Sustainable horticulture in North Queensland: resistance to the adoption of innovations

Dr Breda McCarthy

Department of Economics and Marketing

James Cook University, Townsville

Email: breda.mccarthy@jcu.edu.au (corresponding author)

Andrea Schurmann

The Cairns Institute

James Cook University, Cairns.

Abstract

There are well documented concerns around global agriculture and increasing pressure is placed on farmers to farm more sustainably. However, research into Australian farmers' resistance to innovation in this context is surprisingly scarce.The purpose of this paper is to explore the factors that prevent growers from adopting more sustainable farming practices in North Queensland.
Design/methodology/approach: A total of 22 in-depth interviews were undertaken with growers and key informants. The analysis involved comparing and contrasting the views held by the different respondents and coding the data into major themes, grounded in the literature, that help explain resistance to organic farming methods.
Findings: This study suggests that resistance to innovation comes from the interaction between the technology, financial circumstances, learning barriers, state of the market and the industry. There were switching costs associated with the adoption of chemical-free farming methods. The financial circumstances confronting growers acted as a constraint on action. For growers interested in organic farming, learning barriers exist, such as the inability to find information that is needed, and the fear of losing competitive advantage if information is shared. Resistance is also explained by macro-level forces such as the extent to which the technologies/new practices are considered useful in the industry and market domain. The presence of powerful players in the supply chain also explains resistance to the adoption of innovation.
Keywords: resistance to innovation, organic farming, sustainable horticulture, semi-structured interviews.

Introduction – the intractable problems facing world agriculture

Food is both elemental to life and wonderful. It sustains and nourishes our bodies, strengthens social bonds through the sharing of food and is intertwined with cultural traditions. Local, artisanal or speciality foods are increasingly sought after by discerning food tourists. In the developed world, it is taken for granted that food will always be there when it is needed. Thanks to industrial farming methods, agricultural output has risen dramatically due to mechanization, use of genetic material and increased inputs, i.e., water and agro-chemicals (UN, 2009). However, conventional farming is chemical intensive, a monoculture and typically focuses on maximising production of a single good without considering the local eco-system (Kirk, 2015).

Agriculture is one of the main contributors to global warming; greenhouse gas (GHG) emissions from agriculture have nearly doubled over the past fifty years and could increase an additional 30 percent by 2050, the highest level in history (FAO, 2014). These emissions are due largely to methane produced by livestock, nitrous oxide from the use of synthetic fertilisers and carbon dioxide from the clearing of forests to grow crops or raise livestock. Agriculture contributes to climate change in several major ways and climate change in general adversely affects agriculture (UN, 2009). There are well documented concerns around global agriculture, food and distribution systems. Along with global climate change (GrowCom, 2014; Lin et al., 2012), studies have identified energy use, land clearing, loss of arable land through urban sprawl, water scarcity, decline in water and soil quality, biodiversity losses, the spread of 'super weeds', threats to human health and the environment from over use of pesticides and rise of antibiotic-resistant strains of micro-organisms (Lang & Heasman, 2004; Notarnicola et al., 2012). While consumers worry about the chemical residues on their food, farm workers are often exposed to pesticides, which have harmful effects on human health (Shellhorne et al., 2013). Roughly one-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year (Gustavsson et al., 2011) and this has prompted researchers to think of solutions, such as value-adding and the conversion of waste to bio-energy (Lin et al., 2012). Waste is clearly inconsistent with the concept of ecological efficiency. With the world's population predicted to grow to over 9 billion by 2050, and the rising middle class in China and India demanding more animal protein, more and more pressure is being put on food supply. There is pressure on agriculture to produce more food with less land (FAO, 2009). Many solutions have put forward offered to solve the complex problems facing world agriculture. It is argued that greater awareness of the societal costs of degradation and value of ecosystems services[i] is needed; furthermore, farmers need to have a greater focus on management systems—from crop to whole farm to natural resource area (UN, 2009).

Australian agriculture, productivity and sustainability: incompatible goals?

Agriculture has historically played an important role in the development of Australia's economy. Although the size and importance of the industry has declined relative to rest of the economy, Australia's agricultural output as a proportion of the economy is amongst the highest in the OECD (ABS, 2012). The agricultural sector, at farm-gate, contributes 3 percent to Australia's total gross domestic product (NFF, 2012). The value of Australian farm and fisheries food production was $42.8 billion in 2012-13. Over the past 15 years, the value of Australian farm and fisheries food production grew in real terms by around 0.5 per cent a year. Employment has declined in the sector due to the substitution of machinery for labour (DAFF, 2014b). Recently signed free-trade agreements with China, Japan and South Korea are expected to make overseas trade even easier. Australia is set to prosper from the rising middle class in Asia and growth in demand for high quality good (Australian Government, 2012).

Farming in Australia is very diverse, ranging from small, often family-owned businesses, to very large (family and corporate) businesses. According to GrowCom (2013), there are about 130,000 farms in Australia of which the vast majority are family owned. The farm business has often been in the hands of one family for several generations. Twenty percent of Australia's farms produce 72 percent of the nation's farm output. Production is increasingly concentrated in large operations. Large players have been steadily buying up land from smaller farmers (ABS, 2012). Farmers' terms of trade, in other words, the ratio of prices received to prices paid, has been steadily declining (NFF, 2012). The Australian

supermarket sector is highly concentrated and there is anecdotal evidence of problems with supply contracts (Griffith, 2004). Growers who sell commodities such as fruit and vegetables are price takers (Australian Food and Grocery Council, 2011). Supermarkets are able to exert control of suppliers in various ways: the legal ability to suspend or not renew contracts, the ability to dictate pricing and the ability to set safety and quality standards. Farmers appear to have limited autonomy in the supply chain and simply have to accept this asymmetric distribution of power. It is logical to assume that problems with supply contracts and uncertainties over price may lead to resistance to the adoption of more sustainable farming methods. There are many other challenges facing Australian farmers:

- Increasing age: in 2011, the median age of Australian farmers was 53 and children have chosen to work in other occupations rather than take over the farm (ABS, 2012)
- Severe droughts have left farmers economically vulnerable (DAFF, 2014)
- Drought is considered a key determinant of poor mental health and a defining feature of explanations for increases in farmer suicides (Alston and Kent, 2008)
- High debt levels due to successive bad seasons, along with disillusionment and despair, have led farmers to sell their land (Kirk, 2015).

Australian agriculture is seen as one of the least distorted and most efficient systems in the world (Bjorkhaug & Richards, 2008). In contrast to the EU, farm subsidies were dismantled in the 1980s. Historically, agricultural policy in Australia has been narrowly focused on increased productivity (Hamblin, 2009). It has been argued that the productivist model of agriculture is undermining environmental goals (Pillarisetti, 2002; Hochman et al., 2013), endangering national food security and accelerating rural decline (Dibden & Cocklin, 2005; Bjorkhuag & Richards, 2008; Dibden, Gibbs & Cocklin, 2013; Lawrence, Richards & Lyons, 2013). It has been observed by Dibden and Cocklin (2005: 148) that there is an "increasingly apparent incompatibility between deregulated, competitive, intensive agriculture and the notion of rural sustainability."

Climate change and natural resource management (NRM) is high on the political agenda. Australia is the world's driest inhabited continent with the most variable climate. Climate change creates significant challenges for agriculture (NFF, 2012). Policy measures include the 'Emissions Trading Fund' which is designed to support landowners to adopt on-farm projects and reduce greenhouse gas emissions or sequester carbon in the soil (DAFF, 2014b). Landcare, founded in 1989, aims to support the protection, conservation and rehabilitation of Australia's natural environment (NRM, 2015). Scholars have argued that while Landcare was a successful community-based, 'bottom-up' approach to natural resource management, there were a number of flaws in the program – it placed too much responsibility on individual landowners and denied the responsibility of government, it deflected criticism of government policies that led to land degradation in the first place (Curtis and de Lacey, 1996). Thus, the goal of achieving sustainability (i.e., promoting biodiversity, reducing greenhouse gas emissions, improving soil fertility and so forth) and the goal of increasing productivity may conflict at times, however that doesn't mean they are mutually exclusive goals.

Farming for the future – enhancing sustainability

The concept of sustainable agriculture is a contested one. The question of how to enhance sustainability while maintaining productivity is a difficult one to answer. There are two main schools of thought (Johnson, 2006):

- Modifying, and improving the efficiency of, conventional agriculture
- Promoting certified organic, local and related systems of agriculture

The first school of thought seeks to modify the productionist paradigm, believing that this is the best strategy for sustainable agriculture (Avery, 1999). Those who favour conventional agriculture believe that research and development can boost yields, food output and help agriculture keep pace with growing demand. Policy makers have embraced technologies that help farmers conserve water (i.e., drip irrigation, recycled water). Private companies are researching new genetic varieties, such as low-chill

blueberries, that are suitable for growing in tropical conditions (Rotary FNQ, 2015). Biotechnology and the use of genetically modified (GM) crops, although contentious, are endorsed by Australian policy makers. Precision agriculture also features in policy documents. Precision agriculture is a high-tech farming system that minimises inputs, for example by equipping tractors with a GPS and using sensors to better target fertiliser and pesticide applications (Kirk, 2015). It seeks to unite innovation with conventional agricultural practices in order to achieve sustainability goals.

The second vision seeks to break the productionist hegemony with policies to promote organic and local food (Johnson, 2006). It is argued that the productivist approach is radically incompatible with sustainability values and a more holistic approach to farming should be adopted. The negative features of conventional agriculture are emphasised, such as pesticide use, animal welfare, rural unemployment, transport dependency and so forth (Johnson, 2006). The second school of thought focuses more on organic, bio-dynamic and related farming practices. Organic farming is one approach to sustainable farming that is classified as "deep sustainability" (Hill & MacRae, 1996). Organic farmers eschew the use of synthetic chemicals and artificial fertilisers, but organic farming encompasses much more than that; it is frequently described as an ideology or a holistic approach to farm management. Organic agriculture is based on four key principles: the principle of health, ecology, fairness and care (IFOAM, 2014). In Australia, organic farming is experiencing rapid growth (Department of Agriculture, Fisheries and Forestry, 2011), but it lacks government support (Wheeler, 2011). Ethical and moral factors affect consumer spending and therefore consumers have an impact the sustainability of the agricultural sector (Johnson, 2006). In Australian, consumer demand for organic food is increasing, but market reports show that lack of consistent volumes of supply is hampering growth, and producers cite pricing and cutting of margins to the point where it is not viable for them to risk production of a given crop (Biological Farmers Association, 2012).

There are numerous nomenclatures for sustainable farming methods. They include 'bio-dynamic', 'permaculture' and 'Integrated Pest Management'. All of these systems seek to either eliminate or reduce the need for synthetic fertilisers and chemicals. Agro-ecology is a type of farming seeks to apply ecological concepts and principles to the design and management of sustainable food systems (Kirk, 2015). Ecological agriculture is a multifaceted concept and it generally refers to a form of agriculture that involves "producing more output from the same area of land while reducing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environment services" (Pretty et al., 2011).

Theoretical framework: resistance to innovation

The theory of adoption and diffusion of innovations (Rogers, 1962) has received widespread attention in many disciplines. Although we know a great deal about the factors driving adoption, less is known about resistance to innovation. Resistance to innovation is not simply non-adoption. It seems logical to assume that the factors that drive adoption, such as the utility of the technology, are, by corollary, the factors that inhibit innovation. However, this is not always the case. There is a small, but growing, body of literature on resistance to innovation (Ram, 1987; Ram and Sheth, 1989; Bauer, 1995; Kleijnen, Lee and Wetzels, 2009). Resistance is defined by Ram and Seth (1989, p. 6) as ''the resistance offered by consumers to an innovation, either because it poses potential changes from a satisfactory status quo or because it conflicts with their belief structure." Barriers can be divided into functional and psychological barriers (Ram and Sheth, 1989).

An interesting framework that classifies the types of user resistance to innovations is offered by MacVaugh and Schiavone (2010). They highlight that adoption of technology depends on three key factors: the technology itself (utility, complexity and complementarity), social structure (context, orientation and contagion) and learning (capacity, capability and costs). Furthermore, it is important to consider the individual, the community of users and the market/industry context. Utility refers to the perceived usefulness of the technology. Complexity refers to the degree of difficulty in understanding and using an innovation, or the overall effectiveness of the technology. Complementarity refers to the degree of fit with older technology and this variable depends on what is already in place. Social context refers to material limits to access. Social orientations refer to whether attitudes towards the use of the technology are

negative. Contagion refers to dispersal and whether it is strong enough to displace community norms. Learning capacity refers to the individual's cognitive ability to learn. The capability variable means that learning generated by older technology use does not assist in new technology use. Industry forces hamper individual learning if guidance/resources are inadequate. Finally, costs refer to switching costs such as investment in training, management time and capital expenditure.

It is said that Australia's farmers have a long history of embracing new technologies and innovative practices (ABS, 2012). There is a growing body of literature that seeks to understand why farmers adopt more sustainable farming practices, such as organic farming, local food networks or multi-functional agriculture (Lockie et al., 1995; Lockie, Lyons & Lawrence, 2000; Cocklin, Mautner & Dibden, 2007; Higgins, Dibden & Cocklin, 2008; Wheeler, 2008; Greiner, Patterson & Miller, 2008; Patrick, Barclay & Reeve, 2009; Andreé, Dibden, Higgins & Cocklin, 2010; Lankester, 2012; Alonso & Northcoat, 2013). In contrast, the literature on the sources of resistance to innovations is scant. Studies on barriers to organic farming highlights market issues such as lack of price premiums and small market size along with on-farm issues such as lower yields, pest and disease problems (Wheeler, 2008). Other barriers relate to the knowledge generation process (McKenzie, 2013) and the characteristics of the innovation itself such as complexity, relative advantage and observability (Guerin, 2000). A national survey of 1,329 farm managers in Australia found that lack of funds was the main factor limiting farmers' ability to change their management practices, followed by available time and workload. Motivations to adopt innovation were centred on financial motives, environmental and personal values (Ecker, Thompson, Kancans, Stenekes and Mallawaarachchi, 2012). The findings of these studies are aligned with some aspects of MacVaugh and Schiavone's model: the utility and complexity of the technology; social context (or material limits to access); switching costs and learning capacity. Hence a decision was made to draw on this theoretical framework when analysing the qualitative data.

Methodology

The primary objective of this paper is to explore the factors that prevent independent Australian farmers from adopting innovations that would help them farm more sustainably. The research questions are as follows:

- What are the factors that prevent growers from making a change from traditional agricultural practices to certified organic farming?
- What are the factors that prevent growers from making a change from traditional agricultural practices to other sustainable farming practices across the conventional-organic spectrum?
- Is the non-adoption of innovation explained by variables relating to the technology, social context (i.e., economic constraints), switching costs and learning capacity?

The answers to these questions should offer a good starting point in determining the sources of growers' resistance to organic farming and related farming practices.

A qualitative methodology using in-depth personal interviews was adopted for several reasons. Firstly, there is a lack of empirical investigations on the chosen topic. Secondly, it helps build a trusting relationship between interviewer and the grower. Thirdly, it enables the questioning of participants to evolve during the interview process, which adds depth and richness to the data (Rubin and Rubin, 2005). Finally, given that the concept of 'sustainable farming' is a contested one, a qualitative approach helps capture a diversity of views which is important for theory generation (Bryman, 2004).

Respondents were recruited by using the authors' professional networks, attendance at the AUSVEG trade conference and through snowball sampling (Dragan & Isaie-Maniu, 2012). A sample of 22 growers and key informants were selected. Key informants were defined as agricultural professionals (such as extension officers, scientists, academics and members of natural resource management groups) who conduct research and/or provide advice to horticulturists. The key informant interviews were not intended to be a representative sample, instead the aim was to gain a range of opinions based on the respondent's occupational role. The growers were chosen based on their production system and

availability. Appendix 1 offers a profile of the respondents. As the table shows, there were ten (10) agricultural professionals, one (1) supermarket manager, four (4) conventional growers from three farms, four (4) organic but not certified organic growers and three (3) certified organic growers. The list of approved certifying organisations from the Department Of Agriculture, Fisheries and Forestry was used to verify whether the grower was certified organic (DAFF, n.d). A diverse sample was selected to encourage the expression of different views. Given that the concept of sustainable agriculture is a contested one and there are numerous nomenclatures for sustainable farming methods, different sub-groups were chosen.

In keeping with the conventions of the key informant method (Tremblay, 1957), the interviews were semi-structured with some open-ended questions; the interviews began with a set of 'grand tour' questions (McCracken, 1988) about participants' personal backgrounds and then turned to their views on sustainable horticulture. The interviews with key respondents were conducted over the telephone. Face-to-face interviews took place with growers on their farms in order to build trust and make it easier for the grower to participate in the interview. The interviews with growers began with the collection of some basic demographic data about the farm. The duration of the interviews ranged from 50 minutes to one hour and 45 minutes. All the interviews were audio-taped and transcribed. The primary data collection phase took place between January 2014 and November 2014. The surveys for growers and key informants are contained in appendix 2 and appendix 3. An attempt was made to match the questions to the work of MacVaugh and Schiavone (2010).

Analysis of data

It is notoriously difficult to analyse qualitative data (Patton, 2002) and the process of generating insights is often a mysterious one. The identification of themes was fundamental to this process and the authors followed the process outlined by Miles and Huberman (1994). Individual texts were coded. Codes are tags or labels which are assigned to whole documents or segments of documents such as paragraphs, sentences or words. Kvale (1996) describes this process as one of determining the natural 'meaning units' in the text. The codes were developed using a combination of inductive (from the ground up) and deductive (theory-based) approaches. The review of the literature suggested a list of concepts which seemed likely to have an influence on resistance to sustainability. These included exposure to risk, financial constraints, limited autonomy in the supply chain and free market government policy. However, particular care was taken to avoid prejudging the themes. Once each individual text was coded, the texts were systemically analysed for themes. As Braun and Clarke (2006: 82) suggest, a "theme captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set". Each interview text was analysed and then compared with other texts. Within-case analysis involved writing up a summary of each individual case in order to identify important themes and this was followed by searches for cross-case patterns (Miles and Huberman, 1994). The comparisons were performed informally by reading and comparing statements and looking for positive or negative perspectives. Given the diversity in the sample, an attempt was made to compare and contrast the views of four sub-groups in the sample: conventional growers, certified organic, organic and agricultural professionals. Frequency analysis, such as identifying the number of respondents who held the same opinion, was conducted. There are various ways of achieving reliability and validity, such as using a team of researchers from different backgrounds to code and interpret the data (Patton, 1999) and using secondary data to triangulate the cases (Glaser and Strauss, 1967). This study benefited from having two researchers, from two different disciplines, who analysed the data. Several policy documents on Australian agriculture, climate change and natural resource management informed this study.

Research Findings

In looking at the results as a whole, some interesting patterns became clear. Table 4 lists the factors that drive resistance to the adoption of sustainable farming practices. This table is designed to be read in tandem with the discussion below .The factors discussed are technology, learning, social support, financial and market/industry. In order to gain a basic idea of how relevant each factor was to the

different sub-groups, frequency analysis was conducted. This was simply the number of respondents who mentioned the issue during the interviews.

TABLE 1: Resistance to the adoption of sustainable practices

Research Issue: Type of Barrier	Findings	Frequency of Responses				
		KR	CG	COG	OG	Total
Technology – *Utility Complexity*	Chemical – positive or neutral view; necessary to avoid crop losses	3	3			6
	Chemicals – negative view; need to improve soil health not destroy it	9	1	3	3	16
	Potential for lower yields	3	3	1	1	8
	Cosmetic appearance, blemish-free, poor quality/low grade, food waste	4	3	2		9
	Knowledge-intensive, complex, time consuming, learning by trial-and-error	9	3	3	3	18
	A long conversion period resulting in reduced yields and lower financial returns	4	3			7
	Costs of organic or environmental accreditation/compliance costs	5	1	1	1	8
	High cost of certified organic (biological) inputs.	2	1	1		4
	Expensive technology (precision agriculture, irrigation)	4			1	4
	Ambivalence towards labelling/certification schemes – too dogmatic or not strict enough	5		2	1	8
Learning *Capability*	Strong focus on increasing productivity to detriment of sustainability	4				4
	Lack of knowledge on how reduce dependence on inputs, such as fertiliser and chemicals, and improve soil health	3		1		4
	Conservative nature of farmers/agronomists/extension services/industry associations.	3		3		6
	Lack of incentives, such as co-payment or co-contribution models, particularly for smaller growers	1		1		2
	Competition between growers inhibits knowledge exchange; lack of support	2	1	1		4
	Lack of knowledge transfer between horticultural sectors.		1	1		2
	Lack of extension services, move to ‘paid’ ‘for profit’ services/private consultant	6			1	7
	Lack of farm trials, farmers not permitted to collect their own data.	2		1		3
	Wrong priorities or short-term focus of industry associations (i.e., focus on pests or weeds rather than on long-term environmental issues)	1			1	2
	Lack of research and development.	4				4
Social	Some negative stereotypes, “greenies”, social stigma	2				2
Financial/ *Social Context*	Lack of power in supply chain	3	1		2	6
	Price-takers, price for commodities driven by supply and demand; unpredictable.	4	3	1	2	10
	Financial stress (low profit or high-debt levels) and pressure to cut costs	6	1	2	2	11
	High costs (labour, insurance, energy & freight costs) and need to reduce usage of inputs (chemicals, fertilisers) to save money	9	4	2	2	17
	Distance from large population centres which increases freight costs	1	2			3

Market/ Industry	Niche market, non-mainstream	7	1	1	1	10
	Competition from cheap organic imports				1	1
	Consumers are price sensitive, not willing to pay premium prices for organic food	4	4		1	9
	Lack of a food culture, low interest in healthy, nutritious food, or new varieties, disconnect from nature	3	1			4
	Power of agro-chemical industry, lock-in, disempowerment of farmers	4		1		5

- KR refers to the number of key respondents (KR) who offered this opinion (out of 11)
- CG refers to the number of conventional growers (CG) who offered this opinion; (out of 4)
- COG refers to the number of certified organic growers (COG) who offered this opinion (out of 3)
- OG refers to the number of organic, but not certified, growers (OG) who offered this opinion (out of 4)

Technology-related barriers – moving away from chemicals

Most respondents appeared to focus on the adverse consequences of using chemicals in farming. Chemicals were used in the conventional farming system to help growers achieve their production goals and they were not prepared to sacrifice yields or cosmetic appearance since this would reduce their income. Views on chemical usage varied. Some agricultural professionals and growers saw it as a significant problem. They cited damage to soil health, risks to personal health and the environmental impacts associated with chemical use (i.e., detrimental effects on insects, birds and marine life). The threat to food security and to the social fabric of rural communities was also emphasised. Others believed that chemical usage was not detrimental to personal health and the environment. There was a belief that if the farmer adhered to all regulations then the risks would be minimised (i.e., using personal protective equipment, applying the correct amount, complying with withholding periods, not spraying within 50 metres of a creek, etc.). Growers cited research into 'softer chemicals', chemicals that are not broad spectrum (i.e., don't kill all the beneficial insects), the trend towards targeted spraying rather than spraying according to the calendar and level of residue testing in the supply chain. While there was some degree of concern over misuse of chemicals, the conventional growers saw it as unavoidable, particularly in a monoculture. There seemed to be an acceptance of the requirement for extra chemical and fertiliser usage to increase yields from land that was considered relatively unproductive and difficult to farm, due in part to poor soils and drought. The use of fungicides was prevalent in the tropics and there was uncertainty over whether organic farming methods were suited to a tropical environment. Conventional growers didn't believe that chemical-free produce was necessarily more nutritious than the produce they grew. The complexity of the organic farming system was seen as a barrier to its adoption:

> "But it is a very complicated system growing crops, organics… It takes a long time to become a successful organic grower. You have got to work at your land for a long time to become very successful at it" (Respondent 19).

In the words of another respondent:

> "It's [use of chemicals] a relatively simple, quick fix solution and one that, you know, doesn't require such as comprehensive understanding of the host, the herbivore, pathogen, parasite interaction dynamic – that requires a fair bit of understanding and management, so chemicals have been a way of enhancing productivity in a relatively straightforward way, so I can well understand why people would do that…you've got to understand the system in a way you wouldn't with a conventional farm, you need to know your pests, the natural enemy, also the associated secondary pests as well…so it can be really time-consuming." (4)

The hard work associated with organic farming was seen as a barrier and the labour involved in managing weeds appeared to deter the larger growers:

> "We have to do a lot more slashing and a lot more hand work with whipper snipping but you get a different mix of weeds and different mix of native plants recolonising the area. If you can manage that, and not every farm operation can do that. Not all farms can do that, but because we

are on a small farm we can have a very intimate knowledge of different parts of the property and manage different parts of the property in different ways". (11)

One respondent noted that getting through the three year conversion period was very difficult for growers (15), since learning was by trial-and-error. The small organic growers were faced with the burden of compliance, such as paying registration fees and completing paperwork. The high cost of biological inputs was also cited as a barrier to adoption of organic farming.

Growers exhibited a certain degree of ambivalence towards organic accreditation schemes. There was also some questioning of organic standards amongst growers who were not certified organic but who followed organic practices. One grower (respondent 12) felt that the national certifying body was inflexible, not open to innovation and as a result he was prohibited from using a locally available input (fly ash) from the sugar mills. Some respondents suggested that the accreditation systems lacked integrity and certain products were permissible even though they were not 'organic' and were promoted by the agro-chemical sector (respondents 19 and 14). They felt that the substitution of biological inputs for chemical pesticides was a reductionist approach and showed limited understanding of the holistic, whole-farm approach to regenerative agriculture. One grower resented having to prove that she was a "good farmer" and felt that it was the conventional farmers who should have to pay for polluting the environment. One conventional grower (respondent 2) remarked that the certified organic system was open to rorting (i.e., a grower using chemicals could send samples of unsprayed produce to the laboratory for residue testing and get away with it).

Learning barriers to the adoption of sustainable farming practices

Several organic growers were experimenting with practices to reduce conventional inputs and make their farms more resilient to adverse weather events. These practices included making their own fertilisers, mulching, planting trees as wind-breaks, trellising to protect trees from cyclones, saving seeds from plants that had withstood cyclones. The learning capacity of the individual grower appears to be restricted by forces outside of their control. Several respondents remarked that the industry focus was on increasing production; hence some growers did not understand that a reduction in yields would actually help them save money by reducing inputs, and hence, profitability could be increased. One respondent remarked that deficiencies in financial planning needed to be addressed:

> "I think the level of debt is probably the biggest issue impacting on sustainability. Farmers are just so concerned about their debt levels. They clutch at straws or follow conventional wisdom: we must increase productivity, we must increase productivity. I think where NRM bodes can intervene is to improve farmers' understanding of financial planning - productivity and input costs - and help people do a proper analysis of their costs" (respondent 3).

The conservative nature of farmers, agronomists and farm extension services were seen as a constraint. Some farmers remarked that they were too old to start afresh and learn about organic farming methods. It was remarked that the entire industry was oriented towards conventional agriculture, that agronomists were not educated on the use of non-chemical methods and were seen as agents selling conventional inputs. This has made it very difficult for growers to access advice on alternative farming methods (respondents 14 and 15).

The price-based nature of competition in the sector appeared to undermine the exchange of knowledge. It created "a climate of fear and distrust between farmers" (respondent 15). One respondent spoke about the lack of cooperation in the sector and its ramifications for information exchange:

> "You don't get to share. Information is power…People ring up, try to pick our brains…It's my information, not the department. I'm not bound to give them that information…People can put pepper in the ground, grow it by trial and error, and do it, but they will have problems. O.K, we have developed markets, but do we want to help them? Ultimately that's competition for me." (1)

The 'trial and error' method of learning about pest and disease management was stressed by another grower:

> "It is a learning curve because you can't use a lot of conventional fertilisers. So the biggest thing is not being able to talk to other growers about it. In conventional farming you have got a lot of support, when you get into organics there is not a lot of support. Probably because everyone is trying to keep their secrets. Which is understandable. So it is matter of having to go along and do it and learn as you go." (21)

There was a belief that there was little or no transfer of knowledge between different horticultural sectors. For instance, discoveries in the banana sector, such as the control of pests and disease without using chemicals, did not diffuse to the sugar cane sector. A significant barrier was the lack of farm extension services. In the words of one grower:

> "So I don't see the extension services. They are very light on the ground and they are very restricted in what they can do. So yes bring them back. Bring back the soil conservation people and deal with the real issues". (11)

Several respondents spoke about the need for evidence, field trials or 'test farms' to demonstrate the outcomes. There seemed to be a lack of knowledge on how to access research funding for trials. A few growers remarked that they were willing to collect data but were told that this would not be considered scientific or rigorous. In the words of one key respondent:

> "One of our biggest challenges is getting long-term trials and case studies…so we can get real evidence of how these things work. Some may not work. We need to see what works and what doesn't work…It's very powerful when farmers talk to other farmers…If people can see the evidence for organics, that can be a great boost to their confidence to try it…We are not going to get traction by talking about it, we have to really show it works." (3)

Deficiencies in the area of government funding for agricultural research, lack of research into the health benefits of organically-grown food, and the general lack of support for sustainable initiatives, were highlighted. In the words of one respondent:

> "I think we don't value eco-efficient services, the benefits we receive…we associate it [nature] with market value…and the market is not willing to pay for it. If we're talking about incentives, encouragement, going that extra step, it's just not there." (10).

Learning from one's peers was emphasised. One respondent (14) remarked that networks were critical in helping farmers make the transition to regenerative agriculture; it was "very powerful" when farmers talked to other farmers and this provided them with "a safety net and the confidence to move forward". However, these networks were absent which posed a barrier to the adoption of sustainable farming methods.

Lack of social support as a barrier to the adoption of sustainable farming methods

Social risks were discussed only sporadically. One respondent (14) spoke about the farmers' fear of being ostracised, of being viewed "crazy or way-out" by their community if they adopted unconventional farming methods. Some negative stereotypes on organic farming appeared to be present, such as its popularity with the alternative/green/left-wing segment of the population when it was first introduced many decades ago (respondent 15). Conventional growers felt that organic farming was a lifestyle/hobby style of farming and lacked a commercial focus. Organic farms were associated with neglect and problems with weeds. In the words of one respondent:

> "..it's a bit airy, fairy…I've seen good stuff grown organically, by neglect largely. Organics should be divided into two areas, the serious organic producers in beef, and the growers who grow organically by neglect, whether that's commercial reality, I don't know…" (2)

Financial barriers to the adoption of sustainable farming methods

The most commonly-mentioned type of risk was financial. The growers were confronted with difficult financial circumstances and this posed a barrier in three ways (a) the potential for further losses inhibited the adoption of more sustainable farming methods amongst conventional growers (b) if a decision had been made to adopt organic farming methods, the non-certified growers wanted a safety net or the flexibility to deal with problems, such as a pest outbreak or weed infestation, in their own way (c) while the financial pressures were just as acute for the organic growers, they appeared to have a different world-view from the conventional growers and prioritised issues such soil health and mineral fertility, regenerating the land, improving land values in the long-term, growing nutrient-dense food and safeguarding one's health.

Growers were described as price takers who were selling a commodity product (apart from growers of high quality, niche tropical fruits, spices and rainforest fruits) and consequently they lacked power in the supply chain. The price they got for their produce depended on world market prices. Growers, irrespective of the type of farming method adopted, had to contend with debt and high labour costs, along with insurance, energy and freight costs. They also had to deal with the risk of late payment from agents and the risk of agents going bankrupt. Predatory pricing allegations were made by three growers (i.e., where a large company floods the market with cheap produce, and, in doing so, forces the smaller, premium-priced, organic grower out of business). One respondent spoke about the struggle to survive:

> "I think, in this day and age, sustainability is about survival. I've been down this path. If you listen to community pressure, you've got to be organic and you don't do anything that might damage the environment – and you go broke. That's not sustainable…There are a lot of people on the knife edge now…I've thought about it [going organic] but I've found that people are not willing to pay much more for organic produce…show me an organic farmer who's not on the bones of their ass, and I'll look more seriously at it." (2)

A conventional grower remarked that high labour rates were barriers to the adoption of organic farming methods:

> "It's hard not to use chemicals in the tropics because labour is so expensive. They [the organic growers] really can't get people to pull weeds out effectively…It's hard work in the tropics. You've got so much growth. Everything grows so quickly. It's a hot climate…You might be able to get people to work that bit harder, but in the tropics where it's 90% humidity and 35 degrees, it's really hard to get people to go out and sweat and get good value out the dollars you pay them." (2)

Market and industry barriers to the adoption of more sustainable farming methods

Market and industry factors appeared to restrict the dispersion of sustainable farming methods. The organic food market was seen as niche, small-scale and non-local. The organic growers targeted markets in Melbourne and Sydney. It was felt that there was a limit to the price that Australian consumers would pay for organic produce, and growers made no reference to the export market for organic produce. A few respondents noted the lack of a food culture in Australia, such as the demand for highly processed, convenience foods, rather than the locally-grown, in-season or organic foods that are generally sold through farmers' markets and non-mainstream channels. Although celebrity chefs like Jamie Oliver were seen to influence the market, it was remarked that they did not promote Australian, and seasonal, produce.

Vested interests and the power of the agro-chemical sector were put forward as a barrier to the transition to more regenerative forms of agriculture (respondents 14 and 15). It was stated that growers were 'locked in' to a cycle of using artificial inputs. In the words of one respondent (14):

> "Worldwide, the chemical industry is now worth $2 billion dollars a year and growing. There are 7,000 registered chemicals. The agro-chemical industry has known the whole thing for years - 40,

> 50 years. They knew that when a farmer fertilises, 3 days later, they'll need pesticides. They knew that once a farmer sprays pesticides, they'll get fungi attacks. They've got the entire thing worked out…it's a slippery slope. Once you start, it's difficult for farmers to get off that. What's needed is a paradigm shift…"

Likewise, a grower remarked (16):

> "Utilisation [of chemicals] has been driven by companies and companies don't actually have profitability of farmers even in their corporate mandate. It is not even on their radar… And beyond all of that [health and environmental damage] who is it making rich? It is not making farmers rich. It is making corporations rich…. You have got people coming to your farm telling you what you need based on what they need to sell. That is absolutely ludicrous".

Another key respondent (18) felt that the promotion of chemicals was disempowering the farmers, remarking, "They want people to think that the product they need is formulated in a lab by really clever people in white coats. It is all about disempowerment."

Cross-case analysis

The aim of cross analysis is to highlight themes of integration, or lack thereof that arose from the interviews. There are several points of convergence and divergence that the sub-groups have with regard to sustainability. Nearly all groups commented on the unique aspects of the agricultural industry – variable weather patterns, risk of crop failure, lack of autonomy in the supply chain, financial pressures on farmers. These uncontrollable pressures made it difficult for growers to adopt practices simply because they were more environmentally friendly. There had to be a solid business case for making changes to their farming practices.

Some key informants felt that farming had become more sustainable due to innovations in the area of precision agriculture (i.e., low volume spray technology, GPS systems). Other key respondents had strong environmental values which formed a critical part of the participants' worldview. They were inclined to question the term 'sustainable farming' arguing that the current agricultural model was not sustainable, socially, economically or environmentally. They preferred to use other terms, such as regenerating or rebuilding farming. In general, key respondents were more inclined to speak about contextual forces and comment on policy measures that would support sustainability, such as research and development, co-payments, field trials and farm extension services.

It was clear from the interviews that mainstream/conventional growers were making some attempts to integrate environmental management into their farming practices, such as water conservation, reduction in energy use and more judicious use of inputs, yet they were not highly concerned about chemicals. They were more likely to cite the unfavourable attributes of certified organic farming, such as the conversion period, niche market, unwillingness of consumers to pay premium prices, competition from imports along with typical barriers such knowledge, time and effort. While the certified organic and organic farmers spoke about barriers, they talked at length about the adverse consequences of using chemicals. Their health and environmental concerns drove them to implement changes on their farms. Conventional growers were less likely to have issues with the use of chemicals and artificial fertilisers. The views of organic and certified organic growers were very similar is terms of the need to build up soil health and reduce reliance on chemicals. Both organic and certified organic growers appeared to be very innovative, and they were adopting lesser known and alternative practices that were not accepted by the certifying bodies, and this led to feelings of ambivalences towards organic certifications schemes. In contrast to the non-certified organic growers, the certified organic group believed that organic certification was critical in terms of guaranteeing credibility and accessing markets; they were willing to bear the costs of certification to obtain commercial benefits. The non-certified organic growers gave several reasons why they didn't obtain certification: the strict criteria; one individual had developed his own proprietary system; another grower cited the fees, paperwork and costs of compliance as inhibiting factors.

Discussion and policy recommendations

This study suggests that resistance to innovation comes from the interaction between the technology, financial circumstances, learning barriers, state of the market and the industry. Social factors, or social risks, were discussed only sporadically. There were switching costs associated with the adoption of chemical-free farming methods. The financial circumstances confronting growers acted as a constraint on action. For growers interested in organic farming, learning barriers exist, such as the inability to find information that is needed, and the fear of losing competitive advantage if information is shared. Resistance is also explained by macro-level forces such as the extent to which the technologies/new practices are considered useful in the industry and market domain. The presence of powerful players in the supply chain also explains resistance to the adoption of innovation. This study offers support for the model proposed by MacVaugh and Schiavone (2010). In their framework, three main factors, technological, social and learning, explain resistance to the adoption of organic farming methods. Although MacVaugh and Schiavone (2010) classify a user's lack of material wealth under the heading 'social context', in this paper we emphasise the significance of financial barriers by using a more explicit label.

Our findings are consistent with other Australian and European studies on the barriers to the adoption of sustainable farming practices. Many studies have identified 'good farming' symbols such as high yields and tidy fields as a reason for farmer resistance to change (Sutherland and Darnhofer, 2012). In this study, large yields or productivity were seen as a sign of good farming practice, and conventional farmers were reluctant to sacrifice yields by switching to chemical-free or low-input methods. Cosmetic appearance is an indicator of quality and it determines the price the grower will get for the produce. Fear of the produce being downgraded due to blemishes is another factor that prevents conventional growers from switching to organic methods.

The literature highlights the effects of "lock-in" and "path dependencies" created by the reliance of the agrifood system on chemical inputs and the dominance of actors such as input and seed companies, big co-operatives and food industries (Lamine, 2011). This study classified this variable, lock-in, under the heading 'market/industry' forces. One novel finding from this study is the fear of "lock-in" to another system, certified organic farming; some growers were concerned about becoming dependent on biological inputs, which are sold along with conventional chemicals by the large input companies, and they felt constrained by the demands of accreditation bodies.

The literature highlights the 'cost-price squeeze' on farmers and that reducing inputs is the main reason for converting to low-input farming (Sutherland, 2011). The desire to reduce inputs is the 'relative advantage' (Rogers, 1995) of adopting a new farming method, but it is compromised by other factors, such as labour intensity, risk of low yields and uncertainty about one's ability to learn a new system of farming (de Buck et al., 2001). Wheeler's (2008) study found that financial constraints and market issues are two key barriers to the adoption of organic farming. Other studies show that while financial benefits and environmental factors (i.e., improving soil quality) are key drivers of practice change, the limiting factors are lack of funds, age, lack of time and workload (Ecker, Kancans & Thompson, 2011).

A UK study (Burton, Rigby & Young, 2003) found that attitudes to the environment, along with information networks (e.g. reliance on other farmers) and gender (e.g. being female) influence the adoption of organic farming. Our study did not explore links between gender and resistance to organic farming since the sample was predominantly male. It did highlight the importance of information networks in explaining resistance to innovation. In the literature, it is recognised that sustainable farming methods are knowledge-intensive, transitions are non-linear and they demand strong linkages between stakeholders, farmers and advisors (Hochman et al., 2013; Lamine, 2011). Some research suggests that the organic conversion process demands a radical shift in thinking and the 'forgetting' of much of the knowledge acquired in intensive production (Morgan and Murdock, 2000). Likewise, key respondents in this study talked about 'paradigm shifts'. Recent studies, including the largest study in the world into farm-level sustainability, conclude that social networks are critical to the practice of sustainable agriculture (Campbell et al., 2012; Manson et al., 2014).

This study found that non-adopters of organic farming can be divided into different groups, and it lends support to studies concluding that the conventional/organic binary is restrictive (Sutherland, 2011; Campbell's et al., 2012). According to Campbell's et al., (2012), organic farmers tend to attach more weight to soil biota/soil health and abstract environmental values than other groups of farmers. In this study, soil health was a dominant theme in the interviews with the organic growers (i.e., certified organic, organic, along with just one conventional grower), which reflects their values and the degraded nature of the land in the area.

The literature shows that most 'barriers' to the adoption of innovation have a rational basis such as costs, risk, complexity and incompatibility with other aspects of farm management (Vanclay and Lawrence, 1994). Adoption is complex and conditioned by the accumulation of experience, information, technical skills and physical capital, along with the economic or social circumstances that exist at the time of adoption (Burton, Rigby & Young, 2003). Foster (2013) concludes that, while significant funds for Australian research and development go into IPM related areas, much more could be done to promote sustainable agriculture. As state departments have moved towards a market-driven or client-driven philosophy of service provision (where farmers have to pay for advice), researchers have predicted that this loss of extension officers will have far-reaching consequences for Australian agriculture (Guerin, 2000).

This study offers the following policy recommendations. Demonstration of the benefits of organic farming, providing social contacts and the framework for network-building, is likely to overcome resistance. Social networks should allow growers to learn and build up their confidence in successfully implementing new farming practices. This would increase the 'observability' (Rogers, 1967) of results. More field trials, along with the dissemination of information on how to access funding for trials, are needed. Conventional growers seem to underestimate the demand for organic produce and ignore export market opportunities. Hence, strategies to assist growers, or grower co-operatives, to exploit markets would be useful. Coping with the influence of the agro-chemical sector is also an issue– pesticide producers have done little to make cheaper, biological alternatives to synthetic chemical pesticides available to growers. Clearly there is a need for advisors who are independent from the pesticide suppliers. The experience of financial stress is strongly linked to resistance to organic farming. Consequently, effective promotion of organic farming to those who reject chemical-free methods should focus on the economic dimension, in other words, the cost savings associated with the reduction of synthetic inputs. Promotion of organic farming to the 'organic, but not certified' group could emphasise market access. Fear of paperwork is probably an unfounded barrier and could be addressed by certification bodies. A case could be made for state intervention and introduction of co-payments, eco-payments, tax concessions, pesticide taxes and insurance schemes to assist growers in making the transition to more 'sustainable' farming practices. However, as the role of the government in Australian agriculture has shrunk after the dismantling of subsidies in the 1980s, major policy changes are unlikely to occur. Furthermore, this study found that growers were not in favour of government intervention.

Conclusions, limitations and future research

The purpose of this study was to explore the factors that prevent Australian farmers from adopting innovations that would help them farm more sustainably. This study suggests that resistance to innovation comes from the interaction between the technology, financial circumstances, learning barriers, state of the market and the industry.

This study has several limitations. The data for the study was collected from growers in Northern Queensland; therefore, the findings may not be generalisable to growers in other parts of Australia or in other countries. Furthermore, it is not possible to draw conclusions for other agricultural sectors such as cropping or cattle farming. The research was based on a small sample size and a quantitative study is required to verify the findings. A survey would be useful to explore themes such as the influence of gender, environmental values and attitudes to climate change with the adoption/non adoption of organic farming. Cluster studies would be useful to explore the differences between adopters, non-adopters and other sub-groups. Trans-disciplinary research is warranted, where knowledge from agricultural science, economics, ecology, marketing, sociology and psychology is combined; it is an ambitious proposition, but

may be increasingly necessary given the challenges faced by the sector. This paper supports the call to rigorously measure outcomes, ecological, financial and social, associated with new 'sustainable' farming practices (Campbell et al., 2012).

Acknowledgements

The authors would like to thank James Cook University for supporting this research under the Mid-Career Re-Engagement Grant. We also would like to thank the reviewers and the delegates of the ANZAM 2014 Conference for their constructive feedback on an earlier version of this paper.

References

ABS/Australian Bureau of Statistics (2012). *Australian farmers and farming*. Retrieved May 3, 2015 from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4102.0Main+Features10Dec+2012

ABS/Australian Bureau of Statistics(2015). *4680.0.55.001 - Information Paper: An Experimental Ecosystem Account for the Great Barrier Reef Region, 2015*. Retrieved May 4, 2015, from http://www.abs.gov.au/ausstats/abs@.nsf/mf/4680.0.55.001

Alston, M., Kent, J. (2008). The big dry: the link between rural masculinities and poor health outcomes for farming men. *Journal of Sociology,* 44, 133-147.

Alonso, A., & Northcote, J. (2013). Investigating farmers' involvement in value-added activities: a preliminary study from Australia. *British Food Journal*, *115* (10), 1407-1427.

Andreé, P., Dibden, J., Higgins, V., & Cocklin, C. (2010). Competitive productivism and Australia's emerging 'alternative' agri-food networks: producing for farmers' markets in Victoria and beyond. *Australian Geographer*, *41*(3), 307-322.

Avery DT. (1999). Intensive Farming and Biotechnology: Saving People and Wildlife in the 21st Century. In G. Tansey and J. D' Silva (eds), *The Meat Business: devouring a hungry planet*. London: Earthscan.

Australian Food and Grocery Council and A.T. Kearney Australia Pty Ltd. (2011). *Australian Food and Grocery Council 2020: Industry at a Crossroads***.** Retrieved 19 November, 2013 from http://www.afgc.org.au/2020-industry-at-a-crossroads-report.html

Australian Government. (2012). *Australia in the Asian Century White Paper.* Canberra: Australia in the Asian Century Task Force, Department of the Prime Minister and Cabinet.

Bauer, M. (1995). *Resistance to New Technology.* Cambridge University Press, Cambridge.

Biological Farmers Association. (2012). *Australian Organic Market Report.* Retrieved 12 March, 2013, from http://www.bfa.com.au/Portals/0/Organic%20market%20report%202012-web.pdf

Bjorkhaug, H., & Richards, C. (2008). Multifunctional agriculture in policy and practice? Acomparative analysis of Norway and Australia. *Journal of Rural Studies*, *24*, 98-111.

Braun, V., Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3, 77-101.

Bryman, A. (2004). *Social research methods* (2nd ed.). Oxford: Oxford University Press.

Burton, M., Rigby, D. and Young, T. (2003). Modelling the adoption of organic horticultural technology in the UK using Duration Analysis. *Australian Journal of Agricultural and Resource Economics*, 47: 29–54.

Campbell, H. Rosin, C., Hunt, L., and Fairweather, J. (2012). The social practice of sustainable agriculture under audit discipline: initial insights from the ARGOS project in New Zealand. *Journal of Rural Studies*, 28, 129-141.

Cocklin, C., Mautner, N., & Dibden, J. (2007). Public policy, private landholders: perspectives on policy mechanisms for sustainable land management. *Journal of Environmental Management*, *85,* 986-998.

Curtis, A., and de Lacey, T. (1996). Landcare in Australia: does it make a difference? *Journal of Environmental Management,* 45, 119-137.

de Buck, A.J., van Rijn, I., Roling, N.G., & Wossink, G.A.A. (2001). Farmer's reasons for changing or not changing to sustainable practices: an exploratory study of arable farming in the Netherlands. *The Journal of Agriculture and Extension*, *7*(3), 153-166.

DAFF/Department of Agriculture, Fisheries and Forestry (2014). *Australian Food Statistics*, retrieved May 3, 2015, from, http://www.daff.gov.au/ag-farm-food/food/publications/afs/food-stats-2012-13

DAFF/Department of Agriculture, Fisheries and Forestry (2014b) Annual Report, retrieved May 4th, 2015 from, http://www.daff.gov.au/SiteCollectionDocuments/about/annualreport/2013-14/annual-report-2013-14.pdf

DAFF/Department of Agriculture, Fisheries and Forestry (2011) *Australian Food Statistics 2009-10.* Canberra, ACT.

DAFF/Department of Agriculture, Fisheries and Forestry (n.d). Exporting organic and biodynamic produce, retrieved May 8th, 2015 from, http://www.daff.gov.au/export/food/organic-bio-dynamic

Dibden, J., Gibbs, D., & Cocklin, C. (2013). Framing GM crops as a food security solution. *Journal of Rural Studies, 29*, 59-70.

Dibden, J., and Cocklin, C. (2005). Sustainability and agri-environmental governance. In V. Higgins and G. Lawrence (Eds.) *Agricultural Governance: Globalisation and the New Politics of Regulation* (pp. 135-152). London: Routledge.

Dragan, M., & Isaie-Maniu, A. (2012). Snowball sampling developments used in Marketing Research. *International Journal of Art and Commerce 1*(6), 214-223.

Ecker, S., Kancans, R., & Thompson, L. (2011). Drivers of practice change in land management in Australian agriculture: preliminary national survey results. *Australian Bureau of Agricultural and Resource Economics and Sciences*: Commonwealth of Australia, Canberra.

Ecker, S., Thompson, L., Kancans, R., Stenekes, N., and Mallawaarachchi, T. (2012) Drivers of practice change in land management in Australian agriculture: results of a national farm survey. *Australian Bureau of Agricultural and Resource Economics and Sciences*: Commonwealth of Australia, Canberra.

FAO (2009). *How to feed the world 2050*, Retrieved May 3, 2015, from, http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

FAO (2014). *Agriculture's greenhouse gas emissions on the rise*, 11 April, 2014, Retrieved May 3, 2015, from, http://www.fao.org/news/story/en/item/216137/icode/

Foster, J. (2013). Government policy Strategies Relating to the Enhanced Implementation of Integrated Pest Management: A Review. *Australasian Journal of Environmental Management, 2*(4), 234-244.

Glaser, B.G., and Strauss, A.L. (1967). *The Discovery of Grounded Research: Strategies for Qualitative Research.* New York: Aldine De Gruyter.

Griffith, G. (2004). The impact of supermarkets on farm suppliers. *Australian Economic Review*, 37, 329–336.

Guerin, T. (2000). Overcoming the Constraints to the Adoption of Sustainable Land Management Practices in Australia. *Technological Forecasting and Social Change*, *65,* 205–237.

Gustavsson, J., Cederberg, C., van Otterdijk, R., & Meybeck, A. (2011). Global Food Losses and Food Waste: Extent, Causes and Prevention. *Food and Agriculture Organisation of the United Nations*. Rome, Italy. Retrieved November 20, 2014 from: http://www.fao.org/docrep/014/mb060e/mb060e.pdf

Greiner, R., Patterson, L., & Miller, O. (2009). Motivations, risk perceptions and adoption of conservation practices by farmers. *Agricultural Systems, 99*, 86-104.

GrowCom (2013) The Pineapple Press eNewsletter. Retrieved May 14, 2014 from http://www2.growcom.com.au/growcom_pinepress/March%202014/PP-March-2014.html

GrowCom (2014). Climate Variability. Retrieved 15 December, 2014 from http://www.growcom.com.au/projects/climate-variability

Hamblin, A. (2009). Policy directions for agricultural land use in Australia and other post-industrial economies. *Land Use Policy*, *26*, 1195-1204.

Higgins, V., Dibden, J., & Cocklin, C. (2008). Building alternative agri-food networks: certification, embeddedness and agri-environmental governance. *Journal of Rural Studies*, *24*, 15-27.

Hill, S., & Macrae, R. (1996). Conceptual framework for the transition from conventional to sustainable agriculture. *Journal of Sustainable Agriculture*, *7*(1) 81-87.

Hochman, Z., Carberry, P., Robertson, M., Gaydon, D., Bell, L., & McIntosh, P. (2013). Prospects for ecological intensification of Australian agriculture. *European Journal of Agronomy*, *44*, 109-123.

IFOAM/International Federation of Organic Agriculture Movements (2014). Vision/Mission/Principles of Organic Agriculture [WWW document] Retrieved 23rd November, 2014 from: http://www.ifoam.org/en/vision-mission-principles-organic-agriculture

Johnson, R. B., (2006). Sustainable agriculture: Competing visions and policy avenues. *International Journal of Sustainable Development & World Ecology*, 13, 469–480
Kirk, D. (2015). Farming for the future. *WellBeing*, 156, 48-52.
Kvale, S. (1996). *InterViews: an Introduction to Qualitative Research Interviewing*. Sage Publications, Thousand Oaks.
Kleijnen, M., Lee, N., & Wetzels, M. (2009). An exploration of consumer resistance to innovation and its antecedents. *Journal of Economic Psychology*, 30, 344-357.
Lamine, C. (2011). Transition pathways towards a robust ecologization of agriculture and the need for system redesign: cases from organic farming and IPM. *Journal of Rural Studies*, *27,* 209-219.
Lang, T., & Heasman, M. (2004). *Food Wars: The Global Battle for Mouths, Minds and Markets.* University of Michigan: Earthscan.
Lankester, A. (2012). Self-perceived roles in life and achieving sustainability on family farms in North-eastern Australia. *Australian Geographer*, *43* (3), 233-251.
Lawrence, G., Richards, C. & Lyons, K. (2013). Food security in Australia in an era of neoliberalism, productivism and climate change. *Journal of Rural Studies*, *29*, 30-39.
Lin, C., Pfaltzgraf, L., Herrero-Davila, L., Mubofu, E., Abderrahim, S.,Clark, J., Koutinas, A., Kopsahelis, N., Stamatelatou, K.,Dickson, F., Thankappan , S., Mohamed, Z., Brocklesby, R., & Luque, R. (2012). Food waste as a valuable resource for the production of chemicals, materials and fuels. Current situation and global perspective. *Energy and Environmental Science*, 6, 426–464.
Lockie, S., Lyons, K., & Lawrence, G. (2000). Constructing "green foods": corporate capital, risk and organic farming in Australia and New Zealand. *Agriculture and Human Values*, *17*, 315-322.
Lockie, S., Mead, A., Vanclay, F., & Butler, B. (1995). Factors encouraging the adoption of more sustainable crop rotations in South-East Australia. *Journal of Sustainable Agricultur*e, *6*(1), 61-79.
Manson, S., Jordan, N., Nelson, K., & Brummel, R. (2014). Modeling the effect of social networks on adoption of multifunctional agriculture. *Environmental Modelling & Software,* xxx, 1-14.
NRM/Natural Resource Management (2015). *National Landcare Program*. Retrieved 4 May, 2015, http://www.nrm.gov.au/national-landcare-programme
NFF/National Farmers' Federation (2012). *Farm Facts*. Retrieved 5 May, 2015 from http://www.nff.org.au/farm-facts.html
McKenzie, F., (2013). Farmer-driven innovation in New South Wales, Australia. *Australian Geographer*, *44*(1) 81-95.
McCracken, G. (1988). *The Long Interview*. Thousand Oaks, CA: Sage Publications.
Miles, M.B., and Huberman, M. (1994). *Qualitative Data Analysis: A Sourcebook of New Methods* (2nd ed) Beverly Hills, CA: Sage Publications
Morgan, K., & Murdock, J. (2000). Organic vs. conventional agriculture: knowledge, power and innovation in the food chain. *Geoforum*, 31, 159-173.
Notarnicola, B., Hayashi, K. Curran, M. & Huisingh, D. (2012). Progress in working towards a more sustainable agri-food industry. *Journal of Cleaner Production*. *28*, 1-8.
Patrick, I., Barclay, E., & Reeve, I. (2009). If the Price is Right: Farmer Attitudes to Producing Environmental Services. *Australasian Journal of Environmental Management*, *16* (1), 36-46.
Patton, M.Q. (1999). Enhancing the Quality and Credibility of Qualitative Analysis. *Health Services Research*, 34, 1189-1208.
Patton, M.Q. (2002). *Qualitative Research & Evaluation Methods* (3rd ed). Sage Publications, California.
Pretty, J.N., Toulmin, C., & Williams, S. (2011). Sustainable intensification in African agriculture. *International Journal of Agricultural Sustainability*, 9, 5-24.
Pillarisetti, J.R. (2002). World Trade in Environmentally Sustainable Agriculture Products: Policy Issues for Australia. *Journal of Economic and Social Policy*, *7*(1), Article 4.
Ram, S. (1987). A Model of Innovation Resistance. *Advances in Consumer Research*, 14(1), 208-212.
Ram, S., & Sheth, N.J. (1989). Consumer resistance to innovations: the marketing problem and its solutions. *The Journal of Consumer Marketing*, 6(2), 5-14.
Rogers, E.M. (1999). *Diffusion of Innovations* (4thEd). Free Press, New York.
Rotary FNQ (2015). *Official Guide*. Retrieved May 10th, 2015 from; http://www.fnqfielddays.org.au/
Rubin, H.J., Rubin, I.S. (2005). *Qualitative Interviewing: the Art of Hearing Data*. Sage Publications, Thousand Oaks, California.

Selwyn, N. (2003). Apart from technology: understanding people's non-use of information and communication technologies in everyday life. *Technology in Society*. 25, 99-116.
Shellhorne, N., Renwick, A., MacFadyen, S., (2013). The real cost of pesticides in Australia's food boom. The Conversation, 5th December. Retrieved 10 December, 2014 from: http://theconversation.com/the-real-cost-of-pesticides-in-australias-food-boom-20757
Sutherland, L. (2011). Effectively organic: environmental gains on conventional farms through the market? *Land Use Policy*, *28*, 815-824.
Sutherland, L., Darnhofer, I. (2012). Of organic farmers and 'good farmers': changing habitus in rural England, *Journal of Rural Studies*, 28, 232-240.
Tremblay, M.A., (1957). The Key Informant Technique: A Non-ethnographic Application. *American Anthropologist*, *59* (4), 688-701.
UN/United Nations (2009). International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD). Retrieved May 3, 2015, from, http://www.unep.org/dewa/assessments/ecosystems/iaastd/tabid/105853/default.aspx
Wheeler, S., (2008). The barriers to further adoption of organic farming and genetic engineering in Australia: views of agricultural professionals and their information sources. *Renewable Agriculture and Food Systems*, *23*(2): 161-170.
Wheeler, S. (2011). Review of organic farming policy in Australia: time to wipe the slate clean. *Journal of Sustainable Agriculture*, *35*(8), 885-913.

Appendix 1 -Sample

Table 1: List of Respondents

No.	Respondent	Type	Description of farm/organisation
1	Grower	Conventional grower	Black pepper, 2 hectares.
2	Grower	Conventional grower	Tropical fruits, 89 hectares.
3	Landcare	Regional Land Care Facilitator	Aim is to support Landcare and production groups to adopt sustainable farm and land management practices and to protect Australia's landscape.
4	Horticulture Innovation Australia	Scientist	A not-for-profit, grower-owned Research and Development Corporation (RDC) for Australia's horticulture industry.
5	GrowCom	Communications Officer	Growcom is a not-for-profit organisation that provides training and services to the Queensland horticulture industry.
6	Farm Extension Officer	Advisor	Technical support service for farmers administered by the Department of Agriculture, Forestry and Fisheries (DAFF).
7	Reef Catchments	CEO	Mission is to work collaboratively with the community to improve the condition of the region's natural resources.
8	IGA	Manager	A supermarket in Australia.
9	University	Professor of Agricultural Science	Regional University.
10	Landcare	Director	A not-for-profit organisation responsible for raising awareness and funding for the Landcare movement to support its role in restoring the productivity and value of Australia's natural environment.
11	Grower	Organic, not certified organic	Vanilla, 5 hectares.
12	Grower	Organic, not certified organic, proprietary eco-label	Bananas, 47 hectares.
13	Grower	Certified organic (Australian Certified Organic, formerly BFA)	Bananas and other vegetables. 54 hectares.
14	RegenAG	Co-Founding Director	Enterprise committed to helping regenerate Australia's farms, soils, communities and on-farm livelihoods via the provision of education and training

			opportunities.
15	RegenAg	Co-Founding Director	See above.
16	Grower	Conventional	Bananas, avocados, coffee and sugarcane. 70 plus hectares.
17	Grower	Conventional	Business partner in above farm.
18	Terrain NRM	Staff member	A community-based, not-for-profit organisation supporting natural resource management (NRM) in the Wet Tropics.
19	Grower	Conventional	Potatoes. 70 plus hectares.
20	Grower	Certified organic, (AusQual Organic)	Pineapple and pumpkin (certified organic), and sugar cane (conventional). 70 plus hectares with 5 hectares devoted to organic.
21	Grower	Organic, not certified organic	Value-added juice product, 600 trees.
22	Grower	Certified Organic (NASSA)	Bananas, 72 hectares.

Appendix 2 – Grower Survey

Introduction

Tell me a bit about yourself and your experiences as a grower.

Farm characteristics

What type of produce do you grow?
How many hectares are of your land are devoted to fruit and vegetable growing?
Where do you sell your produce?
Do you supply local markets? Why or why not? Do you export your produce?

Change in farming practices, use of technology, barriers and antecedent factors

What does the term 'sustainable agriculture' mean to you? What about social goals – are social goals/outcomes neglected?
Have you had change your farming practices in response to climate change or unusual weather patterns?
What sustainable production practices do you have in place? What are the benefits of adopting more sustainable farming methods?
What are the constraints that you face in terms of adopting more sustainable horticultural practices?
What caused you to start thinking about options and alternatives beyond conventional agriculture? What motivated you?

Do you use precision agriculture (i.e., using a GPS to better target fertiliser and pesticide applications)?
What was the value of implementing this sustainable land management practice?

What are the main reasons for using chemicals – pesticides, fungicides, etc?
Is your use of chemicals increasing or decreasing? Have you tried to reduce your dependence on chemicals? How?
Do you seek alternatives to chemicals/other ways of combating pests?Are you worried or concerned about the health impacts (poisoning) associated using agricultural chemicals? Are you worried or concerned about the environmental impacts associated with using agri. chemicals?

Have you tried to reduce energy costs? Explain
Waste – do you have to deal with excess or waste produce?
Do you try to use water efficiently?

Have you considered organic farming?
What are the benefits of becoming a certified organic producer?
What are the barriers/drawbacks?
What would help you make the transition to organic farming?

Learning and support

What sources of information do you use (i.e., family, relatives and neighbours; field days; farm extension services; private farm consultants; farm suppliers; growers' associations; NRM groups, banks and financial advisors; education courses, mass media) and how important are these sources of information in enhancing your knowledge of sustainable practices in horticulture?

Are you a member of any Natural Resource Management (NRS) groups? (Landcare, Greening Australia, Terrain NRM) If yes, how has membership of this association helped you adopt sustainable farming/growing practices – has it helped you make you a contribution to the land in which you live and work? Is Supporting Natural Resource Management (NRM) groups important to you?

Government policy

What type of assistance from the government would be useful in helping you overcome barriers to adopting more sustainable practices?

Social context/economic circumstances
Do you think you lack power in the marketplace? Have you ever had to deal with lowered pricing and suspension of contracts?
What type of risk are you exposed to in your line of business?
How do you adapt/deal with these risks?
Do you feel you are rewarded adequately for the risk you take? Does the sale price cover the cost of production?
Have you ever considered “walking off the land”?
Is farming a business or a way of life or a business for you?

Appendix 3 – Key Informant Survey

Introduction

Tell me a bit about yourself and your role with X.

Change in farming practices, technology, barriers, antecedent factors

What does the term 'sustainable farming' mean to you?

With regard to your employer, can you give me some practical examples of how this organization persuades growers to adopt sustainable growing techniques?
Has your association tried to encourage farmers to reduce energy costs? To reduce waste, excess waste? To use water more efficiently? To improve soil quality?
Do you think farming in Queensland has become more or less sustainable over the past decade? Explain

What are the benefits of adopting more sustainable farming methods?
In your opinion, what are the key environmental issues facing Queensland growers today?
How are horticultural practices adapting in response to climate change/unusual weather patterns?

What do you think are the benefits of IPM/low-input farming systems?
What do you think some of the problems of persuading growers to adopt IPM?

Are you worried or concerned about the use of agricultural chemicals and their impacts on health (human health, farmers' health) and the environment?
Why are they used? Is use of chemicals increasing or decreasing? Why?
What do you think are the reasons for increased use of pesticides?

What inspires on farm-innovation?
What role is played by precision agriculture? What are barriers?

What are the benefits of becoming a certified organic producer?
What are the drawbacks?
In you view, is there a divide between conventional and organic growers?

Are you familiar with the term "community supported agriculture"? Does that play a role in sustainable agriculture?
It is argued that one principle of sustainable food systems is "ensuring that food is eaten as close as possible to where it is produced" – what do you think? Is this practical? What are barriers?

Government policy/ productivist orientation
It has been said that "producing food for less can sometimes be a function of efficiencies of scale, but it can also mean reducing costs at the expense of people and the environment." Do you agree or disagree?

Farming is not subsidized in Australia but a range of extension services are available to growers. Do you think this type of support is enough in you view? Could the government do more?

Learning

Are you familiar with any partnerships or collaborations between horticultural sector and NRMs (Natural Resource Management Groups) that are designed to improve sustainability in horticulture?

[i] Ecosystem services are the contributions of ecosystems to benefits used in economic and other human activity. They include flows of tangible items (i.e. timber, fish, food, fresh water, etc.) in addition to intangible services (i.e., human well-being). Examples include the ability to earn an income and gain access to a livelihood, eco-tourism, recreational values, ability to express cultural values (ABS, 2015)