool, while potato farming participants wanted the field and laboratory evidence to inform a pest resistant management strategy for seed potato growers. Farming participants were therefore focused on the output of the research. A focus on the *outputs* of learning rather than the *process* of learning is recognised to be problematic for the establishment of learning environments where iterative and emergent knowledge emerges from collaboration (Bawden, 2010; Blackmore, 2007). Blackmore (2007) argues for the need for learning processes to be constructive, interactive, purposeful and mutually agreed. With minimal farmer engagement in project fieldwork and a focus on the output of science research, the development of a collaborative learning space in both the potato and squash projects was limited.

While potato farmers provided land for scientists to gather data on aphid numbers and on occasions interacted with scientists as they emptied the traps, the engagement was passive. A potato farmer explained involvement and interactions as follows:

> [Scientist's name] would just give me a ring on the cell phone and whip down there and he would change it and count them or take the stuff away and he would count them in a laboratory and find out the results. Often I couldn't be there. Well he did all of it basically I didn't do it.
>
> *Participant R37P*

The Squash Rot project similarly sought no farmer engagement with the fieldwork. A corporate grower/packhouse operator representative on the project committee explained:

> The farmers knew very little of what was going on, we would have just said we are going to do this trial and they would have gone yes - that is it.
>
> *Participant R49S*

With limited or no collaborative engagement in the field, the primary focus of the research in the early period became data collection. The technical difficulty of the data collection also made it more problematic to engage farmers. An agronomist explained:

> [The scientists] wanted to get growers to identify aphids in the bowl traps – but it was a pretty hard ask to get people that aren't that good at looking at aphids to look in a bowl trap, to identify them and count them.
>
> *Participant R32P*

Limited collaborative interaction led to a perception by some potato farmers that the project had a singular science focus. A farmer explained,

> [The scientist] never even monitored the crop when he came out, all he did was empty the trap – he didn't even look at the plants in the paddock or anything to see if there were any aphids on them.
>
> *Participant R35P*

A “space for change” should allow opportunities for participants to learn together where issues between actors can become apparent, negotiated and addressed (Leeuwis & Aarts, 2011). The empirical evidence from the squash and Potato Aphid project shows that when farmers are largely isolated from the fieldwork, projects are unable to foster a meaningful discursive space where partners can share information, communicate and negotiate to build trust and to learn together. Project committees allow partner input, but this research shows interactions typically focus on operational matters. While this may be useful for aligning operational and research components, it does not provide a substitute for active engagement in a learning by doing approach that is integral to effective participatory research (Allen, 1998; Allen, Kilvington, Oliver, & Gilbert, 2001; Botha et al., 2014; Douthwaite et al., 2003). The linear approach to knowledge production in these projects largely reflected the Transfer of Technology (TOT) approach to research and extension (Chambers et al., 1993).

6.2.3 Collaborative knowledge production

In the walnut and Precision Agriculture projects, farmers and scientists engaged in collaborative learning. As Section 5.2.1 revealed, both these projects were established on partnerships that were initiated by the farming groups.

In the Walnut Blight project, the walnut growers, many of whom were research scientists (although none were agricultural scientists), sought intense engagement with the project’s research. The group’s research committee was responsible for leading the research, which focused on new management techniques and bio-control options to reduce growers’ dependency on copper sprays and to enhance orchard management of Walnut Blight. While the bio-control component of the project involved novel and fundamental science, WIG’s research committee complemented this with orchard-focused spraying research that had immediate relevance for all growers. A ‘non-scientist’ grower recalled the knowledge he gained from the project:

> We gained a lot of knowledge. They may not have been able to find a bacteriophage to cure blight but there were a number of other issues we solved like timing of sprays.
>
> *Participant R64Wa*

Similarly farmers in LandWISE, while not scientists like the members of the WIG research committee, nonetheless drew on both explicit codified knowledge and tacit knowledge to address land management issues using precision tools. Farmers' use of explicit and tacit knowledge is evident in the following comment from a LandWISE farmer,

> The University comes here every year, postgraduate students have done work which is great. It takes our time but at the same time we get a chunk of feedback from a range of people…. It will always be in the top farmers nature to have a go to innovate to try something new and once they have done it they don't sit back, they can't help themselves – if I can just tweak that I will make that a bit better – they don't always make it better but … I pride myself that we can improve our soils, we know what a good soil is better than anyone… The environment throws things at us and the water table comes up and down and the land is not quite even everywhere.
>
> *Participant R03L*

Farmers in LandWISE and WIG valued science input and sought engagement with particular specialists (Section 4.4.2). LandWISE's projects involved scientists who were modelers, GIS specialists, soil specialists and crop scientists, while WIG involved science input from biophage experts and a crop specialist. For both farming groups the relevance of the projects to their wider members' farming business was paramount and they expected this relevance to be clearly evident in the project design (Sections 4.4.2 and 4.4.3). Research trials were managed by the farming group. As a LandWISE farmer explained:

> We had the science guys feeding into it, but the science was working for us.
>
> *Participant R04L*

Collaboration for these farming groups incorporated and built upon intense engagement with research design and implementation. A walnut grower described the collaborative nature of their relationship with their science partners by saying, "We were engaged with the researchers all the way" (Participant R56Wa). Often this involved very active engagement. As a walnut grower explained:

> I was climbing up and down trees taking samples of walnut buds and I would take them to Lincoln to analyse bacteriophages and how many Walnut Blight bacteria were in the buds at various times through the season. There was a lot of collaboration.
>
> *Respondent R62Wa*

LandWISE and WIG both employed a 'learning by doing' approach (Allen, 1998; Allen, Kilvington, Oliver, & Gilbert, 2001; Botha et al., 2014; Douthwaite et al., 2003). As part of this approach, both groups demonstrated this through 'learning by using' and 'learning by interacting' (Hekkert et al., 2007: 421). The former involved actively trialing the innovation. A LandWISE farmer who experimented with precision tools emphasised that the best way to learn was by:

> …trying it. If it is a new idea to me I work through it logically, it has to make sense to me, it is not just somebody's idea – I have to be able to make sense of it - whatever the idea I have to make sense of it.
>
> *Participant R03L*

LandWISE farmers were intensely inquisitive and wanted to understand '*why,'* before they would implement new practices or new innovations. As the following two farmers illustrated:

> If I can't justify why we are going to have 20m round every stream - then it doesn't make sense, but if someone tells me that on a 45 degree slope you need 15m to mitigate loose soil runoff to cultivate it, then I would say fair enough – because if you don't, what is the alternative, and that is when you can say that is good practice in those situations.
>
> *Participant R04L*
>
> If someone says we are going to get that amount more yield doing that, why? …I just hear farmers asking more technical questions - why will that work? They are farmers who are really, really competent in their field.
>
> *Participant R03L*

WIG interacted closely with their researchers. This interaction was partly necessitated by the complexity of the biophage research, which involved intricate laboratory research. However the group valued the knowledge co-production with the contracted scientists as the following quote from a walnut grower indicated,

> …right down to the research [the scientist] was designing - we actually got in and had conversations about how she had designed it and questioned her as to why she had done it that way and not this way.
>
> *Participant R56Wa*

The walnut growers' scientific expertise made it possible for them to understand and engage with the complexities of the biophage research. This allowed them to participate in the process of learning rather than wait passively for the scientists to deliver outputs.

LandWISE and WIG farmers saw the science / farmer relationship as a synergy between what Ingram (2008) calls the know-*how* of the farmer and the know-*why* of the scientist. Know-why is connected to the rules and principles of formal knowledge such as science, while know-how draws on the knowledge of experience (Lundvell & Johnson, 1994). This research shows that know-why knowledge assists farmers weighing the risks and benefits of a change of practice. Know-why was sought by farmers who had a broad understanding of science as a development tool.

In the more farm focused components of the research, LandWISE and WIG engaged in self-organised knowledge production and learning. Farmers undertook field trials with their members often only involving scientists as advisors or as analysts of data collected by the farmers. For example, in the benchmarking study coordinated by members of the walnut research committee, growers gathered data on orchard performance under different conditions and a variety of management approaches to develop climate models to target spraying regimes (Thompson, undated). A scientist who observed the group's activity explained:

> The growers would split up in teams to see how to assess and to be trained – as you always have an assessor effect which makes it difficult comparing what you assess - but this way it is more even - because they do all those training walks and they go over it, twice or three times and then they split up in teams – and there is always one in the group that knows something.
>
> *Participant R65Wa*

Self-organised research activities enabled members to be actively engaged in collaborative learning. These learning experiences could be visualised as spaces where farmers shared or exchanged ideas, knowledge or stories. These small discursive spaces, which fostered collaborative engagement and reflect a 'post normal' peer network (Henley, 1999), typically developed around small farmer-led trials and sometimes involved scientists either as active or passive participants. Peer networks provided an enabling environment for co-production of the project's innovation. Farmers provided access to land, human capital, technology, land and local understanding. Scientists provided expert knowledge and a respected approach to research investigation. As a LandWISE farmer explained:

> [The scientists] have got the science input and we have got the hardware to make it happen…
>
> *Participant R03L*

Scientists who engaged with LandWISE and WIG generally took a lesser role in project research as the farming groups expected science input to complement or supplement the farming group's own research and not be the singular focus of the project. Traditional power relationships with scientists giving top down information were replaced by demand-driven collaborative research. While WIG and LandWISE created positive long-term relationships with scientists, this new power dynamic directly challenged linear approaches to research and extension. Scientists who engaged in demand-driven research or were advisers to farmer-led trials, sometimes questioned the methodological robustness and rigour of farmer experimentation. A scientist described the dilemma of working with data collected by farmers that had not been gathered according to strict science protocols as follows:

> People think research is really easy to do but research is hard. And so for instance we have just had a whole bunch of results back from [a farming group] which you cannot do anything with because they haven't followed any of the protocols… There are some issues there to consider about the way that we do science - Should we do it differently? How do we decide what we do differently?
>
> *Participant R48L*

Interviews suggested that no matter how positive the personal relationships were between science and farming actors, integrating scientific and farming knowledge created an uneasy marriage between the evidence-based requirements of scientific knowledge and the knowledge farmers developed from their lived experience. This challenged both the way research was conducted and how it was communicated. AIS and participatory researchers embrace multiple stakeholder engagement in research and recognise both the capacity and capability of non-science stakeholders to enable innovation (Klerkx et al., 2012; Ziegler & Ott, 2012). Farming groups challenging of traditional ways of undertaking research, can unsettle scientists' desire for a robust and rigorous methodology to science investigation. The LandWISE manager talked about the difference between scientists and farmers' research:

> The person who goes into science wants to know the answer and have total confidence before they make a statement… Scientists they just typically have it so they are very very sure. For decisions I make every day I am *pretty* sure and if I am wrong you look at that. But scientists aren't like that… They don't know how to integrate [farmer knowledge].
>
> *Participant R01L*

LandWISE and WIG farmers actively saw themselves as innovators. As a result, research in collaborative spaces that was led by these farming groups blurred traditional research boundaries. These farming groups mobilised codified and tacit knowledge to provide an enabling environment for co-produced knowledge that was relevant to their members.

6.2.4 Negotiated knowledge production

Given the lack of pre-existing relationships, partners needed to become familiar with each other in the Crop Science for Māori project before they could learn to work together as partners. As such, in these kinds of instances the learning space can be regarded as a negotiated space in which partners jostled for position in the partnership. The community expected scientists to develop a deep understanding and respect for *Mātauranga Māori* (Māori knowledge) to establish a foundation of trust on which to build a learning space. As a grower explained:

> We had to teach them tikanga – our protocol – how you respect us on our ground… because they didn't know.
>
> *Participant R11M*

This included respecting and understanding how to operate in the community. The lead scientist explained:

> You have to be really aware of power relationships which a lot of people don't think about, you shake hands and get a big hug - but you have to realise you have a wider responsibility. In Waipiro Bay, when I rushed to another meeting by car, almost running into a car of a community member I apologized immediately to a kaumatua in the community – “I feel very sorry and I hope it won't spoil our relationship”. We were out in these communities with our vehicles from our institute and we learned very quickly to, practice good behaviour, as we were noticed by the community.
>
> *Participant R13M*

Scientists therefore had to temper their initial expectations about project timeframes and create more flexibility in project delivery to provide the space for relationships to develop with the community. A member of the science team stated:

> It was probably three years into the programme before we started to actually get some community feedback.
>
> *Participant R10M*

While scientists were used to relating to farmers, on the East Cape they found the farmer/scientist relationship was not typical, as a scientist said, “up there it was always come in and have a big discussion and it was all very personal” (Participant R20M). In the Crop Science for Māori project there was a foundational requirement for trust-building to enable partners to become familiar with each other’s different ways of knowing and doing. This reflects Yankelovich’s (1999) contention that for effective dialogue, relationships must firstly be humanised.

Traditional teaching platforms that were initially employed by the scientists to ‘educate’ growers about cropping practices proved unsuccessful at capturing grower interest. The lead scientist explained:

> We started with typical classroom stuff and we took a whole stack of papers. We were quite aware of their [particular] needs but still with a mindset of a scientist getting out into a community – and we did all the wrong things. People were falling asleep, it was not working.
>
> *Participant R13M*

In a community that had limited understanding of science as a development tool, scientists needed to rethink their traditional approaches to research and extension.

Classroom-style teaching, which the scientists initially utilised, viewed the community as passive observers and reinforced a top-down linear approach to project research and extension that is known to reinforce the researcher / researched stereotypes (Wadsworth, 2010). Most growers, many of whom were elderly, had not sat in a classroom environment since their school days. As a grower stated:

> I want to go out to the garden - meetings are boring, I lose interest after 30 minutes.
>
> *Participant R11M*

Weather stations which scientists installed on four properties to provide long-term climate data also led to a clash of partners' expectations that was described by one scientist as, "two world's colliding" (Thompson, undated), when growers expected these to provide short-term local weather information. The effectiveness of this climate technology was further impeded by its proprietary software that needed to be installed on individual grower's computers despite some growers not having electricity to power a computer. In addition, even computer savvy growers regarded the software as technically challenging, unreliable, cumbersome, slow and largely impractical as it generated enormous quantities of "irrelevant" scientific data (Participant R08M).

By taking a very reflective approach to their programme delivery, the scientists made significant changes. Classroom teaching was replaced by workshops containing a short seminar followed by extensive field walks. Workshop content was made grower-relevant with popular topics such as weed management becoming a regular feature. The Māori community also provided input to the workshops including running a *tikanga* workshop so scientists could learn about Māori protocols. The lead scientist demonstrated this reflective approach to programme delivery when he stated:

> It was really amazing how we changed. We said that we have to relate to their needs. We have to do things totally differently. I used my own intuition. One thing that helped me - I have a strong farming background… The scientist can bring some things to the table, and [the community] bring other things to the table and so you make it better and stronger. On all steps you are learning. The biggest driver was that it was not about us, but about them.
>
> *Participant R13M*

As the science team's empathy with the community's culture, values and traditions matured, trust was built (Section 5.2.2). These positive relationships, which developed over time, provided the enabling factors for collaborative learning initiatives which sought to incorporate *Mātauranga Māori* and western science knowledge into project learning. This was most evident in the co-production of a cropping calendar to follow the Māori planting year, which recognises *Matariki* (the Māori New Year) as the start of the planting season. For the scientists the calendar acted as tangible evidence of their developing partnership with the community. The lead scientist explained:

> You can build trust but in the end you have to achieve something together. Sometimes you can become lost because you are so busy with relationships. You also realize there were major social issues in some instances, but you cannot solve all their problems.
>
> *Participant R13M*

The Māori community wanted science knowledge to complement not replace their traditional knowledge, so the Māori calendar came about from the input of two knowledges in the partnership (Table 4.3). It acknowledged the plurality of knowledge rather than the integration of knowledge. The calendar illustrates that as trust developed between partners over time a learning space was negotiated that enabled knowledge to be co-produced and where learning was reciprocal.

Once a foundation of trust was built between partners, scientists were able to expand the learning beyond a focus on crop production and address important issues around selling kumara. Growers had initially sought to sell their produce locally but had encountered significant difficulties selling organic produce at a premium price on the East Cape as a community member explained:

> I'd see [grower's name] with her truckloads [of organic kumara] in the main streets and they'd sell one bag. And like sitting there all day – selling one bag. Locally people are not going to pay extra, they prefer to have the non-organic ones, which are going to be cheaper. It's just the way the communities are. There is not much money out there at the moment.
>
> *Participant R15M*

To explore markets beyond the East Cape scientists organised a fieldtrip to an organic wholesaler in Napier (five hours away) which revealed to the growers that the largest organic kumara market was elite restaurants in New Zealand's major cities where chefs paid highly for delicate (small) sized organic kumara. However, this market knowledge directly challenged the cultural values of the growers, who had gained considerable *mana* (prestige) from growing large sized kumara and had stores full of large kumara. For one grower, this market knowledge bought a clash of value systems which was difficult to reconcile. As a community member explained:

> He *can* grow kumara that the market wants. I tell him, and last year he just looked at me and said “what do they want them for, that is just stupid”. And so you get large kumara again. So I say to him this year "gosh those mongrels want those little ones again. So I say “We don't want those big ones - they're a waste of time”. He's turning a little.
>
> *Participant R16M*

Understanding and engaging with markets is critical for innovation (Klerkx, Aarts, & Leeuwis, 2010; Klerkx et al., 2012; Turner et al., 2013). The Crop Science for Māori project showed that project learning needed to extend beyond a singular focus on crop production. However, since engaging with the markets challenged the growers' cultural values, the introduction of other value chain support actors could only occur after a foundation of trust was developed between the foundational partners. While this research shows how important it is for participatory research projects that operate in agricultural innovation systems to engage with other actors in value chains, the Crop Science for Māori project shows that the timing of these introductions must be carefully planned to minimise possible tensions that could unbalance existing or developing relationships.

As relationships developed scientists organised workshops where chefs provided tastings of specialty kumara dishes. Scientists also used community support to organise two Food Festivals on the East Cape to showcase organic produce. These activities allowed the producers (Māori growers), suppliers (the wholesaler) and markets (chefs) to interact and understand each other. As the lead scientist explained:

> The chefs their eyes were popping out of their heads because they said "these are real people growing beautiful crops". They are buying it from the wholesaler, so they never see the real person with hands in the soil. And the growers were amazed to look at all the plates of Māori potato and kumara. Two different worlds came together.
>
> *Participant R13M*

The Crop Science for Māori project shows that in relationships where partners are unfamiliar with each other and where there is a coming together of different knowledge and values, the development of trust as a foundation on which to build partner relationships is central to project learning. However, empirical evidence from the Wheat Calculator project shows that trust building is also needed in more 'conventional' science/farmer partnerships where these actors are more familiar with engaging with each other and where farming partners have more understanding of science's contribution to innovation.

In the Wheat Calculator project the science team held the intellectual property for the research model that underlay the calculator (Section 5.2.2). They viewed the model as a science tool. Wheat farmers wanted changes to the calculator's interface to make it less complicated to use. This misalignment of partner priorities created early tensions. The scientists strongly resisted farmers' recommendations for changes to be made to the interface, as they perceived these changes would compromise the scientific integrity of the underlying model.

Although the scientists' resistance to farmers' recommendations for modifications was initially strong, a technician employed to assist farmers to adopt the technology used her understanding of science and her growing tacit knowledge about the way farmers managed their wheat crop to successfully act as a boundary crosser between the science and farming partners (Veitch et al., 2007). The technician explained:

> Often research-grower relationships are hard to form because the two never meet … I sided with the farmer first then put my research hat on – it made me a better researcher and changed the way I tackled projects.
>
> *Participant R79Wh*

Facilitators, intermediaries, boundary crossers and network brokers are important connectors in innovation systems (Klerkx & Jansen, 2010; Klerkx & Leeuwis, 2009; Policy, 2006 August). These actors can step in and out of 'different worlds' and build bridges between divergent stakeholders (Eames, 2005; Putnam, 2000). In the Wheat Calculator project the field technician assumed this bridging role. The use of a boundary crosser created a negotiated space and the project moved from a linear to a collaborative learning space, which enabled co-development. The technician provided the key to unlock the discursive space by acting as a conduit for communication and dialogue between partners. In so doing, she transformed the project into a learning space.

In the Crop Science for Māori project, 'community' boundary crossers played only a limited role since cultural protocols meant their influence was often restricted to particular communities. While a community *kaumatua* (Māori elder) did provide some assistance with initial introductions, as trust developed between partners, scientists developed a more acute understanding of the community so they could work across boundaries. Scientists however acknowledged their limitations as boundary crossers. As the lead scientist in the Crop Science for Māori explained:

> You will never become a Māori - don't pretend you are a Māori. I am not a Māori. You have to learn really quickly, with all the respect you may earn you are still an outsider and it is still a privilege to be part of these things. That is something you have to be really aware of or otherwise you are overstepping boundaries, and people appreciate it as well if you really step away… you still have to acknowledge your research role. We all moved in that common space between communities and science and suddenly there is no scientist any more. You have to go back to the original role – it is a bit of a dilemma actually.
>
> *Participant R13M*

Both the Wheat Calculator and the Crop Science for Māori projects show that unbalanced relationships between science and farming project partners inhibit the development of co-produced knowledge. However these partnership imbalances can be addressed in a negotiated space where competing storylines can be aired. In this space actors reached what Leeuwis & Aarts (2011: 28) call "coherence, complementarity and/or congruence" through a process of negotiation, dialogue and facilitation. To become a learning space, the negotiated space required effective communication between partners. Boundary crossers facilitated the negotiated space and unlocked the learning space. While these were sometimes actors from outside the project, actors within projects learnt how to develop skills to take on this bridging role, as occurred in the Crop Science for Māori project.

6.2.5 Characteristics of projects that foster or impede the development of collaborative learning spaces

Section 6.2 shows that learning spaces are created in collaborative environments where opportunities are created for knowledge to be co-produced. Knowledge co-production is created from collaboration, trust-building and/or negotiation between participants. Without active collaboration in projects, linear knowledge production occurs. When viewing the six projects through a learning lens, projects in this research were able to be divided into three groupings. Interestingly this same pattern emerged when the projects were independently viewed through a partnership lens in Chapter 5. This consistent 2 x 2 x 2 patterning, with Precision Agriculture and Walnut Blight showing a consistent pattern; Crop Science for Māori and Wheat Calculator another pattern; and Squash and Potato Aphid another pattern for both project partnerships and knowledge production, indicates a strong connection between the development of project partnerships and learning spaces.

Trust building, a critical requirement for the development of partnerships (Section 5.4.2), is equally critical for the creation of collaborative learning. Proactive farming groups who have a research focus, (LandWISE, WIG and FAR), played a central role in connecting science and farming actors in projects as they acted as boundary crossers to assist in the creation of collaborative learning spaces. They also played a critical role creating their own spaces for farmer to farmer learning, where scientists played a more passive role.

The research shows that the creation of collaborative learning spaces is essential for creating the preconditions necessary to foster co-production that is essential for innovation and change. Tables 6.1 and 6.2 summarise the key characteristics in the six projects that impede (Table 6.1) and those that foster (Table 6.2) the development of a collaborative space for learning. Illustrative examples from Section 6.2 support each characteristic.

Table 6.1: Project characteristics that impede collaborative learning spaces

Characteristics	Empirical support from this research
Primary focus on science research - focus on research outputs not learning process	Squash project focused on fieldwork for scientists to be able to develop a rot predictor tool. Potato Aphid project focused on gathering field data for scientists to be able to develop a resistance management strategy.
Project research is scientifically complicated	Squash project fieldwork was technically complicated and so provided few opportunities for collaboration around the specific fieldwork.
Segmented roles for actors – Scientists responsible for the research while farmers take a passive role in project research	In both the squash and Potato Aphid projects scientists undertook the fieldwork. Farmers' input was largely confined to project logistics to ensure science fieldwork aligned with farming operation.
Formal arrangement for collaboration	In both the squash and Potato Aphid projects, steering committees provided the primary site for partner engagement and discussion in the project.
Instructional/ traditional teaching method	In the Crop Science for Māori project scientists began a programme of classroom-based teaching. The community resisted this initial 'teaching' approach to engagement.
Project knowledge production does not align with farming practice	The Wheat Calculator initially did not reflect the way farmers managed their crop.
Organisational infrastructure does not support innovation	Information on aphid numbers on the *Aphid watch* website was too slowly uploaded. Yellow bowl traps presented significant problems with aphid identification. Weather stations in the Crop science for Māori project were technically cumbersome or inappropriate. The isolation of the East Cape presented significant barriers to collaboration
Institutions are not supportive of collaborative innovation and co-production	Industry /community institutional cultures in potato, squash and Crop Science for Māori projects limited knowledge sharing among community participants. In the Wheat Calculator scientists initially viewed farmers as receivers of science knowledge (this was challenged by farmers)

Table 6.2: Project characteristics that foster collaborative learning spaces

Characteristic	Empirical support from this research
Learning by doing approach (Allen et al., 1998; Allen et al., 2001; Douthwaite et al, 2003, Botha et al., 2014)	LandWISE, and WIG farmers actively engaged in field experimentation with and/or without scientists. Farmer experimentation plays a significant part in their understanding of the environment in which they work. WIG's benchmarking orchard work set protocols by which growers could manage their crops to limit the effect of blight. LandWISE undertake farmer-led trials to allow farmers to experience the effects of precision tools for managing their soil quality. This gives them confidence to adapt and apply the learning to their farms and their specific conditions.
Co-development of innovation through learning by interacting and/or learning by using (Hekkert et al., 2007)	WIG engaged extensively with scientists to develop a bacteriophage. LandWISE contracted scientists to engage in field activities with farmers or advise on farmers' trials. In these projects farmers engaged with scientists so they could work in a partnerships where they could share their knowledge and understandings. In these projects and in the Crop Science for Māori project, growers and scientists co-developed knowledge about organic kumara production. Science knowledge was to complement not replace their local/traditional /tacit knowledge. The growing calendar for instance shows how local and science knowledge can be embedded into project learning.
Trust-building / Relationship-building	Trust is essential for collaboration, especially in those instances (Wheat Calculator and Crop Science for Māori) where projects had to overcome difficulties such as past experiences. Trust-building was particularly essential in the Crop Science for Māori project where partners had very different worldviews.
Functioning peer learning networks	LandWISE and WIG created explicit learning networks. These networks consist of farmers actively engaged in the project research, the communities of practice and sometimes scientists. LandWISE's field trials and WIG's benchmarking work are evidence of these active learning networks. LandWISE also include relevant industry players in their networks.
'Science' is valued by farmers as a development tool and embodied in project learning	Research-focused groups (FAR, LandWISE and WIG) understand science as a development tool. They understand science methodology. LandWISE farmers view science as a balance to more "subjective" farmer research. They talk about first principles that underlie their work. WIG's research committee talked openly about the need for evidence-based research. Their benchmarking exercise sought to develop orchard best practice around spraying regimes. Farmer-science relationships became positive learning relationships where the partners developed a shared understanding of the skill sets each bought to the table. FAR, LandWISE and WIG all have research committees.
Local knowledge (gained from farming experience or cultural knowledge) is valued by scientists and embodied in project learning.	Collaborative learning challenges more linear approaches to research. Many of the difficulties that do arise from challenging how scientists might view themselves professionally and personally are overcome through maintaining positive relationships between science and farming participants.

6.3 How different learning spaces affect learning outcomes

Participatory and sustainability science researchers embrace multiple stakeholder engagement as a way of bringing about change and argue that partners learning together and responding to changing circumstances is essential for successfully addressing complex problems such as sustainability (Franklin & Blyton, 2011; Keen et al., 2005b; Komiyama & Takeuchi, 2006; Neef & Neubert, 2011; Stirzaker et al., 2010; Stirzaker, Roux, & Biggs, 2011; Wiek, Ness, et al., 2012). Given that the projects sought to generate knowledge that would lead to change in farming practice, this section explores the learning that emerged from spaces that impeded collaborative learning and from those that fostered multi-stakeholder collaboration.

6.3.1 Learning in projects where collaborative learning spaces are impeded

The Potato Aphid project illustrates the effect on actor learning when knowledge production occurs in projects that do not actively foster collaborative learning spaces (Section 6.2.2). Interviews with farmers who provided land for trials but took a passive role in the project's knowledge production indicated they were willing to adopt simple innovations such as using a more environmentally friendly insecticide to control aphids. They were, however, reluctant to change spray routines and practices such as when and how often they sprayed. This effect is illustrated by the following quotes from two seed potato farmers:

> I am not sure we would change our programme from what we were doing, it will move us towards it perhaps, with more confidence in time, but you don't go and change a programme over night do you on one set of trial work.
>
> *Participant R42P*

> It has taught us some lessons and I think we've got a bit out of it in that respect. Oh just the change in chemicals, different groups of chemicals we use as opposed to just going out there and using just one all the time. But the theory about monitoring your crops to see when an aphid was there and then spraying is all good, but by the time the aphid's there the damage is done.
>
> *Participant R31P*

The adoption of simple innovations such as changing to an environmentally friendly spray can be viewed as single-loop learning (Argyris & Schon, 1978). This learning leads to skill or technology uptake and often only involves minor incremental improvements and changes to practice, in contrast to double-loop learning which promotes a deeper questioning of the values and assumptions that underlie practice (Argyris & Schon, 1978; Keen et al., 2005a; Wildemeersch, 2007). It is argued that learners must reach double-loop learning to bring about significant and importantly lasting change (Ison et al., 2007).

Interestingly though, minimal levels of partner engagement in the Potato Aphid project did appear to stimulate personal enquiry in those farmers whose land was used for trials. A farmer who had a large aphid suction trap on his property and who emptied the trap content each week and couriered this to Crop and Food Research for analysis, talked about how he aligned what he saw in the traps with his personal knowledge of farming in the area:

> It was good for me [to empty the suction trap] because I could have a rough idea what was in the little jar. We were first in the queue, we knew what was going on. It would make you aware that there was a potential problem. It just sort of jogged your memory that they [aphids] were out there. Not only that, I have a good mate who has an airplane and he used to do the aerial spraying and he could always tell me when there were aphid flights because his windscreen would be covered in aphids. It would just about coincide with what I was finding in that aphid trap
>
> *Participant R34P*

Although emptying the content from the trap can be viewed as passive engagement, the farmer's recollection of this activity showed that even with small levels of involvement he aligned his experience to the specific conditions in which he worked and in so doing added to his own tacit knowledge. However, as there was no collaborative learning space, this tacit knowledge was not able to contribute to and complement the more explicit knowledge that was being generated through the science experiments.

Section 6.2 showed that collaborative learning provides a space for knowledge sharing and also for aligning research to practice. Furthermore it showed when there are only limited opportunities for collaboration, misalignment between partners' priorities is likely to occur. In the negotiated space in the Wheat Calculator project, partner priorities were able to be aligned so farmers' knowledge could be included in the development of the project's technology. The Potato Aphid project however shows the effect on learning outcomes when partner misalignment is not resolved through collaboration, negotiation and dialogue. Farmers in the project were reluctant to use the yellow bowl traps as identification of aphids in field traps proved too difficult. A farmer explained:

> He [the scientist] couldn't identify them, he had to take them back to Christchurch and identify them, but he expected us to identify them.
>
> *Participant R35P*

This quote illustrates that misalignment of partners' priorities can act to erode partner relationships. Laboratory testing did little to reassure the same farmer:

> [the scientist] was talking about resistance and putting the aphids in a bloody gas chamber - that really didn't do a great deal for me.
>
> *Participant R35P*

The empirical evidence showed that organisational infrastructure, arrangements and routines need to be supportive of change. Without this, farmers are unwilling to take the risk to change. For example, the *Aphid Watch* website which was maintained by CFR was designed to provide aphid trap data. However, as data were uploaded slowly farmer confidence in its reliability was reduced. As a farmer explained:

> I think the data was good but it was historic data so it's a bit of a waste actually, we need to get real time data.
>
> *Participant 34P*

Farmers were unwilling to change their spraying practices based on potentially outdated information. A previous farmer explained:

> I'd put the [suction trap content] in the mail on Monday morning and Crop and Food may not get that till the Wednesday or maybe Tuesday if they were lucky. By the time they did their counts, it would be Thursday and then Friday before it went on the website - by the time it got put to the website it could have been five days and five days of aphids is five days too many.
>
> *Participant 34P*

Farmers were also concerned about the availability of data and support they could expect to receive after the project funding ceased. A potato farmer explained:

> They had data for three years, I would have liked to see it carry on for a bit longer and just see whether – were we in a three-year high aphid period or a low one. But suddenly it bang stopped and we had no more information come in.
>
> *Participant R39P*

The Potato Aphid project shows that farmers need to develop trust in the scientists, the data and the infrastructural and institutional support to implement a change of practice. As shown by the Crop Science for Māori project (Section 6.2.4), such trust is developed in collaborative learning spaces and relies upon strong partner relationships as much as it does on reliable and robust field data. To change existing practices and routines of calendar spraying in the seed potato sector, growers needed to deeply question an historical practice that saw them calendar spray as a crop insurance against potential disease. As a farmer described:

> We do a calendar spray programme because I just like to make sure that we are controlling the aphids with our chemicals.
>
> *Participant R39P*

For change to occur, farmers needed to discard a practice (calendar spraying) that was used to minimize risk. Seed potato farmers as sector most vulnerable to aphid-borne potato disease showed the strongest resistance to change, as the following quote illustrates:

> [Table and process growers] they won't use an insecticide unless the [aphid] numbers get above a certain threshold whereas from a seed perspective we couldn't allow that to happen.
>
> *Participant R31P*

Resistance was even further intensified in seed potato farmers whose livelihood depended solely on their potato crop. As a farmer explained:

> I said to [scientist's name], if we get [potato blight] virus will you pay the bill.
>
> *Participant R35P*

This farmer, while willing to consider change, required long-term data to make any lasting change. The short time frame of the Potato Aphid project therefore presented a significant barrier to this requirement.

> If we could show a fly pattern – consistent over 10 years - if we could go for 10 years with just those 2 peaks [in aphid numbers] you could do away with the insecticides perhaps in the middle.
>
> *Participant R35P*

The empirical evidence from this research shows that while adoption of a simple innovation (a new insecticide) was acceptable, changes to farming practices (spray routines) met stronger farmer resistance as this required consideration of the assumptions and attitudes that drove an established practice. Passive observation by farmers in projects will not change attitudes that drive practice. Interviews also suggested that 'simple' innovation uptake, which stimulates single-loop learning is, over time, readily discarded. A farmer explained:

> The project influenced me at the time to use CHESS [environmentally friendly insecticide] but that's too damn expensive now, so you go to the cheap ones but that kills everything. You don't know which way to turn because you don't want to kill everything but you want the control.
>
> *Participant 37P*

A research scientist also confirmed that the 'environmental' benefits gained from the Potato Aphid project were discarded in 2006 when the potato industry faced a significant new threat from the potato psyllid. This devastating crop disease is regarded by the potato industry as the "greatest threat" to the viability of New Zealand's potato industry (Potatoes New Zealand, Undated). Economic considerations eroded the small environmental learning that had taken place in the Potato Aphid project.

Without active collaborative learning spaces to enable learning and co-develop innovations, farmer learning is largely confined to single-loop learning that is focused on skill or 'simple' technology uptake. This uptake is more readily discarded, particularly when economic considerations markedly influence farming practices. The Potato Aphid project shows that single-loop learning will be unable to address the complexities of sustainability as gains made during a project's lifespan are not durable and more importantly, they are unlikely to challenge the underlying assumptions that drive current practice.

6.3.2 Learning in projects where collaborative learning spaces are fostered

Intense collaborative engagement exemplified in this research, whether this be farmer / farmer, farming group / farmer, scientist / farmer, scientist / farming group or a mixture of these, triggered consideration of the consequences of practice and changes that led to new ways of knowing and doing. Such learning is indicative of double-loop learning (Argyris & Schon, 1978). Comments from a farmer who had been actively engaged in the Wheat Calculator pilot trials displayed evidence of double-loop learning when he questioned the underlying effects of his farming practice:

> It's changed my thinking…having been around in the early stages of the project, I think about the consequences of certain actions.
>
> *Participant R71Wh*

The farmer claimed to have applied the learning he gained from the Wheat Calculator project to his whole farm management rather than just to the management of his wheat crops. In a similar way, a walnut grower described the gains from active engagement in the walnut project, when she stated:

> We have got smarter about what we're doing. The knowledge base just wasn't there to do that six years ago.
>
> *Participant R55Wa*

Likewise, a LandWISE farmer talking about soil health and the long-term effect of agricultural impacts on the farm said:

> We were talking about farmers growing their own soils and that is a foreign concept even to some scientists. But we were saying that we are out there depleting our soils, so we should be trying to rebuild. We can build our soil it just takes centuries to do it but we damage our soils in decades. For us we have to have this long-term focus. We need to be thinking about the next century.
>
> *Participant R05L*

Collaborative learning appeared to challenge current practice through a discursive process of knowledge sharing and co-production. A LandWISE farmer talked about how learning emerged in a collaborative space:

> Because we are using science and using research organizations, and our own skills, we are basically saying, you show me something better than this. We are doing absolute best practice and we are doing research to check it out… We won't always get our way, we won't always get what we would like, but at least if we are part of making the decisions, we will probably manage it ok.
>
> *Participant R04L*

Learning was typically described as a very active process of engagement. A walnut grower talked about the learning space in a very tangible way, as walking and talking:

> As we walk around someone's orchard - we're always learning things.
>
> *(SCC Interview with walnut growers)*

Collaborative projects stimulated learning opportunities that enabled participants to share, negotiate, discuss, question, interpret and reinterpret. These 'peer networks' (Henley, 1999), had an explicit learning focus. Collaborative learning created a collegial environment and when science input was included, this knowledge was seen to offer specialist, credible and reliable input to support and enhance farmers' local knowledge.

Active engagement also led to greater ownership and acceptance of any research failure. This was most noticeable in the walnut project with the unsuccessful transfer from the laboratory to the orchard of an environmentally benign bio-control for blight, as a replacement for copper-based sprays. A walnut grower explained:

> When there is collaboration between farmers and scientists there is this whole sort of let's share knowledge and an openness to learn from mistakes.
>
> *Participant R55Wa*

Failure was treated as a means to learn rather than an end in itself. While all farming groups in this research accepted that project research might end in failure, FAR, WIG and LandWISE openly talked about actively using failure as a learning tool in their projects. The LandWISE farming group manager explained:

> We have a policy of telling everyone our failings as well as our successes. We had some really resounding failures and we told everybody about them so the next person didn't go and have the same failure...if farmers are on a journey they don't mind failures, because it's just a thing on the way to a bigger goal.
>
> *Participant R01L*

Staying engaged also enabled growers to see complexity. As one of the walnut growers who was on the group's research committee stated about their bacteriophage work:

> I don't think that we really realised how cutting edge of science we were until we got into the project and then discovered that there were whole layers of complexity there that we didn't have the tools for…
>
> *Participant R55Wa*

While the Precision Agriculture projects had benefits for soil erosion in Hawkes Bay and the Wheat Calculator was driven by a need to address nitrate leaching in Canterbury, farmers' conversations indicated that their focus was typically at the paddock or farm scale in order to enhance the farming business. A LandWISE farmer illustrated this in the following quote:

> Most of the time there has to be either an instant return on an idea – and the instant return might relate to cash flow but often the return is related to a multitude of things – maybe ultimately you can farm with less labour, or better soils, or you can keep your grass for longer. It is a bit like that contouring work we are doing, there is no instant return on that but our nutrients are better, our soils are a lot better, our machinery will be looked after better, our yield should be more sustainable, our choice of crop type will grow, and there will be less work done on the land but potentially – it will increase our capital value – that is a security thing if you like – you have to add security to your business.
>
> *Participant R03L*

While the farmer's statement shows he sought and valued environmental benefits, environmental learning even with farmers who had a strong sustainability ethos was typically focused on land *inside* the farm gate. The absence of discussions about catchment impacts suggests impediments for addressing complex issues beyond the farm gate such as the effects of intensification on water quality in rivers. Klerkx & Jansen (2010) similarly acknowledge difficulties in obtaining grassroots farmer support for sustainability projects that address issues beyond the farm gate.

The empirical evidence shows that collaborative learning provides the conditions necessary for double-loop learning, although overt statements of this learning in farmers' conversations were rare in this research. Collaborative learning provides a space to support change. The challenge however lies in moving the focus of attention beyond the farm gate. In all projects in this research the scale of enquiry for both farmers and scientists alike was consistently the paddock or farm. Snapp and Heong (2003) suggest that when tackling complex problems, collaborative engagement needs to mesh together and reconcile differing scales of enquiry. Engaging in double-loop learning will challenge what Blackmore (2007: 517) describes as a "more of the same" approach to learning where the complexity of environmental problems is overlooked or underestimated.

6.2.3 Summary of learning outcomes in different learning spaces

Table 6.3 identifies from the empirical evidence presented in this research, the key learning outcomes when collaborative learning is impeded and when it is fostered in projects. The learning where collaboration is fostered, is more effective for learning that is likely to change assumptions of current practice and more likely to be durable. However, of concern for sustainability remains the continued scale of enquiry at the paddock level.

Table 6.3: Characteristics of learning spaces in projects that impede or foster collaborative learning

Learning Space	Learning Outcomes
Collaborative learning is impeded	More likely to be single-loop learning that is readily discarded as new situations arise, so learning is not durable and does not address underlying assumptions and values that drive current practice.
	Farmers reluctant to change historical or ingrained practices.
	Farmers are more likely to only adopt 'simple' innovations.
	Farmer may engage in personal enquiry but projects failure to capture this enquiry to inform wider project learning.
	Misalignment of partner priorities which remain unresolved and may erode partner relationships limit opportunity for co-production of knowledge.
	May result in farmer skepticism of science input and results.
	When failure of science experimental work occurs the project is seen to only have science learning outcomes.
	Farmers' concerns about risk and economic considerations are prevalent and limit opportunity for change.
	Economic considerations are likely to dominate decisions to adopt and erode environmental gains.
	Scientists' learning about farming practice is limited and may contribute to poor alignment of partner priorities. Understanding of wider structural and institutional support is needed for change to occur.
	Scale of learning: Crop, paddock, farm (largely *inside* the farm gate).
Collaborative learning is fostered	Triggered double-loop learning or the pre-conditions for double-loop learning that led to a consideration of the consequences of farming practice.
	Learning is iterative, emergent and adaptive.
	Learning is active.
	Science input reinforces, enhances and/or complements farmer knowledge.
	Actors learn from failure.
	Depending on knowledge base, farmers can engage with complexity.
	Environmental learning is articulated.
	Scale of learning: Crop, paddock, farm (largely *inside* the farm gate).

6.4 Knowledge sharing beyond the project

As collective action is deemed to be necessary for sustainability (Dale & Onyx, 2005; Pretty, 2003; Pretty & Ward, 2001; Robinson, 2004; World Commission on Environment and Development (WCED), 1987), there is considerable interest in how projects can stimulate collective action to advance sustainability (Cundill et al., 2014; Hubert et al., 2012; Keen et al., 2005b; Muro & Jeffrey, 2008). Findings from this chapter have focused thus far on the learning by individuals who were actively engaged in projects or who provided land for scientists to undertake trials. This focus says little about the effect projects have on the wider communities of practice, or if social learning takes place. Reed et al. (2010) argue that this process takes place when the change that occurs in individuals is transferred to the wider communities of practice through a process of social interaction. Using Reed's notion of social learning, this section explores how effectively projects engaged with their wider communities of practice to effect change.

6.4.1 Social learning in a 'traditional' linear extension approach

Traditional extension typically centres on technology diffusion (extension) occurring after technology development by scientists. Farmers interviewed in this research generally said that this approach occurred when project results were dispersed via a scientific seminar at a research organization followed by a small field excursion. A research scientist generically described such sessions as "Death by PowerPoint" as scientists delivered their scientific results in a PowerPoint presentation with minimal opportunity for farmer discussion. Farmers and scientists similarly commented that research scientists at these events often had difficulty communicating in a way that was accessible to non-scientific audiences as information was typically scientifically dense.

In the science-initiated potato and squash projects 'technology transfer' was scheduled for the final year of the project once the research results were known. Two potato farmers expressed considerable frustration that project findings were repeatedly discussed at many events, when they stated:

> Well that project has been spoken to groups over the last four or five years I suppose and I've heard it on numerous occasions and it just puts you to sleep.
>
> *Participant R31P*

> I don't know how many times it's been presented at different things.
>
> *Participant R35P*

A seed potato merchant judged the success of such extension events based on the number of farmers who remained after the morning tea break, and claimed poorly delivered events had a flow on effect to farmers' attendance at future events. Adherence to a linear approach to extension limited opportunities for discussion and farming respondents said that participants often reverted to 'type' with only known farming industry spokespeople and the science presenters engaging in conversation at formal seminars. Traditional extension where scientists talked about their research results therefore reinforced farming / science stereotypes.

Farming sector cultures also contributed to difficulties in knowledge sharing at extension events. For example respondents claimed the potato sector's culture of secrecy and intense competitiveness contributed to their unwillingness to speak at events (Section 4.2.2). In this sector it was difficult to engender collaboration and knowledge sharing in groups. As an agronomist explained:

> Quite often in a group situation I wouldn't expect any feedback. Then you'd have a discussion later [one on one] rather than in front of everyone.
>
> *Participant R32P*

However there was recognition that the industry needed to address this culture. The previous agronomist and a farming group spokesperson both recognised the need for improved collaboration:

> If they all listen to each other they would learn a lot and challenge their own thinking.
>
> *Participant R32P*

> I talk about things like why is it the dairy industry has farm discussion groups - because they are not competing with one another – they are all selling to the same supplier. It is in everybody's interest to do things better.
>
> *Participant R40P*

Traditional extension approaches followed the transmission approach to communication (Leeuwis, 2004) with the scientist as the reservoir and sender of knowledge and the farmers as passive receivers and adopters of this knowledge. In this approach the emphasis was on educating farmers to improve their awareness, understanding or uptake. Such approaches are argued to rely on an implicit and naive belief that education will bring about support for technologies (Pretty, 1995). Empirical evidence from the literature recognises that information through education events does not necessarily trigger a change in attitude leading to a change in behaviour. For example, a study investigating nurserymen's adoption of crop production practices to improve health and safety outcomes found no correlation between the increased awareness of health and safety practices and the rate of adoption of those practices (Chapman, Newenhouse, & Karsh, 2010).

Projects where there is a focus on the outputs of the research rather than the learning process are presented with a dilemma if the project produces inconclusive results, as occurred in the squash project. Extension usually does not take place, as the project is perceived to have nothing to transfer to farmers. A squash farmer representative explained:

> We couldn't get a very clear picture and it was a waste of time trying to develop a tool that was going to be too variable. [*Packhouse operator's name*] didn't change much about what we did out of the trial. We couldn't really do anything.
>
> *Participant R49S*

Although the squash industry understood that science trials may not be able to provide definitive results, their justification for being involved in the project was reliant on the development of the predictor tool. The project's inability to deliver a tool contributed to the industry's increasing reluctance to engage in future science research. A scientist explained:

> I tried to get things going with them again afterwards because I am quite interested in the plant, but that's when they said they were not investing any more money in R and D and were only focusing on marketing.
>
> *Participant R48S*

6.4.2. Social learning in a collaborative 'feedback' approach

In stark contrast to the potato and squash projects, research-focused farming groups in the Precision Agriculture, Walnut Blight and Wheat Calculator projects embedded 'extension' into the project design from the outset. Activities designed to engage with each farming group's community of practice were not viewed as a linear one-way approach and were not restricted to the final year of a project as they were in the science-initiated projects. Feedback loops between the project and the communities of practice were embedded in the project design. This 'feedback' approach to research and extension was ingrained in the culture of LandWISE, WIG and FAR. The LandWISE manager stated that he refused to work in projects where science institutes only scheduled extension in the final year, since he claimed this prevented valuable feedback between the project and its end users and indicated both a poor understanding of extension and a lack of commitment to project end users.

Farming groups in collaborative projects acted as facilitators by linking their communities of practice to the projects. They ensured a two-way flow of information between project participants and their wider farming community. These facilitators stimulated conversations among the wider farming group membership not directly involved in the projects and played a key mentoring role to facilitate social learning.

'Champion' farmers were visible in the Precision Agriculture, Walnut and Wheat Calculator projects. Such farmers were reported to be innovative, confident, articulate, and eager to experiment and learn. In addition they understood trial failure and most importantly were willing to share and let others see what they were doing. A farmer who played a pivotal role in championing the Wheat Calculator stated, "[We are] prepared to be on display" (Participant R71Wh).

Project champions had a strong sense of community and an internal sense of responsibility, which made them willing to mentor others and be advocates for sustainable farming. A LandWISE farmer even transported his modified Precision

Agriculture harvester from the North Island to the South Island to allow a farmer to trial the technology. When strip tillage was a novel approach to farming in New Zealand, this same farmer strip tilled his most publicly visible paddock to stimulate conversations amongst the farming community in his local area. Such farmers acted as both mentors and conduits for feedback to and from their farming communities of practice. As a LandWISE board member explained,

> LandWISE has to be seen as the breeding ground of the innovation, after that others have to go out and do it for themselves. But LandWISE certainly has a role to show what is the best way of doing it. The reason why LandWISE has been semi-successful is because we have pricked people's interest, because it doesn't happen if you are going to get people top down telling you that you need this. It has to be ground driven.
>
> *Participant R04L*

While formal peer group mentoring has been shown to contribute to stimulating innovative approaches to farming (Davidson-Hunt, 2006) the informal mentoring that occurred in the Precision Agriculture and the Walnut Blight projects played a critical role in taking learning out to their wider farming members. In the Precision Agriculture projects, lead LandWISE farmers actively contributed to championing knowledge about soil management by informally mentoring other farmers.

The importance of engaging the wider farming community in a project was also evident in the Wheat Calculator project where farmer feedback was vital for enabling changes to be made to the calculator's interface. It is estimated that by the end of the project in 2005 around 60% of wheat farmers were using the calculator to reduce nitrogen leaching (FRST, undated). While the FAR manager stated that the calculator's use had declined over time, he contended that the underlying environmental knowledge farmers gained from using the calculator as a decision support tool, and from the 'extension' undertaken by FAR became embodied in the wheat sector's farming practice.

> Current usage of the model is low, but we know that 80% of people going into wheat have changed their fertiliser practices as a result of the information that was contained in the model.
>
> *Participant R75Wh*

Interviews with wheat farmers inside and outside the project supported the claim that sector learning about nitrogen application and water management had driven wider change in farming practice. Farmers who were familiar with using the calculator reported that the tool had supported their on-farm decision-making and had assisted them in changing their nitrogen management. While software issues contributed to a decline in use of the calculator, the interviews showed that farmers who had used the calculator would always describe it as a tool that complemented rather than replaced their tacit knowledge. As the calculator supported and strengthened their decision-making, farmers' confidence increased and their reliance on the tool dissipated. The learning became learned. The Wheat Calculator project bought about a change in the individuals involved in the project, and that change filtered out into the wider community of practice through FAR's extension activities.

Although FAR had not actively engaged farm representatives in the Wheat Calculator project, they came to realize the importance of including these rural professionals when developing their later MaizeN calculator. As a FAR representative explained:

> Don't forget that every one of those reps is going to go and talk to farmers about what they have just seen. So their role is very critical in terms of getting them on board and getting them to understand the background behind it and accept that it might be something useful.
>
> *Participant R67Wh*

LandWISE was very proactive at developing relationships with actors from the value chains. However, LandWISE farmers recognised that innovative approaches to farming practice such as was offered by Precision Agriculture could upset the social dynamics of rural communities. As a LandWISE farmer explained:

> The owners of the land are very keen to see a new idea but the managers are very friendly with the contractors and the managers have got grips on the contracts – and the contracting outfits, the more tractors they have got going and the more hours they are doing and the busier they are, the more reason for their existence. Suddenly if you don't need a team of contractors and a team of staff, you don't actually need a manager and suddenly there is a whole social dynamic there that you have to be aware of.
>
> *Participant R04L*

The LandWISE annual conferences provided a platform for project learning to extend beyond those actively engaged in the project. Members and non-member farmers, industry representatives, regulatory and funding body personnel and national and international Precision Agriculture scientists engaged at the conference in a discursive space. Conference sessions, chaired by LandWISE farmers, contained short talks by presenters from science, industry, regulatory bodies and farming. The LandWISE manager explained that speakers were carefully selected based on their reputation for being able to connect with farmers and be relevant to their farming practice and business. As the LandWISE manager explained:

> It is a culture that we have got within LandWISE that has evolved and speakers now expect that if they are coming to give a talk at LandWISE that they better adapt their talk.
>
> *Participant R01L*

Farmer to farmer knowledge sharing at these events was viewed as mutually beneficial, as one farmer explained, “We are not in my view a threat to each other, we are usually an enhancement to each other” (Participant R03L). LandWISE’s annual conference, workshops and local field excursions enabled a two-way flow of information between their members and those running project field trials. These opportunities provided a discursive environment where actors could share stories and in so doing they created a space for change and knowledge co-production. At a participant observation of a LandWISE field-day, farmers collaboratively engaged in conversations with scientists and rural professionals about how to maintain soil quality. To LandWISE farmers, sustainable farming meant ‘Smart Farming’.

‘Learning by doing’ (Allen et al., 2001) was a prominent feature of a feedback approach. This was particularly evident in the Walnut Blight project’s orchard benchmarking work where WIG’s research committee engaged with wider sector members. As a grower described:

> They had access to this [orchard] to gather their information. They would come out and do the blight count. When the group came here it was just the science committee and they each had a role, counting the blight… there is always the ability for anybody to join the sub-committees, they are not closed …we have a journal called *Health in a Shell* and all the science is then dispersed through that plus we have field trips and seminars and it is all up on the website - and everyone is invited and out they come…
>
> *Participant R54Wa*

Furthermore WIG published a *Walnut Growers'* Manual that contained the results from their trials. As this resource was available for a small cost on their website, walnut growers could benefit from the group's collective learning. LandWISE's *A Guide to Smart Farming* (Bloomer & Powrie, 2011) also captured the learning from their research and was made accessible to a wide non-science audience through the group's website.

Farming groups that were actively engaged in projects ensured those projects remained relevant to farming practice. They embedded "extension" into the project from the outset, which ensured strong feedback loops between their communities and project actors, and they sustained project learning beyond the funded period of the project. As a result, these groups assisted in transferring the change experienced by the individuals actively engaged in the project out to the wider communities of practice.

While FAR, LandWISE and WIG took an active role in facilitating social learning, ECOP had neither the capability nor capacity to engage communities on the East Cape and scientists had to fill this role. However scientists found that they had to work within cultural frameworks that shaped routines and arrangements in Māori communities on the East Cape. This made it difficult to foster social learning. While kaumatua [Māori elders] were identified by scientists as key community members, cultural protocols restricted their sphere of influence to a specific community. As a lead scientist explained:

> You have to engage with the strong community leaders, that is the way to do it and that is the way I am doing it… but even local kaumatua … only have knowledge for that region. Even across the river they may say, *No. No. I can only tell you about the way we do it here*. I never realised there is no one set of traditional knowledge, it is very different everywhere.
>
> *Participant R13M*

The science team needed to understand and work within local and cultural hierarchies, as ignoring or overlooking cultural protocols could jeopardise relationship-building. Cultural norms also inhibited individual growers from wishing to be seen as role models and acting as community mentors. Growers expressed reluctance to be seen as champions for fear that they may be labeled a "favourite" by community members. As one grower explained:

> We don't focus on one person. We would rather focus on the group.
>
> *Participant R11M*

The scientists became aware of grower concerns over receiving too much of CFR's attention, as a scientist explained:

> It was said to us that the community felt like fish in a gold fish bowl. [Grower's name] definitely felt like that – that is why we left him alone in the last year or two - we could see that he was uncomfortable. He made that quite clear.
>
> *Participant R20M*

While scientists showcased the project through two large food festivals to increase the profile of the organic community on the East Cape, efforts on the East Cape were largely targeted at individual growers as the lead scientist explained:

> You are talking to a lot of individuals, not communities, but individuals in communities because that is the only way it works.
>
> *Participant R13M*

The need for scientists to focus on individuals in the Crop Science for Māori project and the growers' reluctance to act as role models impeded opportunities for social learning. Unlike FAR, LandWISE and WIG, ECOP was unable to act as a unifying voice among the organic growers on the East Cape. This limited the capacity for ECOP's to play a critical role in sustaining project learning.

6.4.3 Summary of a feedback approach to extension

Table 6.4 presents the dynamics of a feedback approach to knowledge sharing. These tactics ensure a two-way flow of exchange between communities of practice and active project actors to ensure that project learning goes beyond the individuals actively engaged in project research, and filters out to the communities of practice. It also ensures a flow of information into the project to ensure an alignment of priorities and to address areas of concern as projects are in operation.

Table 6.4: Dynamics of a 'feedback approach' to knowledge sharing

Dynamics/Tactics	Empirical support from this research
Farming groups take a very active and proactive role in connecting the project to their Community of Practice (CoP)	All farming groups except ECOP actively engaged with their wider CoP. The potato and squash groups preferred a more traditional technology transfer model, with significant knowledge transfer occurring only in the final year of a project when the group had "information" to transfer. With the squash project not developing a predictor tool that could be used in the field, farming interviewees stated there was nothing to transfer to the farming sector, although it was suggested that one farming participant may have undertaken his own research into Squash Rot after the project ceased. WIG, FAR and LandWISE actively engaged with their members throughout the project to enable them to stay connected with the project and provide input.
Strong feedback loops established early between project team & the CoP	This was an integral feature of all research-focused groups. LandWISE, WIG and FAR groups actively engaged with their CoP throughout the life span of their projects. Projects were seen as learning projects.
Facilitators (boundary crossers) are used in projects to link farming and science sectors	Research-focused farming groups (FAR, WIG and LandWISE) assume this role. In the Wheat Calculator project a field technician was required to develop strong understanding of farming practice and crop knowledge to feed this knowledge back to the science team to assist with the technology's development. The technician also provided one to one support for farmers wanting to use the technology. The Crop Science for Māori project used a 'boundary crosser' to introduce the science team to the community. This person was a respected community kaumatua.
Projects extensively use project champions and farming mentors	LandWISE, FAR and WIG actively engage lead farmers who mentor other farmers and act as project champions. As the project matures, scientists sometimes assume the role as champions (as they did in the Wheat Calculator and Crop Science for Māori projects). Scientists who take on this role must be effective communicators. Key LandWISE farmers acted as champions by showcasing their work in the group's Smart Farming manual and presented their trial results at the LandWISE annual conference.
Informal networking is encouraged	LandWISE farmers assisted other farmers to trial Precision Agriculture before investing in expensive equipment. LandWISE Board meetings offered opportunities to informally discuss issues. LandWISE engaged farmers in farmer-led field discussions. FAR's farmers valued the opportunities they had to informally engage with FAR and other FAR members. In the Crop Science for Māori project, participants preferred the field walkabouts, where they could talk through their issues. Scientists participated in a number of hui and marae visits, which included sharing food, stories and songs. Scientists and the growers also walked to the top of Mt Hikurangi (a central feature in the East Cape's landscape and a guiding force that had considerable cultural significance to the growers.

Dynamics/Tactics	Empirical support from this research
Projects involve actors from the wider value chain	In the Crop Science for Māori project the team interacted with an organic wholesaler and chefs. LandWISE conferences interact extensively with industry players engaged with precision tools – while they are commercial companies they must present non-commercially focused presentations. Company representatives were engaged (although rather belatedly) in the Wheat Calculator project since they have a critical influencing role in farm management. The Potato Aphid project was managed by an actor from a potato processing company and played a significant role in connecting the project with process and table potato growers. The Squash Rot project was managed by an actor from a large fertiliser company and was pivotal in connecting the project with the major squash players.
Projects use multi-channel approaches to knowledge sharing	LandWISE, FAR, WIG use field days /conferences / workshops to engage farmers in field discussions and trial experience. Crop Science for Māori showcased organic food production on the East Cape through two large organic food festivals and at a New Zealand Geography Association's Annual Conference. Precision Agriculture and Wheat Calculator projects did farm demonstrations and ran farm trials. The Wheat Calculator project used one to one mentoring to enable the farmer gain experience with the calculator under guidance. This direct use of the technology allowed farmers to experience the technology, and to visualise it as a decision support tool rather than a knowledge replacement tool. The knowledge about fertiliser and irrigation then slowly filtered to wider CoP and bought about practice changes in the wider sector. In LandWISE local farmers acted as mentors to assist farmers with change. Web based communication was an integral part of LandWISE's and FAR's communication. Project publications: WIG's grower's manual presented in one document the collective knowledge of the industry that farmers gained through their trials; LandWISE's Smart Farming manual is a collaborative effort between all project participants; Project updates were regularly seen in the FAR newsletter and the Potatoes NZ newsletter. Media stories (Crop Science for Māori; Precision Agriculture, Walnut Blight) directed at farming publications and news media. Science publications for Science to Science CoP – publications occurred in Walnut Blight; Crop Science for Māori; Potatoes projects.

6.5 Summary

This chapter reveals a complex picture of learning in participatory research projects that seek to advance sustainability. The analysis shows that knowledge production needs to be driven by an iterative and collaborative process that is itself informed by effective feedback loops with the communities of practice.

This research shows farmers' engagement or isolation from the research had a direct effect on their ability to learn and their subsequent willingness to adopt new ideas. Where changes to practices were sought as an outcome, farmers needed to actively engage, preferably in a 'learning by doing' process. This engagement occurred most effectively in informal peer networks where participants collaboratively gathered data and engaged in discussions in a collaborative and discursive space for learning. Minimal farmer engagement in project research results in poor learning and limited uptake of project outcomes. The analysis revealed that learning quality and durability were affected by the level of collaboration that occurred during projects.

Where scientists and farmers or farming networks and/or sometimes other stakeholders collaborated in a learning space, and where farmers took a very active role in knowledge production, learning was iterative, emergent and adaptive. While scientists sometimes played a smaller role in the research (LandWISE), each partner's knowledge was valued for what it could bring to the project. Partners negotiated, shared and engaged in a learning space. When there was minimal or more formalized collaboration through steering committees (squash and potatoes), and the farming partner took a passive role, learning was limited and was not durable. In projects that encountered tensions from a misalignment of partners' priorities, as occurred in the Wheat Calculator and to a smaller degree in the Crop Science for Māori project, it was necessary to carefully negotiate a way through tensions through careful facilitation and / or flexibility in programme implementation to allow time for trust to develop between partners. This could only be achieved by working collaboratively in a discursive space that allowed for the necessary negotiation.

Involving the wider communities of practice required strong feedback loops to be built into projects from the beginning. FAR, LandWISE and WIG's active engagement in their project's design and knowledge production ensured the projects were connected with their communities of practice from the outset. Strong feedback loops were maintained by the farming groups not only throughout the lifespan of the project, but also beyond the project. Importantly, this helped to ensure project learning was maintained during the project and sustained beyond the project's funded period.

Participatory research projects need to involve close interaction between farmers, scientists and other relevant stakeholders from the very outset of the project. This ensures a wide base of expertise to promote both a deeper understanding of the problem and possible solutions and also a deeper understanding between partners which results in a trusting relationship. This research shows this is best achieved in a collaborative learning space where focus is not just on creating the learning space but more importantly it depends on the type of learning that is undertaken within that space.

The complexities of sustainability will necessarily require a questioning of the assumptions and values that drive current practice. Learning that goes beyond simple skill uptake is required (Keen, Dyball & Brown, 2005). However, a predominant focus of learning at the paddock or farm scale is unlikely to address the complexities of environmental issues and will likely miss the opportunity for learning for instance about catchment scale complexities or learning to build resilience to cope with uncertainty. Environmental benefits at multiple scales need to be an explicit and stated outcome of the learning process, and be built into the project from its establishment rather than being a fortunate by-product. These issues are explored further in the final two chapters of this thesis.

CHAPTER SEVEN

7.0 Discussion

7.1 Introduction

This chapter synthesises the discussions from the three previous chapters that contained the empirical evidence from the six case studies investigated in this thesis. While the thesis to date has discussed institutions, partnerships, and learning as discrete subjects, in this chapter these dynamics are integrated, as the empirical evidence from the research reveals that formal and informal institutions, partnerships and relationships, knowledge integration and learning are critical and highly inter-related dynamics of participatory research projects and can act to enable or disable innovations that seek to advance sustainability.

The chapter begins by presenting a conceptual model to integrate the previous chapters' discussions about institution, partnership and learning. This model illustrates how project actors and the formal and informal institutions that influence their engagement in participatory research, create both partnerships and relationships that shape a *collaborative learning space*. The model is then applied to the investigated projects to see how each created a collaborative learning space. Understanding the context that shapes collaborative learning allows understanding of not only what works and where but also why it works. Building on this, and using the thesis' empirical evidence, the chapter explores the collaborative learning space in depth, to investigate how this space may be maximised and how the learning within the space is both realised and optimised to advance sustainability.

7.2 Conceptualising a learning space for innovation: The PROCLE model

The PROCLE model (Figure 7.1) has been developed from attributes observed in the six projects investigated in this thesis as presented in Chapters 4, 5, and 6. It conceptualises a collaborative learning space (shown in green) that emerges from the partnership formed between farming and science actors and their institutions.

The model shows project partnerships in applied participatory research projects to be a dynamic union of three major partners from the farming, science and funding sectors, and the formal and informal institutions that shape each partner's engagement within the bounds of the project partnership. The model focuses on institutions, partnerships and relationships, knowledge integration and learning. Although this thesis does not focus on the wider political, social, cultural or economic contexts that shape projects, the model acknowledges and conceptualises these as influencing factors by the surrounding lightly shaded dotted square in which the institutions (farming, science, funding and the project partnership) sit (Figure 7.1). For example the model acknowledges that policy/funding, science and farming institutions as actual or possible influencers of the collaborative learning space are themselves influenced by wider political, social, cultural and economic environments.

Figure 7.1 presents an ideal state, with the collaborative learning space occurring where the farming and science partners overlap within the bounds of the contractual partnership for the project. Underlying the model however is the recognition that the collaborative learning space is an emergent property of the partnership and rarely will be in a constant 'ideal' state, but rather will ebb and flow as partners engage, or do not engage, for collaboration and learning. Of key importance however is what the model illustrates in participatory partnerships about the inter-relatedness of partner relationships, institutions and learning.

The key attributes of the PROCLE model are:

Project Actors (Ellipsoids A, B and C): The major project actors from farming, science and funding are represented in the model. Although farming and science actors enter projects as partners, as Chapter 4 highlighted these actors are situated within institutional contexts that influence how actors conduct themselves in projects. The respective institutions are illustrated as variably sized areas to illustrate their relative size (A, B, C). However, size is not a quantitative measure of physical size, but rather a qualitative representation of relative institutional capacity and capability to engage in participatory research.

Institutions in the model are not simply structural organisations, but as discussed in chapter 1 (Section 1.2.2), a wider interpretation of institution is preferred, that incorporates both formal and informal institutions (Pfahl, 2005). Their conceptualisation in the model is a representation of the institutional capacity to engage in communication and self-organisation to bring about significant change that is recognised as being critical for innovation (Leeuwis & Aarts, 2011). The conceptual model suggests by the position of the institutions that funding availability is a primary driver of innovation at the micro-level as it is situated above the other project partners. However, as will be seen in Section 7.2, the orientation of these institutions can change to reflect their relative influence as a driver of innovation in each project.

Project Partnership (Rectangle – D): Once the project has been established the bounds of the project are agreed between the partners, which essentially lock the contractual partnership into place. The project partnership space is a union between the main project partners (farming and science) and the funding body and is an area wholly within the partners but not necessarily wholly within their area of institutional overlap, as partners may have relationships with each other outside the project and the project may extend beyond the area of the partners' overlap.

P articipatory
R esearch
O ptimal
C ollaborative
L earning
E nvironment

KEY

Institutions - formal & informal

A Funder
B Farming Partner
C Science Partner
D Contractual Project Partnership

Relationships

1 Farming / Science extra partnership relationship
2 Farming / Funder extra partnership relationship
3 Science / Funder extra partnership relationship
4 Farming relationships with farming community of practice exclusive of science
5 Science exclusive of farmers
6 Farming relationship with Funder
7 Science relationship with Funder
8 Realised project relationship = 4 + 5 + 6 + 7 + XI + XII
9 Unfulfilled project relationship

Learning

X Collaborative learning space (intersection B, C, 8) or (XI + XII)
XI Realised collaborative learning
XII Unfulfilled collaborative learning space

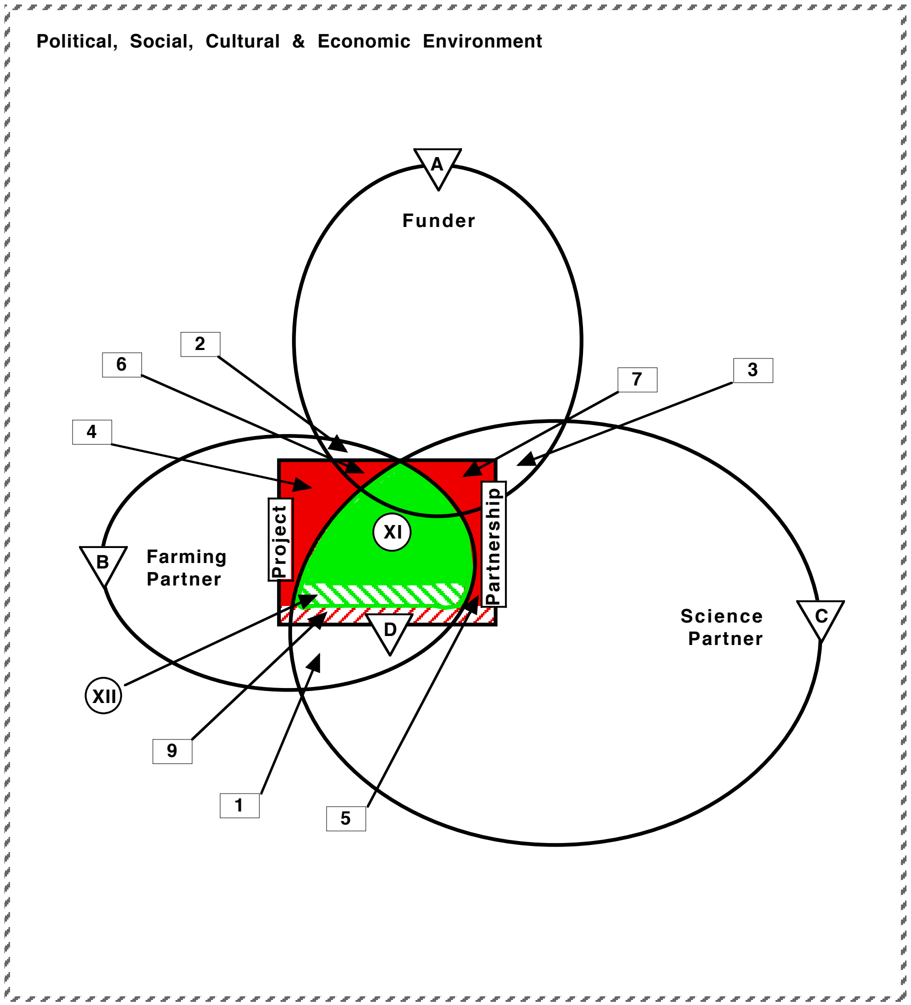


Figure 7.1: The PROCLE model: Participatory Research Optimal Collaborative Learning Emergence

Partnership Relationship (red zone): Project relationships between actors occur within the contractual project partnership area. A project's relationship results from a combination of relationships between different actors as represented by areas 4, 5, 6, and 7 plus the area underlying XI and XII. The combined area of these relationships that lie within the bounds of the project partnership, is the project relationship space, shown in red. Ideally, project relationships will flourish and will fill the contractual project partnership space. However, the model recognises that this is not always the case and project relationships may for various reasons, typically arising from unresolved relationship difficulties, not fill the project partnership space. This unfulfilled project relationship space is shown as a hatched area of red. The hatched red space is derived from an assessment of partnership attributes (see Appendix 2) that largely determine the extent to which participants' expectations are realised in projects. The assessment of partnership attributes is based on the empirical evidence presented in Chapter 5 of the thesis.

Collaborative Learning Space (green zone): The key space that the model generates is the collaborative learning space shown in green. This occurs at the intersection of where farming and science partners overlap within the extent of the project relationship (not the contractual project partnership). The research funder may extend into the collaborative learning space but their inclusion is not a requirement for the generation of this space as they may not have an operational role within the project. The collaborative learning space is the potential space for collaborative learning. The size of the space refers to its capacity for learning and not a numerical indication of the size, such as for example the number of people engaged in it. The solid green area refers to collaborative learning that is fully realised in the project, while the hatched green area refers to uncompleted or unresolved learning where for example the partners were unable, for various reasons, to realise agreed aspects of their project objectives or learn from unintended outcomes such as from any 'failure' of the science outcomes.

The hatched green space is derived from an assessment of learning attributes (see Appendix 2) which determine the extent to which participants engaged in a transdisciplinary reflexive partnership where they collaboratively co-developed innovations. Transdisciplinary partnerships are recognised to provide an enabling environment for collaborative and deliberative learning processes (Polk, 2014; Popa et al., 2015) that are deemed necessary for stimulating the co-production of innovations in agriculture (Klerkx, 2015). The assessment of the learning attributes is based on the empirical evidence presented in Chapter 6 of the thesis.

<u>Political / Social / Cultural / Economic Environment</u>: The model recognises the wider macro environment in which projects exist, and which influences project institutions as outlined in Chapters 1 and 4. This environment, while recognised as shaping formal and informal institutions at the micro-level, has not been a primary focus of the thesis' investigation and is indicated by the use of a dashed outline around its boundary to acknowledge its existence.

Within the model a number of specific sub-spaces are identified to illustrate the range and complexity of relationships present. These emerge from project relationships that result from the overlap of the institutions, both with each other and with the contractual project partnership space. These include relationships that are both within and outside the bounds of the project partnership and are as follows:

- The farming group / farmers may maintain an extra partnership relationship with scientists (1);
- The farming group / farmers may maintain an extra partnership relationship with funders (2);
- The scientists may maintain an extra partnership relationship with funders (3);
- The farmers within the project maintain a relationship with their Community of Practice (CoP) independently of the scientists e.g through field days (4);
- The scientists within the project maintain a relationship with their CoP independently of the farmers e.g peer reviewed publications (5);
- The farming group within the project maintain a project relationship with research funders (6);
- The scientists within the project maintain a project relationship with research funders (7).

The ideal PROCLE diagram set out in Figure 7.1 has been applied in Section 7.3 to each of the individual participatory research projects investigated in this research. These project-focused PROCLE diagrams have been qualitatively compiled from the empirical information collected in the data corpus for each project. The evidence for each visualisation is supported by Appendix 2, which is based on the empirical evidence presented in Chapters 4, 5 and 6.

Key features of each diagram are also individually discussed under a range of headings before comparisons are made across the combined projects. Each PROCLE diagram is discussed under seven headings, which together, consider all the features of the ideal model as follows:

Project PROCLE Diagrams	Ideal PROCLE Diagram Spaces
Partners	B, C
Project Partnership	D
Project Relationship	8, 9
Farming CoP Relationship	4
Science CoP Relationship	5
Funder Relationships	1, 2, 3
Extra-Partnership Relationships	A, 6, 7

Some project PROCLE diagrams have been drawn to include elements not included in the ideal model. These include:

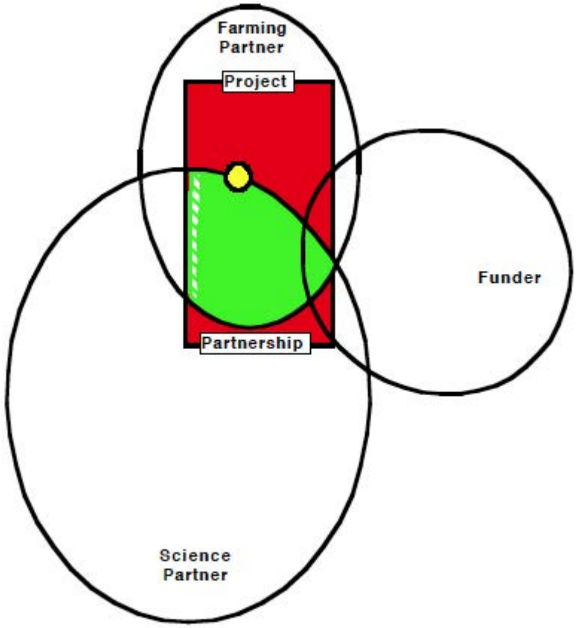
- farming parent groups in the Potato Aphid and Squash Rot projects where the project farming group was a subsidiary of a larger farming industry organisation, in both cases, Horticulture NZ (HortNZ);
- independent consultants employed by project partners in the Walnut Blight, Potato Aphid and Squash Rot projects who played significant roles in these projects.

7.3 Applying the PROCLE model to real world projects

Using the PROCLE model an analysis of the six participatory research projects investigated in this research illustrates the effect that project relationships and institutions have on a project's collaborative learning space. A PROCLE diagram is presented for each project in a series of tables, (Tables 7.1 – 7.6) with the key attributes that have determined the representation of the model for each project listed beside each diagram.

Below each table is a brief analysis of the effect that institutions and actor relationships had on the development of the project's collaborative learning space. The orientation of the diagrams sometimes differs from the ideal model, with the driving partner being positioned at the top of the diagram to reflect the influence they had on shaping the project and to visually demonstrate their relativity to the other partners involved in the project.

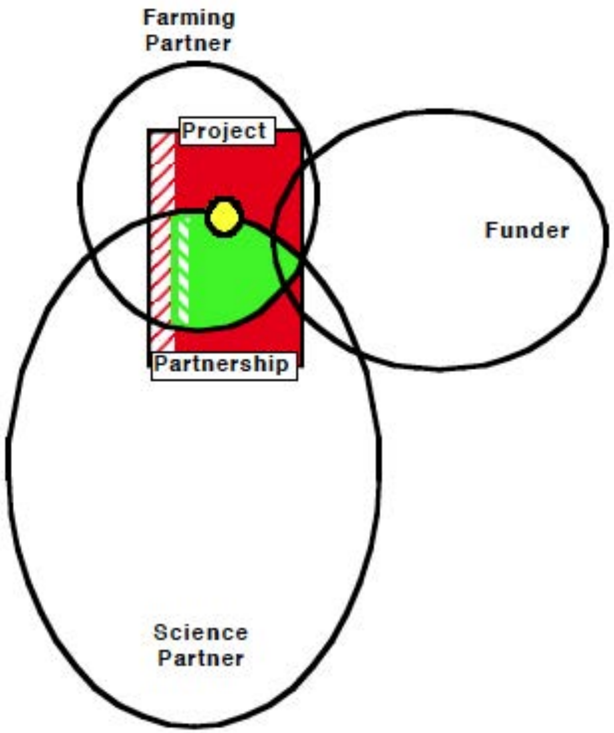
Table 7.1: Precision Agriculture projects – LandWISE and Crop and Food Research

<table>
<tr><td rowspan="7">Farming group-initiated Partnership

</td><td>Partners: The science partners who LandWISE engaged with, belong to large institutional structures that have significant research capability. However, LandWISE's own 'research' confidence, trial experience and their understanding of science as a development tool (4.4.2) reduced the size difference between the partners.</td></tr>
<tr><td>Project Partnership: The project partnership space occupied a large portion of the farming partner area because projects dominated LandWISE's work and provided significant funding (4.4.2). As a farming group-initiated project, LandWISE oversaw their projects (5.2.1), which pulled a large portion of the project partnership into their space. Scientists undertook little independent work in the project, but willingly participated in farmer-led projects and shared insights from their own research with LandWISE members at workshops, field events, in LandWISE publications and at LandWISE's annual conference (6.2.3; 6.4.2).</td></tr>
<tr><td>Project Relationship: Projects were initiated by LandWISE (5.2.1), and their overall management of the project re-orientates the model (cf. the ideal model 7.1). LandWISE engagement with scientists was productive and positive (5.2.1).</td></tr>
<tr><td>Farming CoP Relationship: Projects allowed LandWISE to engage with their CoP (6.4.2). LandWISE undertook numerous field trials independent of the scientists outside of the collaborative learning space (6.2.3), as indicated by the red area contained within their area but outside the green collaborative space.</td></tr>
<tr><td>Science CoP Relationship: These projects had a primary 'applied' farming focus. Scientists engaged with a variety of other scientists within the project space, but the work created few opportunities beyond the projects (6.2.3).</td></tr>
<tr><td>Funder Relationships: LandWISE maintained strong connections with funders, on who they depended. Funding & policy agencies actively participated in the LandWISE conference (6.4.2).</td></tr>
<tr><td>Extra-Partnership Relationships: LandWISE and the science partners maintained positive relationships outside the projects and a science representative sat on the LandWISE board (4.4.2). LandWISE maintained connections with industry players who are invited to enter the collaborative learning space (indicated by the yellow circle) (6.4.2).</td></tr>
</table>

Effect on the Collaborative Learning Space

The positive working relationship LandWISE had with scientists both inside and outside the project, and their understanding of science as a development tool, enabled the collaborative learning space to occupy a relatively large portion of the project partnership. LandWISE also brought in actors (industry, policy and funding) from the wider value chain (indicated by the yellow circle). The inclusion of these players in the collaborative learning space created weak ties with key chain actors and supporters, which is recognised as essential for stimulating innovation (Chwue, 2000; KIT and IIRR; 2010; Klerkx et al., 2012).

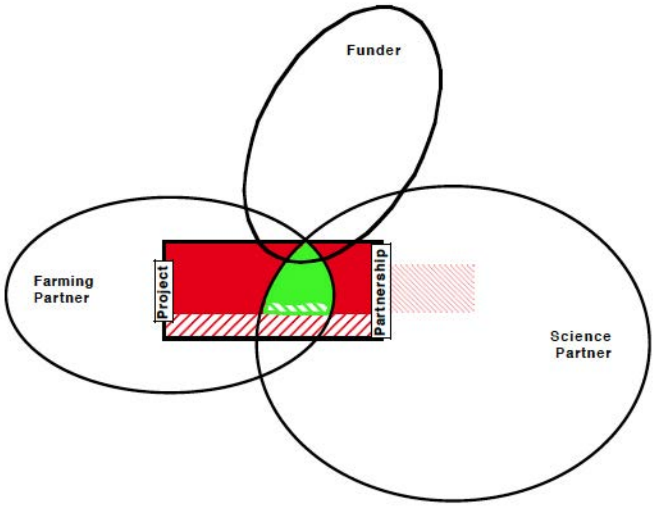
Table 7.2: Walnut Blight project – Walnut Industry Group (WIG), HortResearch and an independent scientist

Farming group-initiated Partnership 	**Partners**: Although the science partners who WIG engaged with were large, WIG's 'research' capability and capacity and their understanding of science as a development tool reduced the size difference between these 'institutions' (4.4.2).
	Project Partnership: Projects were a dominant part of WIG's work and provided a significant portion of their funds. As a farming group-initiated project, WIG oversaw the project (5.2.1) – which pulled a large portion of the project partnership into their space and re-orientated the model (cf. ideal model). WIG contracted an independent scientist, indicated by the yellow circle (who they had previously worked with), to advise/assist them with their orchard benchmarking work (5.2.1). Other partner scientists undertook independent bacteriophage work, although this was overseen by WIG (6.2.3).
	Project Relationship: When WIG engaged with scientists they maintained a productive and positive relationship (5.2.1). However because the project's bacteriophage work was not able to be transferred to the orchard, the relationship did not fill the whole of the project partnership space, as this work was left unresolved (6.3.2). The challenge for WIG will be managing its transition as an industry as it moves to full production.
	Farming CoP Relationship: WIG undertook considerable farmer-led research outside the collaborative learning space (i.e. independent of the scientists) as indicated by the red area. The group connects with their CoP through a variety of extension activities (6.3.2; 6.4.2).
	Science CoP Relationship: PhD research in the bacteriophage work was funded by the project, although this lacked farmer relevance (5.2.1).
	Funder Relationship: WIG invited the funder to all project related 'extension' activities.
	Extra-Partnership Relationship: WIG maintained positive relationships with scientists outside the project and had access to a University research orchard (4.4.2).

Effect on the Collaborative Learning Space

The positive working relationship WIG maintained with scientists, their understanding of science as a development tool, scientific competency of some members and their management of the research enabled the partner overlap to be large and the collaborative learning space to occupy a relatively large section of the project partnership. The uncompleted bacteriophage research and an increasing urge by some WIG members to change their focus to production/market research rather than crop development, limited the extent to which project relationships could occupy the project partnership space and also limited learning in the collaborative learning space.

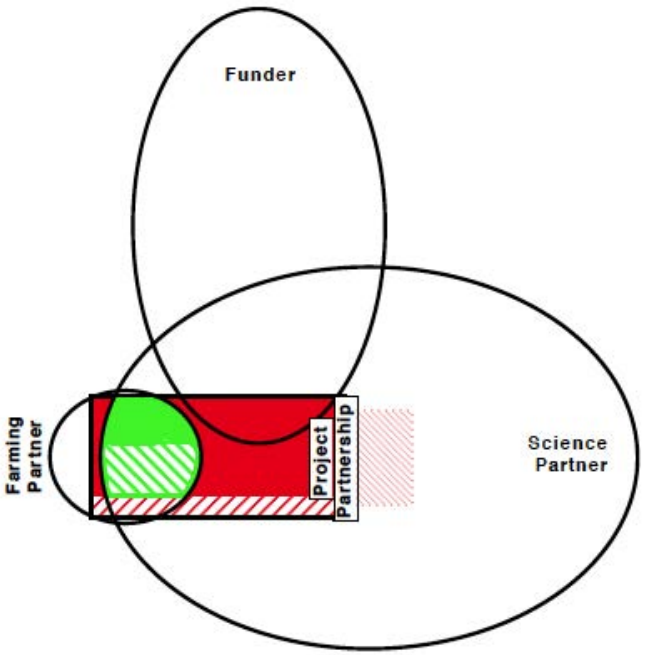
Table 7.3: Wheat Calculator – Foundation for Arable Research (FAR) and Crop and Food Research

<table>
<tr><td rowspan="7">Shared Partnership
</td><td>Partners: FAR's 'research' capability and capacity and their understanding of science as a development tool, minimised the capacity difference between the science and farming partners in this project (4.4.2). FAR's stable funding base enabled it to support staff, which gave it considerable mass as a farming group.</td></tr>
<tr><td>Project Partnership: The Wheat Calculator is one of many projects that FAR undertook. FAR took an active role in shaping the project and although it was a shared partnership, their active management of the project pulled the partnership into their space (5.2.2). While FAR may now re-orientate projects to be more reflective of the farming group-initiated projects above, this was not the case with the Wheat Calculator.</td></tr>
<tr><td>Project Relationship: The lighter pink crossed area indicates significant tensions in the early project stages where scientists resisted farmer input into the tool design. This needed to be resolved before the project could develop a collaborative learning space (5.2.2; 5.3.2; 5.3.3). IP issues remained largely unresolved.</td></tr>
<tr><td>Farming CoP Relationship: Being largely an extension project, FAR had an extensive outreach programme to their CoP (5.2.2; 6.4.2).</td></tr>
<tr><td>Science CoP Relationship: The project emerged out of 20 years of extensive science research. The pilot research sought to enhance understanding of the underlying cirrus wheat model's application in the field (5.2.2).</td></tr>
<tr><td>Funder Relationship: Project tensions required input from the funder.</td></tr>
<tr><td>Extra-Partnership Relationship: FAR and the science institutions maintained a positive relationship outside the project. FAR offices were situated in Lincoln next to its principal science advisors and FAR maintained connections with wider actors and supporters in the value chain including strong international connections (4.4.2).</td></tr>
</table>

Effect on the Collaborative Learning Space

The early relationship tensions prevented a larger overlap between the science and farming partners forming and this affected the size of the collaborative learning space. Although the actors negotiated a positive and productive path forward, the initial tensions and the largely unresolved IP issues prevented the project relationship completely occupying the partnership space. While the farmers did influence some changes to the calculator's interface, it remained overly complicated, leaving the collaborative learning space not completely filled (hatched green area). The solid green area of collaborative learning and its size, while relatively large compared to the Potato Aphid and Squash Rot projects is not as large as the space in the Precision Agriculture and Walnut Blight projects.

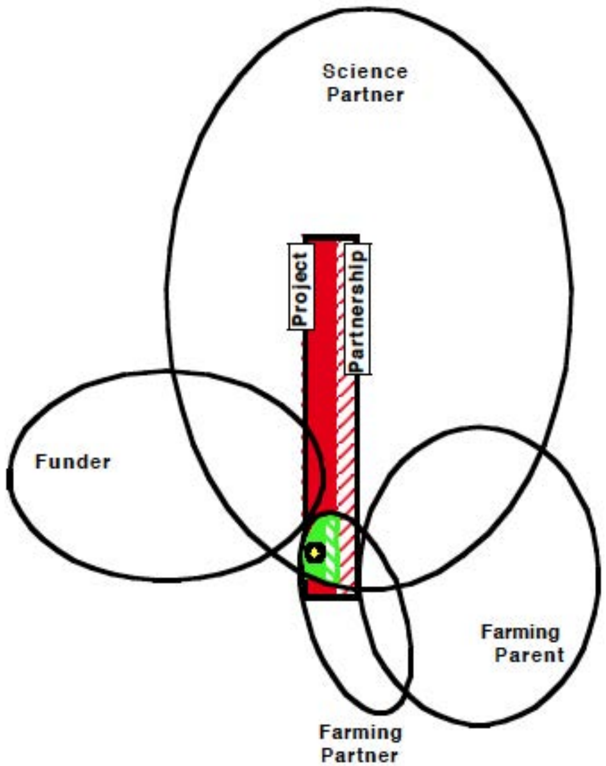
Table 7.4: Crop Science for Māori – East Coast Producers Trust (ECOP) and Crop and Science Research

<table>
<tr><td rowspan="7">Shared Partnership
</td><td>Partners: ECOP was a very small organisation with limited understanding of science as a development tool. The science partners who they engaged with had considerably larger capacity. However, the scientists were guided by a strong participatory ethos, which was set by the funder. ECOPs dependency on its science partner means that it sits largely inside the science area, although as its own entity.</td></tr>
<tr><td>Project Partnership: Community members and scientists collaboratively set the specific Crop Science for Māori objectives, so the overlap is large. The funders set the participatory tone of the project and played a significant role in shaping the project so the model is oriented to reflect this (4.4.2; 5.2.2).</td></tr>
<tr><td>Project Relationship: The community and scientists needed to develop trust. The lighter pink area of the project relationship indicates the period of relationship building in the early stages of the project. As trust was built between the community and the scientists, and the scientists' understanding and acceptance of Mātauranga Māori grew, the community was able to occupy more of the project relationship. Despite this the extent of the science partner's engagement with Mātauranga Māori and participatory research was limited by dynamics from the institutional structures in which they were situated (4.4.2; 5.2.2).</td></tr>
<tr><td>Farming CoP Relationship: Cultural protocols limited growers' willingness to be mentors and role models. The scientists however took a lead role in promoting the project to the wider community (6.4.2).</td></tr>
<tr><td>Science CoP Relationship: The project supported postgraduate research, publications and workshops. Scientists felt stigmatized by their CoP (4.3.3).</td></tr>
<tr><td>Funder Relationship: The scientists worked with the funders to establish the Science for Community Change programme (which Crop Science for Māori was part of), but ECOP was not included in this process so does not overlap the funder (4.2.3).</td></tr>
<tr><td>Extra Partnership Relationships: ECOP, the scientists' and other party relationships only existed within and as a product of the project (6.4.2).</td></tr>
</table>

Effect on the Collaborative Learning Space

While ECOP is housed largely in the science area as an independent body (to indicate the significant role the scientists played in maintaining this project), the project's participatory ethos ensured ECOP was an equal partner. This participatory ethos, created a sizable collaborative learning space (shown in green) and relationship space (red area). However, ECOP's limited capabilities; small numerical size (under 10 growers); limited understanding of science as a development tool; isolated location; cultural barriers that limited dialogue between communities; grower reluctance to showcase work; variability in the science team's perception of the effectiveness and impact of the research; limited ability to reconcile structural support e.g a cool store; led to a significant area of the collaborative learning space (hatched green area) and a small area of the project relationship being unfulfilled (hatched red area).

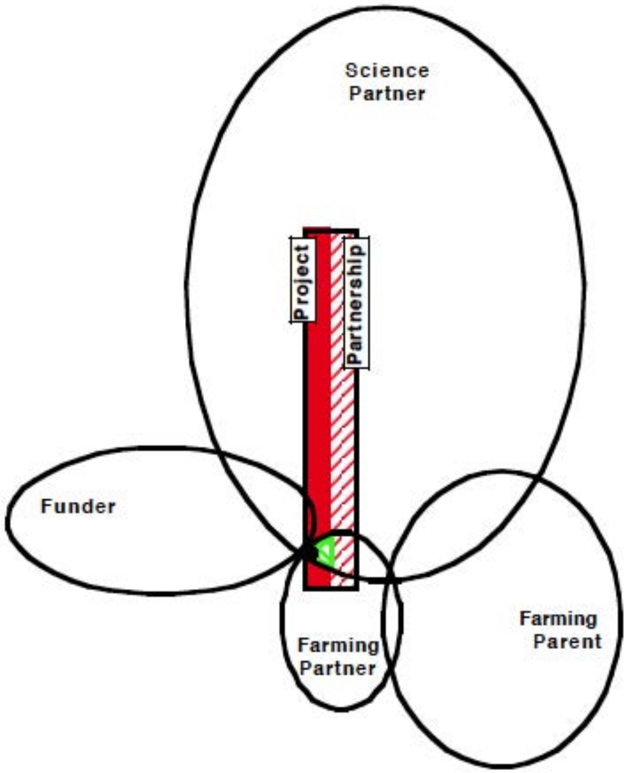
Table 7.5: Potato Aphid project – Potatoes NZ (product group of HortNZ) and Crop and Food Research

<table>
<tr><td rowspan="7">Science-initiated Partnership

</td><td>Partners: Unlike the previous diagrams, the Potato Aphid diagram contains two farming ellipsoids, as Potato NZ is a product group of Horticulture New Zealand (HortNZ). However, Potatoes NZ was the project partner, and although HortNZ is relatively large the science institute had comparatively much larger capacity.</td></tr>
<tr><td>Project Partnership: The project occupied only a small portion of the science and farming partners' areas. Potato NZ engaged in other projects and had a strong focus on production and marketing and so allocated only a small percentage of their levy income to science research. The potato project was a relatively small project for the science partner. The project partnership space occupies only a small section of the farming partner area, due to the significant role that the science team played in initiating and maintaining the project. This is also reflected in the orientation of the model (4.4.2).</td></tr>
<tr><td>Project Relationship: The disparity between the science and farming partners is not rebalanced and so the project and the relationships are housed largely in the science area, to reflect the science focus of this project. The farming and science partners maintained a collegial relationship in the project team and with the 'industry' project manager (yellow/black circle). However the limited pre-existing relationships between partners, the use of a project committee as the principal space for collaboration, the limited willingness to share information within the farming sector, and the science focus of the project limited relationship building and led to a large unfulfilled area of the relationship space within the project partnership space (hatched red area) (5.2.3)</td></tr>
<tr><td>Farming CoP Relationship: The farming group has a strong relationship with their CoP, but barriers created sector competitiveness and limited knowledge sharing (6.4.1).</td></tr>
<tr><td>Science CoP Relationship: The project generated science & conference papers.</td></tr>
<tr><td>Funder Relationship: Assisted with contract. Communication was via project reporting.</td></tr>
<tr><td>Extra Partnership Relationships: There were limited pre-existing personal relationships between actors, although the institutions had positive existing relationships. Potatoes NZ maintained a positive relationship with actors in the wider value chain (4.4.2).</td></tr>
</table>

Effect on the Collaborative Learning Space

The limited overlap between the farming and science partners restricted the space available for collaborative learning (green area). Furthermore the science focus of the project, the farmers' relative isolation from the research and the use of a largely formal platform for engagement (a project committee) did not foster an effective space for learning. The collaborative learning space (green area) was therefore small. The unfilled collaborative learning space (hatched green) occurred from the project not meeting the farming partner's expectations.

Table 7.6: Squash Rot project – Squash Industry Group (product group of HortNZ) and Crop and Food Research

<table>
<tr><td rowspan="8">Science-initiated Partnership
</td><td>Partners: While the project originally began under Kabocha NZ, it transferred into the Squash Industry Group NZ when this became a product group of Horticulture New Zealand (HortNZ). The science institute was comparatively the larger entity and the science focus of the project is represented by the orientation of the model.</td></tr>
<tr><td>Project Partnership: The project partnership space occupied a small section of the farming partner area due to their limited buy-in to the project. This was reflected in no farming financial input (in-kind only) and the significant role that the science team played in initiating and maintaining the project. Unlike the Crop Science for Māori project, the disparity between the science and farming partners is not rebalanced by the actions of any of the major actors, so the project and the relationships are housed largely in the science area, to reflect the science focus of the project (4.4.2).</td></tr>
<tr><td>Project relationship: Project partners maintained a collegial relationship with participants & project manager (yellow circle). However, the limited pre-existing relationships between partners provided no base to establish a strong relationship. Furthermore the competitiveness between farming actors restricted knowledge sharing, which is represented by the small area of red in the farming partner area & the large unfulfilled area of the relationship space within the project partnership space (hatched red area). The use of a project committee as the principal space for collaboration, formalized the relationship but restricted opportunities for developing informal relationships (5.2.3; 6.3.1).</td></tr>
<tr><td>Farming CoP Relationship: Highly competitive, “high risk”, “cut-throat” industry significantly restricted knowledge sharing (6.3.1; 6.4.1).</td></tr>
<tr><td>Science CoP Relationship: Project scientists’ understanding was enhanced but inconclusive results limited wider dissemination of results (6.3.1).</td></tr>
<tr><td>Funder Relationship: Assisted with contract. Communication was via project reporting.</td></tr>
<tr><td>Extra Partnership Relationships: Although the squash farming sector historically had a strong relationship with the science sector, this decreased as the squash industry group preferred to direct its levy funds towards marketing initiatives and research. Industry competitiveness made this a problematic industry to engage (6.4.1).</td></tr>
</table>

Effect on the Collaborative Learning Space

The limited overlap between the farming and science partners restricted the space available for collaborative learning (green area). The use of a project committee with an independent chairperson (yellow/black circle) saw farmers and scientists engage, it did not foster an effective space for relationship building and this is reflected in the large hatched red area. The inconclusive field data, which was unable to be used to develop a predictor tool, limited the extent of the collaborative learning space. This is largely displayed as a hatched green area to reflect unfulfilled learning.

7.4 Maximising the collaborative learning space

Despite the commonality of all projects being participatory partnerships, the above diagrams show that the creation of a collaborative learning space was variable, with the relative size of partner institutions and their orientation, the degree of institutional overlap, the shape of the partnership and within this the project's relationship space, being unique to each of the participatory research projects. Variability is to be expected in participatory research, since context is recognised to shape how projects operate (Reed, 2008). This leads proponents of participatory research to reflect on, and even question, the universal relevance of the findings from participatory investigations (Banks et al., 2013). Collectively the diagrams however reveal that a project's collaborative learning space is influenced by the strength of partner relationships, and the effect of institutional structures and dynamics that together act to enable or disable the collaborative learning space.

The optimal PROCLE model (Figure 7.1) maximises the space allocated to collaborative learning that occurs at the intersection of the farming and science partners and their 'realised' project relationship. Being the conceptualisation of an optimal project, the size of this intersection is formed from strong partner relationships and enabling institutional structures and dynamics that lead to the co-development of innovations. The optimal PROCLE model therefore conceptualises a participatory research project where the collaborative learning space is maximised by both the degree of institutional overlap and the partners' willingness, ability and institutional support to enable a strong and positive relationship with other partners that facilitates collaboration AND most importantly, learning.

Maximisation of collaborative learning in the PROCLE model focuses on collaboration, not on participation. This research does not seek to maximise participation, which could lead for example, to a simplistic belief in the number of participants as evidence of successful collaboration. Neef and Neubert (2011) have similarly argued against tools being used to maximise participatory research. Rather the PROCLE model seeks to conceptualise partner collaboration to allow a visualisation of the space available for learning, which this research labels as the collaborative learning space. The learning within this space still needs to be realised, which is discussed in Section 7.5.

The individual PROCLE project diagrams show however that projects do not always maximise their collaborative learning space. Based on the empirical evidence in this research, the observed variability identifies several key features for maximising the collaborative learning space.

7.4.1 Projects must be seen as opportunities for collaborative learning

To maximise the collaborative learning space, ‘collaborative learning’ must be an intended and explicit outcome of a project that shapes all project processes. Learning is a critical feature of the AIS and participatory literatures (Chapter 2), however this thesis emphasises ‘collaborative’ learning. The collaborative learning space in the PROCLE model occurs at an intersection that itself is shaped both by the degree of institutional overlap and the partners’ willingness, ability and institutional support to engage in a productive learning relationship.

The application of the model to the six investigated projects shows that where the institutional overlap and the partners’ willingness, ability and institutional support to engage in collaborative learning is strongest, the learning within the space is more likely to be realised. This is most clearly evident in the farming group-initiated and -led Precision Agriculture and Walnut Blight projects, where the space for learning is the largest. The maximisation of the collaborative learning space in these projects is brought about by a combination of factors, including institutional factors that support collaboration and co-production, such as the research focus of the farming groups and their understanding of science as a development tool. In addition the membership’s sense of collegiality and their willingness to act as project champions helps to foster both formal and informal channels for engagement.

Furthermore farming groups’ prior relationships with science partners mean the project partnership is formed with a high level of trust already established. As learning is a primary focus of these groups and the projects are led by the groups, project objectives and project outcomes are relevant to farmers and so attract a high degree of interest among the membership. Furthermore as the farming groups keep in close contact with their membership, strong feedback loops are maintained between the membership and the project actors. By maximising project relationships and having supportive institutional structures and dynamics, the Precision Agriculture and Walnut Blight projects were able to maximise the partner overlap and therefore maximise the collaborative learning space.

In contrast, in projects where the collaborative space is minimal such as the Potato Aphid and the Squash Rot projects, the projects had minimal partner overlap. In these projects institutional structures and dynamics led to projects being strongly science outcome focused which restricted their interest and relevance to farmers. The strong economic focus of these sectors also made it more difficult to stimulate wide sector interest in environmental outcomes. In addition the lack of informal channels for interaction and experimentation prevented opportunities for engagement, and most importantly provided few opportunities to capture the valuable tacit knowledge of the farmers. The competitive cultures of the farming sectors prevented a sense of group cohesion, which made it difficult to collaboratively share information.

In addition as collaborative learning was not a central focus, failure to reach anticipated outcomes, while understood and accepted by participants, nonetheless led to disillusionment among the non-science partners. Farmers in the Walnut Blight and Squash Rot projects show significantly different participant responses to each project's failure to develop a technology. In the Walnut Blight project, where collaborative learning was a central focus, participants accepted the project's inability to develop a bacteriophage and farmers instead focused on other aspects of the work that provided valuable insights to orchard management. In the Squash Rot project where collaborative learning was minimal, the failure to develop a squash rot predictor tool while accepted and understood, nonetheless contributed to a wider questioning within the squash industry of the relevance and value of science research (Section 4.4.2).

A focus on collaborative learning takes participatory research projects beyond a focus solely on the achievement of a desired 'science' outcome. Visualising projects instead as collaborative learning spaces that may lead to change allows projects to be viewed as a means to an end and not an end in themselves. A similar argument is put forward by Robinson (2004:381), when he wrote, "sustainability is a process, not an end-state". When viewed as a collaborative learning space, projects that do not achieve their desired outcomes are not destined to have failed, but rather can still make valuable and positive contributions by expanding participants' understanding of the environments in which they operate.

7.4.2 Collaborative learning should begin early

Maximising the collaborative learning space should begin as early as possible to enable partners to engage deeply with each other, to maximise their overlap within the project partnership. This engagement can be further maximised by pre-partnership relationships, which serve to bring partner institutions closer together to create larger overlaps where contractual project partnerships are formed. This was a feature of the Walnut Blight, Precision Agriculture and Wheat Calculator projects where the partners had pre-existing positive relationships. Farming groups who maintained positive relationships with science partners, entered into arrangements in projects with a base of existing trust. These relationships were built on personal relationships and a mutual recognition and understanding of science as a development tool and partner enjoyment in collaborative engagement.

The most successful relationships were noted by farming group partners to be between individuals rather than organisations (Section 4.4.3). Where farming and science partners do not have a prior relationship between the project actors, the potential for a collaborative learning space is limited from the outset, as occurred in the Potato Aphid and Squash Rot projects. However, as the Crop Science for Māori project shows, relationships can be developed through trust-building, but this takes considerable time and the intangible notion of building trust is problematic for institutions that preference tangible milestones (Section 4.3.3).

7.4.3 Partners must work towards a shared vision

For successful collaboration that leads to innovation, actors should have a shared vision (Klerkx et al., 2012; Parkhill et al., in press). The PROCLE model shows that maximising the collaborative learning space requires more than just partners having a shared interest in a common problem (Klerkx et al., 2012. As the AIS literature asserts, innovation is more than just technology development. The empirical evidence from this research shows that successful innovation requires alignment of partners' priorities and preferably, early in the project. This did not occur in the Wheat Calculator project, where misaligned partner priorities were expressed as a clash between the conventional evidence-based research of scientists, and the lived experience of farmers (Section 5.2.2). While projects may not explicitly express misalignment of partner priorities as a clash, as occurred in the Wheat Calculator project, when misalignment is present, it will erode the ongoing collaborative nature of participatory research, that is required to maintain and sustain partner relationships. Without this underlying relationship the learning space will be minimised or may not even develop.

Prior relationships between partners may facilitate collaboration, but they do not necessarily guarantee alignment of priorities. The misalignment and resulting tensions that occurred in the Wheat Calculator project between partners that had an existing relationship, created an impediment which needed to be overcome before collaborative learning could take place. This required the farming partners to clearly articulate their expectations of the project. By doing this, the science partners developed critical understanding of the farmers' priorities, and the partners slowly developed trust that is recognised to be essential in participatory research (Cvetkovich & Winter, 2003; Reed, 2008; Sligo & Massey, 2007).

While the empirical evidence in this research shows that initial difficulties can be overcome, partner relationships appear not to fully recover from significant set backs, particularly those that emerge from epistemological differences. The Wheat Calculator project was able to address initial tensions that presented as a clash between the scientists who viewed the calculator through a research lens, and the farmers who saw its practical benefits in assisting their decision-making around nitrogen and irrigation input. Through facilitation, initial difficulties were able to be addressed and compromise led to changes in the calculator's interface, although its ease of use for farmers was never completely resolved. The farming group however learnt from this experience so that future innovations, such as the Maize N calculator, were designed with considerable farmer input from the outset to ensure they were relevant and user-friendly.

Articulating expectations at the outset enables partner priorities to be better understood. In both the Precision Agriculture and Walnut Blight projects, the farming groups ensured that partners were aware of their expectations that the research was relevant to farmers and that the information from the research was accessible to a farming audience. The demand for relevance and accessibility does not rule out farmer engagement in fundamental research. WIG's support of fundamental research was unusual, but they complemented their experimental bacteriophage work with orchard-focused work that had immediate relevance to growers. The project had a cafeteria of research components to satisfy all tastes.

7.4.4 Collaborative learning requires equitable partnerships

Peer communities of scientific and lay experts have long been advocated for creating shared understandings amongst divergent stakeholders to address complex issues, and stimulate new knowledge and practices (Bruckmeier & Tovey, 2008; Healy, 1999; Leys & Vanclay, 2011; Wynne, 1996). Participatory projects rely on equitable relationships to facilitate an exchange of ideas between stakeholders (Kindon et al., 2007). The PROCLE model illustrates where significant disparity occurs between partners' capacities to undertake participatory research, it is incumbent on the more dominant party to re-balance the relationship. This was clearly seen in the Crop Science for Māori project where scientists, adhering to a participatory ethos, sought not only to collaborate with the community but to understand and embody in project learning both *Mātauranga Māori* and western science knowledge. The kumara growing calendar, the tikanga workshop and the shared community/scientist workshop at an academic conference, all serve to illustrate how partners collaborated and incorporated their different worldviews into project learning.

The PROCLE model shows funders can play an active role in ensuring that any disparities between partners are re-balanced. However, while the research funder may extend into the collaborative learning space, their inclusion is not a requirement for the generation of this space. If the funder does not extend into the project learning space, they still play a critical role in setting the participatory tone for project engagement. The Crop Science for Māori project's participatory ethos was encouraged by FRST as funders of the project. Funders however may be required to enter the learning space to resolve partner issues and assist with realigning priorities to stabilise the project, as was the case in the Wheat Calculator project. The support for participatory research by funding and policy agencies must be viewed positively. Funders' increasing expectations that research has end user relevance (Section 4.2.3) is a motivating factor for encouraging scientists to engage in participatory research. However encouraging participatory approaches will not necessarily see the effective application of this methodology without strong and continuing institutional support for those undertaking these endeavours.

7.4.5 Collaborative learning requires positive and productive relationships

The PROCLE model challenges deterministic interpretations of relationships in project partnerships that visualise projects as being positioned in a linear hierarchy as discussed in Section 2.3.3 (Arnstein, 1969; Biggs, 1989; Cornwall & Jewkes, 1995; Pretty, 1995). Using the empirical evidence from this research, the PROCLE model shows that relationships emerge from the union between partners that creates the partnership. This union is most dynamic in shared partnerships where partners often engage in vibrant negotiation and dialogue to align their priorities as was evident in the Wheat Calculator and Crop Science for Māori projects. The dominance of one partner, in both the science-initiated and farming group-initiated projects makes the relationships appear more stable. However, only in the farming group-initiated projects of the Precision Agriculture and Walnut Blight projects, was the relationship effectively fostered by the 'dominant' farming partner creating an enabling environment that sought a level playing field. This was achieved by each group humanising the relationship between partners, valuing the knowledge that each partner brought to the table and facilitating dialogue and engagement that maximised the collaborative learning space. The 'dominant' farming partner's mindset valued multi-stakeholder engagement.

The PROCLE model acknowledges the contractual partnership as an agreement between partners at the outset of a project. However, more importantly it focuses on the partner relationship that forms inside the contractual partnership. A collaborative learning space requires a positive and productive relationship between partners. The collaborative learning space is markedly affected by the extent to which the relationship fills the contractual partnership. Should a large institutional overlap exist but a broad and deep relationship not exist between partners or among the actors from one of the partners, as occurred in the Potato Aphid and Squash Rot projects, the collaborative learning space will be minimised or not created.

7.5 Transdisciplinary partnerships for collaborative learning

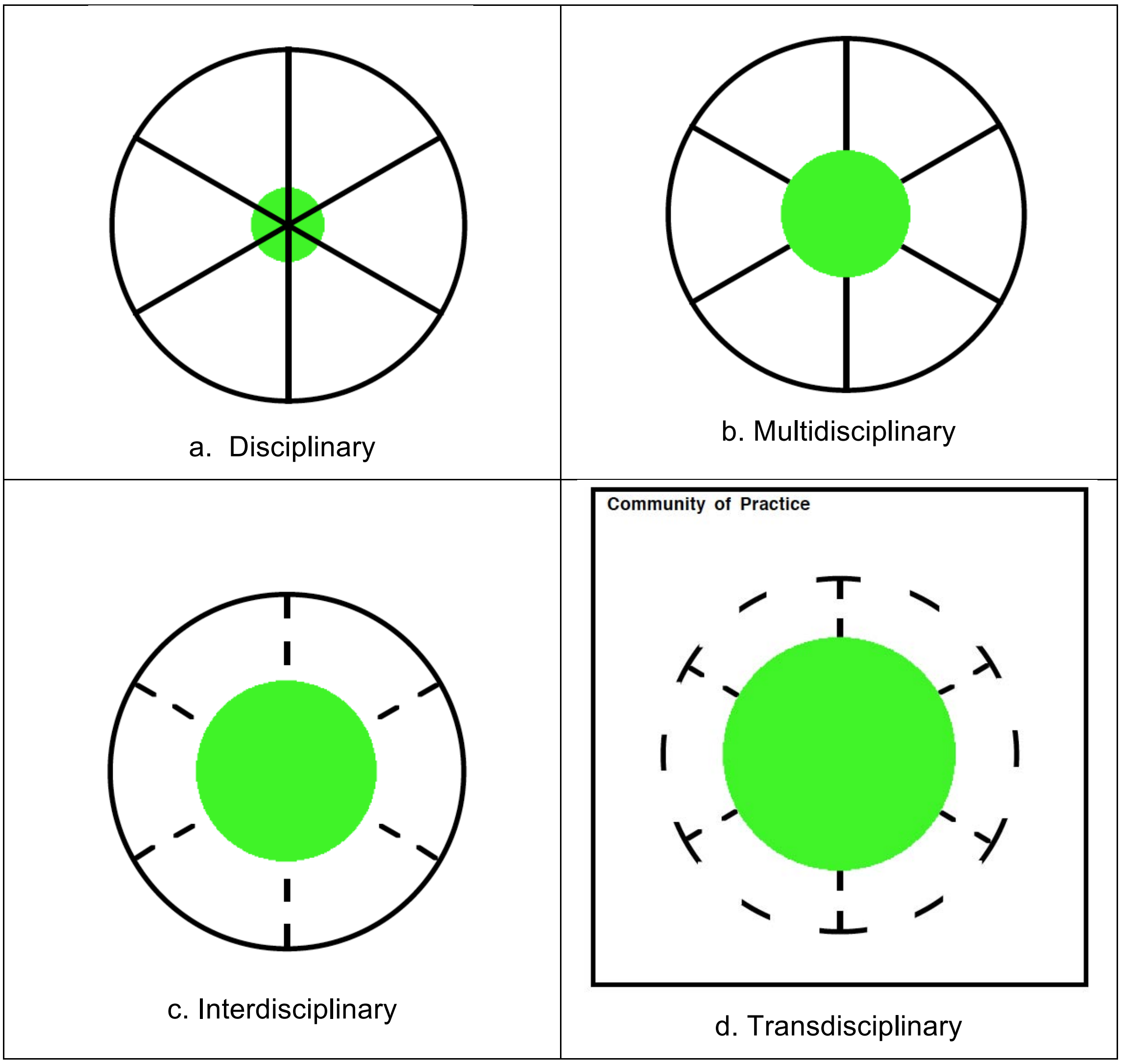
The collaborative learning space is maximised in a transdisciplinary environment where multiple actors problem-solve, innovate and mutually learn. Transdisciplinary partnerships enable collaborative and deliberative learning processes. Using Klerkx's (2015) conceptualisation of disciplinary, multidisciplinary, interdisciplinary and transdisciplinary partnerships for innovation, Figure 7.2 conceptualises the collaborative learning space in the different disciplinarities in a participatory research environment. The conceptualisation of disciplinarities in Figure 7.2 includes non-science contributors in all the disciplinary diagrams since participatory research by its very nature involves actors from outside the science and technology system. These non-science 'disciplines' would include farming groups but could also include other value chain actors/supporters.

The disciplinary model (Figure 7.2a) has discrete disciplines. While the disciplines adjoin each other and acknowledge the presence of each other there is no linkage between them. Disciplines project themselves into the collaborative learning space (shown in green) but contribute only along disciplinary lines with no interaction between them. The result is a small collaborative learning space because it is not maximised as a space for change by interactions between disciplines.

The multidisciplinary model (Figure 7.2b) is the same as the disciplinary model for those parts of the disciplines outside the collaborative learning space. Disciplines enter the collaborative learning space along disciplinary lines. However, within the collaborative learning space disciplinary boundaries are broken down so disciplinary paradigms can interact within the collaborative learning space. The result is a collaborative learning space that is larger than for the disciplinary model because of synergies between disciplines within the collaborative learning space.

In the interdisciplinary model (Figure 7.2c), outside the collaborative learning space disciplinary boundaries are porous so interdisciplinary interactions can occur both within and outside the collaborative learning space. Disciplines enter the collaborative learning space predisposed to other paradigms so synergies within the collaborative learning space are greater. This results in a relatively larger space compared to the previous two models.

.



= Collaborative Learning Space *Adapted from Klerkx (2015)*

Figure 7.2: Spectrum of disciplinarities in a participatory research environment

The transdisciplinary model (Figure 7.2d) has the largest collaborative learning space. Like the interdisciplinary model it has porous disciplinary boundaries both inside and outside the collaborative learning space to allow synergies between disciplines. However, in this model the project actors also connect with their communities of practice to enable them to be engaged and contribute. This further enlarges the collaborative learning space as a result of the multiple knowledges of participants that can be captured so the knowledge that contributes to the collaborative learning space is no longer limited to only those actors who are actively engaged in the project.

Figure 7.2 postulates that both the size of the collaborative learning space and the opportunities for learning within it are enhanced by the porosity of the barriers between the disciplines within the project and engagement with communities of practice beyond the project. This conceptualisation shows that participatory research projects can behave like a traditional 'disciplinary' model, despite scientists engaging with those outside the science and technology system.

Participation of multiple actors from both inside and outside the science and technology system therefore does not by itself guarantee effective and productive collaboration. In this research the science-initiated projects showed clear evidence of the 'disciplinary' model (Figure 7.2a) despite these projects engaging in participatory partnerships. For example, in the Squash Rot project the strong science focus and a farming sector culture beset by competition and restrictions on the open sharing of knowledge, limited the size of the collaborative learning space.

Project actors must actively seek to break down barriers that divide disciplines in participatory research to maximise the collaborative learning space. While projects should aim to be transdisciplinary from the outset, the empirical evidence from this research shows that this does not always occur. However the research showed that projects can transition towards a transdisciplinary partnership through reconciling initial tensions. An example of transitions in practice towards a transdisciplinary environment is shown by the Wheat Calculator project. Initially this project showed signs of being visualised as participatory research using a disciplinary model. However, through facilitation and negotiation 'disciplinary' walls largely constructed by epistemological differences were broken down to move the project towards a transdisciplinary model. Similarly in the Crop Science for Māori project, trust-building that led to a greater alignment of partners' priorities was able to slowly erode the walls between the community and the scientists. This enabled the project to move beyond a multi-disciplinary model into an interdisciplinary/ transdisciplinary model.

The empirical evidence from this research shows that enhanced porosity between disciplines within projects and between project ‘disciplines’ and their CoP are core elements of effective participatory research and vital ingredients in moves towards transdisciplinarity that is recognised to support a move towards sustainability (Polk, 2014; Popa et al., 2015). The spectrum conceptualised in Figure 7.2 enhances understanding of participatory research by showing that participatory research that is heavily weighted towards disciplines places the focus on partnership, whereas participatory research that breaks down disciplinary barriers places its focus on relationships. This important partnership/relationship nexus emerged from the empirical evidence presented in Chapter 5.

7.6 Realising learning in the collaborative learning space to support a move towards sustainability

7.6.1 Introduction

This thesis’ examination of the participatory literature showed learning is a key requirement in participatory research (Pretty, 2001; Reed, 2008). Similarly the Agricultural Innovation Systems (AIS) literature recognises a need for a learning space where actors can collaborate as partners (Darnhofer et al., 2012; Leeuwis & Aarts, 2011). Sustainability science scholars also recognise multi-stakeholder engagement as essential to include a wide range of perspectives into decision-making to enable stakeholders to engage in problem solving (Komiyama & Takeuchi, 2006; Wiek, Farioli, et al., 2012). Furthermore the complexity of sustainability is recognised to require collective and collaborative learning responses to meaningfully address issues (Stirzaker et al., 2010; Stirzaker et al., 2011).

The PROCLE model shows that strong partner relationships and institutional structures and dynamics that support collaboration and enable co-development, will maximise the potential collaborative learning space. Once a project has created its collaborative learning space, the issue then becomes how best to utilise and employ this space, to realise learning in the collaborative learning space. To better understand the realisation of learning in the collaborative learning space, the discussion now explores how effectively the six micro-level participatory research projects in this research, captured the collaborative learning space to support a move towards sustainability.

7.6.2 Illustrating project characteristics that enable learning for sustainability

The thesis' empirical evidence about institutions, partnership and learning, presented in Chapters 4, 5 and 6, identified a number of important characteristics with the potential to enable collaborative learning in projects. These characteristics are tabulated in Figure 7.3 to allow each characteristic to be compared across projects (comparison across rows) and each project to be compared across characteristics (comparison down columns).

Each characteristic was qualitatively ranked for each project, as enabling learning (green); disabling learning (red) or being indifferent (orange). To increase the discrimination for each characteristic, cells of mixed colours were used to indicate a project characteristic that was heterogeneous, to reflect variable actor responses for that characteristic. Figure 7.3 visually presents the characteristic ranks for each project and Appendix 2 details evidence from the projects to support these broad rankings.

Columns have been arranged across the figure in descending order of projects that enable learning. Rows have then been similarly ordered in descending order of learning enablement across the six projects. This ordering concentrated those projects and characteristics with the greatest learning enablement in the top left corner of the figure, and those with the greatest learning constraints in the bottom right of the figure. Comparing these characteristics across the investigated projects provides insight into the effectiveness of individual projects and of projects collectively in realising and most importantly optimising learning for sustainability in the collaborative learning space.

It can be seen that following the rearrangement of the table as described, the projects have grouped into the same three partnership types as found in Chapter 5, with farming group-initiated projects having the greatest degree of learning enablement followed by shared partnerships, where learning enablement was heterogeneous across almost every characteristic and science-initiated projects which largely disabled collaborative learning. Within the science-initiated projects a few characteristics were heterogeneous but none fully enabled collaborative learning.

The characteristics also showed a high degree of clustering so were reordered to form three subsections of characteristics, those relating to partnership attributes, those relating to institutional attributes and those relating to learning attributes. Among the five partnership attributes no projects were ranked as being highly constrained for collaborative learning and two (Precision Agriculture and Walnut Blight) were ranked as being highly enabled for collaborative learning.

Institutional attributes had more mixed ranks with most projects being heterogeneous. Precision Agriculture and Walnut Blight that sought a level playing field by humanising the relationship between partners, valuing, capturing and utilising the multiple knowledge of partners and facilitating dialogue and engagement that maximised the collaborative learning space, were again more highly enabled projects for collaborative learning. Institutional attributes which limited knowledge sharing and which visualised knowledge production as linear with knowledge development undertaken by scientists followed by knowledge transfer to farmers when results were known, such as occurred in the Potato Aphid and Squash Rot projects, constrained collaborative learning.

The learning attributes in Figure 7.3 contain characteristics that should be evident in innovation projects addressing agricultural sustainability. Co-development and trans-disciplinarity indicate evidence of an enabling learning environment for innovation (Curry, Ingram, & Maye, 2012; Hekkert et al., 2007; Ingram, 2008, 2010; Wieczorek & Hekkert, 2012). Furthermore the temporal and spatial dimensions of sustainability have been explored as these were identified in Chapter 1 of this thesis as critical characteristics of sustainability. The longevity of project learning has also been explored to see if the outcomes from collaborative learning are sustained in farming communities beyond the funded period of a project, a characteristic argued to be important in sustainability projects and usually indicative of institutional capacity building at the local level (Pretty, 1995).

All learning characteristics showed significant collaborative learning constraints in the science-initiated projects, whereas in the two farming group-initiated projects some characteristics enabled collaborative learning and some were heterogeneous. The two shared partnership projects were heterogeneous for almost all characteristics.

Figure 7.3: Project realisation and optimisation of learning for sustainability

7.6.3 Understanding learning variability

While a maximised collaborative learning space provides the greatest opportunity for collaborative learning, Figure 7.3 shows that this does not guarantee that collaborative learning will be fully realised. Realising this collaborative learning potential was most related to the type of project partnership, with farming group-initiated partnerships more likely to realise collaborative learning than science-initiated partnerships. Shared partnerships had mixed results. The Crop Science for Māori project, which adhered to a strong participatory ethos, created a relatively large collaborative learning space, but as revealed in Table 7.4, the learning was not able to be fully realised. Indeed all projects did not fully realise the learning potential in their collaborative learning space (as shown in Tables 7.1 - 7.6). To further understand the observed variability in learning between projects, the following features were identified from Figure 7.3:

- When farming groups managed the projects there was a higher degree of collaborative learning enablement than when scientists managed the projects;
- Shared partnerships were almost wholly heterogeneous across all characteristics;
- The science-initiated partnerships had learning attribute characteristics that constrained collaborative sustainability learning;
- Partnership attribute characteristics were more commonly enabling of collaborative learning and in only one case (Squash Rot) was a characteristic judged to be a learning constraint. These characteristics were generally determined by the actors within the project relationship;
- Institutional attribute characteristics were only moderately enabling for learning, and in the Squash Rot project they acted as a strong constrainer of learning. Actors external to each project relationship often influenced the characteristics of the institutional attributes, for example the organisational structure, routines and practices of the CRIs that affect how scientists operate and practice their science (Section 4.3);
- Learning attribute characteristics showed marked variation across the projects and were possibly affected by the interaction of the other major attributes with learning affected by institutional and partnership attributes. For example, co-development is generally dependent on the level of collaboration among project actors and the level of institutional support for the project;
- Of the learning attribute characteristics, those that relied on actor relationships e.g. co-development and transdisciplinarity were generally more enabling of learning. Those that required learning to extend beyond actors' immediate sphere of experience and expertise (spatial dimensions of sustainability) were either heterogeneous or constrained learning;

- The farming group-initiated projects had some learning characteristics that enabled learning while others were heterogeneous. These projects co-developed new knowledge and technology, they sustained learning beyond the project funding, and they acknowledged the temporal dimensions of sustainability. However, learning was more likely to be spatially confined to a focus on farm-level issues;
- It is particularly noteworthy that the single characteristic that showed the greatest constraint to learning was acknowledgement of the spatial dimension of sustainability, which is also the characteristic likely to be most relevant to actors understanding the impacts of agricultural externalities;
- It is also interesting to note that the two projects that were the least learning constrained for the spatial scale of sustainability characteristic were the two projects that sought to address landscape level externalities; nitrogen leaching in the Wheat Calculator project and soil loss in the Precision Agriculture project, although both projects largely confined their focus to the farm scale rather than the landscape scale.

The coloured characteristic ranking system in Figure 7.3 visually shows that scientists and farmers did successfully collaborate in the investigated micro-level participatory research projects, although the extent to which they advanced collaborative learning for sustainability was variable. Scholars show that environmental understanding and learning is enhanced when farmers share observations and results from on-farm experimentation combined with local and scientific agricultural knowledge (Ingram, 2008; Kroma, 2006). These peer networks act as a collaborative space for sharing, analysing and comparing knowledge (Kroma, 2006).

Ingram's (2010) study of farmer networks showed they were pivotal for the emergence of reduced tillage practices in England. Sligo and Massey (2007) found a similar array of benefits from inter-personal contact in dairy farmers' social networks in New Zealand, where access to a wider range of information sources led to knowledge creation, problem solving and risk reduction. Andrew (2003) demonstrated the strength of multi-stakeholder learning networks in regional producer networks in Australia in which stakeholders with a diverse range of research and on-farm experience were able to collaboratively learn about sustainability in grazing systems.

7.6.4 Constraints to learning

This current research similarly confirms that when collaborative learning is maximised and realised, sustainability learning is enhanced as was evidenced in the farming group-initiated projects. However, many outcomes from many of the partnerships were less than optimal and achieving sustainability outcomes in the projects could best be described as a ‘messy’ process.

In the shared partnerships and the science-initiated partnerships the messiness typically arose from actors’ epistemological differences, with scientists viewing themselves as the producers of objective and statistically robust explicit knowledge, while the farmer valued his/her implicit practical knowledge gained through lived experiences. These epistemological differences were most noticeable in the Wheat Calculator project (Section 5.2.2). The evidence from this project confirms Blackmore’s (2007) contention that learning challenges the notion of what knowledge is, as tensions arise over the ‘legitimacy’ of knowledge. The scientists in the Wheat Calculator were concerned that modification of the calculator’s interface to make it more user-friendly compromised the legitimacy of the underlying knowledge that had been gained through 20 years of research. To compromise this they perceived would reduce the robustness of the tool.

Figure 7.3 shows that collaborative learning is further constrained by institutional attributes that act to undermine the essence of the participatory process, a feature also observed in other academic studies (Andrew & Rowbottom, 2005; Murray, 2000; Webber & Ison, 1995). The empirical evidence from this research shows that constraints arise in the formal and informal institutions of all partners - policy, science and farming. They can include policy agencies’ preferences for quantitative measures of project outcomes, science institute pressures to produce publishable outputs, personal preferences of scientists that favour more reductionist approaches to research and privilege scientific knowledge, and competiveness and cultural protocols in farming sectors and communities that restrict knowledge sharing.

As Chapter 1 argued, to adequately address sustainability it must be viewed as a concept that is complex, multidimensional and interconnected. Figure 7.3 reveals that while project actors acknowledged the temporal dimensions of sustainability, there was limited recognition and understanding of agricultural externalities at the landscape level, with project learning instead focused on farm-level effects.

Landscape level problems are regarded as some of the most complex problems to address (Ridley, 2005; Sayer et al., 2013). Figure 7.3 identifies that projects need to have greater consideration and understanding of farming's place in, and its effects on the environment. Without this, the complexity of sustainability is denied. Understanding agricultural systems as complex systems acknowledges the uncertainty, non-linearity, emergence and scale of agricultural effects (Berkes et al., 2003; Murray, 2000; Stirzaker et al., 2010). To do this provides opportunity for adaptive learning, which is recognised as necessary to build capability and resilience in human and natural systems (Darnhofer et al., 2010; Holling & Gunderson, 2002; Stirzaker et al., 2011). As Holling argues (2001: 404):

> …the era of ecosystem management via incremental increases in efficiency is over. We are now in an era of transformation, in which ecosystem management must build and maintain ecological resilience as well as the social flexibility needed to cope, innovate, and adapt.

Adaptive approaches to environmental management challenge traditional approaches to agricultural research. Traditional approaches, often driven by scientific specialism, typically focus on reducing systems to their parts rather than investigating systems as a whole (Stirzaker et al., 2010). Such approaches constrain learning and limit landscape scale transformations that are now widely recognised as necessary for addressing sustainability (see Sayer et al., 2013).

7.6.5 Sustaining learning

Figure 7.3 identified that projects that seek to advance sustainability need to achieve as a characteristic sustained learning beyond the funded period of a project. Pretty (1995) argues that learning processes in participatory projects should seek to ensure action is sustained through building and strengthening local institutions so locals may initiate action themselves. The retrospective view of the projects in this investigation provided an opportunity to explore whether project learning was sustained.

In this research, farming group-initiated projects were the most likely to sustain learning beyond the funded period of the project. The shared partnerships had mixed results, while the science-initiated projects were the least successful at sustaining project learning. The coloured ranking system in Figure 7.3 provides insight about other factors that appear to affect the sustaining of project learning once the project ends.

The two farming group-initiated projects show that sustained learning is likely to occur when partnership attributes support collaboration, so that learning emerges from collaboration and the new knowledge and innovation that is created is co-developed. Project actors can independently experiment, as they did in both the Precision Agriculture and Walnut Blight projects, but they must collaboratively share this learning to co-develop new knowledge or understanding. The sustaining of project learning appeared most enabled where farming groups had the capacity and capability to support project extension so they could engage with their CoP in a transdisciplinary partnership as conceptualised in Figure 7.2d. LandWISE, WIG and FAR took active roles to maintain and sustain project knowledge through extension activities that began early in the project, long before 'final' results were known. As a result, their communities of practice were connected to the projects through strong feedback loops, so even though the CoP may not have been actively engaged in the project, they were still able to connect with it. Project objectives that were relevant to farming practice were most effective at both gaining and sustaining the farming community's interest.

Where farming groups did not have the capacity or capability to undertake extension, as was the case with ECOP in the Crop Science for Māori project, the learning appeared likely to only be sustained with the few growers that participated in the project. While the scientists engaged in extension activities to promote organic kumara production on the East Cape, these activities appeared to build limited capacity in the community. In this project, the focus on individuals limited wider social learning, and was further impeded by institutional barriers that restricted knowledge sharing.

In the science-initiated projects, limited collaborative learning meant actors were unable to learn from research failures and learning that was gained was readily discarded when a new crisis occurred. This was most noticeable in the Potato Aphid project when the sector faced an outbreak of disease from the potato psyllid (Section 6.4.2). The squash and potato sectors were also beset by sector competitiveness where knowledge was viewed for the competitive edge it provided to individuals rather than the collective wisdom it provided the sector.

7.7 Summary

The empirical evidence from the research revealed that formal and informal institutions, partnerships and relationships, knowledge integration and learning are critical and highly inter-related dynamics of participatory research projects. These components form the principal attributes of the PROCLE model presented in this chapter.

The PROCLE model reveals the collaborative learning space as an emergent property created by the strength of partner relationships and the effect of institutional structures and dynamics that together act to enable or disable innovation to advance sustainability. Challenging assumptions and values of current farming practice requires a productive and collaborative space for actors to share ideas, negotiate and engage. The PROCLE model shows when partnerships foster positive relationships, and supportive institutional structures and dynamics that enable co-development, deeper levels of learning around farming's place in and effect on the environment can be fostered in an emergent collaborative learning space to support and sustain both actor learning and a change towards more sustainable outcomes.

CHAPTER EIGHT

8.0 Conclusion

8.1 Introduction

The thesis' central question asked:

> How effectively does micro-level participatory research in the agricultural sector advance more sustainable farming practices in agricultural production systems?

To investigate this, the thesis proposed four focusing questions each concentrating on a specific area of enquiry that emerged from both the sustainability literature discussed in Chapter 1, and the participatory research and farming systems literatures jointly discussed in Chapter 2. These are:

- How do formal and informal institutions affect project partnerships and learning outcomes?
- How are partnerships articulated, formed and fostered in projects?
- How successfully is local and scientific knowledge co-produced in projects to foster innovations that advance agricultural sustainability?
- What effect (if any) does project learning have on actor understanding of the complexity of sustainability?

This final chapter begins by reflecting on these questions before reflecting on participatory research as a methodological approach for developing new knowledge and practice to advance sustainability in agricultural production systems. Finally the chapter reflects on the limitations of the research and proposes further investigation.

8.2 Reflecting on the thesis

8.2.1 Reflecting on the focusing questions

The four focusing questions consider institutions, partnerships and learning and the effect these have both on how participatory research is implemented and on the outcomes of participatory research projects to advance sustainability. The research's empirical evidence focused on *how* actors from science and farming supported by the funding sector created and implemented participatory partnerships to advance sustainability. The six investigated projects were all examples of participatory research partnerships, as they sought engagement of farmers and scientists in a 'participatory' partnership and used 'science' to develop innovations to advance sustainability. The variability both in the implementation of these participatory partnerships and their outcomes indicates that the simple participation of farmers and scientists in partnerships does not guarantee meaningful and durable outcomes for sustainability.

The focusing question relating to institutions (Chapter 4) investigated institutional dynamics that shape actors' visions for change. Multi-stakeholder engagement requires actors to have a shared vision and developing this to enable knowledge from divergent participants to be integrated into project decision-making is a recognised challenge (Allan et al., 2013; Parkhill et al., in press). It is particularly challenging in the area of sustainability, which draws on people's values and preferences about the type of world they wish to live in (Robinson, 2004).

The literature is relatively sparse on understanding how groups might develop shared visions and how such endeavours might manifest in practice. Shared visions or shared values, while recognised as not needing to be all encompassing (Parkhill et al., in press) help groups to understand why particular actions may be taken. Building resilience and capacity in communities by enabling them to self-organise, adapt and learn also supports these efforts (Adger, 2003; Davidson-Hunt & Berkes, 2003). These capabilities are essential for groups to address complex issues such as sustainability (Kates et al., 2005).

To explore the challenges around developing shared visions, the research explored actors' motivations for engaging in participatory research and their expectations of it. The empirical evidence revealed how formal and informal institutions shape actors' perceptions and narratives for engagement in participatory research. Participants bring to projects perceptions and narratives that have the potential to enable or disable the creation of a shared vision that is necessary for co-developing innovations towards sustainability. Of particular concern this research identified critical differences in expectations of participatory research between farming and science sector actors. In simple terms farming groups seek practical and farm relevant tools or knowledge that can be easily communicated, while scientists seek results from rigorous and robust scientific methodologies to fulfil institutional 'research' requirements and to meet the quantitative standards of statisticians and journal publications. The chapter discusses the importance of creating collaborative discursive spaces where project actors can share information, engage in dialogue and negotiate a shared vision. A further vital consideration emerged in this chapter: it is really important to instil appropriate principles and practices early in a project's lifecycle, and maintain commitment to these concerns throughout a project (and beyond).

Chapter 5 investigated the partnerships focusing question by using a novel approach to investigating partnerships according to the actor group that initiated the project. No research was found in the literature that had used this approach, although studies have investigated who sets the research agenda and advocated for multiple stakeholders being engaged in this process (Pretty, 1998). The empirical evidence showed the effect project initiators have both on shaping the research agenda through the project objectives, and importantly on the partner relationships themselves. Science-initiated projects in this research had the greatest difficulty fostering partner relationships and creating shared meaning through communication and negotiation activities, mainly due to these projects having a stronger focus on the science research itself.

The investigation of partnerships contributes to understanding the partnership / relationship nexus of participatory research, through its contention that the notion of partnerships must extend beyond a primary focus of it as a contractual entity. Conceptualizing partnerships instead as a relationship between actors who build shared understanding provides an enabling environment for collaborative learning.

This challenges the temporal boundaries of projects that are typically limited to the funded and contractual period of a 'partnership', which ignores the important temporal dimensions of sustainability having no end point.

The sustainability literature discussed in Chapter 2 claimed successful participatory partnerships ideally foster collaborative and collective enquiry through actors engaging in joint knowledge production. The final two focusing questions addressed knowledge production, integration and learning, specifically in the area of sustainability. Together these were investigated in Chapter 6, as learning is central to the thesis' main question. The empirical evidence shows that in projects where changes to farming practices are sought, the extent and durability of any change in farming practice depends on the depth of involvement of both the farmer and farming group in project design, implementation and knowledge dissemination.

The empirical evidence also led to the thesis proposing a 'feedback approach' to enable connection between project actors and communities of practice throughout and beyond the project timeframe. As Chapter 2 highlighted, it is widely agreed that top down approaches to agricultural research and extension are no longer appropriate. This has been especially evident since the late 1980s, when demand-driven research and extension was increasingly sought to replace publicly funded agricultural extension services (Klerkx et al., 2006). Despite this, two of the projects in this research still employed linear approaches. With no clear blueprint on how to undertake participatory projects, the research offers guidelines to assist practitioners to stimulate deeper levels of environmental learning and foster co-production and learning feedback loops (Tables 6.2 and 6.4). This applied contribution was explicitly sought in the thesis' objectives (Section 1.4.2).

The thesis contributes to understanding around knowledge integration and exchange by showing the effect that both linear and collaborative approaches have on learning outcomes. The research provides empirical evidence to support the contention that for environmental learning to meaningfully address the complexity of issues, actors must go beyond simple skills and information uptake and instead engage in a deeper understanding of issues to question the assumptions and values that drive current practice (Keen et al., 2005a). The participatory and social learning literatures contend that this learning requires double-loop and even triple-loop / multi-loop approaches to learning, rather than single-loop learning (Keen et al., 2005a; Medema et al., 2014). This research has focused on single- and double-loop learning at the micro-level – the "multi-party collaboration processes in which representatives from different stakeholder groups interact" (Medema et al., 2014: 27).

However in addressing the final focusing question about the complexity of sustainability, the research raises reservations about how effectively micro-level projects address the issue of complexity, as project learning remains largely focused on the paddock / farm scale typically with a primary focus on enhancing the farm business. The empirical evidence shows that this provides limited opportunities for engaging with landscape scale complexities that are now recognised to be critical for addressing impacts of agricultural practice beyond the farm gate (Sayer et al., 2013). This provides significant dilemmas for addressing sustainability whose spatial and temporal dimensions require looking beyond immediate and near impacts. Bruges and Smith (2008) even go so far as to question the expectation of policy goals that employ participatory approaches as a means to seek change towards sustainability, when learning is undermined by factors such as farmers' economic considerations. This research supports Bruges and Smith (2008) finding that a primary focus on economic considerations can undermine sustainability endeavours. However, it contends this can be moderated in a collaborative process of engagement built around strong partner relationships and institutional support that creates and maximises a collaborative learning space. The continued focus on the paddock/farm scale, however, reduces the realisation of learning within the space because it overlooks the spatial complexity of sustainability.

While Chapters 4, 5 and 6 individually contribute to understanding how institutions, partnerships and learning influence agricultural projects at the micro-level, of most importance is the research's understanding of the inter-relatedness of these project dynamics. This underpins the thesis' contribution to the wider understanding of participatory research and has universal relevance beyond the agricultural context of the investigated case studies. This understanding has led to the conceptualisation of the PROCLE model which revealed that the strength of partner relationships, as opposed to partnerships, and the effect of institutional dynamics create a collaborative learning space where the co-development of innovations for sustainability occur.

By exploring and conceptualising a collaborative learning space, the thesis builds on the existing intellectual foundations of a wide body of literatures, but most specifically the participatory and farming systems literatures. The thesis' contribution, derived from the PROCLE model and its application to the investigated projects, shows how institutional dynamics and relationships shape and potentially limit the collaborative learning space. The model rejects participatory approaches that seek to maximise participation without creating a collaborative learning space as these are unlikely to create much needed change to advance sustainability.

8.2.2 Reflecting on the central question

While the PROCLE model has universal relevance, the agricultural context of the thesis must not be under-valued. The thesis' central question focused on the effectiveness of participatory research endeavours in advancing agricultural sustainability. The findings advance understanding about the implementation of sustainability in the agricultural sector, by providing insights into collaborative learning in agricultural production systems that are recognised to be urgently needed (Pretty et al., 2010). Among 100 questions of importance for global agriculture that have been identified in a publication written by 55 experts, from 21 countries, across 45 leading agricultural organisations, professional scientific societies, NGOs and academic institutions, is a need to find the most effective models to bring farmers and scientists together. This collective voice across international agricultural sectors seeks not a singular vision but rather the most effective:

> …social learning and multi-stakeholder models to bring together farmers, researchers, advisors, commercial enterprises, policy makers and other key actors to develop better technologies and institutions….
>
> *(Pretty et al., 2010: 229)*

New Zealand's government is also keen to find ways to enhance economic and environmental performance in the primary sectors (PCE, 2004), and this was reinforced by policy actors who participated in this research (Section 4.2.2). There is also growing international interest in the 'innovativeness' of low and medium tech industries such as agriculture (Hirsch-Kreinsen, 2015 (March); Husted & Woodfield, 2015) and it is recognised that innovations, especially in agriculture, must not only be economically viable, they must also be socially and environmentally sustainable (Callaghan, 2009; Foley et al., 2011; Jones et al., 2013).

This thesis' findings about the effectiveness of micro-level participatory research projects to advance sustainability are both timely and relevant. The global urgency for advancing sustainable innovations in agriculture has seen actors from science, farming, government and academia form networks such as the Primary Innovation Network in New Zealand (Agresearch, online) to discuss ways to enhance sustainable agricultural innovation. Central to these discussions is a need to promote transdisciplinary partnerships to facilitate the co-development of sustainable innovations (Klerkx, 2015).

While participatory research is seen as central to this process, the variability of implementation and learning outcomes in the investigated projects in this research raises concerns about how effectively participatory partnerships can advance sustainability. While context will always shape how participatory projects operate (Reed, 2008), the principles of knowledge integration, equitable and trusting partnerships, and collaborative processes should be applied consistently across participatory endeavours. However, the empirical evidence from the research also shows that to cast participatory research aside would be a short sighted and foolish endeavour. Farming groups and scientists in this research did engage in productive and innovative projects to advance learning around sustainability and they did make measurable differences on the ground. To throw away participatory research in a production agriculture context would be equivalent to throwing the baby out with the bathwater.

While the participatory literature provides valuable reasons for the continued employment of participatory methodologies for addressing complex issues like sustainability, the empirical evidence from the six projects in this research suggest that in the context of production agriculture, participatory research needs to be reframed to sharpen its relevance and application in a production agriculture setting. This must incorporate effective engagement with agricultural innovation systems. Prospects for these developments are outlined in the following section.

8.3 Reframing participatory research to advance agricultural sustainability

8.3.1 Collaboration not participation

A project framed as 'participatory research' has the risk of 'participation' being placed at its core, with the potential to create what Ziegler and Ott (2011) claim is an adherence to the participation dogma, where participatory goals are satisfied merely through the inclusion of non-scientists *in* science research. While the collaborative learning space advocated in this research aligns with notions to democratise science (Gibbons, 1999; Lubchenco, 1998) it does not visualise non-scientists as citizen scientists (Irwin, 1995; Kruger & Shannon, 2000). Such framings are increasingly seen as a way forward to engage non-scientists as researchers in science to increase the profile of science and build support and understanding of science among non-scientists (Conrad & Hilchey, 2011; Rossiter, Liu, Carlisle, & Zhu, 2015). Citizen science initiatives risk being driven from the top down adhering to a belief that education will bring about public support for science, a notion advocated through the Public Understanding Model of Science (O'Connor et al., 2003).

Collaborative learning as conceptualised in the PROCLE model is not about non-scientists participating *in* science research, rather it is about non-scientists and scientists researching, collaborating and learning as equitable partners. Each partner brings their own knowledge to advance current understanding or to create new knowledge in an adaptive, emergent and dynamic way to meaningfully co-develop innovations that contribute towards advancing sustainability. The collaborative learning space is therefore optimised by scientists and non-scientists collaborating, not just participating, so a plurality of knowledges can inform learning and decision-making.

8.3.2 Learning not technology development

Interactive, collaborative, collective, adaptive learning spaces are required to address complex issues such as sustainability (Stirzaker et al., 2011). This research contends that participatory projects constructed to maximise a collaborative learning space place 'learning' at the centre of the collaboration.

By placing learning at the centre, actors are less likely to focus solely on technology development. A single-minded pursuit on technology/knowledge development treats sustainability as an end point, a trend increasingly seen in the corporate world (Ihlen & Roper, 2014) which denies the importance of the journey towards sustainability (Robinson, 2004). Learning to advance sustainability must be a dynamic, iterative and adaptive process that leads to concerted action that facilitates individual and collective learning (Section 2.3.2). The empirical evidence shows that the journey towards sustainability is best achieved through collaborative learning and engagement. Sustainability requires all participants to be engaged in problem definitions and solution development. When the collaborative learning space is maximised and the learning inside the space optimised (as was seen in the Precision Agriculture, Walnut Blight and latterly in the Wheat Calculator projects), environmental learning outcomes were advanced both among active project players and in the wider communities of practice. This research shows that when scientists and farmers collaboratively engaged, learning went well beyond the uptake of technology and resulted in changes in individuals and in farming sector practices. Furthermore, collaborative learning could be sustained beyond the funded period of project as was evident in the Wheat Calculator and Precision Agriculture projects.

8.3.3 Co-production not simply knowledge exchange

Worldviews that deny the fundamental importance of knowledge co-production are increasingly viewed as inappropriate and inadequate practice for addressing complex issues such as sustainability (Lane et al., 2010; Sewell et al., 2014). When actors believe that their knowledge and way of knowing is the only legitimate form of knowledge, this creates significant barriers to creating a shared vision. This research shows that unless these barriers are resolved through negotiation and compromise effective collaboration is impeded.

However, integrating multiple knowledges into projects to co-develop innovations presents significant challenges (Allan et al., 2013). The empirical evidence from this research shows that collaborative learning is further impeded where project objectives are heavily weighted towards science outcomes as these largely isolate farmers from the research. This has significant flow on effects to the farming sector's buy-in to a project, the subsequent farmer learning, (particularly if field trial results are inconclusive) and to the farming sector's ability to sustain project learning beyond the project's funded period. When actors co-develop and learn together, trial failures are seen as learning tools. In contrast when collaborative learning is impeded, trials that are perceived to have failed can lead to farmers questioning their continued support for science research.

Collaborative learning blurs the boundaries between different forms of knowledge. This research shows that to foster the necessary co-production of knowledge, actors need to have a mindset that is supportive of collaboration and knowledge co-production. Effective engagement requires partners to acknowledge and respect each other's knowledge and to facilitate the inclusion of these knowledges in project decision-making and the production of new knowledge. Furthermore, the institutions which shape how actors engage in participatory research endeavours, need to provide a supportive framework for collaboration and knowledge co-production.

8.3.4 Trandisciplinary not disciplinary

The PROCLE model views collaborative learning in a transdisciplinary environment where multiple actors problem-solve, innovate and mutually learn. Transdisciplinary partnerships are increasingly seen as important for addressing complex problems such as sustainability, as these partnerships allow actors from both inside and outside the science and technology system to collaborate and co-develop a shared vision (Lang et al., 2012).

For scientists, engaging with partners from outside science enables the values, knowledge, know-how and expertise from fields outside academic disciplinary boundaries to be incorporated into decision-making (Baars, 2011; Gibbons et al., 1994; Klein, 2015; Lubchenco, 1998; Polk, 2014). For farmers, engaging with scientists enables the values, knowledge, know-how and expertise from inside academic disciplinary boundaries to be incorporated into decision-making. This provides what Ingram (2008) calls the 'know why' of scientific understanding. Many of the farming participants in this research openly talked about the importance of understanding the why before they would consider implementing the 'how' of change to their farming practice (Section 6.2.3).

This research shows that a primary focus on science disciplinary knowledge limits collaboration and the opportunities for social interaction, engagement and dialogue. Such framings see farmers as passive observers of science research instead of active collaborators with scientists in research. Ziegler and Ott (2011) assert that the antidote to any bias in science will only ever come from outside the science sector as internal biases by their very nature largely go unnoticed by those on the inside. Scholars who emphasize the importance of enhancing communication and dialogic processes have long argued for partnerships to be built on foundations of equality, empathic listening and the creation of an environment that enables assumptions to be surfaced non-judgementally (Habermas, 1984-87; Yankelovich, 1999). As Yankelovich (1999: 220) claims, “You can argue with Einstein”.

Transdisciplinarity also leads to the potential inclusion of a wider pool of players, including actors from agri-business and recognition of the markets. The projects in this research had minimal engagement with actors from wider innovation systems. This has the potential to lead to a focus on technology development and most importantly it ignores the social systems in which agricultural production systems operate. Engagement with actors outside the science and technology sector is argued to enable innovations by exposing scientists to local knowledge, resources, capabilities and networks (Ziegler & Ott, 2011). The empirical evidence from this research shows that while participatory research was generally accepted as necessary by many of the actors, transdisciplinary partnerships were not strongly fostered at the micro-level (Figure 7.3).

8.3.5 Relationships not partnerships

The empirical evidence from this research shows that effective participatory partnerships must be built on a foundation of trust to enable farmers and scientists to learn together in a trusting and productive relationship. This will require a negotiation of ideas and for any misalignment of actors’ priorities, which are typically driven from epistemological differences, to be articulated and if possible reconciled. This was demonstrated in the Wheat Calculator project (Section 5.2.2). Supportive trusting relationships are necessary for facilitating shared visions. Projects in this research show that participatory partnerships need to go beyond contractual obligations of funding applications as partners engage in ‘relationships’. Partners must understand each other's expectations of the partnership. For example, partnerships in the Crop science for Māori project meant a long-term commitment and respect of cultural values.

Trust building even in more traditional farmer/scientist research relationships needed to be established before collaborative learning could take place. As this research shows, partner-trust building can take considerable time. Partners who had prior relationships began from a significant advantage and were able to engage in collaborative learning more quickly than those needing to establish relationships. Projects are typically visualised as beginning and ending according to the time frame of the funding. This framing denies not only the important temporal scale of sustainability but it also denies the social process of establishing relationships and building community capacity to sustain learning, both of which are not necessarily bounded by funding timeframes. Farming groups openly expressed the importance of building ongoing relationships with individual scientists who they trusted and who understood their needs.

This research shows that relationships form very early in projects, and that the tone of the relationship was affected by the group who initiated the partnership. Initiators shape project objectives and project relationships and this has very marked effects on actor learning and project outcomes. This research provides valuable insight into the partnership/relationship nexus. When partnerships are built on positive personal relationships, the collaborative learning space is maximised. A survey on Technology Transfer in New Zealand (MPI, 2012) revealed a concern among some farmers of a growing disconnect between the science and farming sectors. This research provides valuable insights as to the effects of this disconnect and the importance of relationship building as a way forward.

8.3.6 Reflexive not reflective

Transdisciplinary partnerships enable reflexive and deliberative learning processes (Polk, 2014; Popa et al., 2015) and therefore provide an enabling environment to break down inherent biases that are recognised to privilege science knowledge (Funtowicz & Ravetz, 1993; Klenk & Meehan, 2015; Ziegler & Ott, 2011). Reflexivity questions actions, values, and assumptions that shape current practice. It goes beyond the problem solving dimensions of reflection to instead question the underlying drivers of current practice (Bolton, 2010; Popa et al., 2015). Reflection looks backward while reflexivity helps people to look forward. The collaborative learning space is proposed in this thesis as a way of moving forward.

Viewing projects as reflexive environments creates a need to provide opportunities for reflexion. This is more likely to occur in discursive spaces where actors can collaborate, engage in dialogue, experiment and negotiate. Discursive spaces provide opportunities for actors to learn from each other and to integrate into decision-making the different actors' knowledges in projects (Leeuwis & Aarts, 2011).

The collaborative learning space as advocated in the PROCLE model manifests itself in discursive spaces that emerge from both formal and informal channels of communication. Actors may bring into the collaborative learning space knowledge, ideas, stories and experiences or they may co-construct knowledge, skills and stories through their social interactions with other actors within the space. Leeuwis and Aarts (2011: 27) have conceptualised this discursive environment where actors engage in communication as 'the space for change' (Figure 2.3). The PROCLE model's conceptualisation of the collaborative learning space provides the framework within which such discursive spaces or 'spaces for change' can occur.

However, the research shows that creating a shared vision is made more challenging by the differing motivations and expectations that actors bring to projects. Motivations can directly impede sustainability outcomes. For example when economic considerations were a primary driver of projects considered in this thesis, farmers were more likely to support research that addressed problems they could see, problems of immediate concern and problems where the solutions would increase farm profitability. The spatial and temporal dimensions of sustainability (Section 1.2.4) do not readily fit these criteria.

Reflexive spaces where actors can engage, experiment and negotiate have the greatest enabling environment for questioning assumptions and values that underlie current practice. The most effective spaces in this research were the informal, self-organised organic field gatherings evident in the Walnut Blight, Precision Agriculture and Crop Science for Māori projects where learning was iterative, emergent and adaptive. However, more formal spaces such as conferences could generate this same organic platform, particularly when they were farmer-led as occurred at the

LandWISE conference. Formal spaces such as project steering committees and science-led seminars for farmers were more limited as productive learning environments. Such 'top down' approaches engendered actor 'stereotypes' which inhibited the co-production of knowledge, particularly in the competitive farming sectors.

8.3.7 Systems thinking not reductionism

Farming lies at the interface of natural and social systems (Bawden, 1984; Pretty, 2006; Packham, 2011; Darnhofer et al., 2012). Implementing sustainability in agricultural contexts therefore requires acknowledgement of the multi-dimensional nature of the farming system, its complexity, and the interconnectedness of its social, economic, institutional and environmental contexts. To do this effectively requires systems thinking which recognises interconnections and requires "keeping the 'bigger picture in mind, even when the focus is on a specific aspect or sub-system" (Darnhofer et al., 2012: 7). The science-led projects in this research focused largely on technology development and in doing so ignored the social dynamics of co-produced enquiry which is deemed necessary for learning about sustainability (Robinson, 2004: 376).

Addressing sustainability must consider wider systems effects including the accumulative environmental effects of off-farm externalities. While micro-level research shows only limited attention to issues beyond the farm gate, integrated catchment studies do support multi-stakeholder engagement enabling understanding and recognition of catchment effects (Kilvington & Allen, 2007). Research in New Zealand has shown that multi-stakeholder experimentation in transdisciplinary partnerships can break down institutional barriers and lead to changes at both the catchment and the policy levels (Phillips et al., 2010).

Farmers' need for research that is relevant can bring with it an expectation of outcomes that will directly increase farm productivity and profitability. Such framings are problematic for sustainability where spatial dimensions require consideration of effects beyond the farm gate. An emphasis on farm scale effects, which was evident in all projects in this research, remains a significant impediment to systems thinking and furthermore to the up-scaling of learning to the catchment level. As others have also recognised, scale considerations should be a critical part of participatory research endeavours seeking to address sustainability (Snapp & Heong, 2003).

By engaging with the 'bigger picture' learning can go beyond single-loop to more double-loop approaches and may even lead to multi-loop learning (Medema et al., 2014), although this was not observed in the projects in this research. This thesis shows that where collaborative learning is impeded, learning remains single-loop which denies the multi-dimensional, complex and interconnected nature of sustainability. While collaborative learning provides the necessary pre-conditions for double-loop learning (Section 6.3.2), this research shows that considerable institutional impediments need to be overcome to foster deeper levels of learning. Impediments evident in the projects in this research included a focus on reductionist approaches to science investigation and economic drivers in farming sectors that pull agriculture into the productivist paradigm.

8.3.8 A 'feedback approach' to extension not technology transfer

Participatory projects also need to consider how learning by individuals who actively engage in projects is communicated to the wider communities of practice to enable learning to be scaled out (Douthwaite et al., 2003). When a 'feedback approach' was sought and utilised with communities of practice, projects remained connected and relevant to their community and reciprocal learning could occur through strong feedback loops.

Farming groups play a pivotal role in connecting projects with their members. This research shows that these communications are required to maintain the energy of project delivery during the funded period of a project and they are pivotal for sustaining project learning beyond the funded period. This was most noticeable in the farming groups that had a strong research focus and who actively engaged in the project, or who initiated and led the project. These groups challenge traditional research organisations by actively engaging in research. LandWISE, WIG and FAR all rejected the concept of 'technology transfer', which they saw as an out-dated linear approach to extension that was instigated in the final year of the project. Instead they embedded strong feedback loops in their projects from the beginning.

8.5 Limitations of the research and prospects for further investigation

8.5.1 Reflecting on limitations of the research

All six investigated projects were drawn from the horticultural sector within the wider New Zealand agricultural landscape. In some ways this was an advantage as having all the projects drawn from one sector helped to control project variability that may have been due to the sector of agriculture from which the project was drawn. In other respects it was a limitation as there is no indication of how the conclusions of the research may apply in other sectors of New Zealand agriculture. Even having one project included in the research from another sector may have provided a useful cross-sector reference point to see if similar patterns were exhibited in that project. However, the *within* sector project variability that was revealed in this research may have made the understanding and interpretation of *between* sector variability difficult without this having been an explicit objective of the research.

All six projects were also largely investigated retrospectively, although some direct observation of two projects in their later stages was possible. The limited participant observation that was undertaken did show how this part of the methodology very quickly enriched the researcher's understanding of the nuances of those projects. Not being able to undertake this in all projects was a limitation. The lack of opportunities for direct observation of the projects in action made understanding the projects a more laborious task.

Additionally, some projects had been completed a number of years prior to this research being initiated. This made it more difficult to locate project actors, some of whom had moved to new roles within the horticultural sector and some to new roles outside the sector. Those actors that were located and gave their project perspectives sometimes also had to make an effort to recall their experiences. This presents a potential source of bias as actor recollections from project involvement several years previously may not have been as detailed as recollections from a more recent project involvement.

Projects that had been completed prior to the initiation of this research also made the discovery of project documentation challenging. As all the projects had been partially captured by the Science for Community Change programme project documentation was available through this channel. Had this not been the case then the volume of documentary evidence that was available to this research may have been significantly reduced. The documentation that was available was unfortunately not evenly distributed or consistent between projects. This ‘patchiness’ was a limitation without which there would have been greater possibilities to triangulate the project data collected through participant interviews.

Members of farming groups, especially decision makers, also change as time passes. As this flux of personnel ebbs and flows over the years so potentially does the institutional memory of the farming group. This limitation is likely to be more acute in the smaller and less formally structured farming groups such as the Walnut Industry Group and especially the East Coast Organic Producers Trust, which was formed in a community with capacity and resilience constraints.

As noted in the discussion of the “ideal PROCLE model” it must be remembered that these types of participatory research projects sit within a wider contextual political, social, cultural or economic environment. This research did not attempt to investigate the linkages between the investigated projects and this background as the unit of analysis was focused on the micro-level. The research has identified the very strong influence of formal institutions on participatory research projects, particularly science institutions and it is a limitation that these influences were not able to be more deeply understood by directly investigating the culture of these institutions.

It has been noted in this thesis that the funding base of New Zealand science has continued to undergo evolutionary change and adjustments. As project funding is a very strong influencer of project dynamics it is a potential limitation of the conclusions of this research that the effect of these ongoing changes was not able to be investigated. It is conceivable that the findings of this research may never be able to be enacted if a funding regime was put in place that took a very prescriptive approach to the establishment and management of participatory research projects, especially if this was to be underpinned with a belief in the dogma of participation.

8.5.2 Reflections on further investigation

The PROCLE model is a proposed framework for participatory research projects that has been developed from the findings of this research. When projects are optimally arranged it is proposed that the collaborative learning space will be an emergent property of the framework and within this space lies the opportunities for project learning. Whereas this model has been developed from the retrospective investigation of six horticultural participatory research projects, an obvious opportunity for further investigation is to test the model by proactively applying it to a new participatory horticultural research project to investigate if the postulated emergent properties appear as expected and collaborative learning is indeed realised.

The PROCLE model demonstrates that learning in the collaborative space does need to be realised. Whereas the illustration of the model makes an attempt to acknowledge and represent realisation of both the project relationship and the collaborative learning space, this area could be further enhanced by a deeper investigation of discursive spaces.

Beyond horticulture, a further opportunity for research is to investigate the translation of the model and its properties to other farming systems within New Zealand agriculture, especially animal based farming systems such as sheep and beef farming, or dairying. This type of investigation will allow the claimed universality of the model to be tested and potentially improved as its grapples with the new challenges that would be expected in these very different types of production systems.

Whereas all six investigated projects had the commonality that they were obviously from within the sphere of agriculture, what is less obvious is that they also shared the commonality of being innovation projects. Just as it would be informative to investigate the application of the model within more diverse types of agricultural participatory research so it would be informative to investigate its application in diverse types of participatory innovation projects that were not agricultural but did focus on sustainability. These could include social enterprise type projects, such as waste management or community-based environmental projects that sought to undertake large spatial scale ecological management that is not centred on productive land uses.

8.6 Concluding remarks

This research's empirical evidence shows that for sustainability to be advanced a collaborative learning space needs to be created and maximised and the learning within that space needs to be optimised. Learning occurred best in discursive spaces where actors' visions emerged and evolved as they collaborated, negotiated, learnt and innovated together.

The collaborative learning space as revealed in the PROCLE model provides an enabling environment that fosters learning to support a movement towards sustainability. This is because the collaborative learning space as conceptualised in this thesis is centred on a reflexive process of multi-stakeholder learning that facilitates the co-production of knowledge that leads to innovation to advance sustainability in the agricultural sector.

Reframing participatory research in agricultural production systems reflects Klerkx's (2015) notion of an old wine in a new bottle. However, while not a u-turn in thinking, it nonetheless requires supportive institutional structures and dynamics. This will require changes in the science sector that have been recognised by others (Botha et al., 2014; Hunt et al., 2010 July 4-7; Rivera, 2011; Stirzaker et al., 2011; Ziegler & Ott, 2011). Sir Peter Gluckman (2009 November) New Zealand's Chief Science Advisor emphasised the need for a new approach to science, when he claimed,

> Science is no longer done when the paper is published. Rather, science is only done where there is a consensus between scientist and public, and that is not easy to achieve…Scientists have to spend more time learning to communicate across disciplines and between themselves and the public, and that means listening as well as telling. The age of the patronising scientist has gone.

Popa et al. (2015) argue that science will need to be informed by pragmatism at both the methodological and the organisational levels to challenge existing power structures and ingrained ways of knowing and doing. Tadaki et al. (2014: 1) similarly argue that scientists must cultivate "a critical disposition towards the situated partiality of our scientific practices."

Funding and policy agencies will also need to avoid a focus on simply maximizing participation and quantitative measures such as the number of outreach events and the number of attendees (Section 4.2.3). As Clever and Franks argue (2008: 162), policy needs to move away from "doing more and doing it better", towards "doing it differently". Such framings are argued to move policy away from incremental change (Gouais & Wach, 2013).

Furthermore, farming sectors will need to acknowledge the role that science can play in innovation and scientists will need to acknowledge the role that farmers' lived experience can play in enriching their research. In addition all actors will need to foster enhanced communication and engagement between players and eliminate sector competitiveness that limits knowledge sharing.

Project partners must move out of siloed environments and meaningfully and deeply engage in transdisciplinary partnerships with their project partners and their attendant communities of practise to foster collaborative learning to address complex issues such as sustainability. This will present enormous challenges as change is often met with significant resistance, particularly in the agricultural sector (Allen et al., 2002). As Callaghan (2009, online) notes, to engage in innovation:

> We need to resist our occasional little-mindedness, our parochialism, our tendency to divide amongst ourselves, our tendency to be suspicious of each other.

Moves towards agricultural sustainability require strong partnerships between science and farming communities and supportive formal and informal institutions. Seeking agreement between stakeholders about how to implement sustainability is a key challenge for participatory research. Reframing our current understanding of participatory research and conceptualising it as a collaborative learning space provides the opportunity for knowledge to be co-developed where learning is emergent, adaptive and dynamic and importantly is reflexive so that actors feel empowered to question and challenge their underlying values and practices. It is no longer a question of whether change is needed, it is a question of how best to facilitate the necessary changes. To recoil from this is to abandon the bleeding patient on the table.

Appendices

Appendix 1: Interview Participant Information

Participant No.	Project	Position in Project
R01L	Precision Agriculture	Manager, LandWISE
R01M	Crop Science for Māori	Project Communication and Extension
R02L	Precision Agriculture	Project coordinator, LandWISE
R03L	Precision Agriculture	Farmer, Horowhenua
R03S	Squash Rot project	Grower, Horowhenua
R03Wh	Wheat Calculator	Grower, Horowhenua
R04L	Precision Agriculture	Farmer, Hawkes Bay
R05L	Precision Agriculture	Farmer, Hawkes Bay
R06L	Precision Agriculture	Farmer, Hauraki Plains
R07M	Crop Science for Māori	Grower, East Cape
R08M	Crop Science for Māori	Grower, East Cape
R09M	Crop Science for Māori	Grower, East Cape
R10M	Crop Science for Māori	Science Technician, Hawkes Bay
R11M	Crop Science for Māori	Grower, East Cape
R12M	Crop Science for Māori	Grower, East Cape
R13M	Crop Science for Māori	Research Scientist, Hawkes Bay
R14M	Crop Science for Māori	Research Scientist, Hawkes Bay
R15M	Crop Science for Māori	Growers' Whanau, East Cape

Participant No.	Project	Position in Project
R16M	Crop Science for Māori	Growers’ Whanau, East Cape
R17M	Crop Science for Māori	Technical Institute Lecturer, Gisborne
R18M	Crop Science for Māori	Grower, East Cape
R19M	Crop Science for Māori	Radio Station, Ruatoria
R20M	Crop Science for Māori	Research Scientist, Hawkes Bay
R21M	Crop Science for Māori	Radio Station, Tolaga Bay
R22M	Crop Science for Māori	Grower, East Cape
R23M	Crop Science for Māori	Grower, East Cape
R24O	SFF	Project officer, Waikato
R25O	MAF	Policy, Wellington
R26O	MAF	Policy, Hawkes Bay
R27O	CRI Science Manager	Hawkes Bay
R28O	MAF	Policy, Waikato
R29O	SFF	Wellington
R30O	SFF	Wellington
R31P	Potato Aphid	Seed Potato Farmer, Mid Canterbury
R32P	Potato Aphid	Project Manager, South Canterbury
R33P	Potato Aphid	Research Scientist – Lincoln
R34P	Potato Aphid	Seed Potato Farmer, North Canterbury
R35P	Potato Aphid	Seed Potato Farmer, Mid Canterbury
R36P	Potato Aphid	Seed Merchant, Christchurch
R37P	Potato Aphid	Seed Potato Farmer, Mid Canterbury
R38P	Potato Aphid	Table/Process Potato Farmer, Mid Canterbury
R39P	Potato Aphid	Seed Potato Farmer, Mid Canterbury
R40P	Potato Aphid	Industry Group Manager, HortNZ, Wellington

Participant No.	Project	Position in Project
R41P	Potato Aphid	Seed Potato Farmer, Mid Canterbury
R42P	Potato Aphid	Seed Potato Farmer, Mid Canterbury
R43P	Potato Aphid	Research Scientist, Lincoln
R44P	Potato Aphid	Seed Potato Farmer, Mid Canterbury
R45P	Potato Aphid	Horticultural Industry Spokesperson, HortNZ
R46S	Squash Rot	Grower representative, Hawkes Bay
R47S	Squash Rot	Industry science advisor, Auckland
R48S	Squash Rot	Research Scientist, Hawkes Bay
R48L	Precision Agriculture	Research Scientist/Science Advisor, Hawkes Bay
R48Wh	Wheat Calculator	Research Scientist, Hawkes Bay
R49S	Squash Rot	Grower representative, Hawkes Bay
R50S	Squash Rot	Grower / packhouse owner, Gisborne
R51S	Squash Rot	Industry Manager, HortNZ, Wellington
R52S	Squash Rot	Project Manager, Hawkes Bay
R53S	Squash Rot	Research Scientist, Manawatu
R54Wa	Walnut Blight	Grower, Canterbury
R55Wa	Walnut Blight	Grower, Canterbury
R56Wa	Walnut Blight	Grower, Canterbury
R57Wa	Walnut Blight	Grower, Canterbury
R58Wa	Walnut Blight	Grower, Canterbury
R59Wa	Walnut Blight	Grower, Canterbury
R60Wa	Walnut Blight	Grower, Canterbury
R61Wa	Walnut Blight	Grower, Canterbury
R62Wa	Walnut Blight	Grower, Canterbury
R63Wa	Walnut Blight	Grower, Canterbury

Participant No.	Project	Position in Project
R64Wa	Walnut Blight	Grower, Canterbury
R65Wa	Walnut Blight	Research Scientist, Lincoln
R66Wa	Walnut Blight	Research Scientist, Lincoln
R67Wh	Wheat Calculator	Farming Group employee, Hawkes Bay
R68Wh	Wheat Calculator	Farming Group employee, Canterbury
R69Wh	Wheat Calculator	Farming Group employee, Hawkes Bay
R69O	SFF	Past SFF Officer
R70Wh	Wheat Calculator	Farmer, Manawatu
R70L	Precision Agriculture	LandWISE farmer, Manawatu
R71Wh	Wheat Calculator	Farmer, Mid Canterbury
R72Wh	Wheat Calculator	Farmer, Mid Canterbury
R73Wh	Wheat Calculator	Baker, Huntly
R74Wh	Wheat Calculator	Miller, Mid Canterbury
R75Wh	Wheat Calculator	FAR Manager, Lincoln
R76Wh	Wheat Calculator	Research Scientist, Lincoln
R77Wh	Wheat Calculator	Farming Group employee, Lincoln
R78Wh	Wheat Calculator	Farmer, Mid Canterbury
R79Wh	Wheat Calculator	Field Technician, Lincoln
R80Wh	Wheat Calculator	Grower / United Wheat Grower representative, Canterbury
Informal Interviews (Brief Notes)		
R81Wh	Wheat Calculator	Farmer (Canterbury)
R82L	Precision Agriculture	Farmer, South Auckland, LandWISE conference presentation
R83L	Precision Agriculture	Farmer, South Auckland, LandWISE conference presentation
R84Wh	Wheat Calculator	Farmer, Hawkes Bay, LandWISE conference

Appendix 2: Project realisation and optimisation of learning for sustainability

To undertake a comparative assessment of the projects from which Table 7.1-7.6 and Figure 7.3 were compiled, the following twelve criteria were qualitatively evaluated for each project.

Partnership attributes

- Farming relevance of objectives
- Collaborative project governance
- Mindset of (farming/science) actors towards participatory research
- Positive actor relationships
- Networking and feedback loops in project

Institutional attributes

- Institutional support for participatory research
- Funding security of project including beyond funded period of project

Learning Attributes

- Partners co-develop
- Learning sustained beyond project
- Transdisciplinarity
- Sustainability learning -Temporal /
- Sustainability learning -Temporal

The information presented below for each project, has been drawn from the research's dataset sourced from stakeholder interviews, participant observations and a broad overview of project literature as outlined in the methodology presented in Chapter 3. Much of this information has formed the discussion in Chapters 4, 5 and 6.

Precision Agriculture - LandWISE

Farming relevance of objectives

- Directly relevant to farmers needs so has immediate application
- Strong farmer buy-in

Project governance

- Bottom-up
- Membership support paid staff (to act as project coordinators)
- Receptive to grassroots membership
- Farming group facilitated projects – the group oversees project and sustains project learning even beyond funded period
- Anyone who wants to participate in projects can

Mindset of actors towards participatory research

- Research focus of farming group - understand science as a development tool
- 'Programme' approach to research, so that projects feed into larger programme
- Scientists willing to engage in collaborative endeavours – although feel their input is limited when confined to data analysis and advisory roles
- Highly connected and resourceful membership base – strong social conscience

Project actor relationships

- Long term established relationships with scientists who they contract for project
- Scientists on LandWISE board
- Positive relationships amongst project participants
- Farmer participants include the "willing" – don't involve those who don't listen

Networking and feedback loops

- Strong feedback loops from project to CoP
- Extension embedded into project from the outset
- Multiple communication channels support wider interaction with CoP– conferences, field-days, workshops, website, literature.
- Email communication extends well beyond paid membership
- Established networks with actors in wider innovation system including funders and policymakers

Institutional support for participatory research

- Develop proactive and positive long-term relationships with scientists

- Positive inter-personal relationships among all project actors
- Use of lead farmers in projects and farmer mentors
- Farmers act as project champions
- Farmers, scientists, other innovation actors on farming group board
- Difficulties in innovation system esp. contractors wanting to protect their turf.

Funding security

- Vulnerable to fluctuations in funding and bias in funding that limits 'repeated' project applications –inhibits continuation of work
- Small, voluntary membership – variable funding base
- Dependent on sponsorship / grants

Partner co-development

- Farming group-initiated project - set objectives, developed research design and implemented programme
- Learning by doing approach
- Farmer-led trials
- Conference provides critical reflection of projects - Openly learn from failures
- Produced publication "Smart farming" (Bloomer & Powrie 2011) co-authored with a range of LandWISE partners to communicate trial results

Transdisciplinarity

- Farming group led research largely follows agenda of who initiates project
- Farming group undertakes significant independent research
- Scientists often only contracted as advisors or data analysts

Sustainability learning (temporal / spatial scale of sustainability focus)

- Short to medium term
- Trial = paddock/farm focus with less attention to landscape level
- However work contributes to understanding around soil erosion particularly in the Hawkes Bay

Learning sustained – post project

- LandWISE sustains project learning – institutional memory
- Strong outreach through communication channels
- Supports small number of staff
- Engaged in extensive extensive ' extension work' – e.g.workshops, field days.
- Website –extensive farming resource

Wheat Calculator – Foundation for Arable Research

Farming relevance of objectives

- Relevant to farmers needs - increases profitability / manages regulatory control
- Interface needed to be significantly modified to be useful
- Strong buy-in from FAR, but needed extensive 'extension' to gain sector buy-in

Project governance

- Bottom-up governance
- Levy supports strong number of staff (act as project coordinators)
- Group oversaw project and sustained project learning

Mindset of actors towards participatory research

- Group established with a strong research focus
- Understand science as a development tool
- Group acts as an independent voice /arbiter of trials
- Scientists initially used linear model (rejected farmers input to calculator design)

Project actor relationships

- Significant tensions in the early stages – clash between evidence-based research and lived experience of farmers
- Once resolved very positive relationships
- Scientists had limited understanding of how farmers managed their wheat crops
- Technician managed relationship between farmers and scientists acted as facilitator – boundary crosser

Networking and feedback loops

- Strong feedback loops from project to CoP and vice versa
- Multiple communication channels support wider interaction with CoP– conferences, field-days, website, literature
- Encountered problem when reps were incorrectly using calculator and poorly advising farmers. Had not initially included them in extension
- Use of champion farmers in projects and farmer mentors

Institutional support for participatory research

- Developed proactive and long-term relationships with scientists
- Farmers act as project champions
- FAR and science providers both positioned in Lincoln

- Some wider innovation chain actors not outwardly supportive of calculator – very strong economic focus
- Power structure of contract arrangements

Funding security

- Levy funded so relatively stable funding source
- Uses levy to leverage funds from government funds like SFF

Partner co-development

- Pilot project undertaken by scientists on farmers land to examine and quantify the effects of arable and vegetable cropping practices on nitrate leaching to gain specific local data to develop a prototype wheat calculator
- Shared partnership - wheat calculator project followed the pilot – farming group engaged in setting objectives and co-developing research design

Transdisciplinarity

- Initial epistemological differences between scientist and farming group needed to be resolved
- Increasingly employing scientists as contractors for components of research in FAR managed projects
- Underlying model was a science research tool so not co-developed- scientists had strong sense of ownership

Sustainability learning (temporal / spatial scale of sustainability)

- Short to medium term
- Paddock/farm focus with less attention to landscape level changes
- Technology had strong economic appeal around use of fertilizer and irrigation
- Proactive move by farming group to address regional council concern over nitrate leaching
- Difficult to gauge uptake of technology as no objective quantitative measures, but reported to have bought about noticeable changes in farming practice

Learning sustained – post project

- FAR sustains project learning – institutional memory
- Use of technology decreased over time
- Software installation required
- Software dependent so vulnerable to platform updates
- Confusion over ownership of the calculator given CFR owned the underlying model – who would maintain /pay for updates?

Walnut Blight – Walnut Industry Group

Farming relevance of objectives

- Mixture of fundamental science research with applied research that was immediately relevant to farmers needs
- Strong sector buy-in – although tensions emerging over the need to refocus research away from science towards production and market research as walnuts increasingly moving to production (takes 12 years for trees to mature to be fully productive)

Project governance

- Bottom-up
- Science research overseen by research and development committee members, who have research and funding application experience – this drives the group
- Farming group facilitated projects – the R & D committee oversees project

Mindset of actors towards participatory research

- Farming group understand science as a development tool
- Group established with a strong research focus
- Scientists willing to engage in collaborative endeavours and very aware of uniqueness of small industry group and characteristics of walnut growers

Project actor relationships

- Positive relationships built with all project actors
- Work undertaken in a collegial approach to research
- Scientists contracted to group, but the group builds strong positive relationships with scientists

Networking and feedback loops

- Strong feedback loops from project to CoP and vice versa
- Multiple communication channels support wider interaction with CoP– conferences, field-days, website, literature and particularly the walnut grower's manual which is a collection of learning from the group's experimental work

Institutional support for participatory research

- Developed proactive and positive long-term relationship with scientists
- Research and development committee take mentoring role in farming group
- R & D committee members with expertise to write funding applications

Funding security

- Vulnerable to fluctuations in funding –inhibits continuation of work
- Small, voluntary membership – variable funding base
- Small income from voluntary levy placed on sale of walnut shoots

Partner co-development

- Farming group-initiated project - set objectives, developed research design and implemented programme
- Learning by doing approach
- Farmer-led trial
- Stayed connected with science components of research

Transdisciplinary research

- Farming group led research so largely follows agenda of the group
- Increasingly employ scientists as contractors for components of research which the group manages
- PhD research group funded into bacteriophage research was problematic as too theoretical (different audience to farmers)

Sustainability learning (temporal / spatial scale of sustainability)

- Short to medium term
- Orchard focus

Learning sustained – post project

- WIG sustains learning from projects – institutional memory
- WIG growers manual contains project results
- Fundamental science research undertaken with bacteriophage research was not able to be successfully transferred to orchard research, unlikely to have future benefit to farmers without further fundamental research and significant funding

Crop Science for Māori – East Coast Organic Producers Trust

Relevance of objectives to growers

- Directly relevant – sought to transition Māori community from extensive agriculture to intensive horticulture
- Programme was designed with community involvement
- Programme designed to be sensitive to community's cultural values & protocols

Project governance

- Collaborative engagement but scientists managed the project and project funds
- ECOP membership significantly smaller than first thought
- ECOP – vulnerable organisation – largely dependent on the energy of a few people and availability of funding. Unstable long-term governance

Mindset of farming group towards participatory research

- Explicit participatory research approach
- Differing worldviews between Māori and Western science presented significant challenges for community and scientists alike e.g tikanga protocols for scientists
- Scientists needed to be sensitive and receptive to Mātauranga Māori
- Worked in a community less familiar with science as a development tool

Project actor relationships

- High levels of trust-building required to overcome community's historical experiences of working with researchers
- Science-grower relationships moved from professional to personal over time
- Scientists engaged deeply in community e.g food festivals to promote organic produce, Easter walk to summit of Mt Hikurangi

Networking and feedback loops

- Regular workshops enabled community to engage with wide range of specialists
- Multiple communication channels supported wider interaction with East Cape community–e-newsletter, festivals, literature, Māori kumara growing calendar
- Scientists take lead 'extension' role to assist group to develop crop knowledge
- Field excursions to Napier to visit wholesaler
- Funded excursion for community members to overseas conferences to network
- Engagement with chefs
- Engagement with wider Cape community through festivals
- Individual grower focus of knowledge –therefore limited spread of influence

Institutional support for participatory research

- Scientists developed a programme of education workshops to disseminate cropping knowledge, the class-room based style needed to be teaching was replaced by a mixture of class room combined with informal field excursions
- Use of kaumatua to introduce scientists to the community
- Use of Māori field technician to maintain connection when scientists away
- No cool store – remained a significant concern throughout project
- Isolation of East Cape made produce transportation to market difficult
- Challenge aligning project to corporate requirements
- Professional difficulties for scientists engaged in community-based research
- Communication impediments to knowledge sharing across marae
- Cultural protocols limited use of female mentors

Funding security

- Fully funded by research grants
- Secure only while funding available

Partner co-development

- Shared partnership – SCC programme developed by funder (FRST) and Crop and Food Research, but project objectives collaboratively set with community.
- Community workshops openly discussed and assessed project milestones
- Epistemological differences – emerged over the weather stations - poor quality / non-web based tool / worked on dialup so slow / produced large quantities of data / relied on electricity when some of the growers did not have access to this
- Community engaged in teaching the scientists “tikanga” –project therefore involved significant two-way learning
- Māori Calendar an example of collaborative endeavour that sought to make project relevant to the growers
- Collaborative science/community workshop at Wellington geography conference

Transdisciplinary research

- Interdisciplinary research - Combined both social and physical sciences in participatory research
- Collaborative science/social science papers published
- Sought to recognise and embody into the programme local and traditional/cultural forms of knowledge

Sustainability learning (temporal / spatial scale of sustainability)

- Medium term to long term- sought to embed knowledge in community
- No quantitative measure taken on hectares in crop before start of project as comparative measure for post project

Learning sustained – post project

- Learning largely contained in project individuals
- ECOP has limited capability/capacity to sustain learning

Potato Blight – Potatoes New Zealand

Farming relevance of objectives

- Recognised concern by farming group and scientists of pesticide resistance.
- Wider farming sector buy-in/acceptance was low
- Tensions developed between some farmers and scientists over concerns over the project's relevance

Project governance

- Project committee established with industry person (from potato processing industry) as project manager
- Committee meetings 6/12-monthly – had two farmers as representatives on committee – although they did not always attend meeting
- Farming group had minimal involvement with research – wanted tool to "extend" to their sector

Mindset of actors towards participatory research

- Contribute only a small percentage of levy funds to research
- Farming Group was aware of science as a development tool but strong economic focus – market focused / price sensitive industry
- Farming Group has research and development sub-committee – post project-research must now be relevant to farmers, and always farmer initiated
- Scientists aligned more with TOT model – do the science done to get the extension out

Project actor relationships

- Professional relationship between researchers and farmers
- Positive relationship with project manager
- Personality conflicts arose between science and farming participants

Networking and feedback loops

- Competitive industry
- For seed potato growers contracts to wholesalers determine loyalties
- Scientists published science papers from research
- Publication for growers magazine

Institutional support for participatory research

- Minimal field engagement between scientists and farmers

- Those who had traps on their property did engage in dialogue sometimes when scientist visited property
- Formal ‘science’ seminars used to disseminate information about project
- Formal structures – actors revert to type-set (stereotypes)

Funding security

- Levy funded organisation. Only small percentage goes to towards science research
- Science research dependent on public funding

Partner co-development

- Scientists initiated partnership
- Scientists set objectives and research design
- Development of tool – was to be followed by extension to farmers
- Undertaken by project committee that complied with SFF requirements
- Farmers concerns (e.g reliability of data) not integrated into project evaluation
- Technical difficulties of managing traps
- Speed of trap analysis was problematic – “if I see aphids I have a problem”

Transdisciplinary research

- Disciplinary science research

Sustainability learning (temporal / spatial scale of sustainability focus)

- Largely short term – immediate focus, what I can see
- Individual grower focus of knowledge – limited spread of influence
- Strong economic drivers

Learning sustained – post project

- Farming group involved with initial outreach
- Easily discarded learning with new crisis – potato psyllid disease
- Concern over lack of structural support post project

Squash Rot – Squash Industry Group

Farming relevance of objectives

- Farming group required considerable ‘persuasion’ to join project
- Low buy-in – no financial input from farming group (in-kind only)
- Tool was most relevant to pack house operators
- Largely self-motivated interest for joining project – for all actors

Project governance

- Project committee established with industry actor as project manager
- Committee had pack house representatives from four of the large packhouses
- Farming group had minimal involvement with research – wanted tool to “extend” to their sector
- Farmers involvement more logistical oversight to tie project into farming operations. Mindset of actors towards participatory research
- Historically strong support of science research but this had changed and now farming group and primary market research focus
- Following project – suspended all group science support
- Scientists – driven by the science in the project but did recognise need to involve group in logistics

Project actor relationships

- Professional relationship between researchers and farmers
- Relationships largely Managed through steering committee
- Historical tensions between industry players – limited free flow of information
- No go areas in dialogue

Networking and feedback loops

- Depended on tool to be produced by scientists before any significant feedback between project and CoP

Institutional support for participatory research

- Historical tensions between industry players – limited free flow of information
- Increasing tensions between science and farming group – driven by farming groups move away from science research
- Individualistic competitive industry
- Power structures of contract arrangements
- High risk/high stake industry

Funding security

- Levy funded farming-group
- Farming group chose not to support further project funding post initial period

Partner co-development

- Science-initiated partnership
- Scientists set objectives and research design
- Development of farm tool (predictor – was to be followed by extension to farmers
- Farming partners engaged only in coordinating research with farm logistics

Transdisciplinary research

- Disciplinary science research

Sustainability learning (temporal / spatial scale of sustainability focus)

- Largely short term – immediate focus, what I can see
- Individual grower focus of knowledge – limited spread of influence
- Strong economic drivers

Learning sustained – post project

- Only science outcomes
- No tool produced
- Some evidence that one individual project member may have continued to investigate rot privately but this was done for personal gain and results are not known

Appendix 3: Participant Information and Consent Form

01 April 2007

Dear Participant,

Re: An interview for the purposes of researching 'Communicating Science for Sustainable Land Management'.

My name is Marie McEntee. I am a postgraduate student at The University of Auckland undertaking research for a PhD, in the School of Geography, Geology and Environmental Science (SGGES). I am conducting this research for my thesis on 'Communicating Science for Sustainable Land Management'. My research is part of a wider programme – Science for Community Change, which is funded by the Foundation for Research into Science and Technology. This programme examines six crop production systems in New Zealand, to assess the capacity of agricultural industries and communities to develop and implement technological innovations so they are more resilient, profitable and environmentally sustainable.

My research will focus on the relationship between the stakeholders within each of the production systems. It aims to:

- Gain a deeper understanding of the similarities and differences between farmers and scientists in their perceptions of science, technology and sustainability;

- Examine formal and informal networks that enable communities to act together to bring about shared objectives to support the application of science for sustainable land use;

- Provide a framework to enable more effective communication between scientists and farmers;

- Identify generic principles that will facilitate greater alignment of the multiple objectives of all participants involved in sustainable land management projects.

I am writing to ask if you would assist my research by participating in an interview regarding your experiences in one of the production systems being examined in this research. To help me build a profile of each production system, I would like to discuss, with your agreement, your experience in this crop production system and your perception of the role science plays in bringing about sustainable land management. An interview will take about an hour and I would arrange this for a time convenient to you.

I would like to tape the interview but this would only be done with your consent. Even with your consent, the tape could be turned off at any time. You may also withdraw your participation at any time during the interview. Interview tapes will only be available to myself and will be kept in a secure cupboard in my locked office in the School of Geography, Geology and Environmental Science at The University of Auckland. They will be destroyed immediately after my PhD thesis is submitted.

It is not my intention to make full transcripts of the tapes, however if you are interested I will send you a list of quotes from your interview that I may include in my research. This will provide you with an opportunity to make changes to your comments. Should you wish to withdraw any of your interview comments, you may do so anytime up until December 31st 2010.

Your name will not be used in the research, unless you expressly agree to have information attributed to you. If you wish your confidentiality to be maintained, I will ensure that collected information will not be reported or published in a way that will identify you as a source. I will only refer to you by your general professional position e.g scientist, farmer, community member or manager.

If you agree to my request for an interview, please complete the attached consent form and return it to me in the self addressed envelope provided. Alternatively, if you would like more details, you may phone me on 09-3737599 extn 82499.

At the completion of my study a copy of the summary of findings of this research will be made available to you if you would like this.

Thank you for considering my request. I hope that you are able to assist me with my research as I believe your comments will provide valuable insights.

Yours sincerely

Marie McEntee

Contact Information

Researcher:	Marie McEntee School of Geography, Geology and Environmental Science The University of Auckland Private Bag 92019, Auckland Tel. 09-3737599 ext 82499 E-mail: m.mcentee@auckland.ac.nz
Research Supervisor/ SGGES Acting Director:	Assoc Professor Willie Smith School of Geography, Geology and Environmental Science The University of Auckland Private Bag 92019 Auckland. Tel. 09-3737599 extn.85284 Email: w.smith@auckland.ac.nz

If you have any concerns of an ethical nature you can contact the Chair of the University of Auckland Human Participants Ethics Committee at 373-7599 extn. 87830

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE on .... for a period of .... years, from ..../..../.... Reference ..../..........

THIS CONSENT FORM WILL BE HELD FOR A PERIOD OF SIX YEARS

Title: ''Sustaining Sustainability:
Examining social learning in agricultural extension'"

Researcher: Marie McEntee

Participant Consent Form

I agree to take part in this research.

I have been given and have understood an explanation of this research project. I have had an opportunity to ask questions and have them answered.

I understand that I may withdraw myself or any information traceable to me, at any time up to 31/3/2010, without giving a reason.

I understand that if I agree to audio-recording, that the tapes will be stored in an secure room and destroyed immediately after the researchers PhD thesis has been submitted.

I understand that my name will be kept confidential unless I give permission for it to be used.

- I wish my identity to be kept confidential. **Yes / No**
- I **agree / do not agree** that the interview will be audio-recorded.
- I **wish / do not wish** to receive a copy of the quotes from my interview that maybe used in the research.
- I **wish / do not wish** to receive a summary of the research findings

Signed:

Name:
(please print clearly)

Date:

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE on 18 April 2007 for a period of three years, from 18/4/07 Reference 2007/095

References

Adger, W. N. (2003). Social Capital, Collective Action and Adaptation to Climate Change. *Economic Geography, 79*(4), 387-404.

Aitken, A., & Hewett, E. (2013). *Fresh Facts 2013*. Auckland, NZ: Martech Consulting Group.

Allan, C., Nguyen, T. P. L., Seddaiu, G., Wilson, B., & Roggero, P. P. (2013). Integrating local knowledge with experimental research: case studies on managing cropping systems in Italy and Australia. *Italian Journal of Agronomy, 8*(2), 15. doi:10.4081/ija.2013.e15

Allen, W. (1998). Towards improving the role of evaluation within natural resource management RD programs: the case for learning by doing. *Canadian Journal of Development Studies*(Special Issue XVIII on Results-based Evaluation), 629-643.

Allen, W., Du Plessis, R., Kilvington, M., Tipene-Matua, B., & Winstanley, A. (2003). *Involving the Public in Science and Technology Decision-Making: A Review of National Initiatives*. Retrieved from Wellington, NZ:

Allen, W., Horn, C., & McEntee, M. J. (2010 Nov). *The Science of Uptake: The Uptake of Science.* . Paper presented at the Presentation to the MAF Biosecurity Science Advisory Group, Wellington, NZ.

Allen, W., Kilvington, M., Nixon, C., & Yeabsley, J. (2002). *Sustainable Development Extension*. Retrieved from Wellington, NZ:

Allen, W., Kilvington, M., Oliver, J., & Gilbert, M. (2001). Benefits of Collaborative Learning for Environmental Management: Applying the Integrated Systems Knowledge Management Approach to Support Animal Pest Control. *Environmental Management, 27*(2), 215-223.

Allen, W., Phillips, C., & Fenemor, A. (2010). *Integrated Catchment Management: EIANZ*. http://icm.landcareresearch.co.nz/knowledgebase/publications/public/EIANZ_2010_final.pdf

Ameur, C. (1994). *Agricultural Extension: A step beyond the next step*. Washington, D.C: The World Bank.

Andrew, J. (2003). Key features of the regional producer network for enabling social learning. *Australian Journal of Experimental Agriculture, 43*, 1015-1029.

Andrew, J., & Rowbottom, I. (2005). Communities' Self-determination: Whose Interests Count? In M. Keen, V. A. Brown, & R. Dyball (Eds.), *Social Learning in Environmental Management* (pp. 63-77). London: Earthscan.

Aras, G., & Crowther, D. (2013). Sustainable Practice: The Real Triple Bottom Line. In D. Crowther & G. Aras (Eds.), *The Governance of Risk (Developments in Corporate Governance and Responsibility, Volume 5)* (pp. 1-18): Emerald Publishing Group.

Argyris, C. (1999). *On Organizational Learning* (2nd ed.). Malden, Massachusetts: Blackwell.

Argyris, C., & Schon, D. (1978). *Organizational Learning: A theory of action perspective*. San Francisco: Jossey-Bass.

Arnstein, S. R. (1969). A Ladder of Citizen Participation. *Journal of the American Institute of Planners, 35*, 216-224.

Baars, T. (2011). Experiential Science; Towards an Integration of Implicit and Reflected Practitioner-Expert Knowledge in the Scientific Development of Organic Farming. *Journal of Agriculture and Environmental Ethics*, 24(6), 601-628.

Balint, P. J., & Mashinya, J. (2006). The decline of a model community-based conservation project: Governance, capacity, and devolution in Mahenye, Zimbabwe. *Geoforum, 37*, 805-815.

Banks, S., Armstrong, A., Carter, K., Graham, H., Hayward, P., Henry, A., . . . Strachan, A. (2013). Everyday ethics in community-based participatory research. *Contemporary Social Science, 8*(3), 263-277. doi:10.1080/21582041.2013.769618

Barbour, R. (2001). Checklists for improving roigour in qualitative research: a case of the tail wagging the dog? *BMJ, 322*, 1115-1117.

Barr, N., & Carey, J. (2000). *Influencing improved natural resource management on farms: Understanding factors influencing the adoption of sustainable resource practices*. Canberra, Australia: Social Sciences Centre, Bureau of Rural studies.

Bawden, R. (2010). Ethics and Agricultural Science: A worldview challenge. *Journal of the Australian Association for Agricultural Science and Technology, 23*(3), 19-22.

Bawden, R., Macdam, R., Packham, R., & Valentine, I. (1984). Systems thinking in the education of agriculturalists. *Agricultural Systems, 13*, 205-225.

Baxter, J. (2010). Case studies in qualitative research. In I. Hay (Ed.), *Qualitative Research Methods in Human Geography* (3rd ed.). Ontario, Canada: Oxford University Press.

Beck, U. (1992). *Risk Society: Towards a new modernity*. New Delhi: Sage.

Bendassolli, P. (2013). Theory Building in Qualitative Research: Reconsidering the Problem of Induction. *FQS, 14*(1 Art 25), online.

Berger, P., & Luckman, L. (1991). *The Social Construction of Reality: A treatise in the sociology of knowledge*. London, England: Penguin Books.

Bergmans, A. (2008). Meaningful communication among experts and affected citizens on risk: challenge or impossibility. *Journal of Risk Research, 11*(1-2), 175-193.

Berkes, F., Colding, J., & Folke, C. (2003). Introduction. In F. Berkes, J. Colding, & C. Folke (Eds.), *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change* (pp. 1-29). Cambridge: Cambridge University Press.

Bicker, A., Sillitoe, P., & Pottier, J. (Eds.). (2004). *Investigating local knowledge: new directions, new approaches*. Aldershot, Hants England: Ashgate.

Bidwell, R. D., & Ryan, C. M. (2006). Collaborative Partnership Design: The Implications of Organizational Affiliation for Watershed Partnerships. *Society & Natural Resources, 19*(9), 827-843. doi:10.1080/08941920600835585

Biggs, S. (1989). Resource-poor farmer participation in research: a synthesis of experiences from nine national agricultural research systems. . *On-farm client oriented research: Comparative Study Paper 3.*, The Hague, International Service for National Agricultural Research.

BIRT. (undated). Bake Info. Retrieved from http://www.bakeinfo.co.nz/

Blackmore, C. (2007). What kinds of knowledge, knowing and learning are required for addressing resource dilemmas?: a theoretical overview. *Environmental Science & Policy, 10*, 512-525.

Blunden, G., Cocklin, C., Smith, W., & Moran, W. (1996). Sustainability from the paddock. *New Zealand Geographer, 52*(2), 24-34.

Bolton, G. (2010). *Reflexive practice writing and professional development* (3rd Ed.). London, UK: Sage.

Boon, W., Maryse, M., & Perenboom, J. (2014). Balancing divergence and convergence in transdisciplinary research teams. *Environmental Science Policy, 40*, 57-68.

Bos, J. F. F. P., Smit, A. L., & Schröder, J. J. (2013). Is agricultural intensification in The Netherlands running up to its limits? *NJAS - Wageningen Journal of Life Sciences, 66*, 65-73. doi:10.1016/j.njas.2013.06.001

Botha, N., Coutts, J., & Roth, H. (2008). The Role of Agricultural Consultants in New Zealand in Environmental Extension. *The Journal of Agricultural Education and Extension, 14*(2), 125-138. doi:10.1080/13892240802019147

Botha, N., Klerkx, L., Small, B., & Turner, J. (2014). Lessons on transdisciplinary research in a co-innovation programme in the New Zealand agricultural sector. *Outlook on Agriculture, 43*(3), 219-223. doi:10.5367/oa.2014.0175

Bourhill, A., Shaw, S., & Kerckhoffs, H. (2004). *Organics: Growing the Tairawhiti Region*. Gisborne, NZ: Crop and Food Research.

Bradshaw, B. (2003). Questioning the Credibility and Capacity of Community-Based Resource Management. *The Canadian Geographer, 47*(2), 137-150.

Bradshaw, M., & Stratford, E. (2010). Qualitative research design and rigour. In I. Hay (Ed.), *Qualitative Research Methods in Human Geography* (pp. 69-80). Ontario, Canada: Oxford University Press.

Brierley, G. (2009). Communicating Geomorphology. *Journal of Geography in Higher Education, 33*(1), 3-17. doi:10.1080/03098260802576899

British House of Lords' Select Committee on Science and Technology. (2000). Science and Society, Third Report. Retrieved from http://www.publications.parliament.uk/pa/ld199900/ldselect?ldsctech/38/3801.htm

Bruckmeier, K., & Tovey, H. (2008). Knowledge in sustainable rural development from forms of knowledge to knowledge processes. *Sociologia Ruralis, 48*(3), 313-329.

Bruges, M. (2006). *The Potential of Participatory Approaches for Sustainable Agriculture in New Zealand (unpublished thesis).* The University of Auckland, Auckland.

Bruges, M., & Smith, W. (2008). Participatory Approaches for Sustainable Agriculture: A Contradiction in Terms? *Agriculture and Human Values, 25*, 13-23.

Buhler, W., Morse, S., Arthur, E., Bolton, S., & Mann, J. (2002). *Science, Agriculture and Research: A Compromised Participation*. London: Earthscan.

Burns, T. W., O'Connor, D. J., & Stocklmayer, S. M. (2003). Science communication: a contemporary definition. *Public Understanding of Science, 12*(2), 183-202.

Butler, W.H., & Goldstein, B. E. (2010). The US Fire Learning Network: Springing a Rigidity Trap through Multiscalar Collaborative Networks. *Ecology and Society (Online), 15*(3). Retrieved from http://www.ecologyandsociety.org/vol15/iss3/art21/

Callaghan, P. (2009). Wool to Weta. Retrieved from http://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=10559030

Camillus, J. C. (2008). Strategy as a Wicked Problem. *Harvard Business Review*(May), 99-106.

Campbell, A. (1994). *Landcare: Communities Shaping the Land and the Future*. St Leonards: Allen & Unwin Pty Ltd.

Campbell, A. (1998). Fomenting synergy: experiences with facilitating Landcare in Australia. In N. Roling & M. Wagemakers (Eds.), *Facilitating Sustainable Agriculture: Participatory learning and adaptive management in times of environmental uncertainty* (pp. 233-249). Cambridge: Cambridge University Press.

Canadian Centre on Substance Abuse. (2012). A Systems Approach.

Carr, A., & Wilkinson, R. (2005). Beyond Participation: Boundary Organizations as a New Space for Farmers and Scientists to Interact. *Society & Natural Resources, 18*(3), 255-265. doi:10.1080/08941920590908123

Cash, D. (2001). In order to aid diffusing useful and practical information: Agricultural extension and boundary organizations. *Science Technology and Human Values, 26*(431-453).

Cash, D. W., Clark, W. C., Alcock, F., Dickson, N. M., Eckley, N., Guston, D. H., . . . Mitchell, R. B. (2003). Knowledge systems for sustainable development. *Proc Natl Acad Sci U S A, 100*(14), 8086-8091. doi:10.1073/pnas.1231332100

Chambers, R., Pacey, A., & Thrupp, L. (Eds.). (1993). *Farmer First: Farmer Innovation and Agricultural Research*. London: Intermediate Technology Publications.

Chapman, L. J., Newenhouse, A. C., & Karsh, B.-T. (2010). Evaluation of a 3 year intervention to increase adoption of safer nursery crop production practices. *Applied Ergonomics, 41*, 18-26.

Charmaz, K. (2006). *Constructing grounded theory: a practical guide through qualitative analysis*. London, UK: Sage Oublications.

Checkland, P., & Scholes, J. (1999). *Soft Systems Methodology in Action* (2nd ed.). Chichester: John Wiley.

Chowdhury, A., & Odame, H. (2013). Social Media for enhancing innovation in agrifood and rural development: Current dynamics in Ontario, Canada. In W. Ashton & A. Carson (Eds.), *Journal of Rural and Community Development* (Vol. 8, pp. 97-119): Rural development Institute, Brandon University.

Clancey, M. (2013). Is reflexivity the key to minimising problems of interpretation in phenomenological research. *Nurse Researcher, 20*(6), 12-16.

Clark, M. (2002). Dealing with uncertainty: adaptive approaches to sustainable river management. *Aquatic Conservation: Marine and Freshwater Ecosystems, 12*, 347-363. doi:10.1002/aqc.531

Clever, F., & Franks, F. (2008). Distilling or Diluting: Negotiating the water research-policy interface. *Water Alternatives, 1*(1), 157-176.

Cloke, P., & Le Heron, R. (1994). Agricultural deregulation: The case of New Zealand. In P. Low, T. Marsden, & S. Whatmore (Eds.), *Regulating Agriculture: Critical Perspectives on Rural Change Serie* (pp. 104-126). London, UK: David Fulton Publishers.

Cocklin, C., & Dibden, J. (2005). *Sustainability and change in rural Australia*. Sydney: University of New South Wales.

Commoner, B. (1971). *The Closing Circle: Nature, Man and Technology*. New York: Knopf.

Conklin, J. (2006). *Dialogue Mapping: Building a Shared Understanding of Wicked Problems*. Chichester, England: Wiley.

Conrad, C. C., & Hilchey, K. G. (2011). A review of citizen science and community-based environmental monitoring: issues and opportunities. *Environ Monit Assess, 176*(1-4), 273-291. doi:10.1007/s10661-010-1582-5

Cooke, B., & Kothari, U. (Eds.). (2001). *Participation: The New Tyranny?* London, UK: Zed Books.

Coombes, B., & Hill, S. (2005). "Nawhenua, na Tuhoe. Ko D.o.C te partner" Prospects for co-management of Te Urewera National Park. *Society and Natural resources, 18*(2), 135-152.

Cope, M. (2010). Coding Qualitative Data. In I. Hay (Ed.), *Qualitative Research Methods in Human Geography* (pp. Chpt 14). Don Mills, Canada: Oxford University Press.

Cornwall, A., Guijt, I., & Welbourn, A. (1994). Acknowledging process: challenges for agricultural research and extension methodology. In I. Scoones & J. Thompson (Eds.), *Beyond Farmer First: Rural People's Knowledge, Agricultural Research* *and Extension Practice* (pp. 98-117). London: Intermediate Technology Publications.

Cornwall, A., & Jewkes, R. (1995). What is Participatory Research? *Soc Sci Med, 41*(12), 1667-1676.

Crabtree, B., & Miller, W. (1992). Primary Care Research: A multimethod typology and qualitative road map. In B. Crabtree & W. Miller (Eds.), *Doing qualitative research* (pp. 3-30). Newbury Park: Sage Publications.

Crawford, A., Nettle, R., Paine, M., & Kabore, C. (2007). Farms and Learning Partnerships in Farming Systems Projects: A Response to the Challenges of Complexity in Agricultural Innovation. *The Journal of Agricultural Education and Extension, 13*(3), 191-207. doi:10.1080/13892240701427573

Cundill, G., Lotz-Sisitka, H., Mukute, M., Belay, M., Shackleton, S., & Kulundu, I. (2014). A reflection on the use of case studies as a methodology for social learning research in sub Saharan Africa. *NJAS - Wageningen Journal of Life Sciences, 69*, 39-47. doi:10.1016/j.njas.2013.04.001

Curry, N., Ingram, J., J, & Maye, D. (2012). Knowledge networks for sustainable agriculture in England. *Outlook on Agriculture, 41*(4), 243-248. doi:10.5367/0a.2012.0106

Curtis, A. (1998). The agency/community partnership in Landcare: lesons from state-sponsored citizen resource maangement. *Environmental Management, 22*(4).

Curtis, A., & De Lacy, T. (1996). Landcare in Australia: Does it Make a Difference? *Journal of Environmental Management, 46*, 119-137.

Cvetkovich, G., & Winter, P. L. (2003). Trust and Social Representations of the Management of Threatened and Endangered Species. *Environment and Behaviour, 35*(2), 286-307.

Dale, A., & Onyx, J. (Eds.). (2005). *A Dynamic Balance: Social Capital & Sustainable Community Development* Vancouver: UBC Press.

Daniels, S., & Walker, G. (1996). Collaborative Learning: Improving Public Deliberation in Ecosystem-Based Management. *Environmental Impact Assessment Review, 16*, 71-102.

Darke, P., Shanks, G., & Broadbent, M. (1998). Successfully completing case study research" combining rigour, relevance and pragmatism. *Information Systems, 8*, 273-289.

Darnhofer, I., Fairweather, J., & Moller, H. (2010). Assessing a farm's sustainability: insights from resilience thinking. *International Journal of Agricultural Sustainability, 8*(3), 186-198. doi:10.3763/ijas.2010.0480

Darnhofer, I., Gibbon, D., & Dedieu, B. (2012). Farming Systems Research: An approach to inquiry. In I. Darnhofer, D. Gibbon, & B. Dedieu (Eds.), *Farming Systems Research into the 21st Century: The new dynamic*. Dordrecht, Holland: Springer.

Davidson-Hunt, I. (2006). Adaptive Learning Networks: Developing Resource Management Knowledge through Social Learning Forums. *Human Ecology, 34*(4), 593-614.

Davidson-Hunt, I. J., & Berkes, F. (2003). Learning as You Journey: Anishinaabe Perception of Social-ecological Environments and Adaptive Learning. *Conservation Ecology, 8*(1), article 5. Retrieved from http://www.consecol.org/vol8/iss1/art5

Denzin, N. (1970). *Sociological Methods: A sourcebook*. Chicago: Aldine Publishers.

Denzin, N., & Lincoln, Y. (2003). Strategies of qualitative inquiry. In N. Denzin & Y. Lincoln (Eds.), *The discipline and practice of qualitative research* (pp. 1-40). Thousand Oaks, CA: Sage Publications.

Devine, S. (1997). The science reforms seven years on: A personal view. *New Zealand Science Review, 54*(3-4), 70-74.

Devine, S. (2003). A systems look at the science reforms. *New Zealand Science Review, 60*(2-3), 70-74.

Douthwaite, B., Kuby, T., van de Fliert, E., & Schulz, S. (2003). Impact pathway evaluation: an approach for achiveing and attribting impact in complex systems. *Agricultural Systems, 78*(2), 243-265.

Durie, M. (1998). *Te Mana, Te Kawanatanga: The politics of Maori self-determination*. Melbourne, Australia: Oxford University Press.

Eames, R. (2005). Partnerships in Civil Society: Linking Bridging and Bonding Social Capital. In M. Keen, V. A. Brown, & R. Dyball (Eds.), *Social Learning in Environmental Management: Towards a Sustainable Future* (pp. 78-90). London: Earthscan.

Easton, B. (1997). *The Commercialisation of New Zealand*. Auckland: Auckland University Press.

ECAN, E. C. (2002a). *Nitrate Concentrations in Canterbury: Groundwater - A review of existing data*. Christchurch, NZ: ECAN Report No. R02/17.

ECAN, E. C. (2002b). *Regional Environment Report 1997-2001*. Christchurch, NZ: ECAN Report R02/14.

ECOP. (2002 October). *East Coast Producers Trust - Strategic Development Plan*. Unpublished Report.

Ehrlich, P. R. (1968). *The Population Bomb*. New York: Ballantine Books.

Elzen, B., Barbier, M., Cerf, M., & Grin, J. (2012). Stimulating transitions towards sustainable farming systems. In I. Darnhofer, D. Gibbon, & B. Dedieu (Eds.), *Farming Systems Research into the 21st Century:The New Dynamic* (pp. 431-456). The Netherlands: Springer.

Enticott, G. (2012). Ethnographic Practices and the practices of biosecurity. In A. Franklin & B. P (Eds.), *Researching Sustainability: A guide to social science methods, practice and engagement*. London, UK: Earthscan.

Evans, R. (2011). Case study method in sustainability research. In A. Franklin & P. Blyton (Eds.), *Researching Sustainability: A guide to social science methods, practice and engagement* (pp. 54-70). Oxon, UK: Earthscan.

Evans, R., & Franklin, A. (2008). Forestry for People: An investigation of forestry for people's benefits in two case study regions. Retrieved from http://www.brass.cf.ac.uk/uploads/Forestry_ExecSummary.pdf

Fazey, I., Fazey, J., Salisbury, J., Lindenmayer, D., & Dovers, S. (2006). The nature and role of experiential knowledge for environmental conservation. *Environmental Conservation, 33*(1-10).

Fazey, I., Fazey, J. A., & Fazey, D. A. (2005). Learning More Effectively from Experience. *Ecology and Society, 10*(2), article 4. Retrieved from http://www.ecologyandsociety.org/vol10/iss2/art4/

Federated Farmers New Zealand. (2007). Let's make it work: Why the Resource Management Act must change. Retrieved from http://www.fedfarm.org.nz/files/FFNZ-RMA-Booklet-final-version.pdf

Fenemor, A., Deans, N., Davie, T., Allen, W., Drymond, J., Kilvington, M., . . . Smith, R. (2008). Collaboration and modelling – tools for integration in the Motueka catchment, New Zealand. Retrieved from http://www.wrc.org.za

Fergus, A. H. T., & Rowney, J. I. A. (2005). Sustainable Development: Lost Meaning and Opportunity? *Journal of Business Ethics, 60*, 17-27.

Fernandez-Gimenez, M., Ballard, H. L., & Sturtevant, V. E. (2008). Adaptive Management and Social Learning in Collaborative and Community-Based Monitoring: a Study of Five Community-Based Forestry Organizations in western USA. *Ecology and Society, 13*(2), article 4. Retrieved from http://www.ecologyandsociety.org/vol13/iss2/art4/

Flyvbjerg, B. (2006). Five misunderstandings about case study research. *Qualitative Inquiry, 12*(2), 219-245.

Foley, J. A., Ramankutty, N., Brauman, K. A., Cassidy, E. S., Gerber, J. S., Johnston, M., . . . Zaks, D. P. (2011). Solutions for a cultivated planet. *Nature, 478*(7369), 337-342. doi:10.1038/nature10452

Foundation for Arable Research (FAR). (undated). Website. Retrieved from http://www.far.org.nz/index.php/

Frame, B., Gordon, R. F., & Mortimer, C. (Eds.). (2009). *Hatched: the capacity for sustainable development*. Lincoln: Landcare Research New Zealand Ltd.

Franklin, A., & Blyton, P. (2011). Sustainability Research: An introduction. In A. Franklin & P. Blyton (Eds.), *Researching Sustainability: A guide to scoial science methods, practice and engagement* (pp. 3-16). London, UK: Earthscan.

Freire, P. (1970). *Pedagogy of the oppressed*. New York: Herder and Herder.

Funtowicz, S. O., & Ravetz, J. R. (1993). Science for the Post Normal Age. *Futures, 25*(7), 739-755.

Funtowicz, S. O., & Ravetz, J. R. (1994). The worth of a songbird: ecological economics as a post-normal science. *Ecological Economics, 10*, 197-207.

Funtowicz, S. O., & Ravetz, J. R. (2003). Post Normal Science. Retrieved from http://leopold.asu.edu/sustainability/sites/default/files/Norton, Post Normal Science, Funtowicz_1.pdf

Gibbons, M. (1999). Science's New Social Contract with Society. *Nature, 402(Supplement)*, C81-C84.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The New Production of Knowledge: The dynamics of science and research in contemporary societies*. London: Sage Publications.

Gielens, K., & Steenkamp, J. (2003). Drivers of consumer acceptance of new packaged goods: An investigation acroos products and countries. *International Journal of Research Marketing, 24*, 97-112.

Gilmour, D., & Victoria Dept of Agriculture. (1975). *Agricultural extension in New Zealand's Ministry of Agriculture and Fisheries and demonstration farms in agricultural extension*. Melbourne: Department of Agriculture.

Gladwin, T. N., Kennelly, J., & Krause, T. (1995). Shifting paradigms for sustainable development: Implications for management theory and research. *The Academy of Management Review, 20*(4), 874-908.

Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory*. Chicago: Aldine.

Glasser, H. (2007). Minding the Gap: the role of social learning in linking our stated desire for a more sustainable world to our everyday actions and policies. In A. E. J. Wals (Ed.), *Social Learning towards a sustainable world: Principles, perspectives, and praxis* (pp. 35-61). Wageningen, The Netherlands: Wageningen Academic.

Gliessman, S. (2005). Agroecology and agroecosystems. In J. Pretty (Ed.), *The earthscan reader in sustainable agriculture* (pp. 100-105). London, UK: Earthscan.

Gluckman, P. (2009 July). *Science community needs to wake up*. Paper presented at the Inaugural Speech, Massey University, Palmerston North. http://www.pmcsa.org.nz/wp-content/uploads/Speech-Notes-17-July-09-Massey.pdf

Gluckman, P. (2009 November). *The evolution of science - where is New Zealand groing?* , The University of Auckland. http://www.pmcsa.org.nz/wp-content/uploads/PDG-Lecture-at-Maidment-Theatre-26-November-200911.pdf

Gouais, A., & Wach, E. (2013). A Qualitative Analysis of Rural Water Sector Policy Documents. *Water Alternatives, 6*(3), 439-461.

Granovetter, M. (1973). The Strength of Weak Ties. *American Journal of Sociology, 78*, 1360-1380.

Grundy, K. (2000). Purpose and Principles: interpreting section 5of the Resource Management Act. In P. Memon & H. Perkins (Eds.), *Environmental Planning and Management in New Zealand* (pp. 64-73). Palmerston North: Dunmore Press.

Habermas, J. (1984-87). *The Theory of Communicative Action, 2 vols* (T. McCarthy, Trans.). Cambridge: Polity.

Haggerty, J., Campbell, H., & Morris, C. (2009). Keeping the stress off the sheep? Agricultural intensification, neoliberalism, and ‘good’ farming in New Zealand. *Geoforum, 40*(5), 767-777. doi:10.1016/j.geoforum.2008.12.003

Hall, A., Janssen, W., Pehu, E., & Rajalahti, R. (2006). *Enhancing agricultural innovation: How to go beyond the strengtheningof research systems*. Washington, DC: World Bank.

Hall, A., Rasheed Sulaiman, V., Clark, N., & Yoganand, B. (2003). From measuring impact to learning institutional lessons: an innovation systems perspective on improving the management of international agricultural research. *Agricultural Systems, 78*(2), 213-241. doi:10.1016/s0308-521x(03)00127-6

Hall, M., & Kuiper, D. (1998). Commercialisation and Privatisation of Agrcultural Extension. *Journal of Production Agriculture, 11*(1), 135-140.

Hall, M., Morriss, S., & Kuiper, D. (1999). Privatisation of Agricultural Extension in New Zealand: Implications for the Environment and Sustainable Agriculture. *Journal of Sustainable Agriculture, 14*, 59-71.

Halliwell, J., & Smith, W. (2011). Paradox and potential: trends in science policy and practice in Canada and New Zealand. *Prometheus, 29*(4), 373-391.

Hancock, D., & Algozzine, B. (2006). *Doing Case Study research*. New York: Columbia University.

Hartwich, F., & Negro, C. (2010). The role of collaborative partnerships in industry innovation: lessons from New Zealand's dairy sector. *Agribusiness*, n/a-n/a. doi:10.1002/agr.20231

Healy, S. (1999). Extended peer communities and the ascendance of post-normal politics. *Futures, 31*, 655-669.

Heath, H. (2006). Exploring the influences and use of the literature during a grounded theory study. *Journal of Research in Nursing, 11*(6), 519-528. doi:10.1177/1744987106069338

Hekkert, M., Suurs, R., Negro, S., Kulhlmann, S., & Smits, R. (2007). Functions of innovation systems: A new approach for anlaysing technological change. *Technological Forecasting and Social Change, 74*, 413-432.

Herod, A. (2005). Gender Issues in the Use of Interviewing as a Research Method. *The Professional Geographer, 45*(3), 305-317.

Herriott, R., & Firestone, W. (1983). Multisite qualitative policy research: Optimizing description and generalizability. *Educational Researcher, 12*(2), 14-19.

Hikuroa, D., Morgan, K., Durie, M., Henare, M., & Robust, T. (2011 online). Integration of Indigenous Knowledge and Science. *The International Journal of Science and Society, 2*.

Hing, N., Breen, H., Gordon, A., & Russell, A. (2014). The gambling behaviour indigenous australians. *Journal of gambling studies, 30*(2), 369-386. doi:10.1007/s10899–013–9358–9

Hirsch-Kreinsen, H. (2015 (March)). *Low Tech Innovations*. The University of Auckland.

Hoffmann, V., Probst, K., & Christinck, A. (2007). Farmers and researchers: How can collaborative advantages be created in participatory research and technology development? *Agriculture and Human Values, 24*(3), 355-368. doi:10.1007/s10460-007-9072-2

Hoggart, K., Lees, L., & Davies, A. (2002). *Researching human geography*. New York: Arnold.

Holden, E., Linnerud, K., & Banister, D. (2014). Sustainable development: Our Common Future revisited. *Global Environmental Change, 26*, 130-139. doi:10.1016/j.gloenvcha.2014.04.006

Holling, C. S. (2001). Understanding the Complexity of Economic, Ecological, and Social Systems. *Ecosystems, 4*(5), 390-405.

Holling, C. S., & Goldberg, M. A. (1971). Ecology and Planning. *Journal of the American Institute of Planners, 37*(4), 221-230.

Holling, C. S., & Gunderson, L. H. (2002). *Panarchy: Understanding Transformations in Human and Natural Systems*. Washington: Island Press.

Hopwood, B., Mellor, M., & O'Brien, G. (2005). Sustainable development: Mapping different approaches. *Sustainable development, 13*(1), 38-52.

Hornig Priest, S. (2001). Misplaced Faith: Communication Variables as Predictors of Encouragement for Biotechnology Development. *Science Communication, 23*(2), 97-110.

Hubert, B., Ison, R., Sriskandarajah, N., Blackmore, C., Cerf, M., Avelange, I., . . . Steyaert, P. (2012). Learning in European agricultural and rural networks: building a systemic research agenda. In I. Darnhofer, D. Gibbon, & B. Dedieu (Eds.), *Farming Systems Research into the 21st Century: The New Dynamic* (Vol. 179-200). Dordrecht, Holland: Springer.

Hunt, L. (2003). *Compliance at Work: Protecting Identity and Science Practice under Corporatisation.* (PhD Thesis), Lincoln University, NZ.

Hunt, L. (2009). Doing science in a culture of accountability: Compliance through resistance to alienation and estrangement. *Kotuitui: New Zealand Journal of Social Sciences Online, 4*(1), 25-40. doi:10.1080/1177083x.2009.9522442

Hunt, L., Jayson, B., Campbell, H., Fairweather, J., Greer, G., Lucock, D., . . . Saunders, V. (2010 July 4-7). *Experiences of transdisciplinarity in research on agricultural sustainability*. Paper presented at the 10th European IFSA Symposium, Vienna (Austria).

Hunt, L., Rosin, C., Campbell, H., & Fairweather, J. (2013). The impact of neoliberalism on New Zealand farmers: changing what it means to be a 'good' farmer. *Extension Farming Systems Journal - Research Forum, 9*(1).

Husted, K., & Woodfield, P. (2015). *Innovation in New Zealand's traditional industries*. Paper presented at the Primary Innovations Network Meeting, University of Auckland, February 20.

Ihlen, Ø., & Roper, J. (2014). Corporate Reports on Sustainability and Sustainable Development: 'We Have Arrived'. *Sustainable Development, 22*(1), 42-51. doi:10.1002/sd.524

Ingram, J. (2008). Are farmers in England equipped to meet the knowledge challenge of sustainable soil management? An analysis of farmer and advisor views. *J Environ Management, 86*(1), 214-228. doi:10.1016/j.jenvman.2006.12.036

Ingram, J. (2010). Technical and Social Dimensions of Farmer Learning: An Analysis of the Emergence of Reduced Tillage Systems in England. *Journal of Sustainable Agriculture, 34*(2), 183-201. doi:10.1080/10440040903482589

Irwin, A. (1995). *Citizen Scientist: A study of people, expertise and sustainable development*. Oxon, UK: Routledge.

Ison, R. (2005). Traditions of Understanding: Language, Dialogue and Experience. In M. Keen, V. A. Brown, & R. Dyball (Eds.), *Social Learning in Environmental Management: Towards a Sustainable Future* (pp. 22-40). London: Earthscan.

Ison, R., Maiteny, P., & Carr, S. (1997). Systems Methodologies for Sustainable Natural Resources Research and Development. *Agricultural Systems, 55*(2), 257-272.

Ison, R., Roling, N. G., & Watson, D. (2007). Challenges to science and society in the sustainable management and use of water: investigating the role of social learning. *Environmental Science & Policy, 10*, 499-511.

Ison, R.L., Collins, K.B. & Wallis, P. (2015). Institutionalising social learning: Towards systemic and adaptive governance. *Environmental Science & Policy*, 53, 105-117.

Jago, J., Davis, K., Newman, M., & Woolford, M. (2006). An economic evaluation of automatic milking systems for New Zealand dairy farms. *Proceedings of the New Zealand Society for Animal Protection, 66*, 263-269.

Jelsoe, E., & Kjoergard, B. (2010). Sustainability in agriculture and food production. In K. Nielsen, B. Elling, M. Figueroa, & E. Jelsoe (Eds.), *A new agenda for sustainability* (pp. 135-176). Surrey, England: Ashgate.

Jones, D. L., Cross, P., Withers, P. J. A., DeLuca, T. H., Robinson, D. A., Quilliam, R. S., . . . Kardol, P. (2013). REVIEW: Nutrient stripping: the global disparity between food security and soil nutrient stocks. *Journal of Applied Ecology, 50*(4), 851-862. doi:10.1111/1365-2664.12089

Jones, G., & Garforth, C. (1997). The history, development, and future of agricultural extension. In E. Swanson, R. Bentz, & A. Sofranko (Eds.), *Improving Agricultural Extension: A Reference Manual* (pp. chapter 1). Rome.

Journeaux, P. (2009 June). *Developing an institutional model for the extension and adoption of environmental Best Management Practices by pastoral farmers in New Zealand.* Uinversity of Waikato (MBA), Hamilton, New Zealand.

Journeaux, P., & Stephens, P. (June 1997). *The Development of Agricultural Advisory Services in New Zealand, MAF Policy Technical Paper 97/98*. Retrieved from Christchurch, NZ:

Kates, R. W., Clark, W. C., Corell, R. J., Hall, M., Jaegar, C. C., Lowe, I., . . . Svedin, U. (2001). Sustainability Science. *Science, 292*(5517), 641-642.

Kates, R. W., Parris, T. M., & Leiserowitz, A. A. (2005). What is Sustainable Development? Goals, Indicators, Values, and Practice. *Environment: Science and Policy for Sustainable Development, 47*(3), 8-21.

Kearns, R. (2010). Seeing with clarity: Undertaking Observational Research. In I. Hay (Ed.), *Qualitative Research Methods in Human Geography* (3rd ed., pp. 241-258). Don Mills, Canada: Oxford University Press.

Keen, M., Brown, V. A., & Dyball, R. (2005a). Social Learning: A New Approach to Environmental Management. In M. Keen, V. A. Brown, & R. Dyball (Eds.), *Social Learning in Environmental Management: building a sustainable future* (pp. 3-21). London: Earthscan.

Keen, M., Brown, V. A., & Dyball, R. (Eds.). (2005b). *Social Learning in Environmental Management: Towards a Sustainable Future*. London: Earthscan.

Kelly, D. (2011). Power and Participation: Exploring the traditions of power. In J. Jennings, R. Packham, & D. Woodside (Eds.), *Shaping Change: Natural resource management, agriculture and the role of extension* (pp. 161-170). Australia: APEN.

Kerckhoffs, H., Bruges, M., & Smith, W. (2006). *Participatory research for agronomy: the New Zealand experience*. Paper presented at the Proceedings of the Australian Agronomy Conference: Australian Society of Agronomy.

http://www.regional.org.au/au/asa/2006/concurrent/adoption/4582_kerckhoffslh.htm

Ketterings, Q. M. (2013). Extension and knowledge transfer: adaptive management approaches for timely impact. *The Journal of Agricultural Science, 152*(S1), 57-64. doi:10.1017/s002185961300066x

Kilelu, C. W., Klerkx, L., & Leeuwis, C. (2013). Unravelling the role of innovation platforms in supporting co-evolution of innovation: Contributions and tensions in a smallholder dairy development programme. *Agricultural Systems, 118*, 65-77. doi:10.1016/j.agsy.2013.03.003

Kilpatrick, S. (2003). *Facilitating Sustainable Resource Management: Review of Literature*. Retrieved from Launceston, Australia:

Kilvington, M., & Allen, W. (2007). *Evaluation of the Social Spaces of the Integrated Catchment Management Research Programme:* . Retrieved from Lincoln:

Kindon, S., Pain, R., & Kesby, M. (Eds.). (2007). *Participatory action Research Approaches and Methods: Connecting People, Participation and Place*. London, UK: Routledge.

Kinnect Group. (2014). Evaluation of the Sustainable Farming Fund. Retrieved from https://www.mpi.govt.nz/funding-and-programmes/farming/sustainable-farming-fund/

Kitchen, R., & Tate, N. (2000). *Conducting research into human geography: theory, methodology and practice*. Essex, UK: Pearson Education.

Klein, J. T. (2015). Reprint of "Discourses of transdisciplinarity: Looking back to the future". *Futures, 65*, 10-16. doi:10.1016/j.futures.2015.01.003

Klenk, N., & Meehan, K. (2015). Climate change and transdisciplinary science: Problematizing the integration imperative. *Environmental Science & Policy, 54*, 160-167. doi:10.1016/j.envsci.2015.05.017

Klerkx, L. (2015). *Agricultural Innovation Systems for successful co-innovation - examples from around the globe*. Paper presented at the Primary Innovations Network, February 20 2015, University of Auckland, New Zealand.

Klerkx, L., Aarts, N., & Leeuwis, C. (2010). Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment. *Agricultural Systems, 103*(6), 390-400. doi:10.1016/j.agsy.2010.03.012

Klerkx, L., de Grip, K., & Leeuwis, C. (2006). Hands off but strings attached: The contradictions of policy-induced demand-driven agricultural extension. *Agriculture and Human Values, 23*, 189-204.

Klerkx, L., & Jansen, J. (2010). Building knowledge systems for sustainable agriculture: supporting private advisors to adequately address sustainable farm management in regular service contacts. *International Journal of Agricultural Sustainability, 8*(3), 148-163. doi:10.3763/ijas.2009.0457

Klerkx, L., Koutsouris, A., & Labarthe, P. (2013). Guest Editorial. *The Journal of Agricultural Education and Extension, 19*(3), 217-221.

Klerkx, L., & Leeuwis, C. (2009). Operationalizing Demand-Driven Agricultural Research: Institutional Influences in a Public and Private System of Research Planning in The Netherlands. *The Journal of Agricultural Education and Extension, 15*(2), 161-175. doi:10.1080/13892240902909080

Klerkx, L., & Nettle, R. (2013). Achievements and challenges of innovation co-production support initiatives in the Australian and Dutch dairy sectors: A comparative study. *Food Policy, 40*, 74-89. doi:10.1016/j.foodpol.2013.02.004

Klerkx, L., Van Mierlo, B., & Leeuwis, C. (2012). Evolution of systems approaches to agricultural innovation: concepts, analysis and interventions. In I. Darnhofer, D. Gibbon, & B. Dedieu (Eds.), *Farming Systems Research into the 21st Century: The new dynamic*. Dordrecht, Holland: Springer.

Kolb, D. (1984). *Experiential Learning: Experience as the Source of Learning and Development*. Englewood Cliffs, New Jersey: Prentice-Hall.

Komiyama, H., & Takeuchi, K. (2006). Sustainability science: building a new discipline. *Sustainability Science, 1*(1), 1-6. doi:10.1007/s11625-006-0007-4

Kroma, M. M. (2006). Organic Farmer Networks: Facilitating Learning and Innovation for Sustainable Agriculture. *Journal of Sustainable Agriculture, 28*(4), 5-28.

Kruger, L., & Shannon, M. (2000). Getting to know ourselves and our places through participation in civic science assessment. *Society and Natural resources, 13*, 461-478.

Kuhn, T. (1996). *The structure of scientific revolutions* (3rd edition ed.). Chicago, IL: University of Chicago.

Lachlan CMA. (2013). Catchment Action Plan 2013. Retrieved from http:/www.lachlan.cma.nsw.gov.au/downloads/Catchment_Action_Plan/Lachlan_CAP2013_-2023_Support_Chapters_web.pdf

LandWISE. (undated). website. Retrieved from http://www.landwise.org.nz/

Lane, S., Odoni, N., C, L., Whatmore, S., Ward, N., & Bradley, S. (2010). Doing flood risk science differently: an experiement in radical scientific method. *Transactions of the Institute of British Geographers, 36*, 15-36.

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., . . . Thomas, C. J. (2012). Transdisciplinary research in sustainability science: practice, principles, and challenges. *Sustainability Science, 7*(S1), 25-43. doi:10.1007/s11625-011-0149-x

Laxon, A. (2014). The Price of Milk. *New Zealand Herald*. Retrieved from http://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=11319765

Lee, W. G., Meurk, C. D., & Clarkson, B. D. (2008). Agricultural intensification: Whither indigenous biodiversity? *New Zealand Journal of Agricultural Research, 51*(4), 457-460. doi:10.1080/00288230809510475

Leeuwis, C. (2004). *Communication for Rural Innovation: Rethinking Agricultural Extension* (Third ed.). Oxford: Blackwell Science Ltd.

Leeuwis, C., & Aarts, N. (2011). Rethinking Communication in Innovation Processes: Creating Space for Change in Complex Systems. *The Journal of Agricultural Education and Extension, 17*(1), 21-36. doi:10.1080/1389224x.2011.536344

Leeuwis, C., & Pyburn, R. (2002). Social Learning for Rural Resource Management: introduction to the book. In C. Leeuwis & R. Pyburn (Eds.), *Wheelbarrows full of frogs: Social Learning in rural resource management* (pp. 11-21). Assen, The Netherlands: Koninklijke Van Gorcum.

Leitch, S., & Davenport, S. (2005). The politics of discourse: Marketization of the New Zealand science and innovation system. *Human Relations, 58*(7), 891-912.

Levin, K., Cashore, B., Bernstein, S., & Auld, G. (2012). Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change. *Policy Science, 45*, 123-152.

Levin, S. (1993). Science and Sustainability. *Ecological Applications, 3*(4).

Leys, A. J., & Vanclay, K. V. (2011). Stakeholder engagement in social learning to resolve controversies over land-use change to plantation forestry. *Regional Environmental Change, 11*, 175-190.

Loeber, A., van Mierlo, B., Grin, J., & Leeuwis, C. (2007). The practical value of theory: Conceptualising learning in the pursuit of a sustainable development. In A. E. J. Wals (Ed.), *Social Learning: towards a sustainable world*. Wageningen: Wageningen Academic Publishers.

Longhurst, R. (1999). Gendering Place. In R. Le Heron, L. Murphy, P. Forer, & M. Goldstone (Eds.), *Explorations in Human geography: Encountering Place* (pp. 151-172). Auckland, NZ: Oxford University Press.

Longhurst, R. (2003). Semi-structured interviews and focus groups. In N. Clifford & G. Valentine (Eds.), *Key methods in geography* (pp. 117-132). London, UK: Sage.

Lubchenco, J. (1998). Entering the Century of the Environment: A New Social Contract for Science. *Science, 279*(5350), 491-497.

Ludwig, D. (1993). Uncertainty, Resource Exploitation, and Conservation: Lessons from History. *Science, 260*(5104), 17-36.

MacLeod, C. J., & Moller, H. (2006). Intensification and diversification of New Zealand agriculture since 1960: An evaluation of current indicators of land use change. *Agriculture, Ecosystems & Environment, 115*(1-4), 201-218. doi:10.1016/j.agee.2006.01.003

Mansvelt, J., & Berg, L. (2005). Writing qualitative geographies, constructing geographical knowledges. In I. Hay (Ed.), *Qualitative Research Methods in Human Geography* (pp. 248-265). New York: Oxford University Press.

Massey, C., Morriss, S., Alpass, F., & Flett, R. (June 2004). A Framework for Building Learning: Evidence from the New Zealand Dairy Industry. *Journal of Extension, 42*(3).

McEntee, M., & Mortimer, C. (2013). Challenging the One-Way Paradigm for More Effective Science Communication: A Critical Review of Two Public Campaigns Addressing Contentious Environmental Issues. *Applied Environmental Education & Communication, 12*(2), 68-76. doi:10.1080/1533015x.2013.820630

Medema, W., Wals, A., & Adamowski, J. (2014). Multi-Loop Social Learning for Sustainable Land and Water Governance: Towards a Research Agenda on the Potential of Virtual Learning Platforms. *NJAS - Wageningen Journal of Life Sciences, 69*, 23-38. doi:10.1016/j.njas.2014.03.003

Merrington, G., Nfa, L., Parkinson, R., Redman, M., & Winder, L. (2002). *Agricultural Pollution: Environmental Problems and Practical Solutions*. CRC Press: Boca Raton, FL.

Mezirow, J. (1994). Understanding transformational theory. *Adult Education Quarterly, 44*(4), 222-232.

Millenium Ecosystem Assessment. (2005). Living Beyond Our Means: Natural Assets and Human Well-Being: Statement from the Board. Retrieved from http://www.maweb.org/en/index.aspx

Mills, J., Gibbon, D., Ingram, J., Reed, M., Short, C., & Dwyer, J. (2011). Organising Collective Action for Effective Environmental Management and Social Learning in Wales. *The Journal of Agricultural Education and Extension, 17*(1), 69-83. doi:10.1080/1389224x.2011.536356

Ministry of Agriculture and Forestry. (2010). Ten Years of grassroots action 2010. Wellington: Ministry of Agriculture and Forestry.

Ministry of Primary Industries. (2012). *Survey of technology transfer services to farmers and growers in New Zealand*. Wellington: MPI.

Ministry of Social Development (MSD). (2011). Community Reponse Forum: Hawkes Bay/East Coast Forum. Retrieved from http://www.communityresponse.org.nz/my-community/community-response-model/community-response-forums/hawkes-bay-east-coast-forum.html

Moller, H., MacLeod, C. J., Haggerty, J., Rosin, C., Blackwell, G., Perley, C., . . . Gradwohl, M. (2008). Intensification of New Zealand agriculture: Implications for biodiversity. *New Zealand Journal of Agricultural Research, 51*(3), 253-263. doi:10.1080/00288230809510453

Moody, L., & Cordua-von Specht, L. (2005). Stones: Social Capital in Canadian Aboriginal communities. In A. Dale & J. Onyx (Eds.), *A Dynamic Balance: Social capital and sustainable community development* (pp. 127-140). Vancouver: UBC Press.

Morriss, S., Massey, C., Flett, R., Alpass, F., & Sligo, F. (2006). Mediating technological learning in agricultural innovation systems. *Agricultural Systems, 89*(1), 26-46. doi:10.1016/j.agsy.2005.08.002

MORST. (2010). Establishment of new Ministry

Statement to the Research, Science and Technology sector on 1 June 2010. Retrieved from http://www.morst.govt.nz/about/News/Establishment-of-new-Ministry/

Mosse, D. (2001). "People's Knowledge", participation and patronage: operations and representations in rural development. In B. Cooke & U. Kothari (Eds.), *Participation: The New Tyranny?* London, UK: Zed Books.

Mostert, E., Pahl-Wostl, C., Rees, Y., Searle, B., Tabara, D., & Tippett, J. (2007). Social Learning in European River-Basin Management: Barriers and Fostering Mechanisms from 10 River Basins. *Ecology and Society, 12*(1), article 19. Retrieved from http://www.ecologyandsociety.org/vol12/iss1/art19/

Muro, M., & Jeffrey, P. (2008). A Critical Review of the Theory and Application of Social Learning in Participatory Natural Resource Management Processes. *Journal of Environmental Planning and Management, 51*(3), 325-344.

Murphy, C., Nettle, R., & Paine, M. (2013). The evolving extension environment: implications for dairy scientists. *Animal Production Science*. doi:10.1071/an12347

Murray, P. (2000). Evaluating Participatory Extension Programs: Challenges and Problems. *Australian Journal of Experimental Agriculture, 40*, 519-526.

Mustalahti, I. (2006). How to handle the stick: Positive processes and crucial barriers of participatory forest management *Trees and Livlihoods, 16*, 151-165.

Nadasdy, P. (1999). The politics of TEK: Power and the "integration" of knowledge. *Arctic Anthropology, 36*(1-2), 1-18.

Nagar, R., & Geiger, S. (2007). Reflexivity and Positionality in Feminist Fieldwork Revisited. In A. Tickell, E. Sheppard, J. Peck, & T. Barnes (Eds.), *Politics and Practice in Economic Geography* (pp. 267-278). London: Sage.

Naylor, R., Steinfeld, H., Falcon, W., Galloway, J., Smil, V., Bradford, E., . . . Mooney, H. (2005). Agriculture. Losing the links between livestock and land. *Science, 310*(5754), 1621-1622. doi:10.1126/science.1117856

Neef, A., & Neubert, D. (2011). Stakeholder participation in agricultural research projects: a conceptual framework for reflection and decision-making. *Agriculture and Human Values, 28*(2), 179-194. doi:10.1007/s10460-010-9272-z

Nelkin, D. (1987). *Selling Science: How the press covers science and technology*. New York: WH Freeman.

New Zealand Association of Scientists. (2010). Merger of MORST and FRST. Retrieved from http://www.scientists.org.nz/nzas-press-release/2010/merger-of-morst-and-frst

New Zealand. Office of the Parliamentary Commissioner for the Environment. (2004). *Growing for good : Intensive farming, sustainability and New Zealand's environment*. Wellington, N.Z.: Parliamentary Commissioner for the Environment.

Newman, J., & Moller, H. (2005). Use of Mātauranga (Maori traditional knowledge) and science to guide a seabird harvest: getting the best of both worlds? *Senri Ethnological Studies, 67*, 303-321.

Newton, J., & Parfitt, A. (2011). Striving for mutuality in research relationships *Researching Sustainability: A guide to social science methods, practice and engagement* (pp. 71-88). Oxford: Earthscan.

Nicholson, C., Barr, N., Kentish, A., Dowling, P. M., McCormick, L. H., Palmer, M., . . . Walsh, J. (2003). A research-extension model for encouraging the adoption of productive and sustainable practice in high rainfall grazing areas. *Australian Journal of Experimental Agriculture, 43*, 685-694.

O'Reilly, M., & Parker, N. (2012). 'Unsatisfactory Saturation': a critical exploration of the notion of saturated sample sizes in qualitative research. *Qualitative Research, 13*(2), 190-197. doi:10.1177/1468794112446106

Okali, C., Sumberg, J., & Farrington, J. (1994). *Farmer particpatory research*. London, UK: Intermediate Technology Publications.

Onyx, J. (2005). Introduction. In A. Dale & J. Onyx (Eds.), *Social Capital & Sustainable Community Development: A Dynamic Balance* (pp. 1-10). Vancouver: UBC Press.

Oreszczyn, S., Lane, A., & Carr, S. (2010). The role of networks of practice and webs of influencers on farmers' engagement with and learning about agricultural innovations. *Journal of Rural Studies, 26*, 404-417.

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge: Cambridge University Pres.

Packham, R. (2011). The Farming Systems Approach. In J. Jennings, R. Packham, & D. Woodside (Eds.), *Shaping Change: Natural resource management, agriculture and the role of extension* (pp. 32-51). Australia: APEN.

Padfield, M., & Proctor, I. (1996). The Effect of Interviewer's Gender on the Interviewing Process: A comparative enquiry. *Sociology, 30*, 355-366.

Pahl-Wostl, C. (2002). Towards sustainability in the water sector: The importance of human actors and processes of social learning. *Aquatic Sciences, 64*, 394-411.

Pannell, D. J., Marshall, G. R., Barr, N., Curtis, A., Vanclay, F., & Wilkinson, R. (2006). Understanding and promoting adoption of conservation practices by rural landholders. *Australian Journal of Experimental Agriculture, 46*, 1407-1424.

Parker, W. (2013). Future Outlook and directions for forest industry research. *NZ Journal of Forestry, 58*(1), 29-31.

Parkhill, K., Shirani, F., Butler, C., Henwood, K., Groves, C., & Pidgeon, N. (in press). We are a community [but] that takes a certain amount of energy': exploring shared visions, social action, and resilience in place-based community-led energy initiatives. *Environmental Science and Policy*.

Parson, E. A., & Clark, W. C. (1995). Sustainable Development as Social Learning: Theoretical Perspectives and Practical Challenges for the Design of a Research Program. In L. H. Gunderson, C. S. Holling, & S. S. Light (Eds.), *Barriers and Bridges to the Renewal of Ecosystems and Institutions* (pp. 428-460). New York: Columbia University Press.

Patton, M. (2002). *Qualitative evaluation and research methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

PCE. (2004). *Growing for good: Intensive farming, sustainability and New Zealand's environment*. Wellington: Parliamentary Commissioner for the Environment.

Pennell, K., Thompson, M., Rice, J., Senier, L., Brown, P., & Suuberg, E. (2013). Bridging science and environmental regulatory processes: the role of knowledge brokers. *Environmental Science & Technology, 47*(21), 11985-11992. doi:10.1021/es4025244

Peters, M. (2001). Environmental Education, Neoliberalism and Globalisation: 'New Zealand Experiment'. *Educational Philosophy and Theory, 33*, 203-216.

Pettie, K. (2011). Developing and delivering social science research for sustainability. In A. Franklin & P. Blyton (Eds.), *Researching Sustainability* (pp. 17-36). London, UK: Earthscan.

Pfahl, S. (2005). Institutional sustainability. *International Journal of Agricultural Sustainability, 8*(12), 80-97.

Phillips, C., Allen, W., Fenemor, A., Bowden, B., & Young, R. (2010). Integrated catchment management research: lessons for interdisciplinary science from the Motueka Catchment, New Zealand. *Marine and Freshwater Research, 61*(7), 749-763.

Phillips, T. (1982). How farmers' perceptions of advisers / consultants affect their use of those professionals. *NZ Agricultural Science, 16*(3), 155-156.

Phillips, T. (1985). *The development of methodologies for the determination and facilitation of learning for dairy farmers.* (Masters Thesis), University of Melbourne.

Plant and Food Research. (2010). Statement of Core Purpose. Retrieved from http://www.plantandfood.co.nz/file/pfr-scp.pdf

Platt, J. (1988). What can case studies do? *Studies in qualitative methodology, 1*, 1-23.

Policy, M. (2006 August). *Bridging the gap between environmental knowledge and research, and desired environmental outcomes to achieve sustainable land management*. Wellington: MAF.

Polk, M. (2014, online). Achieving the promise of transdisciplinarity: a critical exploration of the relationship between transdisciplinary research and societal problem solving. *Sustainability Science*. doi:10.1007/s11625-014-0247-7

Popa, F., Guillermin, M., & Dedeurwaerdere, T. (2015). A pragmatist approach to transdisciplinarity in sustainability research: From complex systems theory to reflexive science. *Futures, 65*, 45-56. doi:10.1016/j.futures.2014.02.002

Potatoes New Zealand. (Undated). Potatoes New Zealand Growing Together. Retrieved from http://www.potatoesnz.co.nz/

Pretty, J. (1995). Participatory Learning for Sustainable Agriculture. *World Development, 23*(8), 1247-1263.

Pretty, J. (1998). Supportive policies and practice for scaling up sustainable agriculture. In N. Roling & M. Wagemakers (Eds.), *Facilitating Sustainable Agriculture: Participatory learning and adaptive management in times of environmental uncertainty* (pp. 23-45). Cambridge: Cambridge University Press.

Pretty, J. (2003). Social Capital and Collective Management of Resources. *Science, 302*, 1912-1914.

Pretty, J. (2006). Agroecological approaches to agricultural development: Background paper for world development report 2008. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/9044/WDR2008_0031.pdf?sequence=1

Pretty, J. (Ed.) (2005). *The Earthscan reader in sustainable agriculture.* London ; Sterling, VA: Earthscan.

Pretty, J., Sutherland, W. J., Ashby, J., Auburn, J., Baulcombe, D., Bell, M., . . . Pilgrim, S. (2010). The top 100 questions of importance to the future of global agriculture. *International Journal of Agricultural Sustainability, 8*(4), 219-236. doi:10.3763/ijas.2010.0534

Pretty, J., & Ward, H. (2001). Social Capital and the Environment. *World Development, 29*(2), 209-227.

Probst, K., Hagmann, J., Fernandez, M., & Ashby, J. (2003). Understanding Participatory Research in the Context of Natural Resource Management - Paradigms, Approaches and Typologies. *Agricultural Research and Extension Network (AgREN), Network Paper No. 130*.

Putnam, R. D. (2000). *Bowling Alone: The Collapse and Revival of American Community*. New York: Simon & Schuster.

Ratner, B. D. (2004). "Sustainability" as a Dialogue of Values: Challenges to the Sociology of Development. *Sociological Inquiry, 74*(1), 50-69.

Ravetz, J. R. (2006). Post-Normal Science and the complexity of transitions towards sustainability. *Ecological Complexity, 3*(4), 275-284. doi:10.1016/j.ecocom.2007.02.001

Raymond, C., Fazey, I., Reed, M. S., Stringer, L. C., Robinson, G., & Evely, A. C. (2010). Integrating local and scientific knowledge for environmental management. *Journal of Environmental Management, 91*, 1766-1777.

Rayner, S. (2006, July 21, 2006). Wicked Problems: Clumsy Solutions - diagnoses and prescriptions for environmental ills. Retrieved from http://www.sbs.ox.ac.uk/centres/insis/Documents/jackbealelecture.pdf

Redclift, M. (1987). *Sustainable Development: Exploring the Contradictions*. New York: Methuen.

Reed, M. S. (2008). Stakeholder Participation for Environmental Management: A Literature Review. *Biological Conservation, 141*, 2417-2431.

Reed, M. S., Evely, A. C., Cundill, G., Fazey, I., Glass, J., Laing, A., . . . Stringer, L. C. (2010). What is Social Learning? *Ecology and Society (Online), 15*(4). Retrieved from http://www.ecologyandsociety.org/vol15/iss4/artZZ/

Renn, K. (2004). *Mixed race students in college: The ecology of race, identity, and community on campus*. Albany State University New York Press.

Resource Management Act. (1991), Retrieved from http://www.legislation.govt.nz/act/public/1991/0069/latest/DLM230265.html

Richards, L. (2009). *Handling qualitative data* (2nd ed.). London, UK: Sage.

Richardson, L. (2000). Writing: a Method of Inquiry. In N. Denzin & Y. Lincoln (Eds.), *Handbook of Qualitative Research* (2nd ed., pp. 923-947). Thousand Oaks, CA: Sage Publications.

Ridley, A. M. (2005). The role of farming systems group approaches in achieving sustainability in Australian agriculture. *Australian Journal of Experimental Agriculture, 45*, 603-615.

Rittel, H. J., & Webber, M. M. (1973). Dilemmas in a General Theory of Planning. *Policy Sciences, 4*, 155-169.

Rivera, W. M. (2011). Public Sector Agricultural Extension System Reform and the Challenges Ahead. *The Journal of Agricultural Education and Extension, 17*(2), 165-180. doi:10.1080/1389224x.2011.544457

Roberts, M. (2009). Consultation concerning novel biotechnologies: who speaks for Maori? *International Social Science Journal, 60*(195), 145-151.

Robinson, J. (2004). Squaring the circle? Some thoughts on thr idea of sustainable development. *Ecological Economics, 48*, 369-384.

Robinson, J., & Tinker, J. (1997). Reconciling Ecological, Economic and Social Imperatives: A new conceptual approach. In T. Schrecker (Ed.), *Surviving Globalism: The social and economic challenges* (Vol. 71-94). New York: Saint Martin's.

Robinson, L. (2015). *Using the Diffusion of innovations theory to improve change in the 21st century* Webinar August 18. http://www.enablingchange.com.au/

Roche, M. (2010). Historical research and archival sources. In I. Hay (Ed.), *Qualitative Research Methods in Human Geography* (pp. Chpt 9). Ontario, Canada: Oxford University Press.

Roderiguez, J. M., Molnar, J. J., Fazio, R. A., Sydnor, E., & Lowe, M. J. (2008). Barriers to Adoption of Sustainable Agriculture Practices: Change Agent Perspectives. *Renewable Agriculture and Food Systems, 24*(1), 60-71.

Rogers, E. (1962). *Diffusion of Innovations*. New York: Free Press of Glencoe.

Rogers, E. (1983). *Diffusion of Innovations* (3rd ed.). New York, USA: MacMillian Publishing.

Rogers, E. (2003). *Diffusion of Innovation* (5th ed.). New York, USA: The Free Press.

Roling, N. (2002). Beyond the aggregation of individual preferences. In C. Leeuwis & R. Pyburn (Eds.), *Wheelbarrows full of frogs: Social learning in rural resource management* (pp. 25-48). The Netherlands: Koninklijke Van Gorcum.

Roling, N., & Jiggins, J. (1998). The ecological knowledge system. In N. Roling & M. Wagemakers (Eds.), *Facilitating Sustainable Agriculture: Participatory learning and adaptive management in times of environmental uncertainty* (pp. 283-311). Cambridge: Cambridge University Press.

Roling, N., & Wagemakers, M. (1998a). A new practice: Facilitating sustainable agriculture. In N. Roling & M. Wagemakers (Eds.), *Facilitating Sustainable Agriculture: Participatory learning and adaptive management in times of environmental uncertainty* (pp. 3-23). Cambridge: Cambridge University Press.

Roling, N., & Wagemakers, M. (Eds.). (1998b). *Facilitating Sustainable Agriculture: Participatory learning and adaptive management in times of environmental uncertainty*. Cambridge: Cambridge University Press.

Rorty, R. (1998). *Truth and Progress: Philosophical Papers*. Cambridge, UK: Cambridge University Press.

Rose, G. (1997). Situated knowledges, positionality, reflexivities and other tactics. *Progress in human geography, 21*, 305-320.

Rosendahl, J., Zanella, M. A., Rist, S., & Weigelt, J. (2015). Scientists' situated knowledge: Strong objectivity in transdisciplinarity. *Futures, 65*, 17-27. doi:10.1016/j.futures.2014.10.011

Rossiter, D. G., Liu, J., Carlisle, S., & Zhu, A. X. (2015). Can citizen science assist digital soil mapping? *Geoderma, 259-260*, 71-80. doi:10.1016/j.geoderma.2015.05.006

Roux, D. J., Murray, K., Nel, J. L., Hill, L., Roux, H., & Driver, A. (2011). From Scorecard to Social Learning: A Reflective Coassessment Approach for Promoting Multiagency Cooperation in Natural Resource Management. *Ecology and Society (Online), 16*(1), http://www.ecologyandsociety.org/vol16/iss11/art24/.

Roux, D. J., Rogers, K. H., Biggs, H., Ashton, P., & Sergeant, A. (2006). Bridging the science–management divide: moving from unidirectional knowledge transfer to knowledge interfacing and sharing. *Ecology and Society, 11*(1). Retrieved from http://www.ecologyandsociety.org/vol11/iss1/art4/

Royal Commission of Environmental Pollution. 21st report: Setting Environmental Standards. Retrieved from http://webarchive.nationalarchives.gov.uk/20110322143804/http://www.rcep.org.uk/reports/21-standards/21-standards.htm

Royal Tropical Institute (KIT), & IIRR. (2010). *Value chain finance: Beyond microfinance for rural entreupreneurs*. Amsterdam, The Netherlands: Royal Tropical Institute.

Ruttan, V. (1996). What happened to Technology Adoption-Diffusion Research? *Sociologia Ruralis, 8*, 15-24.

Saldana, J. (2009). *The Coding Manual for Qualitative Researchers* (1st Edition). Los Angeles, CA: Sage.

Saldana, J. (2013). *The Coding Manual for Qualitative Researchers* (2nd Edition). London, UK: Sage.

Sanderson, K., Dustow, K., & Dixon, H. (2012 August). *Economic Impact of Arable Production*. Wellington: BERL.

Sarewitz, D. (2004). How science makes environmental controversies worse. *Environmental Science & Policy, 7*(5), 385-403.

Sayer, J., Sunderland, T., Ghazoul, J., Pfund, J. L., Sheil, D., Meijaard, E., . . . Buck, L. E. (2013). Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. *Proc Natl Acad Sci U S A, 110*(21), 8349-8356. doi:10.1073/pnas.1210595110

Schensul, J. J. (2002). Democratizing Science Through Social Science Research Partnerships. *Bulletin of Science, Technology & Society, 22*(3), 190-202. doi:10.1177/02767602022003003

Schubert, A., & Láng, I. (2005). The Literature Aftermath Of The Brundtland Report 'Our Common Future'. A Scientometric Study Based On Citations In Science And Social Science Journals. *Environment, Development and Sustainability, 7*(1), 1-8. doi:10.1007/s10668-003-0177-5

Scoones, I., & Thompson, J. (1994). Knowledge, Power and agriculture - Towards a Theoretical Understanding. In I. Scoones & J. Thompson (Eds.), *Beyond Farmer First: Rural People's Knowledge, Agricultural Research and Extension Practice.* (pp. 16-32). London: Intermediate Technology Publications Ltd.

Selener, D. (1997). *Participatory Action Research and Social Change*. Ithaca, New York: Cornell Participatory Action Research network: Cornell University.

Sewell, A., Gray, D., Blair, H., Kemp, P., Kenyon, P., Morris, S., & Wood, B. (2014). Hatching new ideas about herb pasturesL learning together in a community of New Zealand farmers and agricultural scientists. *Agricultural Systems, 125*, 63-73.

SFF. (2002). Management strategy for aphid viruses in potatoes Application Form 02/084. Retrieved from http://archive.mpi.govt.nz/applications/sustainable-farming-fund-search

SFF. (2003a). Controlling the Strop: Innovative field cropping practices application form 03/095. Retrieved from http://archive.mpi.govt.nz/applications/sustainable-farming-fund-search

SFF. (2003b). Predicting and Reducing Kabocha Squash Storage Rots Application form 03/090. Retrieved from http://archive.mpi.govt.nz/applications/sustainable-farming-fund-search

SFF. (2004). Sustainable Management of Walnut Blight Application 04/117. Retrieved from http://archive.mpi.govt.nz/applications/sustainable-farming-fund-search

SFF. (2008). Using advanced technology to create sustainable cropping systems application form C08/111. Retrieved from http://archive.mpi.govt.nz/applications/sustainable-farming-fund-search

Sims, L., & Sinclair, A. J. (2008). Learning Through Participatory Resource Management Programs: Case Studies From Costa Rica. *Adult Education Quarterly, 58*(2), 151 - 168.

Sinclair, A., Hebb, D., Jamieson, R., Gordon, R., Benedict, K., Fuller, K., . . . Madani, A. (2009). Growing season surface water loading of fecal indicator organisms within a rural watershed. *Water Res, 43*(5), 1199-1206. doi:10.1016/j.watres.2008.12.006

Skelton, T. (2000). Girls in the Club: researching working class girls lives. *Ethics, Place, Environment, 4*, 167-172.

Sligo, F. X., & Massey, C. (2007). Risk, Trust and Knowledge Networks in Farmers' Learning. *Journal of Rural Studies, 23*, 170-182.

Sligo, F. X., & Massey, C. (2007). Risk, trust and knowledge networks in farmers' learning. *Journal of Rural Studies, 23*(2), 170-182. doi:10.1016/j.jrurstud.2006.06.001

Smith, W. (2002). Developing indicators for sustainability. In I. Bowler, C. Cocklin, & C. Bryant (Eds.), *The Sustainability of rural systems* (pp. 13-34). Netherlands: Kluwer Academic Publishers.

Smith, W., & Montogomery, H. (2004). Revolution or evolution? New Zealand agriculture since 1984. *GeoJournal, 59*(2), 107-118.

Smith, W., Montogomery, H., & Rhodes. (2007). North Island hill country farmers' management response to issues of sustainability. *New Zealand Geographer, 63*. doi:DOI:10.1111/j.1745-7939.2007.00086.x

Snapp, S., & Heong, K. (2003). Scaling Up and Scaling Out. In B. Pound, S. Snapp, C. McDougall, & A. Braun (Eds.), *Managing Resources for Sustainable Livlihoods* (pp. 67-83). London, UK: Earthscan.

Snow, D., & Trom, D. (2002). The case study and the study of social movements. In K. B & S. Staggenborg (Eds.), *Methods of social movement research* (pp. 146-172). Minneapolis: University of Minnesota Press.

Snowden, D. (2002). Complex acts of knowing: Paradox and descriptive self-awareness. *Journal of Knowledge Management, 6*, 100-111.

Sobels, J., Curtis, A., & Lockie, S. (2001). The role of Landcare group networks in rural Australia: exploring the contribution of social capital. *Journal of Rural Studies, 17*, 265-276.

Spangenberg, J., Pfahl, S., & Deller, K. (2002). Towards indicators for institutional sustainability: lessons from an anlysis of Agenda 21. *Ecological Indicators, 2*, 61-77.

Stacey, R. (1999). *Strategic management and organisational dynamics: The challenge of complexity* (3rd Edition ed.). London, UK: Financial Times.

Stake, R. (1995). *The Art of Case Study research*. Thousand Oaks, CA: Sage Publications.

Star, P., & Brooking, T. (2011). The Farmer, Science and the State in New Zealand. In T. Brooking & E. Pawson (Eds.), *Seeds of Empire* (pp. 159-178). New York: I.B Tauris & Co Ltd.

Sterk, B., Kobina, A., Gogan, A., Sakyi-Dawson, O., & Kossou, D. (2013). Five Years After; the Impact of a Participatory Technology Development Programme as Perceived by Smallholder Farmers in Benin and Ghana. *Journal of Agricultural Education and Extension, 19*(4), 361-369.

Stirzaker, R., Biggs, H., Roux, D. J., & Cilliers. (2010). Requisite simplicities to help negotiate complex problems. *Ambio, 39*(8), 600-607.

Stirzaker, R., Roux, D. J., & Biggs, H. (2011). Learning to bridge the gap between adaptive management and organisational culture *Koedoe, 53*(2), 6 pages. doi:10.4102/koedoe.v53i2.1007

Stoecker, R. (2005). *Research Methods for Community Change: A project based approach*. Thousand Oaks, CA: Sage Publications.

Stringer, L. C., Dougill, A. J., Fraser, E., Hubacek, K., Prell, C., & Reed, M. S. (2006). Unpacking "Participation" in Adaptive Management of Social-ecological Systems: A Critical Review. *Ecology and Society, 11*(2), Article 39. Retrieved from http://www.ecologyandsociety.org/vol11/iss2/art39/

Sturgis, P., & Allum, N. (2004). Science in society: re-evaluating the deficit model of public attitudes. *Public Understanding of Science, 13*(1), 55-74.

Sultana, F. (2007). Reflexivity, Positionality and Participatory Ethics: Negotiating Fieldwork Dilemmas inInternational Research. *ACME, 6*(3), 374-385.

Sumberg, J. (2005). Systems of innovation theory and the changing architecture of agricultural research in Africa. . *Food Policy, 30*, 21-41.

Sustainability Farming Fund. (2008/2009). Sustainability Farming Fund: Funding From The Grass-Roots Up: http://www.maf.govt.nz/sff/apply/sff-brochure-2009.pdf.

Tadaki, M., Brierley, G., Dickson, M., Le Heron, R., & Salmond, J. (2014). Cultivating critical practices in physical geography. *The Geographical Journal, 181*(2), 160-171. doi:10.1111/geoj.12082

Tegtmeier, E., & Duffy, M. (2005). External costs of agricultural production in the United States. *International Journal of Agricultural Sustainability, 2*, 1-20.

Tilman, D., Cassman, K., Matson, P., Naylor, R., & Polasky, S. (2002). Agricultural sustainability and intensive production practices. *Nature, 418*, 671-677. doi:10.1038/nature01014

Tippett, J., Searle, B., Pahl-Wostl, C., & Rees, Y. (2005). Social learning and public participation in river basin management. *Environmental Science & Policy, 8*(3), 287-299.

Turner, J., Rijswijk, K., Williams, T., Barnard, T., & Klerkx, L. (2013). Achieving the promise of transdisciplinarity: a critical exploration of the relationship between transdisciplinary research and societal problem solving. *Extension Farming Systems Journal - Research Forum, 9*(1), 89-98.

TVNZ. (2005 March 11). Te Karere (The News).

TVNZ. (2008 April 26). Rural Delivery.

Umali, D., & Schwartz, L. (1994). *Public and private agricultural extension: Beyond traditional frontiers*. Washington, D.C: The World Bank.

UNCED. (1992). Earth Summit. Retrieved from https://www.unsceb.org/content/united-nations-conference-environment-and-development-unced-1992

Urlich, D. (1998). Intellectual capital= competence x commitment. *Sloan Management Review, 39*(2), 15-26.

Van de Fliert, E., & Braun, A. (2002). Conceptualizing integrative, farmer participatory research for sustainable agriculture: From opportunities to impact. *Agriculture and Human Values, 19*(1), 25-38.

van de Fliert, E., Dilts, R., & Pontius, J. (2002). Farmer research teams, farmer field schools and community IPM: Different platforms for different research and learning outcomes. In C. Leeuwis & R. Pyburn (Eds.), *Wheelbarrows full of frogs: Social Learning in rural resource management*. Assen, The Netherlands: Koninklijke Van Gorcum.

Van Den Ban, A., & Hawkins, H. (1988). *Agricultural Extension*. Harlow, England: Longman Scientific and Technical.

Vanclay, F. (2011). Social principles for agricultural extension for the promotion of natural resource management. In J. Jennings, R. Packham, & D. Woodside (Eds.), *Shaping Change: Natural resource management, agriculture and the role of extension* (pp. 62-71). Australia: APEN.

Vanclay, F., & Lawrence, G. (1995). *The Environmental Imperative: Eco-social concerns for Australian Agriculture*. Rockhampton, Australia: Central Queensland University Press.

Veitch, C., Taylor, J., Kilpatrick, S., Farmer, J., & Chesters, J. (2007). *Understanding Community Capacity: Community, Professional and Government Perspectives.* Paper presented at the Second International Conference on Interdisciplinary Social Sciences, Granada, Spain.

Vissak, T. (2010). Reommendations for using case study method in International Business research. *The Qualitative Report, 15*(2), 370-388.

Wadsworth, Y. (2010). *Building in Research and Evaluation: Human inquiry for living systems*. NSW, Australia: Allen & Unwin.

Walker, T., & Ngati Porou. (2004). Valuing Maori ways of knowing and being. In K. Dew & R. Fitzgerald (Eds.), *Challenging Science: Issues for New Zealand Society in the 21st century* (pp. 111-). Palmerston North, NZ: Dunmore Press.

Wals, A., & Rodela, R. (2014). Social learning towards sustainability: Problematic, perspectives and promise. *NJAS - Wageningen Journal of Life Sciences, 69*, 1-3. doi:10.1016/j.njas.2014.04.001

Wals, A., & van der Leij, T. (2007). Introduction. In A. E. J. Wals (Ed.), *Social Learning towards a sustainable world: Principles, perspectives, and praxis*. Wageningen: Wageningen Academic Publishers.

Webber, L., & Ison, R. (1995). Participatory Rural Appraisal Design: Conceptual and Process Issues. *Agricultural Systems, 47*, 107-131.

Weber, J., & Word, C. (2001). The communication process as evaluative context: What do non-scientists hear when scientists speak? *BioScience, 51*(6), 487-495.

Webler, T., Tuler, S., & Krueger, R. (2001). What is a Good Public Participation Process? Five Perspectives from the Public. *Environmental Management, 27*(3), 435-450.

Weick, K. (1989). Theory construction as disciplined imagination. *The Academy of Management Review, 14*(4), 516-531.

Wellcome Trust, & Office of Science and Technology. (2000 October). Sciene and the Public: A review of science communication and public attitude to science in

Britain. Retrieved from http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtd003419.pdf

Welsh, R., & Young Rivers, R. (2010). Environmental management strategies in agriculture. *Agriculture and Human Values, August 28 online*. doi:10:1007/s10460-101-9285-7

Wenger, E. (1998). *Communities of Pratice: Learning, Meaning and Identity*. Cambridge: Cambridge University Press.

Wieczorek, A. J., & Hekkert, M. P. (2012). Systemic instruments for systemic innovation problems: A framework for policy makers and innovation scholars. *Science and Public Policy, 39*(1), 74-87. doi:10.1093/scipol/scr008

Wiek, A., Farioli, F., Fukushi, K., & Yarime, M. (2012). Sustainability science: bridging the gap between science and society. *Sustainability Science, 7*(S1), 1-4. doi:10.1007/s11625-011-0154-0

Wiek, A., Ness, B., Schweizer-Ries, P., Brand, F. S., & Farioli, F. (2012). From complex systems analysis to transformational change: a comparative appraisal of sustainability science projects. *Sustainability Science, 7*(S1), 5-24. doi:10.1007/s11625-011-0148-y

Wildemeersch, D. (2007). Social learning revisited: Lessons from North and South. In A. E. J. Wals (Ed.), *Social Learning towards a sustainable world: Principles, perspectives, and praxis* (pp. 99-116). Wageningen, The Netherlands: Wagenigen Academic Publishers.

Williams, J. M. (2007). Linking science and practice: The pros and cons of the participatory research model. *Ecological Management & Restoration, 8*(3), 158-159.

World Commission on Environment and Development (WCED). (1987). *Our Common Future*. Retrieved from Oxford:

Wynne, B. (1996). May the sheep safely graze? A reflexive view of the expert-lay knowledge divide. In S. Lash, B. Szerszynski, & B. Wynne (Eds.), *Risk, Environment and Modernity: Towards a New Ecology* (pp. 44-83). London: Sage.

Yankelovich, D. (1991). *Coming to Public Judgment: Making Democracy Work in a Complex World*. New York: Syracuse University Press.

Yankelovich, D. (1999). *The Magic Of Dialogue: Transforming Conflict into Co-operation*. New York: Simon & Schuster.

Yin, R. (2003). *Case study research design and methods* (3rd ed., Applied social research methods series ; v. 5 ed.). Thousand Oaks, Calif: Sage Publications.

Yin, R. (2009). *Case Study Research: Design and Methods* (4th ed Applied social research methods series; v. 5 ed.). Los Angeles, CA: Sage Publications.

Ziegler, R., & Ott, K. (2011). The quality of sustainability science: a philosophical perspective. *Sustainability: Science, Practice & Policy, 7*(1), 31-44.