CLIMATE VARIABILITY AND THE AUSTRALIAN SUGARCANE FARMER:

A PHENOMENOGRAPHIC ANALYSIS OF FARMER EXPERIENCES OF MANAGING AND DISCUSSING CLIMATE RISK.

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ABSTRACT

This research contributes to the understanding of how Australian sugarcane farmers conceive of their management of the impacts of the highly variable climate in which their businesses are situated. The historical group extension and information communication environment which support farmer discussions and consideration of climate information is described, particularly in the way in which participative Managing for Climate Risk workshops have been delivered in Queensland, Australia. The decline in the provision of traditional extension services is discussed, and the consequent opportunity that improvements in digital networks provide to augment and or replace extension services with different communication tools. Novel discussion support tools (a series of four machinima, animations produced in a virtual world format) are developed, evaluated and tested in a farmer workshop, delivered in a collaborative, social learning environment, using adult learning principles. Developmental phenomenography is used as the principal qualitative research methodology to understand and describe farmer conceptions of managing and discussing climate risk. Post-workshop survey and semi-structured interview data are analysed phenomenographically within the research to articulate the variation in farmer conceptions to related phenomena. Conclusions and recommendations for the climate science and communication community are developed which may lead to improvements in the ways that farmers are engaged and supported in their learning about managing the impacts of climate variability in the future. Additionally, the opportunity to use phenomenography as a qualitative evaluation methodology in agriculture extension programs is discussed.

CERTIFICATION OF THESIS

This Thesis is the work of Neil Cliffe except where otherwise acknowledged, with the majority of the authorship of the papers presented as a Thesis by Publication undertaken by the Student. The work is original and has not previously been submitted for any other award, except where acknowledged.

Student and supervisors signatures of endorsement are held at USQ.

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TO RUTH, FOR SHARING YOUR LIFE WITH ME

TO LINDA, BRETT, JODIE AND TOM, FOR ALL THE JOYS AND CHALLENGES YOU BRING

TO MUM AND DAD, FOR GIVING AND SUSTAINING MY LIFE

TO ALISON, FOR HER CONSTANT SUPPORT FOR ME AND MY FAMILY

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Format of thesis

This thesis is presented in the format of a 'Thesis by Publication'. Chapter 1 introduces the rationale for the research and the contextual environment in which the research is undertaken. Chapter 2 reviews the literature relevant to the research approach and describes the scope of the research project. Chapters 3 through 6 are presented as either published papers, or constructed and written in an advanced format for journal publication. Chapter 3 has been published in the Journal of Agricultural Education and Extension (Cliffe et al. 2016). Chapters 4 through 6 are in journal ready format. Chapter 7 contains a general discussion which integrates conclusions drawn from the research results linked to key theoretical foundations of the research. Furthermore, Chapter 7 identifies practical and methodological recommendations which constitute outcomes of the research.

Synopsis of thesis with chapters as published or journal ready papers

This research contributes to the understanding of how Australian sugarcane farmers conceive of their management of the impacts of the highly variable climate in which their businesses are situated. The historical group extension and information communication environment which support farmer discussions and consideration of climate information is described, particularly in the way in which participative Managing for Climate Risk workshops have been delivered in Queensland, Australia. The decline in the provision of traditional extension services is discussed, and the consequent opportunity that improvements in digital networks provide to augment and or replace extension services with different communication tools. Novel discussion support tools (a series of four machinima, animations produced in a virtual world format (USQ Digital Futures CRN, 2014a-d)) are developed, evaluated and tested in a farmer workshop, delivered in a collaborative, social learning environment, using adult learning principles. Developmental phenomenography is used as the principal qualitative research methodology to understand and describe farmer conceptions of managing and discussing climate risk. Post-workshop survey and semi-structured interview data are analysed phenomenographically within the research to articulate the variation in farmer conceptions to related phenomena. Conclusions and recommendations for the climate science and communication community are developed which may lead to improvements in the ways that farmers are engaged and supported in their learning about managing the impacts of climate variability in the future. Additionally, the opportunity to use phenomenography as a qualitative evaluation methodology in agriculture extension programs is discussed.

Chapter 3 (Paper 1: published in the Journal of Agricultural Extension and Education)

Chapter 3 documents in detail the process through which Australian sugarcane industry stakeholders are engaged in collaborative learning processes aiming to improve knowledge and understanding of climate variability and their ability to use climate forecasting in farm management decision-making. This published paper (Cliffe et al. 2016) documents for the first time, the recent historical context in which Australian sugarcane industry stakeholders learn about and understand the impacts of climate variability in a participative Managing for Climate Risk workshop. Descriptive statistics and thematic analysis are used as qualitative approaches to provide comparisons of knowledge, skills and understanding in a group of over 200 canefarmers and their advisers.

Chapter 4 (Paper 2: Target Journal – Australasian Journal of Educational Technology)

Chapter 4 reports on the evaluation of a prototype, virtual world produced, discussion support tool (a machinima) with 17 sugarcane industry stakeholders to determine its acceptability as a medium to communicate information about climate risk and support group discussion. With reported reductions in industry communication and extension services, and concurrent improvements in access to digital networks and technologies, machinima may provide an alternative, cost effective media to provide information and support farmer group discussions in the agriculture sector. The use of machinima have not previously been trialled within the

Australian sugarcane industry and few examples exist globally of their use in agriculture generally, either in developed or developing world contexts. Developmental phenomenography is used as a qualitative methodology to analyse the variation in sugarcane industry stakeholder conceptions of machinima key messages derived from analysis of semi-structured interview data. Although phenomenographic analysis is common in other sectors (e.g. education and health), there are few examples where phenomenography and fewer still (if any) where developmental phenomenography has been used as a qualitative methodology in the agriculture sector.

Chapter 5 (Paper 3: Target Journal – Weather, Climate and Society)

Chapter 5 reports on the testing of four different machinima to support discussion in a Managing for Climate Risk workshop. The machinima were used to replace the conventional facilitated discussion that normally occurs at such a workshop. Post-workshop survey data from 90 workshop participants is analysed using developmental phenomenography as the qualitative research methodology to understand the variation in Australian sugarcane farmer conceptions of managing and discussing climate risk in the context of participating in a Managing for Climate Risk workshop.

Chapter 6 (Paper 4: Target Journal – Learning and Instruction)

Chapter 6 reports on analysis of semi-structured interview data collected from 22 farmers who had been participants at Managing for Climate Risk workshops. Developmental phenomenography is used as a qualitative methodology to understand the variation in farmer conceptions of managing climate risk and discussing climate risk with other people.

1. Research rationale, contextual environment and objectives

1.1 Introduction

Droughts, floods and other episodic extreme weather and climate events regularly impact on the agriculture sector in Australia and globally. Farmers face significant management challenges to remain productive, profitable and sustainable when responding to these events, in addition to managing impacts of inter-seasonal and intra-seasonal climate variability that can also be significant. Learning to manage climate variability and climate change impacts is a major issue for the agriculture sector internationally where maintaining and improving productivity to boost sustainable food production is important as global population continues to grow (Wheeler & von Braun 2013). However, on individual farms, climate risk is only one element in a complex business environment which competes for management attention (Crane et al. 2010). Furthermore, there is a known lack of uptake of new technology associated with the management of the impacts of climate variability by farmers. This is especially relevant in developing countries, where use of technology and seasonal climate forecasts could reduce the occurrence of major food shortages and famine (Stone, R 2017, pers. comm., 7th April). Thus, addressing the challenges and opportunities presented by variable climatic conditions by improving understanding of climate forecasts and climate change impacts and enhancing management of climate risks remains a challenge for science educators and communicators (Pidgeon & Fischhoff 2011).

This research study describes the contemporary communication and extension environment within the Australian sugarcane industry which supports farmer learning and skill development concerning management of impacts associated with climate variability. It also documents how Australian sugarcane farmers currently understand management of climate risk and the impact of peer group discussions about climate variability on farmer understanding and learning. Part of the research also investigates the value of new discussion support tools (specifically, customised scripted digital animations called ‘machinima’) in facilitating conversation and farmer learning about climate risk management (Nelson et al. 2002; Stone et al. 2012a; Stone et al. 2012b). Discussion support processes which prompt conversation in farmer groups support social and collaborative learning and are increasingly common within agriculture extension programs (Barrett 2014). The benefits for decision-making, improved understanding and knowledge sharing regarding climate risk management in farmer and broader community discussion processes has been described both in developing and developed country contexts (Roncoli et al. 2009; Peterson et al. 2010; Bartels et al. 2013; Ross et al. 2015). This study provides a case study describing the impact of discussion support processes on farmer learning and understanding within the Australian sugarcane industry focused on managing the impacts of climate variability.

The use of virtual world technology in supporting learning appears to be increasingly more common in the tertiary education sector (Cincioğlu & Zengin 2015; Olinkha & Susan 2015). Second Life™ is a popular virtual world platform with over 48.8 million user accounts and up to 62,000 users online at any time (Voyager 2017). Machinima are digitally recorded films (resembling cartoon-like animations), created in virtual worlds (Middleton & Mather 2008) such as Second Life™ and are also emerging as products to support learning in a range of contexts, including legal studies, disaster management training and language teaching (Butler 2010; Taylor-Nelms & Hill 2014; Cincioğlu & Zengin 2015). Avatars which represent human characters interact and communicate in an artificially created digital environment. Tools, such as machinima, that are developed to explicitly prompt and augment farmer discussion may assist extension services to support farmer learning, knowledge construction and initiate on-farm action. The machinima used in this study are initially evaluated through exposure to individual sugarcane industry stakeholders, then tested in a formal farmer workshop setting to evaluate their impact on group discussion. The outcomes of this research are ultimately focused on improving the capacity of Australian sugarcane farmers to manage the impacts of a highly variable climate. If successful, outcomes of the research will contribute to ensuring the industry remains globally competitive and farmers are better equipped to respond to productivity and environmental challenges they face.

Descriptive statistics (Sandelowski 2000) and thematic analysis (Patton 2002) are used to evaluate farmer learning expressed as gains in knowledge, understanding, skills and aspirations from Managing for Climate Risk workshop processes delivered to farmers across the Australian sugarcane industry. Developmental phenomenography (Bowden & Green 2005) is also applied as a qualitative research methodology to analyse and understand the variation in farmer conceptions of phenomena addressing key research questions.

This introductory chapter introduces the research background and rationale, describes the context in which the research is conducted and outlines the research objectives addressing gaps in current understanding. Additionally, this chapter outlines the format in which the thesis is constructed and presented.

1.2 Climate risk and climate risk management

Managing climate risk frequently focusses on decision-making concerning negative or downside impacts that may result from climate events, whether those events be drought or flood. The Intergovernmental Panel on Climate Change (IPCC 2014) describes risk in qualitative terms as the '…potential, when the outcome is uncertain' for adverse consequences…'. A quantitative definition of climate risk can be described as a product of the probability of a climate event occurring and the adverse or negative consequences that might result (Martínez et al. 2012). Both these qualitative and quantitative definitions of risk and climate risk and many other risk management and assessment processes focus on events which have adverse outcomes. However, best practice climate risk management, particularly in the agriculture sector, should be equally concerned with analysing climate events that have an upside risk or where there are opportunities for improved productivity or profitability that climate events may present to decision-makers. Cobon et al. (2009) provide a useful case study example where analysing the impacts of climate change and associated adaptation responses in the grazing industry focus on both negative and positive risks using a formal risk assessment process. Indeed the World Meteorological Organisation has proposed a useful definition of 'Climate Risk Management' which includes a specific orientation to the identification of both adverse consequences of climate events and the opportunities that those events may present:

> 'A systematic and coordinated process in which climate information is used to reduce the risks associated with climate variability and change, and to take advantage of opportunities, in order to improve the resilience of social, economic and environmental systems' (Martinez et al. 2012, p. 480).

Climate events which impact on productivity, challenge the profitability of agribusinesses and place considerable pressure on rural communities are not new to Australian farmers (McKeon et al. 2004). However, Queensland sugarcane farmers in particular are subject to highly variable rainfall conditions, both at intra-seasonal (Wheeler et al. 2009) and inter-annual (Nicholls et al. 1997) time scales, which impact heavily on productivity and profitability (Everingham et al. 2003; Clarke et al. 2010; CANEGROWERS 2012). The Australian sugarcane industry is located in a region with arguably, the highest variability, compared to other similar climates, globally (Nicholls et al. 1997). Compared to other countries, which are major trade competitors producing similar agricultural commodities, Australia has a higher co-efficient of variation of annual rainfall (Love, 2005). Some of these countries are significant producers of sugar, including Africa and India. Australian sugarcane farmers therefore face significant challenges in managing such a highly variable rainfall environment that key international competitor countries do not.

Managing climate risk workshops have been delivered to the sugarcane industry intermittently and sporadically on an opportunity basis over the last twenty years. A relatively small percentage of the canefarmer population have participated in these processes, compared to the entire population at any specific time. The penetration of regular use of seasonal climate forecasting information may therefore have been limited to extension officers and farmers who have taken an active interest in the use of climate forecast information, and those in their networks who they may influence.

1.3 The Australian sugarcane industry

Sugarcane is predominantly grown in high rainfall or irrigated tropical and sub-tropical areas of Australia adjacent to the coasts of Queensland and north-eastern

New South Wales, with approximately 95% of Australian raw sugar produced in Queensland (Kealley & Quirk 2016). The Australian sugarcane industry supply chain is characterised by a predominance of family farms supplying a small number of large milling entities. Indeed, 89% of sugar cane is grown within family farming enterprises less than 250 ha in area (Valle & Martin 2015), with an average farm size of approximately 85 ha (ASMC 2016). Farmers grow and harvest sugar cane and have a role in transporting the crop some distance to an industrial scale milling factory which crushes and processes the sugar cane into a raw sugar product. The milling company has the major role in the transport and processing of the sugarcane crop and ultimately the marketing of the raw sugar product, or in some cases, further refining the sugar before sale and export. Approximately 4500 farmers supply eight milling companies who operate 24 mills within the areas where sugar cane is grown in Australia (ASMC 2016). In 2015, over 4.9 million tonnes of sugar was produced, with approximately 78% exported, generating over A$1,500 million in export revenue (ASMC 2016). Figure 1.1 illustrates the geographic distribution of major sugarcane growing regions, sugar mills, refineries and ports in Australia.

Figure 1.1: Geographic distribution of major sugarcane growing regions, sugar mills, refineries and bulk sugar terminal ports in Australia (ASMC, 2017).

1.4 Current Australian sugarcane industry extension environment

A wide range of extension services support the management environment in which sugarcane farmers operate in Australia. Most services are funded through joint partnership agreements between growers, millers, natural resource management groups and government agencies. Others (although relatively few compared to more intensive cropping industries such as cotton and horticulture) are provided by commercial consultants. Within the broader Australian farmer population, recent research has indicated that only 18% of farmers were willing to pay for agricultural extension services delivered by non-government entities, even though a third (33%) endorsed the quality of those services (Nettle 2016). Furthermore, within the Australian sugarcane industry 39% of farmers indicated they were unwilling to pay for private sector delivered services, only just behind the grazing industry (40%) (Nettle 2016).

Research funding for the sugarcane industry in Australia is managed by Sugar Research Australia (SRA). It is the primary organisation managing a diverse portfolio of research, development and extension activities and is funded by a statutory industry levy of grower and milling businesses, matched with funding from Commonwealth and state governments (Sugar Research Australia 2016a). SRA investment priorities are shaped by collaboration with key industry stakeholders and are aimed at quickly turning new knowledge into practical outcomes (Sugar Research Australia 2016b).

Productivity services in the Australian sugarcane industry are usually regionally managed, often controlled by boards led by local growers (e.g. Mackay Area Productivity Services Ltd. (Mackay Area Productivity Services 2016); Burdekin Productivity Services (Burdekin Productivity Services 2016)). These services focus on the provision of advice to growers about pests, diseases, crop nutrition, weed control and other productivity issues and also conduct research activities. Commercial entities which have a stake in sugarcane milling operations, in some instances, also fund extension services associated with the mill areas in which they operate (e.g. MSF Sugar; Isis Central Sugar Mill Company) (Nextgenfarmer 2015). Approximately 41% of cane farmers source information and advice from these types of extension services (Nettle 2016). Some sugarcane milling companies also own and control their own farming operations (e.g. Bundaberg Sugar; Isis Central Sugar Mill Company, Wilmar Sugar Australia). Wilmar Sugar Australia own and farm approximately 6600 hectares across four sugarcane growing regions in Queensland and lease a further 2000 hectares to local farmers (Wilmar 2017).

The relative importance of this study is based on the fact that cane farmers in Queensland are subject to highly variable rainfall conditions both at intra-seasonal (Wheeler et al. 2009) and inter-annual (Nicholls et al. 1997) time scales, which impact heavily on productivity and profitability (Everingham et al. 2003; Clarke et al. 2010; CANEGROWERS 2012). Although a wide range of other training opportunities have been available to farmers within the industry, no formal arrangements for the provision of seasonal climate forecast information and training to cane farmers currently exists within the sugarcane industry (Johnston Agribusiness 2004). Farmers informally and opportunistically access weather and climate information through a range of private, university funded and government funded (e.g. Bureau of Meteorology) services and applications located both within Australia and from other international sources. From time to time climate risk training workshops have been conducted where demand and externally sourced funding or sponsorship have been identified (Cliffe et al. 2016). However information about the state of knowledge and use of climate information by farmers within the sugarcane industry in Australia is limited.

1.5 Research background

Effectively managing climate risk is a significant challenge for farmers in both developed and developing countries (Hansen 2002b; Asrar et al. 2012). This challenge is particularly relevant in a physical and socio-cultural environment where climate change increases the uncertainty farmers face in managing their business and where their adaptive capacity may be limited (Marshall et al. 2016). Climate science communicators and agriculture extension personnel play a critical role in communicating complex climate information in a meaningful way to farmers. This role is central to improving the flexibility and capacity of farmers to make decisions and enabling the agriculture sector more broadly to prosper, remain resilient to natural climate variability and climate change risks, and take advantage of opportunities when they arise (Haigh et al. 2015).

The impacts of climate risk on farming operations are many and varied. In the sugarcane industry in particular, the risk of a wet harvest can significantly compromise the capacity of the industry to operate across the entire supply chain.

Unseasonal high rainfall related to a La Niña event during the 2010 harvest period resulted in severe losses to the industry, particularly at the marketing level where sugar was contracted to be sold but could not be delivered. To meet contracts, sugar had to be purchased at very high prices on the global market. The economic impacts of that event flowed through the entire industry and included farmers in regions where harvesting was unaffected by the rainfall event (ASMC 2011; QSL 2011). Seasonal forecasting leading up to this event, which indicated that there was a higher probability of wet harvest conditions, could have been used by the industry to better prepare for the event that developed. Less sugar could have been forward sold by the centralised marketing agency, reducing the amount that needed to be ultimately purchased elsewhere at high prices. Millers could have prepared more proactively for harvest season interruptions due to wet weather within their logistics management and maintenance operations. Farmers could have harvested wetter blocks earlier in the season and left older ratoons which have lower yield potential until later in the harvest season and potentially sacrificed those parts of their crop if required. Climate forecasts are applied to many other sugarcane management decisions throughout the supply chain, including irrigation, nutrient management, planting, infrastructure investment and logistics planning. During Managing for Climate Risk workshops conducted in 2012, many of these types of decisions emerged as options that could have been employed using climate forecast information (CANEGROWERS 2012).

Evaluation of Managing for Climate workshops conducted across agriculture industries in Queensland (CBR 1999) provided many examples of how skills learnt at the workshop were being used by farmers for better management decisions. One third of respondents (56 interviewees) indicated that they had made or saved money from their production decisions as a result of attending the workshop. Many other positive outcomes were reported. Sugarcane industry case study example quotes included:

- '…thought from the SOI that it would be a wet season and we would cut at every opportunity, as we knew the cutting season would be short';
- 'The SOI being neutral encouraged me to plant my (sugarcane) crop early winter. The expectation of La Nina going up in the later part of 1999 has

influenced me not to buy more water allocation. The allocation is a big expense, especially if it is not used';

- 'From the SOI predicted that it would be more like an average year, the decision to plant large areas of land was made and this decision, preparation and planting have been done early. Years ago they would not even think of planting until August…'; and
- 'Harvesting paddocks that could be wet later using SOI values' (CBR 1999).

From a more recent unpublished survey results of canefarmer use of seasonal climate forecast information circulated in a regular email weather and climate email update, further example quotes describe decision-making:

- 'Use seasonal forecast to decide on planting our wetter blocks. If it looks like a wet season end we leave more fallow';
- 'Use of long-range forecast to consider summer crops (soya beans)';
- 'This season I have started irrigating early in the season because of the dry outlook for spring 2015';
- 'Crushing season length. Possible impact on mill supply equity. Potential harvest completion time';
- 'Purchase of temporary water allocation for the expected dry conditions this season'; and
- 'Planting peanuts on low, wet area due to dry outlook. This suits my cane rotation. Serious consideration to how I will programme my water allocation and plan an implementation programme, giving priority to younger ratoons and the peanut crop. This allows me to modify my fertiliser plan in the event of less or no water to some blocks' (Cliffe, N 2015, pers. comm., 21 December).

While seasonal climate forecasts are available to farmers from different national and international agencies, understanding how best to use these in decision-making is critical. Access to digital technologies is rapidly improving, potentially enhancing communication of climate and other information within the agriculture sector. These improvements now support greater opportunities to enhance the capacity of service providers and agricultural educators to more effectively communicate complex information to their varied audiences, but particularly farmers. Innovative tool developments in the digital space, supported by better access from rural and remote locations, have the potential to deliver improvements in learning and decision-making in agricultural systems (Townsend et al. 2013). While a significant disparity currently exists between the capacity of rural and urban areas to access digital networks (Salemink et al. 2015), it is likely that even remote areas will obtain access to affordable, high quality and high speed telecommunications systems in the near future. Digital machinima animations developed and used in this study (Cliffe 2013; Reardon-Smith et al. 2014), provide one such novel tool which will be dependent on efficiently operating high speed digital networks for their effective deployment. They may then provide a useful communication medium to convey contextually relevant and complex messages in an engaging way to promote small group discussion and thereby enhance learning and support improved decision-making within farmer and other associated rural networks (Reardon-Smith et al. 2015).

1.6 Rationale for discussion support tools

Examples of 'decision support' systems (DSS) to assist enterprise managers to manage risk in agricultural production systems (and in many other disciplines e.g. economics) are many and varied (Carter et al. 2000; Cobon et al. 2009; Hochman et al. 2009; Van Meensel et al. 2012) (See also section 2.5). Computer based DSS products are usually designed to process a wide range of variables to model a number of possible outcomes and produce an output to assist the user to make a more informed management decision. Specific DSS products in the agriculture sector extend from broad acre crop management (Woodruff 1992; Hochman et al. 2009) to irrigation scheduling in the sugarcane industry (Attard & Inman-Bamber 2011). Historical deficiencies in the successful deployment of these systems has been documented (Nelson et al. 2002; McCown et al. 2006a; Matthews et al. 2008) along with poor uptake of DSS more generally (Hochman et al. 1994; Cox 1996; McCown 2002a; McCown et al. 2006a). However, the positive influences that participatory engagement and involvement with target stakeholder groups can have when using the systems in a group setting are also acknowledged (Carberry et al. 2002; Jakku & Thorburn 2010; Van Meensel et al. 2012).

While DSS in the agriculture sector vary in type and complexity, a mix of bio-physical modelling capability, guidance from researchers and input from decision-makers who ultimately make the decisions concerned within the system is often part of the process (Nelson et al. 2002). Examples of *discussion* support processes where the focus is on sharing experience and information between farmers and other technical experts without direct engagement with bio-physical models is less well documented in the literature and less well understood. Information and output obtained from biophysical models and DSS may be incorporated to support and prompt discussions but the focus is not on the DSS themselves. Additionally, the linkage between these discussions to their role and impact on influencing climate risk decision-making has not previously been explored. 'Discussion support' systems can further be defined as processes which foster discussion between and amongst key stakeholders and may lead to multiple outcomes including learning, awareness raising and skill development and may also lead to changes in decision-making (Stone et al. 2012b). Although bio-physical models and DSS may feature in these systems, they may not necessarily be central to the process.

This research will contribute to understanding the role of discussion support in influencing learning in the context of climate risk management and decision-making. Supporting the focus of this research, farmer group discussions around the output from bio-physical models was found to be useful in incorporating seasonal forecasting into crop management decision-making (Nelson et al. 2002). The use of video-mediated social networks as a medium to support sugarcane farmer adoption through observation of model farmers appearing in videos has also been trialled in Queensland (Thomas 2011). While this research did not directly incorporate elements which addressed management of climate risk, results indicated that confidence and self-efficacy levels improved following engagement with the medium (Thomas 2011).This research will test whether machinima can productively support discussions informing climate risk decision-making at the farm enterprise level. More broadly, the project will reflect on the possible development and use of machinima to address other aspects of management within the agriculture sector where learning and supported discussion would be advantageous.

The rationale for testing tools, such as machinima, is also strongly supported in the current information and agriculture extension environment where funding and policy support is generally declining, both in Australia and globally. Decline in investment in extension services over recent years has been widely reported and identified. McCown (2001) described the reduction in investment in public agriculture extension in Australia, particularly at the level of the scientist and farmer communities of practice and a trend towards investment which addresses broader issues of environmental and ecological importance. The diminishing trend in investment in publicly funded extension is mirrored internationally. Warner (2006) described an extension environment with increasing privatisation and movement away from publicly funded extension services generally in the USA, and particularly in the state of California. Rivera (2008) confirms this trend and argues that public sector extension has a role in more effectively linking farmers with markets by taking a more active role in the supply chain beyond the farm gate. The role could also facilitate more self-organisation by farmers in groups by supporting them to take responsibility for their own continued improvement and advancement.

These trends in reducing investment in extension services are also echoed in the developing world where Rist et al. (2007) highlighted the relatively greater impact of diminishing and outright loss of services and where problems of food security and poverty are most severe. More recently, Hunt et al. (2012) outline the broad ‘unravelling’ of agricultural research, development and extension services in Australia since the mid-1990s. Leach (2011) collates and details a range of issues impacting on extension services in Australia, ranging from declining investment by governments; fragmentation between key research, development and extension bodies; and a lack of policy consensus about appropriate modes of extension; to the issue of inexperience in extension practitioners engaged in short term project contracts.

With this reduction in support for extension services to agriculture, there is therefore an increasing opportunity to augment traditional, face-to-face and group extension services. Digital and technology based solutions for information and process support delivery may be more cost effective and efficient in improving levels of service to the agriculture sector. With improving access to mobile phone and smart phone technology and faster internet access speeds, the potential to harness digital technologies is increasing in both the developing and developed world. Indeed, Aker (2011) suggests this particularly applies in the developing world where there has been a rapid expansion of information and communication technologies. The viability of using these platforms to deliver information and facilitate learning has improved both technically and in terms of market penetration and warrants the exploration of the use of digital technology applications such as machinima as discussion support tools in the current extension and communication environment.

Machinima, as digitally produced animated recordings, may provide a communication medium which could be customised for the audience concerned and produced remotely for presentation and use with a target group. Animated farmer characters could be developed which depict behaviour, characteristics and vernacular within scripts which the target agriculture sector audience could relate to and empathise with. The potential range of uses for machinima could include face to face extension activities, where researchers and other technical experts, or extension officers with less technical expertise, could employ the tool to aid in starting and facilitating relevant group discussions and conversations between farmers. Further, machinima may be made available as a downloadable, targeted web product accessible to remote users as educational media to prompt family discussions or personal action outside of formally facilitated group activities. This approach would provide more online internet tools to support farmers to obtain information or learn about a topic. Approximately 43% of Australian farmers have indicated that the internet is the primary source for advice and information, higher than any other media source (Nettle 2016).

Other research has focused on facilitating transfer of innovation between farmers using video, radio or other more conventional, less expensive, digital media platforms. Within the Australian sugarcane industry, Thomas (2011) explored the use of video mediated social networks to improve cost-effective adoption and transfer of technology. The study reported farmer-to-farmer transfer of innovations through video observation of model farmers leading to behavioural changes in the target group. The use of multi-media and information communication technologies as an adjunct to conventional extension approaches has shown promise across a range of agriculture education contexts both in the developing (Zossou et al. 2009; Shanthy & Thiagarajan 2011; Van Mele 2011; Cai et al. 2014) and developed world (Deegan et al. 2016). These technologies are generally able to supplement, rather than necessarily replace traditional extension processes (Anastasios et al. 2010), but are able to reach a greater population and wider range of farmers than would otherwise be possible through the application of a diverse range of digital platforms (Jespersen et al. 2014).

A key component of this research focuses on facilitating learning through observation of animated farmer characters in a virtual world machinima discussion. The subsequent farmer discussion that results may then lead to learning outcomes and possible action, leading to adoption of new processes or decision-making. Research outcomes will provide complementary insights into how digital media can support improved and cost-effective information delivery systems to the sugarcane industry and the agriculture sector more broadly. Customised animated machinima may also prove to be a tool that can be used in a range of situations including delivering to remote environments and perhaps internationally, without the need for a climate scientist, expert or other service provider to be physically present in a discussion.

1.7 Research objectives and research questions addressing gaps in current understanding

This study investigates how Australian sugarcane farmers understand their management of climate risk and provides insights into the impacts of peer group discussions on farmer understanding more generally. It is likely that many of the challenges in managing climate risks are shared generically across the agriculture sector to a greater or lesser degree. As with other management issues, a basic level of understanding is required to be able to incorporate any relevant information and technology into the operational decision-making on a farm. Therefore an understanding of climate drivers and the strengths and limitations of seasonal climate forecast information is required to allow any farmer, from any agriculture industry, to be able to appropriately apply that information sensibly within a management context. The challenges do vary, however, within and between industries. For example, within the sugarcane industry, drought is a less important issue in the rain-fed farming system in the wet tropics, than it is in sub-tropical farming systems which are more highly dependent on irrigation. In the wet tropics, too much rainfall and concurrent lower solar radiation levels inhibit growth and can interrupt harvesting operations. The impact of tropical cyclones is also more prevalent in northern growing regions from central Queensland to the wet tropics. The differences are specifically reflected in the climate risk management decisions that are identified by farmers in these different regions (CANEGROWERS 2012). Between industries there are differences too. Drought is less significant for intensive horticulture industries with access to reliable irrigation supplies, compared to dry land cropping and extensive livestock grazing which are highly dependent on rain-fed soil moisture profile accumulation to produce crop or pasture growth.

Within this research, insights into farmer learning and conceptions of managing impacts associated with climate variability and discussing this issue with others, are revealed following exposure to workshop learning and discussion environments and the use of machinima as a stimulus and prompt to group discussion. Developmental phenomenography (Bowden & Green 2005) is applied as a methodological approach within the context of variation theory (Marton 1981; Marton & Booth 1997), as a novel qualitative process within the agriculture sector and used to explore farmer learning and understanding. Phenomenography as a qualitative methodological approach is derived from the field of phenomenology. A phenomenological analysis aims to understand the meaning of the lived experience of a phenomenon for a person or a group of people (Patton 2002). Developmental phenomenography investigates and structurally describes how a group conceives of or experiences a phenomenon. This approach is applied in this study in order to understand how Australian sugarcane farmers manage and discuss climate risk, with and without exposure to machinima animations as discussion support stimuli. In particular, the detailed objectives and key research questions addressed within this study are:

1. Critically review the current delivery of a collaborative and participative learning process which engage farmers in learning about and discussing

climate variability with reference to risk management and decision-making using seasonal climate forecasts;

- RQ1 To what extent have Managing for Climate Risk workshops resulted in changes in participant's knowledge of and skills in using climate risk information, attitudes about the value of the information and aspirations to use the information in their management in the future. (Chapter 3).

2. Critically evaluate a prototype machinima animation with Australian sugarcane industry stakeholders to determine the efficacy of machinima to stimulate discussions and influence learning and climate risk decision-making;

    - RQ2 How do Australian sugarcane industry stakeholders experience machinima as a communication medium and discussion support tool? (Chapter 4).

3. Critically analyse the impact of 'discussion support' on groups of farmers immediately following workshop exposure to machinima facilitated group discussions to determine the variation in conceptual understanding of managing and discussing climate risk;

    - RQ3 How do Australian sugarcane farmers conceptualise managing climate risk following machinima facilitated small group discussion? (Chapter 5); and

    - RQ4 How do Australian sugarcane farmers conceptualise the influence of customised machinima on small group discussions? (Chapter 5).

4. Critically analyse post-workshop farmer understanding of managing climate risk and discussion of climate risk with other people;

    - RQ5 How do Australian sugarcane farmers understand and experience managing climate risk? (Chapter 6); and

- RQ6 How do Australian sugarcane farmers understand and experience discussing climate risk with other people? (Chapter 6).

5. Develop conclusions and recommendations to influence the future application of machinima for the extension of agricultural information to farmers in the sugarcane industry and communication of climate information for agriculture more generally (Chapter 7); and

6. Develop conclusions and recommendations to influence the communication interface between climate science information developers and agriculture consumer/user groups (Chapter 7).

From a methodological perspective the study also demonstrates a rare and perhaps unique example of the use of Variation Theory (Marton 1981; Marton & Booth 1997) in the agriculture sector. The approach aims to contextualise, identify and explore the structural dimensions which describe farmer conceptions of managing and discussing climate risk using a qualitative developmental phenomenographic research approach (Bowden & Green 2005; Åkerlind 2012). Understanding the variation in which farmers conceive of these phenomena of interest by using this research approach may enable recommendations to be made about how to change information and extension processes to improve climate literacy in the agriculture sector and better communicate information to improve climate risk management. The outcomes of this research will therefore aim to be used to inform operational and practical improvements to the extension programs and climate risk communication systems allied to the research, as well as contribute to theoretical understanding of the issues. The advantage of using developmental phenomenography in this study is that it enables a focus on how individuals within a group conceive of a phenomenon related to learning and maps the variation in those conceptions. The outcome of the analysis can then enable them or others to influence or modify the way in which they learn or operate in relation to the study phenomenon (Bowden 2000).

1.8 Unique research contribution

Resolving the research questions within this project will contribute to theory and practice contextualised within an agricultural risk management setting. This includes a contribution to social learning theory focused on theoretical and practical understanding of group to individual transfer of learning (Papanikolaou & Gouli 2010) in the context of management of agricultural climate risk management. In particular, this research makes a novel contribution to an understanding of the use of discussion support tools (such as machinima), in an agricultural context. Additionally, recommendations and conclusions about the role that such tools may play in the broader agriculture extension environment to support and complement existing risk management communication approaches are made. Outcomes of the research will directly inform the climate science and climate risk communication community regarding improvements to the way in which climate information and climate forecasts can be disseminated throughout the agriculture sector.

From a methodological perspective, there are few if any examples of the use of a phenomenographic approach in the agriculture sector as a qualitative, investigatory process to understand how individuals learn and develop conceptions of a critically important management area within their farm business (i.e. management of the impacts of climate variability). This study will therefore introduce a significant new example of the use of developmental phenomenography to this sector.

1.9 Synopsis of Thesis

Key research questions in this study are addressed through production of a series of chapters presented in journal paper format (Chapters 3-6). Chapter 1 has introduced, detailed and explained the research gaps and research questions and provided background information relevant to the research. Chapter 2 critically reviews literature relevant to the research including the key theoretical foundations which underpin the study and methodology used to undertake data collection and analysis. Chapters 3-6, written as four discrete papers, whether published, or in a format ready for journal publication, then focus on addressing the research questions. Chapter 7 draws conclusions from the research findings and discusses the implications for theory and practice. It also suggests opportunities for the direction of future research. Table 1.1 illustrates the research process logical framework, outlining the contextual positions and linkages between each of Chapters 3-6 and outlines the broad research objectives and methodologies employed to address research questions.

Table 1.1: Research process logical framework.

Thesis Chapter	Research Objective	Research Context	Research Questions	Research methodology
Chapter 3	Contextual framing of the historical research landscape	Develop a context around which sugarcane industry stakeholders currently learn about, discuss and aspire to manage climate risk and establish where opportunities may exist which could positively influence farmers and their extension services to improve capacity to manage climate variability.	RQ1 To what extent have Managing for Climate Risk workshops resulted in changes in participant's knowledge of and skills in using climate risk information, attitudes about the value of the information and aspirations to use the information in their management in the future.	Descriptive statistics and thematic analysis
Chapter 4	Developing and evaluating a prototype machinima and testing developmental phenomenography as a research methodology.	Test a prototype machinima as a digital tool to determine its potential acceptability to a broad range of stakeholders from farmers to extension officers as a managing climate risk communication medium and discussion support tool. Develop an understanding of stakeholder conceptions of the key messages that were identified following personal viewing of the prototype machinima.	RQ2 How do Australian sugarcane industry stakeholders experience machinima as a communication medium and discussion support tool?	Developmental phenomenography
Chapter 5	Trialling four machinima within workshops and analysing stakeholder conceptions using developmental phenomenography.	Test a series of machinima designed to support group discussion and improve understanding of managing climate risk in facilitated group workshop settings. Develop an understanding of stakeholder conceptions of managing climate risk following machinima facilitated group discussion and their conceptions of the influence of the machinima on their discussion.	RQ3 How do Australian canefarmers conceptualise managing climate risk following machinima facilitated small group discussion?; and RQ4 How do Australian canefarmers conceptualise the influence of customised machinima on small group discussions?	Developmental phenomenography

Chapter 6	Analysing farmer conceptions using developmental phenomenography.	Develop an understanding of farmer conceptions of managing climate risk following attendance at a Managing for Climate Risk workshop and their conceptions of discussing climate risk with other people.	RQ5 How do Australian canefarmers understand and experience managing climate risk? (Chapter 6); and RQ6 How do Australian canefarmers understand and experience discussing climate risk with other people? (Chapter 6).	Developmental phenomenography

1.10 Conclusion

This chapter introduced the unique research contribution to be delivered in this study and articulated the background and rationale for undertaking the research, along with detailing the research objectives and key research questions to be investigated. A synopsis of the thesis outlines the justification for addressing key research questions by producing journal ready papers within thesis chapters and a research project logical framework is outlined for conduct of the study.

2 Literature review and scope of project

This chapter critically reviews the key areas of literature relevant to how people learn as individuals and in groups and how that learning can be applied in the context of managing climate risk and decision-making. Additionally, the methodological foundations in which this research project is based are further elucidated within the context of the Australian sugarcane industry where research participants are situated. The overall scope of the research is also described to provide boundaries for which conclusions and recommendations are developed.

2.1 Conceptual foundations of learning as individuals and in groups

To adequately address and answer the research questions for this project, a robust understanding of how people learn as individuals and within the context of membership of a group and within a group discussion is required. Figure 2.1 describes a literature lens as a visual representation of the scope of the literature drawn on to develop an understanding of the theoretical areas relevant to this research.

As a visual representation of the theoretical elements underpinning this research, the literature lens begins with defining individual learning and outlining relevant learning approaches and philosophies which articulate my understanding of learning by farmers in the target group. Narrowing the focus to adult and experiential learning, contextualised within a social learning framework provides boundaries to the research which further guides the methodological approaches employed to answer key research questions. Additionally, outlining my understanding of variation theory as it applies to learning in a farmer population, further characterises and provides methodological justification for the approaches employed in data collection and analysis processes.

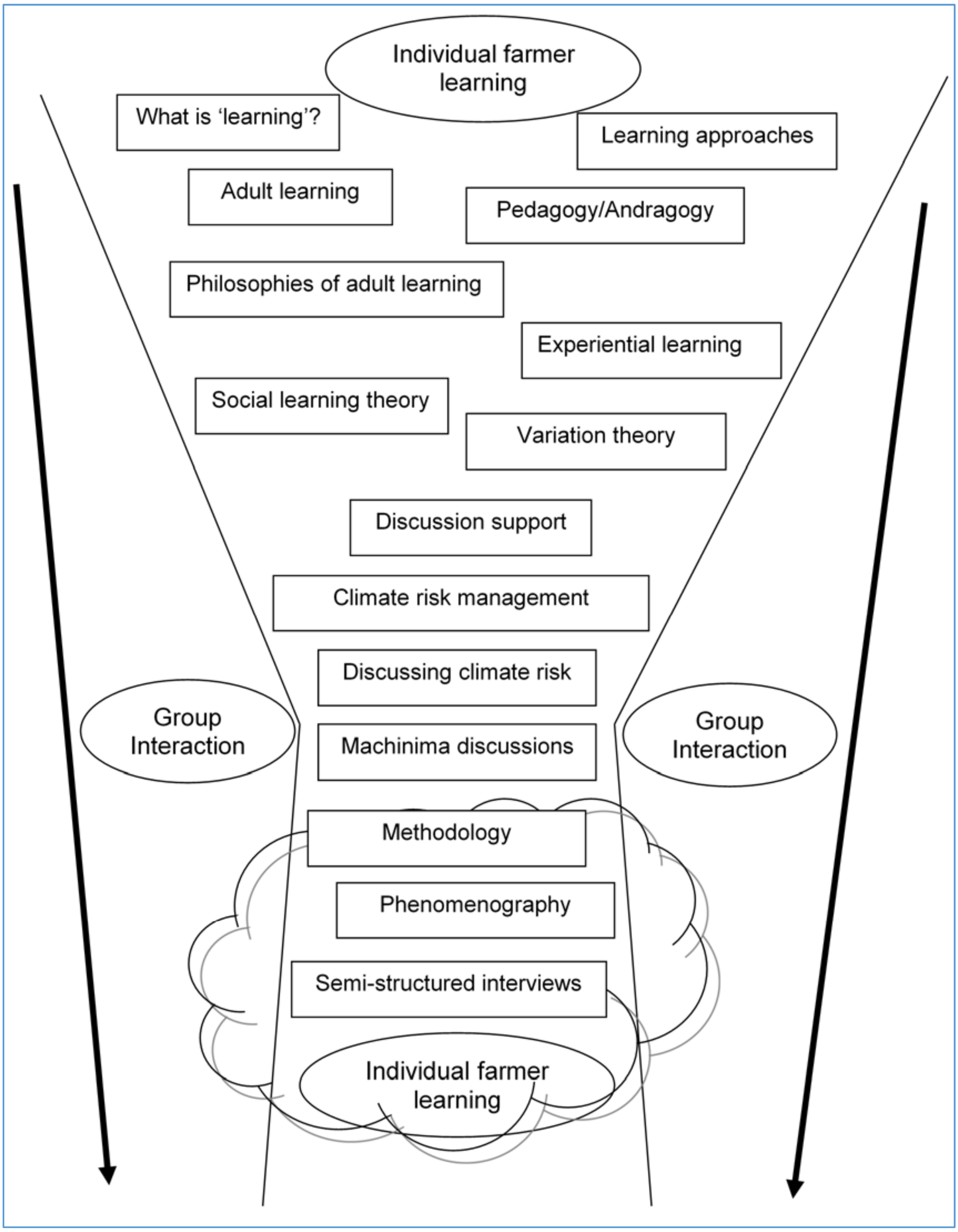

Figure 2.1: Literature lens outlining elements of theoretical and methodological considerations within this research project.

As focus within the lens narrows further the application of group processes using machinima in group interaction and discussion provides the data for phenomenographic analysis of conceptual understanding within the target group of sugarcane farmers. Finally, a new understanding of farmer learning is derived as a result of developing conclusions and recommendations following data analysis. The methodological elements and final results are shrouded in a cloud representing the mystery surrounding the research endeavour as I strive to make a robust scientific contribution.

The research rationale is based on developing an understanding of how canefarmers will learn about and discuss climate risk within the exploratory conditions that will be created in this project. To adequately understand how to shape the experiential conditions appropriately and understand the results that are obtained from the data collection processes, I need a mature understanding of learning theory as it applies to the research. To frame this understanding, comprehension of the meaning of learning as an individual, analysing relevant learning theories and focusing on social learning theory is needed. This understanding is then further contextualised and explored within the framework of agriculture climate risk management knowledge acquisition and skills development processes.

The outcomes obtained through this research are likely to have elements of transferability to the understanding of farmer learning about climate risk management more broadly in the sugarcane industry in Australia and potentially to the agriculture sector generally. Outcomes could therefore also be applicable and worth testing for other industries within the agriculture sector both in Australia and internationally and in developed and developing country contexts.

2.2 Learning as an Individual

In a fundamental sense, learning can be described as a change in the learner’s capability of experiencing something in the world (Fazey & Marton 2002). Fazey & Marton (2002) describe a person’s ‘natural attitude’ as an assumption that an individual’s experience is or becomes their ‘reality’. The person then assumes that their ‘reality’ is shared in some automatic way by other people. However this concept is contradictory to the idea of learning, where exposure to a different experience might lead to a different 'reality'. The concept of exposure to 'variation' in experience therefore breaks this 'natural attitude' by allowing alternate realities, or other ways of understanding a problem or issue, to emerge (Fazey & Marton 2002). One way of breaking the 'natural attitude' may be achieved by organising or facilitating within people the opportunity to share and exchange ideas in groups. Being confronted with different ideas may then lead to a diversity of perspectives about the problem or issue at hand (Fazey & Marton 2002). Understanding information sharing and learning in groups is a key theoretical element of this research.

2.3 Learning as an adult

Situated within this research, individual learners are recognised also as adult learners where principles of working with adult learners as distinct from learners of primary or secondary school age are applied. Burns (2002) summarises three approaches to adult learning, behaviourist, cognitive and humanist/phenomenological. Behaviourist approaches study learning in the context of the scientific tradition using quantitative and experimental approaches where learning and behaviours can be objectively observed and measured. Cognitive approaches emphasise the importance of experience and the use of problem-solving in the development of meaning through which a person learns and behaves in a response to what is real for them as an individual. Humanist/phenomenological approaches focus on experiential learning where individuals strive for self-actualisation to become whatever they are capable of becoming.

The concept of self-actualisation described originally by Maslow (1943) reflects the concepts of adult education where principles of lifelong, self-directed, and student centred learning are central, along with maximising the development of individual potential. This approach positions the 'teacher' as a learning facilitator or learning helper, creating an environment which allows the student to develop emotionally and intellectually, rather than as the sole authority or information source. Participant learning with research subjects in this project will occur in the context of a humanist/phenomenological approach (rather than behaviourist or cognitive approaches) and will be bounded uniquely with the context of how cane farmers view and interact with the world they inhabit.

Adult learning as an andragogical learning approach assumes that the adult has a degree of independence and self-directedness that frames their learning needs and ambitions (Knowles et al. 2015). The adult learner uses their own life experiences to shape their understanding of exposure to new knowledge and how they assimilate that knowledge into an understanding of their own environment and world view. By comparison, pedagogical approaches are framed around dependent learners, child-like in their open receptivity to new knowledge and guided by their instructional experience, led by a teacher, in how that knowledge could help mould their world view.

Knowles et al. (2015) distinguishes andragogy from pedagogy through the adult's movement away from dependency to increased self-directedness as part of personal growth and increasing maturity. There is also an increased focus on the experience that an adult has developed and could be used as an asset in learning engagement. Additionally, adults have some capacity to perceive their own learning needs so may be more highly motivated due to higher levels of self-awareness and understanding. This motivation may then lead to change in behaviour and action as a result of that increased understanding and self-awareness. Knowles makes six specific assumptions about adult learners:

1. The adult learner indeed needs to know something about a particular issue, why, what or how?

2. Through the process of maturing, a person's concept of themselves and their personality develops from being dominated by dependence to one of self-directedness;

3. With maturity, the volume of experience a person can draw on increases and experiential learning educational techniques for problem solving or decision-making will be more effective;

4. With maturity, comes an openness and readiness to learn to address real life problems and social situations that impact on and are relevant to a person;

5. An adult can contextualise their learning by understanding that they are building capacity to develop their own resilience to future issues they need to deal with in the here and now to address problems that are relevant to them; and

6. With maturity, the motivation to learn is internalised within a person. Adapted from Knowles et al. (2015).

In reality, the assumptions about adult learners explored above may overstate the degree to which adults and children can be categorised neatly into pedagogical and andragogical groups and teaching styles tailored to singularly meet one group or another. Indeed Burns (2002) suggests a more helpful division between pedagogy and andragogy would be to consider using the terms ‘teacher-directed’ and ‘self-directed’, as both children and adults may benefit from this more liberal interpretation. A continuum of styles, drawing on processes relevant to the learning goals at a particular time, paired with a depth of understanding about the audience to be engaged in a learning experience, may therefore be a more relevant and useful construct to consider. However, adopting a particular philosophical position related to the way in which interaction with adult learners is to occur is useful to aid in preparing for and facilitating the learning processes which are developed and subsequently used.

Within the theory of adult education, five dominant philosophies have emerged through time, influenced by classical through to contemporary consideration of learning and its context for individuals and within society. Burns (2002) provides a concise summary of these five philosophical traditions, liberal, behaviourist, progressive, humanist and radical. They possess varying characteristics of the teacher and the dominant teaching format, along with other attributes, which distinguish each philosophy. Elements of the progressive and humanist philosophies which underpin this research are outlined in Table 2.1.

Table 2.1: Characteristics of progressive and humanist adult education philosophies (adapted from Burns (2002)).

Philosophy	**Progressive**	**Humanist**
Purpose	To transmit practical knowledge and problem-solving skills to learners	To develop people who are open to change and continued personal learning
Learner	Learner needs, interests and experiences are primary learning elements	Learner is self-directed and highly motivated
Teacher	Guides learners through stimulating experiences	Facilitates and promotes, rather than directs learning
Methods	Problem solving and activity based	Experiential with self-directed group work and discussion
Source of authority	The culture and situation in which the learner finds themselves	The learner as an individual

Transformative adult learning described by Mezirow (1997) contains the key components of critical self-reflection about individual assumptions, the capacity to imagine alternative solutions and different paradigms, and critical discourse where the individual validates their best judgement through processes of discussion with others to analyse and solve problems. Mezirow (2009) further elucidates transformative learning through the description of 'Universal dimensions of adult knowing' which reinforce adult learning as a process by which adults become critical thinkers. Transformative learning extends the humanist philosophy of adult learning by emphasising processes where adults think critically for themselves and seek meaning from their varied experience of the world they inhabit.

Enhancing the capacity of adults to learn from their experience either deliberatively or through indirect, even unconscious processes is a key element within the humanist adult education tradition. Experiential learning theory described by Kolb (1984) is based on cycles of active experimentation, reflective thinking, theoretical abstraction and planned application allied closely to individual learning styles (Honey & Mumford 1986). The robust design of learning activities which appeal to, and explicitly address, individual learning styles within Kolb's theoretical framework, coupled with appropriate transitional processes before and after the learning activity improve the probability that good learning outcomes will be achieved (Dick 2003). Critical reviews of experiential learning as a theoretical construct including Kolb's approach (Holman et al. 1997; Fenwick 2000; Miettinen 2000) which discuss its theoretical origins and cognitive justifications do not detract from its usefulness in framing the way learning activities can be developed when engaging with adult learners. Fenwick (2000) in particular, notes that all learning is essentially experiential whether it occurs in formal or non-formal settings.

2.4 Social learning

Given the context of this research incorporating experiential group learning activities and its particular focus on facilitated group discussion, it is relevant to consider the concept of social learning. Significant debate exists in the literature about how social learning should be defined and whether social learning should be regarded as an approach or philosophy, or discussed in terms of theory and practice (Koutsouris & Papadopoulos 2003). This debate is largely unresolved and it is incumbent on each researcher to define their own position within the social learning literature if that theoretical position it is to be used within a project.

Wenger's social theory of learning (Wenger 2009) is based on four assumptions. Firstly, humans are social beings and this fact is a central aspect of learning. Secondly, knowledge is a matter of capacity or competence in relation to individually valued enterprises, which could be particular skills, aptitudes or interests that a person possesses. Thirdly, knowing is a matter of participating in the pursuit of those valued enterprises so that there is active engagement in the world. Fourthly, there is meaning in our experience and engagement with the world, so that learning has an outcome or product.

Social learning has become increasingly popular as a goal in managing complex natural systems. In particular, it is relevant where there is considerable uncertainty, many different stakeholders may be involved, and responsive and adaptive management capacity is required (Pahl-Wostl et al. 2008; Cundill & Rodela 2012; Rodela 2013). Early thinking about social learning (Bandura & McClelland 1977) conceptualised social learning as 'individual learning that occurs in a social context and is therefore influenced by social norms'. Social learning theory joins behaviourist and cognitive processes to understand and identify with the behaviour of others (Burns 2002).

Reed et al. (2010) attempts to improve the conceptual clarity of the definition, application and processes of social learning. They conclude that if learning is considered to be social learning, it must meet two criteria. Firstly it must demonstrate that a change in understanding has taken place in the individuals participating in a process and secondly, that the learning should go beyond the individual and become part of a wider social unit or community of practice. Social learning within the agriculture sector and in management of natural systems, can be seen as learning processes that are central to producing and using knowledge (Nettle & Paine 2011) and that learning can be described as a permanent change in behaviour, exhibited in action, attitudes or thinking. Learning communities involving farmers, advisers and scientists as participants in both developed and developing countries, that have incorporated principles of adult education and social learning, have led to significant advances in productivity and profitability in the agriculture sector. In a review of 32 agro-ecological partnerships in California, social learning and its positive influence on knowledge exchange and linkages between research and practice improvement were evaluated (Warner 2006). The development of partnerships and social learning communities and particularly knowledge exchange at a peer level from grower to grower was recognised as just as important as the exchange occurring across partnerships between growers, extension agents and scientists. Warner (2006) concluded that further extending and improving the agro-ecological systems in groups is dependent on further engagement with growers and their consultants in social learning systems.

Participatory and collaborative learning, as a practical and applied extension of social learning, where facilitated approaches are based on group interaction and discussion, have become common across the agriculture extension and natural resource management sectors over the last twenty years (Muro & Jeffrey 2008; Rodela 2013). Rather than adopting top-down technology transfer educational approaches, principles of adult and experiential learning have been used to engage and empower stakeholders in shaping their own learning directions and servicing their own information needs and ultimately improving farm profitability (Davis et al. 2012).

The use of highly skilled facilitators, rather than technical advisers, can also be a feature of these activities (Friis-Hansen & Duveskog 2012). Several methodologies have been described which can be classified as participatory and collaborative learning approaches. These include Participatory Action Learning (PAL), Participatory Action Research (PAR), Participatory Action Learning and Research (PLAR) amongst many others. Pretty et al. (1995) lists over thirty terms for variations of participatory approaches. Shared principles amongst these approaches include:

- A defined methodology and systematic learning process;
- Multiple perspectives which seek diversity;
- Involve group learning processes through interaction and group analysis;
- Are context specific;
- Involve multiple stakeholders from experts to lay people; and
- Have a goal of leading to change incorporating many of the elements of innovation systems approaches (Van Huis et al. 2007).

This research is therefore further contextualised within the principles of social and participatory learning and will provide a singular and perhaps unique example of group learning in the Australian sugarcane industry.

2.5 Decision and discussion support systems.

Many examples of DSS to address risk, including climate risk in agricultural production systems, appear in the literature (Woodruff 1992; Carter et al. 2000; McCown et al. 2002b; Cobon et al. 2009; Hochman et al. 2009). Carberry et al. (2002) described the FARMSCAPE participatory action research approach which used '*What if? Analyses and Discussions*' (WifADs) as a central element of the decision support process, whereby farmers and researchers interacted to collaboratively address farm management decisions of interest to both the farmer and researcher. 'Kitchen table' discussions, conducted on farm between the researcher and the farmer, combining farmer knowledge with crop model simulation output, allowed the exploration of various cropping scenarios. Amongst the key learnings described were that a participatory process combines practical and scientific knowledge leading to effective decision support and learning. Importantly, the FARMSCAPE project pioneered linking seasonal climate forecasts based on the southern oscillation index (SOI) phase system (Stone et al. 1996) to crop modelling at soil type and paddock scales.

Although considerable success has been achieved in projects like FARMSCAPE, Nelson et al. (2002) summarises part of the history of DSS and discusses the challenge of engaging enterprise managers in a practical way with computer based 'decision support' simulation tools. The shortcomings of some of these tools are posited to be due to their failure to address the 'subjective/social dimensions of the management system'. Others have also documented the unmet expectations of similar agricultural decision support systems (Hearn & Bange 2002; McCown et al. 2006b; Matthews et al. 2008) including within the sugarcane industry, where lack of end user input was listed as one of the reasons for disappointing system application and uptake (Singels 2007). Most success appears to have been attained when the 'decision support' tools have facilitated social interaction and discussion within a participatory stakeholder approach which can lead to learning, and application of that learning to practice (Carberry et al. 2002). Indeed Nelson discusses the 'dialogue paradigm' which can link research and practice in the context of computer 'simulation-aided discussion support systems' (in this case, Whopper Cropper) with grain growers in north-eastern Australia (Nelson et al. 1999).

In an international context, Stone (2012a) report on the development of machinima using Second Life^{TM} avatars which simulate farmer discussions about managing climate risk to support cotton farmers and their advisors in regional India to improve climate risk management decisions. That research highlighted the need for approaches that were locally relevant, particularly in the way in which machinima simulations mirrored local language, dress and cultural norms. Further, Stone (2012a) concluded that 'innovative education approaches could enhance discussion support' processes. However the need for climate scientists to foster ownership of the process by local extension specialists was also identified as a critical success factor if key informational objectives were to be achieved and incorporated into the decision-making frameworks of local farmers. Developing and testing machinima for use with farmers in a developed world context within this research project provides a unique case study where a discussion support tool may support farmer learning to improve climate literacy and incorporation of climate information into farm management decision-making.

2.6 Seasonal climate forecasting.

The use of seasonal climate forecasting in agriculture to add value by either increasing productivity through maximising yields, or profitability, by reducing costs and optimising inputs, and in managing risk, has been well documented (Hammer 2000). Meinke & Stone (2005) describe the different climate phenomena impacting on rainfall variability and the risk management framework in which the use of climate forecasts is situated. Discussion of the usefulness and value of forecasts is also contextualised within agricultural decision-making processes. Everingham et al. (2002) describe applying climate forecasts within the sugarcane industry in Australia across the value chain from growers to millers to marketers. Everingham et al. (2006) also acknowledge the importance of co-learning in participatory stakeholder approaches to maximise adoption and use of seasonal climate forecasts and enhance industry decision-making. This research accesses and uses contemporary and industry relevant climate forecasting information and output when engaging with sugarcane industry research participants concerning management of climate risk.

Seasonal climate forecasts, for the purposes of this research, are defined as products which provide information to decision-makers of the probability of rainfall over three month periods. Examples of these include those derived using statistical analyses of historical rainfall and include maps of rainfall probabilities of exceedance, based on 'phases' of the SOI (Stone et al., 1996). Rainfall outlooks for the similar periods sometimes with longer lead times, can be derived from dynamical modelling systems (Molteni et al. 1996) which attempt to simulate and model coupled ocean and atmosphere interactions in real time. These outputs can also be produced in maps as a spatial representation of a region or the globe, displaying the probability of a rainfall threshold exceedance. For both products, rainfall thresholds expressing decile, tercile or median exceedance can be developed. These map products are available to users through access to a range of websites (e.g. www.longpaddock.qld.gov.au (State of Queensland, 2017); www.bom.gov.au (Commonwealth of Australia, 2017)).

The extent to which rainfall forecasts are useful for sugarcane farmers is reflected in the range of strategic and tactical management decisions that industry has identified across canegrowing regions in Australia (CANEGROWERS, 2012). Planting, nutrient management, irrigation and harvesting decisions are the most frequently cited decisions that climate and weather information can support. However supply chain management, sugarcane processing and infrastructure investment decisions have also been identified by farmers and processors as decisions that can benefit from current and improved seasonal climate forecast information. Farmers have indicated forecasts are useful throughout the year to inform the different management activities that occur (CANEGROWERS, 2012).

2.7 Agro-political and socio-cultural elements impacting on farmer research participants

Understanding the cultural elements of the extension environment in which sugarcane farmers become exposed to new technologies and practices is helpful in shaping the development of the research methodology which will investigate how farmers learn in a general sense and learn from each other in particular. Of relevance to this research are the agro-political and socio-cultural elements peculiar to the sugarcane farmers involved in this study.

Australian canefarmers are represented by two industry bodies, Canegrowers Organisation and the Australian Cane Farmers Association (ACFA). Canegrowers Organisation, the largest grower representative group, leads the industry as an agro-political body, representing approximately 75% of cane farmers (CANEGROWERS 2017). Canegrowers Organisation takes an active role in advocacy and lobbying of governments and other organisations across a wide range of issues. Very active and successful advocacy by these representative grower bodies have led to extensive support for productivity and natural resource management initiatives for the sugarcane industry over many years. Farmers have traditionally accessed freely available extension services via shed meetings and other communication initiatives and have indirectly made funding contributions to these services via industry levies matched by other state and federal government funding. It could be argued that the success of this advocacy has led to a generalised culture of dependency and entitlement in the sugarcane industry where farmers still expect these services to be provided without any further cost impositions.

More recently, support for farmers has occurred in response to water quality challenges related to impacts on the Great Barrier Reef where approximately 34% of cane farmers adopted improved practices in the first two years of Reef Plan 2009 (State of Queensland 2013). However support for adoption of these improved practices has often been delivered in co-funding arrangements where growers directly contribute their own funds to purchase new equipment or construct on-farm structures. These initiatives contribute to both productivity and environmental outcomes related to the reef program objectives and also include those activities funded under the Reef Rescue program (Reef and Rainforest Research Centre 2015).

With the average age of cane farmers rising, mirroring the trend in agriculture in Australia more generally (Rogers et al. 2013), the use of computers and information technology within groups of older farmers generally declines (Park 2015). However, over time as a natural process of succession occurs, subsequent generations of farmers with higher levels of computer literacy will take over farm management. Hunt (2014) describes a cultural and demographic shift observed among younger farmers, in at least one sugarcane region, where younger farmers have higher technical and business management capability and are less inclined to accept the local agro-political leadership compared to older farmers in that region.

A range of opportunities and barriers to communication and engagement exist related to the particular agro-political and socio-cultural peculiarities that exist within the target group of sugarcane farmers this research is targeting. However, these would appear to be no more or less challenging to address than in any other agricultural industry. However it is important to understand the cultural milieu in which the research itself and the research participants themselves are positioned, so that the methodologies employed can be applied appropriately.

2.8 Research methodology

2.8.1 Research paradigm

Justification of methodological approaches is a critical component within all research activities. Crotty (1998) provides a logical framework for describing a research process where the researcher can illustrate their epistemological position, or their theory of knowledge, positioned in the theoretical perspective and their methods used in addressing key research questions. This framework is informed directly by the research purpose and objectives and reflects how a knowledge of reality can be constructed. From an ontological perspective this project adopts a non-dualist, interpretivist approach where understanding and explaining the human and social reality are key elements (Crotty 1998). A dualist philosophy is one of objectivism and positivism in a quantitative methodology where the researcher is separate to the objective and design of the research. I adopt a non-dualist theoretical perspective to develop an understanding of how Australian canefarmers come to know and understand the management and discussion of climate risk in a social learning environment. As the research investigator, I am intimately involved in the design and analysis developed for this study, not independent from it, as would be the case in a dualist methodological approach. Therefore, this study concerns the qualitatively different ways in which farmers experience and understand their world, their relation to each other and particularly their relationship to the phenomena of interest in this research.

My research journey and the associated framework I have employed (Table 2.2) has been inductive, whereby iterations of understanding and enlightenment have emerged over the life of the research project. Research questions emerged and were addressed as the research progressed. I remained open to and flexible in approaches I employed, but also understood that methodological justification for approaches was essential throughout the research process. At a personal level I needed to understand the bias I brought to this research, given the nature of my historical relationship with the sugarcane industry and my research subjects (canefarmers) that I have had, in a general sense, my entire life.

Table 2.2: Epistemological, theoretical and methodological research framework employed in this research project (Adapted after Crotty (1998) and Box (2012) (Positions and methods adopted in this research shaded in grey).

Philosophy	Epistemology	Theoretical Perspective	Methodology	Methods
Dualist Non-dualist	Objectivism Constructivism Subjectivism	Positivism Interpretivism - Phenomenography - Phenomenology - Symbolic interactionism - Hermeneutics Critical inquiry Feminism Postmodernism Etc.	Experimental research Survey research Ethnography Phenomenographic research Phenomenological research Grounded theory Heuristic inquiry Action research Discourse analysis Feminist standpoint research Etc.	Sampling Measurement and scaling Questionnaire Observation - Participant - Non-participant Interview - Semi-structured - Unstructured - Structured Focus group Case study Life history Narrative Visual ethnographic methods Descriptive statistics Statistical analysis Data reduction Theme identification Comparative analysis Interpretive methods Content analysis Conversation analysis; Etc.

The world view that guides this research and investigation is based on a constructivist perspective with the fundamental understanding that research into the human world is different to the natural world (Patton 2002). Within this epistemological position each research subject's 'way of making sense of the world is as valid and worthy of respect as any other' (Crotty 1998). Within this research project I arrive at an informed understanding, from my own and that of my study group, about farmer conceptions of the management and discussion of climate risk. Constructivism is allied closely to the conceptual framework I will use to describe and understand how the research subjects learn and take action from their exposure to the machinima that will be evaluated in this research project. Constructivism acknowledges the unique experience of each individual and that each person's view of the world is valid and worthy of respect. Applying qualitative approaches, I deal with a double hermeneutic (a method or principle of interpretation) (Crotty 1998), where I firstly need to understand the nuances of language and meanings that my research subjects express in relation to the phenomena under study. Secondly, I need to reconstitute those meanings in the language of qualitative social research. This approach contrasts with a dualist, positivist, quantitative research approach where researchers construct meaning around the language of scientific terms and definitions within a single hermeneutic.

Ontologically, constructivism is predicated on a relativist perspective of reality, where knowledge is relative to the limited nature of the mind and conditions of knowing and that multiple realities exist to which research can shed light on to provide understanding. There is therefore no absolute truth I am seeking, but rather a 'truthful' experience relative to the context of this study. Further, as Guba & Lincoln (1994) describe, this reality is understood through the formation of mental frameworks, with a social and experiential basis, that tend to be local and specific in nature, and dependent for their formation on how individuals or groups hold those frameworks.

From an epistemological perspective, as a researcher within this project, I am linked to my study group through the interactions that we have had both before and over the period of the research, through workshops I have delivered to canefarmers, the interview processes I have conducted and further facilitation of group discussions I have conducted over time. Using a constructivist approach I will familiarise myself with research subjects, in this case, sugarcane industry stakeholders (particularly canefarmers), and make value judgements about their learning behaviours through robust and defensible qualitative research methods to explain and understand those behaviours. A mix of methods will be used, including workshop evaluation, individual surveys, pre and post workshop events and semi-structured interviews. The qualitative data will be collected through the research journey as individual research participant views and opinions, which through phenomenographic and simple descriptive statistical analyses, will result in thematic representations of variation in conceptions and experience, learning, attitudinal change, expression of aspirations and skills acquisition.

2.8.2 Research methodology

Methodologically, within this research project, learning outcomes are qualitatively evaluated by documenting responses which investigate the knowledge, understanding and skills of farmers in the context of peer group and multi-stakeholder discussions and interactions. Numerical survey data is analysed using descriptive statistics (Sandelowski 2000). Evaluation data from historical climate workshops is analysed to contextualise traditional extension processes. Data is collected both at and following similar workshops where participants observe and are exposed to machinima consisting of animated, simulated, peer discussions. Short machinima animations describing farmer conversations about farming decisions incorporating climate risk were developed and recorded within Second Life™ as a virtual world production platform. Second Life™ has been a popular virtual world platform for over ten years with over 48.8 million user accounts and up to 62,000 users online at any time (Voyager 2017).

The use of adult learning principles will be central to the group facilitation activities employed within this research project and will be delivered in the context of progressive and humanist traditions (Burns 2002). Specifically, in relation to the farmer participants engaged in this research, their past experience, needs and interests will constitute key elements of their learning. Furthermore it is assumed that they will be motivated and self-directed in engaging with the learning that accrues from the processes of engagement. Additionally, the 'teacher' within this process will act as a facilitator to develop a supportive learning environment which allows participants to guide the direction of the learning experience in ways which support their needs. Therefore, for the purposes of this research, elements of the facilitated learning processes are delivered based on experiential learning principles connected to adult learning andragogical assumptions (Knowles et al. 2015). Also, in a practical sense, participants in this research will be exposed to the opportunity for transformative learning in an environment which attempts to enhance their critical thinking skills and leads to some plan or action within their management regime.

The success or otherwise of the use of machinima in influencing discussion is demonstrated by the description of conceptions (a 'conception' being 'the way in which a person experiences a specific aspect of reality or a phenomena') (Bowden & Walsh 2000; Marton & Pong 2005) which canefarmers elaborate upon through survey or interview processes. Learning outcomes will be expressed as change in participant Knowledge, Attitudes, Skills and Aspirations (KASA) (Bennett 1975; Rockwell & Bennett 2004). KASA outcomes have emerged from the program evaluation literature and can be used to demonstrate success in agriculture evaluation activities (Curnow et al. 2011) and extension more broadly (Roberts & Coutts 2011). While other project and program evaluation methods could be used, the use of Bennett's Hierarchy and its decision focused approach which evaluates against KASA and practice change outcomes, is well established in the agriculture sector, particularly in Australia (Roberts & Coutts 2011).

A developmental phenomenographic methodological approach (Bowden & Green 2005) is used to develop an understanding of the way in which research participants experience managing and discussing climate risk generally and as a result of their exposure to machinima. Phenomenography, first described in detail by Marton (1981), postulated the existence of complementary first and second order states concerning the conceptions of reality by people. The first order state relates to how individuals orient themselves to and explain the world around them. The second order state relates to how people orient themselves to their experience and perspectives of the world around them. Research of second order states, addressed through a phenomenographic approach, aims to describe, analyse and understand people's experiences of a phenomenon of some kind.

The fundamental research unit of phenomenography is described as the 'different ways of understanding' or 'conceptions' of a phenomenon (Marton & Pong 2005) which are then represented in the form of 'categories of description' (Marton 1981). The objective of a phenomenographic study is to outline a number of qualitatively different representations of the way in which a phenomenon is experienced, along with the structural, hierarchical relationship between those different representations. The structural relationship is described as the 'outcome space' and provides an understanding of the different ways that a phenomena can be experienced. Akerlind (2005a) emphasises the importance of structure, characterised by development of the outcome space in phenomenographic research, believing it to be:

1. The epistemological underpinning of the research approach;
2. Capable of increasing the potential for practical application of research outcomes; and
3. Providing focus on both the variation and commonality in conceptions of a phenomenon in a group.

Examples of phenomenographic research studies have been wide and varied in their subject areas and include tertiary education (Brew 2001; Gibbings et al. 2010); nursing research (Sjöström & Dahlgren 2002); the construction sector (Törner & Pousette 2009); conceptions of the environment (Loughland et al. 2002); and the food manufacturing sector (Iivonen et al. 2011). However, there appears to be a relative paucity of studies analysing farmer learning using a phenomenographic approach in an agricultural context beyond a study of horticultural entrepreneurs in Finland (Levander 1999).

Phenomenographic data analysis includes a number of elements that, rather than occurring in a set sequence, take the form of an iterative process. Understanding about conceptions of a phenomenon are built over time and the qualitative data is analysed, reanalysed and compared to develop categories of description and an outcome space. McCosker et al. (2004), in a study of women's experience of domestic violence, describes seven elements within the process of data analysis. These include:

1. Familiarisation with data by reading and re-reading survey or interviewee responses;
2. Condensing data into manageable elements;
3. Comparison of condensed responses;
4. Grouping of similar responses;
5. Articulating categories of description as they emerge from the responses;
6. Labelling categories of description; and
7. Contrasting categories to define the essential meanings expressed about each phenomenon.

Through this process of qualitative data analysis, structural relationships between categories of description can be developed to form a hierarchical outcome space to develop insights into how a group of people understand or conceive of an issue or phenomena of interest. As deeper understanding of the group relationship to the phenomena emerges in the outcome space it becomes possible to develop strategies to influence a problem or situation in a practical sense by developing learning or other communication interventions to make a positive impact on that situation. In their study of domestic violence, for example, McCosker et al. (2004) found that:

> *'The manner of framing questions and the language used when asking women about domestic violence influences the women's responses. Education about domestic violence for health professionals needs to incorporate women's language and view'* (McCosker 2004, p.7)

The practical outcomes of their study could therefore directly inform domestic violence services for women and the way in which health professional education programs about domestic violence were developed.

Further elucidation of the categories of description can be made by developing 'themes of expanding awareness' which describe the 'external horizon' or boundaries of the phenomena described within the analysis of the research participant's data. Then, within each theme of expanding awareness, internal relationships between the categories of description describe 'dimensions of variation' and represent what is known as the 'internal horizon' of an aspect of the phenomena. As an example, Akerlind (2005b) studied the variation in ways of experiencing being a university researcher. Four categories of description were identified, along with five themes of expanding awareness. Table 2.3 describes the dimensions of variation across each theme, beneath each category.

Table 2.3: Key aspects of the range of variation in ways of experiencing being a university researcher (Adapted from Akerlind (2005b)).

Category of description	**1 Academic Duty**	**2 Personal achievement**	**3 Personal understanding**	**4 Benefiting a community**
Themes of expanding awareness	**🡐---------------------Dimensions of variation--------------------🡒**			
Research aims	Fulfil academic role	Become well known	Solve a puzzle	Make a contribution
Research process	Identify and solve a problem	Discover something new	Investigate an interesting question	Address broad issues in the community
Research outcomes	Concrete products	Academic credibility	Personal understanding	Benefits to the community
Underlying feelings	Neutral to satisfaction	Frustration to joy	Interest and enthusiasm	Passionate engagement
Purpose of publication	Satisfy requirements	Make work know	Gain feedback on work	Encourage change

Within Table 2.3 the dimensions of variation are structurally and hierarchically inclusive within the categories of description with the different themes providing more detail about the way in which the research group experience the study phenomenon.

Alternative qualitative methodological approaches to study this problem could include discourse and conversation analysis. Discourse analysis (Van Dijk 1985; Gee & Green 1998) and conversation analysis (Ten Have 2007) focus on analysing in detail the discussion or conversation that research subjects engage in and, in an educational context, can explore how knowledge is constructed in a social or more formal educational environment. In the context of this research I argue that a phenomenographic approach is more useful because the focus of study is on:

- Research subject's experience of the phenomenon of managing and discussing climate risk;
- Machinima, as discussion support tools, may influence discussion and learning; and
- Linkages to potential actions or management decisions may stem from that experience.

Critics of phenomenography have made theoretical arguments about biases that researchers might bring to data collection in the way that questions are framed and answers interpreted (Säljö 1997; Richardson 1999). However within this qualitative research project, potential bias is explicitly acknowledged and steps taken to minimise its impact including:

- Development of interview questions that do not lead respondents to a pre-determined research conclusion;
- Detailed explanation of how data was collected and analysed, including how categories of description and outcome spaces were derived;
- Explicit acknowledgement that the judgement of the researcher's interpretation is influenced by their experience with the subject matter; and
- Exposing the research results to peer reviewed scrutiny through conference presentations and paper submissions.

The use of phenomenography as a research approach may provide a novel qualitative research methodology for program evaluation purposes to describe the relationship of a target group to phenomena linked to program delivery objectives. The hierarchical approach described within Bennett's program evaluation model (Bennett 1975; Rockwell & Bennett 2004) resembles the structural relationship between categories of description that emerge within an outcome space in a phenomenographic analysis. The potential for phenomenographic analysis for program evaluation purposes is discussed in the final chapter of this thesis.

2.8.3 Data collection and analysis

Data collection within this project occurred through a series of stages and involved re-analysis of workshop evaluation data from a climate workshop series conducted in 2012; the conduct of semi-structured interview processes described as 'standardised open-ended interviews' by (Patton 2002); collection of pre, mid and post workshop survey data using Likert scales (Likert 1974); and open-ended questions. Within interviews, open-ended questions were developed for interviewees who offered responses related to understanding the variation in participant conceptions of managing climate risk and that resulted from exposure to machinima discussions and the group discussion that ensued during workshops.

Data analysis was predominantly conducted using a phenomenographic approach and associated analysis techniques (Ashworth & Lucas 2000; McCosker et al. 2004; Åkerlind 2012). The exception to this approach, within this research, involved analysis of historical workshop data (Chapter 3), where thematic analysis (Patton 2002) of survey data and descriptive statistics (Sandelowski 2000) were employed to analyse data. Workshop participants who attended workshops conducted during the research project self-selected following invitations from third party sugarcane industry service providers. Workshop participants who were subsequently interviewed were selected using a maximum variation, purposeful sampling approach (Patton 2002), to provide a diverse range of views within the target population of farmers and sugarcane industry stakeholders. The use of semi-structured or open interviews are often the most commonly used data collection technique to provide the primary sources of data for phenomenographic analysis (Bowden 2005). Written survey data can also be analysed phenomenographically (Kettunen et al. 2016) in situations where it may be impractical to conduct interview processes.

The apparent truth derived within this research is constructed within boundaries which explicitly identify and recognise any contrary examples that emerged through the analysis of data collected. A critical element of good phenomenographic practice is the reading and re-reading of the data (interview transcripts or survey data) to appropriately construct categories of description. Silverman (2013) warns of the problem of anecdotalism and emphasises the importance of using multiple methods to provide opportunities to triangulate findings. This approach, along with recording the frequency at which particular categories of comments was made and simple statistical comparisons, supports the validity of the research findings.

2.9 Boundaries of the research

The research findings described in this thesis will provide specific guidance to improve extension approaches and communication processes by which seasonal climate forecasting may support the Australian sugarcane industry. In particular the research outcomes are intended to support sugarcane farmers to more effectively manage climate risks in the future. Although the research boundaries of the study are defined within the population of Australian canefarmers and the findings relate specifically to the Australian sugarcane industry, the research outcomes are highly likely to have application to other primary industries in Australia. The findings are also likely to have application to the way in which climate risk extension process are developed more broadly. This may be relevant, both in Australia, and internationally, where the challenges of managing the impacts of climate variability and adapting to climate change are globally applicable. Indeed, the World Meteorological Organisation recommends that relationships between consumers and providers of climate information be improved to customise tools and products which will support better decision-making across the agriculture and other sectors (Hewitt et al. 2017).

The scope of this research and key assumptions, particularly concerning learning by individuals and groups and the engagement processes used to interact with and collect data from research participants, has been outlined in this Chapter. However, the scope of research extends further to the application of phenomenographic research principles in the methodology employed in this research and provides a novel perspective for investigation of the social phenomena of farmer learning from group discussion and farmer relationships to the phenomena of managing climate risk. Wherever possible, attempts have been made to explicitly outline any limitations in the research approach and articulate acceptable solutions to overcome those limitations.

2.10 Conclusion

This chapter introduced the underlying epistemological, ontological and theoretical foundations on which this research project is based. Descriptions of adult and social learning principles are outlined in terms of their relationship to how the research is conducted, along with the relevant aspects of the contemporary Australian sugarcane industry extension environment. Justification of the methodological approaches used to resolve research questions are also outlined and discussed along with data collection and analysis processes and a description of the boundaries within which the research is situated.

3 Developing the capacity of farmers to understand and apply seasonal climate forecasts through collaborative learning processes

This chapter, published in The Journal of Agricultural Education and Extension (Cliffe et al. 2016) outlines the workshop context in which farmer group learning and discussions about managing climate risk have historically occurred in the sugarcane industry in Australia. As the first phase of research in this project, the current situation regarding the way in which sugarcane farmers are engaged in a facilitated process to learn about management of climate risk is described. The chapter sets the scene for the future phases of research which then use novel tools and methodologies to discover how the current situation can be improved and enhanced. Workshop learning objectives, facilitation frameworks (Malouf 2003; Kolb & Kolb 2005) and specific workshop processes are described and their use justified. This paper provides a detailed description of the entire facilitation framework and specific processes used in a Managing for Climate Risk workshop to meet a specific set of learning objectives. Other examples appear in the literature of the outcomes of similar climate risk learning processes in agriculture (George et al. 2006). However, none previously published describe the detail that would allow others to replicate workshop delivery with similar stakeholder groups.

The paper reports on results of an evaluation of learning objectives related to a series of thirteen climate workshops delivered to the Australian sugarcane industry in 2012. Analysis of participant self-assessments demonstrates the efficacy of this participative and collaborative workshop approach as a mechanism to improve the capacity of farmers to understand and manage climate risk. The paper also compares differences in self perceptions of understanding and capacity between farmer, extension officers and other sugarcane industry stakeholders. Discussion processes used in these workshops are described to provide a comparison between this more conventional approach and the use of machinima as discussion support tools that are reported in subsequent chapters (4 and 5) of this thesis.

The key research question that is addressed in this chapter is:

RQ1 To what extent have Managing for Climate Risk workshops resulted in changes in participant's knowledge of and skills in using climate risk information, attitudes about the value of the information and aspirations to use the information in their management in the future?

Title: Developing the capacity of farmers to understand and apply seasonal climate forecasts through collaborative learning processes.

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3.1 Abstract

Purpose: This paper documents and evaluates collaborative learning processes aimed at developing farmer's knowledge, skills and aspirations to use seasonal climate forecasts in management decisions.

Methodology: Thirteen workshops were conducted, engaging over two hundred sugarcane industry stakeholders across major sugarcane production regions in Australia in 2012. Workshop design incorporated a range of processes aimed at promoting participant interaction, stimulating discussion, collecting farmer experience of regional climate variability, improving understanding of climate drivers and increasing participant skill in interpreting climate forecasts linked to farm management decisions. Post workshop participant surveys collected quantitative and qualitative data for statistical analysis and manual thematic coding.

Findings: Over 68% of workshop participants identified improved decision-making and risk reduction as the main benefit for them from the use of seasonal climate forecasting products. High median self-evaluation ratings for gains in skills, knowledge and understanding of climate forecasts and perceived benefits in using climate forecasts in on-farm decision-making were found across occupation groups. No significant differences in self-evaluation rating gains were found between cane farmer, extension officer and milling staff groups suggesting that extension officers are less than optimally informed and skilled to support farmers in understanding and applying seasonal climate forecasting in their management.

Practical Implications: Strategically developing the capacity of extension officers and other service providers to understand and interpret seasonal climate forecasts may increase adoption of improved climate risk management practices in farmer networks.

Originality/Value: This paper contributes an example of evaluation of collaborative learning in facilitated agriculture Managing for Climate Risk workshops and discusses the value of learning through small group discussion.

Key Words: Collaborative learning, Small group discussion, Seasonal climate forecasting, Agricultural climate risk, Extension, Sugarcane farming.

3.2 Introduction

3.2.1 Current climate risk extension environment

In recent years, significant investments have been made in climate change adaptation research and communication initiatives, particularly in Australia (NCCARF 2014). Concurrently, public sector agencies with traditional roles in supporting more conventional climate risk training and communication processes now appear to have changed their focus to policy and regulation, rather than delivery aspects of service provision (Cristóvão et al. 2012). This has resulted in reductions in services focused on training to develop better farmer management of climate risk. In some jurisdictions support for public/private research, development and extension (RD&E) partnership models is increasing with direct public funding of RD&E only available where market failure of these services has occurred (DAFF 2013). These structural changes to the way in which climate risk management extension services are delivered has led to the loss of coordinated and coherent strategies to improve farmer management of climate variability. Coinciding with these structural changes in service provision, agricultural extension services more generally have widened in their scope. They now incorporate natural resource management, social and environmental issues where farmers are as likely, or in some cases more likely, to interact with private sector or community-based environmental extension service providers as they would with public sector extension services (Vanclay & Leach 2011).

Contemporary agricultural extension methods have embraced approaches which emphasise the importance of capacity building in multiple forms (Coutts & Roberts 2011b). These approaches build on historical lessons and include focusing on social and collaborative learning where group interaction and principles of adult learning are applied. Cooperation between farmers, advisers and scientists in participatory and social learning experiences can have significant impacts on farmer capacity to manage risk and uncertainty (Warner 2006). Indeed, deliberative facilitation of dialogue and discussion supporting social learning can enhance the capacity of individuals to deal with complexity and ultimately improve decision-making (Cundill & Rodela 2012).

Building capacity to manage climate risks through the use of Seasonal Climate Forecasting (SCF), particularly amongst farmers, relies on effective communication processes (Hansen 2002a). Furthermore, engaging with industry stakeholders in participatory learning activities which support and promote development of skills and understanding can contribute to improvements in the capacity of farmers to use SCF (Patt et al. 2005; Roncoli 2006). Underpinning the participatory processes used in this research are concepts of establishing and facilitating discussion between a climate scientist and farmers in an environment conducive to learning. This approach aims to elicit improved knowledge and understanding of climate information and improved ability and confidence to access and apply SCF information which participatory approaches can support (Peterson et al. 2010; Bartels et al. 2013). When participation is seen as an integral component of planned extension, appropriate facilitation methods are more likely to be used that will achieve project objectives (Reed 2008). Additionally, collaboration with potential users of climate information also informs training design and how forecasts are communicated to better support decision-making (Podestá et al. 2002; Roncoli 2006).

3.2.2 Climate variability and the Australian sugarcane industry

Effectively managing the impacts of climate variability in agriculture continues to challenge farmers in Australia and globally (Stone & Meinke 2006; Vogel & O'brien 2006; Unganai et al. 2013). Managing climate variability impacts is particularly relevant for the Australian sugarcane industry which is situated in the continental north-eastern coastal agricultural belt, from north of Cairns in Queensland to north-eastern New South Wales (Figure 3.1). While tropical and sub-tropical conditions provide warm and wet environments conducive to sugarcane production, this geographical position is situated in a climatic zone experiencing very high comparative global rainfall variability (Nicholls et al. 1997). Although approximately 60% of sugar produced in Australia depends on irrigation (Inman-Bamber 2004), in most regions, significant rainfall is required to supplement crop water requirements due to seasonal, summer dominant, rainfall patterns and high inter-annual variability.

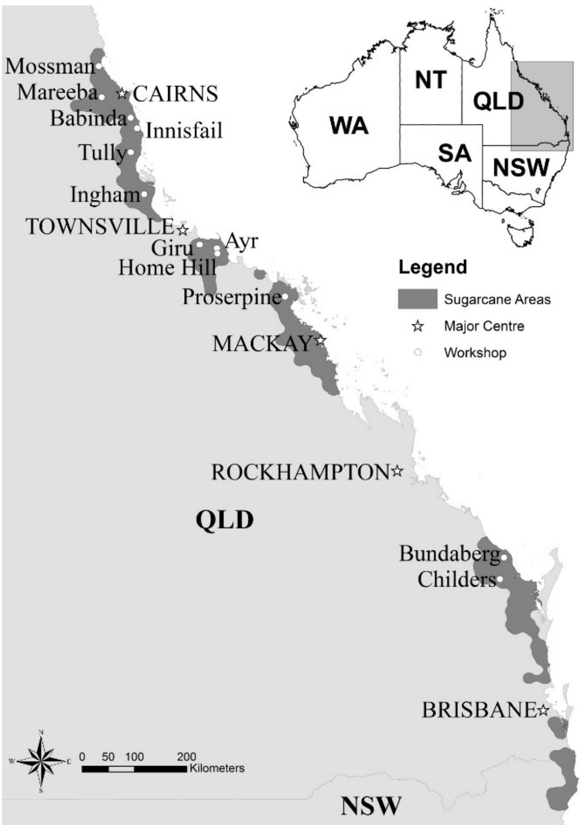

Figure 3.1: Australian sugarcane growing regions, major centres and workshop locations.

Within the Australian sugarcane industry, development and refinement of probability based SCF information accessible to farmers and other industry stakeholders can assist decision-making throughout the value chain, particularly for irrigation, harvesting and marketing management (Everingham et al. 2002). Coupled with advances in SCF using statistical (Stone et al. 1996) and dynamical modelling systems (Molteni et al. 1996) over the last twenty years, there are now greater opportunities to use forecasts to inform decision-making in the sugarcane industry. However, the probabilistic nature of most SCF information has often led to confusion and misunderstanding amongst users and potential users and remains a communication challenge (Peterson et al. 2010). Although access to weather and climate forecast information through the internet and elsewhere is widespread across the agriculture sector, useful interpretation of that information is, to a large extent, taken for granted. The use of participative approaches which foster collaborative learning and discussion can build capacity and develop the skills required to apply this information in climate risk management decisions in the Australian sugarcane industry and global agriculture more generally.

The particular challenges of managing for climate variability within the Australian sugarcane industry were brought into clear focus during the harvesting season of 2010 which coincided with a strong La Niña event. Record quantities of cane could not be harvested due to unseasonal rainfall during the harvest period, with approximately six million tonnes left in the field (ASMC 2011). Economic losses to the industry were magnified due to marketing strategies which forward sold product that could not be delivered from local production. Interest in building capacity to better understand and manage climate variability across the sugarcane industry, stimulated by the experience of 2010, led to development and delivery of a series of Managing for Climate Risk workshops in 2012 sponsored by the peak sugar marketing body, Queensland Sugar Limited. The objectives of the workshop program were to improve resilience across the sugarcane industry sector to future climate shocks caused by climate variability or climate change impacts.

3.2.3 Improving climate risk management and practice

Attendance at climate risk workshops has been correlated with better understanding of, and attitude towards, the usefulness of SCF (McCrea et al. 2005). The skills to apply climate information from SCF are broadly recognised by potential users as important, although one survey showed only 28% of producers rated themselves as competent in applying such skills (George et al. 2007). Managing for Climate Risk workshops tailored to support farmer learning, understanding and application of weather and climate forecasts were delivered across Queensland agricultural industries in the 1990s and early 2000s (Cliffe et al. 1999; Clewett et al. 2000). Research commissioned by the Queensland Government in 1999 indicated that 70% of farmer respondents had used skills learnt at these workshops to some extent and a third had saved or made more money from production decisions as a result of applying those skills (CBR 1999). However, few of these workshops have been delivered in Queensland in the last ten years, despite evidence of demand for these learning activities. Indeed, Marshall et al. (2011) report, from a study conducted in northern Australia's rangelands, in which over 85% of graziers expressed interest in attending a workshop to learn about SCF.

This research investigates whether sugarcane farmer's climate risk understanding and management skills are improved through a participatory workshop process using social and collaborative learning, application of adult learning principles and facilitated group discussion. The key research question addressed was the extent to which the Managing for Climate Risk workshops resulted in changes in participant's knowledge of and skills in using climate risk information, attitudes about the value of the information and aspirations to use the information in their farm management in the future (i.e. KASA–Knowledge, Attitudes, Skills, Aspirations–criteria) (Bennett 1975; Rockwell & Bennett 2004).

3.3 Methodology

A total of thirteen workshops were conducted by the research team across twelve sugarcane growing regions in Australia from February to May 2012 (Figure 3.1).

Workshop participants were drawn from regional farming, milling and extension groups (Table 3.1). The workshops were attended by a total of two hundred and seventeen (217) participants. Of the 206 participants who completed post-workshop surveys, most respondents (80.6%) identified as cane farmers, with sub-groups also identifying as harvesting contractors and representatives of Canegrowers organisation. Milling staff (8.3%) and sugarcane industry extension officers (5.3%) were other major groups represented at the workshops.

Table 3.1: Workshop participant demographic information: gender, region and business interest.

Attribute	Demographic details
Gender	Female 13% Male 87%
Region: Workshop location and participant numbers ( )	Far North Queensland: Mossman (19), Mareeba (9), Babinda (11), Tully (22), Innisfail (16), Ingham (33). Burdekin: Giru (4), Ayr (26), Home Hill (18). Central: Proserpine (10). Bundaberg: Bundaberg (10/8), Childers (20).
Business interest/s (Respondents could nominate multiple interests)	Canefarmer - 80.6% Canegrowers Organisation - 14.6% Harvesting Contractor - 13.1% Milling staff - 8.3% Extension officers - 5.3% Other (Grazing/Horticulture/Consultants etc.) - 8.7%

Partnerships developed with regional Canegrowers organisations supported farmer attendance at workshops by promoting the workshops to members and organising workshop venues. Participants self-selected, registered their interest and attended the workshop independently from the research team. Interactive half day workshop processes were designed with intentional flexibility to allow general or specific climate and weather issues brought to workshops by participants to be addressed.

Workshop learning objectives were designed to support participants to improve their knowledge of, and skills in using, SCF information. Specific learning objectives were framed around KASA criteria (Bennett 1975; Rockwell & Bennett 2004) and workshop design and delivery was based on developing a process to engage participants in a positive environment conducive to their learning needs. Workshop design used experiential learning principles (Kolb 1984; Roberts 2006) to challenge participants to consider their current experience of managing climate risk, reflect on their experience, develop rules of thumb to manage climate variability and identify specific examples to turn learning into practice.

3.3.1 Workshop processes

3.3.1.1 Scene setting

Workshops began formally with an outline of the program and participants identifying topics they wanted covered. Where possible, issues were included in workshop content or acknowledged and put aside if outside the scope of the workshop. Workshop guidelines (Reed 2008) were established to develop group ownership in maintaining an optimal environment for participant learning and discussion. Modified socio-drama (Howie 2010) was used as an icebreaker and warm-up activity. Participants physically positioned themselves on an imaginary line along a continuum based on responses to questions related to their farming experience and shared information about their positioning on the line. Participants then split into pairs and undertook a paired interview process (Pretty, et al. 1995) discussing significant climate events experienced in their lifetimes. Facilitated plenary discussion recorded these events on a sixty year timeline beginning in the 1950s and moving through to the current year. These modified historical timelines (Bartels et al. 2013) provided participants with visual representations of their local experience of regional climate events. Extreme events, including floods and cyclones, were recorded on the upper section of the timeline, with droughts recorded on the lower section.

3.3.1.2 Technical delivery of climate information

A professional climatologist presented two climatology mini-lectures. The first covered major climate drivers including El Niño Southern Oscillation (ENSO), Southern Oscillation Index (SOI) phases, Madden Julian Oscillation (MJO) and decadal variation in the southern hemisphere Sub-tropical Ridge. Correlations between climate drivers and seasonal rainfall in north-eastern Australia were discussed, referencing the regional rainfall patterns reported above. Mini-lecture two explained the interpretation of SCF rainfall probability maps and ENSO monitoring products. Malouf's information delivery framework (Malouf 2003) was used to structure the mini-lecture delivery. Following the two mini-lectures, small groups discussed the information presented and developed questions to clarify issues or expand understanding. Small group discussions and plenary debriefing question and answer sessions allowed participants to extract further meaning and to draw conclusions about the material presented.

3.3.1.3 Reinforcing knowledge and skills

To reinforce learning and understanding, participants were provided with workbooks and asked to complete a number of individual written exercises (Drabick et al. 2007) related to the technical information delivered in the mini-lectures. Exercises included:

i. Identifying and naming historical monthly sea surface temperature (SST) patterns associated with different ENSO patterns;

ii. Interpreting mystery (unlabelled) historical monthly SOI series and graphs to suggest future SOI movements and regional rainfall for the season ahead;

iii. Interpreting regional rainfall probabilities using European Centre for Medium-Range Weather Forecasting products, including rainfall probability maps:

    - exceeding the median;
    - lowest 20% of climatology; and

- ♦ highest 20% of climatology;

iv. Interpreting forecast NIÑO-3 SST anomaly plumes to understand current and future ENSO conditions.

Participants worked through exercises individually, but were encouraged to discuss questions and answers in groups. For Exercises One, Three and Four, facilitated plenary discussion of answers occurred after allowing time to complete each section. For Exercise Two, each of seven SOI data series were debriefed in plenary in sequence, after participants reached a view on the likely direction of SOI and magnitude of rainfall likely in the season ahead. Mystery years were then identified and monthly SOI values and rainfall totals for the region for that year compared to participant's earlier discussion about SOI direction and rainfall. In this way, participant understanding of regional rainfall variability and its relationship with historical SOI patterns and ENSO conditions was developed.

3.3.1.4. Linking understanding to decisions

A video case study of a canefarmer explaining the use of SCF to make machinery investment decisions was shown as an example of SCF use in practice. Used as a stimulus prior to small group discussion, the video challenged participants to identify other management decisions where SCF information could also be applied. Groups developed lists of tactical and strategic management decisions, matched to SCF products, and identified the time of year the forecast is needed and the lead time required. Following small group discussion, groups shared their lists in a plenary session.

3.3.1.5 Workshop evaluation and data collection

A summative evaluation process using workshop survey forms (Appendix A) was used to collect data at the completion of each workshop, with participants completing forms voluntarily and anonymously. Workshop process design and implementation were underpinned by assumptions that the achievement of learning objectives would positively affect changes in the KASA criteria as perceived and reported by workshop participants. Quantitative data was collected using ten point respondent self-measurement Likert scales (Likert 1932; Dawes 2008) to rate changes in the KASA criteria (Table 3.2).

Table 3.2: Post-workshop quantitative evaluation questions using a 10 point Likert scale.

Question No.	Question	KASA Criteria
Question 1	Overall, how useful did you find the workshop in terms of better considering climate risk issues within your industry/business? (Low usefulness to high usefulness)	Attitude
Question 2	Rate your level of gain in understanding of general SCF information (Low gain to high gain)	Knowledge
Question 3	Rate your level of gain in understanding of interpreting SST maps (Low gain to high gain)	Skill
Question 4	Rate your level of gain in understanding of interpreting SOI data (Low gain to high gain)	Skill
Question 5	Rate your level of gain in understanding of interpreting ECMWF maps (Low gain to high gain)	Skill
Question 6	Rate your level of gain in understanding of using products to determine rainfall probability in the season ahead (Low gain to high gain)	Skill
Question 7	Based on this workshop, how much potential benefit do you see in using SCF products to assist your on-farm planning? (Low benefit to high benefit)	Attitude
Question 8	How likely are you to use this SCF information in your decision-making? (Low likelihood to high likelihood)	Aspiration

Post-workshop qualitative evaluation questions were aimed to further elucidate participant learnings, perceived benefits/barriers to SCF use and beneficial workshop processes (Table 3.3).

Table 3.3: Post-workshop qualitative evaluation questions.

Question No.	Question
Question 1	What aspects of the workshop, if any, were particularly helpful?
Question 2	What could have been changed/included to make it more helpful?
Question 3	What are the main benefits for your industry/business that could result from using SCF products?
Question 4	What might stop you using SCF products or applying what you learnt today?
Question 5	Other comments about the workshop/process you experienced today?

Responses were entered into the 'YourData' management system (Coutts 2014), providing a mechanism for collating, storing, exporting, analysing and reporting data. Quantitative data provided response ranges, minimum, maximum and median values for evaluation questions from respondents, across stakeholder groups and regions. Qualitative response data was manually coded to identify recurring themes within the data. Theme frequencies are presented as percentages of total responses for each question in the study. Direct quotes from participant responses are reported for codes with higher relative percentages (greater than 10%) and selected because they were perceived to be representative of particular response codes.

3.4 Results

3.4.1 Workshop usefulness and KASA change

Median response ratings to quantitative evaluation questions were high across the three major occupation groups with median responses to most questions rating at or above 8.0 (Figure 3.2). The rating ranges within responses to each question were highest within cane farmers compared to the other demographic groups analysed in this study. Within the farmer group the higher ranges were in response to skills related questions. This may indicate that, for at least some of these farmers, their perceived skill improvement in this area was low, compared to the other groups and may have been due to their attendance at previous workshops. Ranges within the extension officer group were smaller which indicates greater similarity within this group and perhaps less regular use of particular SCF products, coupled with a lack of experience in directly making management decisions in the way that farmers or millers would.

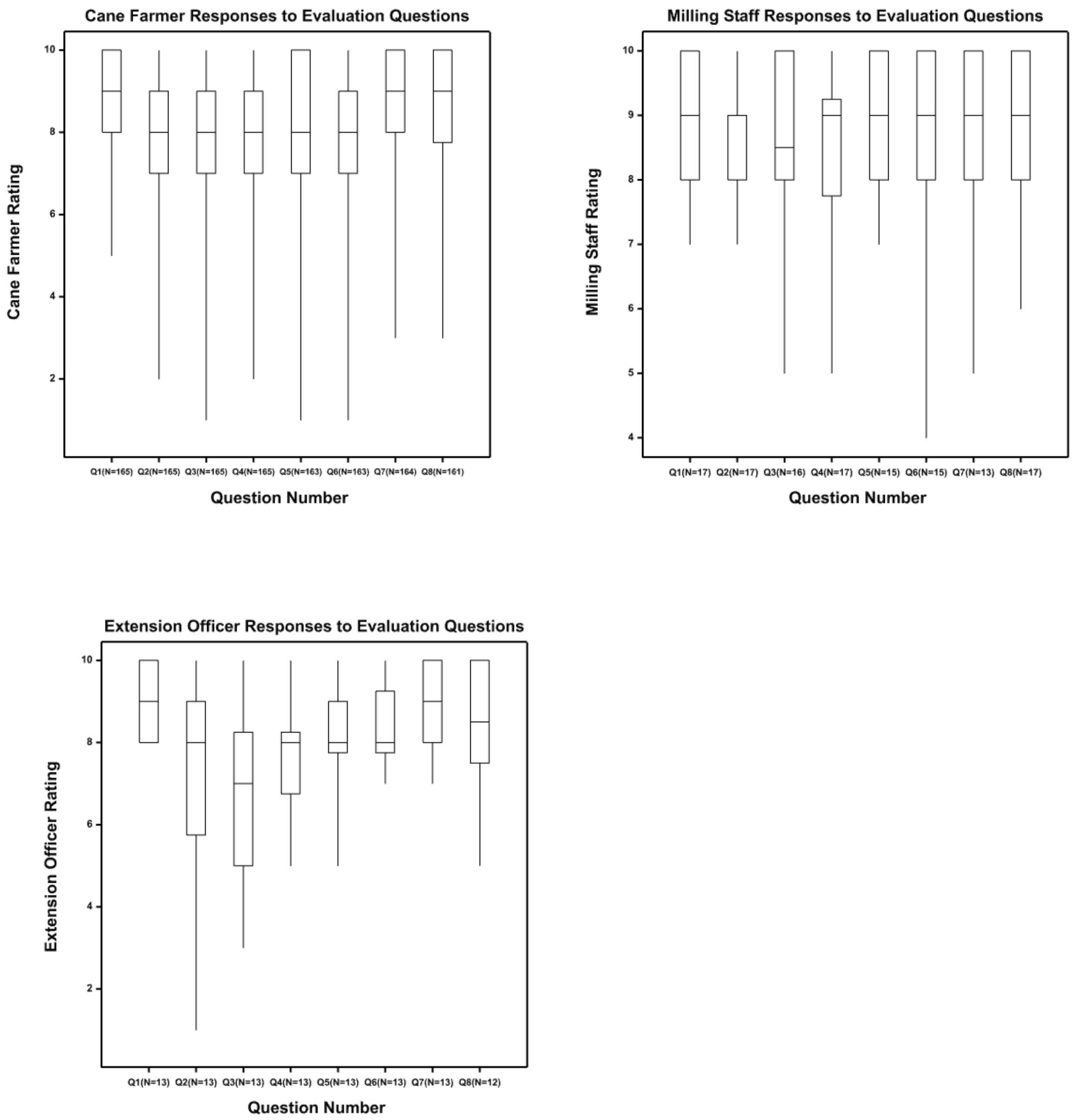

Figure 3.2: Cane Farmer, Milling Staff and Extension Officer ratings of quantitative evaluation questions (Box plots display Median, Minimum, Maximum, 25th and 75th percentile values from responses on a 10 point Likert scale).

Very high median values across most questions for the milling staff suggest they had the most to gain from attending the workshop and may have been starting the workshop with a relatively low base in understanding and use of the workshop material. Using a random permutation test (Roff & Bentzen 1989), no significant associations between different regions or occupations provided by respondents were identified (p>0.05).

3.4.2 Manual coding of participant comments

Table 3.4 lists the top three themes developed against questions collected from qualitative responses from workshop participants. Participant quotes illustrate representative responses under themes. Over 20% of participant comments regarding helpful workshop aspects related to improved learning and skill development, reinforcing the high ratings obtained in quantitative data relating to those areas. Changes suggested by participants included providing more examples and allowing more time to explain concepts and tools. Around 15% of participants indicated that lack of confidence in the reliability of SCF products or limited accessibility to the information might stop them from applying their learning from the workshop. The main benefits from using SCF products identified by over 60% of participants were improved decision-making with mention of specific management decisions.

Table 3.4: Manually coded response themes (top three), participant quotes and frequency of mention for climate workshop evaluation questions.

Question	Response theme and participant quotes	Number of Mentions (%)
Q1: What aspects of the workshop, if any, were particularly helpful? (*n*=194)	1. References to weather/climate forecasting: • *'Explaining different weather patterns, how to read and follow them'* 2. Better understanding/learning: • *'Learning how to understand and predict future events using SOI, MJO, ECMWF'* • *'General understanding of forecasting; real understanding of SOI'*	59(30.4) 46(23.7)

	3. Reference to skill development: • *'Use of SOI in autumn in predicting weather patterns for the year'*	41(21.1)
Q2: What could have been changed/included to make it more helpful? (*n*=100)	1. Activity was good/No change: • *'Covered subject very well'* 2. Provide more information and examples: • *'Forecast for 7-28 days'* 3. More time for explanations/Longer workshop: • *'Allowing more time to explain tools'*	39(39.0) 21(21.0) 18(18.0)
Q3: What are the main benefits for your industry/business that could result from using SCF products? (*n*=190)	1. Improved decision-making and risk reduction: • *'Better decisions based on lowest risk'* 2. Specific mention of management decisions: • *'Pricing of sugar, knowing what the rest of the world is doing'* • *'Using forecasts to make irrigation and fertilising timing decisions'* 3. Better planning: • *'Better planning/timing of operations'*	131(69.0) 118(62.1) 67(35.3)
Q4: What might stop you from using SCF products or applying what you learnt today? (*n*=102)	1. Nothing: 2. Confidence in reliability of the products: 3. Availability/Accessibility of information:	23(22.6) 16(15.7) 15(14.7)
Q5: Other comments about the workshop/process you experienced today? (*n*=101)	1. Good process: • *'Very good interaction between participants and presenters'* • *'Smaller groups worked well'* 2. Informative: • *'Very informative; easily understandable'* 3. Well presented: • *'Most impressive, detailed presentation'*	36(35.6) 26(25.7) 19(18.8)

A wide range of management decisions were identified by participants in responses to the question about the main benefits resulting from the use of SCF. Over 62% of participant responses identified management decisions of some kind. Table 3.5 lists decisions identified, their frequency and percentage. Respondents often mentioned multiple management decisions when responding to identifying benefits of using SCF products. Where management decisions were mentioned in responses, almost 40% of respondents mentioned one decision, 34% two decisions and 15% three decisions. Two respondents were able to identify eight specific management decisions. Planting, harvesting and sugar marketing were the management decisions most frequently mentioned by participants.

Table 3.5: Coded responses within the response theme 'Specific management decisions mentioned' (*n*=118).

Specific management decisions mentioned	**Number of Mentions (%)**
Planting cane	56(47.5)
Harvesting cane	32(27.1)
Sugar marketing	21(17.8)
Ratoon management	17(14.4)
Fertilising	17(14.4)
Irrigation	17(14.4)
Budgeting	15(12.7)
Chemical application	12(10.2)
Maintenance	11(9.3)
Start of crushing and season length	11(9.3)

Small group discussions identified lists of management decisions linked to particular SCF products needed at specific times of year, with associated lead time. Lists of regional decisions produced in these workshops were published in a Canegrowers Climate Variability Booklet (CANEGROWERS 2012). Over 91% of respondents requested that follow-up information be provided in the form of concise emails updating the seasonal outlook. Less than 3% of respondents indicated they did not want to receive any follow-up information.

3.5 Discussion

Positive evaluation results reflected in high KASA self-assessment ratings and references to knowledge acquisition and skill development in manually coded qualitative data indicate that these climate workshops met participant needs and overall workshop learning objectives. Of particular interest were high ratings for respondent attitudes to ‘potential benefit of using SCF products in farm planning’. This indicates respondents are likely to have a positive attitude towards accessing SCF products and applying them in decision-making, post-workshop. The question querying the ‘likelihood of using SCF in decision-making’ also rated highly, indicating respondent aspirations to apply learnings from the workshop and confirming potential benefits of workshop attendance.

Participant self-assessments of knowledge in summative evaluation processes, similar to those applied in this study, are commonly applied in training courses (Sitzmann et al. 2010). Self-assessment appears strongly related to participant reactions and only moderately related to self-efficacy (Sitzmann et al. 2010). However, self-efficacy, defined as the judgement of what individuals can do to accomplish a certain performance, is proposed by Bandura (2006) to be a ‘major determinant of intention’. While self-assessments of knowledge and skills in this study may be indicative of participant intentions and feelings about the workshop, qualitative data analysis coded into themes also reflected the knowledge acquisition and skill development found in the KASA ratings. The triangulation of quantitative and qualitative results appears to provide further evidence of participant learning.

The similarity of results between the three dominant occupation groups in this study is somewhat surprising. It could have been expected that extension officers in particular would have higher knowledge of SCF information and skills in interpreting SCF products than farmers. This would therefore have been reflected in significantly lower median ratings for this group’s gains in understanding. This result suggests that extension staff in the sugarcane industry may be less than optimally informed and skilled to support farmers in their understanding and application of SCF in their businesses. Extension officers are considered to be mavens who have the capacity to exert a positive influence on large numbers of farmer clients. To maximise best practice climate risk management for farmers and agriculture in general, it may be necessary to more strategically target developing the capacity of extension officers to understand and extend the use of SCF information.

Predominantly positive themes (Table 3.4) developed from coded respondent comments appear to reinforce the robustness of the workshop process design. Over 35% of participants who provided additional comments about the workshop or process made comments which suggest that the workshop developed a positive learning environment. Providing opportunities for interaction early in the workshop fostered a collaborative atmosphere where all could contribute. Paired interviews captured participant experience allowing creation of historical timelines of weather and climate events. These timelines provided reference points of climate phenomena for discussion later in the workshop when identified events often coincided with historical ENSO periods. Participants were able to link newly found understanding of climate drivers to their local experience.

Analysis of themes developed from qualitative data support literature suggesting that collaborative learning can occur through structured and unstructured small group discussion and interaction, which Pai et al. (2014) suggests promotes transfer of knowledge and a depth of understanding that working individually may not provide. Results also support the concept that small group discussion can lead to individual learning that may not be possible for individuals working independently or in isolation (Olivera & Straus 2004). Group discussion in these workshops, framed around identifying decisions referencing SCF information, challenged participants to connect earlier learning to management applications. The design of workshop processes in this research which supported group discussion, questioning and interaction between stakeholders appears to have led to the achievement of workshop learning objectives. These results support research identifying the benefits of using interactive learning techniques, group discussion and participatory methods in training activities (Francis & Carter 2001) where participatory methods were identified as more useful than more traditional methods. The value of components of collaboration including social interaction and cognitive challenges that occur in debate and conversation in groups (Pai et al. 2014) also appear to have contributed to individual learning outcomes reflected in this study.

Although attending a Managing for Climate Risk workshop in itself may not directly link to the use of SCF information, the correlation that exists between workshop attendance and improved understanding of SCF described by McCrea et al. (2005), may positively contribute to the capacity of farmers to more effectively manage climate risks and opportunities. In these workshops, participants made linkages between SCF products and many management decisions, indicating workshop processes and associated discussion primed their thinking about potential uses of climate information in their personal situations. The identification and linkage of management decisions to the use of particular forecast products observed in farmers in this workshop can influence changes in management that may potentially occur if forecasts are adopted by users (Ash et al. 2007). Further investigation of the use of SCF information and application of learnings obtained at workshops may be warranted to further evaluate practice change and adoption rates. There may also be scope to develop social learning networks within local farmer groups after attending workshops. This would facilitate ongoing farmer interaction which could support better decision-making by individuals at the farm level and at a regional scale in harvesting groups and in milling operations.

3.6 Conclusions

This case study provides further evidence that combining relevant and contemporary scientific knowledge of major climate drivers with robust workshop facilitation processes in a collaborative learning environment develops farmer capacity to understand and interpret climate information and identify applications of SCF to management decisions. Facilitated small group discussion processes support identification of multiple management decisions to a degree which is unlikely for individual farmers working independently. Factors which appear critical to foster productive discussion include providing structured and unstructured opportunities for farmer interaction, sophisticated workshop process design and experience in group facilitation. Although a specific case study, these findings support the broader collaborative learning and climate risk management literature, indicating the potential relevance of these approaches to situations in other industries and countries.

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3.8 Additional information included post-publication of this journal article

Annual sugarcane crop water use varies across Australian sugar growing regions from 1590 mm in the Burdekin region where effective rainfall is approximately 600 mm, to 990 mm in the Grafton region where effective rainfall is over 780 mm (Holden and McGuire, 2014). Irrigation requirements to adequately support crop growth vary between regions where the shortfall between crop water demand and rainfall needs to be filled. Full irrigation is therefore common in the Burdekin region where rain-fed systems in the Grafton and Innisfail regions rarely see deployment of irrigation to support crop growth. Where possible, in the Mackay and Bundaberg regions, supplementary irrigation support crop water demands at key times within the crop cycle, post-planting and post-harvest to support crop establishment and promote ratoon growth.

Malouf's information delivery framework describes a three step linear process of designing an instructional session. The first section can involve delivery of a mini-lecture, followed by a participant activity related to the content of the mini-lecture.

The third and final section challenges participants to evaluate and debrief what has been covered in the session (Malouf, 2003).

Results for this study were obtained from collection of data from three occupation groups, canefarmers, milling staff and extension officers. Milling staff and extension officers represented around 9% and 6% of responses so compared to the numbers of farmers (around 85% of respondents). Conclusions are therefore drawn with the caution that extension officers and milling staff represent much smaller groups of respondents than the farmer group.

Regarding the comment (Page 58) concerning the economic losses suffered by the sugar industry in the 2010 season, the marketing strategies which forward sold product that could not be delivered from local production were the responsibility of Queensland Sugar Limited (QSL), the primary marketing organisation for Australian sugar. Farmers at that time had little to no control over marketing their own product. This has changed since 2010 where farmers can forward sell a significant proportion of sugar from their crop.

Attendance and participation at workshops was organised by Canegrowers Australia regional groups and no attempt was made to ensure a particular target group of growers attended. Business size, gender or other demographic targets were not employed in attracting workshops participants.

4 Evaluating machinima as a tool to support peer group discussions in the agriculture sector

Chapter 4 focuses on the evaluation of a prototype machinima (virtual world produced animated video) produced to be tested with a diverse group of sugarcane industry stakeholders including canefarmers, extension officers and industry representatives and represents the second phase of research in this project. The analysis is designed to determine the initial acceptability of machinima as a communication and discussion support medium and to provide feedback to machinima developers about what changes could be made to enhance communication and production values of the product. The chapter builds on the concept of developing a product which would complement and support the collaborative learning workshop environment described in Chapter 3 (Cliffe et al. 2016), where sugarcane farmers are engaged in a facilitated process to improve their climate literacy and build their knowledge, skills, awareness and aspiration to use seasonal climate forecasting information in their farm management decision-making.

A phenomenographic approach is used to qualitatively represent the interviewee's conceptions of key messages contained within the machinima presentation and to define the structural relationships between the categories of description that emerged within the consequent outcome space. Within this research project this analysis is used to assist the researcher's understanding of, and confidence in, phenomenography as a research methodology, prior to using the approach in subsequent project data collection and analysis activities.

The chapter is constructed in journal article format consistent with preparation for future journal publication targeting the 'Australasian Journal of Educational Technology'.

The key research question that is addressed in this chapter is:

RQ2 How do Australian sugarcane industry stakeholders experience machinima as a communication medium and discussion support tool?

Results of this phenomenographic analysis were presented as a conference paper at the EARLI SIG 9 Conference at Regent's Park College, University of Oxford, UK, 1-3 September 2014.

EARLI – European Association for Research into Learning and Instruction.

SIG 9 – Special Interest Group (Phenomenography and Variation Theory).

Title: Evaluating machinima as a tool to support peer group discussions in the agriculture sector

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4.1 Abstract

Purpose: This paper documents processes used and the results of an evaluation of a prototype machinima (a short digital film created in a virtual world environment) used to expose a range of Australian sugarcane industry stakeholders to a novel learning and discussion support tool to improve the management of climate risk.

Methodology: Seventeen semi-structured interviews were conducted in 2013 with cane farmers, extension officers and Canegrowers Organisation representatives across major sugarcane growing regions in Queensland, Australia. Phenomenographic analysis was used to analyse the variation in key messages as experienced by interviewees and collected in the interview data. Structural relationships between categories of description were then defined in an outcome space. To evaluate machinima production attributes, interviewee comments were thematically coded to provide information on the range of positive, negative or neutral aspects of the machinima to improve development of future products.

Findings: Conceptions of key messages varied from messages which concerned basic information about awareness of weather events impacting on farming to simple observation of farmer avatars discussing how weather information could be potentially used. Higher level conceptions included the prompting of potential use of information in management decisions and in other elements of farming to, at the highest level, drawing conclusions about management of climate risk more generally. Interviewees across the three stakeholder groups made positive comments about the potential of machinima for generating farmer group discussion. All stakeholder groups provided above average ratings for the value of the tool in supporting farmers to take action in relation to information presented in the machinima. Results indicate that machinima elicit a wide range of conceptions from simplistic observations of avatar conversations and their content to identification of deeper conceptions where viewers assimilate machinima content into their broader understanding of decision-making and business management.

Practical Implications: Positive evaluation responses provide confidence that machinima can be used in a wider study to test their effectiveness in directly supporting farmer group discussion and learning about climate risk. Constructive suggestions to improve the production values of the machinima for future products provide guidance to digital media developers about further customising the product for future testing and use. Phenomenographic analysis is a useful qualitative research methodology to analyse variation in learning and understanding in a farmer population in an agricultural context.

Originality/Value: The use of machinima in an agricultural context to support farmer learning and prompt group discussion has been very limited. This study provides a novel example of machinima designed for use in an agriculture context in the developed world, and the first with the Australian sugarcane industry addressing management of climate variability linked to cane farming practices. The use of phenomenography in an agricultural situation provided by this study is a significant contribution to the literature, where very few examples in this context exist.

Keywords

Machinima, Virtual worlds, Agriculture extension, Social learning, Discussion support, Managing climate risk, Phenomenography

4.2 Introduction

Creative applications of new digital technologies are revolutionising the way in which people work, conduct business, learn and interact with each other, both in their professional and personal lives. Younger generations in the developed world in particular have lives which appear to be inextricably entwined with mobile technologies which support social networking, recreational pursuits and also pervade many work places. In the agriculture sector, digital technologies are also making significant differences to the way traditional farming businesses have historically operated. However, significant inequity between urban and rural communities in access to high quality, reliable internet services remains (Townsend et al. 2013). Improving access to digital networks and technologies has allowed advances in precision farming, record keeping and development of smart phone apps to access weather forecasts and communicate more effectively with business contacts via email and SMS (Roberts & McIntosh 2012). Increased global digital connectedness provides new opportunities for novel social networking and collaboration, particularly to support learning in target groups.

Collaboration between farmers, advisers and scientists occurring through collaborative and social learning experiences can have significant positive impacts on farmer capacity to manage risk and uncertainty in the agriculture and resource management sectors (Warner 2006). These impacts include building knowledge and skills which can improve the resilience of the agriculture sector generally, and farm businesses in particular, to business shocks resulting from climate impacts or economic downturns. Opportunities for learning through formal and informal collaboration in agriculture have historically been high in many countries. However funding and policy support for agriculture extension services is generally declining in developed countries, with trends towards service privatisation (Warner 2006; Leach 2011; Hunt et al. 2012). The capacity of existing agriculture extension services to meet the demands of farm managers for information and services by relying on traditional extension and communication models (particularly publicly funded extension services) is diminishing (Warner 2006).

Concurrent with reductions in extension service provision, improvements in digital technologies and communication, including higher speed internet and improved connectivity, have allowed greater opportunity to access online information and services and participation in a globally networked economy (Knight 2015). However levels of inequity in service accessibility, reliability and transmission speeds remain, both between developed and developing countries and between urban and regional/rural areas (Knight 2015; Salemink et al. 2015). Acknowledging the existence of 'digital divides' at a range of different scales, there are opportunities to trial novel digital approaches which can provide alternative information delivery methods for farm managers and rural communities. The use of virtual world platforms is an example of a creative digital media where tools can be constructed for communicating and interacting with stakeholders and their groups, efficiently and at comparatively low cost (Mushtaq et al. 2017).

Advances in digital technologies, particularly in computing power and processing speed, have also led to development of numerous decision support tools in agriculture. Many of these tools provide answers or management guidance for particular problems and use complex biophysical modelling of many different variables (Woodruff 1992; McCown et al. 1996; Hearn & Bange 2002). Some also incorporate management of climate variability through the inclusion of seasonal climate forecasting information (Carter et al. 2000; Hochman et al. 2009). Participatory, interactive, multi-stakeholder discussion-based approaches, combined with decision support system output, have proven effective in supporting decision-making (Carberry et al. 2002). However the intensive nature and expense of supporting initiatives of this type militates against broad implementation beyond discrete, focused research project activities. The current decline in the agriculture extension and communication environment also exacerbates this issue.

Many barriers and challenges to the broad adoption of agriculture decision support tools by farmers and decision-makers have been identified. These have included general farmer reluctance to use computer programs through which the tools are designed and delivered. Additionally the format in which many decisions support tools are presented, where only a partial analysis of a decision is assessed, may be less optimal than a farmer's own experience (Hayman 2003; Jørgensen et al. 2007;

Matthews et al. 2008; McCown et al. 2009). Few tools have been developed explicitly to support group discussion and collaborative learning which could incorporate farmer knowledge into their own management solutions (Nelson et al. 2002). Nelson et al (2002) suggest that discussion support moves beyond decision support and that there is a distinction between decision support and discussion support systems. They conclude that 'discussion support systems are designed to facilitate dialogue about management practice that is relevant and significant to the decision-maker' (Nelson et al. 2002). We suggest that, beyond simply prompting dialogue and discussion, a discussion support system should facilitate social and collaborative learning experiences for the individuals involved. Marx et al. (2007) suggests that experiential processing and understanding, including group interaction and discussion, will support understanding of probabilistic climate forecasts and potentially improve climate risk decision-making. If this process is successful it will allow individuals to assimilate expert, peer group and their own understandings and experiences into making appropriate management decisions relevant for their own situations.

Social and collaborative learning can occur through structured and unstructured small group discussion and interaction (Pai et al. 2014). Group discussion can also lead to individual learning that may not be possible for individuals working independently or in isolation (Olivera & Straus 2004). Studies of experiences of student learning through face-to-face and online discussions in a higher education context (Ellis et al. 2006), indicate that particular groups of students can have learning experiences that are of higher quality through the deeper learning that can result from face-to-face discussion. However, the way in which discussion tasks are designed by teachers and facilitators may help students to understand the learning advantages that might accrue from both face-to-face and digitally-based group discussion processes and also take more advantage of the benefits that electronic, on-line discussion platforms can provide (Ellis et al. 2006; Bliuc et al. 2010).

Facilitating interactive dialogue and discussion through designing, developing and evaluating a low cost tool to effectively support existing agricultural communication and extension efforts is a key objective of this research. In addition to facilitating discussion, the tool will ideally provide contextually relevant information, challenge traditional thinking and promote group discussion in situations with or without the presence of advisers or scientists. The tool could therefore stand alone as a potential catalyst for change in thinking and practice, or to augment learning and prompt action to access relevant information or expert advice from other sources. Facilitating group discussion and learning in an immersive virtual world has particular technical and interaction challenges distinct from traditional face-to-face and other modes of group interaction, but can provide exciting opportunities for social learning (Wang et al. 2014). Challenges include the risks of miscommunication that can occur where gaps in understanding result from the process of remote interaction, language issues and potential technical difficulties concerning the variable reliability of digital access between potential users (Wang et al. 2014).

The use of virtual world platforms to support learning in a range of educational contexts appears to be gaining momentum. Much of the literature focuses on the capacity for students to enter and interact with a simulated environment to provide a diverse range of creative opportunities to address a range of educational objectives as varied as disaster response management (Taylor-Nelms & Hill 2014) to food hygiene inspection (Woods 2010). Some studies have focused on educational contexts which support collaborative learning and have shown a capacity to supplement, rather than displace, face-to-face learning with reports of increases in student interest and participation in learning activities, as well as personal and group knowledge construction (Andreas et al. 2010; Girvan & Savage 2010). Other research has focused on using virtual world video clips or ‘machinima’ (‘machine animation’) to provide tools which use a virtual world environment to support particular educational objectives often in higher education, university settings (Middleton & Mather 2008; Butler 2010).

To develop a prototype discussion support tool in this project, the virtual world platform Second Life™ was used to create a virtual world video clip or ‘machinima’ (‘machine animation’) (Reardon-Smith et al. 2014; Reardon-Smith et al. 2015). Second Life is a three-dimensional, real time, multi-user, virtual world where characters (avatars) can interact with each other and the simulated environments they inhabit and in which they can move, navigate and communicate in virtual communities (Salmon 2009). As a platform, Second Life™ is one of the most commonly used to research the use of virtual worlds to support collaborative learning in the education sector (Dass et al. 2011; Rahman et al. 2014). It is also expanding into a range of genres, largely based on its affordability as a creative digital development platform (Fosk 2011).

Early trials of machinima in agriculture (Stone 2012a; Stone et al. 2012b) indicated that the language and context in which characters in the animation are depicted is important in successfully engaging with targeted farmer groups. The prototype machinima used in this project, targeting Australian sugarcane farmers, was developed using iterative design-based research principles (Reeves 2006) where machinima developers worked closely with an extension practitioner with strong links to industry and a well-developed understanding of industry cultural mores. A machinima scenario was chosen which represented a typical sugarcane farm and a group of farmer avatars discussing their preparations for the approaching harvesting season. Evaluating the prototype machinima has provided important information and insights to guide development of future machinima for use in the agriculture sector.

The key research question addressed in this study explored how agriculture service providers, extension officers and farmers in the Australian sugarcane industry experience a customised prototype machinima as a communication medium and discussion support tool?

4.3 Methodology

4.3.1 Prototype machinima development

The prototype machinima scenario developed for this study consisted of animated farmer avatars discussing climate risk in the context of a harvest management decision using a particular climate forecast outlook. An example transcript of the harvesting decision machinima script appears in Appendix B. The machinima set and characters were developed to represent, in a virtual sense, a typical farming situation and farmer personalities with specific attributes that would make it contextually relevant for the target farmer group. Figure 4.1 illustrates a screenshot of the farmer avatars in discussion. Major set elements included a farm house, machinery shed, tractors, harvester and a sugarcane crop as backdrop. Other elements such as tools, tyres, a fridge and a farm dog were included to provide minor details in support of major design elements (Figure 4.2). The machinima script was developed within a contemporary Australian canefarmer conversational idiom to optimise the way in which farmers could identify with the avatar characters as they viewed the simulated virtual discussion. The informational content of the machinima script focused on the use of seasonal climate forecasts in cane harvesting planning and decision-making. The script for the prototype machinima was developed by the principal researcher for this study.

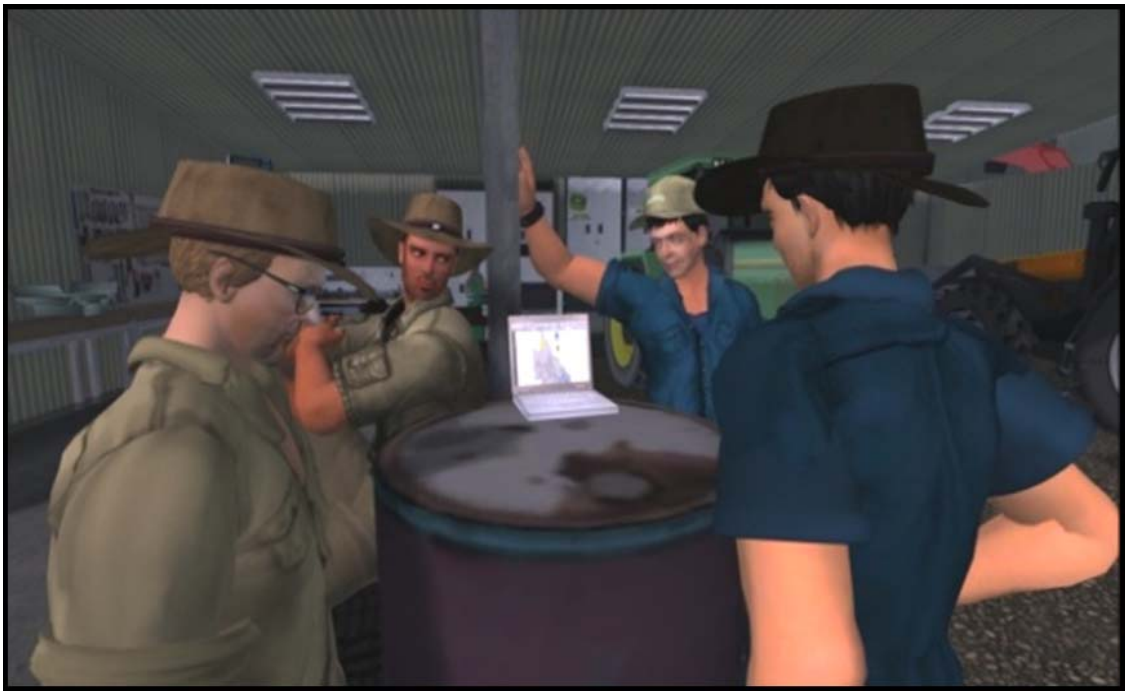

Figure 4.1: Machinima screenshot illustrating farmer avatars in discussion.

Figure 4.2: Machinima screenshot illustrating elements of the sugarcane farming scene, including the machinery shed and sugarcane crop.

4.3.2 Participants

A total of seventeen interviews were conducted with sugarcane farmers (seven), extension officers (six) and Canegrowers Organisation (the agro-political body which represents Australian cane famers) representatives (four). Interviewees were selected following their participation at one of a series of Climate Variability Workshops which were conducted across the major Australian sugarcane growing regions in 2012 (Cliffe et al. 2016). Interviewees were selected to provide diversity in regional locations (4), age (22 – 67 years old) and gender (4 Female/13 Male). Farmer interviewees were further selected to provide a range in production systems from wholly dryland (rainfall dependent) to supplemental irrigation where crop production is augmented at particular critical times by the use of irrigation. Extension officers in the sugarcane industry who provide an interface between researchers and farmers to facilitate the adoption of new and/or established best management practices were chosen from different regions. Canegrowers Organisation represent the interests of regional cane farmer groups across all business aspects of the sugarcane industry. The organisation also provides input to agro-political issues impacting on the industry. Within this organisation, three regionally based Chief Executive Officers and the State Senior Manager (Environment and Natural Resources) were interviewed for this study. Overall, interviewees were selected from six Queensland sugarcane growing regions and the central office for the Canegrowers Organisation in Brisbane, Queensland, Australia (Figure 4.3). Interviews were conducted in Mossman, Gordonvale, Babinda, Proserpine, Mackay, Bundaberg and Brisbane.

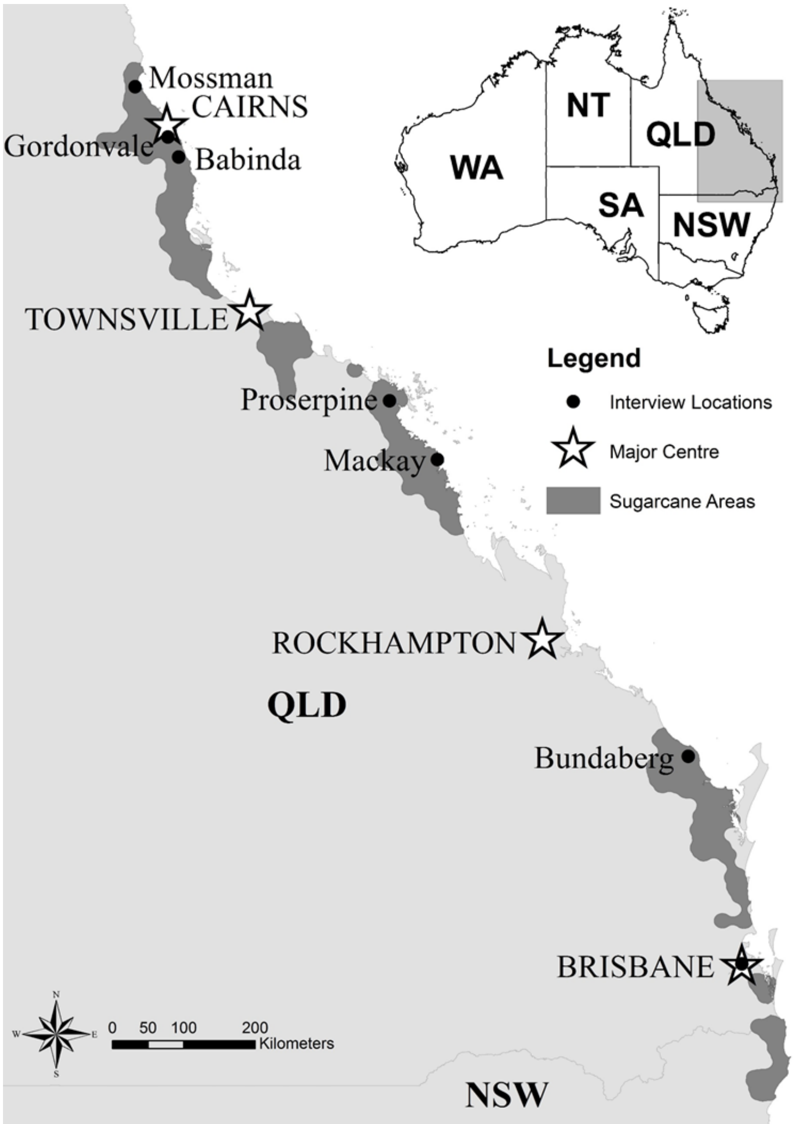

Figure 4.3: Interview locations across Australian sugarcane growing regions.

4.3.3 Interview technique

A semi-structured interview process was conducted to evaluate stakeholder responses to the prototype machinima video animation as a climate risk management discussion support tool. To maximise the comfort level of interviewees, interviews were conducted in person on the farms of the cane farmers or in the offices of the extension officers and Canegrowers organisation representatives. The interviews were conducted in three parts using a series of guiding questions (Appendix C). Following a general introduction which explained the research process, interviewees viewed the prototype machinima on a laptop computer. After viewing the machinima, in section one of the interview, interviewees were asked to respond to questions which explored the key attributes of the machinima design and the informational objectives of the avatar conversation. This included rating the value of the tool in ‘supporting canefarmers to take some action, small or large, in relation to the information presented’. In section two, interviewees were asked to respond to questions which explored their opinions about their preferred climate information delivery platform needs. Initial interviews were considered as pilot interviews to test the interview instrument and allowed fine tuning of questions if required. Field notes were collected for each interview noting relevant points about the venue, timing, setting, demeanour of the interviewee and conduct of the interview.

This paper focuses on the results from section one of the interview. Individual interviews were recorded with the consent of interviewees using an IPad and ‘Voice Record’, a free, downloadable application, with a back-up copy made using a portable digital voice recorder. Interview duration varied between 18 minutes to 44 minutes with most interviews taking 25 to 30 minutes to conduct.

4.3.4 Interview analysis

Interview recordings were manually transcribed verbatim into individual word documents. Data were hand coded to develop key thematic elements and patterns (Patton 2002) highlighted by interviewees within each of the interview questions. In most cases in this early data consolidation and evaluation stage, and depending on the question concerned, comments were coded as ‘Good’, ‘Neutral’ or ‘Improve’ to develop frequency indicators for the data. Comments by interviewees were then selected to represent a richer contextual understanding of the frequency information that had been calculated.

To evaluate and understand interviewee conceptions of the prototype machinima as a possible medium to convey information and prompt discussion, a phenomenographic research approach was employed (Åkerlind 2005b; Bowden & Green 2005). A phenomenographic approach aims to discover the variation in understanding, awareness or ways that people experience a phenomenon (Marton & Booth 1997). The outcomes of a phenomenographic analysis can provide a deep insight into the different ways that people understand and experience a phenomenon. Results from a phenomenographic analysis can be displayed as a range of categories of description represented in a structured hierarchy to provide a logical framework for understanding how a group of people conceive of a particular phenomenon. The categories of description within the outcome space are related and describe the variation in ways in which the phenomena is conceived of by the study group at a particular point in time.

Phenomenographic analysis processes (Åkerlind 2005a; Akerlind 2005b) consist of the principal researcher reading and re-reading interviewee transcripts with responses allocated to different categories based on the variation in responses that are detected. Ideally, a team based approach to analysing interview transcripts can provide a capacity to compare and contrast categories of description and ensure a greater level of rigour to the final outcome space that is described (Bowden & Green 2005). However data analysis in this project was conducted solely by the principal researcher in an iterative process (McCosker et al. 2004) following guidelines for interpretive rigour described by Akerlind (2012). Direct quotes from interviewees were used to represent and highlight the important aspects which illustrate individual categories of description.

4.4 Results

Results reported from the data collected in participant interviews include a phenomenographic analysis of interviewee transcripts; thematic coded analysis of stakeholder comments about the appeal of the machinima in conveying messages to farmers; and interviewee quantitative rating of the value of the machinima in supporting farmers to take some action.

4.4.1 Phenomenographic analysis of key messages as conceived by interviewees

The interviewee's conceptions of key messages that flowed from viewing the machinima and avatar discussion are described as categories of description in a structure which points to a logical hierarchy within an outcome space (Figure 4.4).

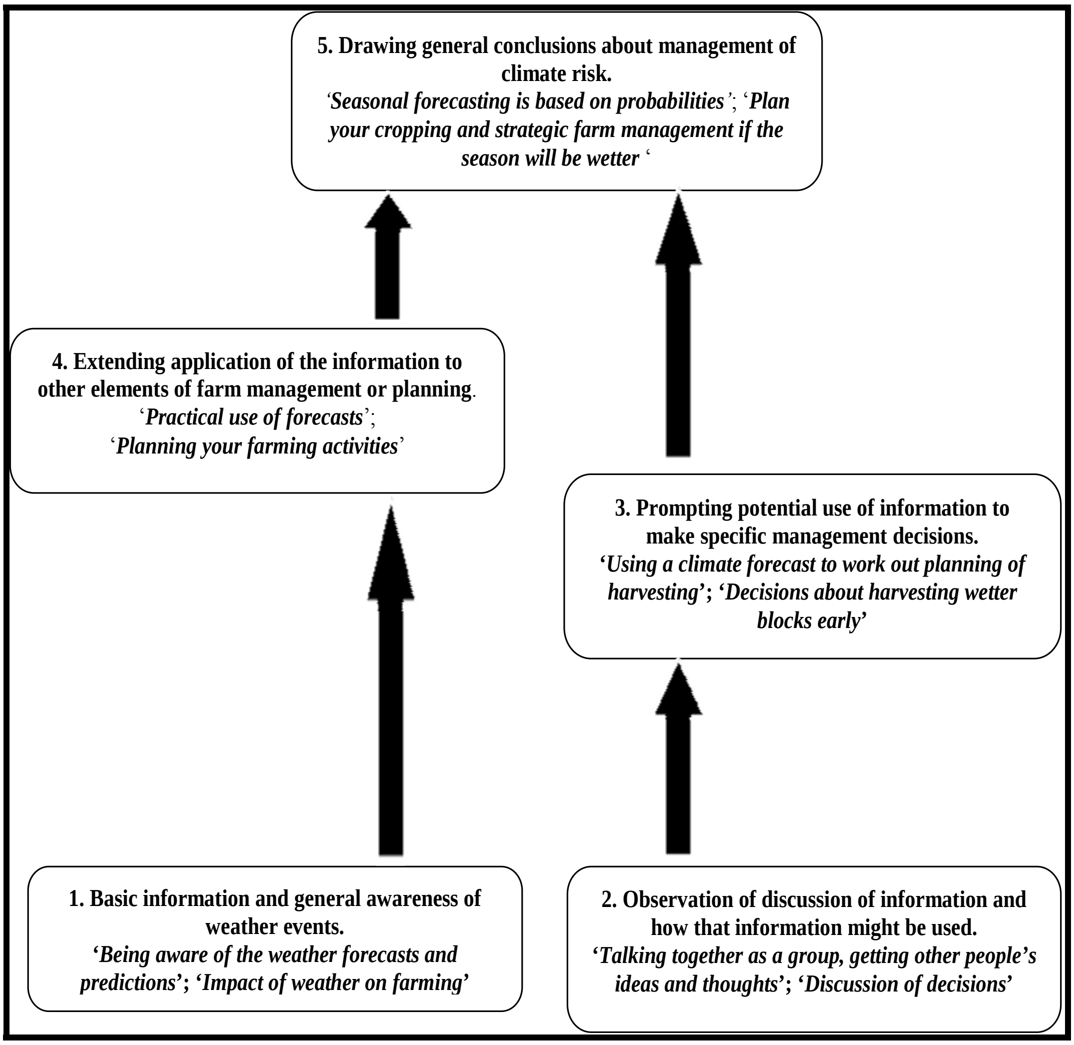

Figure 4.4: Outcome space describing the structural relationship between categories of description for stakeholder conceptions of machinima key messages.

Interviewee comments directly informed development of the categories of description and provide insights into interviewee's conceptions of the key messages from the machinima. Categories which appear lower in the hierarchy are indicative of surface or superficial conceptions, while higher categories describe conceptions which appear to reflect deeper understanding and could lead to personal action.

In Category 1 machinima key messages are experienced as basic information and general awareness of weather events, while Category 2 key messages are experienced as simple observation of the discussion of the information and how that information might be used. Category 3 key messages are experienced as prompting potential use of the information to make specific management decisions. Specific decisions related to the harvesting decisions that could be informed by using climate information were mentioned including ‘Using a climate forecast to work out planning of harvesting’ and ‘harvesting wetter blocks early’. However in Category 4 key messages are experienced as extending application of the information to other elements of farm management or planning that were not mentioned specifically within the machinima discussion that was observed by interviewees. The message was about reinforcing use of forecasts and planning across your farming activities. In Category 5, key messages are experienced as drawing general conclusions about management of climate risk. Interviewees were able to draw personal conclusions about the key messages that appeared to demonstrate a higher level of understanding about how information could be used or what the information meant, through formulation of a personal principle or rule of thumb. So comments like ‘Seasonal forecasting is based on probabilities’, and you could ‘plan your cropping and strategic farm management if the season will be wetter’ represent the higher level of self-interpretation expressed within the outcome space.

The most commonly mentioned key messages (Table 4.1) mentioned by interviewees related to ‘decision-making focused on harvesting’ and ‘raising awareness of climate forecasts and predictions’. ‘Planning of farming activities’, ‘discussion between growers to share ideas’ and ‘using forecast tools’ were mentioned several times. The ‘source of climate information’ was mentioned twice as a key message, along with ‘forecast probabilities’ and ‘attitude to risk’. The key message described by one farmer was ‘planning and decisions about farming activities, cutting blocks early or late, rotation of blocks’. Two extension officer comments included ‘discussion of decisions’ and ‘using a climate forecasts for harvesting planning’.

Table 4.1: Key message themes with frequency of mention by interviewees.

Key message themes	Frequency of mention
Decision-making, particularly focused on harvesting	10
Raising awareness of forecasts and predictions	9
Planning	5
Using forecast tools	4
Discussion between growers to share ideas	4
Source of climate information	2
Forecast probabilities	2
Attitude to risk	2
Pretty basic message	1

4.4.2 Appeal of machinima as a tool to convey messages to farmers

Interviewees were asked to describe the appeal of the machinima as a tool to convey messages to farmers and comments were later coded into good/neutral/improve (Table 4.2). Many interviewees indicated that the machinima format was an appealing way to convey messages to farmers. Interviewees across all three stakeholder groups made comments about the machinima having the potential to generate discussion in farmer group situations with one farmer suggesting the format had 'high value' and one extension officer saying 'I'd like to see it tested'. Over twice as many comments could be characterised as good (28) compared to those that suggested improvement was needed to make the format palatable to farmers (12) (Table 4.2). The comment indicating the most negative response to the machinima came from a Canegrowers Organisation representative who suggested that the product was 'not appealing at all, as farmers relate more to real people than animations'. Comments that were categorised as neutral (8) or suggestions for improvement included several suggesting that there would be a 'mixed reaction' from viewers and that the reaction would depend on the demographic of the viewer (e.g. young/old, computer literate or not, climate savvy or not).

Table 4.2: Interviewee comment categories, counts and quotes across stakeholder groups for appeal of machinima as a tool to convey messages.

Comment Category	Comment Count	Interviewee Quotes
Good	28	**Farmers:** 'Very real, a good way of doing it'; 'Good tool for prompting and helping a discussion and opening a discussion up'; 'It gives an opportunity for questions to be asked in a discussion'; 'High value'; 'It will promote discussion, that is the strong point'. **Extension Officers:** 'Excellent to use at a workshop or shed meeting to get discussion going'; 'It has capacity to create interaction and discussion'; 'I'd like to see it tested'. **Canegrowers Organisation:** 'Very innovative'; 'With increasing costs and climate change this information needs to be made available to growers to support their decision-making'; 'I'm passionate about it'; 'Run by someone in a group, quite effective in the context of a group discussion'.
Neutral	8	**Farmers:** 'There might be a mixed reaction in a shed meeting, from some saying it's a joke to others saying it's useful'; 'Could be part of a package leading up to the start of the season'. **Extension:** 'You'll get a mixed reaction'; 'More appeal for use by extension officers to take out and use it with growers, one-on-one or in groups'; 'It's more appropriate now to a normal group of farmers and less appropriate for more informed growers'.
Improve	12	**Farmers:** 'Older growers won't look at it on a computer'; 'Younger growers are more up to speed so you don't want to talk down to them'; 'Need other discussions related to forecasts, especially extremes of wet or dry'; 'you need more meat [in message] to promote a robust discussion'. **Extension:** 'If the characters flowed and moved more naturally, that would enhance the visual experience'; 'For a more knowledgeable audience, incorporate an expert character into the video'; 'If changes were made, its usefulness for creating discussion and information transfer would improve and value would go up'. **Canegrowers Organisation:** 'For individual growers, not as effective'; 'Younger growers will not need this prompting'; 'It's not appealing at all as farmers would relate more to real people than animations'.

4.4.3 Quantitative rating of machinima

Interviewees were asked to reflect on viewing the video and the feedback they gave, and to rate (on a scale of 1-10) the value of machinima in supporting canefarmers to take some action, small or large, in relation to the information presented in the video (Table 4.3). The low range rating provided by the Canegrowers Organisation representative related to the use of animated farmer characters rather than real actors or real farmers in the product. The mid-range ratings provided by three of the farmers related to the simple nature of the messages in the animated avatar discussion. For some of the interviewees, their knowledge of climate impacts and use of seasonal forecasting information was more advanced and this appeared to have impacted on their rating, as nothing new or relevant for them was portrayed in the machinima.

Table 4.3: Statistical analysis of interviewee ratings of the value of machinima in supporting cane farmers to take some action, small or large, in relation to information presented in the product (Rating scale 1-10).

Interviewee Group	Mean	SD	Range
Farmers	6.9	1.4	5 - 9
Extension Officers	7.2	0.75	6.5 - 8
Canegrowers Organisation	6.4	2.3	3 - 8

4.5 Discussion

The use of machinima developed in a virtual world platform and fully immersive virtual world experiences which support learning, or facilitate different methods of communication, are providing new opportunities to engage with target audiences. As distinct from real time experiences in immersive virtual world platforms which allow individuals to become characters that navigate and interact with and within a created digital environment, machinima, by their design, are intended to be viewed in a format that is similar to a YouTube video, animation, or other created digital media (Fosk 2011). Machinima provide a capacity to create three dimensional simulation and/or visualisation scenarios which depict personal relationships, situations or activities designed to influence target audiences (Middleton & Mather 2008). Both mediums can support group discussion processes, the first by interaction with characters in the virtual world as an avatar, the second by observing avatar interaction and reflecting on the meaning derived from that interaction.

4.5.1 Potential benefits of using machinima

The predominance of positive comments, particularly by the farmers and extension officers interviewed in this study, suggest that machinima may support existing extension activities by promoting and supporting discussion and facilitating group interaction in farmer meetings and workshops. The results suggest that the machinima are likely to prompt questions and may provide extension officers with another mode of innovative engagement within the communication and extension programs they conduct with farmers. The product is therefore likely to be useful in supporting social and collaborative learning within the targeted farmer groups.

Phillips (2015) outlines the comparative advantages of machinima by linking their value to the benefits of social learning, experiential learning and agricultural extension processes. Lim (2009) further proposes an explicit learning framework in relation to the specific use of Second Life™ and associated products like machinima. This framework can link directly with curricular development activities or extension program development to shape the way in which the technology is employed and led by the learning objectives and the needs of the target learning group. The framework focuses on the nature of learning and is articulated as learning by exploring, collaborating, being, building, championing and expressing. The framework can guide educators in determining the appropriateness of content and delivery mechanisms for the particular learning objectives concerned (Lim 2009).

Compared to other video production and animation formats, machinima provide a cost effective alternative allowing creative visual scenarios to be developed for a range of educative purposes (Butler 2012; Mushtaq et al. 2017). The relative cost per canegrower as an information communication opportunity for machinima production is AU$9 similar to Climate Clips videos, and compared to AU$4 for DVDs, AU$10 for virtual bus tours and AU$120 for bus trips and field days (Mushtaq et al. 2017).

Butler (2012) also argues that development of machinima can become a longer-term sustainable resource which can be deployed and used for several years in a range of educative contexts relevant to the learner group for which they were developed. Machinima are clearly seen as an animated product and in contrast to video productions using actors or actual industry representatives, may not become dated to the same degree and therefore can have a longer useable lifespan. Machinima can also be cost effectively and relatively easily revised and re-contextualised for different target audiences (Mushtaq et al. 2017).

4.5.2 Potential barriers to use of machinima

Several areas of improvement were identified by interviewees which are likely to influence the success or otherwise of machinima as a useful product to support farmer learning and engagement. The unevenness in the visual experience identified by several interviewees highlights the expectations that viewers have of their video, television or cinematic experience. Exposure to other visual media from YouTube videos, television, interactive computer gaming environments and extending to animated cartoon shows, movies or advertisements that people are regularly exposed to currently are invariably of high quality and future machinima need to match this quality to meet viewer expectations if possible. More significantly, interviewees identified that the underlying informational content and messages should be of a higher value which could develop more interest, provide novel information or advice, and promote more robust discussion in a group. Balancing the informational content in the machinima with the level of understanding in a group could be challenging as some group members may have limited understanding, while others have a highly developed knowledge of the subject matter. A staged or incremental increase in complexity of the information within each machinima developed, where there is a message of some sort for all potential viewers, may resolve this issue.

While machinima in this study were produced within Second Life™, and consist of avatars choreographed and scripted artificially to interact in a farm setting, the potential exists in the future for farmers to actively engage in a virtual world to adopt their own avatar characters. Interaction within this environment would allow farmers and other industry experts to meet, discuss and learn about issues relevant to their business in real time without leaving their farms. While older farmers today may be unlikely to adopt this mode of communication, younger farmers who have been brought up in a highly connected digital world, and are familiar with online gaming environments, may be more receptive to virtual worlds as meeting places and active discussion and learning environments. Indeed Wang (2014) describes facilitation of university student groups by other students within Second Life^{TM} and proposes a range of recommendations for facilitators to maximise successful application of the use of this technological approach including adequate planning and use of co-facilitation techniques. The research concluded that, with further emergence of on-line and virtual learning environments, educators and those responsible for facilitating learning in groups need to prepare for the particular challenges that facilitation in virtual rather than physical environments presents. Additionally Wang (2014) suggests that, with increasing global connectivity, training students to become facilitators in the virtual world will be critical.

Further challenges to the use of full immersion as a character in Second Life^{TM} are highlighted by Sanchez (2009), who suggests that the orientation to understand the construction of the avatar character and building of and access to the environment is a greater barrier to users who may be less engaged with technologies than those who have a natural inclination to work in a virtual environment. This transactional barrier, where there is an investment required in spending the time to understand and join the environment before engaging directly with it, may act in favour of machinima as the communication medium. Machinima allow the learner to play the role of a consumer of the product rather than needing to develop the skills to join and navigate within the virtual environment. Mamo et al. (2011) also identified difficulties students faced in using and navigating in Second Life^{TM}. Their research concluded that the virtual learning environment could be improved by developing objects or simulations which users could interact with, or by producing avatars that appeared as experts in the topic areas being explored in the scenarios to better support student learning.

4.5.3 Potential Implications for learning

The results from this study demonstrate the value of using a phenomenographic approach to collecting and analysing these data. In particular, the structure that becomes apparent following identification of the categories of description provides a valuable insight into the variation in the ways that interviewees identified their understanding of key messages from viewing the machinima. Categories 1 (key messages seen as ‘Basic information and general awareness of weather events’) and 2 (key messages seen as ‘Observation of the discussion of information and how that information might be used’) appear to indicate a relatively low level of interpretation of the key message with referencing of simple descriptions of information or describing the social setting and conversation that was displayed in the machinima. At a slightly higher level (i.e. Category 3), interviewees commented on the specific management decisions that were referred to in the machinima and therefore were able to make direct connections to farm management decisions. At a further higher level, Category 4 responses show a deeper level of interpretation with comments which extended application of the content beyond the material that was covered or mentioned explicitly in the machinima. Within the highest category, Category 5, conclusions were drawn which are suggestive of a deeper understanding of the implications and meaning of the information covered in the machinima. Categories 4 and 5 point to the development of thinking beyond the narrative script delivered in the machinima and learnings which are outside of the bounds within which the script was constructed. These unintended positive learning outcomes suggest that machinima have an, as yet, relatively untapped potential as a novel tool to support individual, social and collaborative learning settings.

4.6 Conclusion

Machinima can elicit a range of constructive conceptions in relation to the research phenomena and particularly related to the informational objectives of the script developed for avatar characters. Viewers identified simple messages from the machinima narrative along with deeper conceptions where viewers assimilated machinima content into their broader understanding of decision-making and business management in the sugarcane industry indicating learning beyond the boundaries within which the machinima script was developed. The generally positive results obtained by trialling the prototype machinima in this research provides a basis to further develop machinima and expand their use to a more formal workshop situation. Responding to the suggestions for improvement by interviewees, particularly concerning increasing the visual appeal of the machinima to match the visual experience obtained in other digital media, and by ensuring the informational content matches farmer expectations, will also improve the product and increase the likelihood of its use within extension programs. This will allow more detailed evaluation of the capacity of machinima to support learning and group discussion in situations where farmers are exposed to the product in a live extension environment.

The exposure of machinima in this study to individuals rather than groups of farmers represents a limitation in this study. Concluding that this communication medium will support facilitation of discussion and learning may therefore be premature. However, there appears to be enough generally positive evidence to support further development and trialling of the technology with canefarmer groups.

5 Stepping out into the abyss, using machinima with farmer groups

This Chapter outlines the third phase of research conducted in this project. After initial evaluation of the prototype machinima was conducted (Chapter 4), a further four customised machinima were developed (Reardon-Smith et al. 2014; Reardon-Smith et al. 2015) for testing in a series of Managing for Climate Risk workshops (See Chapter 3) (Cliffe et al. 2016) with a modified process. Within these workshops, the machinima were used to replace the traditional small group discussion element of the workshop. Workshop participants were surveyed before, during and immediately following workshop delivery. Data from the final survey is analysed in this chapter using developmental phenomenography as a research approach to developing an understanding of the variation in farmer experience of managing climate risk following small group discussion and the influence of the machinima on small group discussion.

The chapter is constructed in journal article format consistent with preparation for future journal publication targeting the journal 'Weather, Climate and Society'.

The key research questions addressed in this chapter include:

RQ3 How do Australian canefarmers conceptualise managing climate risk following machinima facilitated small group discussion?; and

RQ4 How do Australian canefarmers conceptualise the influence of customised machinima on small group discussions?

Title: Machinima facilitated discussion of climate risk in farmer workshops: An analysis of farmer conceptions of managing and discussing climate risk.

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5.1 Abstract

Purpose: This paper documents and evaluates the use of customised machinima to facilitate farmer small group discussions to develop insights and understanding of (1) farmer conceptions of managing climate risk following group discussion; and (2) farmer conceptions of the influence of machinima on small group discussion.

Methodology: Developmental phenomenography is used to analyse survey data collected from ninety farmers immediately following participation in a Managing for Climate Risk workshop. Structural relationships between categories of description are illustrated in outcome spaces for each research question along with the dimensions of variation within themes of expanding awareness.

Findings: Customised machinima used as discussion support tools positively impact on farmer group discussion and consideration of climate risk management. The application of developmental phenomenography as a research approach provided a deeper understanding of how farmers understand, apply and aspire to use climate risk information in their businesses. This research approach can be applied as an evaluation method to describe the variation in experience of learning in a group.

Practical Implications: Farmer's increased self-awareness of their capacity limitations provide opportunities for educational interventions and improved communication methods to address knowledge and skill deficiencies. Though more resource intensive, as a methodological approach, developmental phenomenography has potential as a program evaluation tool to use where understanding variation in learning is an important research objective.

Originality/Value: This paper contributes a novel example of the use of customised machinima as a discussion support tool in a developed world context to support farmer discussion of climate risk management. Further, the paper applies principles of developmental phenomenography in an agriculture sector context which are otherwise rare in the research literature.

Key words

Group discussion, Machinima, Developmental phenomenography, Climate risk management, Self-efficacy

5.2 Introduction

The decline in support for farmers, across the developed and developing world, from traditional communication and extension services is challenging the agriculture sector capacity to remain competitive and resilient in the face of a diverse range of environmental, economic and societal challenges (McCown 2001; Warner 2006; Rist et al. 2007; Rivera 2008; Leach 2011; Hunt et al. 2012). Climate change impacts, financial drivers which threaten economic viability and increasing community expectations which demand demonstrable, environmentally sustainable practices are conspiring factors which add to the complexity of farm management in the new millennium (Cobon et al. 2009; Raymond & Robinson 2013). Concurrent with the decline in extension services and increase in complexity of dealing with challenging issues, participatory processes using principles of experiential, social and collaborative learning as their foundation, appear to be generally diminishing. Private providers and agribusiness have become more involved in targeted service delivery and have filled some gaps (Stone 2011), where traditional extension services have been depleted or removed entirely. Novel solutions which harness the increasing capacity of digital technologies may assist in addressing the communication gap that exists between farmers and service providers and could facilitate useful discussion and conversations to support individual learning and build skills and capacity.

This paper reports results from a phenomenographic analysis of qualitative survey data from farmer workshops where a novel discussion support tool, a customised machinima video animation, is used to facilitate group discussion and individual learning to support improved climate risk management. Facilitated group discussions can form an integral part of learning processes which aim to stimulate reflection, harness ideas and capture contributed wisdom from the lived experience and alternative perspectives of people in the groups concerned (Ellis et al. 2004). Supporting group discussion in agriculture has traditionally been the domain of extension agents or agricultural consultants from the public sector and increasingly from private sector providers and consultants who charge farmers fees for services (Marsh & Pannell 2000; Stone 2011).

However, support for publicly funded extension services is diminishing in many situations in the developed world (Warner 2006; Leach 2011; Vanclay & Leach 2011; Hunt et al. 2012; Labarthe & Laurent 2013) while its overall effectiveness in terms of return on investment has also been challenged in the developing world (Umali-Deininger 1997; Benson & Jafry 2013). Concurrent with these changes in the extension services landscape, there are differences between farmers in their willingness and capacity to pay for private sector support from consultants, particularly where their economic circumstances are challenging (Umali-Deininger 1997; Rivera et al. 2002; Feder et al. 2011; Benson & Jafry 2013). These issues suggest that alternative communication approaches may be required to fill or augment the gap that exists between farmer's demand for information and extension service's organisational ability to provide services. Indeed Benson & Jafry (2013) suggest that the range of different extension service providers, whether they be public, private, or from non-government organisations, need to converge and work together to respond adequately, efficiently and cost-effectively to address the needs of farming communities and societal expectations more broadly. The need for convergence in service provision is also particularly relevant in the current agricultural environment where farmers are challenged by higher societal pressures to improve environmental responsibility by reducing or entirely negating, nutrient, chemical or sediment pollution of waterways (Blackstock et al. 2010; Fazey et al. 2013) and operating in an increasingly variable and changing climate system due to the impacts of climate change (McCrum et al. 2009; Crane et al. 2011; Tall et al. 2014).

The benefits of social, cooperative and collaborative learning through group discussion to support individual learning and decision-making are well documented (Brookfield & Preskill 2005; Johnson & Johnson 2009; Pollock et al. 2011; Van Blankenstein et al. 2011; Kyndt et al. 2013; Barrett 2014). Meta-analyses of small group learning in the education sector have reported positive outcomes for student performance, when compared to individual learning (Lou et al. 2001), and more positive attitudes to learning generally (Springer et al. 1999). Studies of face-to-face and online discussions have also suggested that students who believe discussions will assist their understanding and learning are more predisposed to use face-to-face discussion as a way to deepen their understanding of a particular topic than students who place less value on discussion (Ellis et al. 2004; Goodyear & Zenios 2007; Bliuc et al. 2010). Furthermore, when comparing face-to-face with online discussions during critical thinking tasks, one or two initial face-to-face sessions, where students can brainstorm, negotiate and share opinions and ideas spontaneously, appear to be advantageous before moving to an online discussion format (Guiller et al. 2008). Ellis et al. (2004) also found that the experience of learning through discussion has a positive correlation with student performance.

In the agriculture sector, farmer discussion groups are commonly used to discuss relevant issues which tackle technical and agronomic challenges, and to support learning about new technology or farm business management (Hennessy & Heanue 2012; Murphy 2012; Smith et al. 2012; Barrett 2014; Anil et al. 2015). In particular, discussion groups support social and experiential learning which encourages adoption of best practice and new technologies by farmers (Hennessy & Heanue 2012) and builds social capital to enhance individual and group learning (Sobels et al. 2001). While technology and other forms of adoption in the agriculture sector are dependent on a wide range of personal, social, cultural and economic variables (Pannell et al. 2006), facilitating farmer opportunities to interact with each other in social networks to build social capital is recognised as an important factor in raising awareness and disseminating information (Prokopy et al. 2008). Indeed, Knowler & Bradshaw (2007) conclude that social capital is a universally significant factor in influencing adoption in agriculture. Therefore, continued development of strategies to build social capital and facilitate interaction and group discussion which support individual and group learning are likely to remain important for the agriculture extension discipline. If deployed appropriately, these strategies should continue to contribute to more profitable, productive and environmentally sustainable farm enterprises into the future.

Traditional agriculture extension activities including field days and workshops are widely acknowledged to successfully facilitate peer interaction, support learning and build skills and capacity both in the developing and developed world (Davis et al. 2012; Waddington et al. 2014). However, their cost relative to other communication approaches can be significant and their reach in terms of adequately covering targeted client groups is almost invariably limited. Additionally, selection bias may see particular sections of a farmer group demographic taking advantage of extension activities at the expense of other farmers who may choose not to participate (Hennessy & Heanue 2012). Furthermore, smaller but still productive farms may be disadvantaged by not being actively engaged by extension providers, public or private (Labarthe & Laurent 2013). Alternatives which take advantage of new technological platforms are therefore needed to augment and improve communication and learning opportunities which have the potential and capacity to reach all farmers across the agriculture sector.

Support for the use of novel digital media solutions to the challenges of engagement between stakeholders are particularly relevant in the farming sector and are based largely on relatively recent technological improvements which have improved access to and uptake of digital technologies (Diem et al. 2011). The proliferation of social media and Smart Apps allows farmers access to useful information and tools that was not possible even a decade ago and can play an important role in delivering agricultural information (Aker 2011). The use of a virtual world digital platform to develop a customised machinima animation which supports farmer learning and discussion about climate risk management has potential to deliver an inexpensive, cost effective, communication tool to support extension and communication activities (Mushtaq et al. 2017). While field days remain amongst the most popular delivery mechanism by which farmers in many regions collect relevant information for their businesses (Anil et al. 2015), machinima produced in the virtual world of Second Life^{TM} provide a cost effective complementary extension medium to more traditional, resource intensive modes of communication used in the agriculture sector (Easdown & Starasts 2004; Stone et al. 2012b; Mushtaq et al. 2017). Although this research specifically targets management of climate risk in agriculture, the approach has potential application across the spectrum of topics of interest to farmers, as well as communication and education across other industry sectors.

The objective of this research is to test four machinima in the context of a Managing for Climate Risk workshop (See Chapter 3) (Cliffe et al. 2016) to assess their capacity to facilitate productive discussions, in workshop settings, about managing climate risk and to influence the way participants in those discussions consider managing climate risk. Managing climate risk is an important aspect of farm management and is becoming more important with the challenge of global climate change (Traore et al. 2015). Participative workshops which foster interaction and support discussion are widely used to improve understanding of climate information and promote use of seasonal climate forecasts (Cliffe et al. 1999; Clewett et al. 2000; Jagtap et al. 2002; Nelson et al. 2002; George et al. 2006; Peterson et al. 2010; Roncoli et al. 2011). Machinima interventions which were developed to stimulate thinking and group discussion may replicate some of the beneficial elements of discussion that occur in traditional participative workshop processes (See Chapter 3) (Cliffe et al. 2016).

A developmental phenomenographic approach is used in this research to provide a methodological framework which supports turning research findings into practical outcomes. The research results will be used to develop recommendations for improvements to the way in which climate risk information is conveyed to farmers and the extension processes used to engage farmers in collaborative learning activities. The improved understanding of farmer's relationship to the phenomena under study derived from the research results allows refinement and improvement of existing and future communication and engagement strategies to be developed rather than contributing solely to an improved theoretical perspective of the research problem. Brookfield & Preskill (2005) suggest that 'discussion is an infinitely varied and multifaceted reality experienced by students in multiple ways' and that methods of evaluating discussion should be conducted through processes which allow self-reporting to develop meaningful conclusions. Phenomenographic analysis focuses on data collected from respondents through a range of qualitative techniques, predominantly interviews, but survey data can also be used.

The developmental phenomenographic approach (Bowden & Green 2005) adopted in this research is used to investigate farmer conceptions of managing and discussing climate risk described in qualitative survey data collected immediately following a Managing for Climate Risk workshop (See Chapter 3) (Cliffe et al. 2016). The research objectives of phenomenographic analyses are to develop insights into the variation in ways that people experience a phenomenon (Marton & Booth 1997) within a sampled group at a particular point in time. These insights can then be used to develop theoretical understanding and practices which can be applied more generally within the broader population of interest. Phenomenography has been widely applied as a research approach in the education, health science and business sectors. However, examples of its application in the agriculture sector appear to be very rare. In reviews of phenomenographic research studies, which included over two hundred papers and articles, no examples of the approach being used with farmers in an agricultural context were documented (Bruce et al. 2011; Harris 2011). Beyond these reviews, two research papers from Finland studying conceptions of fifteen rural entrepreneurs about interaction with researchers, six of whom engaged in at least some primary production activity (Iivonen et al. 2011) and knowledge conceptions of thirty-two horticulture entrepreneurs (Levander 1999), appear to be amongst the few phenomenographic studies which relate to an agriculture context.

This research study represents a unique example of the use of a developmental phenomenographic research approach to analyse the variation in experience of farmer knowledge, understanding and skills related to management of climate risk and their experience of discussing climate risk issues with their peers using machinima as a stimulus to group discussion. The key research questions investigated in this study include:

1. How do Australian sugarcane farmers conceptualise managing climate risk following small group discussion?; and
2. How do Australian sugarcane farmers conceptualise the influence of customised machinima on small group discussions?

5.3 Methodology

A series of five Managing for Climate Risk workshops was conducted across a diverse range of sugarcane growing regions in Australia in January and February 2015. Workshop locations extended from the wet tropics in far northern Queensland (Gordonvale and Tully) through Central Queensland (Proserpine and Mackay) to the Southern Queensland sugarcane growing region (Childers) (Figure 5.1).

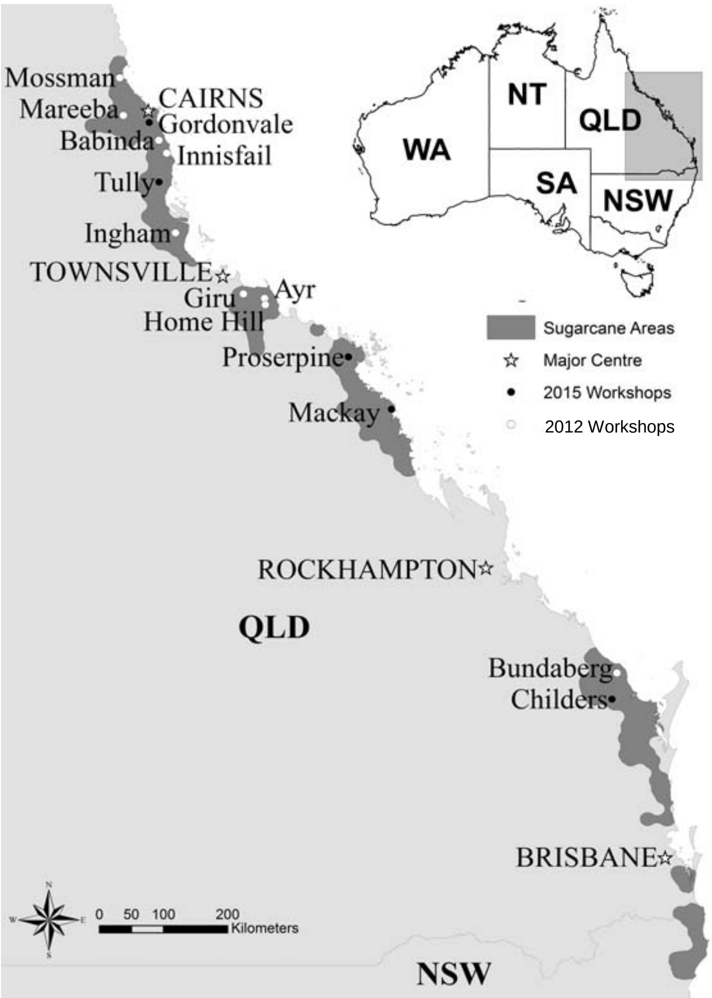

Figure 5.1: Managing for Climate Risk workshops conducted across Australian sugarcane growing regions in 2012 and 2015.

Workshops conducted in 2012 reported in Chapter 3 are also included in Figure 5.1 for comparative purposes. The geographical distribution of workshop locations provided a wide range of climatic conditions and diversity in farm enterprises. The workshops were attended by one hundred and thirteen (113) participants who were drawn from several regional farming groups. Of the workshop participants, all of whom completed workshop surveys (Appendix D), ninety (90) identified as sugarcane farmers; the survey data for this group is analysed and reported in this paper. Table 5.1 outlines the demographic attributes of the surveyed farmer group.

Table 5.1: Climate workshop farmer participant demographic information: gender, region, age bracket and self-rated skill in using computers and digital technologies.

Attribute	Demographic details
Gender	Female 11% Male 89%
Region: Workshop location and participant numbers ( )	Far North Queensland: Gordonvale (22), Tully (11) Central: Proserpine (22), Mackay (22) Bundaberg: Childers (13)
Age Bracket	65^+ yrs – 14.4% (Wise elders; born pre - 1946) 50-64 yrs – 47.8% (Baby boomers; born 1946 - 1963) 40-49 yrs – 18.9% (Hippie babies; born 1964 - 1972) 33-39 yrs – 12.2% (Gen X; born 1973 - 1980) 22-32 yrs – 6.7% (Gen Y; born 1981 - 1990)
Self-rated skill in using computers and digital technologies	Advanced 14.3% Intermediate 38.1% Basic 40.5% Nil 7.1%

Almost 38% of respondents were under 50 years of age, while 48% of survey respondents could be classified as baby boomers (50-64 years). The workshop age distribution of older respondents over 65 years (14%) was lower than would be expected compared to the agriculture sector across Australia (23%) and fewer female farmers were represented (11%) compared to the national proportion of 28% (ABS 2012). Anecdotally, through personal observation, there appear to be generally fewer women involved in the sugarcane industry who would identify as farmers.

The Managing for Climate Risk workshops were delivered within the context of a training model extension project approach (Coutts et al. 2011a) where workshop objectives included building farmer understanding and skills to manage climate risk. The detailed workshop process described in Chapter 3 (Cliffe et al. 2016) was used as a framework to include a machinima facilitated group discussion instead of the traditional facilitator led group discussion and to subsequently collect and analyse farmer conceptions of the machinima and their impact on group discussion and perceived management of climate risk. Four different machinima were developed for use in the workshops focusing on different elements of farm management and incorporating elements of climate forecast information (USQ Digital Futures (CRN), 2015). The machinima topic areas included irrigation (USQ Digital Futures CRN, 2014c), nutrient (USQ Digital Futures CRN, 2014a) and harvesting (USQ Digital Futures CRN, 2014b) management and an avatar family discussion of decisions about general farm planning (USQ Digital Futures CRN, 2014d). The traditional facilitated group discussion section used in these workshops was replaced with a section that included viewing, discussing and recording key points raised in each of the four different machinima that farmer groups were exposed to. The machinima were projected on a large screen through a data projector connected to a laptop computer. External speakers were used to amplify the machinima soundtrack. The detailed steps in this section included:

1. A brief introduction to each machinima stating "We'd like to present a short video where farm management issues are being discussed. After viewing the video we'd like you to discuss the key messages or issues that the video raised for you."
2. The irrigation management machinima was played first.
3. At the completion of playing the irrigation management machinima, groups were invited to discuss the 'Key messages or issues the video highlighted for you…', with the statement projected on screen during the group discussion.
4. Groups were asked to record the key points from their discussion on butcher's paper.
5. Group discussion was allowed to progress for approximately 7–10 minutes, but was stopped earlier if groups had finished.
6. Individual groups reported on the key points or issues they had discussed to the larger workshop group in a plenary session.

7. A second, third and fourth cycle of steps 1-6 (with minor variations to avoid repetition) was used for viewing and group discussion of the nutrient management, harvesting management and planning machinima.

The only exception to the above process was removal of the irrigation machinima for the two workshops conducted in the wet tropics (Gordonvale and Tully), where irrigation is not commonly used as part of the farm management system in that region. Following the viewing of the machinima and the group discussion session, groups were separately asked to discuss and specifically evaluate the videos (machinima) by recording their strengths, weaknesses and any other comments.

Data collection from individual workshop participants consisted of three concise written surveys. These surveys were completed at different times in the workshop process:

1. At the beginning of the workshop (to capture current self-identified ratings of knowledge, skills and aspirations to use climate forecasting information and current use of seasonal climate forecasts);
2. Mid-way through the workshop, after presentation of information about climate drivers and climate forecasting and individual workbook exercises had been completed (to capture gains in ratings of self-identified knowledge, skills and likelihood of using climate forecasting information in the future); and
3. At the end of the workshop (to capture gains in ratings of self-identified knowledge, skills and likelihood of using climate forecasting information in the future, demographic information and specific research questions related to conceptions of managing climate risk and the machinima facilitated group discussion session).

The data reported in this paper include responses to the following questions from Survey 3:

- Regarding the small group discussion of climate risk and farm management decisions, how did this session impact on your thinking about managing climate risk?

- In what ways did the video animation influence the discussions in your group?

5.3.1 Phenomenographic research process

Phenomenographic data analysis processes (McCosker et al. 2004; Akerlind 2005b) were used to analyse survey responses from workshop participants to develop an understanding of the variation in farmer conceptions of the phenomena of, firstly, managing climate risk following group discussion and, secondly, of machinima facilitated group discussion. An iterative seven step analysis process, modified from McCosker et al. (2004), included:

1. Familiarisation with the survey responses by reading and re-reading survey respondent data;
2. Comparing survey responses;
3. Grouping survey responses;
4. Articulating categories of description as they emerged from the data;
5. Labelling categories;
6. Contrasting categories to define the essential meanings respondents expressed about each phenomenon and dismissing categories which were not related to the study phenomena; and
7. Identifying dimensions of variation across categories of description, within themes of expanding awareness to further describe and understand research respondent conceptions of the phenomena.

Following emergence of the categories of description, the structural relationship between them is described in an outcome space which is illustrated diagrammatically in an inclusive hierarchy. Data is expressed both in the researcher's interpretation of the voice of research participants in the survey data and in quotes from individuals which represent meaning related to categories of description (Bowden & Green 2010). Themes of expanding awareness within which dimensions of variation are described further help to explain the range of understandings of the phenomena that exist within the group of research subjects (Akerlind 2005a; Akerlind 2005b). The dimensions of variation describe elements of the phenomena that are related across the categories of description but display some variability across each category. This internal relationship between the dimensions of variation across categories of description also represents what is known as the internal horizon within a phenomenographic analysis. Further, the themes of expanding awareness then describe the external horizon which is related to how limits of each particular phenomenon can be specified within the research (Marton et al. 1993). The detailed descriptions of themes of expanding awareness and dimensions of variation provide a deeper understanding of the phenomena under study. This process can potentially identify areas of practical intervention to improve capacity development or communication processes, and highlights the benefit of using developmental phenomenography as a methodology.

Ensuring there is clarity around the methodological variation in the application of the phenomenographic approaches used by researchers is identified by Åkerlind (2012) as an important consideration. Elements of methodological variation that require elucidation to ensure academic rigour is maintained throughout the research process, particularly related to how data is analysed, include:

- The amount of each transcript considered (from small excerpts to whole transcripts). In this study, which uses workshop survey data rather than interview transcripts, comments collected were by their nature concise and therefore all individual response data provided by farmer participants was considered in developing categories of description and constructing an outcome space.
- Varying emphasis on collaborative development of the outcome space (from individual researchers to research teams). In this study, an individual researcher independently developed categories of description and consequent outcome spaces.
- Strategies to manage the data. In this study, there is a focus on describing themes of expanding awareness and the dimensions of variation which have emerged and are related within the outcome space.
- Varying ways of developing a logical structure to connect different meanings. In this study the outcome space emerges from the data, but there is explicit acknowledgement that the researcher's interpretation is influenced by his/her experience with the subject matter (Åkerlind 2012).

By ensuring a consistent approach to treatment of the data and its analysis there is a higher likelihood that the resulting conceptions and description of their relationship can be faithfully represented in the categories of description that emerge. This approach will then support the development of a relevant outcome space, themes of expanding awareness and dimensions of variation.

5.4 Results

5.4.1 Farmer conceptions of managing climate risk following group discussion

The four categories of description which emerged from analysis of the respondent data can be connected logically within an outcome space in an inclusive hierarchy (Figure 5.2). Direct farmer quotes from the survey data are used to illustrate categories within the outcome space. The categories of description for managing climate risk emerging following group discussion reflect an impact which begins at a higher, through to a more basic level. Within Category 1, managing climate risk following small group discussion is seen as using climate information in planning and farm management decision-making. The category emerged as farmers linking climate information directly to use in decision-making and planning activities in their business following the group discussion activity at the workshop. Farmers were further able to identify specific management decisions that would benefit from the use of climate forecasts. Within Category 2, managing climate risk following small group discussion is seen as aspiring to understand and use climate information in decision-making. Group discussion appears to have inspired expressions of interest in further improving understanding of climate information and learning how to use the information in decision-making. Farmers expressed a desire and aspiration to proactively seek out information and use climate forecasts.

Category 1. Managing climate risk following small group discussion is seen as using climate information in planning and farm management decision-making

'Using climate information to make decisions'; 'Use seasonal forecasting to evaluate capital expenditure items, fertiliser and irrigation timing and harvesting/planting operations'; 'Plan ahead with the best information'

Category 2. Managing climate risk following small group discussion is seen as aspiring to understand and use climate information in decision-making

'Made me more eager to use forecasting tools to schedule inputs on farm'; 'I will be checking and learning more about the climate for making farm management decisions'

Category 3. Managing climate risk following small group discussion is seen as developing an increased knowledge and awareness of climate risk issues

'Made more aware of climate variability'; 'Makes me more aware of the potential to manage risk'; 'Learnt about new tools to use'

Category 4. Managing climate risk following small group discussion is seen as reinforcing traditional and current practices

'Just reinforced what I am doing'; 'Supports decisions currently made'; 'Confirmed my thinking'

Figure 5.2: Outcome space describing farmer experience of managing climate risk following small group discussion, including representative quotes from farmers.

Within Category 3, managing climate risk following small group discussion is seen as developing an increased knowledge and awareness of climate risk issues emerging as farmer's knowledge and awareness of climate risk issues that impact on their farm management increase following group discussion. There was a greater awareness of climate variability and the potential value of tools which may help to manage climate risk, but without an apparent explicit commitment to use the information or tools. Within Category 4, managing climate risk following small group discussion is seen as reinforcing traditional and current practices, where farmer management of climate risk was based on traditional knowledge and practice. Group discussion appears to have reinforced whatever is recognised as traditional practice without indications that improvement to management should be made or is even necessary.

Dimensions of variation within four themes of expanding awareness (Table 5.2) were also identified within this outcome space; these further describe the structural details and relationship between the categories of description identified above. The four themes concern Climate risk management (***CRM***), Knowledge and understanding of climate risk management (***K***), Influence on decision-making (***INF***) and the Impact of group discussion on farmer conceptions of management of climate risk (***IMP***). By delving deeper into themes of expanding awareness and dimensions of variation, it is possible to further elaborate on meanings expressed by survey respondents and participants in the workshop farmer group discussions.

Table 5.2: Dimensions of variation and themes of expanding awareness for 'Managing climate risk following small group discussion'.

Categories of Description	**1 Using climate information in planning and farm management decision-making**	**2 Aspiring to better understand and use climate information in decision-making**	**3 Developing an increased knowledge and awareness of climate risk issues**	**4 Reinforcing traditional and current practices**
Themes of Exp. Awareness (Ext. Horizon)	**Dimensions of Variation (Internal Horizon)**			
Climate risk management (CRM)	***CRM1 Proactive use of climate information to manage climate risk*** #	***CRM2 Expressing confidence to apply climate information in future climate risk management*** #	***CRM3 Acknowledging gaps in knowledge base which when addressed might support improved climate risk management*** #	CRM4 Relying on prior experience and local knowledge to manage climate risk
Knowledge and understanding of climate information (K)	***K1 Comprehensive, with self-identified capacity to access and connect climate information to specific management decisions and planning contexts*** #	K2 Moderate, with self-identified desire to learn more about and apply climate information	K3 Moderate to low, with self-recognition that improved understanding of climate information might be of value	***K4 Unchanged, with current understanding of climate information guiding management practice*** #
Influence on decision-making (INF)	***INF1 Improved understanding leading to more confidence to make decisions using climate information*** #	***INF2 Improved level of confidence to learn more about climate information and apply it to decisions in the future*** #	INF3 Increased awareness of the potential application of climate information to management decisions	INF4 Decision-making is unchanged or supports current decision-making frameworks
Impact of group discussion (IMP)	***IMP1 Enhanced understanding and use of climate information*** #	***IMP2 Enhanced aspirations to understand and use climate information*** #	***IMP3 Enhanced awareness of current knowledge and understanding of climate info.#***	***IMP4 Limited impact in changing understanding, knowledge or practice*** #

Referred to in Results and/or Discussion section

Within the 'Climate risk management' (***CRM***) theme, dimension ***CRM1*** described proactive use of climate information in managing climate risks and ***CRM2*** describes a confidence to learn about and apply information in the future, connected to the aspirational use of climate information in decision-making. ***CRM3*** describes a self-identified deficiency in knowledge which might support improving climate risk management.

Knowledge and understanding of climate information (***K***) emerged as having increasing self-capacity to access climate information and relate it contextually to farm management and planning in ***K1*** through a continuum where knowledge was largely unchanged, beyond the current understanding that already existed in farmer's minds, in dimension ***K4***.

An increase in confidence to make decisions using climate risk information and learn about climate information for future application purposes also emerged from the 'Influence on decision-making' (***INF***) theme, within both dimensions ***INF1*** and ***INF2***.

The dimensions of variation across the 'Impact of group discussion' (***IMP***) theme indicate that the group discussion enhanced understanding and use of climate information, enhanced aspirations to understand and use climate information and enhanced awareness of current knowledge and understanding of climate information within dimensions ***IMP1***, ***IMP2*** and ***IMP3*** respectively. However dimension ***IM4*** emerged as the impact of group discussion having limited impact in changing understanding, knowledge or practice.

5.4.2 Farmer conceptions of machinima facilitated group discussion

Four categories of description emerged from respondent data describing an outcome space for farmer conceptions of machinima facilitated group discussion. Figure 5.3 illustrates an outcome space describing a continuum from a higher level of complexity of conceptions of the machinima facilitated discussion, to the machinima having no significant impact.

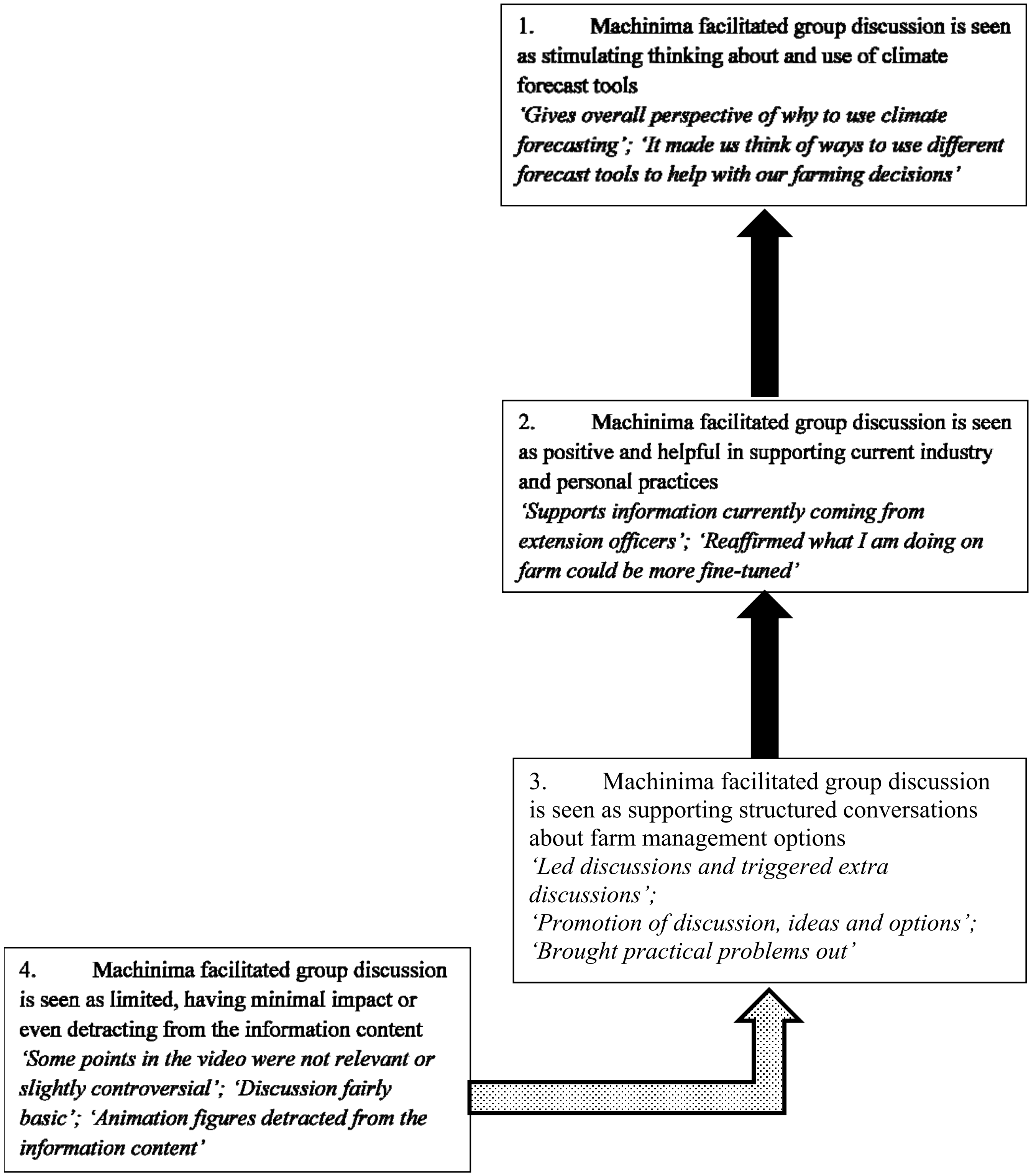

Figure 5.3: Outcome Space describing farmers' experience of machinima facilitated group discussion including representative farmer quotes.

Within category 1 machinima facilitated group discussion conceptions emerged as potentially leading to actions relating to the use of climate forecast tools and information and stimulating potential decision-making through using and applying climate information. Within category 2 machinima facilitated group discussion conceptions emerged as helping to support and reinforce current recommended industry and personal practices. Within category 3 machinima facilitated group discussion conceptions emerged as supporting structured conversations about farm management options. Within category 4 machinima facilitated group discussion conceptions emerged as having limited impact.

In Figure 5.3 a partially shaded arrow links category 4 to category 3 to represent that the experience of some farmers indicates that the machinima facilitated discussion had little positive or productive influence on the discussion. The outcome space remains structurally inclusive of all four categories and a hierarchy remains defined between Categories 4 through to 1. Direct farmer quotes from the survey data are used to illustrate categories within the outcome space.

Dimensions of variation within three themes of expanding awareness were identified within the outcome space (Table 5.3), which describe the structural details and relationship between the categories of description. The three themes concern the impact of the group discussion on farmers involved in the discussion (***I***), prompting potential use of climate or other information shared during the group discussion (***P***) and how group discussion linked climate forecasts to farm management options (***L***).

Table 5.3: Dimensions of variation and themes of expanding awareness for 'Farmer experience of machinima facilitated group discussion'.

Categories of Description	**1 Stimulating thinking about and use of climate forecast tools**	**2 Machinima facilitated group discussion is seen as positive and helpful in supporting current industry and personal practices**	**3 Supporting structured conversations about farm management options**	**4 Limited, having no impact or detracting from discussion**
Themes of Expanding Awareness (External Horizon)	**Dimensions of Variation (Internal Horizon)**			
Impact on discussants (I)	***I1 High with self-identified challenges to thinking about and using climate forecast information*** #	***I2 High with positive references to discussion and confirming current farm management practices*** #	***I3 High with discussion triggering structured conversations about farm management ideas and options*** #	***I4 Limited, neutral or no impact*** #
Prompting potential use of climate information (P)	***P1 Direct references made to discussion supporting future use of climate information*** #	***P2 Use of climate information is connected to current extension advice and industry practice*** #	***P3 None, with the focus entirely on aspects of general farm management practice*** #	***P4 No linkage to use of climate information in farm management*** #
Linkage to use of climate forecasts in decision-making (L)	***L1 Direct references made to farm management decision-making*** #	***L2 Direct references made to farm management decision-making*** #	***L3 Direct references made to farm management decision-making*** #	***L4 No linkages to the use of climate information in farm management*** #
# ***Referred to in Results and/or Discussion sections***				

The ‘Impact on discussants’ theme was high for three of the four dimensions (***I1***, ***I2*** and ***I3***) with increasing complexity in the way in which the impact related to categories of description. At the highest level this was characterised by challenging conventional thinking, through confirming appropriate management practices and triggering useful conversations about farm management. However, for the fourth group, the impact of discussion experienced emerged as having limited, neutral or no impact (***I4***).

Direct references were made to the discussion supporting future use of climate forecast information within the ‘Prompting potential use of climate information’ theme (***P1***). Use of climate information connected to current extension advice and industry practice (***P2***) indicated that extension services play an important role in conveying information to farmers. References were also made to aspects of general farm management that are not solely related to management decisions connected to managing climate risk (***P3***). At the lowest level no linkages were made for the use of climate information in farm management (***P4***).

Given the development of the machinima script focused on climate risk management, it is unsurprising that within the theme of ‘Linkage to use of climate forecasts in decision-making’, direct references are made to farm management decision-making across three of the four dimensions for this theme (***L1***, ***L2*** and ***L3***). No linkages to climate information are made within ***L4***.

5.5 Discussion

Phenomenographic analysis of conceptions of managing and discussing climate risk using customised machinima as a discussion support stimulus has provided a deeper understanding of the variation in farmer experience of managing impacts of climate variability and their experience of machinima facilitated group discussion.

5.5.1 Farmer's experience of managing climate risk following group discussion

Developing an understanding of farmer conceptions of managing climate risk immediately following group discussion provided an insight into their capacity to deal with a variable and changing climate. In particular, this study has discovered aspects of the variation in the awareness, knowledge, skills and potential use of climate information within this group which allows a deeper evaluation of the range of experience of these canefarmers. This phenomenographic analysis has provided an idealised representation of the range of possible ways (Åkerlind 2005) that the phenomenon of managing climate risk following group discussion in this group exists within the broader canefarmer population. Farmer conceptions have emerged through this analysis in such a way as to provide a triangulating source of evaluation material. The analysis develops an understanding of the different levels of understanding of what farmers are considering following exposure to a workshop learning process and where managing climate risk is discussed in small groups.

Expressions emerging from the analysis which indicated farmers are aspiring to understand and use information to improve their climate risk management (***CRM***) indicate an increasing level of self-confidence about the tools and information that are being learnt about and discussed in small groups. This result complements and confirms other research that listening and learning within farmer group discussions contributes to increasing confidence about a particular topic or management practice (David 2007; McGuire et al. 2013). Additionally, self-acknowledged gaps in knowledge which emerged from dimension ***CRM3*** suggest that farmers may possess a self-awareness to understand where they are deficient in an area of understanding or are not accessing potentially useful tools, and that there is now a potential opportunity to address that deficiency. Both these elements of increasing confidence and self-awareness contribute to the improved perceived self-efficacy (Bandura 1977, Bandura 1993; Chiaburu & Marinova 2005; Shen et al. 2013) that farmers will need to possess as climate variability and climate change challenges continue to impact on their farm management and livelihoods (Eakin et al. 2015).

Three of the four dimensions of variations within the ‘Knowledge and understanding of climate information’ theme indicated that farmers’ describe a perceived high self-capacity (***K1***), the desire to learn (***K2***) and a recognition of the potential value of climate information (***K3***). This result provides encouragement for the climate science community to proactively engage and collaborate with the farming community to support their learning and understanding of climate information and its applications. The spectrum of self-efficacy and self-awareness expressed by farmers within this group suggests that a proportion of the farmer population are ready and likely to be receptive to the delivery of climate information and open to the potential benefit it might bring to their management system. The incorporation of farmer knowledge and understanding links to the increasing confidence to make decisions using climate information expressed in two of the four dimensions of variation within the ‘Influence on decision-making’ theme (***INF1*** and ***INF2***). The self-confidence elements inherent within these themes also supports the potential collaboration and engagement that could be made between farmers and climate science educators and scientists.

The ‘Impact on group discussion’ theme highlighted the value of discussion in supporting potential and aspirational use of climate information and also the knowledge and understanding that is relevant to the subject (***IMP1*** – ***IMP3***). This result supports the knowledge construction and critical thinking aspects that can flow from face to face discussion processes that has been identified in other studies (Joiner & Jones 2003; Ellis et al. 2006; Guiller et al. 2008; Bliuc et al. 2010). Farmers tend to trust the knowledge and experience of other farmers and this provides an incentive to join with other farmers in either formal discussion groups, or to be engaged through extension activities where facilitated discussion is a key element. Two key reasons to join discussion groups provided by farmers have included the exchange of ideas that occurs within the group process and the benefits and enjoyment that comes from the social interaction that occurs (Barrett 2014). However for some in the research group in this study the group discussion was conceived of as having had a limited impact on changing knowledge or practice (***IMP4***). This result suggests that for some, the discussion made only minimal or little contribution to their consideration of managing climate risk.

The categories of description which form a structurally logical and parsimonious outcome space (Figure 5.2) and the dimensions of variation in this study can be related directly to project evaluation logical frameworks used in agriculture extension. In particular the results of this study complement and support the evaluation criteria found in Bennett's Hierarchy (Bennett 1975; Rockwell & Bennett 2004; Roberts & Coutts 2011), where measuring changes in knowledge, skills and aspirations are significant objectives within this theoretical program and project evaluation framework. Use of phenomenographic analysis as a research approach may therefore provide another prism through which to understand and evaluate how capacity is being improved and adoption of new technology and tools is progressing in farming populations. For example, an outcome space, themes of awareness and dimensions of variation that emerge from a different phenomenographic study of farmer conceptions of a phenomenon may be limited in their sophistication in terms of what would be expected following delivery of an extension program of some kind. Appropriate interventions may then be designed which lead to modifications in delivery of future programs to achieve the intended capacity building or adoption results that are required.

5.5.2 Farmer's experience of machinima facilitated group discussion

Developing an understanding of farmer conceptions of machinima facilitated group discussion has provided an insight into the way in which tools such as machinima impact on the conversations held in small groups and how those discussions are linked to thinking about and using climate information. The categories of description and outcome space which emerged from this study illustrate a range of experience of the phenomenon from having a limited impact on discussion through to stimulating thinking about and use of climate forecast tools. The group discussion is also seen as positive and helpful, with the machinima providing a structure around which a conversation about farm management options can occur, with or without reference to climate risk.

The high impact on participants in the discussions identified within this study described within three of the dimensions of variation (***I1***;***I2*** & ***I3***), appear to demonstrate the value of the use of the machinima as discussion support tools and confirm the value of discussion itself in building knowledge and supporting critical thinking. The discussion appeared to challenge farmer thinking about and use of climate forecast information and was seen as positive in confirming current management practices and in triggering a structured conversation.

However, for the fourth dimension of variation (***I4***), the impact of discussion had limited, neutral or no impact. This result may reflect the different personalities and preferred learning styles of individuals within the discussion groups. Learning styles play an important role in both social and academic learning settings (Kyprianidou et al. 2012). For example, Kolb's experiential learning framework suggests individuals have different preferences for processing and perceiving information (Kolb 1984) and, if these preferences are neglected within the context of the learning environment that is facilitated, the quality of their learning experience may be diminished (Kolb & Kolb 2005). Some individuals may lack the social skills which allow them to feel at ease in a group discussion situation (Ellis et al. 2009), while others have a perception that their performance is in some way being judged and therefore feel threatened by the process. Findings from studies in other sectors indicate that previous educational experience and socio-cultural barriers can also exist in peer groups, acting to inhibit learning, particularly where participants are wary of exposing themselves to the judgement of their peers (Platzer et al. 2000). These barriers may have led to the experience, for some participants, of discussion having limited impact, no impact or even detracting from the activity.

Direct references were made to the discussion supporting future use of climate forecast information within the 'Prompting potential use of climate information' theme (***P1***). The machinima facilitated discussion therefore appears to have supported conceptions within the group which would promote future use of climate information. The design of the machinima with informational messages directed at focusing the discussion on elements of on-farm climate risk management was able to contribute to influencing the intentions of discussants. Connection of the use of climate information to current extension advice (***P2***) is not a surprising result. However, it reinforces the need to ensure that extension advisors are fully engaged in understanding and appropriately delivering climate information and associated forecast messages to farmers (Cliffe et al. 2016).

References made to aspects of general farm management that are not solely related to decisions connected to climate risk (***P3***) suggest that the machinima stimulated a more holistic consideration of farming risk. Although management of climate risk was the primary objective within the original design of the machinima script, the tool was able to elicit broader conceptions than those that might have been intended. Furthermore, this result is consistent with conceptions of key informational messages which were collected during trialling of the prototype machinima. That analysis (Chapter 4) identified that viewers of the machinima identified other management activities and business elements unrelated to the machinima script and key messages that were developed within it. The final dimension identified no linkage to the use of climate information in farm management (***P4***) suggesting that some in the group would not be prompted to use the information. This conception is likely to be linked to underlying scepticism and distrust about the use and value of forecast information or an underlying lack of understanding of the strengths and limitations of using climate information (Stone & Meinke 2006; Mase & Prokopy 2013). Overcoming the distrust and scepticism that exists in the advisory and farmer community will be challenging. However it is likely to be possible as seasonal forecasts become more reliable and understanding in the farmer community about interpreting probabilistic information improves.

Farmers were able to make direct references to specific farm management decisions within three of the four dimensions of variation when linking use of climate information to decisions (***L1***; ***L2*** & ***L3***). This result endorses the value of the machinima facilitated discussion process where the machinima was structured to guide and focus discussion around climate risk and a management decision. At the lowest category of description and lowest dimension of variation, no linkage with climate information is described (***L4***).

The outcome space and nine of the twelve dimensions of variation for farmer experience of machinima facilitated group discussion reflect the overall positive impact of the use of the machinima as a discussion support tool in this study. At the very least, the use of machinima did no more harm than might be expected when individuals might be uneasy or feel overwhelmed in any other group discussion environment. The outcomes suggest that machinima have a positive role to play in supporting and focusing discussion as an extension tool.

5.5.3 Limitations of this research.

While this study provides unique insights into Australian sugarcane farmer's conceptions of management of climate risk following group discussion and machinima facilitation of that discussion, it is also subject to a number of limitations. Ideally, phenomenographic research processes benefit from a collaborative, team based approach to analysing data to develop categories of description and their associated relationships and themes of expanding awareness (Bowden 2005). As this doctoral research was conducted remotely, by a single researcher, it was impractical to conduct a collaborative analysis process. This limitation was addressed by communicating the research approach and preliminary findings through development and delivery of a range of peer reviewed conference papers, posters and presentations throughout the research journey (Cliffe et al. 2013; Cliffe et al. 2014a; Cliffe et al. 2014b; Cliffe et al. 2014c; Cliffe et al. 2015). This approach allowed a level of critical exposure of the research methodology and 'communicative validity' described and endorsed by Åkerlind (2012). Additionally, as this analysis is one of relatively few reported within an agricultural context, there is scope to further apply developmental phenomenography in other research situations in the agriculture sector and build on the experience this research project has documented.

Further, the self-selected sample of Australian sugarcane farmers who attended the Managing for Climate Risk workshops are not necessarily representative of the farmer population (nor of farmers in general). Additionally, it is likely that farmers who chose to attend the workshops may be more highly motivated and open to new information than others who, for whatever reason, chose not to attend. Higher levels of individual self-efficacy are related to motivation to learn and pre-training motivation (Colquitt et al. 2000; Chiaburu & Marinova 2005), so the farmers who attended may represent a more highly motivated segment of the farmer population. However, no data were collected to develop an understanding of participant motivations in attending the workshop. Notwithstanding the relatively small number of farmers who were part of this study, the generic outcomes described here are likely to have application more broadly across the sugarcane industry in Australia and indeed may extend further across the agriculture sector. The results also indicate that testing machinima in other situations in the agriculture sector, both in developed and developing countries is warranted.

5.6 Conclusion

Customised virtual world machinima, developed as discussion support tools, appear to have a positive impact on the way in which farmers discuss and consider management of climate risk and also on the way in which they consider overall farm management. Farmers expressed a self-awareness of limitations in their knowledge, understanding and skills concerning managing climate risk. The fact that this issue is self-identified by farmers suggests that they may be receptive to educational interventions or appropriate communication methods which address their deficiencies in knowledge, understanding and skills. The ranges that are apparent within dimensions of variations also indicate that there is significant scope for improvements to be made, and appropriate interventions developed, which will support farmers within the population to move from continuing within their current practice to actively use climate forecasting in their decision-making processes. Furthermore, participation in discussion can actively support use of climate information in decision-making.

The use of developmental phenomenography as a research approach to assist in evaluation of agricultural extension programs and activities is a novel concept and provides a depth of understanding of issues concerning learning and application of knowledge that other more conventional evaluation methods might not provide. However, phenomenographic analysis is more resource intensive, particularly in the time required to collect and analyse responses, and may therefore be impractical to apply in some circumstances.

Developing appropriate tools and communication approaches, including further refinement of machinima used in this research provide avenues for further research, development and implementation in the agriculture extension and education field. Successfully deploying these tools and approaches is likely to lead to improved use of climate information in decision-making, improved climate risk management at the business and industry scale and increase the resilience of the agriculture sector to future climate shocks.

5.7 Acknowledgements

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Mr Peter Davis, ICACS, USQ, produced the map in Figure 5.1.

6 But what do canefarmers really think about managing and discussing climate risk?

This chapter outlines the fourth and final phase of research conducted in this project. The chapter was prepared for and presented as a peer reviewed conference paper accepted for oral presentation and published in proceedings of the European Association for Research into Learning and Instruction Junior Researcher (EARLI - JURE) conference in Limassol, Cyprus, 23-24th August, 2015.

After attending Managing for Climate Risk workshops conducted in January and February 2015, 22 farmer participants were interviewed to collect and analyse their conceptions of managing and discussing climate risk. Principles of developmental phenomenography were applied in the research approach to analyse semi-structured interview data. Categories of description within two outcome spaces are described for two key research questions, along with dimensions of variation within themes of expanding awareness.

The chapter is constructed in journal article format consistent with preparation for future journal publication targeting the journal 'Learning and Instruction'.

The key research questions that are addressed in this chapter include:

RQ5 How do Australian canefarmers understand and experience managing climate risk?; and

RQ6 How do Australian canefarmers understand and experience discussing climate risk with other people?

Title: Farmer experiences of managing and discussing climate risk: A phenomenographic study.

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6.1 Abstract

The purpose of this paper is to present results of a phenomenographic study of the variation in farmer experience of managing and discussing climate risk in the weeks following exposure to interactive workshop processes and tools which promote learning and group discussion. Managing climate variability impacts in agriculture remains a significant challenge to farmers globally. Uncertainty about climate change impacts also increases management risk in the agriculture sector. Farmer workshops and discussion groups provide collaborative learning environments where individual learning and skill development can occur and contribute to improving their capacity to manage risk. A ‘discussion support’ tool, created as a virtual world Second Life[TM] animation or machinima was used as a novel approach to support farmer discussion within a Managing for Climate Risk workshop process. An investigation of farmer experience in managing and discussing climate risk was conducted using a developmental phenomenographic approach and semi-structured interviews of 22 Australian sugarcane farmers. Dual outcome spaces emerged from the interview dataset which describe the structural variation in farmer’s experience of managing and discussing climate risk. The variation, identified as categories of description within the outcome space for farmer management of climate risk, identified inclusive extrinsic and intrinsic categories and an aspirational category described as ‘improving knowledge and likely future use of climate information’. The outcome space for farmer discussion of climate risk described variation in a linear hierarchy from weather as a priority topic of conversation, through promoting personal understanding, to prompting personal action to source and use climate information. The results of this research have application to the broader agriculture sector and may provide cost-effective alternative communication media in a sector where clients are widely dispersed, traditional extension services are diminishing and digital technologies are improving. The connection between the results obtained in this study to practical implications and considerations for further research, communication, or implementation processes indicate the strength of developmental phenomenography as a qualitative research approach.

Keywords

Developmental phenomenography, Social learning, Agricultural climate risk, Small group discussion.

6.2 Theoretical background

Learning to manage climate variability and climate change impacts is a major issue for the agriculture sector internationally where maintaining and improving productivity to boost sustainable food production is important as global population continues to grow (Wheeler & von Braun 2013). However, on individual farms, climate risk is only one element in a complex business environment which competes for management attention (Crane et al. 2010). Addressing the challenges and opportunities presented by improving climate risk management and understanding of climate forecasts and climate change remains a challenge for science educators and communicators (Pidgeon & Fischhoff 2011).

Workshops which support farmer reflection about current practice and promote interactive discussion of climate risk management issues have successfully supported farmer learning in the past (George et al. 2006; Cliffe et al. 2016). Collaborative, participatory and social learning experiences which foster collaboration between farmers, advisers and scientists can also lead to significant improvements in farmer capacity to manage risk and uncertainty (Warner 2006). Opportunities for learning through formal and informal collaboration in agriculture have historically been high in many countries. However, declining funding and policy support for agriculture extension services in developed countries, with trends towards service privatisation (Leach 2011; Hunt et al. 2012), appear to have produced a more challenging environment to conduct productive farmer group activities and collaborative stakeholder interaction to improve understanding, promote learning, and increase adoption of new tools, techniques and technologies.

Advances in computing and systems modelling have led to development of numerous decision support tools in agriculture which provide answers to particular problems using complex biophysical modelling of many different variables, including climate (Hochman et al. 2009). However over the years, their broad adoption by farmers has been limited (McCown et al. 2009). Few have been developed explicitly to support group discussion which could incorporate farmer knowledge into solutions (Nelson et al. 2002). Improvements in computing technologies and digital communications, including increasing global access to high speed internet, provide environments for development of new information delivery platforms to support farmer discussion and learning.

In this project, virtual world Second Life^{TM} animations (machinima) were developed as discussion support tools to promote farmer discussion aimed at facilitating learning within farmer groups. Machinima design and script development focused on managing climate risk and adapting to a changing climate in the Australian sugarcane industry. Preliminary data collected from seventeen semi-structured interviews provided proof of concept, with results indicating machinima may have a positive role in communicating to farmers, stimulating discussion and learning in a new and innovative way (See Chapter 4) (Cliffe 2013). Four machinima were then trialled within a Managing for Climate Risk workshop to understand the impact on group discussion and understanding of management of climate risk (See Chapter 5). Communication media which take advantage of novel digital technologies and foster individual, social and collaborative learning through group discussion may provide attractive alternatives which allow farmers to learn about managing climate risk and more efficiently incorporate climate information into their decision-making (Reardon-Smith et al. 2014; Reardon-Smith et al. 2015; Mushtaq et al. 2017).

Developmental phenomenography (Bowden & Green 2005) is applied as a research approach in this study to reveal the depth, detail and complexity of variation in farmer experiences and conceptions of managing and discussing climate risk and the structural relationships between categories of description that are present in this group. A developmental phenomenographic approach, rather than a pure phenomenographic approach (Marton 1986), is used in this study because the research aims to deliver recommendations that will influence the development of climate risk communication and extension processes to better engage farmers in the future. The critical aspects of variation in experiencing the phenomena being studied, along with their structural relationships, are elements of this approach that are attractive to researchers seeking to deliver practical outcomes when compared to other more theoretical approaches.

There appear to be relatively few examples of phenomenographic studies applied in agricultural contexts where farmer conceptions of aspects of their management environment have been studied. A study by Iivonen et al. (2011) focused on identifying and understanding conceptions of entrepreneurial learning within a group of fifteen food processors across different operational scales including six primary producers. Levander (1999) explored the conceptions of knowledge of 32 horticultural entrepreneurs involved in nursery stock and glasshouse production using a phenomenographic approach to understand the knowledge construction process and its implications for extension processes. Given the rarity of examples of the use of phenomenography as a qualitative research approach in the agriculture sector in Australia and internationally, this study provides an opportunity to contribute to filling the gap in the use of this methodology in the literature.

6.3 Research aims

This research investigates tools and processes that may positively influence the communication, delivery and use of climate risk information by farmers. Therefore, understanding the experience of farmers as research subjects, who relate to the phenomenon of managing climate risk on a daily basis and are consumers of climate information, is critical. The objects of study in this research are the relationship between the farmer subjects and the dual phenomena of ‘managing climate risk’ and 'discussing climate risk'. The phenomenon of 'managing climate risk' relates to the personal experience of farmers and their conceptions of what managing climate risk means to them individually, while the phenomenon of 'discussing climate risk' relates to the personal experience of farmers and their conceptions of discussing climate risk with other people. An improved understanding of farmer experience and conceptions of these phenomena will ultimately lead to the better design and delivery of services, information products and decision support tools.

The key research questions addressed in this study include:

- How do Australian canefarmers understand and experience managing climate risk?; and
- How do Australian canefarmers understand and experience discussing climate risk with other people?

6.4 Methodology

Climate risk management workshops have been used as a communication and extension delivery process in Queensland, Australia for over twenty years. These workshops are delivered to the agriculture sector with the objective of improving the resilience of farmers to future climate shocks caused by climate variability or climate change. Workshop process design and implementation principles are underpinned by assumptions that achievement of learning objectives would positively impact on changes in knowledge, understanding, skills and attitudes to the use of climate information to manage climate risk more effectively (Cliffe et al. 2016). The workshop evaluation framework is based on KASA criteria (Rockwell & Bennett 2004) which were incorporated into written pre, mid and post workshop participant evaluation surveys as described in Chapters 3 and 5.

Virtual world animated machinima were trialled as a novel inclusion into these workshops and used to promote discussion and critical thinking about managing climate risk. The machinima depict farmers in backgrounds replicating Australian sugarcane farms. Scripts were developed in which avatar characters discussed farm management issues impacted by climate risk. Four separate machinima were developed which covered a range of farm management situations, portraying farmer characters discussing harvesting, irrigation, nutrient management decisions and a family discussion about farm planning. Workshop participants were exposed to the machinima within facilitated workshop situations, followed by small group discussion in which the machinima and their narrative content were discussed.

Within this research project, five climate risk management workshops were conducted across three geographically and climatically distinct Australian sugarcane industry regions. Of the 113 workshop participants, over 72% identified themselves exclusively as cane farmers, while 24% were aligned to sugarcane industry extension, technical or productivity services. Workshop participants self-nominated to attend the workshops based on invitations extended through third party regional industry representative organisations. These regional Canegrowers Australia organisations marketed the workshop to their farmer members, arranged suitable workshop venues and received registrations independent of the research team. Workshop participants were therefore considered likely to be more interested in weather and climate issues than their peers who did not attend.

Following the Managing for Climate Risk workshops, 22 semi-structured interviews were conducted with a sub-group of workshop participants who were farmers (Interview questionnaire – Appendix E). A purposive sampling approach selected an intentionally diverse group of interviewees using the following criteria:

- Interviewee age (65+; 50–64; 40–49; 33–40; 22–32; < 21);
- Geographic distribution (spread across regions where workshops were conducted);
- Gender (Female; Male);
- Scale of farm business (Small family farm to large corporate farm); and
- Interviewee's quantitative rating (on a scale of 1–10, with 1 being 'Low usefulness' and 10 being 'Very useful') of the 'Usefulness of the machinima in supporting group discussion of climate risk management' derived from responses to a qualitative and quantitative evaluation survey completed by participants at the conclusion of the workshop activities (Ratings provided by the selected interviewees ranged from 4–10).

Principles of developmental phenomenography proposed by Åkerlind (2005) were employed to design the interview questions and collect and analyse data. A semi-structured interview instrument was developed with a series of open questions and a number of prepared prompts to tease out lines of inquiry offered by interviewees. An interview preamble and opening question were always used to contextualise the research project and give the interviewee an opportunity to relax by explaining their farming operations in detail. Two critical questions were asked in every interview:

- What does managing climate risk mean to you?; and
- What is your experience of discussing climate risk with other people?

While these two core questions concerning the phenomena under study were used in all interviews, and questions and prompts concerning the machinima were also used, other questions and prompts were used as required when the interview was losing focus or momentum. Interviewees were invited to offer any further information they perceived as relevant or provide a response to a question that they expected to be asked but were not, before the interview was concluded. Initial interviews were considered as pilot interviews to test the interview instrument to allow fine tuning of questions if required. All interviews were conducted within two weeks of workshop participation and in the majority of cases conducted at the interviewee's farms or homes at a time that was convenient to them. Field notes were collected for each interview noting relevant points about the venue, timing, setting, demeanour of the interviewee and conduct of the interview. Dual digital recordings were made using a tablet and smart phone application.

Interview data analysis was conducted by the primary author rather than as part of a team based analysis process (Åkerlind 2005; Bowden 2005). This approach has limitations, in particular due to relationality issues (Bowden 2005) including the primary author's historical relationship to the phenomenon, the object of study and some of the research subjects, through his professional activity as an agricultural extension adviser who had organised and facilitated many Managing for Climate Risk workshops over the years. However, limited resources precluded adopting a team based approach and the relationality issues are explicitly acknowledged. Indeed, other studies conducted by individual researchers face similar limitations but remain as robust contributions to understanding and explaining variation in learning and understanding in multiple, diverse contextual situations (Lameras et al. 2012; Forster 2015; Khan 2015).

Separate and discrete analyses used the single interview dataset to address the two different but related research questions, beginning with farmer conceptions of managing climate risk, followed by discovering farmer conceptions of discussing climate risk. The process was iterative in nature and was modified from processes described by McCosker et al. (2004) and Sjöström & Dahlgren (2002), where stages of analysis include familiarisation, condensation, comparison, grouping, articulating, labelling and contrasting. Activities involved in the interview transcript analysis included:

- Listening to and transcribing recorded interviews (18 by the author and 4 by an external administration service) *(Familiarise)*
- Re-listening to all interviews to check for transcription accuracy and correcting where required *(Familiarise)*
- Reading individual corrected transcripts *(Familiarise)*
- Re-reading transcripts and relating transcript sections to the objectives of the study *(Condense)*
- Compare sections across the entire dataset *(Compare)*
- Grouping related sections *(Group)*
- Developing draft categories of description for related sections *(Articulate)*
- Assigning section quotes to categories of description *(Label)*
- Re-reading section quotes to check for correct assignment, re-assignment to different categories or removal from the final set *(Label)*
- Review draft categories of description by checking meaning in original transcript sections and amending where required to arrive at a final set of categories *(Contrast)*
- Drafting an outcome space by defining the structural relationship between categories of description *(Contrast)*

Further analysis identified dimensions of variation across the categories of description, within themes of expanding awareness to further describe and understand respondent's conceptions of the phenomena. The dimensions of variation further describe detailed elements of the way that participants experience a phenomena that are related across the categories of description but display some variability across each category. The internal relationship between the dimensions of variation across categories of description represents the internal horizon, while the themes of expanding awareness then describe the external horizon related to how the limits of each particular phenomenon can be specified within the boundaries of the research (Marton et al. 1993).

The outcome space outlining the structural relationships between categories of description, along with the detailed descriptions of themes of expanding awareness and dimensions of variation provide a deeper understanding of the interviewee's experience of the phenomena under study. This process can then identify possible areas of practical intervention which may improve capacity development or communication processes, and highlights the benefit of using developmental phenomenography as a methodology.

6.5 Results

Phenomenographic analysis led to development of two outcome spaces based on categories of description derived from interview data for the objects of study in this research. Dimensions of variation within themes of expanding awareness emerged from the data to provide more detailed descriptions of the variation in farmer experience of managing and discussing climate risk. Farmer quotes and interview transcript numbers are used to provide examples related to categories of description.

6.5.1 Managing climate risk

Seven categories of descriptions which define farmer conceptions and experience of managing climate risk are illustrated as an outcome space in Figure 6.1. Interpretation of the categories of description which emerged from the data in a branched inclusive structure, emerged as aspirational (Asp), extrinsic (Ext) (Branch A) and intrinsic (Int) (Branch B) factors related to the research subjects. The aspirational category is described as farmers experiencing managing climate risk as a future aspiration to be able to improve their knowledge and use of climate information and reflecting on its significance to future business viability (Asp 1).

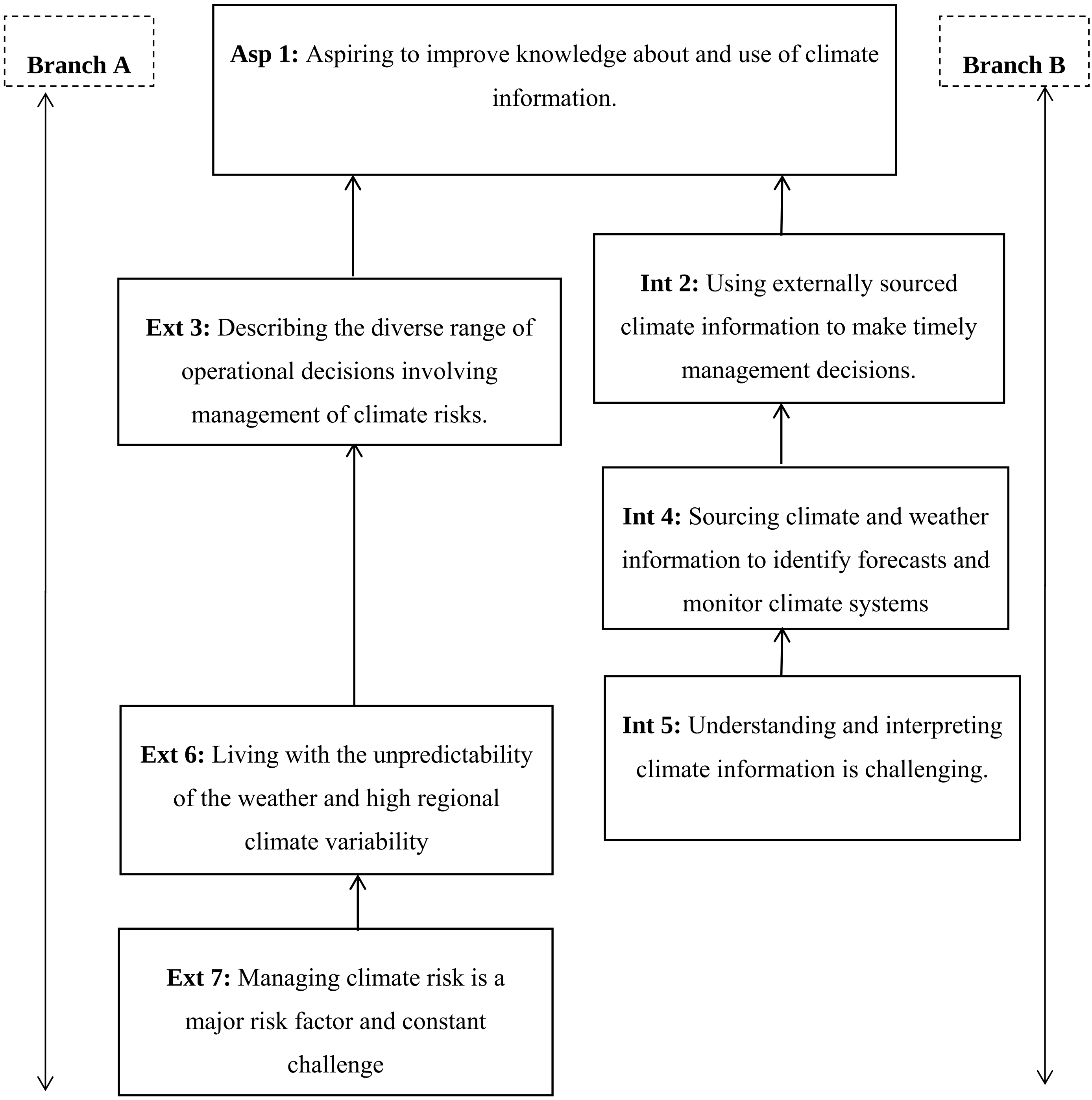

Figure 6.1: Outcome space describing the structural relationship between categories of description of farmer experience of managing climate risk. (Category Key: Asp = Aspirational; Int = Intrinsic; Ext = Extrinsic).

Intrinsic categories are those described as being internal to or within the experience of farmers as they relate to the phenomena of managing climate risk. These include: descriptions of personal use of climate information in decision-making (Int 2); personally sourcing climate information to identify and monitor forecasts and climate systems (Int 4); and personal understanding of climate information being challenging due to its complexity (Int 5). Extrinsic categories are those described as being external to or outside of farmer control as they relate to the phenomenon of managing climate risk. These include: experiencing managing climate risk in terms of describing the range of operational decisions impacted by weather and climate (Ext 3); living with the unpredictability and high variability of weather (Ext 6); and climate risk as a major risk factor that is a daily challenge to manage (Ext 7).

Table 6.1 lists categories of description with associated farmer expressions which illustrate farmer experience of managing climate risk. The interviewee quotes provide representative examples of expressions which support the articulation of their associated categories of description. Table 6.2 describes the detailed final categories of description in addition to interviewee transcript number and transcript page numbers for associated expressions. The number of expressions give an indication of the pool of interviewee data which contributed to development of each category of description. The number of quotations extracted from interviewee transcripts which contributed to each category of description varied. Seven interviewees contributed to the smallest pools of extracted data (Int5; Ext 6). Eighteen interviewee transcripts contributed to the largest pool of extracted data contributing to a category of description (Ext3). The number of quotes contributing to each category of description also varied. The smallest number of quotes from which a category of description emerged was twelve (Ext7). The largest number of quotes from which a category of description emerged was fifty (Ext3). No judgement is made from a phenomenographic perspective about the difference in frequency of quotes or interviewee transcripts that contribute to development of a category of description. Each category of description emerges from robust analysis of the data in such a way as to properly reflect the variation in conceptions that research subjects have in relation to their experience of the phenomena (Bowden & Green 2005).

Table 6.1: Categories of description for farmer experience of managing climate risk and associated examples of farmer expressions (Category Key: Asp = Aspirational; Int = Intrinsic; Ext = Extrinsic).

Category of description	Farmer expression examples (Interviewee transcript number)
Asp1: Aspiring to improve knowledge and use leading to future business viability	'I'd like to continually get better at being able to decipher available information and get better at making decisions.' (3) 'With new computer models of the weather, I hope to get a better understanding looking forward.' (4)
Int 2: Using externally sourced climate information for timely decision-making	'If I want to spray, I've got some weed control to do, I'll monitor wind forecasts.' (10) 'I use the forecast of the 4 day outlook all the time when we're planting, spraying.' (12)
Int 4: Sourcing climate and weather information for monitoring climate systems	'We keep an eye on the El Niño or La Niña forecast.' (8) 'I keep an eye on my sea temperatures and my SOI. Where I was focused before on just two weeks ahead. Now I look at seasonal climate.' (14)
Int 5: Understanding and interpreting climate information is challenging and confusing	'I think, a lot of those climate forecasting tools are involved, complicated.' (17) 'I generally view weather forecasting with some caution all the time, because we've been getting led up the garden path.' (18)
Ext 3: Describing a diverse range of decisions involving climate and weather risks	'Managing climate risk is fertiliser application timing, planting timing and chemical application for sure.' (6) 'Harvesting is the main thing. I schedule harvesting around the risk of wet weather late in the year.' (15)
Ext 6: Living with the unpredictability of weather and high regional variability	'It's the unpredictability of the weather. I think that's going to be around with us for a while yet.' (1) 'Lifestyle is dictated by the weather, which is unfortunate, but that's how it is.' (16)
Ext 7: Managing climate risk as a major risk and representing a constant challenge	'It would be right up there. On a scale of 1–10, between 8 and 10 for sure.' (7) 'You're dealing with climate risk every day.' (9)

Table 6.2: Detailed final categories of description of 'Managing climate risk' with interviewee transcript numbers and associated page numbers.

Category	**Description**	**Interview Transcript No.** (Page Nos.)
Asp1	Managing climate risk is described as aspiring to improve knowledge about and use of climate forecast information. Familiarity with climate and weather should be developed to the same extent as other elements of farm management. Farmer's best interests would be served by improving personal understanding of the weather. The use of climate forecasting information will be a big part of future business viability, with farmers at any scale being able to derive benefits from its use. The impacts of climate change will also need to be considered.	**2**(5,26); **3**(17); **4**(1,2,7,12,13,14,19); **6**(12); **9**(5,7); **11**(14); **12**(6); **14**(7); **15**(25); **17**(4,5,11); **19**(10); **20**(4,9,16); **21**(14); **22**(21-22)
Int2	Managing climate risk is described as using externally sourced climate information to guide and make timely management decisions and reduce risk. Farmer age, experience, local knowledge of climate and weather variability and education level, play an important role in the use of forecast information in manipulating farm inputs and managing risk. Forecast accuracy is improving and there is increasing confidence in using climate forecasts to make management decisions. Better use of climate and weather forecasting results in risk reduction. The value of using forecasts to alleviate climate risk by reducing costs and increasing income is significant.	**2**(8); **3**(19); **4**(2,8,9,11,20); **5**(4,15); **8**(2,4); **9**(8,9); **10**(3,4,6); **11**(5,6,13); **12**(4,5-6,7,11); **13**(3); **14**(6,8,9,10,21); **15**(12,13); **16**(3,6); **17**(3,6,12); **20**(4,8,9,10,13, 14)
Ext3	Managing climate risk is described as a diverse range of operational farm management responses which involve tactical and strategic business decisions, farm planning, supporting management of critical decision points and managing climate extremes. Temporal and spatial factors within farm business operations are an important element of managing climate and weather risks in a farming context.	**1**(8,9,19,21); **2**(3,4,8); **3**(10,12); **5**(4,6,14); **6**(4,5,6,7,9); **8**(2,3,4,5,6); **9**(5,8,9,10); **10**(5,7); **11**(5,9); **12**(3); **13**(2); **14**(6,8); **15**(4,6,10,15,18); **16**(2); **19**(2,18) ; **20**(3,4,5,7); **21**(5,8); **22**(5,8)
Int4	Managing climate risk is described as sourcing climate and weather information from the media and internet to identify forecasts and monitor climate systems. Short term forecasts for weather in the next two weeks have a high priority, compared to forecasts for the longer-term. Multiple information sources can be linked to develop trust in the accuracy of the information. Detailed forecast information informs seasonal rainfall predictions. Linkages to technical experts can provide useful climate updates. Customised regional forecasting services would support information requirements of farmers who are interested in climate and weather information.	**1**(15,17); **2**(5,22,23,24); **3**(14,15); **4**(11); **5**(13-14,26-27); **8**(3); **11**(5,6); **12**(12); **14**(7,16); **15**(12,16); **16**(6); **17**(4); **18**(13); **19**(11,20); **20**(6); **21**(5,6); **22**(5,21)

Int5	Managing climate risk is described as challenging for farmers to understand and interpret due to the complexity of information and conflicting forecast information which can lead to confusion. Forecasting is viewed with caution due to confusion, inaccuracy and lack of regional focus. A gap exists between farmers who use climate forecasting tools and those who do not due to the complexity of the material. Faith in forecasting has been lost due to inaccuracy of forecasts.	**1**(31); **2**(8,9,15,16,29); **4**(9,10); **5**(22); **17**(14); **18**(7,12,13,14); **19**(9)
Ext6	Managing climate risk is described as living with the unpredictability of the weather, the high variability of regional weather patterns and climate extremes. Farmers have to accept and live with the weather conditions they receive and there are limited options to respond to the weather. Farmer lifestyle is dictated by unpredictable weather impacts. Although scepticism about the accuracy of forecasts remains an issue for a proportion of farmers and weather can't be directly controlled, farmers can take responsibility for managing the impacts that result.	**1**(9,20,21); **2**(3,4,28); **4**(7,20); **10**(6); **16**(3,5); **18**(10); **19**(2)
Ext7	Managing climate risk is described as managing a major risk factor in farming which has an impact on the majority of aspects of farm management. Variability in climate and weather are described as major risks which have priority in farm management and which represent a daily challenge in dealing with business risk and are a major determinant of profitability.	**1**(5); **2**(3,28); **4**(1); **7**(2,4); **9**(5); **12**(3); **14**(5,9); **20**(13,14)

Dimensions of variation within three themes of expanding awareness were identified within both branches of the 'Managing climate risk' outcome space (Table 6.3), which further describe the structural details and relationship between the categories of description. Branch A relates to that part of the outcome space including Extrinsic categories of description and the Aspirational category of description. Branch B describes that part of outcome space including the Intrinsic categories of description and also the Aspirational category of description.

Table 6.3 describes Branch A which includes ***Asp1*** and extrinsic categories of description, themes of expanding awareness and dimensions of variation within those themes for managing climate risk:

- The impact on business resilience and viability (***ImpBus***) Theme describes an acknowledgement of the impact of climate variability on business but with no acknowledgement of capacity to respond or prepare for that variability. However, within the higher categories of description, variation is expressed as an ability to identify decisions and the capacity to improve resilience with better knowledge and use of information.

- The variation within the farm management response ***(ManResp)*** Theme acknowledges the importance of climate risk within the lowest category, without identifying capacity to manage that risk. Variation within higher categories describes simply managing and responding to impacts, to more proactively, strategically managing climate risk and suggesting that there will be expansion of opportunities to manage climate risk more effectively in the future.

- Within the potential scope of application of climate information ***(AppScop)*** Theme, variation is described as being very limited or narrow, to wider with application to a diverse range of tactical and strategic management decisions. At the aspirational level, variation is conceived of as having a scope that is very wide and could include applications and responses not used or made currently and include responses to future climate change impacts.

Table 6.3: Themes of expanding awareness and dimensions of variation of 'Managing climate risk' outcome space: Branch A.

Branch A	**Managing climate risk is seen as**			
Categories of Description	**Category Asp 1** Aspiring to improve knowledge and use of climate information	**Category Ext 3** Describing decisions about managing climate risks	**Category Ext 6** Living with the unpredictability of weather and climate variability	**Category Ext 7** Being a major risk factor and constant challenge
Themes of Expanding Awareness (External Horizon)	**Dimensions of Variation (Internal Horizon)**			
Impact on business resilience and viability *(ImpBus)*	Improved knowledge and use will improve resilience and viability	Ability to identify decisions with significant exposure to climate risk which impact on resilience and viability	Recognition of the impact of climate variability on business resilience and viability	Recognition of the impact of climate variability on business resilience and viability
Farm management response *(ManResp)*	The application of climate information in farm management responses will expand further in the future	A diverse range of tactical and strategic farm management responses are possible	Farm management responses are focused on managing impacts rather than in proactive ways	Climate risk is acknowledged as a major management challenge without identifying any significant farm management responses
Potential scope of application of climate information *(AppScop)*	Very wide, including future currently unconsidered applications and possible responses to climate change impacts	Wide with the possibility of impacting on multiple tactical and strategic decisions across the business spectrum	Narrowed to dealing with decisions concerning the impact of climate events as and when they occur	Very limited

Table 6.4 describes Branch B which also includes ***Asp1*** and intrinsic categories of description, themes of expanding awareness and dimensions of variation within those themes for managing climate risk.

Table 6.4: Themes of expanding awareness and dimensions of variation of 'Managing climate risk' outcome space: Branch B.

Branch B	**Managing climate risk is seen as**			
Categories of Description	**Category Asp 1** Aspiring to improve knowledge and use of climate information	**Category Int 2** Using climate information to make timely decisions	**Category Int 4** Sourcing information to identify forecasts and monitor climate systems	**Category Int 5** Challenging because climate information is difficult to understand and interpret
Themes of Expanding Awareness (External Horizon)	**Dimensions of Variation (Internal Horizon)**			
Levels of personal capacity *(PersCap)*	Personal capacity to use climate information should increase to the level of other components of the farm business	Increased personal capacity to source and use climate information when making decisions	Increased personal capacity to access climate information	Personal capacity is limited and the complexity of climate information makes it difficult to understand and interpret
Confidence to address climate risk issues *(Conf)*	Very high, with positive expressions about current and future use of climate information	High and increasing with confidence to make better informed decisions	Low, with suggestions that more customised information is needed to improve confidence	Very low, with perceptions of conflicting forecast information and the lack of understanding eroding confidence
Perception of forecast value *(ForeVal)*	High and improving acknowledging that farmer's at any scale can use forecasts	High and improving with recognition that use of forecasts can reduce costs and increase income	Moderate acknowledging that multiple forecasts can be combined with expert opinion to update climate knowledge	Low with limited faith in the accuracy of forecasts

Variation in levels of personal capacity ***(PersCap)*** is described in the lowest category as low, with the complexity of climate information being a barrier to understanding and interpretation. At higher levels there are increases in capacity to be able to access and use climate information in decision-making and at the aspirational level that capacity to use climate information should increase to the same level as other areas of the farm business. Variation in the confidence to address climate risk issues ***(Conf)*** Theme emerged as a continuum from very low due to conflicting forecast information and difficulty in understanding forecasts eroding confidence, to low with suggestions of more customisation of information to improve confidence in the information. However, high and very high confidence to address climate risk also emerged as expressions of the ability to make better decisions now and in the future. The perception of forecast value ***(ForeVal)*** Theme described variation ranging from low, related to limited faith in forecast value to moderate where multiple forecasts could be combined with expert information to update knowledge. Higher perceptions of value were expressed as recognition that costs could be reduced and income increased by use of forecasts, and that forecasts could be used at a range of scales and situations.

6.5.2 Discussing climate risk

Six categories of description which define farmer conceptions and experience of discussing managing climate risk are illustrated as an outcome space in Figure 6.2. Categories of description emerged in an inclusive linear structure, where at its highest level, farmers are prompted to take personal action to source and use climate information (**C1**). At the next level farmer’s personal management capacity and personal actions and plans are confirmed through discussion with their peers (**C2**). In category **C3** the experience of discussing climate risk improved farmer understanding to support better management. The positive influence of advisors or other farmers as sources of advice is reflected in **C4**. A level of scepticism and lack of confidence in forecast accuracy (**C5**) would appear to undermine the potential use of climate information, notwithstanding that weather and its impact is a priority topic of conversation amongst farmers (**C6**).

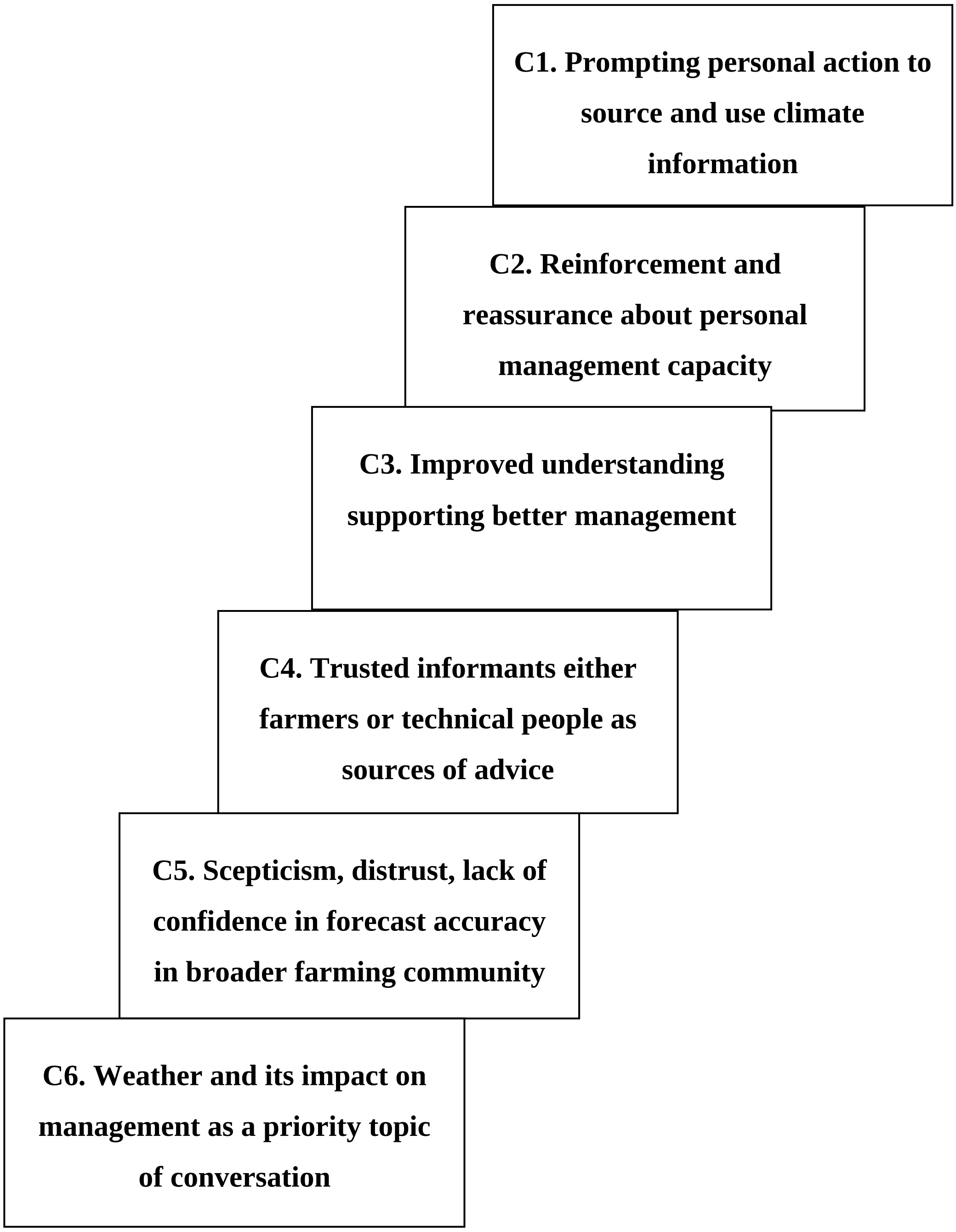

Figure 6.2: Outcome space describing the structural relationship between categories of description of farmer experience of discussing climate risk.

Table 6.5 lists categories of description with associated farmer expressions which illustrate farmers' direct experience of discussing climate risk. As in Section 6.5.1 above, the interviewee quotes provide representative examples of expressions which support the articulation of their associated categories of description.

Table 6.5: Categories of description for farmer experience of discussing climate risk and associated examples of farmer expressions.

Category of description	Farmer expression (Interviewee number)
C1: Action to source and use climate information	'I like to listen to the knowledge they're relaying but I also like to know where their getting their knowledge from so I can go there as well.' (3) 'I discuss with other farmers how important it is to focus on climate risks, rather than things that aren't going to actually make profit, compared to managing your climate, against your farming practices'. (7) 'Our group found that what was discussed was what we would have been discussing ourselves as well. So it really confirmed the plan that we would have been doing in those circumstances.' (15)
C2: Reinforcement and reassurance about personal capacity	'Everyone's got their own opinion and ya sort of collaborate them all and ya can come to some sort of conclusion.' (8) 'We can interpret some signs on websites on our own…, but if you get a group together and look at it, everyone's got a different take on it and you all come to a consensus at the end of it and usually, it ends up pretty right. Because everyone can discuss it you know.' (14) 'From a personal point of view, I think the fact that they're in the same situation as I am, makes me feel, not alone, a bit more confident.' (19)
C3: Improved understanding supporting better management	'Going forward, looking into better ways of managing, getting an idea of what the weather might be ya know further on down the track and that sort of thing.' (4) 'It becomes general knowledge when you are talking amongst yourselves because a lot of it had to do with the SOI. I can distinctly remember that the SOI was looking bad and that we had a prolonged dry period.' (5)
C4: Trusted informants as sources of advice	'Farmers have always been the weather predictors. People in the town ask us, so most farmers have knowledge, whether it's just traditional knowledge or getting into this stuff a bit more.' (11) 'I ring up and he keeps an eye on the weather, most farmers ask him anyway, he looks at it and he'll tell ya.' (16)
C5: Scepticism about forecast accuracy	'Well we're all basically the same. We're all dealing with the weather. We all say, if only you knew what the weather was going to do.'(4) 'I think I pick that up when I discuss, from other farmers. I don't think I'm alone in that scepticism or that distrust.' (19)
C6: Weather as a priority topic	'You talk to anyone on the priority to anyone on the land and it's the weather.' (1) 'That's my first topic of conversation always. Look, it's a big influence on our business.' (6) 'Farmers always talk about the weather, everyone's talking about, ya know the big floods and all that sort of thing.' (12)

Detailed final categories of description are listed in Table 6.6, along with interview transcript numbers and transcript page numbers for associated expressions. The number of expressions give an indication of the pool of interviewee data which contributed to development of each category of description. The number of quotations extracted from interviewee transcripts which contributed to each category of description varied. Two interviewees contributed to the smallest pool of extracted data (C5). Twelve interviewee transcripts contributed to the largest pool of extracted data contributing to a category of description (C2). The number of quotes contributing to each category of description also varied. The smallest number of quotes from which a category of description emerged was three (C5). The largest number of quotes from which a category of description emerged was sixteen (C2).

Table 6.6: Detailed final categories of description for 'Discussing climate risk'.

Category	Description	Transcript No. (Page Nos.)
C1	Discussing managing climate risk with peers stimulates action to source and use climate information to identify options and source information which allows strategies to be employed on farm. Discussion can confirm plans which have been developed, actions that have been taken and prompt personal action.	**1**(19-20); **3**(21); **5**(16,17,18,20); **7**(4); **12**(4); **15**(15,21); **16**(8)
C2	Discussing managing climate risk with peers combines the wisdom of experienced farmers with forecast information to draw personal conclusions. Listening to and evaluating peer perspectives can reinforce personal thinking and provide comfort and reassurance for individuals about their own management capacity. Bouncing ideas off others is a good thing, allowing individuals to take what is useful and discard what is not.	**1**(21); **3**(19-20,20); **5**(18); **6**(7,8); **8**(7); **10**(8); **13**(5); **14**(17,17); **15**(19,20); **16**(7); **18**(9); **19**(16)
C3	Discussing managing climate risk with peers improves understanding of the science and general knowledge about climate forecasting. Discussion of specific climate patterns and learning from past experiences supports management of future climate events.	**4**(16-17,18,19); **5**(7); **12**(7)
C4	Discussing managing climate risk with peers leads to development of confidence in other farmers or technical people whose knowledge and experience in climate risk management and climate forecasts is more highly valued than others. Experienced farmers act as local consultants regarding regional climate impacts.	**3**(20); **6**(13); **16**(8); **18**(10); **22**(15)
C5	Discussing managing climate risk with peers identified that there is general scepticism, distrust and a lack of confidence about the accuracy and value of weather and climate forecasting amongst the wider farmer community.	**4**(16); **19**(13,14)
C6	Discussing managing climate risk with peers is a common topic of conversation amongst farmers and includes sharing information about weather events that have occurred and are likely to be coming. Weather conditions, especially rainfall and its impact on crop growth and management, is often an opening subject of conversation and a priority topic for discussion.	**1**(34); **2**(11); **6**(10); **11**(15); **12**(7); **18**(9); **21**(15)

Dimensions of variation within three themes of expanding awareness were identified within the ‘Discussing climate risk’ outcome space (Table 6.7), which further describe the structural details and relationship between the categories of description. The three themes concern the impact of the group discussion on farmers involved in the discussion, in terms of supporting action and decision-making (***SUP***), the confidence farmers have to manage climate risk (***CON***) and the positive influence of the discussion (***POS***). Where discussion supports action and decision-making a key affect appears to be the enhancement to personal understanding that is derived from talking about climate risk with peers and other informants. The improvements to understanding then appear to better equip farmers to take action, whether it be to make a farm management decision incorporating climate information or prompting sourcing some information from a trusted peer, expert, or other source. The latter two themes describe a linear ranking of confidence and positive influence which suggests that where conceptions have both emerged as high to very high, that farmers are more likely to link discussion to take some action which may include accessing advice from others or directly incorporating information into decision-making.

Table 6.7: Themes of expanding awareness and dimensions of variation 'Discussing climate risk' outcome space.

	Discussing climate risk is seen as					
Categories of Description	**C1** Prompting personal action to source and use climate information	**C2** Reinforcement and reassurance about personal management capacity	**C3** Improved understanding supporting better management	**C4** Trusted informants, farmers or others as sources of advice	**C5** Identifying scepticism, distrust, lack of confidence in forecast accuracy	**C6** A Priority topic of conversation, focused on weather and its impact on management
Themes of Expanding Awareness (External Horizon)	**Dimensions of Variation (Internal Horizon)**					
Supporting action and decision-making (***SUP***)	Improved ability to assimilate understanding supports decision-making	Discussion with peers improves understanding and leads to better decision-making	Recognition of the importance of weather and climate provides opportunities to improve understanding to support decision-making	Trusted peers and other key contacts are accessed for advice without a clear link to action.	Negative perceptions of forecast accuracy inhibits use in decision-making	Though impacts of weather are commonly discussed, limited power to mitigate impacts is identified
Confidence in managing climate risk (***CON***)	Very high	High	Moderate	Low	Low	Low
Positive influence of discussion (***POS***)	Very high	High	Moderate	Minor	Low	Low

6.6 Discussion

Results from farmer conceptions of managing climate risk emerged as a hierarchical series of categories of description, intrinsic (internal to the experience and control of farmers), extrinsic (external to, or outside the control of farmers) and at the highest level, aspirational (where farmers aspire to improve and use their knowledge to contribute to and maintain their business viability). Further description of variation within themes of expanding awareness highlighted (i) how farmer conceptions related to perceptions of climate information and its use; and (ii) opportunities to positively influence how farmers access and learn how to use forecast information.

Results from analysis of farmer discussions of climate risk indicated a range of conceptual understandings, from weather and climate being a priority topic of conversation; to a level of scepticism and distrust of forecasts; to incorporating and acquiring knowledge and understanding of forecast information into actions and farm management decisions. Variation in conceptions of this phenomenon was identified as a linear continuum of low through to very high confidence in managing climate risk or the positive influence of discussion. Variation was also identified within a theme of supporting action and decision-making, where the importance of understanding weather and climate was acknowledged, notwithstanding levels of scepticism that were identified about forecast accuracy.

6.6.1 Managing climate risk

Results highlight the intrinsic factors which support farmers in their use and application of climate information, but also emphasise the challenge of presenting climate information in communication formats that are easily understood and that minimise confusion. They also indicate that interviewees are successfully sourcing and integrating climate information into their business management and decision-making. However this analysis also suggests that more should be done by the various scientific bodies that generate and communicate climate forecasts to better package, deliver and explain that information to key consumers of their product. Currently there appears to be too much complexity in the communication of climate information, identified in the way that some farmer’s conceptions of climate information are described in this study. This, combined with lower levels of confidence and understanding to enable use of climate forecasts which are also identified, reinforces the need to appropriately package climate information for farmers. Addressing this issue may then enable farmers to more easily assimilate the material into their understanding and management systems.

Asrar et al. (2012) also highlights the critical need to further develop the science to provide useful climate information for agriculture, and beyond, across other sectors. Additionally, Mase & Prokopy (2013), in an extensive review of a range of studies in the agriculture sector from the developed world, particularly Australia, the United States and Canada, reported under-utilisation of weather and climate information in agricultural decision-making frameworks. A key recommendation from that extensive review suggests that 'interdisciplinary and participatory processes involving farmers and advisors have the potential to improve use of weather and climate decision support tools' (Mase & Prokopy 2013, p. 47). Hence the potential identified in the review and also in this study support improvements both in packaging of forecast information and the processes by which it is developed and incorporated into user decision-making systems.

Extrinsic factors highlighted within the outcome space for this study confirm the background environment in which farmers experience managing climate risk: climate risk remains a major risk factor; farmers exist in a climatic environment that is highly variable; and almost all major operational decisions involve elements of managing climate risk. The scepticism about forecast accuracy that is also highlighted suggests that agencies who produce and deliver forecast information by developing and using climate models need to address this issue in their communication processes. While leadership of modelling to improve the science and skill of climate forecasts may best be developed through top-down approaches, Garbrecht & Schneider (2007) suggest a hybrid approach for development and delivery of forecast information, which also uses participatory processes as a useful model. This model explicitly links modelled forecast output to agricultural end users of climate forecast information via consultants or local extension services and agriculture specialists familiar with agronomic and other technical needs within agricultural decision-making. The importance of extension agents, consultants and other trusted informants in brokering climate information to assist agriculture decision-makers has been highlighted in a range of studies thus emphasising the importance of social learning and participatory processes in improving capacity to manage climate risk (Carberry et al. 2002; Keogh et al. 2004; Meinke & Stone 2005; Furman et al. 2011; Cliffe et al. 2016).

Beyond the intrinsic and extrinsic factors described in this element of the study, farmers also experienced managing climate risk as an expression of hopefulness through aspiration. This result may provide encouragement and justification for climate scientists working in this field that there is fertile ground in which to work with elements of the industry who are eager consumers of their products. Aspirations expressed in the results, also extended to an indication that the scope of application of climate information would also include responding to future climate change impacts, as well as improving current management decision-making processes. Case studies which document real world examples of decision-making using probabilistic forecast information would be a useful adjunct for the research outcomes described here.

6.6.2 Discussing climate risk

Similarly to the results obtained for conceptions of managing climate risk, farmers were able to relate their experiences of discussing climate risk, predominantly with other farmers, but also with other people. However, the amounts of data derived to analyse their relation to 'discussing climate risk' were less than those for 'managing climate risk'. During the interview process, interviewees appeared to have greater difficulty sharing their experiences of discussion. This may have been due to the challenge of sharing something that could be constructed more directly from their experiences, personal opinions and beliefs (i.e. their experience of managing climate risk themselves), compared to something that relied on their memory of experiencing an actual discussion of climate risk with another person and subsequently processing and relating that experience to the interviewer.

Decisions concerning management of climate risk on farm are generally made individually either through a process of individual thinking and consideration or through informal discussions with other members of the farm management team, others within their social networks and triangulation of multiple information sources (Crane et al. 2010; Mase & Prokopy 2013). Therefore the instances of formally discussing climate risk that interviewees could draw on to relate to, are likely to be relatively fewer than the instances of recall of managing climate risk themselves. Furthermore, individuals may not identify discussions they have had as explicitly concerning climate risk, but rather be about specific farm management decisions in which dealing with climate risk is but one of several factors to consider (Crane et al. 2010).

Climate risk appears as a significant risk factor for farmers, described in an extrinsic category of description within the ‘managing climate risk’ outcome space. Similarly, weather in general is a major topic of conversation amongst farmers identified in this outcome space. In the broader farming community and to some degree within the interview group, the scepticism about forecast accuracy and consequent distrust of forecast information provide a further challenge for both the climate forecasting and science communication communities to address (Hammer et al. 2001; Hartmann et al. 2002; Mase & Prokopy 2013). The other categories which appear in this outcome space provide a level of optimism that if confidence in forecast accuracy and communication of that information can be improved, then farmers will source and use that information in their decision-making processes. Farmers also use other farmers and trusted informants as sources of information and to test ideas, so this group of trusted informants could be targeted through extension and communication to become mavens for transfer of climate information to the broader farming community and assist in the dissemination of information that would improve understanding of that information.

Concurring with other studies, e.g. Crane et al. (2010), it is interesting to note that most farmers interviewed used the terms ‘climate’ and ‘weather’ inter-changeably, without making concrete distinctions between the two terms. The experience of managing weather or climate risk doesn’t appear to represent any meaningful practical difference to farmers. Scientists however, distinguish weather as being short term (days/weeks) and more contained spatially, while climate has a longer-term meaning (months/years) and is considered within a larger spatial context (Hansen 2002b). This may or may not represent a challenge to communicating climate information and improve understanding and application and may therefore warrant further research.

6.6.3 Methodological discussion

Structuring this research project using principles of developmental phenomenography has provided a framework to investigate how a group of sugarcane farmers in Australia experience managing and discussing climate risk. The structural relationships between the categories of description which populate the outcome spaces that have emerged from the phenomenographic analysis illustrate the qualitatively different ways farmers relate to the study phenomena. The analysis provides a deep understanding of the way in which farmers understand, currently use and aspire to use climate information in the future. The analysis has also revealed the ways in which farmers experience discussing climate risk with fellow farmers and other people. Describing and elucidating dimensions of variation within themes of expanding awareness provided a deeper understanding of farmer conceptions of the phenomena studied, and allowed conclusions to be developed to influence future research and practice.

6.7 Study Limitations

Limitations of this study include the single researcher, rather than team based approach to phenomenographic data analysis. Team based phenomenographic analysis may have provided a higher level of rigour to the qualitative analysis and resulted in different elements and emphases in the outcomes of the study. Additionally, the data collected in this study are derived from a group of canefarmers who self-selected their attendance at a Managing for Climate Risk workshop and therefore are likely to have a greater interest in managing weather and climate variability than the general canefarmer population. Results can therefore be expected to differ if a broader cross-section of canefarmers participated in the climate workshops, were exposed to group discussion tools and processes, and then were interviewed.

6.8 Conclusions

This research is a novel case study within the phenomenographic literature and agriculture sector which focuses on discovering farmer conceptions of management and discussion of climate risk through the development of two outcome spaces emerging from a single dataset. Outputs of this project have successfully mapped the qualitatively different ways in which a group of farmers experience both managing and discussing climate risk, a risk which has a major impact on business profitability and long term viability in the agricultural sector. The connections between the results obtained in this study to practical implications and considerations for further research, communication and implementation processes in the climate science and extension community are an advantage in using this methodological approach. Indeed the development of collaborative networks which include farmers and key informants including industry advisors, researchers and other relevant stakeholders should be developed to support social learning processes and improve the capacity of individuals and the agriculture sector more generally to better manage the impacts of climate variability and adapt to climate change. Discussion processes between farmers and with their key informants appears to support learning and action which will improve capacity to manage climate variability in the agriculture sector.

Developmental phenomenography, as a qualitative research approach, has provided a new and deeper understanding of the range of meaning and understanding by which farmers manage and discuss climate risk. This has provided the possibility to develop practical recommendations that can be implemented by the climate science community, science communicators and sugarcane industry stakeholders.

7 Conclusions and Reflections

This final chapter reflects on conclusions developed in the different components of this study. A narrative is developed which connects the different elements explored within the research questions the study has investigated. Discussion focuses on developing conclusions and recommendations from the research which will lead to practical applications, both for the climate science applications, communications and extension community and those who might employ developmental phenomenography as a research methodology. My appeal to take theory into practice is informed by my belief that practice not informed by theory is perhaps fantasy, while theory that is divorced from practice is philosophy. Philosophical argument can and does inform intellectual debate about an issue, but risks being unable to inform and influence practice if theory and practice are not linked and complementary to each other.

This research contributes to the understanding of how Australian sugarcane farmers understand the management of impacts of the highly variable climate in which their businesses are situated. The historical group extension and information communication environment which support farmer discussions and consideration of climate information is described, particularly in the way in which participative Managing for Climate Risk workshops have been delivered in Queensland, Australia. The decline in the provision of traditional extension services is discussed, and the consequent opportunity that improvements in digital networks provide to augment and or replace extension services with different communication modalities. A novel discussion support tool (a series of machinima) is developed, evaluated and tested in a farmer workshop, delivered in a collaborative, social learning environment, using adult learning principles. Developmental phenomenography is used as the principal qualitative research methodology to understand and describe farmer conceptions of managing and discussing climate risk. Post-workshop survey and semi-structured interview data are analysed phenomenographically within the research to articulate the variation in farmer conceptions to related phenomena. Conclusions and recommendations for the climate science and communication community are developed which may lead to improvements in the ways that farmers are engaged and supported in their learning about managing the impacts of climate variability in the future.

7.1 Research Question One

Chapter Three developed the context around which sugarcane industry stakeholders currently learn about, discuss and aspire to manage climate risk and establishes where opportunities may exist which could positively influence farmers and their extension services to improve industry capacity to manage the impacts of climate variability. The research objective relevant to this study was to contextually frame the historical research landscape in which this research is positioned. This was achieved by critically reviewing the current delivery of a collaborative and participative learning process aimed at engaging Australian sugarcane farmers in learning about and discussing climate variability and decision-making using seasonal climate forecasts. The key research question addressed in Chapter Three is: RQ1 ‘To what extent have Managing for Climate Risk workshops resulted in changes in participant’s knowledge of and skills in using climate risk information, attitudes about the value of the information and aspirations to use the information in their management in the future?’.

7.1.1 RQ1 ‘To what extent have Managing for Climate Risk workshops resulted in changes in participant’s knowledge of and skills in using climate risk information, attitudes about the value of the information and aspirations to use the information in their management in the future?

The gains in understanding of the key learning objectives reported across all stakeholder groups indicate that facilitated, experiential, collaborative learning workshop approaches are successful in assisting participants to understand and interpret seasonal climate forecast information. Furthermore, understanding can then be transformed into linkages to specific farm management decisions identified by individuals through the processes of small group discussion. The influence of small group discussion on transfer of knowledge to the individual reported in this study confirms observations found in other research (Pai et al. 2014). The small group discussion components deliberatively included within workshop planning and implementation processes are a critical element supporting assimilation of workshop learning objectives into farmer understanding and management of climate risk.

No claims are made here regarding actual decision-making by workshop participants using seasonal climate forecasting information post-workshop. Formal attribution requires further study to address wider questions about decision-making in general. Management decisions are multi-factorial by nature so attribution to one key element such as a single seasonal climate forecast is likely to be problematic. Other elements of decisions, cost/benefit, productivity outcome, environmental impact or lifestyle play an important role in actions taken by decision-makers to manage risk along with individual attitudes to risk (Backus et al. 1997; Jakku & Thorburn 2010). Nevertheless, further investigation into the role of a seasonal forecast in decision-making in the sugarcane industry would provide greater insight into the way in which climate forecast information can be tailored to industry needs.

A key unexpected result obtained within this study reflects on the potentially lower than optimal knowledge and understanding of seasonal forecast information reported within the extension officer group surveyed. This suggests that extension officers and advisers, a key group of influencers in the sugarcane industry, are relatively poorly positioned to positively influence farmers in how they might effectively use climate information in their decision-making processes. At worst, if this group is sceptical about the value of climate forecast information, they may be actively or inadvertently undermining dissemination and use of the information in their farmer networks. In a practical sense, this outcome suggests that extension officers should be actively targeted by the climate science communication community to improve their knowledge of climate information and understanding of the strengths and limitations of using seasonal climate forecasts in farm management decision-making. It is therefore not simply a matter of broadly targeting and engaging farmers in these processes, but to more effectively and efficiently communicate the use and value of seasonal climate forecasting to the key individuals who have the capacity to influence farmers and therefore need to be engaged.

The role of a robust workshop process design is reinforced in the results obtained from workshop evaluation reported in this study. Processes which are intentionally designed to be participatory in nature will therefore provide an atmosphere where collaborative learning opportunities are optimised for the learner and support improved knowledge and understanding of climate information. This result confirms other research in the agriculture and other sector training literature (Francis & Carter 2001; Millenbah & Millspaugh 2003; Dougill et al. 2006), but is particularly relevant in relation to training which supports understanding and use of climate information (Patt et al. 2005; Roncoli 2006; Roncoli et al. 2009; Peterson et al. 2010; Bartels et al. 2013; Ross et al. 2015). Moreover the use of participatory farmer workshops described in this research are likely to lead to the productive discourses between users, advisers and scientists which will improve resilience to climate variability and increase capacity to adapt to climate change impacts (Vogel & O'brien 2006).

Although these types of climate risk workshops have been delivered to the sugarcane industry intermittently and sporadically on an opportunity basis over the last twenty years, only a relatively small percentage of the canefarmer population have participated in the process, compared to the entire population at any specific time. Time and farm succession processes over the decades has also seen a turnover in farm management, with a new cohort of farm managers taking over managerial responsibility of farm businesses over the last two decades. The penetration of regular use of seasonal climate forecasting information may therefore have been limited to those extension officers and farmers who have taken an active interest in the use of climate forecast information, and those in their networks who they may influence.

Research Question One - Conclusions and Recommendations.

Conclusion One: Robust workshop processes which are designed with intentionality to be participatory and experiential in nature will provide an atmosphere where collaborative learning opportunities are optimised for the learner and lead to improved knowledge, skills and understanding of climate information and seasonal forecast products.

Conclusion Two: Extension officer knowledge and understanding of climate risk information and its interpretation in the sugarcane industry is at a similar level to farmers.

Recommendation One: Further research be conducted into the attribution of the role of seasonal forecasts in decision-making in the sugarcane industry and the agriculture sector more broadly to provide greater insight into the way in which climate forecast information can be tailored to industry needs.

Recommendation Two: Further research be conducted to determine if improvements in farmer knowledge and understanding reported at Managing for Climate Risk workshops leads to use of climate information and seasonal climate forecasts in farm management decision-making.

Recommendation Three: Extension officers should be actively targeted by the climate science communication community to improve their knowledge of climate information and understanding of the strengths and limitations of using seasonal climate forecasts in farm management decision-making.

Recommendation Four

Participatory Managing for Climate Risk workshop processes should be actively supported through climate risk policy, research, development, extension and program evaluation activities as a process to improve farmer and adviser knowledge, understanding and skills to apply seasonal climate forecast information within farm management decision-making processes.

7.2 Research Question Two

Chapter Four reported on the testing of a prototype machinima to determine its potential acceptability to a broad range of stakeholders from farmers to extension officers as a managing climate risk communication medium and discussion support tool. The research objective was to develop and evaluate the prototype machinima and test phenomenography as a research methodology. Understanding of variation in stakeholder conceptions of the key messages (which were identified following personal viewing of the prototype machinima) was developed and reported using developmental phenomenography as a qualitative research methodology. The key research question addressed in Chapter Four is: RQ2 ‘How do Australian sugarcane industry stakeholders experience machinima as a communication medium and discussion support tool?’.

7.2.1 RQ 2: How do Australian sugarcane industry stakeholders experience machinima as a communication medium and discussion support tool?

The prototype machinima developed for testing in this element of the research elicited a range of constructive conceptions in relation to the research phenomenon which related directly to the informational objectives around which the machinima was designed. Beyond simplistic conceptions and descriptions of key messages, research participants described deeper conceptions related to climate and business risk management in the sugarcane industry. These conceptions were above and beyond the expected objectives of the script and animated machinima content. In these cases, participants made links to decision-making in other elements of their business beyond those specifically referred to in the machinima. Furthermore, they were also able to draw general conclusions about using climate risk information.

Compared to other visual communication media, machinima have a number of advantages. In a study comparing the learning outcomes in management skills training, Donovan (2015) found that two thirds of learners in the study preferred machinima to DVDs as a learning communication medium. Importantly, achievement of specific learning outcomes was not diminished between the uses of either media. Participants also reported being more able to focus on the key message in the machinima due to an absence of distractions appearing in the machinima compared to the human actors modelling behaviour in a DVD video production. Additionally, learners described the machinima as being more ‘real’ than the DVD where actors appeared. This was attributed to the lower expectations of learners, indicating that they understood that the machinima and characters portrayed within it were conveying a message that might be relevant in the real world rather than depicting a version of reality using human actors (Donovan 2015). Results obtained in this study concur with those found by Donovan (2015). Some interviewees indicated that there were advantages in having avatars rather than real cane farmers because other farmers who knew of those particular farmers could have negative perceptions of some elements of their farming operations. Those negative perceptions may then lead them to discount or discredit the messages that the machinima product might be trying to convey. Some interviewees then also specifically mentioned the relative advantage of having avatar characters to avoid the potential negative connotations that real farmers or real human actors might elicit within the machinima viewers. Two of the extension officers interviewed noted that machinima could be ‘a catalyst for discussion, because it focuses the discussion’, and that the ‘animations add humour that real actors might not’. A Canegrowers Organisation representative suggested that ‘older farmers might be mesmerised by this, that someone had invented it. They’d engage with it’. One farmer commented specifically that it was ‘good using caricatures rather than real people it’s a real strong point’ (Cliffe 2013).

However, some cautionary perspectives were provided by participants which counter comments above about the use of avatar characters. One Canegrowers Australia interviewee indicated that ‘It’s not appealing at all as farmers would relate more to real people than animations’. Phillips (2015) also expresses reservations about the use of digital virtual world products in some circumstances, where older learners may see the use of cartoons as a silly way of learning. Butler (2012) reflects on this issue suggesting that the use of machinima and other novel digital visual media in learning may be resisted by some people due to a mixture of personal and societal distinctions between what might be viewed as ‘play’ versus what is viewed as ‘learning’. However the possibilities that this new digital discussion support tool may have some potential are probably best expressed through the comment of one extension officer who was interviewed and said about the potential of machinima ‘I’d like to see it tested’ (Cliffe 2013).

Interviewees in this study generally had many more positive comments to make about the machinima and its appeal in conveying key messages to farmers compared to neutral or negative comments. Additionally, as described above, not only were the key messages that were the informational objectives of the machinima identified, but a range of other significant messages were understood by viewers. These additional messages, while collateral to the principal messages, demonstrate that machinima have the potential to add value to facilitating learning and communication beyond that which was expected when the machinima was initially designed. In relation to the use of the machinima to support group discussion, interviewees generally endorsed the product directly or suggested that with design improvements the tool would be valuable to prompt and support group discussion about relevant industry issues.

As an extension tool or part of an extension approach within the Australian sugarcane industry, machinima are comparable in cost to a range of other digital extension media (Virtual bus tour, Climate clips), with the exception of DVD (real world video content) production which was the least expensive to produce for large populations (Mushtaq et al. 2017). However, in contrast to some of these other digital tools, machinima are specifically designed and scripted to include contextually relevant farmer discussions which could support farmer learning and discussion. Mushtaq et al. (2017) further report that, with further production efficiencies, machinima production costs would be likely to reduce over time.

Extending the use of virtual world environments, such as Second Life™, beyond production of machinima as a static discussion support tool, future applications are likely to see facilitated discussion occur within virtual worlds. In such a scenario, each human participant would have their own avatar and interact on a virtual platform with other human participants through their avatars, led through a process, meeting, or discussion by a person acting as a facilitator avatar. Wang et al. (2014) found that many of the elements of facilitation that are important in real world human interaction are also important in the virtual world. Ensuring sessions are adequately planned and preparing for behavioural challenges between avatar participants are important elements, along with developing processes and strategies to manage avatar interaction. However, extra flexibility and dexterity to be able to manage technical issues which may arise during the virtual world discussion would be required by the facilitator. Use of virtual world technologies to facilitate group learning are likely to continue to evolve and become more common in the future. Subsequent generations of learners, who have been exposed to these environments, and computer gaming technologies in particular, are likely to be more comfortable in both participating in and facilitating virtual world discussions.

The generally positive results obtained by trialling the prototype machinima in this research provided a sound basis to further develop, modify and test additional machinima as discussion support tools in a formal workshop situation. Responding to the suggestions for improvement by interviewees in this study will be important in the future in making machinima more broadly acceptable to users and potential viewers of the tool. This is particularly relevant regarding increasing the visual appeal of the machinima to match the visual experience obtained in other digital media, and by ensuring the informational content matches viewer (farmer, extension officer and advisor) expectations. This will ultimately improve the quality of the product and increase the likelihood of its use within extension programs. These results provided confidence to further test and evaluate the capacity of machinima to support learning and group discussion in workshops or other situations where farmers are exposed to the tool in a live extension environment.

Using developmental phenomenography as a qualitative research approach in this study provided an understanding of the variation in conceptions of key messages contained in the machinima within this group of interviewees. Applying a phenomenographic approach has provided the opportunity to understand and describe a structural hierarchy within the variation described by interviewees. This hierarchy ranged from a superficial awareness and understanding of the impact of weather on farming, to the description of a more advanced understanding of managing climate risk observed through viewing of the machinima. Testing phenomenography within this element of the research project provided a high degree of confidence in the applicability of the methodology when investigating subsequent research questions within this project.

Research Question Two - Conclusions and Recommendation.

Conclusion Three: Customised machinima have potential as a communication medium to convey information and key messages to viewers and as a discussion support tool to support participatory group extension activities in the agriculture sector.

Conclusion Four: Phenomenographic analysis of conceptions of key messages contained in the machinima indicated that elements of the informational aims of the machinima were successfully elicited. Further, higher and broader conclusions were drawn about more complex farm management elements which both related to and were unrelated to the informational aims of the machinima.

Conclusion Five: Developmental phenomenography provides a useful qualitative methodological approach to understand the variation in conceptions of a phenomenon within a research group. Furthermore the description of an outcome space articulated through phenomenographic analysis provides an understanding of the hierarchy and structural relationships between those conceptions.

Recommendation Five: Further development and testing of machinima as a medium for communication and tool to support group discussion is required in a workshop situation. This will help to determine if the advantages and benefits of machinima described by individual viewers carries over to participants viewing machinima in a group discussion situation.

7.3 Research Questions Three and Four.

Chapter Five reported on testing a series of machinima designed to support group discussion and improve understanding of managing climate risk in a facilitated group workshop setting. The research objective was to trial four machinima within workshops and analyse stakeholder conceptions of managing climate risk following machinima facilitated group discussion and their conceptions of the influence of the machinima on their group discussion. Developmental phenomenography was used as a qualitative research methodology to analyse the way in which individuals experienced the study phenomena. The key research questions addressed in Chapter 5 are: RQ3 ‘How do Australian canefarmers conceptualise managing climate risk following machinima facilitated small group discussion?’; and RQ4 ‘How do Australian canefarmers conceptualise the influence of customised machinima on small group discussions?’.

7.3.1 RQ3: How do Australian canefarmers conceptualise managing climate risk following machinima facilitated small group discussion?

The challenges of managing the impacts of climate variability in the regions where sugarcane is grown in Australia have been outlined earlier in this study (Chapters One and Two). Those challenges are somewhat theoretical in nature, in the sense that climate variability can be described independently through analysis of the historical climate record (Nicholls et al. 1997). Impacts on agriculture from climate variability can also be inferred or directly studied using a range of methodologies reliant on the use of various climate data sources and seasonal climate forecasting systems (Molteni et al. 1996; Stone et al. 1996; Everingham et al. 2003). However, to directly understand the impact of climate variability on an individual farmer and their business requires analysis of a range of variables related to productivity, profitability and social impacts. No analysis of this type was conducted in this study. The research question focused on in this section develops an understanding of canefarmer conceptions of managing climate risk following a small group discussion and captures a range of impacts to climate identified by the research subjects. In this study, a series of machinima were used to model farmer conversations about managing climate risk in relation to particular farm management issues.

The application of a phenomenographic approach to analyse farmer conceptions of the phenomenon of managing climate risk following group discussion provides a novel method to evaluate learning in a workshop setting (Chapter 5). The results obtained in such analyses provide a deep understanding of the variation in knowledge, understanding, confidence and aspirations in a group at a particular point in time. For example, in this study, there were expressions of confidence in using and accessing climate risk tools and information by farmers following group discussion which appear within the themes of expanding awareness. This provides science communicators and extension staff with a level of assurance that at least for some farmers in the population, they are able to assimilate decision support information concerning climate risk into their decision-making frameworks and reinforces the value of farmer-to-farmer discussion processes (Barrett 2014). Importantly too, results indicated levels of individual self-awareness about deficiencies in personal understanding following group discussions. The appreciation and identification of areas which would support improvements in individual knowledge and understanding, as well as where to access tools and information is useful for farmers to acknowledge. This will allow farmers to source material to fill the gaps they have self-identified and therefore provides personal ownership of this expressed need. This result will also further support agencies who are the providers of relevant information and tools in servicing the needs that are identified by farmers. Furthermore, the potential for improvements in self-efficacy levels highlighted in these results are related to self-awareness of knowledge deficiencies and improved self-confidence in decision-making (Bandura 1977; Chiaburu & Marinova 2005; Bandura 2006; Freund & Kasten 2012). These attributes will be important in supporting famers to more pro-actively manage climate variability and adapt to a changing climate in the future.

The 'impact of group discussion' theme described in the results indicated that discussion was likely to lead to enhanced understanding of and aspirations to use climate information. However, for some members of the population, the discussion had only a minimal impact on their consideration of managing climate risk. Those individuals for whom this conception applies may have individual learning preferences which are inhibited by being part of a group and may be better served through other conventional knowledge transfer mechanisms. For many participants in this study, however, it appears that the group discussion had a positive impact on the way in which they experience and conceive of managing climate risk.

The identification of categories of description and their hierarchical representation in an outcome space, along with elucidation of themes of expanding awareness within those categories, provide avenues for potential supportive interventions. Communication and extension programs can be designed or re-designed to fill highlighted gaps in understanding with appropriate resources. Where aspirations to improve knowledge or use of climate risk information and tools have been identified, service providers can have confidence to work further with the population to extend and improve their self-efficacy and capacity.

Methodologically, there appears to be considerable value in using a phenomenographic approach in supporting program evaluation activities. The categories of description that emerged in this analysis relate well to other evaluation methodologies which attempt to capture information about aspirations, improvements in understanding, knowledge and skill development criteria (Rockwell & Bennett 2004). The method can provide a different perspective on the range of experience around particular evaluation criteria, either explicitly or implicitly, expressed by the targeted group engaged in an extension program. In particular, the process may be better able to identify and highlight unintended outcomes or consequences than other evaluation methodologies. Therefore, the potential assumptions and presuppositions about outcomes from an evaluation that might apply in other evaluation processes have the potential to be constrained and may be better validated through rigorous application of the phenomenographic approach.

It must be acknowledged, however, that applying a phenomenographic approach for evaluation purposes will necessarily be more resource intensive both in time required to conduct an analysis and associated budgetary requirements. This may therefore become a disincentive to applying such an approach in evaluation contexts. However, additional investment in resources allocated to more intensive evaluation processes may be warranted, if more profound impact is to be demonstrated within program evaluations. Ultimately the relative costs and benefits will need to be weighed against evaluation objectives to determine if phenomenography should be used.

Research Question Three - Conclusions and Recommendation.

Conclusion Six: Farmer expressions of self-awareness of limitations in their knowledge, understanding and skills concerning managing climate risk provide an opportunity for science communicators and extension programs to improve climate information delivery and decision support processes for the Australian sugarcane industry and for the agriculture sector more generally.

Conclusion Seven: Farmer expressions of aspirations to learn more about managing climate risk and apply information in their decision-making frameworks, indicates that fertile ground exists to improve the capacity of Australian sugarcane farmers to manage climate risk more effectively in the future.

Conclusion Eight: Application of developmental phenomenography has potential to provide a novel approach to program evaluation processes which could identify future program interventions and unintended outcomes of programs.

Recommendation Six: Climate risk communicators need to improve the methods through which seasonal climate information is developed, packaged and communicated to Australian sugarcane farmers and the farmer population more generally.

Recommendation Seven: Developmental phenomenography should be applied in a range of other agriculture sector program evaluation contexts to further determine its suitability as an evaluation methodology.

7.3.2 RQ4: How do Australian canefarmers conceptualise the influence of customised machinima on small group discussions?

Results of phenomenographic analysis of farmer experience of group discussion following exposure to machinima in this study was varied. At its lowest level farmers described the impact of the machinima on discussion as limited. However, progressing through more sophisticated levels, experiences of stimulating and challenging thinking about and using climate forecast information and tools were elicited. Machinima were seen as providing a structure around which conversations and discussion could occur. This result mirrors results obtained during testing of the prototype machinima where individual respondents predicted that the machinima would be a ‘catalyst’ and ‘focus’ for discussion (See Section 7.2). As three of the four themes of expanding awareness for ‘Impact on discussants’ were positive at different levels, a level of confidence about the value of machinima in productively influencing discussion may be inferred.

A number of valid reasons may explain why the machinima impact on discussion was described as limited by a portion of the farmer respondents in this study. These may include personal learning styles, social barriers to interaction in some individuals or attributes of the machinima themselves. Further, the way in which the machinima were introduced prior to the discussion may have lacked appropriate context which would have made individuals more open to the product itself, the messages contained within it and the subsequent discussion that ensued. The limitations described by respondents could be further explored in the future to improve the way in which machinima could be better incorporated into a facilitated discussion support process.

Encouragingly, a theme related to ‘Prompting potential use of climate information’ emerged from the analysis which supports the value of group discussion in potentially prompting some individual action by farmers. It also directly reinforces the value of machinima supporting the discussion and providing the conversation catalyst and focus described above. Direct references were also made to farm management practices impacted on by climate within, but also beyond, those explicitly mentioned in the machinima scripts, indicating that farmers could link and discuss information around managing climate risk in a more holistic sense. It is also interesting that references to other areas of farm management risk, unrelated to managing climate risk, also appear in the analysis. There would appear to be considerable scope to extend the production and use of machinima to other areas of farm management to support productive group discussion and challenge conventional thinking. Indeed, Canegrowers Australia are actively supporting the development of new machinima to address other areas of management risk in the Australian sugarcane industry as a result of the outcomes of this research (Kealley, M 2017, pers.comm. 19th May).

Research Question Four - Conclusion and Recommendations.

Conclusion Nine: Machinima can successfully be employed as a discussion support tool to provide a catalyst, focus and structure for farmer conversations about managing climate risk in the Australian sugarcane industry. Furthermore, it is highly likely that customised machinima will be effective in supporting discussions across a range of management issues more broadly across the agriculture sector.

Recommendation Eight: Where farmer group discussion is an important element of extension programs, customised machinima should be developed to address other areas of farm management and tested to determine their relative value and efficacy.

Recommendation Nine: Continued refinement of machinima and the process by which machinima are introduced into discussion support processes is warranted to address perceived limitations in the value of the product.

7.4 Research Questions Five and Six

Chapter Six develops an understanding of farmer conceptions of managing climate risk following attendance at a Managing for Climate Risk workshop and analyses farmer conceptions of discussing climate risk with other people. The research objective was to analyse farmer conceptions of these phenomena using developmental phenomenography. The key research questions addressed in Chapter Six are: RQ5 'How do Australian canefarmers understand and experience managing climate risk?'; and RQ6 'How do Australian canefarmers understand and experience discussing climate risk with other people?'.

7.4.1 RQ5: How do Australian canefarmers understand and experience managing climate risk?

Analysis of canefarmer understanding and experience of managing climate risk resulted in emergence of an outcome space with three groupings of conceptions. Conceptions were described as intrinsic (internal to the experience and control of farmers), extrinsic (external to or outside the control of farmers) or aspirational (where farmers aspire to improve and use their knowledge of climate risk information to enhance their business viability).

While the higher level intrinsic factors support farmer sourcing and application of climate information, the challenge of communicating climate information to minimise confusion and maximise utility were also identified. Within the lowest intrinsic conception, farmers indicated that forecasting information and tools can be complicated and difficult to interpret. From the range of different climate forecast agencies globally, forecast information for any one particular period can be perceived as having conflicting messages when viewed from the user perspective. Forecast providers use different forecast models to provide forecast outputs for the same period and the output may therefore vary, leading to different forecast guidance. Doblas-Reyes et al. (2013) suggests that appropriately combining the range of available relevant forecast information is needed to support user needs along with identifying a forecast system with the greatest positive skill for the regions of interest. If forecast information is packaged in this way it may better support the decision-making needs of farmers and other user groups.

Faith in forecasts can also be lost due to perceived lack of accuracy and limited regional customisation of some forecast products. It is likely that these perceptions fundamentally reflect a lack of knowledge and understanding of the strengths and limitations of forecast information, and particularly a lack of understanding and skill in interpreting risk-based probabilistic information. Gains in skills, knowledge and understanding of climate information reported in Chapter 3 (Cliffe et al. 2016) support the need to continue improving the capacity of farmers and their advisors to understand and interpret climate drivers and associated forecast products. Further investment is required to support services and activities, such as Managing for Climate Risk workshops, which will improve climate literacy and understanding of seasonal climate forecast information amongst primary industry stakeholders.

Stone (Stone, R 2017, pers. comm., 7th April) reports that, for the expensive research and development investment that has been undertaken in climate systems modelling over these past 30 years, there is less than 10% uptake, particularly in developing countries. Siregar & Crane (2011) and Unganai et al. (2013) also identified a disconnect between provision of seasonal climate forecast information and the capacity of farmers to understand and ultimately use forecasts in decision-making. Siregar & Crane (2011) identified the lack of subsequent use of climate information in farm management decision-making following capacity building workshop activities where farmers appeared to understand and value the climate forecast information provided. The research concluded that a range of other technical and social factors impeded use of climate forecasts and recommended that future workshops should be facilitated using experiential learning approaches which would empower farmers to assimilate the climate information more effectively into their own management systems (Siregar & Crane, 2011). Unganai et al. (2013) also found little evidence of use of climate forecast information and that there was inappropriate matching of climate forecast information to the needs of the farmers who also experienced difficulty in interpreting probabilistic forecast information.

The methods by which climate information is communicated are critical if the information is to be used and incorporated within decision-making processes. Speranza (2010) emphasises the importance of communicating the uncertainty inherent within climate forecasts and how probabilistic information should be explained to farmers and other forecast users. Indeed Unganai et al. (2013) concluded that a drought forecast without the use of probabilistic forecast information may be appropriate for small landholders in Zimbabwe, through simply using a binary, drought/no drought forecast. In contrast, Patt et al. (2005) describes farmer engagement workshops in another region of Zimbabwe, where probabilistic forecasts are explained and linked to management practices in the year ahead. In this example, a stepwise facilitated approach appeared to allow time for farmers to reflect on previous seasons and successfully incorporate their own experience and the current climate forecast into their decision-making processes (Patt et al. 2005).

Canefarmers in Australia are likely to require a more sophisticated application of probabilistic rainfall information as drought impact or severity is not the only climate variable that is relevant for the industry. Forecasting of a range of extreme climate events including heatwaves, floods, tropical cyclones, storm events, as well as droughts, will be useful to the sugarcane industry and other agriculture industries in Australia. Forecasts of this nature are more likely to empower farmers to manage negative impacts of climate variability and also to take advantage of opportunities presented by favourable climatic events.

It is also clear that farmers do not appear to readily differentiate between weather and climate in the way that the climate science and climate risk extension community may define the terms. When asked questions about management of climate risk, examples of dealing with weather phenomena were often provided by farmers. The terms appear to be used interchangeably, with 'weather' often used as a 'catchall' term when climate might be more appropriate in a pure definitional sense. As an example, a reference in this study to management of spraying operations by monitoring of wind forecasts clearly incorporates understanding of use of short-term weather forecasting rather than longer-term climate forecast information. Mase & Prokopy (2013) concluded that there is potential to improve use of both weather and climate decision support tools by users in the agriculture sector, particularly through the networks of farmers and advisors. Participatory workshop processes involving farmers, advisors and climate scientists which improve skills and understanding are an avenue to support better application of climate and weather forecast information and tools. While climate workshops are a more intensive approach to build farmer and adviser capacity, further refinement and better customisation and packaging of climate forecast information in general is required to enhance its utility for decision-makers. A multi-faceted, multi-layered approach to providing information across a range of communication platforms, including building individual farmer capacity, is needed to maximise dissemination and informed use of climate forecast information.

The extrinsic conceptions of management of climate risk by farmers confirmed the importance of climate as a risk factor for Australian sugarcane farmers. These farmers recognised that they live in a highly variable climatic zone and that many, if not most, farm management decisions are impacted by that climate variability. This realisation has potential to provide an incentive for the agriculture sector generally to better incorporate climate forecasts into their decision-making frameworks. However, a significant barrier to use of climate forecast information, highlighted as an extrinsic conception within this analysis, is farmer scepticism about forecast accuracy. As described above, farmers can struggle with understanding the expression of probabilities within forecasts and have difficulty coping with lack of certainty in forecast expression. In contrast, between use of climate information and other information in farm management, some decisions have a much higher degree of relative certainty. In a spraying decision, for example, a recipe of chemical ingredients may exist for how to control a pest or weed and farmers follow that recipe to conduct a spraying operation. Provided the recipe is followed, a relatively certain outcome can be expected. However, a probabilistic rainfall forecast may express a likelihood of being above or below a particular rainfall threshold (e.g. the median), or within a certain part of a rainfall distribution (e.g. a tercile or decile range). The forecast is therefore entirely accurate in terms of the outcome, in that the amount of rainfall ultimately received is predicted to fall above or below the threshold described. However, the utility of the forecast is then only relevant to the user if the expression of the relative probabilities in the particular forecast make a difference to a management decision the user is making. Therefore, the importance of building climate literacy, improving understanding of probabilities and managing uncertainty within the farmer and adviser community, and the agriculture sector generally, is critical. If these approaches are successful, climate risk information will be more seamlessly incorporated and appropriately applied within operational farm management decision-making processes.

Finally, this research provides significant encouragement to the climate research and climate communication community due to the aspirational expressions by farmers to improve their knowledge and use of climate information. Results also extended the scope of the findings beyond management of the impacts of climate variability to farmers indicating that their capacity to respond to future climate change impacts would also be improved. These research outcomes support earlier reported research findings regarding the importance of social and participatory processes aimed at improving the capacity of the agriculture sector to better manage climate risk (Carberry et al. 2002; Keogh et al. 2004; Furman et al. 2011; Cliffe et al. 2016). If climate information and associated communication platforms can be improved and customised in collaboration with users to meet their needs, there is a higher likelihood that the information will be applied productively and profitably by the target groups.

While this study has not investigated the motivation of farmers to attend and participate in climate risk workshops, future research could be targeted at understanding what triggers and stimuli may support broader scale engagement of the farmer community in climate risk learning opportunities. Whether or not probabilistic forecasts are useful for canefarmers, has not been analysed within this research but could also provide critical information which supports development of user-friendly information and customised information which may support improved climate risk management. Collecting case study information which document real world examples of decision-making using probabilistic forecast information including cost/benefit analyses would be a useful adjunct for the research conclusions and recommendations described in this research.

Research Question Five - Conclusions and Recommendation.

Conclusion Ten: Farmer's aspirational, and higher level intrinsic and extrinsic conceptions of management of climate risk are actively supporting the sourcing and use of climate information which will improve farm management of the impacts of climate variability.

Conclusion Eleven: Farmer's climate literacy levels and levels of scepticism about forecast accuracy are barriers to expanding the use and application of climate forecast information in operational farm management decision-making.

Recommendation Ten: Further improvements in the interdisciplinary and participative development of customising, packaging and communicating climate forecast information are needed to improve agriculture sector climate literacy levels, understanding of forecast probabilities and use of climate information in agricultural decision-making.

7.4.2 RQ6: How do Australian canefarmers understand and experience discussing climate risk with other people?

The linear hierarchy which emerged in the outcome space described for conceptions of the phenomenon of discussing climate risk with other people indicate that discussion of weather and climate and its associated impacts are a common topic within farmer network conversations. Scepticism of forecast accuracy also emerged as a theme within farmer network discussions. The analysis demonstrated that farmers identify peers and other trusted informants including advisors, as key sources of information and the support of these relationships is used to test ideas and concepts.

The analysis indicated that discussions that famers have with key informants can result in personal action to source and use climate information or confirm planning options that were developed. The importance of key informants in supporting learning and action in agriculture is noted in other research (Oreszczyn et al. 2010; Eastwood et al. 2012). The power of network interactions and discussions to positively support and influence action is an important finding. It confirms the value of collaborative, participatory and experiential learning objectives that support discussions farmers may have, both in formal Managing for Climate Risk workshop settings, but also outside of these settings during other informal peer-to-peer interactions. Additionally, the more general principle of the value of farmer networking and interaction in discussions with a range of key informants to positively influence learning and potential adoption is supported in this study. Oreszczyn et al. (2010) suggest that interactions and discussions with other potential adopters influences the receptivity of the individual to adopt a new technology or practice. Furthermore, discussions with experts and other key informants who are not farmers, plays an even more important role in learning and influencing action. Eastwood et al. (2012) endorses the value of farmer learning through experiential processes but also emphasises the value of on and off-farm networks to support social learning. Decision-support systems which are integrated into social learning approaches to support farmer learning and decision-making in a supportive stakeholder network were more effective (Eastwood et al. 2012).

Conclusions from this analysis also emphasise the value of face-to-face interactions and discussions impacting positively on critical thinking skills (Guiller et al. 2008). These interactions are therefore more likely to support farmers to confidently incorporate climate information into their management systems through critical analysis of the strengths and limitations of that information. Understanding how to apply climate information appropriately will support robust decision-making which allows farmers to effectively and profitably manage the impacts of climate variability.

Research Question Six - Conclusion and Recommendations.

Conclusion Twelve: Discussion and interaction between farmers and with their key informants has the potential to support learning, knowledge construction and personal action to improve management of the impacts of climate variability and adapt to climate change.

Recommendation Eleven: Collaborative networks which include farmers and key informants including industry advisors, researchers and other relevant stakeholders should be developed to support social learning processes and improve the capacity of individuals and the agriculture sector more generally to better manage the impacts of climate variability and adapt to climate change.

Recommendation Twelve: Key informants (including industry advisors) within industry groups should be targeted by climate science communicators to improve their individual capacity to understand climate information and seasonal climate forecasts, and empowered to influence farmers in their networks to access and use climate information productively in their businesses.

Table 7.1 lists all conclusions and recommendations developed for key research questions addressed in this research project.

Table 7.1: Conclusions and recommendations developed for key research questions addressed in this research project.

Research Question	Conclusions	Recommendations
RQ1	**Conclusion One:** Robust workshop processes which are designed with intentionality to be participatory and experiential in nature will provide an atmosphere where collaborative learning opportunities are optimised for the learner and lead to improved knowledge, skills and understanding of climate information and seasonal forecast products. **Conclusion Two:** Extension officer knowledge and understanding of climate risk information and its interpretation in the sugarcane industry is at a similar level to farmers.	**Recommendation One** - Further research be conducted into the attribution of the role of seasonal forecasts in decision-making in the sugarcane industry and the agriculture sector more broadly to provide greater insight into the way in which climate forecast information can be tailored to industry needs. **Recommendation Two** - Further research be conducted to determine if improvements in farmer knowledge and understanding reported at Managing for Climate Risk workshops leads to use of climate information and seasonal climate forecasts in farm management decision-making. **Recommendation Three -** Extension officers should be actively targeted by the climate science communication community to improve their knowledge of climate information and understanding of the strengths and limitations of using seasonal climate forecasts in farm management decision-making. **Recommendation Four** - Participatory Managing for Climate Risk workshop processes should be actively supported through climate risk policy, research, development, extension and program evaluation activities as a process to improve farmer and adviser knowledge, understanding and skills to apply seasonal climate forecast information within farm management decision-making processes.

RQ2	**Conclusion Three** - Customised machinima have potential as a communication medium to convey information and key messages to viewers and as a discussion support tool to support participatory group extension activities in the agriculture sector. **Conclusion Four:** Phenomenographic analysis of conceptions of key messages contained in the machinima indicated that elements of the informational aims of the machinima were successfully elicited. Further, higher and broader conclusions were drawn about more complex farm management elements which both related to and were unrelated to the informational aims of the machinima. **Conclusion Five** - Developmental phenomenography provides a useful qualitative methodological approach to understand the variation in conceptions of a phenomenon within a research group. Furthermore the description of an outcome space articulated through phenomenographic analysis provides an understanding of the hierarchy and structural relationships between those conceptions.	**Recommendation Five** - Further development and testing of machinima as a medium for communication and tool to support group discussion is required in a workshop situation. This will help to determine if the advantages and benefits of machinima described by individual viewers carries over to participants viewing machinima in a group discussion situation.
RQ3	**Conclusion Six** - Farmer expressions of self-awareness of limitations in their knowledge, understanding and skills concerning managing climate risk provide an opportunity for science communicators and extension programs to improve climate information delivery and decision-support processes for the Australian sugarcane industry and for the agriculture sector more generally. **Conclusion Seven** - Farmer expressions of aspirations to learn more about managing climate risk and apply information in their decision-making frameworks, indicates that fertile ground exists to improve the capacity of Australian sugarcane farmers to manage climate risk more effectively in the future.	**Recommendation Six** - Climate risk communicators need to improve the methods through which seasonal climate information is developed, packaged and communicated to Australian sugarcane farmers and the farmer population more generally. **Recommendation Seven** - Developmental phenomenography should be applied in a range of other agriculture sector program evaluation contexts to further determine its suitability as an evaluation methodology.

	Conclusion Eight - Application of developmental phenomenography has potential to provide a novel approach to program evaluation processes which could identify future program interventions and unintended outcomes of programs.	
RQ4	**Conclusion Nine** - Machinima can successfully be employed as a discussion support tool to provide a catalyst, focus and structure for farmer conversations about managing climate risk in the Australian sugarcane industry. Furthermore, it is highly likely that customised machinima will be effective in supporting discussions across a range of management issues more broadly across the agriculture sector.	**Recommendation Eight** - Where farmer group discussion is an important element of extension programs, customised machinima should be developed to address other areas of farm management and tested to determine their relative value and efficacy. **Recommendation Nine** - Continued refinement of machinima and the process by which machinima are introduced into discussion support processes is warranted to address perceived limitations in the value of the product.
RQ5	**Conclusion Ten** - Farmer's aspirational, and higher level intrinsic and extrinsic conceptions of management of climate risk are actively supporting the sourcing and use of climate information which will improve farm management of the impacts of climate variability. **Conclusion Eleven** - Farmer's climate literacy levels and levels of scepticism about forecast accuracy are barriers to expanding the use and application of climate forecast information in operational farm management decision-making.	**Recommendation Ten** - Further improvements in the interdisciplinary and participative development of customising, packaging and communicating climate forecast information are needed to improve agriculture sector climate literacy levels, understanding of forecast probabilities and use of climate information in agricultural decision-making.
RQ6	**Conclusion Twelve** - Discussion and interaction between farmers and with their key informants has the potential to support learning, knowledge construction and personal action to improve management of the impacts of climate variability and adapt to climate change.	**Recommendation Eleven** - Collaborative networks which include farmers and key informants including industry advisors, researchers and other relevant stakeholders should be developed to support social learning processes and improve the capacity of individuals and the agriculture sector more generally to better manage the impacts of climate variability and adapt to climate change.

		Recommendation Twelve - Key informants (including industry advisors) within industry groups should be targeted by climate science communicators to improve their individual capacity to understand climate information and seasonal climate forecasts, and empowered to influence farmers in their networks to access and use climate information productively in their businesses.

7.5 Concluding personal reflections on the research journey

7.5.1 In the beginning…

When I began this research journey in 2013, I had over twenty year's experience working with Queensland and Australian primary producers to support their improved management of the impacts of climate variability. In recent years, that support has extended to assist the agriculture sector in Queensland to adapt to current and potential impacts of climate change. My work has focused on the engagement, extension and communication aspects of working with farmers to improve their climate literacy, understanding of the impacts of climate variability on their farming systems, how to make decisions which incorporate seasonal climate forecast information and understanding how to adapt to climate change impacts. Through a range of personally developed and applied project evaluation activities I was able to develop some understanding of the impact of my own efforts and the efforts of the colleagues I worked with in achieving our objectives. However, the processes were often less than systematic in their application, in the sense that they often did not form part of a formal program evaluation process. In many cases, my evaluation efforts focused on ensuring that I was satisfied that I was delivering an activity that was useful to producers, enjoyable for them to participate in and provided feedback on my personal performance.

During the last two decades, I had supported or led two significant projects which sought to independently evaluate climate risk management extension activities. External evaluation of Managing for Climate workshops (CBR 1999) supported the effectiveness of the workshop engagement process and provided many examples of how skills learnt at the workshop were being used by farmers for better management decisions. One third of respondents (56 interviewees) indicated that they had made or saved money from their production decisions as a result of attending the workshop. Many other positive outcomes were reported. In 2011, I developed a process for engaging with the agriculture sector to identify impacts of climate variability and climate change and develop potential adaptation strategies. Independent evaluation

(Coutts 2011a) indicated the process was highly successful in engaging and building capacity in participants. The survey reported improvement in how participants understood risks and opportunities associated with managing climate change impacts and intended to plan for managing impacts of climate variability and adapt to climate change. In a general sense, I therefore had some confidence from these formal and independent evaluation activities that I had an ability to deliver activities to support change in farmer behaviours around managing climate impacts. Intuitively too, I was confident that I was 'making a difference'.

Notwithstanding these formal evaluation processes and the historical and ongoing evaluation processes I personally conducted, including my positive intuitions, nagging doubts and concerns continued to pervade my psyche about whether I was truly achieving the outcomes that are important in my work. Developing and designing the methodological approaches I used to answer the research questions addressed in this research project allowed me to investigate some key aspects relevant to the way in which farmers learn about, manage, and discuss managing impacts of climate variability. Critically for me the process also allowed me to chase my elusive personal goal of justifying my professional existence as an extension officer.

7.5.2 Reflections on phase 1 – Learning outcomes in a workshop setting

Within the first element of the research (Chapter 3), I was able to reflect on and analyse the impact of a workshop process explicitly incorporating deliberatively designed learning objectives. Prior to delivery of that series of workshops, my workshop design had been looser and less well defined, without robust evaluation criteria linked to learning objectives forming a central component of workshop delivery. While workshops had been conducted intermittently across the sugar industry for over twenty years, a relatively small percentage of sugarcane farmers would have attended compared to the entire population and a new generation of farmers has moved into management roles across the industry. The use of collaborative learning workshop design and shaping of evaluation criteria allowed me to use descriptive statistics (Sandelowski 2000) to compare gains in knowledge, understanding and skills, which were self-identified by workshop participants. Further, the analysis provided me with a qualitative appreciation of participant's aspirational incorporation of their knowledge and skills into their decision-making frameworks. This analysis (Cliffe et al. 2016), conducted with the rigour supported by the peer review process, provided me with a high degree of confidence that the workshop process outcomes were making a real difference in supporting my key client target groups and should be endorsed and supported in the future.

However, the surprising outcome of this study was that sugarcane industry advisers and extension officer's knowledge and skill sets regarding understanding and interpreting climate risk information were apparently no more advanced than the farmers they were engaging with. This finding revealed a new evidence-based direction for investment in engagement and skill development within the network of support services which work directly with farmers. If the adviser and extension officer network knowledge and skills could be supported we might expect that more farmers would be reached and more effectively supported in managing climate impacts in their businesses. The contextual background described in this first element of the research paved the way for exploring other elements of the way in which farmers understood management of climate risks, discussing climate risk with others and developing strategies which would enhance engagement with the agriculture sector in the future.

7.5.3 Reflections on Phase 2 – Evaluating a machinima using a phenomenographic approach

As a professional extension officer, I also identify as a professional facilitator, who has a critical responsibility to support interaction, conversation and discussion in groups I engage with. The discussion processes which occurs within social and collaborative learning processes described in this research are a critical element which supports learning and knowledge construction. The communication processes are not one way and top down, rather they are interactive and constructive and collaborative between top and bottom. As a learning facilitator, I am responsive to participant requirements and expectations, with the flexibility to modify processes to cater for their varying needs. In the second phase of this research (Chapter 4), I was able to test a prototype machinima which could support group discussion. An added benefit of this research was that if the tool was ultimately proved to be useful, it could also be deployed as a tool to support advisers and extension officers to more effectively convey messages about climate risk and perhaps other elements of farm management.

I found, contrary to my initial scepticism about the value of machinima, support for the concept across the diverse range of sugarcane industry stakeholders I interviewed, from farmers and advisers to industry organisation representatives. Conclusions developed from the thematic analysis of interviewee comments indicated that the machinima was viewed more positively than negatively, both as a communication medium and support for farmer group discussion. Importantly, there was support from both farmers and farm advisers to see it tested more formally in a workshop setting. Using and testing phenomenographic analysis as a qualitative methodology, the results demonstrated that the informational messages that were contained in the machinima did indeed form part of the conceptual understanding of interviewees. These key messages emerged within the categories of description that were part of the outcome space described as part of the phenomenographic analysis process. The fact that higher level conceptions also emerged in terms of key messages that interviewees identified was unexpected. Conclusions and generalisations constructed at a higher level to the key messages and applications of the message more broadly than that at which the machinima was designed, indicate the potential for machinima as a learning and discussion support tool. The machinima prompted a level of thinking and ideation beyond which I, as a machinima script creator, could have imagined. On this basis, I had confidence to further test machinima in a formal farmer workshop process. Methodologically also, I had confidence that phenomenography had potential to provide a deeper and more nuanced understanding of group conceptions of a phenomenon.

7.5.4 Reflections on Phase 3 – Using machinima as a discussion support tool linked to understanding of farmer management of climate risk

Beyond farmer's self-identification of their gains in knowledge, understanding, skills and aspirations following participation in a Managing for Climate Risk workshop, I also wanted to understand more about the impact of peer group discussion on farmer's conceptions of managing and discussing climate risk (Chapter 5). In these Managing for Climate Risk workshop processes, four new machinima were used to prompt participant group discussion, so a link could be made to the use of the tool in supporting the discussion that ensued. The conclusions obtained from the analysis reveal the range in farmer confidence levels to use and apply climate information, farmer reflections on self-awareness and self-efficacy and aspirational eagerness to learn indicated by farmers. These conclusions are directly relevant for the climate science community and its engagement with farmers and the agriculture sector generally. The research, development and extension of information within the climate science community needs ongoing development and improvement, along with design and refinement of appropriate delivery platforms which provide useable climate information and forecasts for the agriculture sector. There are opportunities to build on the levels of farmer confidence and self-efficacy that emerged from the analysis. Equally there are opportunities to improve engagement to support farmers within the sector who are sceptical or uncertain about the value of the information for use in their business decision-making processes.

Reassuringly, the use of machinima provided the catalyst, focus and structure for the discussion for which it was intended and therefore supports the role for which this tool was developed. The conclusions also endorsed the expectations that were derived from the analysis of the prototype machinima indicated by participants in the earlier part of the research project (Chapter 4), which were positive in terms of its potential. Additionally, given that other elements of farm management were prompted by discussions of the machinima content, it is likely that different machinima can be developed and deployed to address other areas of management in the sugarcane industry, but also more broadly across the agriculture sector, nationally and internationally. The wider application and use of machinima would benefit from further technical refinement and improving the visual appeal of the product. However, based on the conclusions reached in this research, machinima are likely to be successful as a novel communication medium both in supporting productive discussions and facilitating learning.

Following the conduct of the phenomenographic analysis, both at this stage and later in the research, it became clear to me that the methodology has potential for use in program and project evaluation processes. Where learning outcomes are a central part of a program or project, developmental phenomenography has the potential to identify the range of conceptual understandings within the group engaged in that project. The process can describe the variation in learning conceptions that exist within the group, following program or project delivery processes. Though more resource intensive in its application, developmental phenomenography can provide a deep understanding of the range of learning and responses to a phenomenon and can highlight perhaps unexpected and unintended outcomes more successfully than other qualitative research approaches might have the capacity to achieve. Particularly in programs and projects where teams are involved, the resources may exist for team members with the skills to support application of this methodology. They are likely to have the skillset and passion to undertake the detailed data collection, analysis and comparison processes that are key elements of a team based phenomenographic approach.

7.5.5 Reflections on Phase 4 – Real time farmer conceptions of managing and discussing climate risk

Interviewing farmers one on one post-workshop in their own environment provided an opportunity to collect and analyse data on conceptions of management of climate risk at a deeper, more personal level. The analysis showed that farmers do indeed source and use climate information in their farm management decision-making frameworks and that there appear to be aspirational, extrinsic and intrinsic drivers which support those actions. This conclusion gives me great personal reassurance that the work I do is ‘making a difference’ and achieving objectives I wouldn’t necessarily have seen unless this research had been undertaken. However, more can be done to address the barriers that were also identified in the analysis. In particular, key barriers were identified that related to the connected elements of low climate literacy levels and the scepticism that surrounds the accuracy of climate forecast information. If these impediments can be adequately addressed then even deeper inroads will be made into improving the capacity of the entire farmer population to profitably use climate information in their farm management. This is a challenge the climate science community and industries in the agriculture sector in a broad interdisciplinary sense need to address. If the agriculture sector is to improve its resilience to climate shocks, manage the impacts of climate variability and adapt to climate change, these barriers must be overcome. More effective collaboration between parties involved will require commitments to work productively together, supported by additional resources to deliver the outcomes that are needed.

Conclusions developed from the analysis of farmer conceptions of discussing climate risk have confirmed the potential support for learning and knowledge construction and prompting action that comes from interacting with other farmers and key informants. Conversations and discussions which occur formally or informally are likely to lead to the learning and action outcomes that farmers described in this analysis. Knowing that discussion can positively influence farmer behaviour and learning should influence how the advisory and extension services which work with farmers structure engagement processes. Opportunity for interaction and discussion should be integral parts of robust extension processes which are designed to support social and collaborative learning outcomes.

7.5.6 The bottom line…

Building the capacity of farmers to enhance the productivity, profitability and environmental sustainability of their management systems remains a primary of goal of extension and advisory services in the agriculture sector. The communication and engagement platforms which can support this goal are many and varied. Within a digital world, new platforms, undreamed of only ten to twenty years ago, are now available to support farmers and their advisors. However, putting to one side all the bells and whistles that new technologies can provide, the act of one-on-one communication with another person through conversation and discussion is essential to humans as social beings. This interaction has benefits in supporting learning beyond that which interaction with a computer or other communication mediums can provide. The capacity to argue and debate, critically analyse through discussion and negotiate positions, are examples of interaction at a human to human level that are difficult to replicate in other ways.

Interaction between farmers and advisors in discussion groups, workshops, shed meetings or other situations where participation and discussion are encouraged can provide a safe and productive environment for learning, knowledge construction and critical thinking. This productive environment does not just materialise organically, but needs to be actively and thoughtfully planned for and facilitated. Developing and delivering a robust facilitated process which creates the most conducive environment for learning, training, decision-making or planning, is as important as the primary activity for which the workshop is being conducted. Where the learning objectives concern management of climate risk, creating a positive environment is even more critical, as farmers may be sceptical of the value of the information being presented. Where climate change issues are being addressed, part of the farmer group might be openly hostile to the topic itself, reflecting levels of scepticism in the broader community as a whole.

The use of machinima in this research provided an alternative stimulus to facilitate a farmer group discussion than a workshop facilitator might otherwise undertake. The advantage of this tool related to the topic of promoting learning about managing the impacts of climate variability (but which could be applied generically to many other topics) becomes evident where a group facilitator may want to introduce a concept into a group discussion in a more stimulating and novel way. The machinima provides a mechanism to introduce a dialogue between avatar characters which resembles a discussion that a group of farmers may have in a contextually relevant but digitally contrived setting. The avatar conversation may be able to broach elements of an issue that the facilitator may have difficulty raising. Additionally, it may provide multiple perspectives about an issue that places a mirror before the farmer audience and gives them permission to then discuss varying perspectives in the ensuing discussion.

The initial fears I had regarding the acceptability of the machinima as a tool to present to farmers were realised to some extent by some viewers expressing negative views about the tool. However, the majority of farmers and others who viewed the machinima could see the tool for what it was designed to be i.e. a visualisation of farmers discussing an issue to which they could relate, in a visual setting that was also contextually relevant to their industry. Overall the machinima were acceptable as a communication medium and were also able to support and generate relevant discussion around the issues for which each machinima was developed. Evidence provided in this study supported the value of the tool in providing a focus for discussion, promoted development of ideas and identified deeper conceptions which promoted the use of climate forecasting tools in decision-making. Hence, both the informational and discussion promotion objectives of the machinima were met, and even exceeded, in the outcomes of the study that have been described.

The outcomes of this research, more broadly, have also demonstrated that many farmers in the population are willing and able to use climate forecasting in their management decision-making systems. The Managing for Climate Risk workshops demonstrate that learning outcomes are achieved and that farmers go away from those learning events with knowledge and understanding about strengths and limitations of climate forecast information and some ideas about where to access relevant material. There is also demonstrated use of climate forecasts by farmers to make better management decisions by appropriately applying the probabilistic information they contain. Though the levels of capacity are not consistent across this entire stakeholder group, the level of penetration of use of this information within the group would appear to be relatively high and the outcomes of use of that information have been positive.

However, a key barrier for the Australian sugarcane industry, and the agriculture sector generally, occurs post-workshop. There are a plethora of information sources using different climate models from different parts of the world. This makes it difficult for farmers to easily access and remain up to date with relevant forecasts that will assist them in decision-making. Understanding and interpreting climate information is challenging and there is a need to improve the way that information is packaged and delivered to farmers to allow them to assimilate it quickly and easily into their management and decision-making frameworks. The climate science research, development and extension community need to work collaboratively with farmers and industry generally to better customise and deliver information to farmers and other decision-makers in the agriculture sector.

The use of developmental phenomenography as the dominant qualitative research methodology used in this study has provided a deep insight into Australian sugarcane farmer's conceptions of their experience of managing the impacts of climate variability and their experience of discussing climate risk with other people. The phenomenographic approach has provided a rich and detailed analysis of the variation in conceptions of the phenomena explored in the number of studies reported in this research. The approach is intensive and time consuming to conduct, but rewarding in terms of the detailed pictures relating to the phenomena that have emerged from the process. There are opportunities to use the approach in other studies in the agriculture sector where variation in conceptions of a phenomenon or descriptions of variation in learning are of interest. Furthermore, there is potential to use the approach in program evaluation processes, particularly where learning outcomes are a critical objective of such programs.

In conclusion, undertaking this research project has provided me with an opportunity to understand, in a more profound sense, how farmers perceive and conceive of the climate risk management issues I have invested much of my professional career in supporting them to address. This research has enabled me to crystallise key elements of what it means for farmers to better understand how they can proactively and productively manage climate impacts in their business. Furthermore, as a professional learning facilitator with highly developed process expertise, but more limited climate science content expertise, I have been able to explore the importance of farmer discussions with peers and others and to better understand how that discussion impacts on their learning and conceptual understanding of management of the risks associated with climate variability. I will now be able to move forward and play my part in implementing the recommendations developed through this research with more confidence, supported by evidence provided from this research.

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APPENDICES

APPENDIX A: POST-WORKSHOP PARTICIPANT SURVEY FORM (CHAPTER 3)

1. Please indicate the group below that best describes your interests (Tick more than one if appropriate):

    □ Canegrower
    □ Harvesting Contractor
    □ Miller
    □ Canegrowers organisation
    □ BSES
    □ Productivity Services
    □ Other ____

2. Overall, how useful did you find the workshop in terms of better considering climate risk issues within your industry/business?

    □ No use Low usefulness □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 Very Useful

3. What aspects, if any, were particularly helpful?

4. What could have been changed/included which would have made it (even) more helpful?

5. Please rate your level of gain in understanding about the following areas covered during the workshop:

    5.1 General Seasonal Climate Forecasting Information

    None □ Low gain □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High gain

    5.2 Interpreting Sea Surface Temperature Maps

    None □ Low gain □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High gain

    5.3 Interpreting SOI data

    None □ Low gain □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High gain

    5.4 Interpreting ECMWF Maps

    None □ Low gain □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High gain

    5.5 Using the products to determine the probability of rainfall in the season ahead

None □ Low gain □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High gain

6. Based on this workshop, how much potential benefit do you see in using seasonal forecasting products to assist your on-farm planning?

   None Low benefit □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High benefit

7. How likely are you to use this seasonal forecasting information in your decision-making?

   Low likelihood □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High likelihood

8. What are the main benefits for your industry/business that you think could result from the use of seasonal forecasting products?

9. What might stop you from using these products or applying what you learnt today?

10. Please make any other comments about the workshop or process you have experienced today:

11. Are you interested in accessing regular updates on the seasonal outlook to support your decision-making?

   □Yes □No

   If you are happy to provide your name for further follow up, please add your name, email and other contact details below:

Thankyou

APPENDIX B: DRAFT MACHINIMA SCRIPT FOR HARVESTING MANAGEMENT DECISION.

Scene: Informal shed meeting at Alan's

Time of year: Mid June, within a fortnight of the crushing starting

Characters:

Merv An innovative canegrower who is accessing climate information from USQ on a regular basis; Bernie's son & Alan's neighbour.
Des Canegrower, somewhat sceptical about climate forecasting (but benignly so…)
Alan Canegrower; Merv & Bernie's neighbour
Bernie Canegrower; Merv's dad.

Script:

Merv: Morning guys, how's tricks? Geez Al … clean shed mate! Haven't you got enough to do around here?

Alan: Aw, y'know what they say Merv … tidy shed, tidy mind. How's town?

Merv: Pretty quiet, I just had to pick up some parts for our haul outs. Nice to see the weather cooling up a bit prior to the crushing … should bump our CCS up a bit.

Des: You bet mate, I reckon it was close to a frost on the flat below our place this morning. Early in the season to be that cool…

Merv: Yea, you're not wrong. Hey, the crushing starts in a couple of weeks … are you guys ready to go?

Alan: We're close to being ready. Just doing a final check on all our gear. We should be right by the time it's our turn in the group to cut.

Des: Yeah … well, we're ready to go. We only had a few minor repairs after last season. We're cutting first in our group and provided the weather holds we'll be right to go as soon as the mill gives us the green light.

Bernie: Now you've mentioned the weather … Merv, did you check the USQ monthly climate update last night like you were goin' to? What did it say for the start of the crushing?

Merv: Yeah, I did. Actually, it looks like we could be heading into another El Niño. At least, the current outlook is that it might be a bit drier than normal in the next couple of months.

Bernie: That's great for harvest at least!! The last thing we need at the moment is another year like 2010. The back end of that year was really wet and we ended up with a lot of standover cane we couldn't get off. If we got that sort of forecast again, I reckon we'd be a bit more cautious and harvest the wetter blocks at the start of the crush, so we wouldn't get caught again at the back end.

Merv: Yeah, I agree. But this year we might do better to leave the wetter blocks til the end of the crushing as they'll hang on better with the drier conditions.

Alan: Sounds like a plan Merv. Not putting all your eggs in one basket and hedging your bets a bit.

Des: Still Merv … you're not putting too much faith in those forecasts are you?

Merv: Well I reckon it's better than flipping a coin. The forecasts give you a pretty good indication of the chances of rainfall being above or below average and how likely it might be to be very high or very low. They develop these forecasts using probabilities so, as long as you understand that and what the risks might be, you can make an informed decision.

Des: Sounds a bit like rocket science mate. Still … where do we get this information that you've tapped into?

Merv: There's a few options, but I access it through the USQ website. Here … I can bring it up on the laptop if you want to have a look.

Des: Give us a geezer then, Mr Techhead … amazing the stuff you can find these days at the push of a button.

Merv: Watch it with the name calling, Desmondo! (all laugh)

Alan: Right lads, how about we share a coldie while Merv sets the laptop up…??

Bernie: A man with a plan! I like your thinking, Al… (Dog barks) … so does Butch! (all laugh)

APPENDIX C: PROTOTYPE MACHINIMA SEMI-STRUCTURED INTERVEW INSTRUMENT (Chapter 4)

Evaluation of machinima with sugarcane industry stakeholders.

Interview Questionnaire

Part 1:Machinima evaluation

Can you describe your reactions as you viewed the video?

(Follow up with questions of clarification if needed for this question and following questions…)

How would you describe the length and pace of the video?

How would you describe the characters in the video?

How would you describe the setting for the video?

What do you think are the key messages that are discussed in the video?

What parts of the video were appealing?

What parts of the video could be improved?

How could the video be improved to better simulate a real farmer discussion?

How appealing is this style of video format as a way to convey messages to canefarmers?

Reflecting on viewing the video and the feedback you just gave, overall, how would you rate the value of this sort of video in prompting canegrowers to take some action, small or large, in relation to information presented in the video?

☐ No value Low value ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 High value

Stepping back from the discussion of the video you just viewed and commented about and thinking more generally about the way canefarmers value and use climate information I'd like to ask you some further questions. These questions are about where you and canefarmers access climate information and what particular needs you might have to improve the delivery of climate information to better support your business.

Part 2:Climate information digital delivery platform needs…

Can you describe where canefarmers access seasonal climate forecasting information currently?

How well do these information services currently meet canefarmers needs?

What improvements to the way that the information is delivered would better support canefarmers needs?

Thinking about the electronic and digital delivery of information generally, can you describe what an ideal delivery mechanism for climate information for canefarmers might look like?

Part 3 Demographic information

What sugarcane producing region do you come from?

What sugarcane industry stakeholder group or groups to you belong to?

What is your gender?

Male ☐ Female ☐

What year of birth bracket do you fall in to?

- 1946 – 1963
- 1964 – 1973
- 1973 - 1981
- 1981 – 1991

- 1991 –

How many years experience have you had in the sugarcane industry?

Number of years:___________

How would you rate your level of expertise in using computers and the internet?

Low level of expertise □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High level of expertise

What is your highest level of formal education?

- Primary
- Secondary
- Tertiary (graduate)
- Tertiary (postgraduate)
- Other

APPENDIX D: PRE, MID AND POST-WORKSHOP SURVEY PARTICIPANT FEEDBACK FORMS (CHAPTER 5).

Section A: Pre-workshop survey form

Please take a little time to read the questions or statements and consider your response…

Please rate your current level of understanding of:

1 General Seasonal Climate Forecasting Information

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

2 Interpreting Sea Surface Temperature (SST) maps

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

3 Interpreting Southern Oscillation Index (SOI) data

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

4 Interpreting European Centre for Medium range Weather Forecasting (ECMWF) maps

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

5 Using the above products to determine the probability of rainfall in the season ahead

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

6. How much potential benefit do you currently see in using seasonal forecasting products to assist your on-farm planning?

None □ Low benefit □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High benefit

7 How likely are you to use seasonal forecasting information in your decision-making given your current knowledge?

Not at all □ Low likelihood □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High likelihood

8 To what degree are you currently using seasonal forecasting information in your decision-making?

Not at all □ Rarely □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 Frequently

Thank you

Section B: Mid-workshop survey form

Please take a little time to read the questions or statements and carefully consider your response…

Please rate your level of gain in understanding of:

1 General Seasonal Climate Forecasting Information

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

2 How to interpret Sea Surface Temperature (SST) maps

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

3 How to interpret Southern Oscillation Index (SOI) data

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

4 How to interpret European Centre for Medium range Weather Forecasting (ECMWF) maps

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

5 Using the above products to determine the probability of rainfall in the season ahead

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

6 How much potential benefit do you see in using seasonal forecasting products to assist your on-farm planning?

None □ Low benefit □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High benefit

7 How likely are you to use (or use to a greater extent) seasonal climate forecasting information in your decision-making now?

Not at all Low likelihood □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High likelihood

Thank you

Section C: Post-workshop survey form

Please take a little time to read the questions or statements and carefully consider your response…

1 Overall, how useful did you find the workshop in terms of better considering climate risk issues within your industry/business?

□ No use Low usefulness □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 Very Useful

2 How useful was the video animation in supporting your group discussion of climate risk management.

□ No use Low usefulness □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 Very Useful

Please rate your level of gain in understanding of:

3 General Seasonal Climate Forecasting Information

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

4 How to interpret Sea Surface Temperature (SST) maps

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

5 How to interpret Southern Oscillation Index (SOI) data

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

6 How to interpret European Centre for Medium range Weather Forecasting (ECMWF) Maps

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

7 Using the above products to determine the probability of rainfall in the season ahead

None □ Low □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High

8 Based on this workshop, how much potential benefit do you see in using seasonal forecasting products to assist your on-farm planning?

None □ Low benefit □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High benefit

9 How likely are you to use (or use to a greater extent) seasonal climate forecasting information in your decision-making now?

Not at all Low likelihood □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 High likelihood

Please indicate the groups below that describe your business of group affiliation: □ Canegrower □ Harvesting Contractor □ Miller □ Canegrowers organisation □ Productivity Services □ Other	Please rate your skills in using computer/digital technologies: □ Advanced □ Intermediate □ Basic □ Nil	Please indicate the bracket which best describes your age: □ (65+) □ (50-64) □ (40-49) □ (33-40) □ (22-32)

What aspects of the workshop were particularly helpful?

What could have been changed/included which would have made it (even) more helpful?

Regarding the small group discussion of climate risk and farm management decisions, how did this session impact on your thinking about managing climate risk?

In what ways did the video animation influence the discussions in your group?

Please make any other comments about the workshop or process you have experienced today:

If you are happy to provide your name for further follow up, please add your name, email and other contact details below: Thank you

APPENDIX E: DATA COLLECTION INSTRUMENT FOR SEMI-STRUCTURED INTERVIEWS FOLLOWING MANAGING FOR CLIMATE RISK WORKSHOP (CHAPTER 6).

Interview Sections/Questions	**Prompts (if needed)**	**Rationale and/or Process**
Introduction: I'd like to talk to you about your experiences of learning about managing climate risk and discussing climate risk with other farmers. Is it okay to record our conversation so it will make it easier for me to write up your exact words afterwards?		• Summarise outline of research objectives • Introduce interview process • Obtain consent to proceed and sign consent form • Obtain approval to record interview
1. Can you describe your farm and farming operation to me in general terms? 2. What motivates you to be a canefarmer?	• Farm size and Ha under cane? • Tonnes of cane harvested on average? • Irrigation? • Labour? • Business structure? Question why (???) for deeper probing…	• Developing rapport with the farmer • Collecting farm profile information • Developing rapport with the farmer.
3. Please describe your experience of managing climate risk on your farm? Can you describe an example of where you had to manage climate risk on your farm	Question why (???) for deeper probing…	To elicit information about the farmer's experience of management of climate risk
4. What personal methods or strategies you have developed to manage climate risk?	• Question why (???) for deeper probing… • What is meant by that particular term or concept…?	To elicit information about knowledge and strategies to manage climate risk.
5. What is your experience of the overall usefulness of climate risk information?	Question why (???) for deeper probing…	To elicit information about usefulness of climate risk information.
6. Please describe your experience of using climate risk information?	Can you give an example…? Question why (???) for deeper probing…	To elicit information about use of climate risk information.

7. How do you hope to manage climate risk in the future?	Question why (???) for deeper probing…	To elicit information about future use of climate risk information.
8. Please describe your experience of discussing managing climate risk with other farmers.	Question why (???) for deeper probing…	To elicit information about the farmer experience of the group discussion of management of climate risk.
9. How would you describe the use of the video animations shown at the workshop?	Question why (???) for deeper probing…	To elicit information about participant conceptions of the machinima use in the workshops.
10. That covers everything I wanted to ask, is there anything you'd like to add or something you think I should have asked you?	Question why (???) for deeper probing…	To provide opportunity to elicit further information about managing climate risk relevant to the farmer.