‘The Lot of the Farmer’

Climate change adaptation in the Victorian wine industry

Rhianna Dean

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A thesis submitted in partial fulfillment of the requirements of Lund University International Master’s Programme in Environmental Studies and Sustainability Science (30hp/credits)

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Submitted 20th May 2013

Supervisor: Dr Kimberly Nicholas, Lund University Centre for Sustainability Studies

Abstract

In recent years there has been significant research conducted into how predicted climate change scenarios could negatively impact wine grape quality across various regions in the world. This has highlighted the particularly vulnerable state of the wine industry to climate change, and the important role research in this area can play in identifying new knowledge and conceptual frameworks regarding broader climate change adaptation behaviour in agriculture.

In this thesis, I explored what climate change adaptation looks like in the context of the Victorian wine industry. Using a framework influenced by current theories of resilience and vulnerability, I identified the important role practical actions play in contributing to adaptive capacity. Through the use of existing literature and six semi-structured interviews, I identified a comprehensive inventory of adaptation actions that are available to the wine industry. I designed and administered an online survey of 86 Victorians working in wine businesses to assess their current practices and future priorities regarding the adaptation actions, and whether various factors, such as climate change perceptions and business size, influence the implementation of these actions.

The survey revealed evidence of a diverse range of adaptation actions taking place across the wine industry adaptation domains of site selection, planting, winemaking, business, and utility decisions. When looking at future adaptation priorities, there appear to be strong tendencies towards improving energy efficiency; incorporating organic and biodynamic techniques into vineyard management; using social media as a means to strengthen business; and diversifying the potential revenue-raising activities that take place at a business site. However, the overwhelming majority of respondents have not used in the past, and do not prioritise using in the future, adaptations including relocating to new locations, altering their planting practices, or using technological fixes to environmental stressors (with the exception of water management).

Demographic factors influenced the adaptation actions undertaken. Individuals who reported a perception that climate change will have a negative impact on business were more likely to have implemented and also planned more adaptation actions. Interestingly, the perception that climate change will have a positive impact was also associated with an increase in actions implemented. This could indicate that actions are being undertaken to take advantage of 'positive' impacts of climate change, and that actors who have an opinion on climate change are also more likely to be pro-active with implementing new actions. Business size also played an important role in adaptation actions, with larger businesses more likely to implement adaptation actions than those managed by individuals who perceived that climate change is happening, human caused and will have a negative impact on business. This implies that financial resources are an important barrier to adaptation, if individuals who believe climate change is a problem are unable to act on this belief due to financial constraints.

The data collected illustrate a willingness of actors to engage in adaptive actions that relate to both biophysical and business strategies when facing increased vulnerability and change. Farm-scale actors are pro-actively engaging with their value chains and consumers – they are not simply sensitive to these systems, they are active participants in them. Future research and agricultural climate change adaptation policies will need to increasingly recognise this, particularly when mapping vulnerability and resilience.

Keywords: Agriculture, Australia, Business Management, Climate Adjustment, Resilience, Viticulture

For Ella Gasson, who epitomised elegant resilience,

and supported my every whim with love and encouragement.

I miss you dearly.

Unending thanks to:

Kim - for your supervision, remarkable patience and encouragement

The Martin - Halinoja families - för dina ständiga kärlek, stöd och rådslag

Ben - for believing in me, even when I think the mountain is too high

Mum – for ensuring I could see the world far beyond our context

Heartfelt thanks to the grape growers and wine makers who generously shared their knowledge, experiences and products with me.

For your love and support:
Dad, Robyn, Peter, Rhys, Phillip, Lara, Nicole, Anna, David och min Palatset familjen

Over the past two years I never felt 'homeless' thanks to the warmth and generosity of: *Mikael, Tillie, Daniel, Ben, Johannes, Francisca & David, Renee & Lauren, Ian & Robyn, Antonia & Tim*

And to the LUMES family - the only people who can truly understand what a unique experience the past years have been. Your friendship, enthusiasm and positive energy will forever inspire me.

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"To drink wine is
to drink nature"
-Len Evans

1 Introduction

'*To drink wine is to drink nature*' – is the statement greeting visitors to a family-owned and -operated winery in the northwest of Victoria. This comment, attributed to one of Australia's most prominent wine figures Len Evans, is perhaps the most succinct explanation of why there is an increasing focus on studying the wine industry in relation to global environmental stresses and climate change. A bottle of wine encapsulates its environment - its terroir[*] - in a unique and delicate way. Grapevines and the wine they create are sensitive to minute changes in temperature, extreme weather events, soil quality, and pest and disease pressures (Jones 2003; Jones *et al.* 2005; White *et al.* 2006; Webb, Whetton, & Barlow 2008). It is for this reason that scientists and policy makers interested in agriculture and climate change adaptation[†] are increasingly looking towards this luxury crop as a place of early learning and knowledge that may be applied to staple crops such as wheat, rice, corn or soya with their major contributions to global trade and caloric consumption (Lobell, Cahill, & Field 2007; Lobell *et al.* 2008; Lobell & Field 2007; Schellnhuber 2009; Schlenker & Roberts 2009; Park *et al.* 2012)

The production of quality wine is dependent on many factors, and is where value is created in this crop (Caprio & Quamme 2002; White *et al.* 2006). As the global wine market is flooded with an oversupply of high-quality wine - the "wine glut" - negative pressure on crop values leads to lower crop prices paid to producers (O'Donnell, Fell, & Shafron 2012). Therefore, any loss in quality cannot adequately be substituted with increased yield levels.

In recent years there has been significant research conducted into how future climate scenarios will impact wine grape quality across various regions in the world (Jones *et al.* 2005; White *et al.* 2006; Webb *et al.* 2008; Jones & Webb 2010; Nicholas *et al.* 2011). These studies have been instrumental in highlighting the particular vulnerabilities faced by this crop, and have also captured a number of potential adaptation actions available to grape growers and wine makers in response to these vulnerabilities. These studies have led to ongoing research projects considering adaptation responses and transformation in the sector in Australia (Park *et al.* 2012).

Jones and Webb (2010) have demonstrated that climate's influence on agribusiness '*is at its most evident when looking at viticulture and wine production*'. Grapevine phenology (the timing of development) is sensitive to even the slightest average temperature variations and extreme weather events (Jones & Webb

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[*] Wine writer Max Allen (2010) defines *terroir* as encompassing '*the unique geological history and soil profile of each vineyard site; how the slope of the land is angled to the sun; the climate and rainfall; human influences such as how the vines are trained, how the vine canopy is managed – and how all these factors produce a specific and recognizable taste in the wine from that vineyard, year after year. Simply defined, terroir is the combination of country, climate and culture that makes a wine taste unique*'.

[†] Throughout this thesis, 'adaptation' refers to the processes of 'climate change adaptation'

2010) – both of which are expected as a result of global warming (Howden *et al.* 2007; Adger & Barnett 2009; Garnaut 2011). It is this sensitive nature of grapeviness, and the industry they support, that enables it to act as an early-warning system for problems that other food crops may face as the impact of global warming develops (Anderson *et al.* 2008; Jones & Webb 2010).

In the following thesis, my aim is to contribute to this ongoing body of research through conducting a quantitative survey of Victorian wine businesses in order to learn which adaptive actions are presently being used in the industry, what priorities are for the future, and whether the implementation of adaptation actions are influenced by factors such as climate change beliefs and business size.

1.1 Case study location

Winegrapes are predominantly grown in temperate south-west and south-east Australia in areas known as wine regions, or Geographical Indications[‡] (Webb 2006). Wine is Australia's third most valuable export commodity, with an export value of >AU$2 billion per year. In the 2011-12 financial year, there were 1.62 million tonnes of grapes crushed in Australia, making it the 4th largest grape exporter globally and contributing to a combined domestic and export sales value of >AU$4 billion (Food and Agriculture Organisation (FAO) 2011; Australian Bureau of Statistics (ABS) 2013)

The state of Victoria, Australia (Figure 1-1) was selected as the case study area for this research. Being my home state it was the ideal location to conduct interviews, as I could build on existing relationships I have in the industry and could easily travel to various wine regions. Having grown up near the Yarra Valley wine region, I found it particularly rewarding to develop a greater personal understanding of how a global phenomenon such as climate change interacts with a place and industry so close to my heart.

Figure 1-1: Map of Australia with the state of Victoria highlighted in Red

[‡] A Geographical Indication (GI) is an official description of an Australian wine zone, region or sub-region. The main purpose of the GI system is to protect the use of regional names under international law, similar to the Appellation naming system used in Europe (although much less restrictive in terms of viticultural and winemaking practices) (Webb 2006)

There are more than 850 wineries making wine from approximately 2,900 vineyards in Victoria (Tourism Victoria 2010). Although not the largest in terms of volume produced each year, Victoria's viticultural map is more densely populated and has more wine regions than any other state in Australia, which is partly due to it having the greatest diversity in viticultural climates and soils (Tourism Victoria 2010; Halliday 2012).

Figure 1-2: Map of Victoria with its six official wine zones marked with red, and 21 official wine regions marked in brown.

1.2 Climate change research and the wine industry

1.2.1 Climate change and Australia

There is now scientific consensus that profound, human-induced climate changes can be anticipated in coming decades (IPCC 2007; Fussel 2009), and have already begun to be witnessed in Australia (Cocklin & Dibden 2009; Garnaut 2011). The decade ending in 2010 was Australia's warmest since record keeping began – and this follows a trend of each decade being warmer than the previous since the 1940s (Garnaut 2011). Indeed, the extreme conditions that were a backdrop to the Victorian Black Saturday bushfires in 2009, and the Queensland cyclones and floods in 2011, are consistent with projected changes to the severity of weather events and highlight Australia's vulnerability to climate-related disasters (Department of Climate Change 2010; Garnaut 2011).

Research also indicates that precipitation patterns are expected to become more variable and unpredictable; it is believed that climate change has already contributed to reduced rainfall patterns and increased rates of evaporation in Western Australia and south-eastern Australia (Department of Climate Change 2010). These scenarios could be exacerbated by the El Niño Southern Oscillation, which itself could be affected by global warming and become less predictable (Cocklin & Dibden 2009; Collins *et al.* 2010; Hadarits, Smit, & Diaz 2010). In response to these predictions, the Australian Government has stated that adaptation activities will be a '*substantial ongoing challenge for all Australians will into the future*' (Department of Climate Change 2010) and that individuals and businesses will play an important role in this effort.

1.2.2 Key implications of climate change on wine businesses

Research shows that climate change will effect both grape quality, yields and the business operating environment of the wine industry. Jones et al. (2005) have found that an average warming of 2°C in the next 50 years would cause regions producing high-quality grapes at the margins of their optimal climatic limits to exceed their climatic threshold, resulting in difficulties ripening balanced fruit used to produce existing varieties and wine styles (Jones *et al.* 2005). They show that many European regions appear to be at or near their optimum growing season temperatures, with further studies in Chile, the United States and Australia also predicting that some regions of these New World wine-producing countries are at risk of reaching their optimum thresholds if even moderate average temperature increases of 2°C occur (White *et al.* 2006; IPCC 2007; Webb, Whetton, & Barlow 2007a; Fussel 2009; Hadarits *et al.* 2010). In their study into how increases in atmospheric carbon dioxide concentrations and changes in temperature and radiation could affect Italian Sangiovese and Cabernet Sauvignon yields, Bindi *et al.* suggest that with climate change there will be greater variability between good and bad yielding years (Bindi *et al.* 1996).

In extensive studies conducted at the CSIRO and University of Melbourne, it has been found that '*without adaptation, winegrape quality may be reduced at a national scale in Australia from 7 to 39% by the year 2030, and from 9 to 76% by the year 2050 (all uncertainties considered)*'(Webb *et al.* 2008). Climate changes have been shown to impact grape growing through average temperature increases and a greater frequency of extreme weather events (Hall & Jones 2009), impacts that can lead to phenological changes, water stress, damages due to natural disasters, increased disease pressure, changes to suitable geographic areas for grape growing and can lead to increased financial and logistical pressures.

Average temperature increases have been found to speed up the phonological stages of wine grapes, which can be detrimental or beneficial to quality depending on attributes of the growing season and variety (Hadarits *et al.* 2010). This has been shown in Australia to lower quality through accelerating the growing season and leading to harvests during times of warmer temperatures (Webb *et al.* 2007a). High temperatures through the growing season and at harvest can cause reduced berry weight (Caprio & Quamme 2002), earlier sugar ripeness and a loss of acidity (causing off balance ripening profiles and a loss of freshness), desiccated fruit (Jones et al 2005) and compressed harvest dates (late-harvest varieties are more sensitive to warming) (Anderson 2008). Pest and disease pressure is also likely to increase and shift to new areas with warmer winters and warmer night temperatures (Anderson *et al.* 2008).

A greater volatility in weather patterns and frequency of extreme weather events is expected with rising average global temperatures, increasing instances of heatwaves, drought, storms, altered precipitation patterns, frost and bushfires (Howden *et al.* 2007; Garnaut 2011; Stafford Smith *et al.* 2011). All of which

can cause damage to or reduce the quality of grape crops. The probability of heatwaves in Australia (5< days over 35C) doubles with a 1°C average temperature rise, and increases five-fold with a 3°C increase (Keller 2010). These heat stress events, and an increased frequency/severity of drought are likely to exacerbate the aforementioned impacts of higher average temperatures, water stress and rates of evapotranspiration (Anderson 2008). During the 2009–10 Australian vintage the national average price of wine grapes fell by 12%, from the 2008–09 level (Victorian Department of Environment and Primary Industries (DEPI Vic) 2011). In warm climate regions, prices fell by 19% to the lowest price in over a decade (O'Donnell *et al.* 2012). It has been recognised that this fall in production primarily reflected lower yields due to shortages of irrigation water in some regions and a prolonged heatwave in November 2009 (O'Donnell *et al.* 2012). In Victoria, these conditions were believed to contribute to a 13.8% decrease in wine grape production across the state compared to 2008-09 (Victorian Department of Environment and Primary Industries (DEPI Vic) 2011)

Precipitation patterns are also expected to become less predictable during summer months in South East Australia as the climate changes (Hayman, Leske, & Nidumolu 2009). Unseasonably high precipitation during vérasion[§] and harvest is particularly disadvantageous because it increases disease risk and hinders growth (Hadarits *et al.* 2010). The 2010-11 vintage in Victoria suffered high losses due to unseasonably wet and cool weather, with flooding also impacting on several wine regions (O'Donnell *et al.* 2012).

Figure 1-3: Vineyards in the Yarra Valley surrounded by burnt forest, still recovering from the Black Saturday bushfires. Most of the region's 2009 vintage was ruined by smoke taint and a number of wineries and vineyards were damaged in the fires. (Photograph: Rhianna Dean, February 2012)

[§] 'Vérasion' is the physiological stage in the development of a grape berry when it begins to ripen, as indicated by a softening of the fruit & and a change in colour.

1.3 Research questions

When reviewing existing research into the Australian wine industry and its vulnerability to climate change, it has become apparent that a shift is taking place from the identification of exposures and stresses associated with climate change, into a phase of investigating the adaptive capacity of the industry (Webb 2006; Webb, Whetton, & Barlow 2007b; Jones & Webb 2010; Galbreath, Klass, & Charles 2012; Park *et al.* 2012). Much of this current focus is targeted at understanding the behavioural cues and organisational structures that support adaptation (Fleming & Vanclay 2010; Park *et al.* 2012). However as highlighted by Berrang-Ford et. al. (2011), adaptive capacity encompasses both the intention to act, and the actions themselves. When considering how adaptation in practiced in the Victorian wine industry, I therefore wish to contribute by identifying a comprehensive inventory of adaptive actions that relate to both biophysical stresses (Nicholas & Durham 2012a) and the financial exposures that are associated with climate change vulnerability.

Furthermore, I would like to investigate which of these actions have recently been implemented, and what are priorities for the future. I am also interested to know if there are key factors that can influence the implementation and prioritisation of these actions. Recent research has found that key beliefs about climate change - that it is real, human caused and harmful - are important predicators of support for climate policies and societal action (Ding *et al.* 2011). This recognition of the importance of risk perception has also been included in recent IPCC definitions of adaptation, which highlights that adaptation '*involves changes in social and environmental processes, perceptions of climate risk, practices and functions to reduce potential damages or to realise new opportunities*'(Adger *et al.* 2007). There is also evidence in the literature that the financial benefits and/or costs associated with adaptive activities at the vineyard level can play a significant role in their uptake (Fleming & Vanclay 2010; Hadarits *et al.* 2010).

In the following thesis I will investigate the overarching research question:

"How is climate change adaptation practiced in the context of the Victorian wine industry?"

I will develop my response to this over-arching question through answering four sub-questions:

RQ1: *What adaptation actions have people been taking in their wine businesses?*

RQ2: *What adaptation actions are priorities for the future?*

RQ3: *What do Victorian grape-growers and winemakers think about climate change?*

RQ4: *Are financial resources a more influential factor than climate change perception in adaptation action implementation and prioritisation?*

2 Theoretical Framework and Methodological Approach

The new field of sustainability science seeks to improve understandings of complex social-ecological interactions through pursuing interdisciplinary research agendas. It is explicit in it's aim to provide knowledge that can be applied in real-world settings that simultaneously supports human needs and the life-support systems of the planet (Bolin *et al.* 2000; Kates *et al.* 2001; Ostrom 2007).

This focus on interdisciplinary solutions to complex global issues has of course influenced my own thoughts on my research approach. Khagram et. al. (2010) have created a useful conceptual foundation for interdisciplinary environmental research in response to the increasing creation of research programs that exist outside of traditional disciplinary and institutional boundaries. In order to ensure my own self-awareness as a researcher and improve the ability of my research to fit within the sustainability science research program, I have used this framework as a basis for understanding my own work (Figure 2-1).

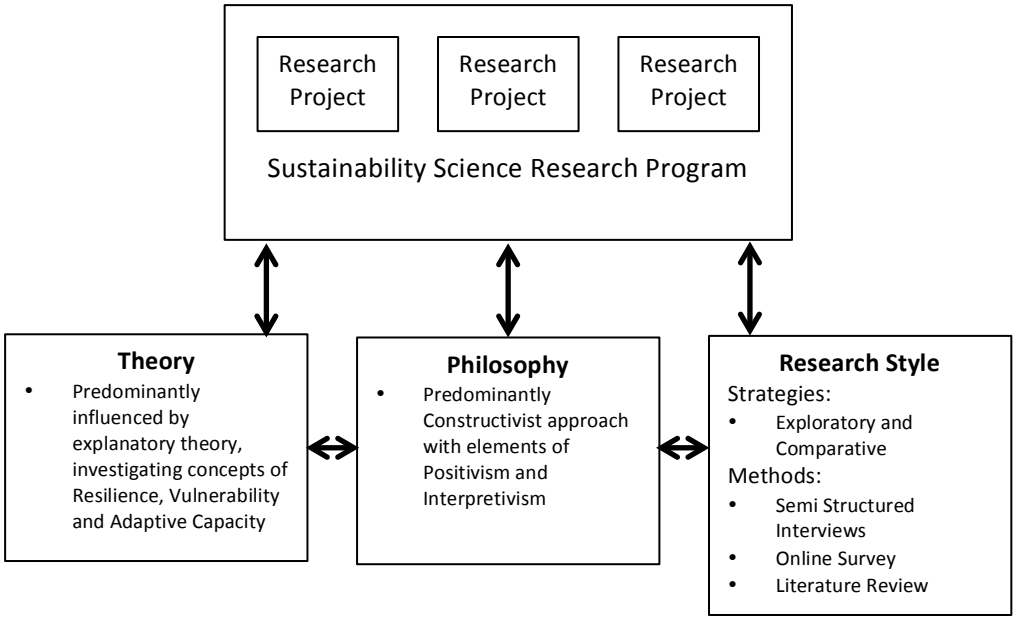


Figure 2-1: Schematic diagram based on the framework designed by Khagram et. al. (2010) depicting how my research design is conceived. My thesis is one project among many that contribute to the research program of Sustainability Science. I have identified my theory type (the ways in which knowledge generated by this thesis is organized), philosophy or philosophies of knowledge (the nature and validity of the knowledge this thesis seeks to generate), and research style/s (guides the practical gathering and organization of knowledge generated by this thesis).

2.1 Philosophy of Knowledge

The underlying philosophy of knowledge that exists within each researcher inherently influences how the phenomena being considered is defined, as well as what constitutes valid knowledge about the phenomena (Khagram *et al.* 2010). I believe that academic enquiry and the knowledge it generates is always through the prism of the researcher's own worldview. The constructivist manner in which I see the world has both shaped, and been shaped by, the studies I have undertaken. That said, I do believe in 'common-sense'

approaches to academic enquiry and its application in real-world experiences. When considering an issue from a social-ecological perspective, I do believe in the existence of an external reality that is shaped by natural forces, and although humans affect and are affected by our environment (Bolin *et al.* 2000), there do exist laws that we are bound by – for example without water, a grapevine will not grow. I do not believe, however, that we can ever be truly objective in our investigation of these externalities.

I found this influence of both positivist and constructivist traditions on my philosophy of knowledge perplexing when initially considering my research strategy. On further reflection I came to realise that this state is precisely what is asked of us as Sustainability Scientists. To conduct research with an awareness of the broad worldviews that may influence us, and to build our methods and data is response to this. As highlighted by Khagram et al:

> *'The philosophy of sustainability science blends positivism with interpretivism and constructivism through its promotion of science as a powerful problem-solving tool and its acknowledgement that different and often competing, multiply situated, culturally rooted perspectives exist and influence the nature-society interaction'* (Bolin et al. 2000)

This plural approach is also well suited to an exploratory design that draws on both qualitative and quantitative methods to explore an issue (Creswell & Clark 2007: 87).

2.2 Theoretical Approach

Theoretical applications *seek to organize knowledge into coherent conceptual frameworks* (Khagram *et al.* 2010). Having been trained in sustainability science for the past two years, I recognise that a variety of theoretical standpoints have influenced my work. I have approached this thesis with dominant theoretical underpinnings of explanatory theory, which aims to construct conceptual categories and models, and uncover interlinked causal mechanisms both within and across cases (Khagram *et al.* 2010). Connected to grounded theory, this approach suits my tendency to have an interplay between theory and empirical research throughout this thesis process. I have used this iterative approach to define concepts of adaptive capacity, resilience and vulnerability, and investigate relations between them that shed light on empirical reality.

2.2.1 Adaptive Capacity

Even with global mitigation efforts to limit greenhouse gases being implemented, it is widely accepted that we will see global mean temperature increases beyond 2°C in the next decade, with a significant likelihood of mean warming of 4°C or more above preindustrial levels (IPCC 2007; Webb *et al.* 2007a; Adger & Barnett 2009; Fussel 2009). This could exacerbate existing vulnerabilities beyond acceptable barriers and move social-ecological systems into new states that could be difficult to adjust to . This acknowledgement has

seen an increase in research and action regarding adaptation to expected climate change impacts (Berrang-Ford *et al.* 2011). There is also a concern that insufficient attention is being paid to the establishment of pre-emptive adaptation actions in policy and planning[**], a concern highlighted by deficiencies in prevention and preparedness for recent extreme weather events (Repetto 2008; Adger & Barnett 2009).

The conceptualisation of adaptation has evolved in recent years, highlighted in the changes made to IPCC definitions of adaptation (see Annex 1). It is increasingly recognised that adapting to climate change is seldom a process that exists in isolation from other pressures and changes, and indeed may take place in the context of non-climatic windows of opportunity (Nelson, Adger, & Brown 2007; Moser & Ekstrom 2010). Adaptation encompasses observed or expected changes in both climate and associated extreme weather events (Adger *et al.* 2007). Including extreme weather events explicitly in the scope of adaptation is important, as these events are not always thought of in relation to climate change, yet are expected to increase in future scenarios, and can result in a disproportionate amount of damages, economic loss and vulnerability (IPCC 2012).

Adaptation strategies and actions can range from short-term coping to longer-term, deeper transformations in policy, practices and behaviour (Moser & Ekstrom 2010). It is also important to recognise that although the impacts of climate change are often viewed as problems, there is significant opportunity to take advantage of new situations that promote innovation and development (Nelson *et al.* 2007). Adaptation strategies and actions may or may not succeed with their original purpose, and can interact with other system dynamics in unexpected ways causing both positive and negative feedbacks (Moser & Ekstrom 2010). In essence, adaptations are influenced by an *intention*, they are not an outcome. Adaptation to climate change is an ongoing-process, reflecting many factors or stresses (Adger *et al.* 2007).

2.2.2 Resilience and Vulnerability

I believe one of the most significant additions to the 2007 IPCC definition of adaptation is the prominence of resilience and vulnerability theoretical discourse (Annex 1). In their assessment of adaptation in Australian agricultural sectors (Teague, McLeod, & Pascoe 2010), Howden et al. (2007) also highlight that *'[climate change] response strategies need to focus on developing more resilient agricultural systems (including socioeconomic and cultural/institutional structures)'.* This progression in adaptation discourse is a recognition of the interdependence and complex interaction that climate change impacts have with other

[**] Professor Robert Repetto has coined the term '*Adaptation Myth*' – that just because an [actor] *can* adapt does not imply that it/they *will* adapt, at least not in the efficient and timely way needed if major damages are to be avoided. His Working Paper published in 2009 used the case of New York city's flood and sea surge preparedness as an example – where an awareness of adaptation requirements and planning existed, yet the implementation of actual 'actions' based on future vulnerability scenarios was potentially insufficient. A scenario that hurricane Sandy recently proved to be very accurate. A similar situation was seen in Australia in 2009 during the Black Saturday bushfires, where 173 people were killed, and a subsequent royal commission found that emergency services and preparedness strategies were not sufficiently adequate for the climatic conditions predicted

influences, and that instead of attempting to maintain a constant state, adaptation should be seen as an ongoing process that allows for flux and development – concepts central to present conceptualisations of resilience theory (Adger, Arnell, & Tompkins 2005; Folke 2006).

In order to conceptualise the interaction between resilience and vulnerability, which I believe is lacking in the literature, and operationalize these terms in my study of the Victorian wine industry, I developed a theoretical framework that demonstrates how adaptive capacity lies at the interface of these two theories (Figure 2-2). Models of resilience and vulnerability share a focus on shocks and stresses experienced in a social-ecological system, the response of the system, and their capacity for action (Adger 2006).

Since its emergence in the field of ecology in the 1970's (Holling 1973), resilience theory has developed with the contributions of various disciplines to incorporate coupled human-environment system perspectives (Turner *et al.* 2003). Resilience the context of adaptation now refers to two major concepts: the amount of change or disturbance a system can absorb before it changes radically in function and structure, which I have termed '**protection'**; and the system's capacity to self-organise and maintain options for development in emerging circumstances, which I have termed '**opportunity'** (Adger 2006; Nelson *et al.* 2007)

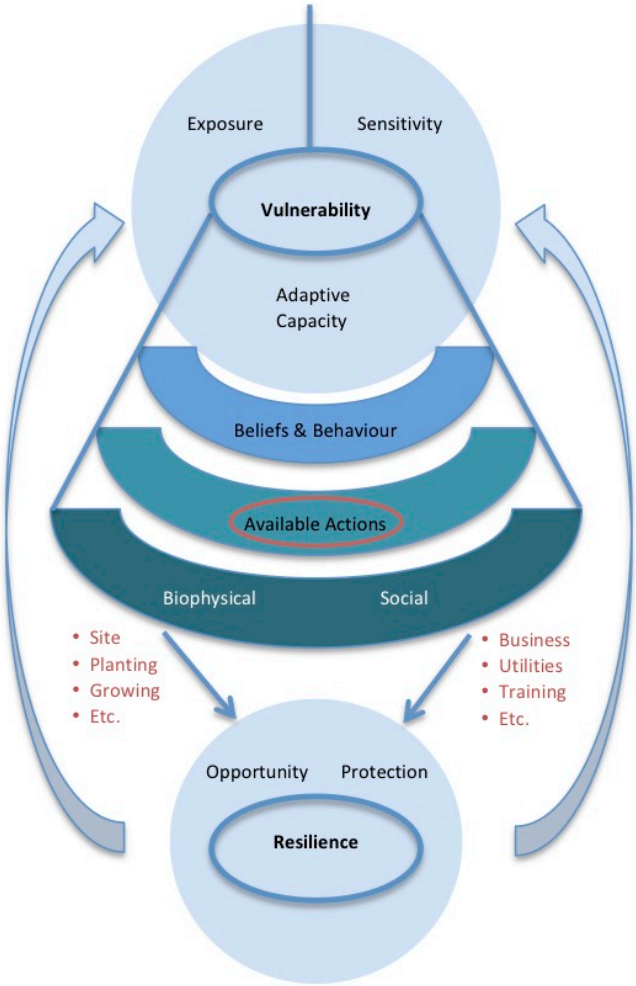


Figure 2-2: ***Resilience and vulnerability interaction****. This conceptual model was developed during my thesis to demonstrate the interaction between resilience and vulnerability and how my research into adaptation actions relates to these processes. The outer blue arrows represent the influence a system's resilience has on how sensitive and exposed it can be to a particular vulnerability. The expanded vulnerability component of adaptive capacity demonstrates how, in turn, this component influences the resilience of a system through the application of available adaptation actions (circled in red) that can either exploit opportunity or provide protection. The beliefs and behaviour of an actor influence the available actions they chose to draw on. In an agri-business context, these actions can relate to both biophysical and social strategies – examples of which are listed in red bullet points. My research will focus on these available actions and some of the potential beliefs and behaviour that can influence their application.*

As highlighted by Adger (2006), vulnerability is influenced by the build up or erosion of social-ecological resilience elements, as displayed by the outer arrows in Figure 2-2. Vulnerability is defined as a function of exposure, sensitivity and adaptive capacity in the face of stress (Adger 2006; Eakin & Luers 2006). Adaptive capacity is, at its core, made up of behaviour and beliefs, and practical actions that an actor can draw on or change in order to enhance the protection of the system and/or develop opportunities (Preston & Stafford-smith 2009), as demonstrated by the inner arrows of Figure 2-2.

As highlighted in the introduction of this thesis, much is known about exposures and sensitivities of the wine industry, and some suggestions of adaptive biophysical strategies have been identified (Hadarits *et al.* 2010; Jones & Webb 2010; Nicholas & Durham 2012b). When considering the adaptive capacity of the Australian wine industry, a national research program is presently investigating aspects of behaviour change, transition and discourse that contribute to adaptive capacity, predominantly looking at the '**Beliefs and Behaviour**' tier of adaptive capacity (Figure 2-2) (Fleming & Vanclay 2010; Park *et al.* 2012). In their creation of a vulnerability scoping diagram for the wine industry in California, Nicholas and Durham (2012) identified a number of '**adaptive actions**' available to grape growers and winemakers, particularly '**biophysical actions**'. Galbreth (2012) has compiled similar inventories of '**adaptation actions**' in relation to the Australian industry, with the inclusion of a number of what I have termed '**social actions**'.

I hope to contribute to this body of work by creating a comprehensive inventory of adaptation actions that are being implemented at the farm level now, and are priorities for the future. These actions, born of a process that commences with the recognition of vulnerability, will combine with behaviour and beliefs to either absorb disturbance and reinforce a state of resilience, or see the system transition into a new state.

2.3 Research Strategy

A two-step exploratory approach was taken in the design of this research using both qualitative and quantitative data collection methods (Figure 2-3). The premise of such a design is that an exploration is needed of a developing phenomenon, such as climate change adaptation, and is particularly useful when a researcher needs to identify important variables to study quantitatively (Creswell & Clark 2007: 86). In order to fully conceptualise the pressures on wine businesses, qualitative semi-structured interviews were conducted, which provided additional variables that were added to the inventory of possible adaptation actions subsequently used in a quantitative closed-question online survey. Exploring producers' experiences and insights has been used in this, and other similar research, as *'the starting point to identify problematic conditions, as well as processes leading to vulnerability and the capacities and strategies used to adapt'* (Hadarits *et al.* 2010). This follows a two-step exploratory design model, where *'the results of the first method (qualitative) can help develop or inform the second method (quantitative)'* (Greene et al., 1989, in: Creswell & Clark 2007: pg. 86).

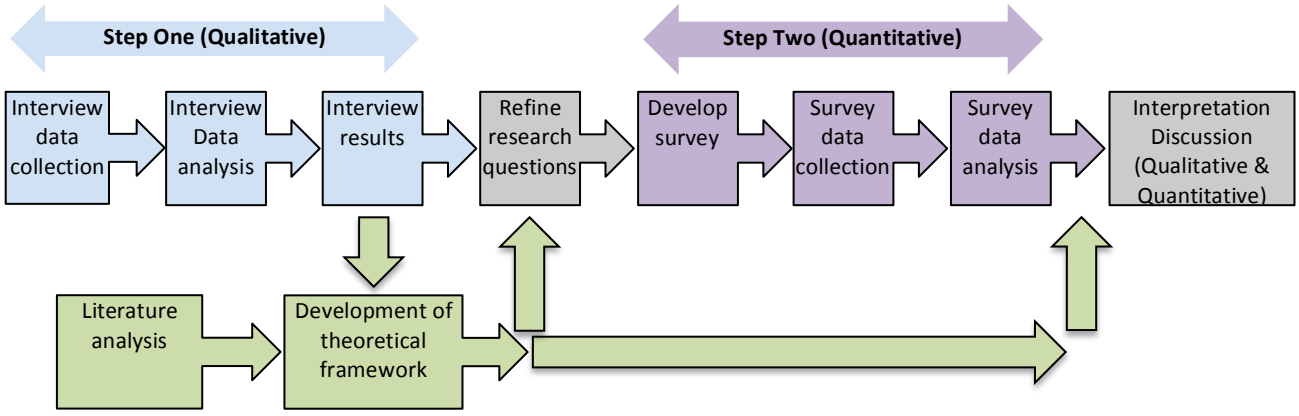


Figure 2-3: The research process used in this thesis, adapted from 'Exploratory Design Instrument Development Model' (Creswell & Clark 2007: 76). Blue text boxes represent Step One (the qualitative data collection phase) and purple text boxes represent Step Two (the quantitative data collection phase) of this research strategy. The two grey text boxes represent times of interpretation and inclusion of the iterative theoretical and literature review processes (as described in the lower green text boxes).

2.3.1 Semi-structured Interviews

The first step of data collection (Figure 2-3) in this exploratory design was a series of six semi-structured qualitative interviews (Bryman 2008:438) conducted on-site at five different wine businesses in the Yarra Valley (south east of Melbourne) and Rutherglen in the North-East Victoria. The Yarra Valley was selected as it was close to my home and I was familiar with the region. Rutherglen was selected as it provided a different variety, climate and environmental pressure picture to the Yarra Valley, and I had existing contacts in the region.

In order to avoid the self-selection bias that can result from mass-email approaches, I developed a list of potential interviewees with a wine store-owner and business associate of my family's. He was able to provide me with an introduction to a wide variety of wine businesses that I could call personally. This direct approach was helpful in establishing a rapport with various participants, and more conducive to receiving an invitation without having to first provide specific information that could bias a participant's willingness to be interviewed.

All people interviewed fit three criteria:

1. They were the owner and/or a primary decision maker in the business they were involved in
2. Their business was located in one of two regions I was able to physically visit; the Yarra Valley or Rutherglen
3. The primary focus of their business was wine grape growing and/or wine making

Interviews took place between 30th January – 2nd February 2012 in Rutherglen, and on the 16th February 2012 in the Yarra Valley. In order to ensure some cross-case comparability (Bryman Pg 440), I used a set of guiding questions (Annex 2), however as my main objective was to understand the interviewee's point of

view of what they feel is relevant and important, the interviews were conducted in a way that allowed for divergence from the set questions (Bryman 2008: 437). All interviews were recorded in their entirety using Express Dictate software, and ranged in length from 30 – 80 minutes.

Each interview was conduced on-site at each wine business at a time that suited the interviewee. Being on-site was the best way for me to develop a greater understanding of the dynamics of grape growing and wine making in Victoria through first-hand observations, having informal conversations with winery staff and being shown how specific actions are implemented (and sharpening my appreciation for high-quality premium wine). This field experience enhanced the relevance of my study (Nicholas & Hinckley 2011).

Interview Analysis and Outcome

As highlighted by Ryan and Bernard (2003), '*without thematic categories, investigators have nothing to describe, nothing to compare, and nothing to explain. If researchers fail to identify important categories during the exploratory phase of their research, what is to be said of later descriptive and confirmatory phases?*' Themes, fundamentally, are the concepts we are tying to describe through research and can often be group loosely into categories (Ryan & Bernard 2003). Themes were developed from my interviews through an iterative and reflexive examination and re-examination of raw interview data (Braun & Clarke 2006). The first step of theme identification took place during the transcription of each interview, which allowed some reflection on the conversations that took place (Ryan & Bernard 2003). A basic content analysis was undertaken where the subjects discussed in each response were noted and possible themes associated with climate change adaptation actions identified (Bryman 2008 Pg 282). This was particularly important as many discussions took place outside the frame of the guiding interview questions, and it is never possible to anticipate all the themes that may arise prior to data analysis (Dey 1993: 97-98).

Transcripts were then printed and reviewed using a range of coloured markers (Figure 2-4) that related to: climate change associated environmental stress scenarios; pre-identified adaptive capacity 'dimensions' (Galbreath 2011a; Nicholas & Durham 2012); themes noticed during the transcription phase and, as yet, unclassified themes or points of interest. As discussed by Ryan and Bernard (2003), there is a wide range of analysis tools available when conducting a content analysis. As the purpose of this interview stage was exploratory, and needed to be undertaken rather

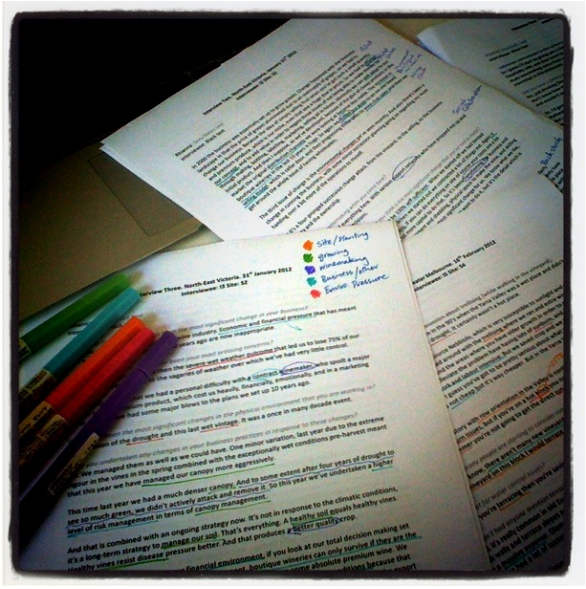


Figure 2-4: Colour-coding transcripts during my theme analysis process (Photo: Rhianna Dean)

rapidly, the tools used were repetition of concepts and words, as were particular similarities and differences within and between each interview.

It was clear that some overarching themes that existed in the interviews were indeed consistent with adaptive capacity dimensions already identified by Nicholas and Durham (2012) and Galbreath (2011). It was also evident that some of the themes identified in the interviews suggested additional adaptive actions that were taking place in the field, particularly related to business and utilities decisions.

In their vulnerability analysis for the hazard of climate-related decreases in yield and quality of premium winegrapes in California, Nicholas and Durham (2012) identified a number of adaptive capacity strategies. These were cross-referenced with inventories of adaptive strategies included in a recent survey conducted by Galbreth focusing on wine business responses to global warming in Tasmania, Australia (Galbreath 2011a; Galbreath *et al.* 2012). A table identifying pertinent adaptation actions was created using adaptation dimensions and actions identified in these existing studies and the themes found in my empirical data collected during interviews (Annex 3). Throughout this thesis, adaptation actions are grouped into overarching categories called Site, Planting, Growing, Winemaking, Business and Utilities 'dimensions' (Annex 3).

This data was then used in the creation of the second step of this research strategy, a structured online survey. Data collected in the interview process was also used to contribute to the thesis discussion, providing the opportunity of having first-hand opinions and statements that relate to key discussion topics.

2.4 Online Survey

2.4.1 Survey Development

The second phase of this exploratory research design (Figure 2-3) was the development of a web-based survey (Annex 4) – undertaken using Survey Gizmo software. Online surveys are advantageous as they are low cost, provide attractive and user friendly formats and suit international research with their fast response times (Bryman 2008: 653). There is also evidence that online surveys have fewer unanswered questions and better responses to open questions (Bryman 2008: 653).

In order to answer questions relating to recent actions **(RQ1)** and future priorities **(RQ2)**, survey respondents were asked about their implementation and prioritization of adaptation actions that fall under six different dimensions: site, planting, growing, winemaking, business and utilities (Annex 3). The full list of pre-identified adaptation actions was developed through both *a priori* and inductive approaches used during the literature review and semi-structured interviews (Figure 2-3) (Ryan & Bernard 2003).

To find out what recent actions had been implemented **(RQ1)**, respondents were asked if they had

undertaken any of 35 adaptation actions in their winery or vineyard in the past five years. A timeframe of five years was selected as it was in 2007 that Australia elected a new government who had campaigned on taking action on climate change, establishing an emissions trading scheme and ratifying the Kyoto Protocol – moving climate change issues to the forefront of the national dialogue (Rootes 2008). It was also in 2007 that key climate change and wine industry research was presented at the thirteenth Australian Wine Industry Technical Conference (Webb *et al.* 2007a).

After extensive revision of the survey questions, I decided on different response options for different dimensions. Recent site, planting, business and utilities actions were more suited to discrete (yes/no/don't know) responses, as these actions were most likely to be implemented on a 'once off' basis. Recent growing and winemaking actions were suited to continuous/ frequency scale ('never', 'occasionally', 'sometimes', 'regularly' or 'consistently') as these actions were most likely to be undertaken repeatedly or seasonally.

For information about the future priorities of wine businesses **(RQ2)**, respondents were asked about the priority they attributed to implementing a condensed inventory of 16 actions in the next 10 years[††] (Annex 3). The number of actions was condensed into more general 'strategy' groups, primarily for user-friendliness. I designed the survey to be quickly answered and did not want people to skip the future priorities section because it seemed repetitive. It is for this reason that some actions were combined. Response options available were based on a priority scale.

To capture data related to climate change perceptions **(RQ3)**, the Yale Project on Climate Change survey format was used as a basis for my own (Leiserowitz, Maibach, & Roser-Renouf 2009). I deemed these pre-existing survey questions to be clear, direct and diverse enough to capture information regarding attitudes and uncertainties that may exist in the surveyed population. Similar Australian surveys were considered (Leviston & Walker 2011), however I believed their questions were not sufficiently robust. Survey participants were asked if they believed that climate change is happening, and if they do, whether it is caused primarily by natural or human factors. They were then asked what kind of impact they thought climate change would have on their business in the next thirty years (see footnote below) and for their opinions regarding the introduction of the Australian carbon tax.

To provide robust cross-tabulation options and address what influential factors exist in relation to adaptation action implementation **(RQ4)**, supplementary data relating to the demographic factors for each individual (age, education, gender) and the business they represent (location, size, etc.) was also captured

[††]A timeframe of 10 and 30 years were selected for RQ2 and RQ3 as this would be approaching the 2030 and 2050 climate modeling scenarios used in key research presented to the Australian wine industry at the thirteenth Australian Wine Industry Technical Conference, and subsequently published in key industry journals and periodicals by Webb, Whetton & Barlow (2008a; 2008b)

in the survey. Prior to its finalisation, a pilot survey was tested by three of the interviewees. In this test-version of the online survey, there was space to write comments and provide feedback, which was used to modify the final survey. The final survey was online from the 18th May – 16th June 2012.

Participant recruitment and sampling

In order to gain a large sample of survey participants, a number of different methods were used to communicate with and recruit wine industry professionals. Emails were sent out through 6 regional industry associations, 1 state industry association, and 218 individual emails. Initially it was my intention to use snowball-sampling methods (Bryman 2008: 202) by enlisting the support of state and regional grape grower and wine maker associations. I hoped they would be able to email the survey link to their members and that this would bring greater legitimacy and higher response rates. All 22 regional associations in Victoria and the state-wide Wine Victoria were emailed and asked if they would be willing to participate in this endeavour. Six regional associations responded positively and agreed to email the survey to members, as did Wine Victoria. In a number of cases I was never able to make contact with a representative from certain regions, via email or phone. On reflection of comments made by my interview participants regarding regional industry associations, it became clear that their focus is often on marketing and event planning rather than research and extension activities.

My interviews also highlighted that not all wine businesses are members of regional associations, and that personal communication and relationships are important in the industry. I therefore decided to send personalised emails to every wine business listed in the Wine Regions of Victoria guidebook (Tourism Victoria 2010), to members of independent winemaker collectives (South Pack, The Young Bunch) and a selection of businesses listed on the comprehensive Australian wine website www.winediva.com.au. This personalised strategy proved to be the most successful in generating complete survey responses.

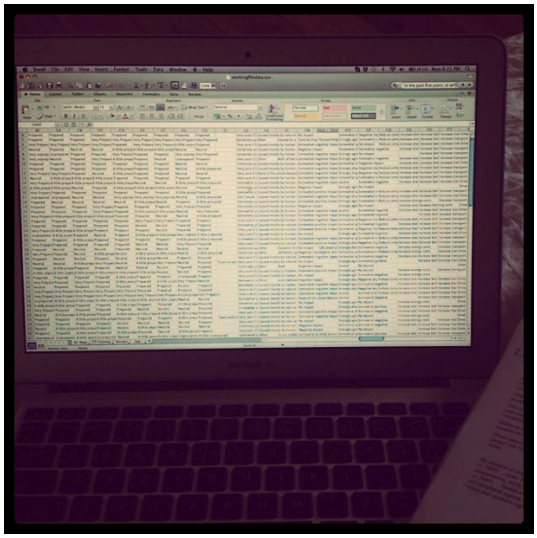


Figure 2-5: Ask many questions, you'll have many answers. Raw survey data from Survey Gizmo transferred into MS Excel for analysis (Photo: Rhianna Dean)

Survey Analysis

The online survey was opened 120 times by potential respondents. 81 respondents completed the full survey, 13 partially completed and 26 exited without any data being recorded. Of the 13 partial responses, five partial responses were included as they contained complete data relating to RQ1 and/or RQ2, thus comprising the total response of 86 surveys included in a final data set that was

exported into MS Excel to be analysed (Figure 2-5). Once in Excel, response rates were counted for each question and reported as a percentage of the N value of each response group, as reported below. Data were grouped for analysis based on criteria (e.g., combining all the 'positive' – 'yes' 'regularly' and 'consistently' – response percentages for RQ1 (Figure 3-3)) and graphed using Microsoft Excel and modified in Adobe Illustrator software.

2.5 Ethics

Being a researcher carries certain responsibilities. It is my personal belief that all researchers should actively consider the ethical implications of their research process, regardless of the ethical guidelines and regulations they are operating under. Particularly when conducting research in a country such as Australia, where ethics play a large part in the academic process (Australian Reseach Council 2007), one must be prepared to discuss and articulate these implications. How I addressed prominent **ethical research principles** (Silverman 2010: 153-4) can be found in Annex 5.

3 Results

3.1 Survey Respondent's Profiles

Survey responses showed that the Victorian wine industry is typified by a large number of small private or family-owned businesses that are managed by people who are responsible for a variety of tasks in their business. The vast majority of people surveyed had post-high school education (many with university degrees), and believe that climate change is happening and human caused.

Businesses from all Victorian wine zones are represented in this survey, as well as four who grow and/or purchase grapes from multiple Victorian zones, and one business that grows and/or purchases grapes from multiple national zones, including in Victoria. The spread of respondents from the various wine zones in Victoria varied widely. This is partly due to the overall number of possible respondents from each zone (i.e. Port Phillip has the largest number of wineries in Victoria, whereas Gippsland has few (Halliday 2012).

3.1.1 Individual Profiles

The demographics of the respondents recorded in this survey are consistent with demographic trends seen across the Victorian Wine Industry (Inga Ting 2013). The majority of respondents were males (81%), with a majority of them over the age of 55; the women respondents were more likely to be younger and have been working in the industry for fewer years (see Table 3-1). All respondents were over the age of 25 and had been working in the wine industry for at least five years.

	Respondent's age			**Years in the wine industry**		
	25-34	**35-54**	**55+**	**5-15**	**15+**	**NA**
Male (N=69)	4%	39%	57%	38%	59%	3%
Female (N=16)	13%	37%	50%	69%	31%	0%

Table 3-1: Demographic data (respondent age and number of years in the industry) of survey respondents, broken into gender groups. Male (N=69) data is shown across the blue row, female data (N=16) is shown across the green row.

The majority of respondents are responsible for a variety of tasks at their business (Figure 3-1). When asked about their key responsibilities, 31% selected 'General/executive management and winemaking equally' with a further 18% selecting 'Other' and all including a comment that equated to 'all of the above'. This is a predicable scenario as many of the respondents work at small-scale, family owned businesses (Section 3.1.2), and demonstrates the diverse skill-set required when working in this setting.

As can be seen in Figure 3-2, all respondents completed high school. Eighteen percent of respondents have completed a certificate or diploma, 43% have completed a bachelor degree, and a further 11% undertook an honours year. 13% of respondents have gone on to post-graduate studies (Masters or PhD).

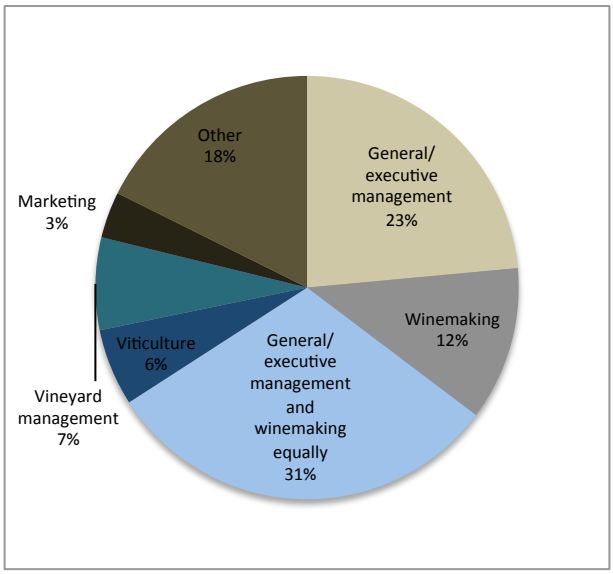


Figure 3-1: Percentage breakdown of survey responses to the question: 'What is your primary role at your business? (N=85)

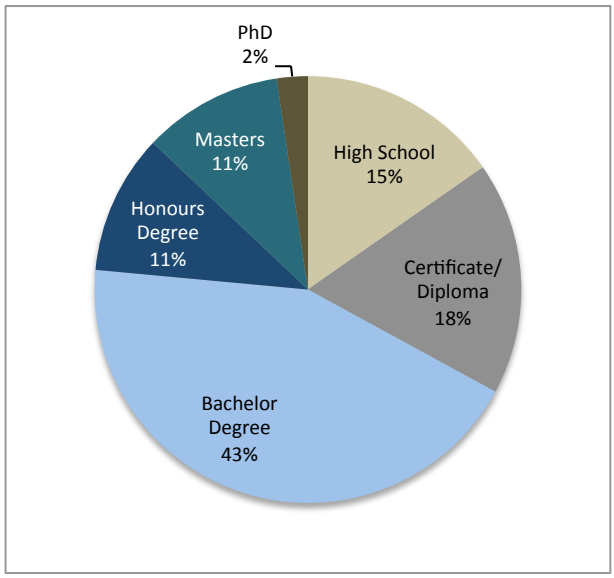


Figure 3-2: Percentage breakdown of survey responses to the question: 'What is the highest level of education you have completed?' (N= 85)

3.1.2 Company Profiles

The vast majority of businesses surveyed identified as Private/Family Owned (97%) and are considered to be small, with more than two-thirds of respondents producing less than 10,000 cases of wine and grossing less than AU$1 million in the last financial year. The high number of respondents from smaller businesses was to be expected, as many corporate wine businesses are not state-specific and may not have been reached by my communications. This response rate is also consistent with wider trends in the Australian wine industry, where out of 2,420 wine companies nation-wide in 2010, 20 companies produced 90% of Australian wine (GWRDC 2011) and 81% of Australian wineries crushed less than 50 tonnes of grapes (Australian Bureau of Statistics (ABS) 2010).

Despite many of the businesses surveyed being considered small, 59% of respondents who provided export data reported being involved in some level of export activities. 18% of businesses recorded having sales higher than 25% going to export markets. This highlights the global nature of the wine industry today, and the importance that transport costs, exchange rates, and global consumer preferences have on the success of many wine enterprises.

3.2 Environmental Stress Preparedness

Overall, the majority of respondents feel prepared for most environmental stress scenarios. Respondents feel least prepared to deal with frost, with approximately half feeling neutral or unprepared in some way to deal with this event. They were also less prepared to deal with flood and lower mean growing temperatures, with 30% or more of respondents feeling neutral or unprepared for these events. It is important to note that in all of these cases, the number of people who feel 'unprepared' was much less than those who feel 'neutral' (Table 3-2). Respondents felt most prepared to deal with drought (only 1 respondent feels unprepared for this situation), closely followed by pest and disease pressure and heatwaves (Table 3-2).

	Environmental Stress Scenario								
	Drought	**Increased pest and disease pressure**	**Heatwaves**	**Higher mean growing season temperatures**	**Excessively high rainfall**	**High humidity**	**Flood**	**Lower mean growing season temperatures**	**Frost**
Prepared	87%	84%	83%	79%	78%	73%	70%	63%	51%
Neutral	12%	14%	12%	16%	13%	22%	17%	29%	34%
Unprepared	1%	2%	6%	5%	9%	5%	12%	8%	14%

Table 3-2: Percentage of respondents (N=86) who felt 'Prepared', 'Neutral' or 'Unprepared' to deal with the nine listed environmental stress situations. In the original survey respondents were given a scale of seven different response options, which have been combined in this table. 'Very Unprepared', 'Unprepared', and, 'A little unprepared' responses were added together into a general ***'Unprepared' group****, 'Neutral' responses remained as they were collected in the original survey, and, 'A little prepared', 'Prepared', and, 'Very Prepared' responses were added together into a general* ***'Prepared' group****.*

3.1 What adaptation actions have people been taking in their wine businesses?

When asked about actions implemented in the past five years, survey respondents could choose from discrete responses for Site, Planting, Business and Utilities dimensions and a frequency scale with five response options for Growing and Winemaking dimensions. For the remainder of this study, reference to **'positive'** adaptation action data includes **'yes', 'regularly'**, and **'consistently'** responses. Furthermore, Growing and Winemaking domain responses have been grouped for this analysis, and from here forward the following terms will be used for each data group: **'Regularly'** refers to 'regularly' and 'consistently' response data. **'Occasionally'** refers to 'Sometimes' and 'Occasionally' response data.

The most common action implemented in the past five years was using canopy management techniques to provide increased shade and/or cooling, with more than 70% of respondents regularly implementing this action in their vineyard (Figure 3-3). Growing and Business were the only dimensions that had actions regularly implemented by more than 60% of respondents.

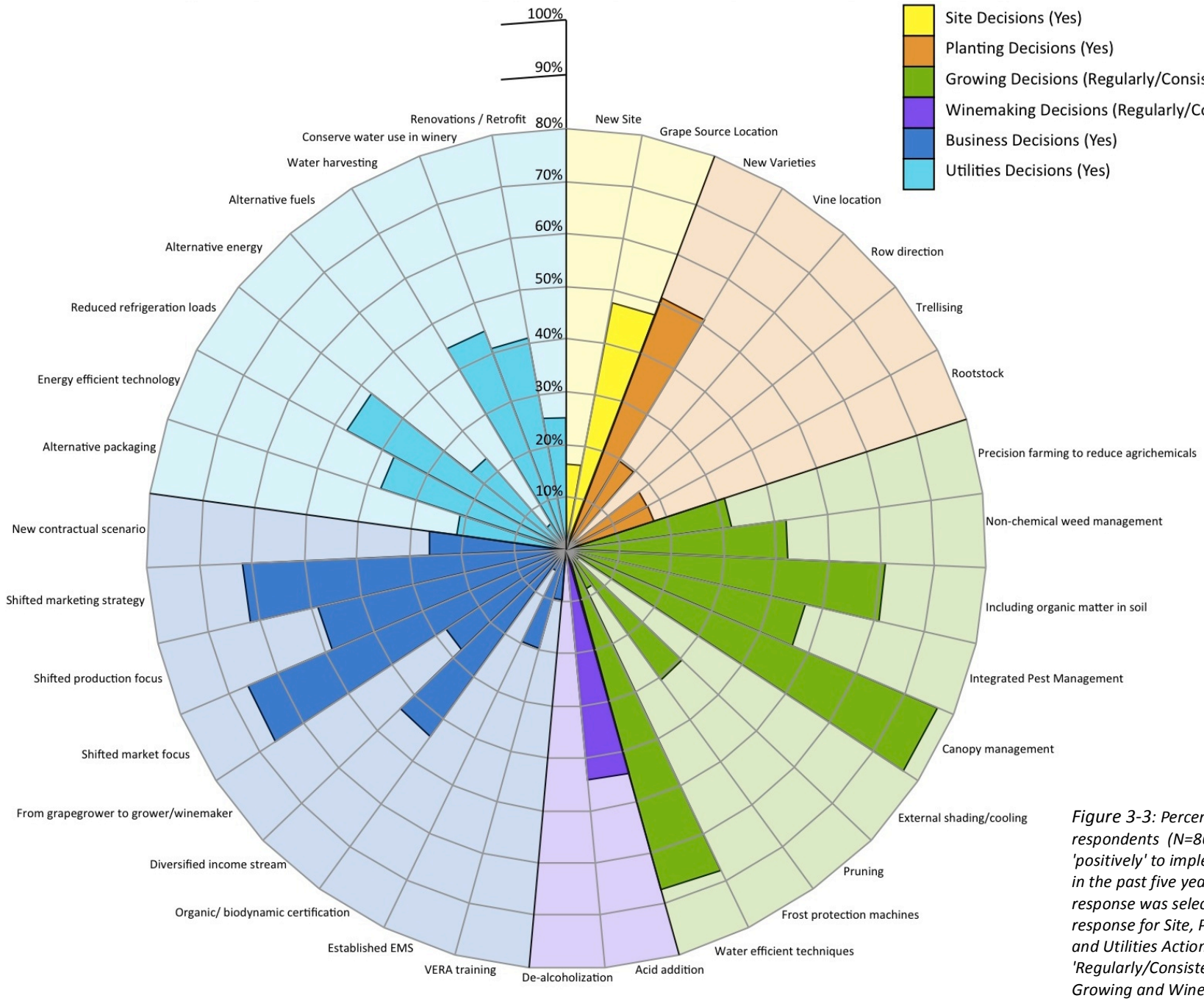


Figure 3-3: Percentage of respondents (N=86) who responded 'positively' to implementing an action in the past five years. A positive response was selecting a 'yes' response for Site, Planting, Business and Utilities Actions, and a 'Regularly/Consistently' response for Growing and Winemaking actions.

3.2.1 Site and Planting Actions

Actions that relate to Site and Planting were some of the least implemented actions from across all dimensions in the survey (Figure 3-3). Only two respondents have planted their rows in a new direction in the past five years, and there were only 14 businesses (16%) who have made a decision to purchase or lease land in new locations. Less than 20% of respondents have undertaken actions that relate to vine location, row direction, trellising strategies or choice of rootstock (Figure 3-3). Actions regarding a change in varieties and grape source location were more widely implemented, with 70% of respondents having either started sourcing grapes from a new location or planting/sourcing new varieties.

3.2.2 Growing Actions

It is extremely uncommon for businesses to alter vine-environment interaction through the use of technological fixes such as external shading or cooling systems or using wind machines as a frost protection action. Less than 10% of respondents reported using these practices regularly. However, more than two thirds of respondents (67%) did report improving water efficiency in the vineyard, which can include the instillation of technological solutions such as drip irrigation and using soil moisture sensors (Figure 3-3).

The most common regularly implemented growing actions over the past five years were canopy management techniques to provide increased shade and/or cooling (77%), using water efficient techniques in the vineyard (67%) and including organic matter in soil management strategies (60%).

Responses for actions relating to reducing the use of agrichemical use (precision farming, manual weed management, and integrated pest management) were split fairly evenly between ‘never’, ‘occasionally’ and ‘regularly’ groups (Figure 3-3), with approximately two-thirds of respondents using these techniques at some time in the past five years.

3.2.3 Wine Making Actions

There was a great difference in response to the two winemaking actions included in the survey. Only one respondent uses de-alcoholisation processes in the winery on a regular basis, with 21% of respondents using this practice occasionally. The vast majority of respondents have used acid addition practices to balance their wine at some point in the past five years, with 44% regularly, and a further 35% occasionally, implementing this action. As highlighted in Section 1.2.2, high temperatures lead to high sugar levels in grapes and lower acid. High sugar content ferments into high alcohol levels and can cause unbalanced wine flavours, which is why both of these strategies can assist winemakers in adapting to warmer growing season and harvest temperatures and heatwave events.

3.2.4 Business Actions

When asked about recent business actions, there were a number of interesting trends evident in the data. Despite high responses related to the incorporation of organic and biodynamic principles in their growing practices (see 2.1.2 above), only four respondents have received organic or biodynamic certification in the past five years (Figure 3-3). Only 9% of respondents have undertaken training in the key governmental environmental risk assessment tool (VERA) and only 20% have implemented an environmental management system (EMS) (Figure 3-3). Of the eight respondents who have undertaken VERA training, six of them have also implemented an EMS.

Almost half of the respondents have diversified their business to include other revenue-raising activities (Figure 3-3) such as establishing a cellar door, restaurant/cafe, offering accommodation, conducting public winemaker courses etc. A number of businesses also reported undertaking particularly transformational business actions, with a combined 43% significantly altering their contractual scenario and/or shifting from being solely a grape grower to becoming a grape grower/wine maker (Figure 3-3).

More than two thirds of respondents reported recently shifting their market focus, for example making changes to their international/local market reach, developing a marketplace niche, or working with a specialised distributor. More than 60% reported shifting their marketing strategy (e.g., re-branding their product, establishing social media campaigns), and 49% of respondents reported shifting their production focus (e.g., size of production, quality profile) (Figure 3-3).

3.2.5 Utilities Actions

The implementation of actions relating to utilities (energy and water) were varied in the past five years. Only 6% of respondents have switched to using alternative fuels such as biodiesel or ethanol, while 23% of respondents have started to purchase or generate alternative energy. Few respondents (24%) have made the decision to undertake renovations or retrofit their winery (i.e. improving insulation, changing roofing materials, building underground cellars) in order to reduce energy requirements (Figure 3-3).

The most prevalent utilities actions implemented in the past five years were related to water and electricity use, with 48% of respondents reducing refrigeration loads, 44% establishing water harvesting systems, 41% conserving water use in the winery, and, 38% including energy efficient technologies in their wineries (e.g., Fitting LED lighting, variable speed devices, energy-rated pumps/ compressors /fans etc.) (Figure 3-3).

3.3 What adaptation actions are priorities for the future?

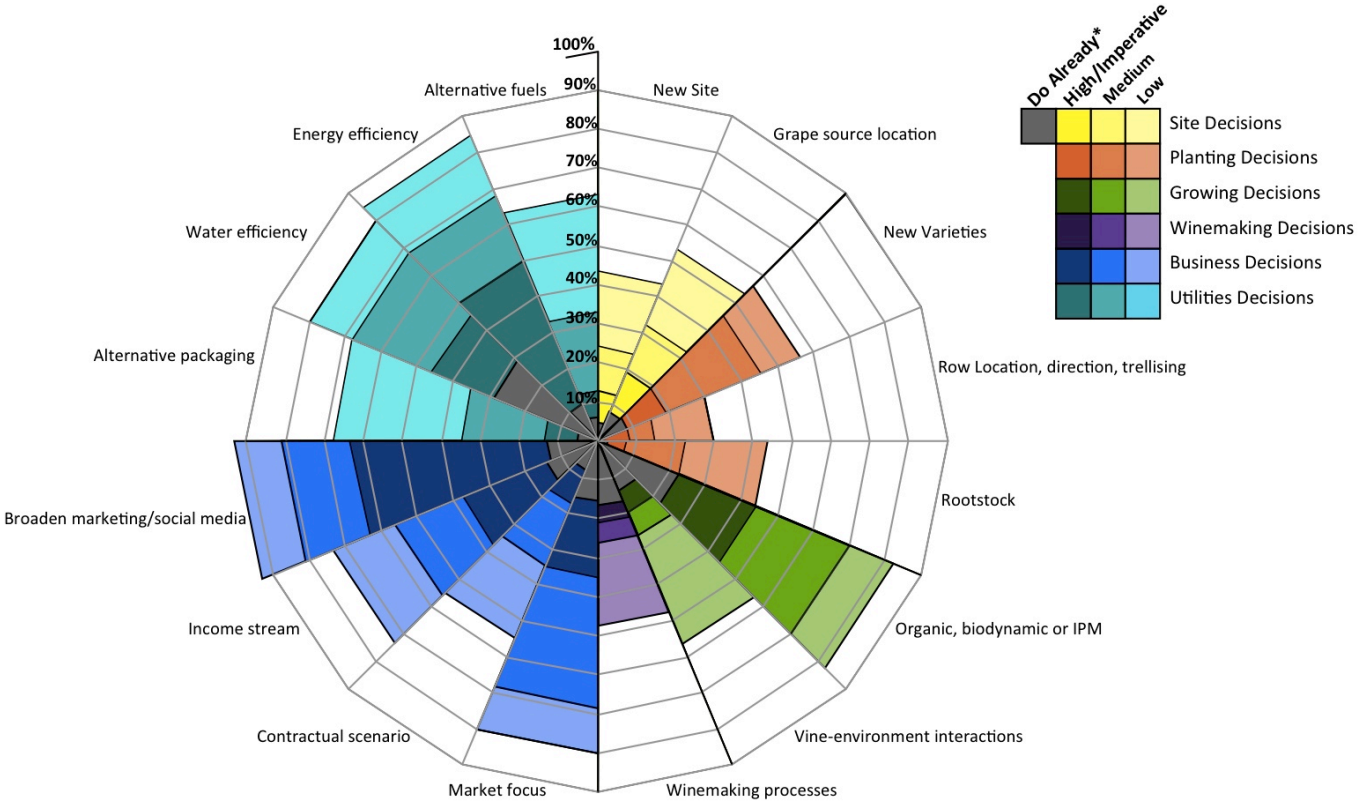


Figure 3-4: Scaled percentage of responses (N=84) to the question: 'When thinking of actions you would like to implement in the next 10 years, what priority do you give to the following actions?' (The full response option for'Do Already' was 'we do this already and do not intend to upscale this action'.

When asked about action priorities for the next 10 years, respondents could chose from a priority scale of five response options for all dimensions (Figure 3-4). For the remainder of this thesis '**high priority'** refers a combined group of both 'high' and 'imperative' data responses, which are also groups in Figure 3-4.

When looking at priorities for the future (Figure 3-4), there are similar patterns to recent actions implemented (Figure 3-3), with the highest priorities also coming from the Business, Utilities and Growing dimensions. Respondents were less likely to see Planting and Site actions as a priority, which is consistent with their recent actions in these dimensions.

Site and Planting actions were not identified often as high priorities. Approximately half of all respondents did not have any priority to make changes to their site location, grape source location and rootstock choices. The overwhelming majority of respondents have no priority to change their row locations, direction and/or trellising techniques (Figure 3-4). Interestingly, when asked if 'changing the type or composition of varieties you grow that you think will be better suited to future climate conditions,' only 27% of respondents felt this was a high or medium priority (Figure 3-4). However, when looking at actions taken in the past five years, more than 50% of respondents planted or sourced new grape varieties they had not previously grown (Figure 3-3).

Grape growers are prioritising the implementation of growing actions that relate to the use of organic and biodynamic strategies to build resilience in their crop (such as minimizing agrichemicals, improving soil quality through reduced tillage or cover crops, integrated pest management or establishing biodiversity corridors). Almost half of respondents see this as a high or medium priority for the next ten years (Figure 3-4), with and additional 23% already implementing these actions. This is in contrast to only 12% of respondents seeing the implementation of growing actions that work to alter vine-environment interaction, such as adding frost protection, shade cloth or sprinkler cooling, establishing wind breaks etc., being a high or medium priority (Figure 3-4).

Winemaking responses were very evenly split between no priority and some priority for action or maintaining existing practices (Figure 3-4) – this is likely to have been influenced by the divergent trends evident in actions from the past five years – with the vast majority of respondents using acid addition, and the vast majority not using de-alcoholization (Figure 3-3). Interestingly, only 10% of winemakers see it as a high or medium priority to incorporate any of these techniques into their winemaking process in the future (Figure 3-4).

The three actions that were most often referred to as a 'high priority' came from the Business and Utilities dimensions (Figure 3-4). By a large margin, the highest priority for respondents is to broaden their social media reach and/or wine-club lists, with 68% of respondents viewing this as a high or medium priority. This was closely followed by priorities to improve energy efficiency and actions that would shift market focus or develop a new wine brand/niche (Figure 3-4). Six out of the eight Business and Utilities actions were seen as a high or medium priority by more than 30% of respondents (Figure 3-4).

3.4 What do Victorian grape-growers and winemakers think about climate change?

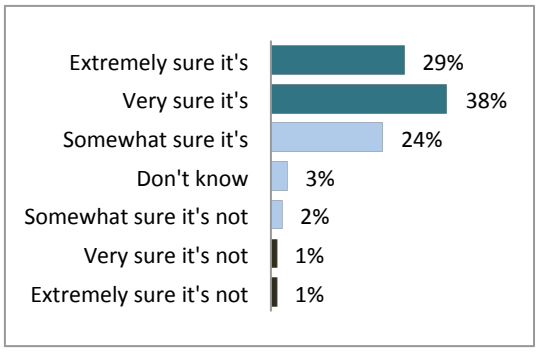


Figure 3-5: Responses to the survey question 'What do you think? Do you think climate change is happening?' (n=86)

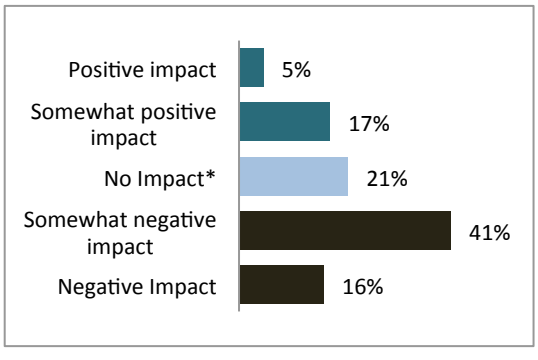


*Figure 3-6: Responses to the survey question 'What impact do you think climate change will have on your business in the next 35 years?' (n=86) *the category 'No Impact' includes responses 'No Impact' (19%) and 'None because I do not believe climate change is happening' (2%)*

As can be seen above in Figure 3-5, the majority of respondents are very or extremely sure climate change is happening (67%). There is also evidence, however, that some uncertainty exists amongst more than a quarter of respondents, with 29% reporting they are *somewhat sure/unsure* or *don't know* if climate change is happening. Of this group, it is important to note that 24% err towards the opinion that climate change is happening. There were only 2 respondents who were very or extremely sure climate change is not happening.

When looking at the perceived impact that climate change could have on their businesses (Figure 3-6), there was a mixed response. Of the respondents who believe that climate change exists, 22% feel that it could have a somewhat positive or positive impact, 21% do not think it will have any impact, and 57% believe it could have a somewhat negative or negative impact.

More than half of the respondents feel that climate change is caused mostly by human activity (Figure 3-7). This is consistent with data collected in a CSIRO Australia-wide study, which found 46.5% of people think that climate change is happening, and that humans are contributing significantly to it (Leviston & Walker 2011). The majority of respondents who selected 'other' volunteered a comment that equated to 'a combination of human and natural', which is a common volunteered response is other climate change perception research (Leiserowitz *et al.* 2009).

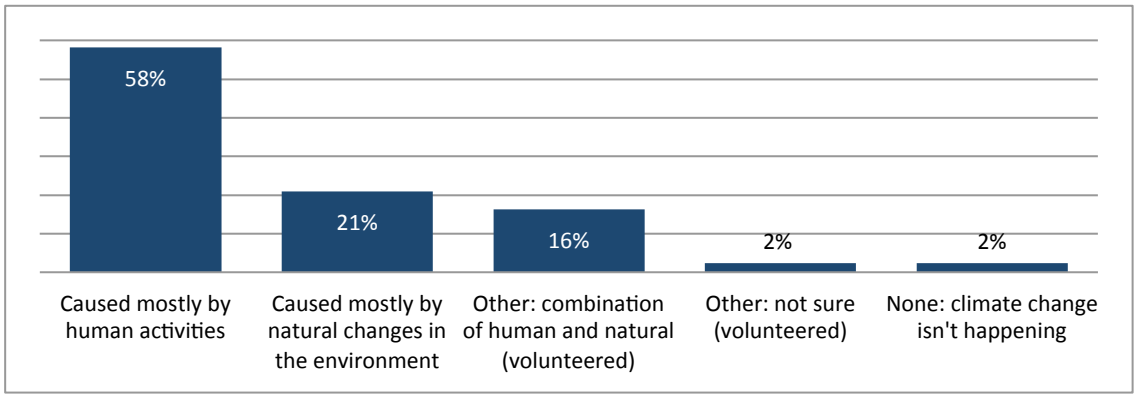


Figure 3-7: Percentages of response selections to the question 'If Climate Change is happening, do you think it is: Caused mostly by human activities; Caused mostly by natural changes in the environment; Other: volunteered statements that equated to 'combination of human and natural'; Other: 'not sure', or; None: climate change isn't happening.' (N=86)

3.4.1 *Opinions on the introduction of the Australian carbon tax*

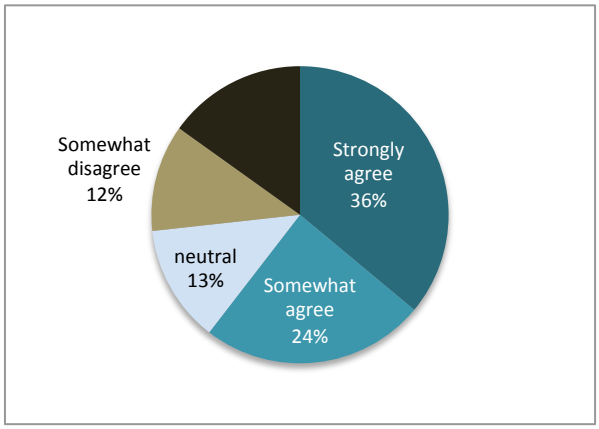


Figure 3-8: Percentage of responses to the question: Do you agree with the concept of pricing carbon emissions?? (N=86)

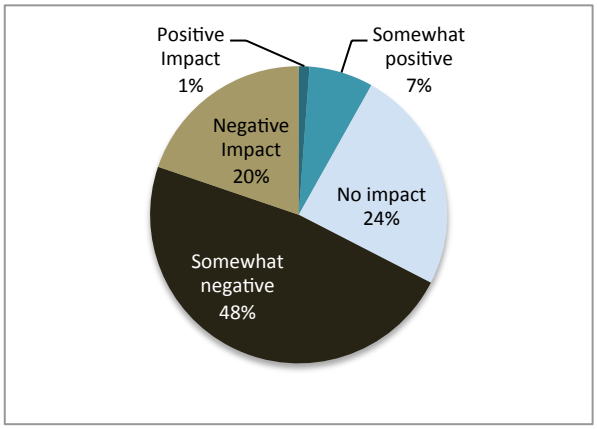


Figure 3-9: Percentage of responses to the question: What kind of impact do you think the Carbon Tax will have on your business? (N=86)

In relation to their Climate Change beliefs, survey participants were also asked for their opinions on the Australian carbon tax, which was due to be implemented in July 2012 – shortly after this survey was undertaken. A majority of respondents (60%) support pricing carbon emissions (Figure 3-8), despite the fact that 68% believe the carbon tax will have a negative impact on their business (Figure 3-9). Only six respondents (7%) reported attending any form of training or workshop related to the introduction of the tax. The only identifiable patterns to emerge from this group was that four of the six respondents strongly agreed with the concept of pricing carbon, and none of the six felt that the carbon tax would have any positive impact on their business. All six believed climate change is happening and is caused by human activities. However, these six respondents ranged between believing climate change would have a negative, somewhat negative, somewhat positive and positive impact on their business. The vast majority of survey respondents believe the carbon tax will increase energy, bottling and transport costs (Figure 3-10), which is consistent with Wine Australia predictions (Wine Australia 2013). Many respondents also believe that the carbon tax will encourage industry innovation, technological development and investment in energy efficiency (Figure 3-10).

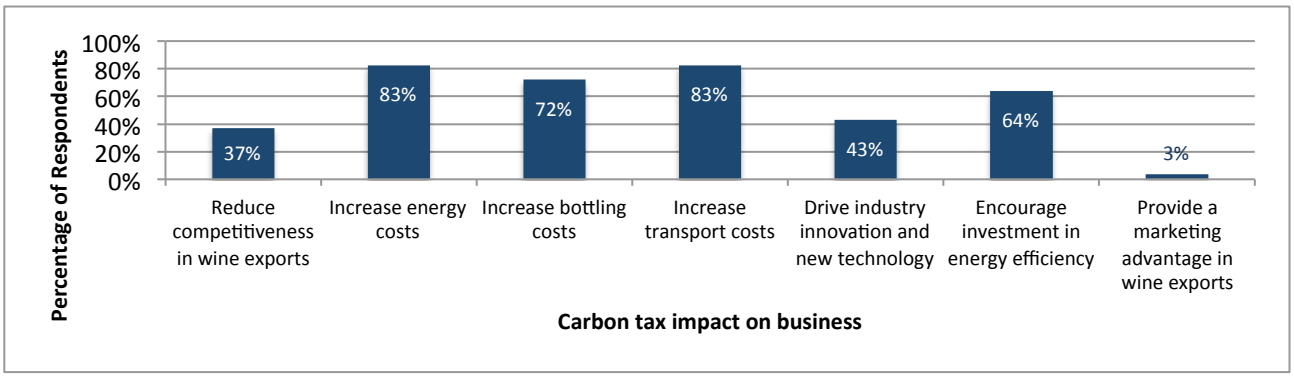


Figure 3-10: Percentage of total survey respondents who believe the carbon tax will cause any of the following impacts: reduced competitiveness in wine exports; increased energy costs; increased bottling costs; increased transport costs; drive industry innovation and new technology; encourage investment in energy efficiency, and/or; provide a marketing advantage in wine exports.

3.5 Are financial resources a more influential factor than climate change perception in adaptation action implementation and prioritisation?

3.5.1 Key climate change beliefs and adaptation action implementation

Is there a pattern between the respondents who believe climate change is happening, human caused and negative to their business (as discussed in Section 1.3) and the number of adaptation actions implemented, compared to responses from the total population surveyed? As can be seen below in Figures 3-11 and 3-12, there is often a slight increase in the average of adaptive actions implemented or prioritised in the majority of dimensions when the factors of 'Happening, Human, and Negative' are taken into account, particularly

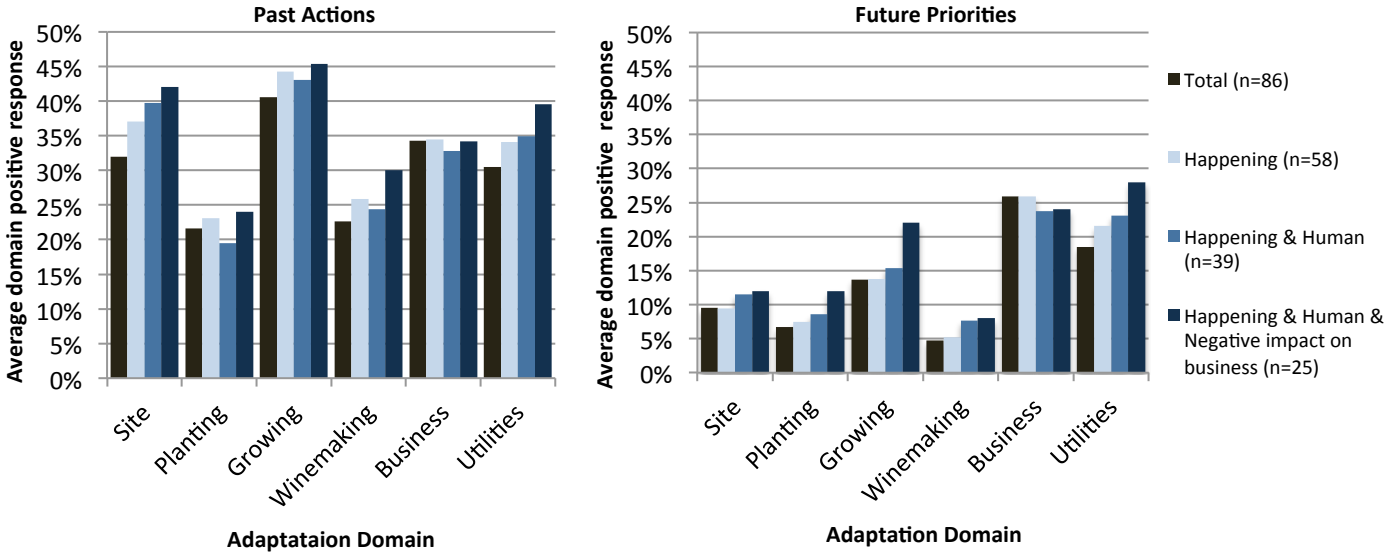


Figure 3-11: ***Recent adaptation action implementation comparisons between the total respondent cohort and various climate change perception groups.*** *The response data relating to adaptation action implementation in the past five years for the four listed cohorts (total respondents (N=86); those who believe climate change is happening (N=58); those who believe climate change is happening and human caused (N=39), and; those who believe climate change is happening, human caused and will have a negative impact on their business (N=25)) was split into separate groups, where the number of 'positive' ('yes', 'regularly' or consistently') response rates for each adaptation action was counted and the average number of positive responses for each adaptation dimension (Site, Planting, Growing, Winemaking, Business and Utilities) was then calculated. These average domain positive response rates were then compared across the four cohorts to create this column chart.*

Figure 3-12: ***Future adaptation action priority comparisons between the total respondent cohort and various climate change perception groups.*** *The response data relating to adaptation action prioritisation for the next 10 years for the four listed cohorts (total respondents (N=86); those who believe climate change is happening (N=58); those who believe climate change is happening and human caused (N=39), and; those who believe climate change is happening, human caused and will have a negative impact on their business (N=25)) was split into separate groups, where the number of 'positive' ('high' and 'imperative' priority) response rates for each adaptation action was counted and the average number of positive responses for each adaptation dimension (Site, Planting, Growing, Winemaking, Business and Utilities) was then calculated. These average domain positive response rates were then compared across the four cohorts to create this column chart.*

This ascending pattern is most evident in the recent and future Growing and Utilities dimensions. An anomaly of this pattern of action did exist in the Business dimension, where there is actually a slight decline in average actions implemented or prioritised by the group who believe climate change is happening, human caused and will have a negative impact on their business (Figures 3-11 and 3-12).

When considering these data, it is interesting to note that there were a number of specific adaptation actions that did see a greater difference in positive responses between the total group, and the cohort of respondents who feel climate change is happening, human caused and will have a negative impact (Table 3-3). The actions that saw more than a 15% difference in responses between these two cohorts were sourcing grapes from a new location, using integrated pest management, acid addition, reduced refrigeration loads, and energy efficiency (Table 3-3).

Past Actions	***Percentage of total respondents***	***Percentage of 'Happening, Human and Harmful' respondents***
Sourced grapes from new location	**48%**	**64%**
Changed the Rootstock	17%	28%
Non-chemical weed management	42%	52%
Integrated Pest Management	**47%**	**72%**
Acid addition	**44%**	**60%**
Energy efficient technologies	37%	48%
Reduced refrigeration loads	**48%**	**68%**
Alternative fuels	6%	16%
Renovations and retrofitting	24%	36%
Future Priorities		
Organic, biodynamic, or IPM	21%	32%
Water efficiency	18%	32%
Energy efficiency	**39%**	**65%**

Table 3-3: Displays individual adaptation actions that displayed more than a 10% 'positive' response rate difference between the total number of respondents (N=86) and the cohort of respondents who believe climate change is happening, human caused and negative to their business (N=25). Actions with more than a 15% difference between the two groups are shown in bold.

Unfortunately, with only four respondents being very or extremely sure climate change is not happening, it was not meaningful to compare groups who do and do not believe climate change is happening. However, the four respondents who do not believe climate change is happening have implemented few actions in the past five years. Of the three respondents in this group who gave data on their future priorities, there were only three 'high priority' actions identified. Two respondents view establishing/broadening their social media as a high priority action, with one of these respondents also seeing changes to their contractually scenario as a high priority.

3.5.2 Climate change impact perception and adaptive action implementation

As seen above, respondents who feel that climate change will have a negative impact on their business were more likely to have implemented or prioritise the implementation of adaptation actions in several dimensions (Figures 3-11 and 3-12). It was for this reason that a further comparison was undertaken using only the factor of whether respondents felt that climate change would have positive, negative or no impact on their business in the next 35 years (Figures 3-13 and 3-14). This was also possible as there were adequate data groups for each response.

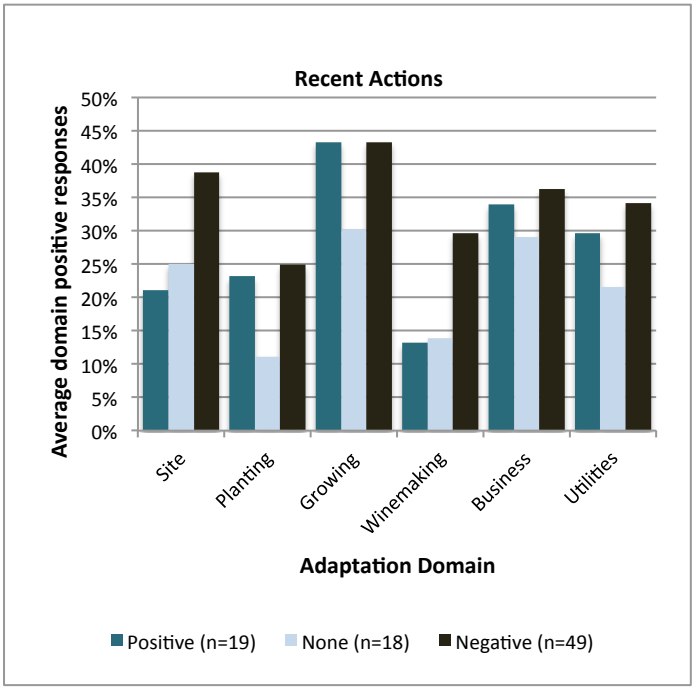


Figure 3-13: ***Recent adaptation action implementation comparisons between respondent's climate change impact beliefs.*** *The response data relating to adaptation action implementation over the past five years for the three listed cohorts (those who believe climate change will have a positive impact on their business (N=19), no impact on their business (N=18), and, a negative impact on their business (N=49)) was split into separate groups, where the number of 'positive' ('yes', 'regularly' or 'consistently') response rates for each adaptation action was counted and the average number of positive responses for each adaptation dimension (Site, Planting, Growing, Winemaking, Business and Utilities) was then calculated. These average domain positive response rates were then compared across the three cohorts to create this column chart.*

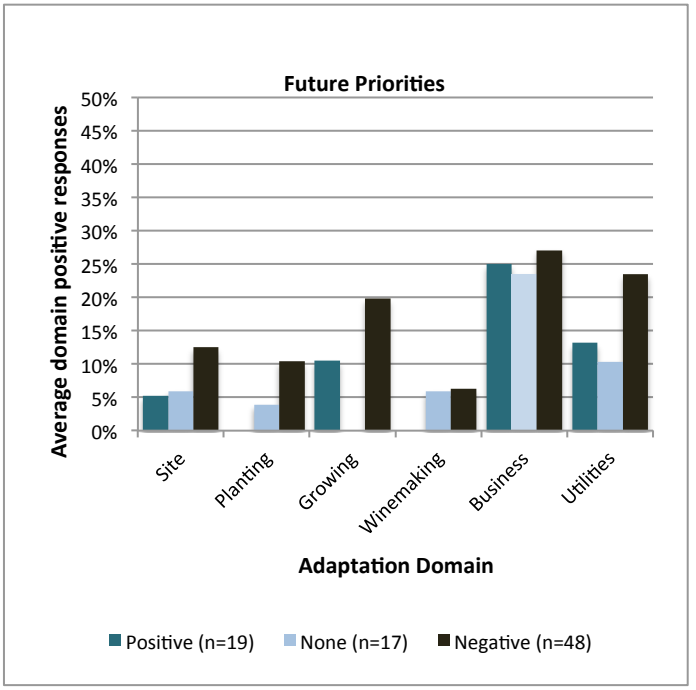
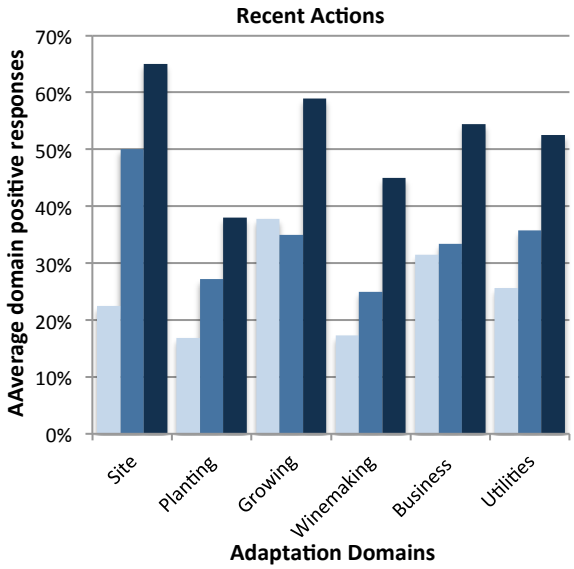


Figure 3-14: ***Future adaptation action prioritisation comparisons between respondent's climate change impact beliefs.*** *The response data relating to adaptation action prioritisation for the next 10 years for the three listed cohorts (those who believe climate change will have a positive impact on their business (N=19), no impact on their business (N=17), and, a negative impact on their business (N=48)) was split into separate groups, where the number of 'positive' ('high' and 'imperative' priority) response rates for each adaptation action was counted and the average number of positive responses for each adaptation dimension (Site, Planting, Growing, Winemaking, Business and Utilities) was then calculated. These average domain positive response rates were then compared across the three cohorts to create this column chart. N differ in each figure as there were two respondents who did not provide data on their future priorities*

As can be seen in Figure 3-13, there is a strong pattern of action across all dimensions when a negative impact is perceived. Interestingly, it is also common for action to be greater when either a positive or negative climate change impact is perceived compared to those who feel climate change will have no impact, as is evident in recent Planting, Growing, Business and Utilities actions and future Growing, Business and Utilities priorities.

The only dimension that consistently followed the assumption that a negative climate change impact perception would generate greater action was in relation to site decisions. In both recent actions and future priorities (Figures 3-13 and 3-14) respondents who felt climate change would have a negative impact on their business were more likely to have purchased or leased land in new locations or prioritise doing this in the next 10 years.

3.5.3 *Business size and adaptation action implementation*



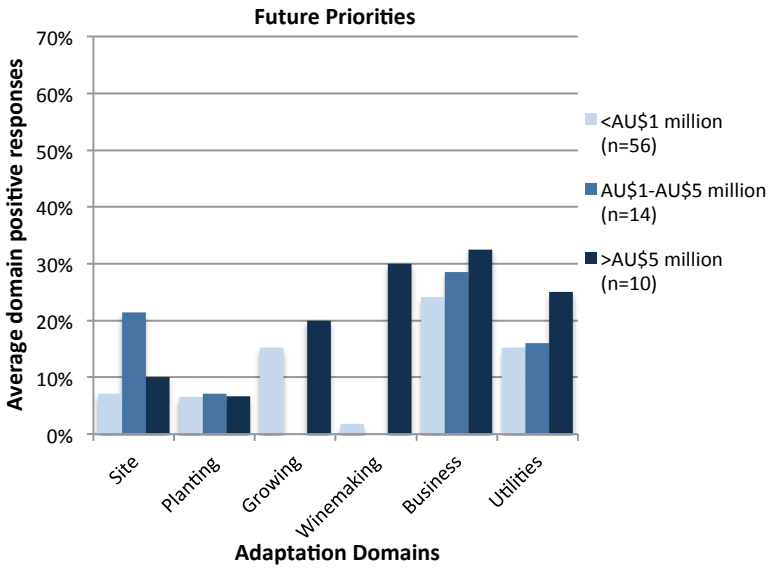


Figure 3-15: ***Recent adaptation action implementation comparisons between business sizes.***
The response data relating to adaptation action implementation over the past five years for the three business size cohorts (Gross sales revenue of <AU$1 million (N=56); AU$1-5 million (N=14), or; >AU$5 million (N=10)) was split into separate groups, where the number of 'positive' ('yes', 'regularly' or 'consistently') response rates for each adaptation action was counted and the average number of positive responses for each adaptation dimension (Site, Planting, Growing, Winemaking, Business and Utilities) was then calculated. These average domain positive response rates were then compared across the three cohorts to create this column chart.

Figure 3-16: ***Future adaptation action prioritisation comparisons between business sizes.***
The response data relating to adaptation action prioritisation for the next 10 years for the three business size cohorts (Gross sales revenue of <AU$1 million (N=56); AU$1-5 million (N=14), or; >AU$5 million (N=10)) was split into separate groups, where the number of 'positive' ('high' and 'imperative' priority) response rates for each adaptation action was counted and the average number of positive responses for each adaptation dimension (Site, Planting, Growing, Winemaking, Business and Utilities) was then calculated. These average domain positive response rates were then compared across the three cohorts to create this column chart.

In some studies wine producers have revealed that a key vulnerability to dealing with climate change is income (Fleming & Vanclay 2010; Hadarits *et al.* 2010). This factor was applied to my data, and indeed there does appear to be a relationship between the size of a business (in financial terms) and the average number of actions implemented.

As can be seen in Figure 3-15 businesses that generate sales greater than AU$5 million are consistently more likely to have implemented a greater range of actions in the past five years than those whose sales are less than AU$5 million per year. Interestingly however, high and imperative action priorities for the future 10 years are less dependent on income (Figure 3-16).

4 Discussion

> *'As climate change bites, and as the effects of the financial meltdown continue to ripple through both domestic and export markets, an increasing number of growers and winemakers have realised that business as usual simply isn't going to cut it any more. More and more people – including, crucially, people in the largest wine companies as well as the smallest – are thinking very deeply about true sustainability; thinking about adapting to and hopefully mitigating the effects of climate change; thinking about growing grape varieties and making wine in a way that better expresses their unique patch of country.*' (Allen 2010)

In his book 'Future Makers: Australian Wines For The 21st Century', Australian wine writer Max Allen chose to focus on what he has termed the 'resistance movement' in Australian wine - industry members incorporating sustainable viticultural techniques, limiting water use and reinvigorating the importance of terroir in their winemaking (Allen 2010). He has highlighted that this movement is in response to both financial and environmental pressures facing the industry and is taking place from small-scale boutique to large commercial businesses. From the data collected in this study it would appear that these anecdotal observations of Allen's are indeed correct. Wine businesses in Victoria are making a diverse range of changes to their biophysical and social practices. The interview and survey data collected for this thesis support the notion there is momentum developing in the industry to incorporate sustainable practices and efforts are being undertaken to strengthen business narratives and communicate this with consumers.

4.1 Adaptation Action Implementation

As seen in the Results section above, the survey revealed evidence of a diverse range of adaptation actions taking place across the wine industry adaptation domains of site selection, planting, winemaking, business, and utility decisions. When looking at future adaptation priorities, there appear to be strong tendencies towards improving energy efficiency; incorporating organic and biodynamic techniques into vineyard management; using social media as a means to strengthen business; and diversifying potential revenue-raising activities that take place at a business site. However, the overwhelming majority of respondents have not used in the past, and do not prioritise using in the future, adaptations including relocating to new locations, altering their planting practices, or using technological fixes to environmental stressors (with the exception of water management).

4.1.1 Site and Planting

In literature relating to the wine industry and climate change vulnerability, it is common to find suggestions of site re-location as a prominent adaptation action (Jones *et al.* 2005; White *et al.* 2006; Webb *et al.*

2007b; Anderson *et al.* 2008; Galbreath 2012). However, as seen in Figures 3-3 and 3-4, very few respondents have done this recently, or see this as a future priority. Besides the obvious capital and time needed to implement such an action, I believe there are also significant cultural and social factors that do not make this a desirable action for many in the industry. As was highlighted in recent research by Park et al. (2012), and reiterated by my interviewees, many winemakers and vineyard owners have '*strong emotional connections to their farms, lifestyles, regions and participation in wine production*' (Park *et al.* 2012).

Throughout my interviews, reference was made to the importance of the social connection, support and collaboration that exists between winemakers in each region. These formal and informal regional networks were highlighted as a main source of information and learning by interviewees, with some going so far as to nominate these relationships as a key reason they chose a particular location in the first place:

> *"That was part of the reason why we decided to stay in [the region], the network of professional support – we had loans of equipment, tractors, some of the cuttings here came free from other vineyards. The region has a strong history of families, and there is a strong familial bond, but I also think if you're new, and willing to get in there and have a crack*[‡‡] *and be part of the community then the community will support you."* (Interviewee Two)

This attachment to place is also influenced by the particularly intergenerational nature of the wine industry and the historical importance of terrior to many winemakers. More than 95% of the respondents surveyed were from a 'private and/or family owned' business (Section 3.1.2). Three interviewees were involved in an intergenerational family business, and the other three talked about the future of their business with reference to their children's involvement (one of these interviewees eldest child was just starting an agricultural science degree). As one interviewee stated: "*You know, once you buy your block, you're there for life… I want a farm - not for financial reasons - I want my own block of dirt where I can do things they way I've always wanted to do. Something my daughter can inherit, hopefully if I've paid it off by then." (Interviewee Five).*

[‡‡] To '*have a crack*' is a colloquial expression used in Australia and New Zealand that equates to attempting something that looks challenging or is new (usually with gusto)

The intergenerational nature of the wine industry could be one of its great strengths. Research by market analysis firm Nielsen has found that in 2012 family wine producers overtook private label growth for the first time in five years and that Australian family wine producers have increased their sales in the bottled wine market recently by $200 million. This took place in a market where 90% of the extra dollars consumers spent in wine went to imported New Zealand wines or labels owned by major retailers (Finnegan 2012). Nielson analysts have reported that '*Australian family wine producers have shown great resilience by nurturing their brands through the good times and the bad, emerging in great shape'* (Finnegan 2012).

Figure 4-1: A photograph taken on the steps of multi-generational winery Yalumba during the '*Next Generation 2011*' tour organised by and for members of *Australia's First Families in Wine* – a marketing and knowledge sharing initiative created by 12 large family-owned Australian wineries. Together they represent 16 Australian wine regions across four states, and between their families have more than 1200 years of winemaking experience. This initiative works to promote their family owned wine businesses at events across Australia and internationally. (Photo: http://www.australiasfirstfamiliesofwine.com.au)

This attachment to place is also supported by the preference of survey respondents to adjust the varieties they grow or source, and to incorporate grapes bought-in from other growers rather than looking to relocate their site (Figures 3.3 and 3.4). Purchasing grapes from other locations is a more flexible action for many wineries, and can also be adjusted from year to year. The preference for this action also highlights the ability for winemakers, particularly larger wine producers, to shift their purchasing power to different regions or vineyards – an action that can provide flexibility and resilience for winemaking businesses, but simultaneously cause increased vulnerability and instability for grape growers if their buyers decide to change their source location. This finding is supported by that of Nicholas and Durham (2012) who also find that '*smaller growers tied to a particular piece of land, and experienced with a certain suite of varieties, may also find their response options more limited than larger landholders with more diverse holdings, or integrated grower/winery operations'.*

Interestingly, the most implemented and prioritised Site or Planting action was to plant or source new grape varieties (Figures 3-3 and 3-4), however in a number of interviews there was concern expressed about introducing new varieties into the market, with consumer preference also being identified as a vulnerability exposure in Nicholas and Durham's (2012) wine industry vulnerability assessment. It is common for particular regions to be well-known for specific varieties, which can pose a challenge in creating consumer demand and brand recognition of something new. I believe this preference to grow and sell new varieties above any other Planting action is closely related to a wine businesses' willingness to

engage with their consumers and develop new products. This demonstrates the importance that Business actions play in the creation of a comprehensive adaptive strategy, and is likely to contribute to the high number of businesses implementing new marketing and communications actions.

The very low responses for implementing or prioritising any other Planting action (Section 3.1.1 and Section 3.2) is likely a result of both a preference to maintain existing planting techniques, and could also be influenced by the economic downturn and wine glut that have impacted the industry in the past five years (O'Donnell *et al.* 2012). When planting actions were being discussed with one interviewee, he made the comment that there was a diversity of innovative planting actions available, but that they are not evident in the industry at present as '*not many people are putting in vines*' (Interviewee Five). This was also demonstrated by two of the interviewees discussing the fact that North-South facing vine rows are often not suited to certain sites, and that changing row direction is an action being considered more in the industry to adapt to higher temperatures and heat-spikes; but there was little evidence from my survey that this has taken place in the past five years or is a priority for the future (Figures 3-3 and 3-4). It is highly likely that the low responses for Planting actions is linked to a decline in new plantings. Recent Australian Bureau of Statistics data has found that prior to the start of the 2012 harvest there was a net removal of 2,920 hectares of vines from the Australian production base, that removals have exceeded plantings each year since 2008 and plantings have continued a long-term downward trend over the past decade (Wine Australia 2012).

4.1.2 Growing & Winemaking

As was evident in the Site and Planting dimensions above, there is a preference for implementing actions that can be initiated in an incremental or flexible manner. A tendency to adapt to changes in weather and extreme events as they evolve has developed a resilience in Australian agricultural activities (Preston & Stafford-smith 2009), and is seen a strength of the wine industry. A confidence in this capacity to adapt to changing growing season conditions is reflected in the high preparedness perceptions of the majority of respondents (Table 3-2). Actions that require greater capital investment, such as de-alcoholisation, precision farming, external shade/cooling mechanisms and frost machines, are less likely to have been

Figure 4-2: Geese free-range at a winery in North-East Victoria as part of an integrated pest management strategy (Photograph: Rhianna Dean)

implemented or be a high priority compared with simple, cheap actions like canopy management (Figures 3-3 and 3-4).

There has been a substantial focus on actions that relate to reducing agrichemical use, incorporating biodynamic principles, and adjusting growing conditions with natural and hands-on techniques in the past five years (Figure 3-3). The momentum to continue with these actions is noticeable in data relating to future action, where more than 70% of respondents nominated the incorporation of organic, biodynamic or IPM strategies into their growing practices as a high or medium priority for the next 10 years (Figure 3-4).

The motivations for incorporating these actions into grape growing does not appear to be to attain any specific organic or biodynamic certification, as so few respondents have attained certification in the past five years (Figure 3-3). It is more likely that these techniques are used to complement other growing practices that build resilience against extreme events, weather damage and pests and diseases. In contrast, grape growers chose to use technological fixes or pre-emptively alter grapevine phenology much less often. This agrees with research by Nicholas and Durham (2012), who also found in their study of Californian winemakers that reactive or short-term anticipatory actions are more likely to be implemented than long-term actions. As noted by one interviewee: *"This year we adapted the way we were growing the vines through various growing practices to suit the season we predicted we might have, based loosely around the concept of global warming and the La Niña cycle, and local weather patterns". (Interviewee Three)*

The high level of water-related actions across both Growing and Utilities dimensions does highlight that investing in costly technological fixes is undertaken when stress levels reach a certain threshold or are experienced over a long period of time – such as they were during the decade-long drought that ended in 2010 (Webb *et al.* 2009; Jones & Webb 2010). All interviewees mentioned the drought as a catalyst for investing in new water efficiency measures. A preference to use technological actions only when absolutely necessary is also evident in Winemaking data, where almost half of respondents used acid-addition practices in the past five years, yet less than 10% see the listed Winemaking actions as a high or medium priority for the future. Survey respondents listed the cost of de-alcoholisation processes as the barrier to them using this action – only one respondent used this action in the past five years.

Many interviewees reported the unseasonably wet 2011 vintage as a more devastating and difficult growing scenario to deal with than the drought conditions that had driven so much change in the industry. Disease pressure and slow ripening conditions caused by the cool and wet conditions were devastating for many in the industry (O'Donnell *et al.* 2012). Interestingly, 78% of survey respondents say they feel prepared for excessively high rainfall (Figure 3-2). This highlights that having the confidence and knowledge to adapt to new situations does not necessarily mean that one can or will in time (Repetto 2008). Sudden or unusual stress can be particularly devastating. As one interviewee noted: "*I reckon people have short*

memories, but everyone learnt a lot last year. We went from zero rainfall to incredibly wet, and it was a bit off the charts. I think everyone got caught with their pants down a bit"[§§].

4.1.3 Business and Utilities

All interviewees mentioned changes to their business models, marketing strategies, and concerns for the industry as a whole during Stage One of this thesis process. Concerns over the global wine glut, less certain contractual scenarios, the global image of Australian wine, and lack of consumer demand for variety diversity were mentioned as key concerns.

It was for this reason I decided to include a number of Business and Utilities actions in my inventory. Effects of climate change will not just be felt in biophysical processes of agricultural enterprises – rising utilities and transport prices due to climate mitigation activities will impact operation costs (Wine Australia 2013), the decision to adjust varieties will require concerted marketing activities, and, large wine companies will have the flexibility to shift their contracts to optimal growing regions, leaving other grape-growers to find a new ways to sell their product.

As seen in the survey and interview data collected, producers see themselves as having agency in their marketplace. All interviewees talked about their marketing strategies and the importance of interacting with consumers, and business actions were some of the most implemented and prioritised actions by survey respondents (Figures 3-3 and 3-4).

> *"We've modified our business plan significantly, such that we don't have any middlemen now and we basically deal directly at cellar door. We are compelled to become our own distributor. It's more work, but a higher yield financially, which equals financial sustainability." – Interviewee Six*

Interaction with the market, and the financial capacity to make changes, highlighted the importance of what I have termed Social Actions in adaptive capacity (Figure 2-2). More than 25% of respondents have set-up their own wine label in the past five years, and many others have shifted their market or production focus (Figure 303). This trend is supported by industry wide data: Despite there being a 20% national decrease in grapeprowers between 2000-2010, there was a 102% increase in registered wine companies (from 1,197 to 2,420) during the same time period (GWRDC 2011). Two of the interviewees have recently made the switch from being contract grape-growers to producing wine under their own label, and in both cases this has been a positive experience for each business. These experiences are examples of a longer-

[§§] To 'be caught with one's pants down' is a colloquial expression used in Australia and New Zealand that equates to being caught off-guard or unawares

term trend in the wine industry. Market analysis firm Nielsen has found that nearly two-thirds of recent market share losses by large companies went to small- to mid-size wine producers, and forecasts that market growth will flow to those with portfolios of wine above $10 a bottle (Finnegan 2012).

Both of the interviewees who have started their own wine brand recently discussed the intense competition and need for exceptional quality in this section of the market. The trend for grape growers to enter the market with their own wine production businesses will create greater competition and deliver high quality products to consumers – however this will not be a model that all grapegrowing businesses can follow en-masse. The concern that this trend will flood the market with premium wines from small independent winemakers, causing a 'boutique-wine glut' in Australia, was highlighted by one of the interviewees:

> *"It kind of feels like in the last 24 months every man and his dog have started a wine label. It's all small - everyone wants to make 24 pellets of wine and sell it for forty dollars and they think it will be no problem. If you go into one of the main wine stores in Healseville and ask them to point out the new wine labels made by small growers who have started their own label recently, there will be dozens. But as soon as you're small, you need to start charging $40 a tube before you can make any money, and there's only so many restaurants that can sell a bottle that is $80 on their wine list.*
>
> *So that's why I say that if I started now it would be really difficult. We're [established boutique winemakers] just fortunate that we got a head start and could see this future. I mean it's wonderful that all these people are making wine. When I walk into a bottle shop and think 'that's cool, that's a variety or a style that no one's making in the Valley and now here's a guy making it in his shed on the smell of an oily rag[***], and it's an interesting wine'. And people want a story. It helps to move the product…. But I'm just not sure if there's enough room [in the market]. Especially domestically, there are not enough people who want to spend that amount of money on wine." (Interviewee Five)*

The establishment of new wine labels, and the competition that creates, requires businesses to engage with their customers, generate brand loyalty and broaden their market reach. Nielson have predicted that if Australian brands can do this, as much as 70% of wine market growth in the next three years will flow to Australian wine brands, compared to less than 10% of market growth in the past five years, and that '*the*

[***] '*the smell of an oily rag*' is a colloquial expression used in Australia and New Zealand that equates to doing something with very little money or resources

real challenge lies in better story telling on brand values as well as [developing] alternative routes to market' (Finnegan 2012). In the data it is apparent that many wine businesses are using their site as a platform to do this - through the diversification of their income streams through establishing cellar doors, cafes, or accommodation (Figure 3-3) and participating in innovative regional events (Figure 4-3). These activities can create an experience for consumers and the opportunity to build wine-club lists and social media connections. Building a narrative around their business was seen as vital to many of the interviewees and is supported by the fact that broadening social media reach and marketing activities was overwhelmingly the highest priority for survey respondents (Figure 3-4).

Figure 4-3: 'The Sweet Cycle' winery tour event in Rutherglen in April 2013, which included visits to two of the wine businesses that participated in my interviews. (Photographs © Cameron Clarke / Rutherglen Wine Experience & Visitor Information Centre - https://www.facebook.com/rutherglenvic)

Other than the broadening of social media and marketing activities, the second most prioritised future actions related to Utilities, particularly water and energy (Figure 3-4). The four most recently implemented Utilities actions, (reducing refrigeration loads, establishing water harvesting systems, conserving water use, and, including energy efficient technologies in wineries), correspond directly to adaptation actions discussed in the 2008 Garnaut Climate Change Review in response to the indirect affects of climate change on the wine industry: increases in the cost of purchasing water and rising energy prices (Anderson *et al.* 2008). As discussed above (Section 4.1.2), data gathered in this study reinforces other study findings that issues concerning water stress have been a focus for many in the Australian wine businesses (Galbreath 2012) and the influence that the recent drought has had on the widespread uptake of actions relating to water access and use. This form of experiential learning and subsequent behaviour change is typical of long-term experiences of environmental stress and impacts of climate variation (Myers *et al.* 2012).

The high number of respondents prioritising energy efficiency actions in the future (Figure 3-4) has likely been influenced by the introduction of the Australian carbon tax in 2012 and the trend for grapegrowers to produce their own wine. Wine Australia has found that the introduction of the carbon tax will particularly

impact on energy and freight costs in the wine industry (Wine Australia 2013), and survey respondents also agreed with this (Figure 3-10). However more than two thirds of respondents also felt the carbon tax would encourage investment in energy efficiency (Figure 3-10) – indicating an atmosphere of motivation to improve energy efficiency.

With an increase in businesses starting to produce their own wine, winemaking equipment and storage facilities (which require significant electricity input) must be established. As one interviewee who has made this change in their business noted: *"Refrigeration is our biggest expense in the whole enterprise. We've changed our business model to include winemaking, so the earlier thinking about power has to change. Solar power – converting the sun to energy to the refrigerator – is what we need to do" (Interviewee Four)*

An interesting issue raised in the Utilities dimension also demonstrates the multiple, and occasionally conflicting, drivers of change. In this survey, respondents were asked whether they had switched to using alternative packaging such as lightweight glass bottles, plastic PET bottles, recycled bottles or Tetra Pak vessels, as doing so could reduce their energy and transport costs (Galbreath 2011b), as well as complementing brand values and marketing – which a number of respondents have done in the past five years (Figure 3-3). However, a number of survey respondents and interviewees who have made changes to their packaging moved to using denser, heavier glass bottles – which are costlier and require more resources in production and transport - in order to improve the quality perception of their product.

4.2 Climate Change, Business Size and Adaptation

Larger businesses are more likely to implement adaptation actions than individuals who perceived that climate change is happening, human caused and will have a harmful impact on their business (Figures 3-11, 3-12, 3-15 and 3-16). This implies that financial resources are an important barrier to adaptation, if individuals who believe climate change is a problem are unable to act on this belief due to financial constraints.

Financial consideration was also a prominent theme throughout the interviews I conducted, with statements about making changes in the vineyard or winery in relation to environmental stresses often followed by a comment regarding the financial viability of making such a change. The prominence of financial viability was highlighted by Interviewee Three: *"I like to be reasonably black and white with making decisions and planning. We need to be, we're running a tight ship from a monetary and staffing perspective".* The finding that economic merit can have a strong influence on the implementation of climate change adaptation and mitigation actions is supported by a number of other recent studies into climate change, the wine industry and sustainable agriculture (Fleming & Vanclay 2010; Galbreath 2012; Galbreath *et al.* 2012; Nicholas & Durham 2012a).

Importantly, what can be considered a barrier to adaptation can also be the key to unlocking supportive attitudes towards implementing adaptive strategies and changes. As highlighted by Fleming and Vanclay (2010) '*those who are influenced by economic discourse can be motivated to support action by stimulating their need to maintain competitiveness and to be involved with climate solutions developed by industry. To increase the desire for, and adoption of, actions in this discourse, the potential financial benefits and future costs need to be clearly identified'.*

When considering the potential impact that climate change will have on one's business, there were two clear patterns. Individuals who reported a perception that climate change will have a negative impact on business were more likely to have implemented and also planned more adaptation actions (Figures 3-13 and 3-14). Interestingly, the perception that climate change will have a positive impact was also associated with an increase in actions implemented. This could indicate that actions are being undertaken to take advantage of 'positive' impacts of climate change, which is an important characteristic of adaptation (Adger *et al.* 2007). This could also indicate that actors who are engaged with climate change issues are also more likely to be inquisitive and pro-active with implementing new actions and display knowledge-seeking behaviour. In their research into personal belief influences on climate change perception, Myers et al. (2012) have found that low motivation to think about climate change can impede processing of climate change data, and that people with strongly held beliefs are likely to engage in motivated reasoning about global warming.

4.3 Limitations

One of the most significant limitations I encountered during this thesis process was the timing of data collection. Unfortunately the time of year available to me to conduct interviews coincided with the start of vintage in Victoria, which limited the number of people who had time to take part in interviews. In hindsight, attempting to conduct research in the wine industry in Victoria between the months of January-May is problematic and ideally I would recommend allowing a longer timeframe when conducting agricultural research in order to build wider networks and have greater flexibility with time. Having limited access to a vehicle and needing travel significant distances across Australian agricultural regions was also problematic while trying to maintain a flexible approach to interviews.

The solution to having limited time for field work – using an online survey – was helpful in collecting data from a wider population, but also had some limitations, particularly with reach and response (Bryman 2008: 653). By using email communication and online technology I was limiting my sample to those who are computer literate and 'online'. The issue of 'inbox fatigue' was mentioned by one of my interviewees – he finds the amount of industry emails he receives overwhelming and has stopped reading them. By sending personal emails I attempted to overcome this issue, however most grapegrowers are not listed in the

directories I was able to use. This is likely to have created a bias in my data towards winemaking businesses. My attempt to make the online survey user-friendlier by not having mandatory responses meant a number of surveys could not be included in analysis due to insufficient data. A small sample population also limited this study. This was particularly evident when separating data into groups for comparisons.

On reflection of the LUMES thesis process, I can clearly see that the challenges of establishing a new interdisciplinary research paradigm globally are also reflected in my own work. To feel competent in discussing both social and environmental processes and how they relate to empirical data and broader theoretical discourse did cause moments where I felt lacking in clarity, decisiveness and confidence. Yet this experience is perhaps one of the most important lessons of this thesis, and although it may have been a limitation in the process itself, it will remain as one of the most positive lessons I could learn as a student of sustainability science. Humility, patience and embracing the 'art of muddling through'.

5 Conclusion

Climate change adaptation is practiced in a robust manner in the Victorian wine industry, with a focus on growing, business and utilities actions. There is evidence that relationships exists between an individual's climate change beliefs, the financial resources available to a business, and the likelihood of a greater array of adaptation actions being implemented and prioritised.

Drivers of change are likely to be diverse and interrelated for wine businesses. It is not the intention of this study to suggest that individual actors should be aiming to implement all of the adaptation actions listed in the inventory created. Complex dynamics will cause vulnerabilities to differ across the diverse business and geographic landscapes of the Victorian wine industry, and climate change is but one of many issues businesses must adapt to. As highlighted by Howden et al. (2007), '*translating adaptation options into adaptation actions requires consideration of comprehensive risk management frameworks*'. What is important is recognising that a diversity of actions, encompassing both biophysical and social aspects of an agricultural enterprise, are important to support resilience.

> *"What we've got to do is set up a situation were we're able 'to deal'. And that's were, with climate change, I think we have to look at things over a long-term average and the diversity of situations we will have to deal with" – Interviewee Two*

Farm-scale actors are pro-actively engaging with their value chains and consumers – they are not simply sensitive to these systems, they are active participants in them. Future research and agricultural climate change adaptation policies will need to increasingly recognise this, particularly when mapping vulnerability and resilience.

Learning and innovation are increasingly recognized as key elements for successful adaptation (Nelson *et al.* 2007; Folke *et al.* 2010) and the sharing of experiences and knowledge among actors in a system is

believed to be important for coping with climate change and nurturing an adaptive learning process (Smit & Skinner 2002). The strong connection to place and social collaboration that exists in the wine industry presents an opportunity to facilitate knowledge sharing and innovative extension activities. Survey respondents' keen attitude towards engaging with social media demonstrates their willingness to communicate and develop networks in new ways. Particularly with the emergence many new wine businesses in an evolving market, ensuring that dynamic spaces for interaction and learning are facilitated should be a high priority for the industry as a whole and the government departments that support it.

When asked how prepared they felt about various environmental stresses, one survey respondent selected 'neutral' for every scenario. They then left the comment '*that's the lot of a farmer*'. This common Australian turn of phrase was used to highlight the unpredictable nature of a farming enterprise, and the uncertainty that can exist in such an environment. However it is also a great example of how multifaceted a wine business is, where individual actors are considering the full spectrum of adaptation domains on a daily basis. They really must think of *the lot*.

The process of vulnerability and resilience is an ongoing cycle. The purpose of strengthening adaptive capacity is not to end vulnerability, rather it is to recognise and take advantage of its integral role in facilitating innovation, opportunity and diversity, and I'll cheer to that!

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