THE SENSITIVITY AND ADAPTABILITY OF THE GRAPE AND WINE INDUSTRY IN THE MAULE REGION OF CHILE TO CLIMATE CHANGE

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ABSTRACT

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This paper examines the sensitivity and adaptability of the Chilean grape and wine industry to climate change in the context of other stresses via a case study in the Maule Region. The research was conducted using a vulnerability approach, which is based on the empirical documentation of exposures and adaptive capacity. Key informant interviews, semi-structured interviews and a focus group were used as the primary data sources. The climatic exposures to which growers and producers are exposed include wet springs, spring frosts, wet falls, high growing season temperatures, and drought. These exposures were placed in the context of other conditions, including market price, currency fluctuations, national and international rules and regulations, and labour availability. The Maule Region has not developed extensive suites of adaptation strategies because the grower- and producer-identified exposures have not yet threatened their operations' viability. Future climate change may be beneficial and accommodate the cultivation of new varieties. However, many of the climatic exposures are projected to be exacerbated into the future, and the adaptive strategies currently used may not be effective into the future. The national government, a lack of education and market uncertainty hinder the industry's ability to manage exposures.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

AGRIMED	*Centro de Agricultura y Medioambiente* or Agriculture and Environment Centre
BIH	Basic Irrigated Hectares
BSE	Bovine Spongiform Encephalopathy
CERA	Agrarian Reform Centres
CHP	Chilean Peso
CONAMA	*Comisión Nacional del Medio Ambiente* or National Environment Commission
DGA	*Dirección General de Aguas* or National Water Directorate
ENSO	El Niño-Southern Oscillation
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GG	Grape Grower
GW	Grape and Wine Producer
IPCC	Intergovernmental Panel on Climate Change
SAG	*Servicio Agrícola y Ganadero* or Agricultural and Cattle Service
USD	United States Dollar
UNFCCC	United Nations Framework Convention on Climate Change
UP	*Unidad Popular* or Popular Unity
WP	Wine Producer

CHAPTER 1: INTRODUCTION

1.1 Research Rationale

It is widely recognized that human-induced climate change is a reality (IPCC, 2007), to which two response options exist: 1) mitigation; and 2) adaptation (Smit et al, 1999; Füssel and Klein, 2006). Mitigation initiatives generally aim to reduce the concentration of greenhouse gases – those deemed responsible for inducing climate change – in the atmosphere. Although mitigation is recognized as a necessary step towards stabilizing greenhouse gas concentrations in the atmosphere, adaptation is considered an essential coping mechanism in order for the risks and opportunities associated with climate change to be reduced or realized (McCarthy et al, 2001; Smit and Pilifosova, 2003; IPCC, 2007), as even if greenhouse gas emissions are drastically reduced, the effects of climate change are unavoidable (Füssel and Klein, 2006; IPCC, 2007).

Climate change is increasingly recognized as a significant stress to ecosystems and to human resource use systems and settlements (McCarthy et al, 2001; Tompkins and Adger, 2004; Wilbanks et al, 2007; Easterling et al, 2007). In particular, climate change and variability are projected to significantly alter the world's agricultural landscape (Smit et al, 2000; IPCC, 2001, 2007; Easterling et al, 2007; Wilbanks et al, 2007). Agriculture is particularly sensitive to changing climatic conditions, and an emergent body of scholarship has been devoted to identifying challenges and opportunities for adaptation in this sector

(Adger, 1999; Smithers and Blay-Palmer, 2001; Leichencko and O'Brien, 2002; Belliveau et al, 2006; Yang et al, 2007). The grape and wine industry is of particular interest in the context of climate change and agriculture because of its fine sensitivity to climate, its high site specificity and the longer time frame of decisions associated with perennial crops (Jones et al, 2005; White et al, 2006; IPCC, 2007).

Weather and climate play a major role in the quality and quantity of grapes and wine produced; baseline climate has been noted to significantly influence wine style, and climate variability to influence wine yields and quality differences (Jones and Hellman, 2003; Jones, 2005; Battaglini, 2008). White et al (2006) identify three essential climatic conditions for quality grape and wine production: 1) adequate heat accumulation; 2) low risk of severe frost damage during the growing season; and 3) the absence of extreme heat. The importance of weather and climate for grape growing and quality wine production, and the potential effects climate change may have on wine style, yield and quality, underline the need to better understand how climate change will affect the industry, and how the industry might respond (Jones, 2005; Battaglini, 2008).

The industry constitutes a major economic sector in many countries, and the effects of climate change are already being reported (AFP, 2004; AP, 2006; Kakaviatos, 2006; Berger, 2007). Burgundy and Bordeaux, major wine producing regions in France, have experienced increases in both temperatures and overall wine quality, and England, an emerging wine producing country, is beginning to produce sparkling wines that some say are comparable to those of Champagne, France (Jones, 2004; 2007). In Chile, wine production and exports contribute significantly to the national economy; in 2005, wine constituted over 10% of the country's exports, valued at US $883 million (MDA, 2005). This industry is currently thriving and continues to grow at a rapid rate, particularly in the O'Higgins and Maule viticulture regions located in the Central Valley (Gwynne, 1999; Collier and Sater, 2004).

The Maule Region is the heart of grape and wine production in Chile (Vinos de Chile 2010, 2008), and its success stems from favourable adjustments to market and competitive advantages, the agrarian reform, aggressive foreign investment, the adoption of neoliberal economic policies, and other changes over the past five decades, including climate change. As a result of agricultural restructuring policies in Chile, many agriculturalists in Maule have moved away from traditional crops (e.g. wheat, maize, sugarbeet, potato and beans) towards non-traditional crops (e.g. tender fruit and wine grapes) (SAG, 2006b). Traditional *Vinifera* grape varieties (e.g. País) that were well-suited to the climate, vigorous and easy to maintain have been largely replaced with more popular *Vinifera* varieties such as Cabernet Sauvignon and Carménère; while these new varieties require irrigation, they benefit from higher demand and prices (del Pozo, 1998; Muñoz et al, 2008). Climate-related losses experienced in Maule include crop losses following unusual rainfall during grape maturation in 2002, and the drought of 2008, which resulted in reductions in grape and wine yield. With respect to gains, dry grape maturation in certain years has facilitated the cultivation of high quality wine grapes.

The impacts of climate change on agriculture have been extensively researched, using a wide variety of approaches (Easterling et al, 1993; Mendelsohn et al, 1994; Chiotti and Johnston, 1995; Smit et al, 1996; Bryant et al, 2000; Smit and Skinner, 2002). With climate change, Maule is expected to experience an increase in temperature, a decrease in precipitation, and changes in extreme events and streamflows (the primary source of irrigation water in this context), all of which may have significant implications for grape growers and wine producers (McCarthy et al, 2001; Jones et al, 2005; Easterling et al, 2007). Although considerable attention has been given to the ways in which grape development will be affected by increasing temperatures and decreasing precipitation (White et al, 2006), and how changes in phenology will affect grape and wine production (Jones et al, 2005), fewer researchers have investigated the role of climatic and non-climatic risks and opportunities that are important to grape growers and wine producers, how these conditions will affect the wine sector and how the sector will respond to these risks and opportunities.

The restructuring of agriculture in Chile and the importance of weather and climate in the success of the grape and wine industry in Maule sparks the question: how sensitive and adaptable is the industry to climate change?

Traditionally, assessments of climate change impacts on agriculture have generally employed a top-down, scenario-based approach (Rosenzweig, 1985; Smit et al, 1989; Smit and Skinner, 2002). This approach begins by generating a climate change scenario and modelling the interaction between future climate conditions and agriculture (Feenstra et al, 1998). The role of human agency in alleviating climate and weather impacts was initially excluded in these assessments (Curry et al, 1995), but was later acknowledged and incorporated by arbitrarily assuming adaptations (Parry et al, 1998; Smit and Skinner, 2002). Although climate impact assessments provide insights into the seriousness of climate change, a number of assumptions are made, including with respect to the attributes of climate that are important to producers and the responses they will have to these circumstances.

The emerging vulnerability assessment field builds on these climate change impacts assessments by, seeking to identify those conditions that are relevant to producers (commonly termed ‘stresses’, ‘forces’, ‘sensitivities’, ‘exposures’, ‘exposure-sensitivities’, etc) and producers’ responses to these conditions (commonly termed ‘coping’, ‘dealing’, ‘adapting’, ‘managing’, etc) thereby highlighting the role of farm-level decision making in the adaptation process (Brklacich et al, 1997; Chiotti et al, 1997; Smit et al, 1997, 1999; Smit and Skinner, 2002; Wall et al, 2004; Reid et al, 2007). The vulnerability approach is distinct from climate impact assessments because it requires researchers to gain insights from the affected system itself— in this case agricultural producers— as to the variables or factors that are important for decision making; that is, these variables are not assumed *a priori*. The approach also recognizes that there are numerous forces influencing a system, not just climatic ones, and that an improved understanding as to how these forces manifest to create multiple risks and opportunities is needed to fully know the vulnerability of a system. It is important to note that the approach acknowledges that the forces influencing a system are context specific and dynamic in nature, as they may change over space and time, and according to political, social, economic and environmental circumstances. Vulnerability assessments have been successful in understanding the climatic and non-climatic forces that influence decision making (often termed 'exposures', 'sensitivities' or 'exposure-sensitivities' in the literature) and discovering the role of human agency in the adaptation process (often termed 'adaptive capacity' in the literature) (Belliveau et al, 2006; Yohe and Tol, 2002). This approach offers a lens through which to investigate the grape and wine industry in the Maule Region's sensitivity and adaptability to climate change.

1.2 Research Aim and Objectives

The broad aim of this research is to assess the sensitivity and adaptability of the grape and wine industry in the Maule Region to climate change in the context of other dynamic conditions. Consistent with this aim, the objectives of this research are:

1. to identify the conditions to which grape and wine producers in the Maule Region are currently sensitive;
2. to document the ways in which grape and wine producers in the Maule Region are adapting to the identified conditions; and
3. to assess the future vulnerabilities of the grape and wine industry in the Maule Region under climate change.

1.3 Thesis Structure

This thesis is comprised of six further chapters. Chapter Two offers a review of the literature relevant to this study, and includes a discussion of two distinct approaches to investigating climate change and agriculture. Chapter Two also provides insights into agriculture's complex decision making environment. Chapter Three describes the study region with respect to its political, economic, social and environmental characteristics.

Chapter Four outlines the approach to the research, paying particular attention to the methods of data collection and analysis. The results of the research are reported in Chapters Five and Six. The grape and wine industry's current vulnerability to climate change is examined in Chapter Five taking into consideration other dynamic forces affecting them. Chapter Six highlights the industry's future vulnerability to a range of projected climatic changes, which is a function of the capacity of the region's grape and wine industry to adapt. Chapter

Seven, the final chapter, summarizes the key findings of the research and highlights both its the scholarly and practical contributions. The chapter concludes with recommendations for future research.

CHAPTER 2: CLIMATE CHANGE AND AGRICULTURAL SYSTEMS

Two broad bodies of scholarship are critically explored in this chapter in order to both provide a context for this research and describe the scholarship to which this research contributes. The first examines the issue of climate change with respect to agriculture, within which there are two main approaches – impact assessments and vulnerability assessments. The second highlights the dynamic and complex nature of agricultural systems, including the connections across scales, the drivers of agricultural change and the characteristics and components of decision making and risk management. Both bodies of scholarship are reviewed with emphasis on the leading perspectives, main concepts, predominant approaches and methods employed. This chapter concludes with a summary of this literature.

2.1 Climate Change and Agriculture

2.1.1 Impact Assessments

Concerns surrounding climate change and how it might affect agriculture and food production have stimulated research into how climate change might impact upon agricultural production (Reilly and Schimmelpfennig, 1999). Traditional assessments of climate change impacts on agriculture employed a hierarchical, top-down approach (Rosenzweig, 1985; Smit et al, 1989; Smit and Skinner, 2002). This approach, illustrated in Figure 2.1, begins by generating a climate change scenario and modelling the interaction between future climate conditions and an agricultural system (Feenstra et al, 1998). The outputs from these models are used in: 1) spatial analyses to estimate shifts in productive agriculture (Newman, 1980; Blasing and Soloman, 1984); 2) Ricardian analyses to estimate changes in land value (Mendelsohn et al, 1994); and 3) climate impact modelling to estimate changes in land suitability and crop yields (Brklacich and Stewart, 1995; Winkler et al, 2002).

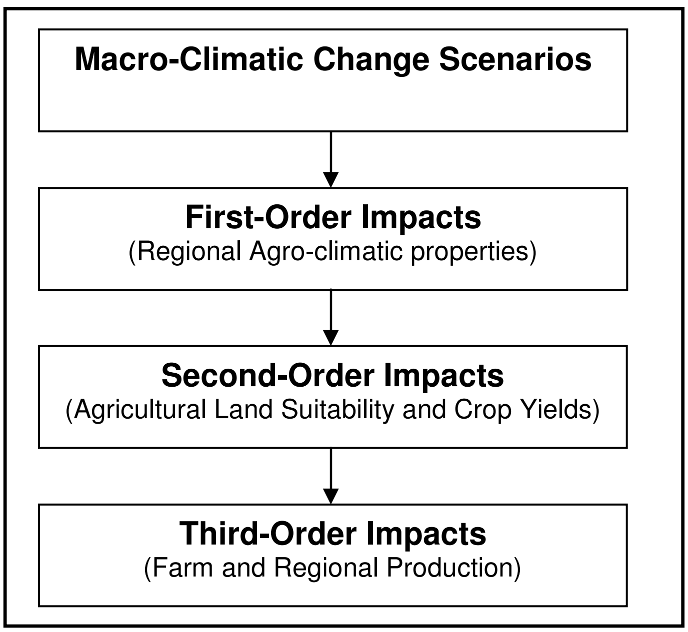


Figure 2.1: Framework for Assessing Impacts of Climate Change on Agriculture (Wall et al, 2007)

Initially, impact assessments did not consider the dynamic relationships that exist within human-environment systems. It was assumed that the agricultural system did not respond in any way, and that temperature and precipitation were the only variables of importance to the agricultural system (Rosenzweig, 1985; Smit et al, 1989). The exclusion of human agency in alleviating climate and weather impacts, also commonly referred to as ‘dumb farmer scenarios', is one criticism of this approach (Füssel and Klein, 2006). Human agency was found to play a key role in the adaptation process and thus researchers have sought to incorporate farmer responses (e.g. changes in crop type and the adoption of irrigation) into their models (Easterling et al, 1992; Mendelsohn et al, 1994; Bryant et al, 2000; Smit and Skinner, 2002). However, with no first-hand documentation as to what actual responses might be, they were arbitrarily assumed by the researcher (Smit and Skinner, 2002). Farmers were then deemed 'clairvoyant' as they were assumed to have perfect knowledge of the climate and therefore adapt to everything (Smit et al, 1996). Impact assessments do not take into account the complex decision making environment within which farmers operate and oversimplify the decision making process. Farmers' perceptions of climate, social and family circumstances, experience, values and access to resources were all found to influence decision making, but these factors were not adequately incorporated into impact assessments (Bryant et al, 2000).

Although numerous assumptions are made in these impact assessments, they provide thoughtful insights into future climatic conditions and serve to emphasize and aggregate (broadly) the seriousness of climate change. Given the *a priori* assumptions about adaptations frequently made in this scholarship, questions arise as to whether the assessments provide realistic representations of actual decision making (Tol et al, 1998). Farmers operate within a diverse set of economic, environmental, social and political conditions, in addition to climatic conditions, that affect decision making, and this approach is not yet capable of incorporating these conditions into analyses (Risbey et al, 1999; Nelson et al, 2007). The emerging vulnerability assessment field addresses the limitations of impact assessments and seeks to explore the nature of agricultural systems' vulnerability to climate change. This scholarship is described in the following section.

2.1.2 Vulnerability Assessments

The concept of vulnerability evolved from natural hazards studies (Cutter, 1996; Janseen et al, 2006), risk management studies (Hewitt and Burton 1971; Hewitt, 1997), and food security research (Füssel and Klein, 2006; Leichenko and O'Brien, 2002). The term 'vulnerability' has taken on a variety of meanings due to its widespread applicability, although the majority of definitions refer to the potential for loss or harm (Vogel et al, 2007; Cutter, 1996; Füssel, 2007).

Vulnerability has been widely applied in the global environmental change scholarship because it is an inclusive concept, recognizing that human and natural systems are not independent of one another, homogenous and unable to adapt to changing environmental, social, political and economic conditions, whether they be anticipated, realized or perceived (Polsky et al, 2007). Rather, human and natural systems are viewed as intimately coupled, and differentially exposed, sensitive and adaptable (Polsky et al, 2007).

Table 2.1: Selected Definitions of Vulnerability within the Climate Change Literature

Source	Definition
Adger, 2006	Vulnerability is a state of susceptibility to harm from exposures to stresses associated with environmental and social change and from the absence of capacity to adapt.
Leichenko and O'Brien, 2002	Vulnerability refers to the extent to which environmental and socio-economic changes influence the capacity of regions, sectors, ecosystems, and social groups to respond to various types of natural and socio-economic shocks.
IPCC, 2001; 2007	Vulnerability to climate change is the degree to which systems are susceptible to, and unable to cope with, the adverse impacts of climate change.

In the climate change field, the term 'vulnerability' is widely used because it is the one adopted by the United Nations Framework Convention on Climate Change (UNFCCC). Although an array of definitions exists (refer to Table 2.1), it is generally accepted that vulnerability is a function of exposure and adaptive capacity (IPCC, 2001, 2007; Smit and Pilifosova, 2003). As a system's exposure increases, its vulnerability also increases, and as its adaptive capacity increases, its vulnerability decreases (Smit and Pilifosova, 2003). Figure 2.2 illustrates this relationship, which can also be formally expressed as:

$$V_{ist} = \boldsymbol{f}\,(E_{ist}, A_{ist})$$

Where: V is Vulnerability of system *i* to climate stimulus *s* in time *t*
E is Exposure of *i* to *s* in *t*
A is Adaptive Capacity of *i* to deal with *s* in *t*

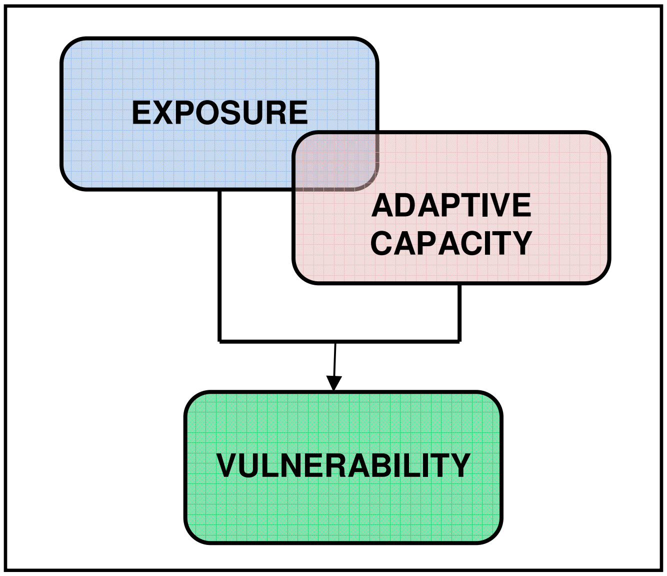


Figure 2.2: Conceptual Model of Vulnerability Used in the Climate Change Literature

Exposure refers to the interaction of the characteristics of the physical stimulus (e.g. climate) with the occupancy characteristics of the system (e.g. land use and livelihood choices) (Smit and Wandel, 2006). In other words, exposures cannot be considered in isolation, and do not only reflect the system's physical location, or the biophysical stimulus. Exposures represent the degree or manner in which a system experiences conditions to which it is sensitive. That property is related to broader social, economic, political, environmental and cultural circumstances (Smit and Wandel, 2006).

The Intergovernmental Panel on Climate Change (IPCC) and many others conceptualize vulnerability as relating to exposure, sensitivity and adaptive capacity, where exposure refers to the physical condition or hazard and sensitivity refers to the degree to which a system is adversely or beneficially affected by or responsive to a stimulus (McCarthy et al, 2001; Yohe and Tol, 2002, Smit and Pilifosova, 2003; Adger et al, 2004). The model shown in Figure 2.2 conceptualizes exposure as a property of the system, including its sensitivity, not just a property of the external environment. Hence, exposure for the purposes of this thesis captures elements of both exposure and sensitivity.

In the scholarship, vulnerability is recognized as being context specific and dynamic in nature, and therefore the relationships expressed in the equation noted above will vary by location, sector, community, time, scale, etc (Adger, 1999; Kelly and Adger, 2000; Leichenko and O'Brien, 2002; Vásquez-León et al, 2003). The vulnerability concepts have been employed to serve a variety of purposes. Some seek to quantify vulnerability (Luers et al, 2003), statistically identifying vulnerable areas (Thomas et al, 2007) or map vulnerability (O'Brien et al, 2004), while others seek to characterize vulnerability and understand the complex processes that contribute to it (Adger, 1999; Ford and Smit, 2004).

The vulnerability approach has been advocated in the climate change and adaptation literature because it recognizes there are numerous forces influencing a system, and that understanding how these forces manifest to create risk and opportunity for the system is essential to understanding vulnerability (Luers et al, 2003; Ford and Smit, 2004; Adger, 2006; Füssel, 2007). It also provides insights into the forces and processes involved in adaptation or through which adaptation initiatives might be undertaken (Füssel, 2007). The empirical application of this approach begins by gaining insights from the system itself regarding the climatic and non-climatic conditions that are important to it and how it responds (Smit and Wandel; 2006; Tschakert, 2007). These conditions are not assumed *a priori*.

Vulnerability assessments have been successful in discovering the role of human agency in the adaptation process and understanding the climatic and non-climatic forces that are relevant to the system and play an important role in decision making (Belliveau et al, 2006). They have been particularly insightful in understanding the vulnerability of agriculture to climate change (Brklacich et al, 1997; Chiotti et al, 1997; Smit et al, 1997, 1999; Smit and Skinner, 2002; Wall et al, 2004; Reid et al, 2007; Wall et al, 2007; Tschakert, 2007; Thomas et al, 2007; Yang et al, 2007). Belliveau et al (2006) found there are a number of factors that are problematic for grape growers and winery operators in the Okanagan Valley, British Columbia, including climate risks (e.g. rain at bloom and harvest) and other risks such as market demand, fluctuations in tourism, government policies and programmes, technology access or failure, and economics. This study highlighted how the presence of multiple risks or exposures influences the nature of producers' vulnerability to climate variability and change. Empirical applications of the vulnerability concept face challenges, including the difficulty of capturing all the forces and processes inherent in exposure and adaptive capacity. Much work in the vulnerability scholarship is directed towards the identification of adaptation strategies or means of increasing adaptive capacity. These two concepts are discussed in further detail in the following section.

2.1.3 Adaptation and Adaptive Capacity

The concept of adaptation evolved out of evolutionary biology (Smit and Wandel, 2006) and has taken on a variety of definitions in the literature (refer to Table 2.2). Most of the emerging climate change and variability scholarship involves the discussion of adaptation (Burton, 1997; Luo and Lin, 1999; Nelson et al, 2007). Adaptation to climate change has been highlighted as being important for two reasons (Smit and Skinner, 2002): 1) the impacts of climate change can be reduced through adaptation (Tol et al, 1997); and 2) adaptation is an important response strategy or policy option to concerns about climate change (Fankhauser, 1996; Smith, 1996).

Table 2.2: Selected Definitions of Adaptation in the Literature

Source	Nature	Definition
Smit and Wandel, 2006	General	Adaptation refers to the process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, risk or opportunity.
Nelson et al, 2007	General	Adaptation is a process of deliberate change in anticipation of or in reaction to external stimuli and stress.
IPCC, 2001; 2007	Specific to climate change	Adaptation refers to the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harms or exploits beneficial opportunities.
Pielkie, 1998	Specific to climate change	Adaptation refers to adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli and their effects of impacts.

Important elements in scientific analyses of adaptation to climate change are described in Figure 2.3. These elements include identifying: who or what adapts? To what is the system adapting? How does adaptation occur? How good is the adaptation? Studies of adaptation usually involve an analysis of a combination of these elements. In climate change impact assessments, the *what* is assumed to be changes in average or mean temperature and precipitation, yet some adaptation studies suggest that it is climate variability and the magnitude and frequency of extreme events, not average temperature and precipitation, that are particularly problematic for society, including agriculture (Brklacich and Smit, 1992; Smithers and Smit, 1997; Klein and MacIver, 1999). Chiotti et al (1997), for example, found that 80% of farm operators in Southern Ontario who responded to a survey identified moisture extremes to be the most problematic climate condition.

Adaptation is a complex process that does not occur in isolation (Koch et al, 2007). The characteristics of the exposure— both the physical stimulus and the characteristics of the system itself— will influence the process and form of adaptation employed. Adaptations can be influenced by the spatial (localized vs. widespread) and temporal (frequency and duration) properties of an event, the rapidity of their onset, their magnitude, and the economic, political, social and institutional circumstances in which the stimuli are experienced (Smithers and Smit, 1997; Nelson et al, 2007).

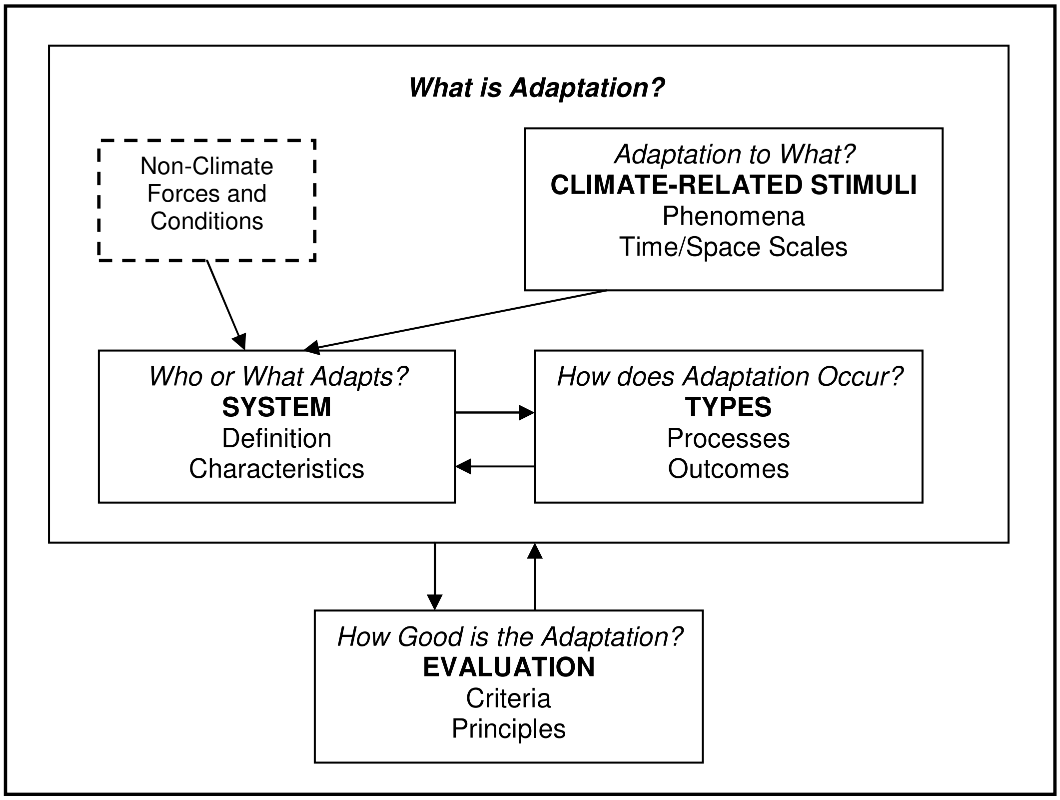


Figure 2.3: Adaptation to Climate Change and Variability (Smit et al, 1999)

Analysts have predominately sought to characterize adaptation in agriculture. Smit et al (1999) provide a summary of how adaption processes and forms have been differentiated in the agricultural adaptation literature (refer to Table 2.3); Smit and Skinner (2002) offer intent and purposefulness, timing and duration, scale and responsibility and form as the major distinguishing characteristics of adaptation. While there is a good understanding of different types and forms of adaptation in agriculture, actual or potential useful adaptations carried out at various scales within the agricultural system (e.g. farmer, farm, region and government policy) are not well understood, nor is the process through which adaptation occurs (Tol et al, 1998; Smit and Skinner, 2002).

Table 2.3: Summary of the Common Attributes Used to Differentiate Adaptation Processes and Forms (Smit et al, 1999)

General Differentiating Concept or Attribute	**Examples of Terms Used**	
Purposefulness	autonomous spontaneous automatic natural passive	planned purposeful intentional policy active strategic
Timing	anticipatory proactive ex ante	responsive reactive ex post
Temporal Scope	short term tactical instantaneous contingency routine	long term strategic cumulative
Spatial Scope	localized	wide spread
Function/Effects	retreat - accommodate - protect prevent - tolerate - spread - change - restore	
Form	structural - legal - institutional - regulatory - financial - technological	
Performance	cost - effectiveness - efficiency - implementability - equity	

The focus of agricultural adaptation to climate change research has recently shifted away from characterizing adaptive responses towards identifying actual farm-level adaptation strategies and understanding the underlying factors affecting decision making by asking those making the decisions themselves (Liverman, 1999; Leichenko and O'Brien, 2002; Brondizio and Moran, 2008). Participatory methods are generally used to investigate actual adaptation strategies and the processes behind the adoption of these strategies. Surveys, workshops, semi-structured interviews, ranking exercises and participatory mapping are among the methods used (Mortimore and Adams, 2001; Eakin, 2003; Belliveau et al, 2006; Conde et al, 2006; Brondizio and Moran, 2008). Studies reveal that farm-level adjustments and adaptive capacity vary significantly based on a variety of factors relating to the farm (Bryant et al, 2000; Belliveau et al, 2006).

Adaptive capacity is a term used in climate change discourse and it refers to a system's ability to adjust to exposures or risk (Wheaton and McIver, 1999; Smit and Pilifisova, 2002; Yohe and Tol, 2002). It is socially constructed, as adjustments to climate change are dependent on both the availability of resources and the degree to which individuals or groups are entitled to utilize resources (Adger and Kelly, 1999; Adger, 2003). A number of determinants of adaptive capacity that stem from social vulnerability discourse have been identified in the literature, including economic wealth, technology, information, the availability and distribution of resources, social and human capital, institutional structures and risk perception (Adger and Kelly, 1999; Smit and Pilifosova, 2003). The importance of these determinants varies from system to system due to varying contexts.

‘Coping range’ is a term often used synonymously with adaptive capacity, although some researchers see ‘coping’ as very distinct from ‘adapting’ (e.g. Thomalla et al, 2006). It relates to both the magnitude of an event and the ability of a system to cope with a range of conditions. When the magnitude of an event exceeds a system’s coping range the system finds itself in a vulnerable state. Figure 2.4a illustrates the ability of a system to cope with a certain level of variability in climatic conditions (drought conditions in this example). When an event falls outside the system’s coping range (an extreme drought), severe consequences may result. Figure 2.4a also indicates that a system will be able to cope with a gradual increase in mean temperature so long as it remains within the system’s coping range. Figure 2.4b illustrates that shifts in mean temperature result in shifts in the magnitude of variability around the mean. Extreme events then become problematic as they more often fall outside a system’s coping range. It is important to note that a system’s coping range may change over time as the system adapts and accommodates for deviations in normal conditions (Smit et al, 1999).

Figure 2.4a: Hypothetical Time Series for Drought Conditions

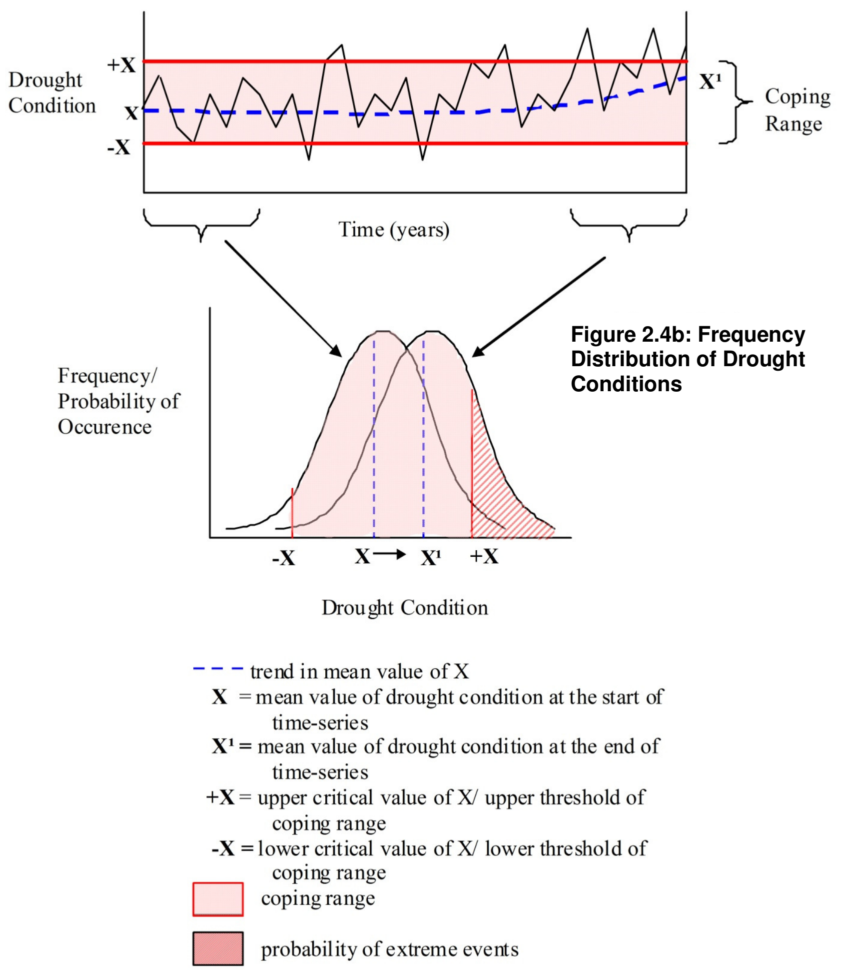


Figure 2.4b: Frequency Distribution of Drought Conditions

Figure 2.4: Hypothetical Time Series for Drought Conditions and the Frequency of Drought Conditions (Hewitt and Burton, 1971; Smit et al, 1999)

Adaptations are manifestations of adaptive capacity, and adaptive strategies and adaptive capacity are strongly influenced by social, environmental, biophysical, political, institutional and economic contexts (O'Brien and Leichenko, 2000; Belliveau et al, 2006). Differing contexts mean that different systems experience and respond to changing conditions in different ways. In jurisdictions where crop insurance is available or perhaps subsidized, for example, the feasible adaptive strategies are different from places where no crop insurance exists. Therefore, the process and form of adaptation as well as the capacity to cope with changing conditions will vary from time to time, place to place, region to region, farm to farm, etc. The complexity of agricultural systems and the various forces influencing agricultural decision making are addressed in the following chapter.

2.2 Agricultural Complexities

This section explores the literature that investigates the circumstances that shape agricultural decision making in order to provide a foundation for understanding adaptation to climate change in agriculture. It begins by examining the agricultural systems body of scholarship, which highlights the complex, multi-scale nature of agricultural systems and the multiple forces influencing the system. The factors that have stimulated adjustments in agriculture in the past are then described. Concluding the section is a discussion of the inherent riskiness within agriculture and how risk is managed.

2.2.1 Agricultural Systems

The agricultural systems perspective evolved to bridge the gaps created by what some believed was fragmented agricultural research. Previously, research was highly specialized and focused on components of agriculture, such as soil science and entomology. The agricultural systems approach to research is a multidisciplinary approach created to integrate this knowledge (Bradshaw, 1995).

In the agricultural systems literature agriculture is treated as a complex system influenced by broader functioning systems: ecological, economic, social and political (Bryant and Johnston, 1992), which are intricately connected along multiple scales (e.g. international, national, region, farm and farmer) (Olmstead, 1970; Bryant and Johnston, 1992; Cocklin et al, 1997). The individual farm is the primary unit of analysis in the agricultural systems literature, itself comprised of interrelated and overlapping sub-systems (Bradshaw, 1995). The farm, for example, is influenced by endogenous (e.g. perceptions and capital) and exogenous (e.g. government subsidies, international markets and exchange rates) forces.

An understanding of the broader functioning system is needed in order to understand farm-level processes such as adaptation (Bryant and Johnston, 1992). The literature stresses that every agricultural system is unique, that forces join together to create a spatial hierarchy of farm-level exposures, that responses to risks are influenced by farmers' perceptions and experiences of risks, and that farmer respond to the manifestation of the forces acting together, not just one particular force (Bryant et al, 2000; Eakin, 2000; Nelson et al, 2007). Each agricultural system will be confronted with a variety of stresses stemming from numerous forces manifesting differently depending on the system of interest, and each system will respond differently in the face of changing conditions. It is important to note that these conditions can create opportunities, not just risks, for agricultural systems.

Not only is agriculture operating within a broader functioning system creating risks and opportunities for the farm, but over the past 50 years, agriculture has undergone drastic transformations resulting from paradigm shifts that have motivated, and been motivated by, political, economic, institutional, social and environmental systems. The next section discusses the paradigm shifts and circumstances that have contributed to the restructuring of agricultural systems.

2.2.2. Drivers of Agricultural Change

In developed countries, growing urban markets resulting from the industrial revolution fostered the creation of a commercial mode of agricultural production based on a capitalist, industrial model (Parson, 1999; Bryant and Johnston, 1992). This new model for agriculture consisted of the substitution of capital for labour, the spatial expansion of agricultural production, immersion into the global marketplace, and more specialized forms of farming and enterprise (Parson, 1999; Klein and Kerr, 1995; Bryant and Johnston, 1992). Agriculture became highly specialized, intensive and spatially concentrated, resulting in a decrease in the number of farms and an increase in farm size (Bowler, 1992). Farmers had to accommodate new economic, technological and market circumstances, which were reflected in terms of land arrangements and use, rural population trends, income returns and operational arrangements (Parson, 1999).

Post-industrial society challenged industrial agriculture as growing health concerns regarding food quality and rural populations surfaced and the Green Revolution became mainstream (Bryant and Johnson, 1992). Consumers began to question conventional agriculture practices, particularly in terms of product quality (Holm and Kildevang, 1996). One popular case which commanded global attention involved the United Kingdom's beef industry, where scientists linked a disease found in cows called Bovine Spongiform Encephalopathy (BSE), also commonly referred to as mad cow disease, to Creutzfeldt-Jacob disease in humans (Palmer, 1996). Human health dangers and the technological processes associated with genetically modified foods have also motivated consumers to question the quality and trustworthiness of food products (Palmer, 1996; Bredahl, 2001).

In response to human health concerns, environmental well-being was brought to the forefront of agriculture (Holm and Kildevang, 1996). The adoption of environmentally sustainable farming practices became more widespread and there was greater diversity in the production system, necessitating more in-depth knowledge for appropriate and adequate farm management (Bryant and Johnston, 1992).

Not all farmers have benefited during these two periods of agricultural restructuring, particularly those who have been unable to convert their traditional farming system, in both developed and developing world contexts. Killick (2001) highlights a few reasons why developing world farmers have been unable to integrate into a global economy, including market access, government policy stances, access to market information, market integration and farmer assets, all of which significantly influence the ability of farmers to succeed in a commercialized world.

Perhaps not to the same degree, but many of the same patterns described above are present in the developing world (Reardon and Barrett, 2000). Wilkinson (1995) states that agroindustrialization in developing countries relates to three sets of changes: 1) the growth of agroprocessing, distribution and farm-input provision activities off-farm; 2) institutional and organizational change in the relationships between agroindustrial firms and farms; and 3) changes in the farm sector. Post-industrial agricultural changes are just recently being reflected in developing countries, primarily due to restrictions imposed by importing countries (Timmer, 1998). Figure 2.5 provides an illustration of large scale trends and describes how these trends have influenced agriculture and development in developing countries.

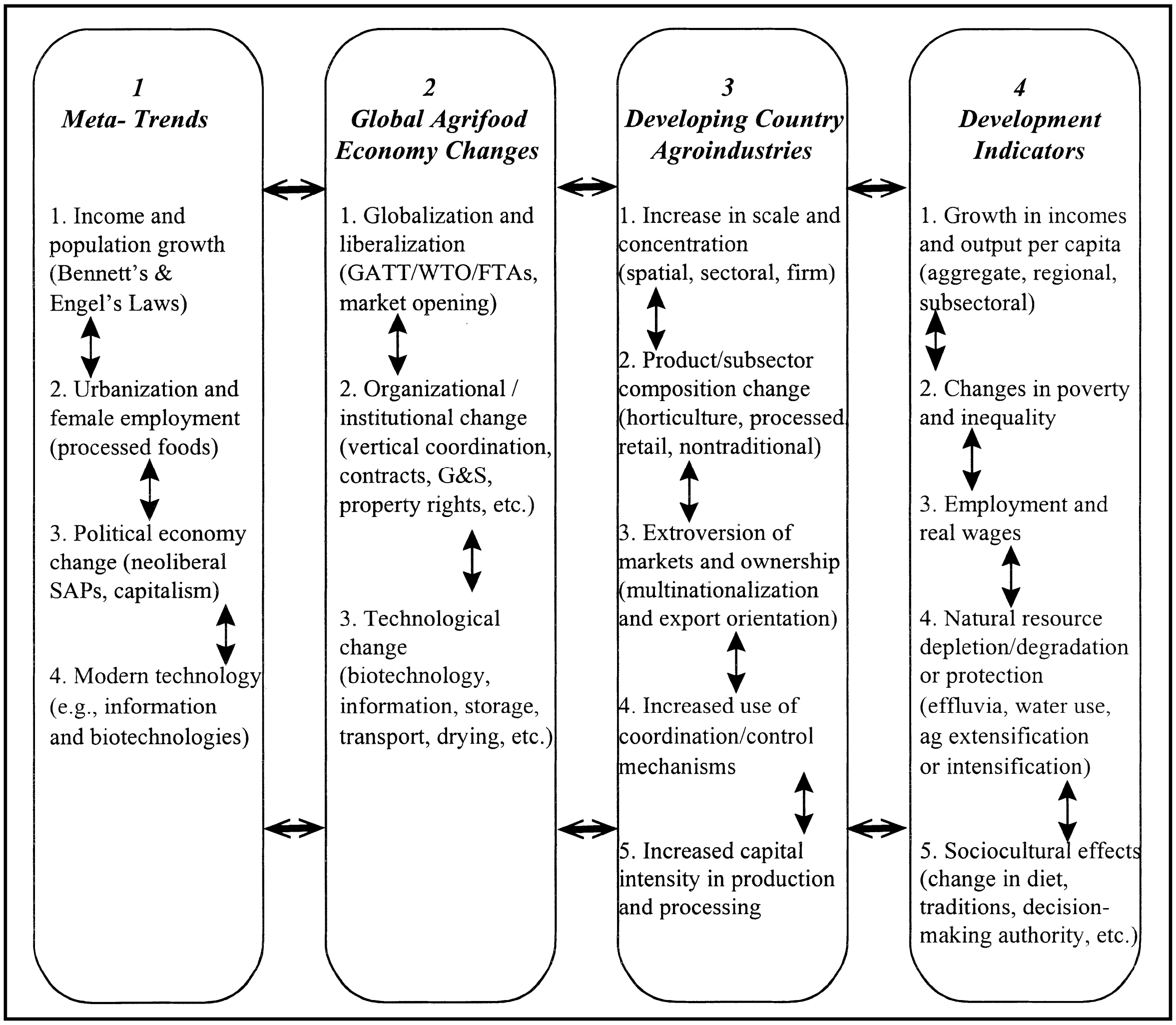


Figure 2.5: Flow Diagram Indicating the Linkages Among Globalization, Agroindustrialization and Development (Reardon and Barrett, 2000)

Most developing countries were excluded from the global economy in the post-war era. International agencies and agreements have played a key role in restructuring agriculture in developing countries. Market- oriented economic reforms imposed by the World Bank, the International Monetary Fund and other external political and economic powers appeared through structural adjustment programs—an international effort to stimulate stagnant agricultural sectors by promoting capitalist farming (Mellor, 1998). The Uruguay Round of 1994 and other regional trade agreements have facilitated the integration of developing world agriculture into the global economy via agricultural liberalization (Killick, 2001). Countries have begun to capitalize on their comparative advantages and are moving away from targeting domestic markets towards global markets and exporting their agricultural goods (Collier and Sater, 2004). State intervention in the sector has been slowly reduced, land tenure structure transformed, and technology transfers adopted, including biotechnology, information, storage and transportation (Kay, 1998; Reardon and Barrett, 2000). Domestic agricultural production has been highly exposed to international competition and subject to aggressive foreign direct investment (FDI). All these forces stimulated responses in farmers and resulted in drastic changes in agriculture, including the move away from traditional crop production, increases in farm size and scale of production, the need for capital to remain viable, increases in productivity and regional specialization and differentiation (Kay, 1997; Reardon and Barrett, 2000).

The situation described above is certainly the case in wine sector in Chile. The grape and wine industry in Chile grew rapidly after the adoption of agricultural liberalization and market-oriented economic policies (Kay, 1997; Collier and Sater, 2004). Although many producers were able to adapt their operations to the industrial mode of production, others were not as adaptable. Entrepreneurship, farm size, access to capital, agricultural policies and its biases, technical knowledge and agro-climatic factors greatly influenced the response and management strategies available to producers in this newly liberalized economy (Kay, 2002).

This literature highlights just a few of the exogenous forces that have played a key role in shaping agriculture in both developed and developing world contexts that are beyond the individual farmer's control. The ways in which farmers have responded and will respond to stimuli vary depending on farm-level characteristics, including the operating environments, personal factors, risk perception and the risk management strategies available to farmers (Bryant and Johnston, 1992). Risk and risk management in agriculture are described in the following section.

2.2.3 Agricultural Risk and Risk Management

Agricultural systems are constantly confronting risky and uncertain situations. Risk is created when a course of action is taken and the outcome of the action is uncertain, whether it is a gain or a loss (Hardaker et al, 2004; Fleisher, 1990). The outcomes are dependent on two variables: 1) the actions chosen; and 2) future events that are largely uncontrollable (Fleisher, 1990).

Agriculture is inherently risky; farmers are required to make decisions regarding their operations (e.g. what to plant and where to plant it) without knowing the outcomes of their decisions (Fleisher, 1990). Risk can stem from a variety of sources. Hardaker et al (2004) suggest there are 6 types of risk in agriculture: production, price/market, institutional, human/personal, business and financial. Table 2.4 provides a summary and some examples of these types of risks from the grape and wine industry. Fluctuations in economic, cultural, political and environmental conditions, for example, can create risks for farmers, as they have the potential to affect their economic and social well-being (Wandel and Smit, 2000; Smit et al, 1997).

It has been widely documented that the management strategies adopted by farmers are particularly influenced by their perceptions of risk (Fleisher, 1990; Bryant and Johnston, 1992; Smit et al, 1997; Legesse and Drake, 2005). Smit et al (1997) evaluated farmers' riskiness in corn hybrid selection in the face of climate variability and found that farmers' decisions regarding which corn hybrid to plant were made based on past experiences and performances. Farmers were more willing to take risks after a good year than after a bad year. Farmers' perceptions of risk are therefore largely based on previous experiences, and the management strategies they adopt largely reflect these experiences. Not only are risk management strategies (often referred to as adaptations) intrinsically linked to farmers' perceptions of risk, but they are implicit within the business decision making process (Smit and Skinner, 2002; Wall et al, 2007).

Table 2.4: Types and Descriptions of Risk in Agriculture with Examples from the Grape and Wine Industry (Adapted from Fleisher, 1990; Hardaker, 2004)

Type	Description	Examples
Production risk	Stems from the unpredictability of weather and the uncertainty of regarding performance	Weather events (e.g. extreme rainfall) or pests and diseases (e.g. red ant, botrytis) that reduce yield
Price/Market risk	Refers to the uncertainty surrounding price variations in farm inputs and outputs during the decision making process	Increases in fungicide prices that increase input costs and low USD exchange rates that decrease income
Institutional risk	Results from changes in the rules and regulations that govern agriculture. Includes *political risk*, the uncertainty in policy legislation, its implementation and its potential for unfavourable effects, *sovereign risk*, the possibility of foreign governments failing to honour commitments, and *relationship risks*, the uncertainty surrounding business interactions and agreements	Restrictions in the use of fungicides. Wine buyers not satisfying their contracts. Wine producers not buying the grapes contracted from grape growers
Human/Personal risk	Refers to the people who work on and operate the farm and the potential to reduce profitability	Carelessness of workers during pruning can reduce profitability at harvest
Business risk	Essentially all the uncertainty influencing farm profitability and farm business performance, independent of the way the business is financed, including the aggregate effects of production, price/market, institutional and human/market risk	The combination of all the examples listed above reducing the profitability of the operation
Financial risk	Refers to the method financing the business	Lack of available credit

Risk perception is complex and multi-faceted. This is reflected in the three main factors that influence risk perception among farmers proposed by Leiss and Chociolko (1994): 1) the degree to which the hazard is understood; 2) the degree to which it involves feelings of dread; and (3) the size and type of the population at risk. Risk management strategies often vary significantly among similar producers due to variations in risk attitudes (Fleisher, 1990). Three types of risk attitudes have been identified in the literature: risk aversion, risk indifference and risk preference (Fleisher, 1990). Risk averting farmers are cautious and tend to prefer less risky decisions. They are likely to sacrifice some amount of income to reduce probability of low income or losses. Risk indifferent farmers make decisions based on highest expected values, regardless of outcome distribution. Risk-preferring farmers prefer more risky decisions and would not give up the possibility of gains to eliminate possible losses (Fleisher, 1990). The factors and attitudes described above vary from person to person, and therefore risk management strategies also vary.

Farmers typically avert, reduce or avoid risk through management (Hazell, 1986). There are numerous risk management strategies available to farmers and the ones adopted reflect risk attitudes, discussed above, as well as farmers' abilities to bear the costs (Hardaker et al, 2004). Jolly (1983) identifies two types of risk management responses: those attempting to control risk exposure and those controlling the impact on the farm. Kay et al (2004) go further and categorize strategies according to the risk being managed. Table 2.5 provides examples of risk management strategies that have been used in the grape and wine industry.

Table 2.5: Examples of Potential Risks / Exposures and Risk Management / Adaptive Strategies in the Grape and Wine Industry (Adapted from Jackson and Schuster, 2007)

Risks/Exposures	Risk Management /Adaptive Strategies
Spring frost kills primary bud and reduces grape quantity and quality	• Plant frost-sensitive varieties at high elevations, not in valleys
Heat stress reduces grape quality and quantity	• Plant heat-sensitive varieties at low elevations
Carelessness of workers during pruning can reduce profitability at harvest	• Fire or re-train workers

Climate change is one source of risk that has generated much attention in the literature, yet it has been found to be among many risks affecting agriculture (Smithers and Blay-Palmer, 2001; Belliveau et al, 2006). Climate risks needs to be placed in the context of other risks in order to fully understand the agricultural decision making environment (Bradshaw, 2007). Belliveau et al (2006) investigated farm-level risks and opportunities and their results indicate that the presence of multiple risks and opportunities greatly influence the vulnerability of, and the adaptive strategies utilized by, grape growers and winery operators. Management strategies are often not only useful in averting risk but also as adaptations to climate change and variability. Understanding risk, risk perception and risk management is therefore necessary to understand adaptation to climate change in the agricultural sector.

2.3 Summary

This research is informed by and contributes to the bodies of scholarship related to climate change and agriculture and agricultural complexities. The climate change and agriculture scholarship provides insights into the various approaches, including impact and vulnerability assessments, used to understand the issue of climate change and how it will influence agriculture. The scholarship on agricultural complexities highlights the complex decision making environment within which farmers operate as well as the multiple forces influencing the farming system at various scales. Vulnerability assessments recognize the need to understand the complex processes through which farm-level adaptation occurs. The ways in which the core ideas drawn out of the Agricultural Complexities section of this thesis (section 2.2) relate to the basic vulnerability framework are shown in Figure 2.6.

Climate change has the potential to create both risks and opportunities for the grape and wine industry in the Maule Region. Maule is an ideal location for grape and wine production, although there is an increasing incidence of water shortages and other conditions influencing production (Santibañez, 1999). The conceptual model of vulnerability discussed at the onset of this chapter was used to guide the empirical research into the vulnerability of grape and wine producers in the Maule Region to climate change and is used to structure the discussion of results in this thesis. Through a case study in the Maule Region’s wine sector, this research seeks to understand the risks and opportunities faced by grape growers and wine producers, to document their responses in light of these risks and opportunities, and to highlight how climate change might influence the industry in the future. The case study of the Maule Region's grape and wine industry builds on the climate change, agricultural systems and development literature explored in this chapter. The following chapter provides a detailed description of the study region.

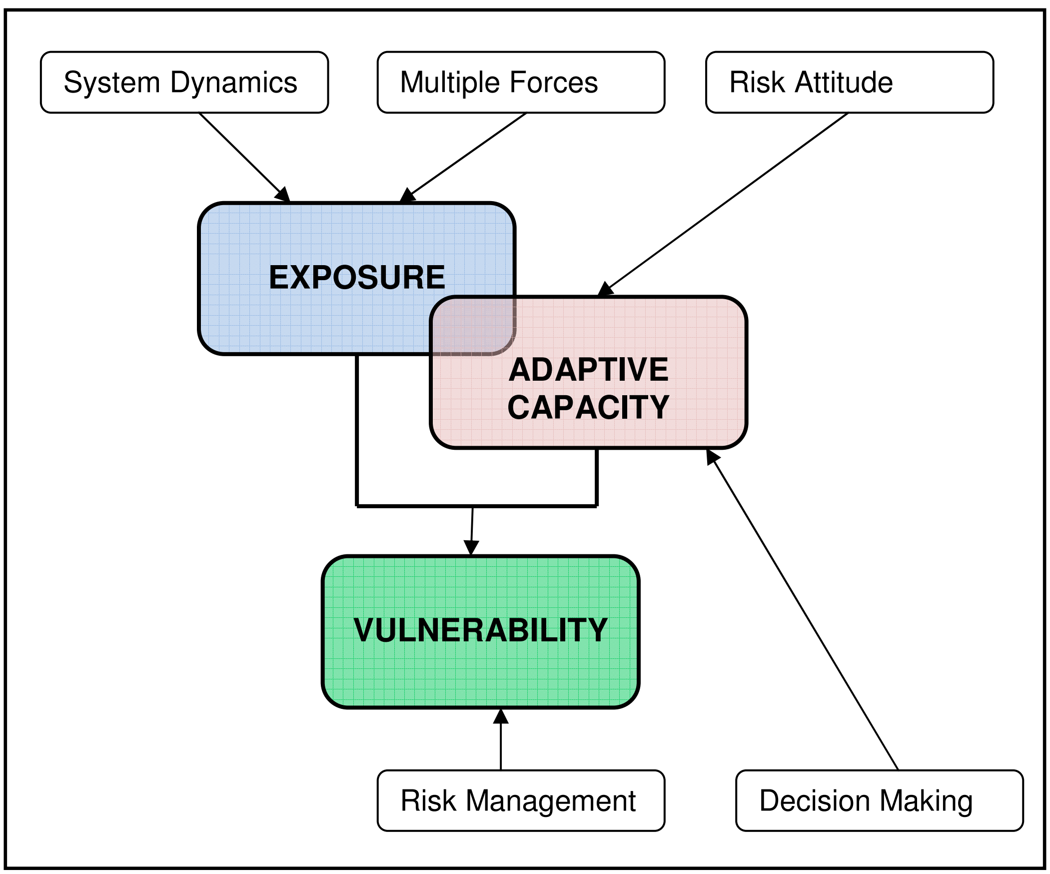


Figure 2.6: Relationship between Agricultural Complexities Literature and Vulnerability Framework

CHAPTER 3: STUDY REGION

The purpose of this chapter is to describe the study region. The study region chosen for this case study is Maule, Chile. The chapter begins with a discussion of the predominant political and economic forces that have been critical in shaping agriculture in Chile, followed by a discussion of the water sector, because water is vital to the success of the grape and wine industry in Maule. The chapter then summarizes the stages of grape development and wine making as well as the evolution of the industry. It concludes with a description of the geography of Maule and the characteristics that facilitate and constrain grape and wine production in the region.

3.1 Agricultural Restructuring in Chile and the Water Sector

The agricultural landscape in Chile has undergone dramatic changes in the past 50 years. Political and economic forces have been the primary drivers of these changes. One particular force that has significantly influenced agricultural patterns is the water sector. This section explores the political economy of agricultural restructuring in Chile and provides a description of the water sector.

3.1.1 Political Economy of Agricultural Restructuring in Chile

With 75% of its Gross Domestic Product (GDP) generated from exports, and a large portion stemming from the agricultural sector, Chile, shown in Figure 3.1 with its administrative regions, is currently highly integrated in the world economy

(FITA, 2007). This, however, has not always been the case. There have been many fundamental structural changes in Chile's political and economic systems over the last 50 years that have facilitated this growth. In particular, both the move away from a state-controlled economy towards a free market economy and the adoption of aggressive neoliberal economic strategies by the military regime have proven to be economically beneficial, although the distribution of social benefits has been less than equal (Díaz and Korovkin, 1990; Bauer, 1997).

Figure 3.1: Map of Chile and its Administrative Regions

Salvador Allende, head of the *Unidad Popular* (UP) and the first Marxist to win a democratic election, became president of Chile in September 1970 (Sobel, 1974). At the time, Chile was plagued by economic underdevelopment and dependence (Johnson, 1973; Sideri, 1979). Underdevelopment perpetuated poverty, while dependence on international structures facilitated underdevelopment (Johnson, 1973). The Chilean government was unable to make decisions with respect to its economy, politics and social life due to the constant interference of external economic and political powers (e.g. the World Bank and the International Monetary Fund) (Johnson, 1973). The UP government felt that a socialist society would be the best way of getting Chile out of this state of underdevelopment and dependence. The socialist Allende government highlighted the need to limit the operation of the capitalist system and thus implemented drastic economic restructuring policies that primarily sought to nationalize the industrial sector and transform inequities in the agricultural sector.

Food imports of agricultural products had doubled despite abundant land resources and favourable climates for food production in the late 1960s (Johnson, 1973). Chile's traditional land structure was composed of a number of types of rural labourers with varying tenure status. Table 3.1 provides a summary of the class structure in the Chilean countryside prior to the Allende government.

Table 3.1: Class Structure in Chilean Countryside, 1966 (Steenland, 1977)

Class	Number	% of Population
Latifundista	12,737	2
Rich Peasants (who permanently hire outside labour)	42,980	7
Middle Peasants (occasionally hire outside labour)	141,474	21
Minifundistas (own their own land but hire no outside labour)	132,021	20
Foremen and Custodians	45,9717	7
Inquilinos (wage workers living on farm)	82,367	12
Medieros (sharecroppers)	26,861	4
Afuerinos and Voluntarios (wage workers from outside the farm)	179,778	27
Total	664,189	100

Chile's countryside was dominated by a small number of large farms, a large number of small farms, and landless workers (Thiesenhusen, 1995). Most of the productive agricultural land was in the hands of the few; over three quarters of the agricultural land was held by large estate owners (*latifundistas*), each employing more than 12 workers. Farm labourers who lived on the farm (*inquilinos*) were given small parcels of land (*chacras*) as payment for their duties in addition to a small wage, and those who did not live on the farm (*afuerinos*) were given cash payments for their labour. *Inquilinos* were typically allowed to grow corn, beans and squash on their *chacra* for subsistence or sale at the market by the *latifundistas (*Thiesenhusen, 1995*)*. Small land holders (*minifundistas*) on small farm plots (*minifundios*) accounted for 78 percent of farms even though they occupied 5 percent of total farm land (Thiesenhusen, 1995). Many large estates (*fundos*) were later sold and purchased by Chilean elites. Farming on these *fundos* was halted because the buyers were not interested in agriculture, and farmers also had limited access to technology and markets, which discouraged extensive agricultural production (Steenland, 1977). Through agrarian reform—initiated by Frei, the president who preceded Allende, and radicalized aggressively by Allende—this land structure system was transformed.

The radical agrarian reform adopted by Allende sought to undo the social inequities created by the *latifundio* system, reduce poverty and speed economic growth by rapidly expropriating a large number of *latifundios* (Burnett and Johnson, 1970; Thiesenhusen, 1995; Collier and Sater, 2004). The UP supported the poor rural farmer (*campesino*), recognizing the vast inequalities that existed, and attempted to redistribute wealth and income among *campesinos* (Murray, 1997). At the time, *campesinos* had no voice, little or no land, and no means to acquire land. They were predominately poor rural farmers and workers that depended on the *latifundio* owner for credit, land, markets for their products, and employment. Allende aimed to create a classless society in the Chilean countryside and planned to do this through the expropriation of all farms over 80 basic irrigated hectares (BIH) in Chile within a two and a half year time frame

(Steenland, 1977). One BIH is a unit of measure that is equivalent to one hectare of irrigated land in the Greater Santiago area.

Democratically elected *campesino* councils were created at the local, regional and national levels in order for everyone to participate in the agrarian reform process (Johnson, 1973). The reform targeted one geographic region at a time as opposed to estate by estate. The expropriated land, now under public ownership, was redistributed among rural farmers and workers (*campesinos, inquilinos, afuerinos*). Agrarian reform centres (CERAs) were then created (Thiesenhusen, 1995). CERAs were state farms that employed *campesinos* who received a straight salary. In addition, *campesinos* were given small plots in which most produced vegetables for subsistence purposes (Steenland, 1977). CERAs were funded by the state and the state received 90 percent of their profits. The state was also responsible for marketing the products. CERAs were designed as a transition stage; after two years, the members (*socios*) of the CERA would decide whether to continue working it collectively or subdivide it into privately held plots. The intention was to benefit all *campesinos* that did not have sufficient productive land and stable employment. However, only rich *campesinos* were able to obtain land rights, while poor *campesinos* provided the labour for the farms (Steenland, 1977).

Allende created numerous programs aimed at increasing both agricultural production and *campesino* income. These programs provided credit, technological assistance and training, and guaranteed markets and prices for all their products (Johnson, 1973). Working capital such as machinery was also expropriated to avoid decapitalization by previous owners and to make it feasible to continue production (Johnson, 1973).

By 1972, there were few farms larger than 80 BIH remaining in Chile. The bourgeoisie and previous owners of the *latifundio* began to control farms between 20 and 80 BIH, which were transformed into large, capitalist farms, while the *minifundios* held parcels of land less than 5 BIH (Steenland, 1977).

Beans, corn, squash, wheat, and sugar beet were traditional crops produced on farms in Chile in the early 1970s (Gwynne and Kay, 1997). These products satisfied the domestic market and did not change during Allende's presidency because agricultural production was predominately driven by internal demand. The State, *socios* of the *asentamientos*, CERAs and the large, capitalist farms—who controlled a large percentage of the productive land—controlled production. The richest groups of *campesinos* were the ones empowered by Allende's agrarian reform and the ones who obtained land rights in the *asentamientos* and CERAs.

General Augusto Pinochet led a military coup backed by the United States that overthrew the Allende government on September 11, 1973 (Kay, 1997). Shortly thereafter, Chile underwent a complete political economic transformation. The military government acted quickly to undo much of what the Allende government had effected (Thiesenhusen, 1995). Chile moved away from a state-controlled economy towards a free market economy. A neoliberal economic model was introduced; sectors of the economy were privatized, agrarian reform was halted, funding for agriculture was cut back, and the formation of unions and collectives banned (Collier and Sater, 2004).

Pinochet was a dictator whose regime was violently oppressive and intolerant of those who did not share his views regarding Chile's future. With no prior economic training, military generals were put in charge of important institutions (Collier and Sater, 2004). Recognizing they did not have the skills to restructure the economy, Pinochet enlisted the infamous "Chicago Boys", neoliberal Chilean economists trained at the University of Chicago, to create a free market and decentralized the economy (Collier and Sater, 2004). The Chicago Boys reversed Chile's state-interventionalist trend by opening up the economy and capitalizing on the country's comparative advantage in market exports, particularly agriculture (Díaz and Korovkin, 1990; Collier and Sater, 2004). A purposeful attempt to facilitate the creation of large, capitalist farms was also made.

Allende's agrarian reform came to an immediate stop. Again, there were major transformations to the landholding structure. Much of the land that had been expropriated by the Allende governments was re-expropriated and returned to former owners or to companies, such as those involved in the forestry sector

(Gwynne and Kay, 1997). The remainder of the land was divided into small plots (*parcelas*) and distributed among selected land-reform beneficiaries (Jarvis, 1992). The redistribution of land is shown in Table 3.2, where the 1972 column represents agrarian reform under Allende and the 1979 column land reform under the Pinochet government. Plots of land were given to *campesinos* that could prove they worked on the farm prior to expropriation, were the household head, and were not involved in strikes or invasions during the Allende government (Thiesenhusen, 1995). This process assured that land was given to older, less-educated farmers (*asentados*).

Table 3.2: Proportion of Land Accounted for by Different Sized Farm Units (Murray, 2002)

Size Category	1972	1979
< 5 BIH	9.7	13.3
5-20 BIH	13	29
20-80 BIH	38.9	36.3
>80 BIH	2.9	16.9
Reform sector	35.5	0
Public agencies	0	4

Unable to afford the family farm, partly due to the slashing of government spending on agriculture, many small plot owners were forced to sell their *parcelas* and were left landless; some left agriculture altogether, others worked as labourers (Echenique and Rolando, 1991). Approximately 30 percent of land-reform beneficiary *parcelas* had been sold by late 1979, 60 percent of these had been purchased by larger farmers (Jarvis, 1985). Many former landowners who received their property back in the re-expropriation process decided to sell a portion or all of their land as well (Maffei, 1978; Jarvis, 1985). Land continued to be accumulated by larger Chilean landowners who had access to capital (Jarvis, 1985). After the legalization of corporate farming, corporations purchased large parcels of land in some of the better fruit-producing areas (Jarvis, 1985).

There was a large shift towards export after the adoption of neoliberal economic policies, although a very small fruit export sector had been established prior to Pinochet. Much of Chilean agriculture was characterized by highly-capitalized, labour-intensive, commercial farming that was directed toward export markets (Collier and Sater, 2004). The Pinochet regime recognized there was an opportunity to satisfy foreign fruit markets during the Northern Hemisphere's winter and thus implemented agro-industry policies that heavily subsidized fruit production and export, including wine grapes (Haggard and Kaufman, 1995; Collier and Sater, 2004). During the regime, the Chilean fresh fruit export sector increased from $30-949 million (Kay, 1997), with many large farmers moving out of traditional crop production (e.g. beans, corn, beet, squash and wheat) and into higher value fresh fruit production (e.g. wine grapes, table grapes and citrus) (Gwynne and Kay, 1997). Farmers who specialized in traditional crops found themselves vulnerable to international markets because of cheap imports and decreasing internal demand (Gómez, 1979; Kay, 1997). Many traditional farmers went bankrupt, while some peasant farmers shifted production to vegetables such as beans for export or to sell in Santiago's markets (Collier and Sater, 2004).

Inequalities arose among farming regions, among farmers and among labour sections (Gwynne and Kay, 1997). In an effort to reverse inequalities, the Pinochet government attempted to partially reverse the neoliberal policies. It imposed tariffs on imports of traditional crops and sought to gradually modernize peasant agriculture that was deemed viable, and make it more productive (Gwynne and Kay, 1997). Despite this attempt, regional disparities in production, productivity and income were evident; Regions V and VI were export-oriented and Regions VII and IX were more traditional (refer to Figure 3.1); the export-oriented regions tended to focus on tender fruit production, while the more traditional regions focused on forestry and livestock production.

Chilean agriculture during the Pinochet government can be characterized in two very different ways: 1) capitalist Chilean elites primarily producing fresh fruits for export; and 2) peasant farmers producing traditional crops largely for the domestic market. Capitalist agriculture dominated the agricultural sector through land holdings, markets and production. Chilean elites held the majority of the land and dominated production for export markets. This was supported by the government through subsidies and other incentive structures.

The military regime's inflexibility surrounding its economic policies caused an economic recession, resulting in mass opposition mobilizations (Díaz and

Korovkin, 1990; Collier and Sater, 2004). The Coalition of Parties for Democracy (*Concertación de Partidos por la Democracia*, or simply *Concertación*), a group of centre-left parties that has won every presidential election since the regime, lobbied to have an election and defeated Pinochet's government. In 1990, Patricio Aylwin became the first democratically elected president in Chile since Allende.

The *Concertación* government's decision to maintain a neoliberal free-market economy has also had significant implications for agriculture in Chile. Chilean wine exports, for example, more than quadrupled from 1995 to 2005 (Figure 3.2). In 2004, there were many small farms, few large farms, but most of the usable agricultural land was occupied by the large farms. Many small farmers in agricultural producing regions have sold their land to international marketing companies because land values are skyrocketing and they see this as an opportunity to pay debts (Murray, 1997).

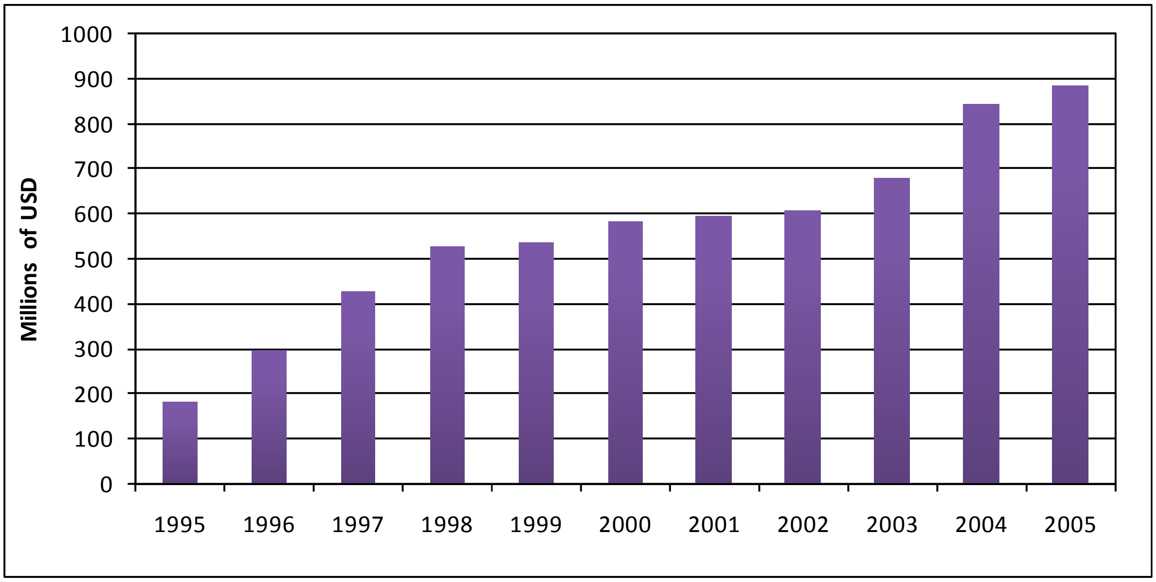


Figure 3.2: Value of Chilean Wine Exports from 1995-2005 (Data Source: SAG, 2006a)

Reconversion of agricultural production patterns aimed at increasing profitability has been given much attention by the *Concertación* government. Mainly large farmers have profited from reconversion policies. Farmers can adjust to changing profitability in two ways: 1) by changing land use patterns (i.e. shifting to more profitable activities); and 2) by raising production yields (Kay, 1997). Larger farmers have the capacity to adjust, whereas most small farmers do not have access to the capital and technology needed to make these transitions (Kay, 1997). Large farmers were able to make the transition to non-traditional crops such as wine grapes; whereas few small farmers have successfully made the transition; most find themselves either struggling with non-traditional crop production or just getting by with traditional crop production.

The adoption of irrigation has significantly increased the global competitiveness of Chilean agriculture, particularly the grape and wine industry. Water for irrigation is allocated via water rights and obtained through canals and wells. The Chilean water sector is distinctive on a global scale and thus warrants further explanation. The following section describes the water sector in Chile and its importance to agriculture and irrigation.

3.1.2 Chilean Water Sector

After the adoption of a neoliberal economic model during the Pinochet government, sectors of the economy as well as property rights were privatized; state regulation weakened, and in 1981, the Water Code established, which transformed the country's system of water rights (Bauer, 1998; Collier and Sater, 2004).

In Chile's constitution water resources are defined as a 'National Good of Public Use' because they are essential for life, the economy, society and the environment. The State is responsible for regulating water use in such a way that meets society's demands for water (Productivity Commission, 2003). The Water Code, the principal legislation governing water resource management, defines access to and use of water, and establishes a water market (Corkal et al, 2006). The Code declares that water is public property, to which the state can grant private rights of use (Bauer, 1997).

The Water Code did not place conditions on what rights can be used for and applicants are not required to specify what the right will be used for (Corkal et al, 2006). Rights holders do not pay taxes or fees for acquiring or maintaining rights, they have no obligation to use their right, nor are they required to advise the water rights agency, the National Water Directorate or *Dirección General de Aguas* (DGA), of their intent to change the location or types of uses of water rights (Bauer, 1997). Water rights in Chile are held separately from property rights; that is, one can own a parcel of land without owning the water or rights to the water on that land. This has allowed for more flexibility in resource allocation (Bauer, 1998).

Traditional water users, including farmers, were granted rights based on their historical use (Bauer, 1997; Budds, 2004). Rights are allocated by the national government and when there are simultaneous competing requests for water rights they are auctioned and granted to the highest bidder. Water user associations are responsible for the delivery of water, which occurs primarily through canals for irrigation purposes (Easter and Hearne, 1994). Once all rights are allocated, future transfers are to take place through the market (Budds, 2004). Rights may be freely bought, sold, mortgaged, transferred or traded (Corkal et al, 2006). Legally, rights are specified in volumetric terms (e.g. litres/second), but in practice, many are expressed as a proportion of flow or as shares of canals (Bauer, 1997; Productivity Commission, 2003).

The DGA has little authority over private water use, as most management decisions are made by private individuals, and no one has the authority to cancel or restrict water uses once rights are granted (Bauer, 1997). Rights holders have secure ownership of the rights they are granted, which provides more incentive to invest in greater productivity in agriculture, for example. Water rights markets are utilized in Chile with the intent of optimizing the allocation of water resources and maximizing water use efficiency under the assumption that market pricing will force the highest value use of water, that private property rights promotes individual freedom of choice, and that markets are more politically neutral than the State in resource allocation (Bauer, 1997; Haddad, 2000; Budds, 2004).

The Water Code was established to promote agricultural development, increase legal security of private water rights, and to raise the efficiency and productive value of water uses by relying on market forces (Bauer, 1997). Since the Water Code was established in 1981, there has been significant investment in agriculture and hydro-electricity, and in some cases, water-use efficiency has increased, primarily due to individual investment in more efficient technologies (Bauer, 1998; Corkal et al, 2006). However, since the Water Code's main concern was irrigation, it did little to address multiple water uses (Bauer, 1998). Coordinating different uses thus depends on institutional structure and the Code's general logic (i.e. private bargaining and exchange among property owners), rather than specific provisions (Bauer, 1998). As a result, there are increasing conflicts among water users.

In 2005 there was an amendment to the Water Code which sought to promote more efficient and sustainable uses of water; other amendments include requiring those applying for water rights to justify the amount requested. The DGA now has the authority to deny these requests. In an attempt to deter water rights hoarding, those who do not use their allocation are subject to a tax (Morales and Espinoza, 2005). The effectiveness of this tax is questionable because large agricultural producers have the majority of water rights and paying a tax that ensures future access to water is often well worth their while (MDA, 2005).

Water resources are being used more efficiently and water allocation is more efficient in areas where water resources are scarce and have a high economic value, particularly where there is intensive and high-value agricultural production, largely due to modern irrigation technology (Gómez-Lobo and Paredes, 2001). The grape and wine industry is one agricultural activity that has experienced considerable growth and expansion as a result of increased irrigation accessibility and availability. Irrigation has made it possible for low quality vineyards to be replaced with higher quality varieties. This trend is most prominent in the Maule Region, a region whose grape and wine industry has a long history and has undergone drastic transformations. The following section provides a brief history of the Maule wine sector and a description of the geography of the Maule Region.

3.2 Maule Region: History and Geography of the Grape and Wine Industry

This section reviews the history and geography of the grape and wine industry of the Maule Region. It first summarizes the stages of grape development and wine production— a basic understanding of these processes is necessary to appreciate the results of this research. It then offers a detailed geographical background of the region, and concludes with a review of the historical evolution of the industry.

3.2.1 Grape Development and Wine Making

The following stages of grape development were extracted from Jackson and Schuster (2007).

1. **Advanced Bud Swell**: Dormant buds begin to swell when mean ambient temperatures reach a minimum of 10 °C. This represents the first growth stage. Vineyard management practices to ensure bud survival are essential during this time. Weeds can be removed or sprayed, soils tilled and herbicide and sulphur applied to deter pests and diseases.

Photo Credit: Michigan Wines

Photo Credit: Quady Winery

2. **Bud Burst and Early Shoot Growth**: A six to ten week period consisting of rapid shoot and root expansion, leaf development and flower cluster formation follows. This grand period of growth requires vineyard management practices that

focus on successful fruit development. Practices usually involve manipulation of shoots to avoid excessive shading, reduce humidity and facilitate spray application, which prolong ripening and appearance of diseases such as powdery mildew.

3. **Flowering (capfall)**: Flowering occurs approximately eight weeks after bud burst and once mean ambient temperatures have reached 20℃. The flower sheds its cap when anthers are ready to be released. The pollen from the anthers is transported by light winds and after two or three days fertilization is complete. The pollinated flowers are considered 'set', while those not fertilized drop off or 'shatter'. Pests and disease monitoring is essential.

Photo Credit: Jewel

4. **Fruit-set to *véraison***: Fruit-set begins three weeks after pollination and refers to the transformation of flowers into berries. Fruit growth occurs in three stages. Berries first swell quickly during a rapid period of cell division (stage 1), followed by a 10 day pause in growth (stage 2), after which growth resumes again only by cell expansion, rather than division, and sugars accumulate (stage 3). At this point berries begin to accumulate sugar and colour (*véraison*) and begin

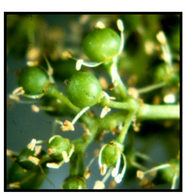


Photo Credit: UC Davis

the ripening phase. Vineyard management may be necessary as the vine's foliage and weeds may become too dense and diseases may arise.

5. ***Véraison*:** *Véraison* is a vital stage in berry growth and wine quality development, lasting five to eight weeks. The vine must be in balance and experience a growing season with high heat summation. During this stage, chlorophyll levels decrease, the berries soften, their acidity drops and they change colour, facilitating the formation of characteristic aromas and complex flavours. Rain, disease or frost can lead to premature picking, compromising the potential for a high quality wine. Once grapes are deemed ripe, they are harvested. The vineyard is then prepared for dormancy via pruning, leaves fall off the vines and vine dormancy initiated.

Photo Credit: Ragen

The steps involved in white and red wine production are also extracted from Jackson and Schuster (2007) and can be found in Figures 3.3 and 3.4, respectively. Generally, three different types of wine exist in Chile: regular, reserve and grand reserve. Regular wines are made with regular grapes, reserve wines are made with high quality grapes, and grand reserve wines are made with exceptional quality grapes. Producers often sort their high quality grapes and group them according to the three categories to create the opportunity for these three types of wines to be vinified.

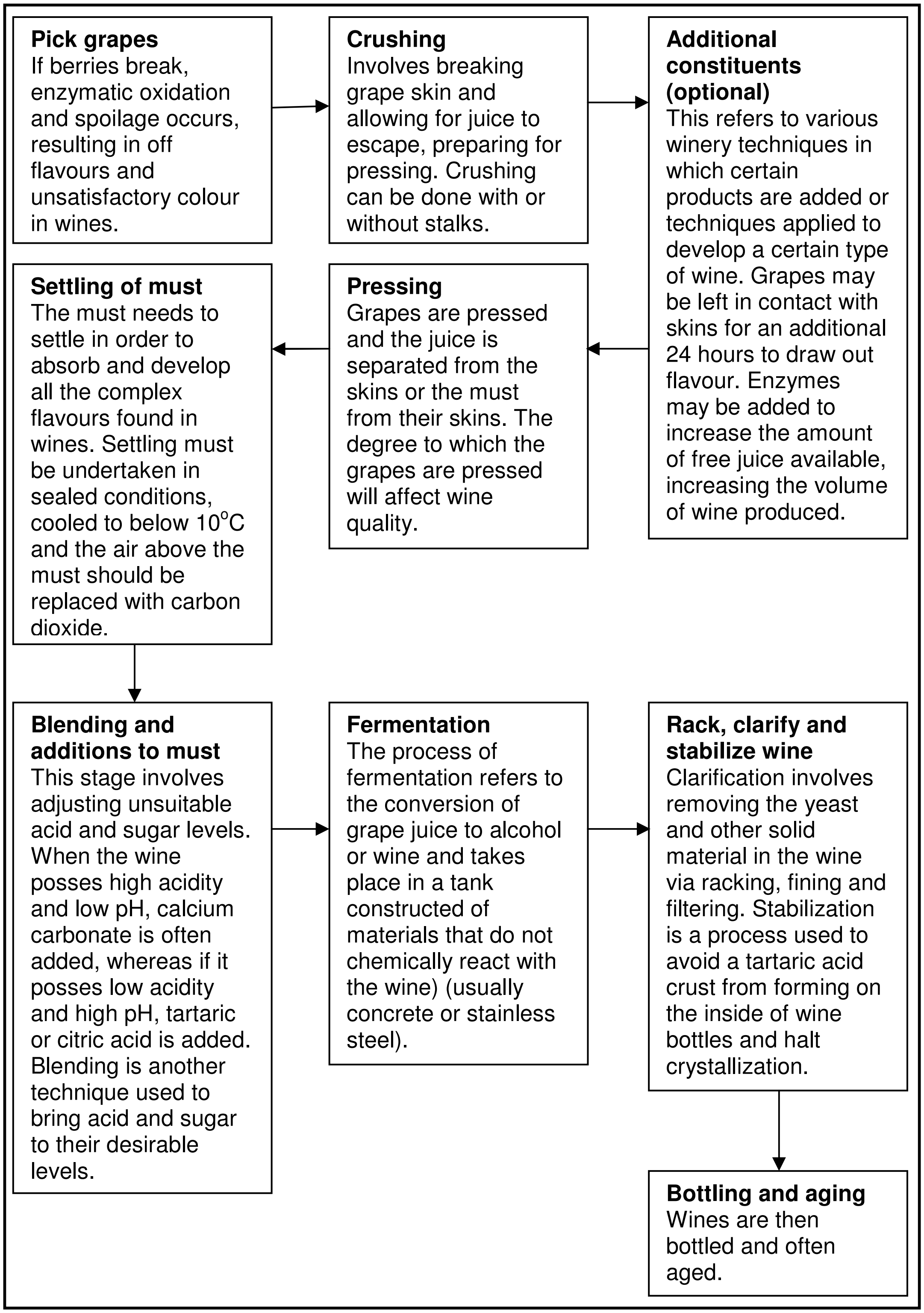


Figure 3.3: Steps in White Wine Production (Jackson and Schuster, 2007)

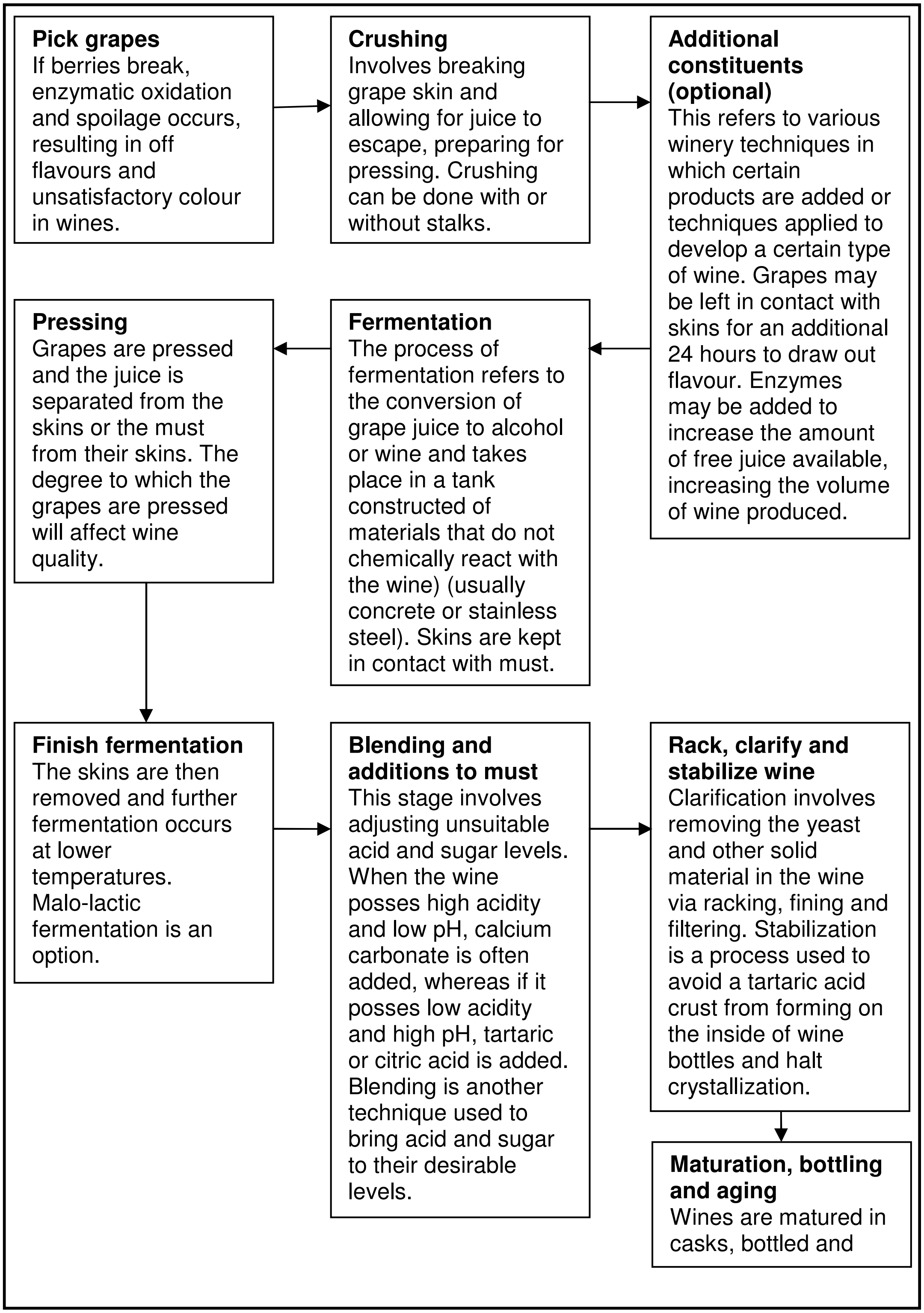


Figure 3.4: Steps in Red Wine Production (Jackson and Schuster, 2007)

3.2.2 Geography of the Maule Region

The Maule Region, the seventh administrative region in Chile, is located between 34^{o} and 36^{o} S (Figure 3.5). Maule is the region with the most hectares of planted vineyards in all of Chile, and it also produces the most wine (Table 3.3). Silviculture and agriculture are the primary economic activities in the region, as it is comprised of over 2.2 million hectares of what is considered productive land, half of which is prime agricultural land, the other half silviculture land (Díaz, 2007). The Maule, Lontué and Teno Rivers are major water sources which supply irrigation water via canals for the 45,000 silvo-agricultural producers in the region (Díaz, 2007). Maule is largely export oriented, producing a wide variety of tender fruit, in addition to cellulose, for export, including apples, raspberries, cherries, kiwis, oranges, peaches, blueberries, table grapes and wine grapes (Table 3.4). Grape growing is the most prominent and widespread landuse in Maule, and its grape and wine industry generates much of the economic activity in the region (Lobos A, 2006).

Table 3.3: Number of Hectares of Wine Grapes Planted and Litres of Wine Produced By Region in Chile (Data Source: SAG, 2006b) *'ND' Indicates No Data

Region	Wine Grapes (ha) 1996	Wine Grapes (ha) 2006	Volume of Wine 2006
IV (Coquimbo)	110	2,270.6	15,841,796
V (Valparaíso)	1,807	5,539.7	17,073,947
VI (Liberator)	9,173	33,855.7	259,471,392
VII (Maule)	26,010	50,314.5	396,473,757
VIII (Biobío)	13,000	13,999.6	1,9652,768
IX (Araucanía)	0	17.2	ND*
X (Los Lagos)	0	4.6	ND*
XIII (Metropolitan)	5,904	10,790.6	93,897,993
Total	56,004	116,792.5	802,411,653

Table 3.4: Hectares Planted of Selected Fruit in Maule (Data Source: ODEPA, 2008a)

Fruit	Hectares Planted
Cherry tree	5485.7
Plum tree	1787.5
Peach tree	378.6
Kiwi	5480.1
Apple tree	20609.2
Olive tree	2593.1
Pear tree	1927
Table grapes	342.5
Blueberry	2018.5
Raspberry	2328

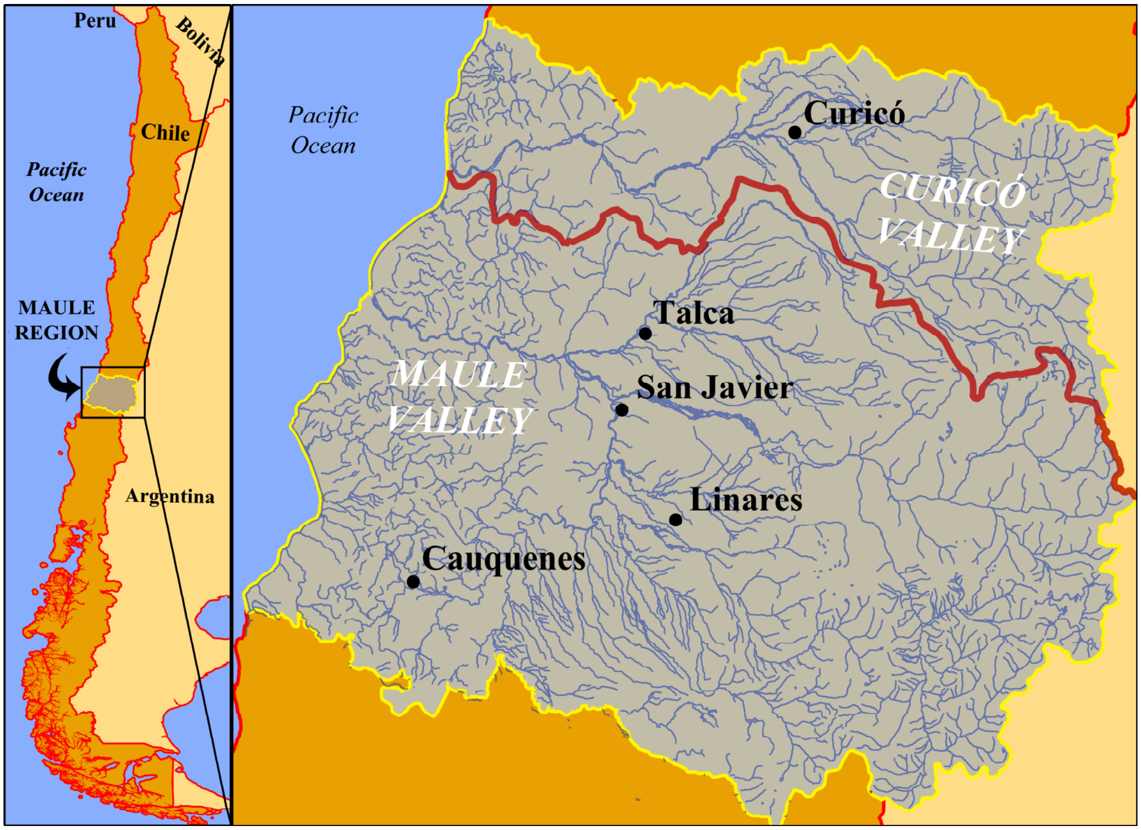


Figure 3.5: Map of Chile, the Maule Region and the Curicó and Maule Valleys

A variety of soil types are found in Maule, ranging from alluvial, fine and mixed, as well as soils derived from conglomerates, breccias, volcanic ash and tufa. Most of the region's soils are loam and loamy clay, near the coast the soils are less fertile, composed largely of granitoid (Vinos de Chile 2010, 2008).

The Maule Region is divided into two wine producing valleys – the Curicó Valley and the Maule Valley (Figure 3.5). The Curicó Valley is located in the northern portion of the region, spans 5,362 km^2 and holds 13% of the growers in the region, while the Maule Valley is located in the centre and south, spans

20,300 km^2 and holds 87% of the region's growers (see Table 3.5) (Muñoz et al, 2008).

Table 3.5: Characteristics of the Curicó and Maule Valleys in 2008 (Adapted From Muñoz et al, 2008)

	Area (ha)	Area in Wine Grapes (ha)	Number of Wine Grape Growers
Curicó Valley	536,200	17,143	1,258
Maule Valley	2,030,000	115,949	4,114

All Chilean climates are present in the Maule Region, thus allowing for all varieties grown in the entire country to be grown in this one region. The region encompasses 4 geographical and climatic zones: Coastal Plains Coastal Zone, Coastal Mountains Intermediate Zone, Central Valley Pre-Mountain Zone and Andes Mountains Eastern Zone (Wittmer et al, 2005). The Coastal Plains Coastal Zone, the westernmost zone located beside the Pacific Ocean, is characterized by a warm, temperate climate with winter rains and high atmospheric humidity; the Coastal Mountains Intermediate Zone in the western part of the central valley is characterized by a warm, temperate climate with winter rains; the Central Valley Pre-Mountain Zone in the eastern part of the central valley is characterized by a cool, temperate climate with little winter rain; and the Andes Mountains Eastern Zone is tundra due to the high elevation (it is in the Andes Mountains). There is little grape production in the Coastal Plains Coastal Zone and the Andes Mountains Eastern Zone; the majority of grape production occurs in the Coastal Mountains Intermediate Zone and the Central Valley Pre-Mountain Zone.

Generally, the climate in the two zones where wine grapes are grown is considered Mediterranean and is characterized by heavy winter rains and a long dry period that begins in spring (November) and ends in summer (March) (Vinos de Chile 2010, 2008). The dry period facilitates excellent grape maturation, and since rain during harvest is rare, grape quality remains rather consistent. The sharp contrast that exists between maximum and minimum daily temperature assists grape cultivars in developing colour and aroma and gradual maturation (Vinos de Chile 2010, 2008). Monthly average temperature, average daily maximum and minimum temperatures, and mean monthly average temperatures for Curicó and Talca, the two major cities in the two valleys within the Maule Region, are illustrated in Figures 3.6 and 3.7. The most precipitation falls in winter (May, June, July and August in Talca, and May, June and July in Curicó) in the form of rainfall when the temperature is low, and the largest difference between daily maximum and daily minimum temperatures occurs in the summer months in both cities, although this difference is much larger in Curicó (i.e. the difference between daily maximum and minimum temperature is much greater in Curicó than in Talca); Curicó is warmer than Talca in the summer and cooler than Talca in the winter. The Pacific Ocean, located west of the region serves to moderate the temperature, and the Andes Mountains, located east of the region, permit the cultivation of several different grape varieties at different elevations (Lobos A, 2006).

The vineyards closer to the mountains experience a cooler climate and great diurnal temperature fluctuations– preferred conditions for white grapes, whereas the rising temperatures towards the coast is preferred for reds (Vinos de Chile 2010, 2008). White varieties grown include Chardonnay, Sauvignon Blanc, Semillón, Gewurztraminer, Riesling, Torontel, Muscatel and Chenin Blanc, and red varieties include Cabernet Sauvignon, Merlot, Cabernet Franc, Carménère, Carignan, Syrah, Pinot Noir, Malbec and Petit Verdot (Hola Vino, 2007).

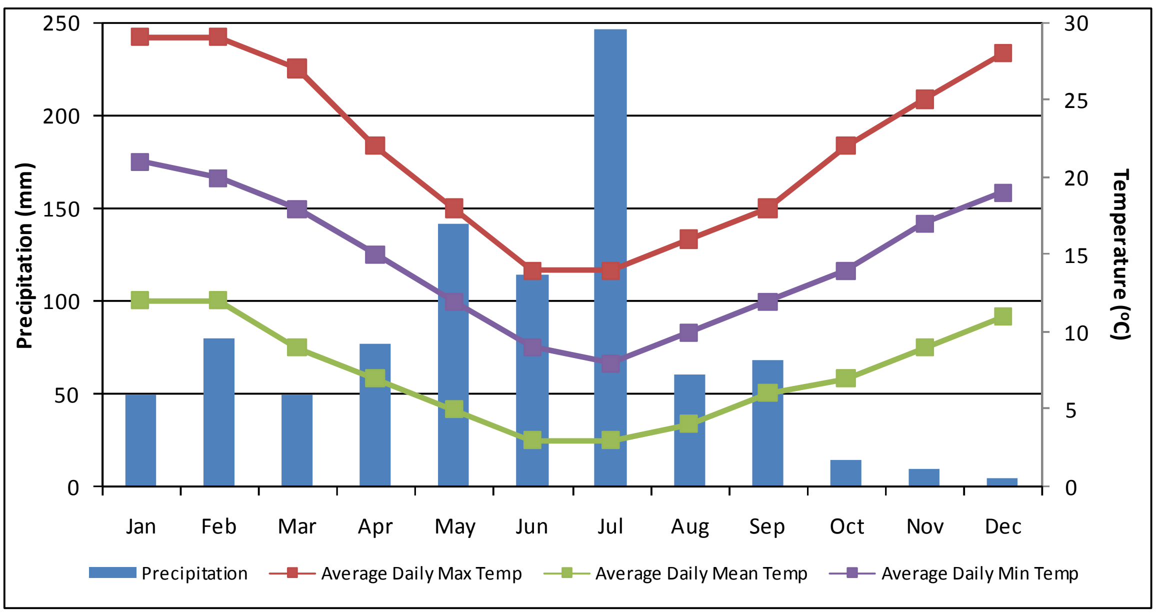


Figure 3.6: Average Precipitation and Temperature for Curicó (Data Sources: CustomWeather, 2008; The Weather Channel, 2008)

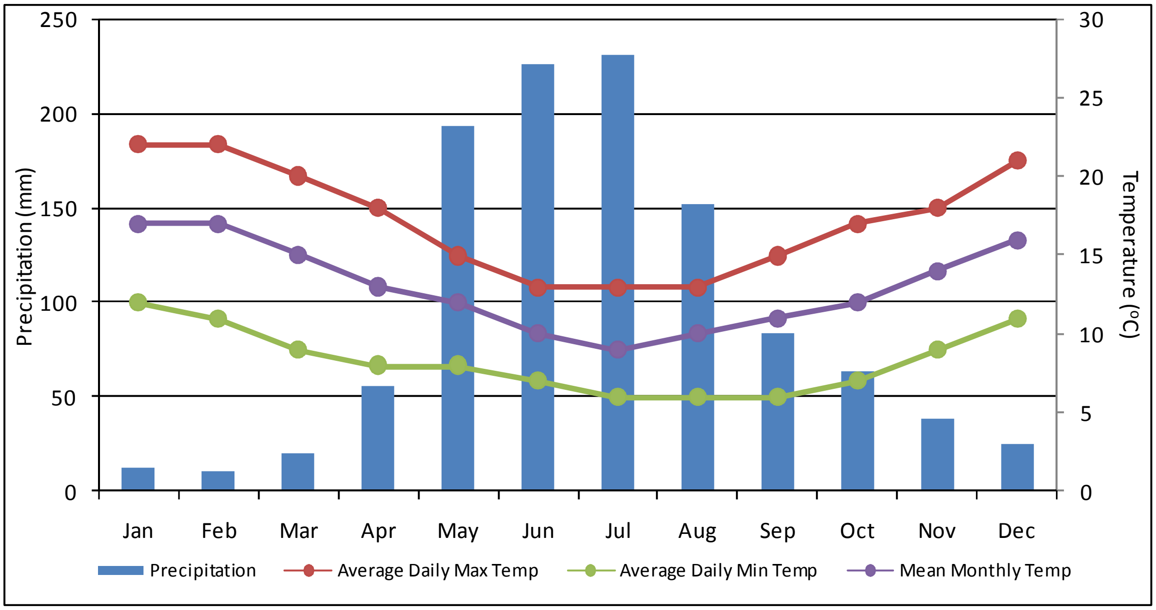


Figure 3.7: Average Precipitation and Temperature for Talca (Data Sources: CustomWeather, 2008; The Weather Channel, 2008)

The biophysical and climatic conditions coupled with the fact that Chile is the only wine producing country in the world free of *phylloxera*, the problematic fungal condition, make it a favourable location for producing quality wines. The grape and wine industry in the Maule Region has undergone recent expansion and success attributed to factors beyond those that are biophysical. These factors are discussed in the following section.

3.2.3 History of the Grape and Wine Industry in Maule

The Spanish conquistadores brought wine grapes, *Vitis Vinifera*, to Chile in the mid-sixteenth century. País was the first variety planted, and at first, the wine produced from País grapes was primarily used in religious ceremonies. After Europe's vineyards were destroyed by the root louse *phylloxera* in the

1800s, Chile remained free of *phylloxera* due to its isolated geography, which later made it attractive for Europeans to bring their varieties to Chile because grafting was not required (Visser and de Langen, 2006); varieties such as Cabernet Sauvignon, Merlot, Pinot Noir and Sauvignon Blanc were introduced.

In the early and mid 1900s, wine in Maule was produced for the domestic market, as national consumption was at its highest during this time—50-60 litres per capita— but it was also of poor quality, produced primarily with low quality País grapes (Crowley, 2000). Over 60% of the vineyards planted were of poor quality wine grapes (Benavente, 2006). Growth of the industry was restricted after the Alcohol Law of 1938 was passed, which placed limitations on the number of hectares of vineyard planted and the amount of wine produced per capita. Investment in the industry halted due to limited competition and focus shifted to producing quantity rather than quality (Crowley, 2000; Benavente, 2006).

The liberalization of agriculture and the relaxation of vineyard restrictions combined with growing worldwide demand for quality wine later presented Chile with an opportunity to satisfy an international market. Meanwhile, the economic crisis of the 1980s caused wine consumption in Chile to decrease to less than 20 litres per capita. Overproduction during this time motivated wineries to seek export markets, and luckily wine consumption during this time increased sharply in the United States, Canada and the United Kingdom (Benavente, 2006).

Equipment and inputs were imported to satisfy the technical development of the industry, with the use of stainless steel in the fermentation process marking the first major innovation; the second is attributed to Miguel Torres for the introduction of small oak barrels, both of improved wine quality and put Chile on the international market as a producer of quality wine (Benavente, 2006).

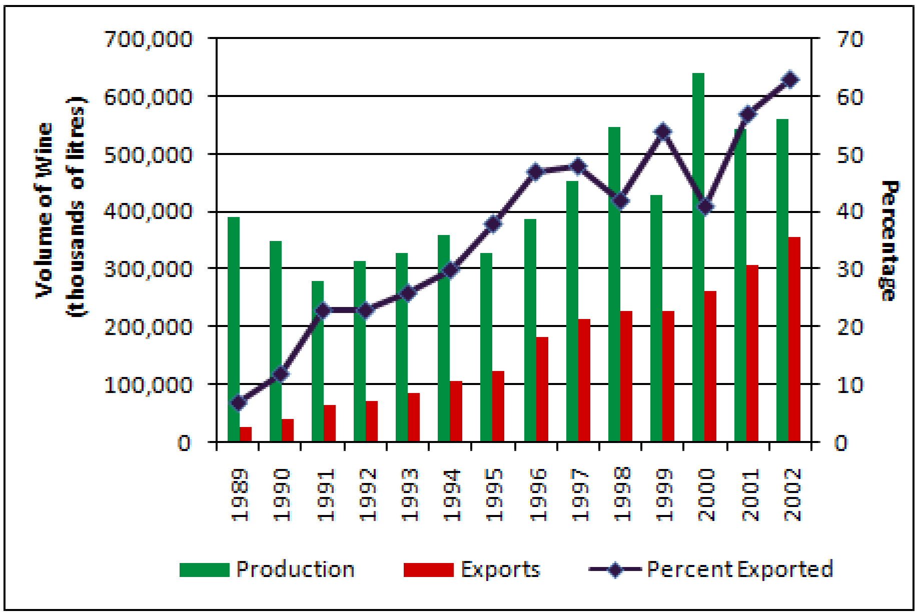


Figure 3.8: Production and Export of Chilean Wine 1989-2002 (Data Source: Benavente, 2006)

The Chilean government supported the expansion of the grape and wine industry by funding international travel for viticulturalists (persons partaking in the art/science of grape growing for wine) and oenologists (persons partaking in the art/science of wine making) to become familiar with new practices and update their knowledge, and also by subsidizing export endeavours. Exports increased from 7 to 63 percent from 1989 to 2002 (Figure 3.8), foreign investment in the industry grew (Table 3.6), higher quality French varieties replaced the lower quality País, and numerous new vineyards appeared.

Table 3.6: Sample of Foreign Investment in the Maule Wine Sector in 2007 (Vinos de Chile 2010, 2008)

Company	Country	Investment (million USD)
Kendall-Jackson	USA	20.7
Marnier-Lapostolle	France	19.8
Seagram Company	Canada	19.6
Rederiet Odfjell	Norway	12
Robert Mondavi Co	USA	11
Francisca Wineyards	USA	10.3
Barons de Rothschild	France	7.5
Chateau Dassault	France	7
División Vinos BBVA	Spain	5
Mercantil Costarricense	Costa Rica	4.2
Chateau Larose	France	3
Icuma Anstalt	Germany	2.9
European Wine Co	Holland	2.8
Magnotta Winery	Canada	2
Viña del Nuevo Mundo	France	2

Decree 464 of 1994 established the standards for denominations of origin by implementing a labelling system for wine produced in Chile with the aim of differentiating quality (Benavente, 2006). Viticultural zoning norms were created along with rules to guide zoning. Wines were placed into three categories: 1) wines with a guarantee of origin; 2) wines without a guarantee of origin; and 3) table wines (WIPO, 1994). Labels with a guarantee of origin can indicate the viticultural zone in which the wine was produced, the variety, the harvest year and the expression ‘Bottled in Origin’ (WIPO, 1994). Wine labels with these specifications can be used only if a) at least 75% of the wine was produced with grapes grown in the zone on the label; b) at most 25% of the wine came from grapes grown in other zones; and c) no table grapes were used. Wine labels without a guarantee of origin can indicate variety and harvest year and can only be used if they satisfy a), b) and c) described above (WIPO, 1994). Table wine labels can only indicate it is a table wine. Producers are required to register their wines with the Agricultural and Cattle Service (*Servicio Agrícola y Ganadero*, or SAG), the body responsible for monitoring and administering this labelling system, and must complete a long list of documentation (e.g. harvest dates, contracts) before SAG grants them permission to use the system.

Restructuring of the wine industry has certainly benefited the Maule Region. In addition to containing the country’s largest area of vineyards, Maule both produces and exports 50% of Chile’s wine (refer to Table 3.7). There are thousands of grape growers and wine producers (between 3,500-5,500) in Maule, ranging from small, medium to large in size, with operations possessing highly varied degrees of capital and experience (Vinos de Chile 2010, 2008; Muñoz et al, 2008). After Pinochet liberalized agriculture, the Curicó Valley experienced aggressive foreign capital investment, which resulted in the establishment of new, modern vineyards, while the Maule Valley remained dominated by small producers who struggled to adapt their operations to the new economic circumstances (Benavente, 2006). Many maintained their traditional País vineyards and have largely been supported by the State (Díaz, 2007).

Table 3.7: Maule Wine Statistics, 2004 (Data Source: Lobos A, 2006)

	Chile	Maule Region	Maule as a percentage of Chile
Area planted (acres)	272,056	116,980	43%
Wine production (litres/yr)	630,000,000	297,000,000	47%
Wine exports (litres/yr)	467,000,000	234,000,000	50%

The industry in general has experienced ups and downs in the last few years. The amount of grapes harvested in early 2008 was significantly lower than in the past few years due to a harsh winter with low temperatures and recent grape employee strikes (van Berkel, 2008). From 2001-2003 high costs of primary materials needed to make wine and the decreasing USD negatively affected wine producers (Gill, 2005). In response, growers and producers have increased the number of hectares planted over the last several years. Similarly, the number of hectares of certain higher quality wine grape varieties planted, Carménère for example, has significantly increased over the past few years because these varieties are fairly well adapted to Chile's climate and soil, and wine producers are beginning to realize the market advantage of producing these varieties (Langman, 2000).

Adaptation in the Maule Region grape and wine industry has been essential. The industry has thrived because of its ability to accommodate and adapt to changing conditions, and will likely need to continue to do so in the future. These changing conditions affected growers and producers differently, and farm-level adaptations also differed among them. Investigation into farm-level adaptation will shed light on the decisions, conditions and circumstances that were favourable for some and not others. The following chapter delves into the research methods employed to satisfy the aim and objectives outlined in section 1.2.

CHAPTER 4: METHODS

The aim of this case study is to assess the sensitivity and adaptability of the grape and wine industry in the Maule Region to climate change. The purpose of this chapter is to outline the manner in which the research was undertaken, including the broad approach as well as data collection and analysis methods. It is divided into four sections. The first section describes the research approach used to guide this research. The steps taken in order to prepare for this research are discussed in the following section. The methods employed for data collection and interpretation and analysis procedures are detailed in the last two sections.

4.1 Research Approach

In order to achieve the objectives of this research, a vulnerability assessment perspective was adopted. Vulnerability is conceptualized a function of the exposure of a system to risks and opportunities and the adaptive strategies employed by the system to adapt (Kelly and Adger, 2000; Yohe and Tol, 2002; Smit and Wandel, 2006). The strength of the empirical application of the vulnerability approach lies in the need for the "system" itself to identify exposures and adaptations, based on the logic that the system can best articulate what is important to it and how it responds (Smit and Wandel, 2006); that is, this approach begins by gaining insights from the system about the conditions that are important and relevant to it and the strategies it employs to manage these conditions— the conditions are not assumed *a priori*. The system, for the purposes of this research, is the Maule Region grape and wine industry.

Vulnerability assessments are increasingly utilized to investigate the issue of climate change and agriculture (Adger and Kelly, 1999; Luers et al. 2003; Vásquez-León et al, 2003; Belliveau et al, 2006; Reid et al, 2007) because they offer a holistic and dynamic perspective of vulnerability, recognizing the inherent complexities within agricultural systems, rather than oversimplifying them. This approach facilitates investigation into the multiple stresses, risks and opportunities confronting agricultural systems, the adaptive responses employed, and the factors influencing responses (e.g. Belliveau et al, 2006). The framework for vulnerability assessment illustrated in Figure 4.1 has been successfully to the agricultural sector (Leichenko and O'Brien, 2002; Luers et al, 2003; O'Brien et al, 2004; Tschakert, 2007); however, few use participatory methods as the primary research instruments. The analytical framework for vulnerability assessment presented in Figure 4.1 is consistent with the objectives of this research. The empirical application of this approach involves two stages: an assessment of past and current vulnerability (Objectives 1 and 2); and an assessment of future vulnerability (Objective 3).

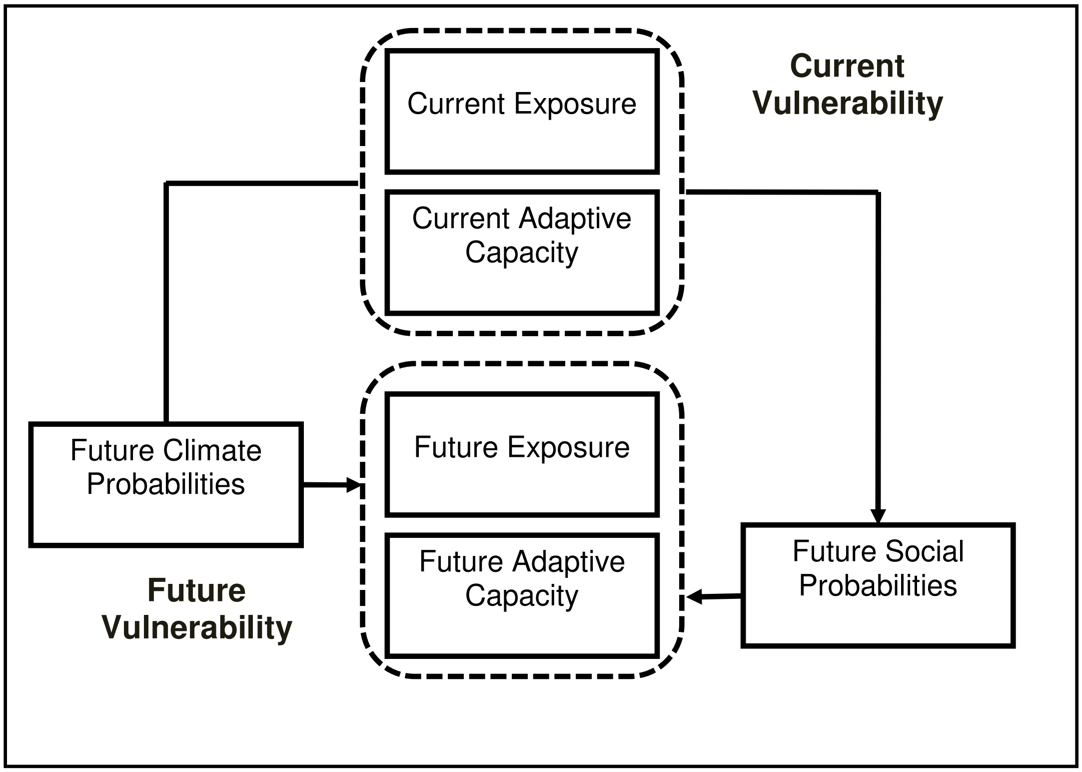


Figure 4.1: Analytical Framework for Vulnerability Assessment (Ford and Smit, 2004)

Assessment of current vulnerability requires the identification of both past and current climatic and non-climatic related conditions that have been problematic or beneficial to grape growers and wine producers in the Maule Region and the documentation of management strategies used to help cope with these conditions. It also requires an understanding of the factors facilitating or constraining the adaptation process. Future vulnerability builds on current vulnerability. Assessment of future vulnerability is accomplished by estimating future exposure to changing climatic and non-climatic conditions via probabilities in changes in the identified current exposures, by identifying new future exposures and by postulating producers' ability to cope with or accommodate these conditions.

4.2 Research Preparation

A preliminary field visit in April of 2007 served to assess the feasibility of the research. Six grape growers and wineries on the Wine Route (*Ruta del Vino*) were visited, all of which expressed great interest and willingness to participate. This field visit also provided the researcher with the opportunity to familiarize herself with the culture and language in Chile. She is a native of Uruguay, a Spanish speaking country in South America; however there are differences in social and cultural norms and Spanish dialect spoken.

Upon arrival in Chile (April 2008), three weeks were spent in Santiago at the Agriculture and Environment Centre (AGRIMED) at the University of Chile where collaborator Dr. Santibañez is based. Access to the university's library was obtained and a review of both English and Spanish literature pertaining to the research question was conducted. Daniela Armijo, Dr. Santibañez's assistant, reviewed the interview guide to make sure the questions were properly worded and culturally sensitive. The interview guide was previously approved by the University of Guelph Ethics Board prior to the field season (the only changes made were in the translation). Hugo Romero, a PhD student under Dr. Santibañez's supervision, provided a list of contacts generated from a previous study where he investigated changes in grapevine phenological stages throughout the region. Nidia Brunel, another PhD student under Dr. Santibañez's supervision living in Talca, offered her home and assistance for the duration of the field season in Maule and proved to be invaluable as a cultural guide and research and logistics coordinator. Nidia was briefed on the goals and objectives of the research and kindly arranged interviews with a few people in the industry she knew. Pablo Molinos, an oenologist representing Wines of Chile (*Vinos de Chile*), a body that serves to promote Chilean wine internationally, is a collaborator on the project who provided contact information for producers in the region that are members of Wines of Chile.

4.3 Data Collection

The approach to this research necessitates gaining insights from the producers themselves and calls for the adoption of participatory methods in the primary data collection process (Smit and Wandel, 2006). Participant observation would be ideal but could not be employed due to time constraints, and questionnaires would not allow for the detail in the forces, processes and adaptive strategies required to fulfill the objectives. A multi-method approach was adopted in order to explore multiple avenues for understanding interviewee experiences (Brewer, 2000) and to ensure rigour and trustworthiness in the results (Baxter and Eyles, 1999). Data were obtained primarily through grower and producer interviews, as well as from key informants from regional institutions and those with intimate knowledge of the industry. Direct observation served as a means of enhancing the information collected in the interviews and further understanding interviewee responses and industry dynamics. Secondary sources were reviewed to verify and compliment the information provided by participants.

4.3.1 Key Informant Interviews

Seven (7) key informant interviews were conducted to provide context for the research. Informants were purposefully selected based on their experience and knowledge of the grape and wine industry, or who were willing to participate in the study, and included oenologists and institutional representatives. The researcher sought out key informants who could provide in-depth information key to understanding both industry dynamics and the forces influencing the industry. The key informant interview was semi-structured and based on previously determined generic questions structured according to the components of vulnerability (i.e. exposure and adaptive capacity). Table 4.1 provides a sample of questions key informants were asked. The semi-structure allows for interviewees to freely articulate their responses and for further exploration of unforeseen topics. Each interview was tailored to each interviewee's background in a manner that would capture the information possessed by the informant.

Table 4.1: Selected Questions from Key Informant Interview Guide

Theme	Sample Questions
Background	• What is your position? • What is your relation to the grape and wine industry? • In what ways do you interact with the grape and wine industry?
Exposure	• What forces are influencing the industry? How? • Why do you think these forces have affected them? • What risks and opportunities do you foresee for the industry?
Adaptive Capacity	• How have these forced affected the industry? • How has the industry responded? • What do you think is needed for the industry to better cope with these forces?
Role of Institution	• What do you see as the role of this institution in helping the industry? • In what ways do you help the industry? • How do you see yourselves helping the industry in the future?

4.3.2 Grower and Producer Interviews

Based on the seven key informant interviews, forty six (46) in-depth, semi-structured interviews were conducted with grape growers and wine producers in the region. Interviewees were selected using a purposive, snowball sampling technique. The three persons (Hugo, Nidia and Pablo) described in the previous section provided a short list of potential interviewees (15, 15 and 3 contacts, respectively), many of which were contacted and semi-structured interviews solicited. Once each person was contacted, those willing to participate in the study were interviewed and asked to provide additional contacts. The interviewees were purposively sampled because the approach adopted requires gaining insights directly from a specific group of people in the Maule Region—grape growers and/or wine producers – and because interviewees had to have intimate knowledge of vineyard management decisions in order to provide the information required to satisfy the aim and objectives of the study. The goal was to obtain the most diverse sample possible.

The semi-structured interviews followed an interview guide composed of categorical and open-ended questions (Patton, 2002). A copy of the interview guide can be found in Appendix A. The interview guide ensures consistency throughout interviews for future comparability purposes, that important themes are covered and assures a more systematic and comprehensive interviewing process (Bernard, 2000; Patton, 2002). The semi-structure allows for flexibility in the interview and for the researcher to gain an in-depth understanding of varying personal contexts, while the open-ended nature of the questions allowed both interviewees to describe their experiences in their own words and the researcher to ask for clarification and further investigate unexpected topics (Kvale, 1996; Ritchie and Lewis, 2003).

The interview guide was structured according to the vulnerability approach, with exposure, adaptation and adaptive capacity as the main themes. Table 4.2 provides a sample of questions from the interview guide (see Appendix A). More specifically, the first section of the interview guide explored characteristics of the operation. The second section sought to understand current vulnerability by identifying exposures and adaptations to risks and opportunities as well as adaptive capacity. In this section interviewees were asked to specify which years over the past ten were good and bad, why, how they responded in these years, and what facilitated or constrained their responses. This approach was successfully applied in the Canadian grape and wine industry by Belliveau et al (2006). However, due to a variety of factors, including cultural differences, this approach was not as successful in the Chilean context. Participants were then asked what, over the past ten years, has made years better than average and below average for their operations. The third section was specific to climate to ensure climate was addressed in the interview, while the fourth section catered to the investigation of future vulnerability through the exploration of future risks, opportunities and current and potential coping mechanisms.

Table 4.2: Selected Questions from Producer Interview Guide

Theme	**Sample Questions**
Exposure	• What years were above and below average for your operation? Why?
Adaptive Strategy	• How did you manage this problem?
Adaptive Capacity	• Did any factors facilitate or constrain this process?
Future Exposures	• What risks and/or opportunities do you foresee in the future?
Future Adaptive Capacity	• How might you cope with these risks and/or opportunities? • What do you need to better prepare for the future?

Interviews were conducted in the homes of interviewees, at coffee shops or in the vineyard or winery, and were digitally recorded (except those who did not consent to audio recording) to ensure nothing was lost and all information was documented completely and fairly (Patton, 2002). Extensive notes were taken during the interviews not recorded. All interviewees were informed about the purposes of the research (without mention of climate in order to avoid prompting and remove bias with respect to climate change) and asked to sign a consent form which included the option to remain anonymous and refuse digital recording (see Appendix B and C for English and Spanish consent form, respectively).

The location of the vineyards and wineries spanned the geographical and climatic zones of the region that are conducive to grape production; the size and attributes of growers and producers varied significantly. Figure 4.2 is a map showing the location in which interviews took place and Table 4.3 presents a summary chart of interviewee characteristics.

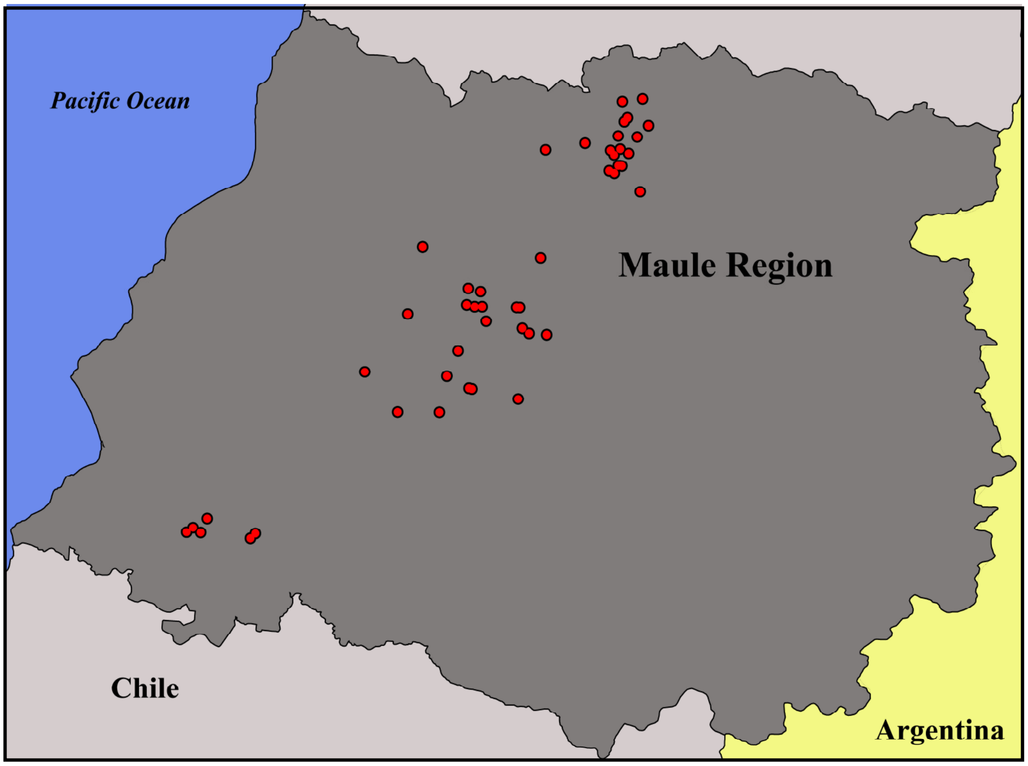


Figure 4.2: Location of Interviews

Table 4.3: Characteristics of Interviewees

	Mean	**Median**	**Mode**	**Range**
Vineyard Size (ha)	29.3	107.5	150	5 - 2,000
Winery Size (litres)	3,420,037	1,280,000	1,500,000	6,000 - 18,000,000
Other crops?	Yes: 48%		No: 52%	

Three operation types, or groups, emerged from the interviews: 1) Grape Growers (GG); 2) Grape and Wine Producers (GW); and 3) Wine Producers (WP). The Grape Growers (GG) group are just involved in the production of grapes; the Grape and Wine Producers (GW) group grow their own grapes, vinify grapes into wine and sell bulk and/or bottled wine; and the Wine Producers (WP) group are involved just in the vinification of grapes into wine and sell bulk and/or bottled wine, they do not grow their own grapes. The acronyms for the operation types (or groups) will be used throughout this thesis for simplicity in discussion and to avoid confusion, otherwise the terms used refer to the interviewees as a whole (e.g. 'growers and producers' refers to all growers and all producers; 'growers' refers to all grape growers, including those that produce wine; 'wine producers' refers to all wine producers, including those producing grapes). Thirteen (13) Grape Growers (GG), thirty-one (31) Grape and Wine Producers (GW), and two (2) Wine Producers (WP) were interviewed.

4.3.3 Direct Observation

Direct observation is a method used to observe the study environment and participants, and involves documenting what is being observed, a useful reference for future interpretation and analysis (Patton, 2002). Multiple stresses and adaptive strategies (e.g. late pruning) were observed first-hand, serving as a means of triangulating the components of current vulnerability (i.e. grower- and producer-identified exposures and adaptive strategies). Observations regarding the interview settings and impressions made throughout the field season were documented in a field notebook. The notebook also provided the researcher with the opportunity to reflect and elaborate on the nature of the information received (Patton, 2002).

4.3.4 Secondary Sources

Secondary sources were reviewed in order to verify the information provided by interviewees and to provide a context for the study. Sources included publications, documents, government and historical records, climatological data and any other pertinent material that enriched the study. The library at the University of Chile and institutional websites were the primary secondary sources used. Secondary sources were consistently reviewed wherever and whenever possible to supplement and complement data obtained from other sources, particularly as they related to the exposures identified by interviewees, the adaptive strategies they employ, potential future exposures and future adaptive capacity (e.g. changes in: hectares of grapevines planted overtime, water supply, temperatures, precipitation, grape prices, exchange rates, etc). Future climate change scenarios were obtained from the National Environment Commission (*Comisión Nacional del Medio Ambiente, or* CONAMA) and AGRIMED.

4.4 Data Interpretation and Analysis

Data analysis focused on the in-depth, semi-structured interviews, and was complemented by key informant interviews, direct observation and secondary sources. All data were assessed in light of the components of vulnerability—exposure, adaptation and adaptive capacity. Analysis of the interview data began with a review of the audio from each interview. Pertinent interviewee responses (i.e. those relating to exposure, adaptation and adaptive capacity) were extracted and transcribed into a spreadsheet organized according to the interview guide. An example of the spreadsheet can be found in Table 4.4. The spreadsheet allowed for all the data to be viewed simultaneously, facilitating comparisons. Answers were entered in short form and linked to more lengthy descriptions stored in a summary document to ensure interpretation was not lost. Important stories and quotes were compiled into a separate document.

Table 4.4: Sample of Spreadsheet Used for Analysis

	How long have you been in the business? (years)	**Has it always been grapes? (y=yes; n=no)**
1st Interviewee Name	30	y
2nd Interviewee Name	10	n

Once all interviews were entered into the spreadsheet, summary graphs, tables and descriptive statistics were generated in relation to the components of vulnerability. Exposures, or the conditions identified by growers and producers to which they are sensitive, adaptive strategies, or the approaches taken to manage or cope with the identified exposures, and adaptive capacity, or factors facilitating or constraining adaptation, were listed and described. Exposures, adaptive strategies and adaptive capacity were further sorted according to sub-themes developed by the researcher during the analysis that reflected broad forces influencing the system (i.e. weather, economic, production, social and institutional), the broad strategies employed to manage these forces (i.e.

vineyard management, business management, winery management, etc) and the factors facilitating or constraining adaptation (i.e. government policy and programs, information, market and education). Figure 4.3 provides a sample of the analysis process, with the components of vulnerability as the starting point, further characterized into sub-themes.

After the exposures and adaptations were listed and described, exposures and adaptive strategies were examined in relation to one another to see if there were any connections among them. Grower- and producer-identified exposures and adaptations strategies were cross-checked and supported with secondary sources. After current vulnerability was characterized, exposures identified as being important by interviewees and the associated adaptive strategies were assessed in light of future climate change to reveal future vulnerabilities, including future exposure and future adaptive capacity. It is recognized that future social, political and other conditions will influence the nature of future vulnerability, but for the purposes of this thesis, future vulnerability was assessed in light of future climate change. The following chapters delve into the results of this analysis.

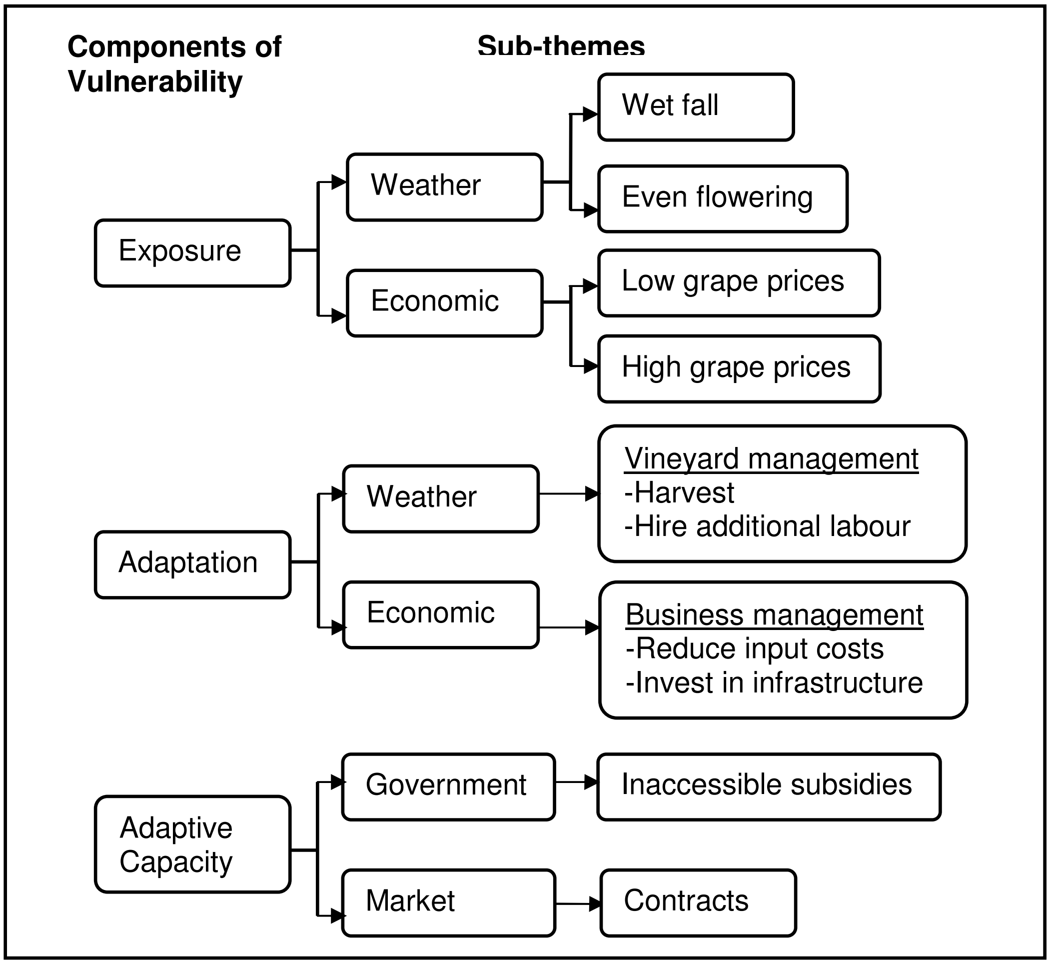


Figure 4.3: Sample of Analysis Process

CHAPTER 5: CURRENT VULNERABILITY

The previous chapters highlighted the complex decision making environment within which farmers operate and the numerous risks and opportunities they manage. The purpose of this chapter is to document the risks, opportunities and management strategies identified by grape growers and wine producers, using the approach and methods successfully applied by Ford et al (2006; 2007), Belliveau et al (2006); Reid et al (2007). This chapter is devoted to the discussion of current exposures and adaptive strategies—the two components of current vulnerability. This dialogue demonstrates the complex process of adaptation, a facet of the literature identified as necessitating further consideration. Discussion in this chapter draws upon the data collected in the interviews and secondary sources where appropriate. The findings reflect the exposures and adaptations broadly of the region.

While exposure, adaptation and adaptive capacity are often discussed separately when referring to the nature and scope of vulnerability, this chapter emphasizes, throughout the discussion of the results of this case study, that the components of vulnerability are not independent of one another and are highly dynamic. An exposure, for example, may prompt an adaptation that effectively constrains other adaptations and reduces adaptive capacity. Though each exposure is discussed individually in this chapter, it should be noted that they are inextricably linked to other forces creating the same exposure, or several exposures resulting from the same force. Adaptations are discussed as they relate to exposures but are inevitably linked to other exposures, adaptations and may serve to facilitate or constrain other adaptations.

5.2 Current Exposures and Adaptive Strategies

The interview guide asked grape growers and wine producers to identify both good and bad years, as a means of identifying, with minimal bias, the conditions influencing good and bad years, and the response strategies undertaken. 'Good' and 'bad' was not specific enough for growers and producers, with most asking for clarification as to what 'good' and 'bad' meant. Good, for example, could refer to production, market or economic characteristics. Many growers and producers do not keep formal records of their operation and it is not a cultural norm to discuss or note good and bad years. The growing season also extends over two calendar years, making it confusing when interviewees did identify years, with the researcher requiring clarification as to which part of the growing season the year identified referred to. Often seasons could be classified as good and bad, creating more confusion (e.g. one season was good in terms of price but bad in terms of production). When interviewees were asked generally about their experiences, or the factors contributing to below- or above-average conditions, they described in-detail the forces to which they are exposed and the adaptive strategies they employ. Specific years were rarely identified.

It is important to note that all exposures identified lead to financial gains or losses, and this economic factor significantly affects interviewees and their decision making. A summary of all the exposures to be discussed is shown in Table 5.1. Consistent with the findings of Smit et al (1997), growers' and producers' determination of whether a year was good or bad was largely based on the experiences of the previous year. "*This year [2008] feels good because it was better than last year*" and "*this year is a normal year but it feels good because it was much better than last year, which was bad*", a couple of interviewees commented. This section reports on the exposures identified by growers and producers as being important to them, and the adaptive strategies they employ to adapt to these exposures.

Table 5.1: Exposures Identified By Interviewees

Force	Exposure
Production	<u>Beneficial/Opportunity</u> • High yields • High quality <u>Problematic/Risk</u> • Low yields • Low quality
Economic	<u>Beneficial/Opportunity</u> • High prices • Low prices <u>Problematic/Risk</u> • Low USD • High input costs • Contracts
Weather	<u>Beneficial/Opportunity</u> • Frost-free spring • No rain during flowering • Large daily temperature fluctuations • Dry harvest <u>Problematic/Risk</u> • Wet fall • Wet spring • Spring frost • High temperatures • Drought
Institutional	<u>Problematic/Risk</u> • International rules and regulations • National rules and regulations
Social	<u>Problematic/Risk</u> • Labour shortages

5.2.1 Forces Creating Opportunities

Figures 5.1, 5.2 and 5.3 illustrate the years indicated as being good and the conditions that lead to the year being good. The number of interviewees who identified good years is relatively small compared to the sample size (n=46), and the GW group seems to have a better recollection of specific years that were above average for their operations. The years 2000, 2001, 2007 and 2008 were identified as being good years by the GG group, the past nine years by the GW groups, and the past three years by WP group. The forces identified by interviewees as creating above average conditions, or opportunities, are shown in Figure 5.4. Interviewees appear to be highly sensitive to production, weather and economic forces. A break down by group can be found in Figure 5.5.

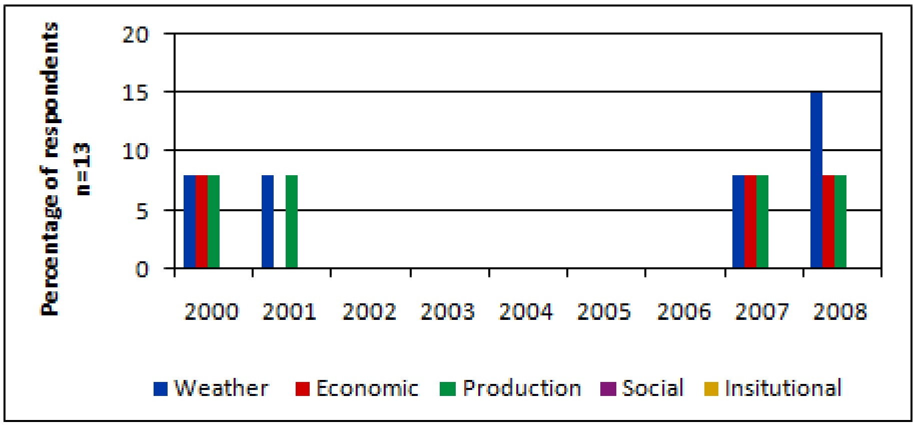


Figure 5.1: Good Years Identified By Grape Growers (GGs)

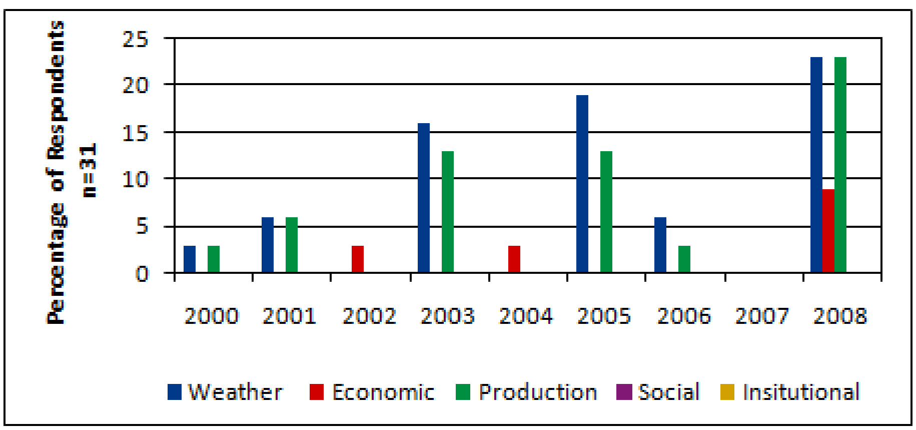


Figure 5.2: Good Years Identified By Grape Growers and Wine Producers (GWs)

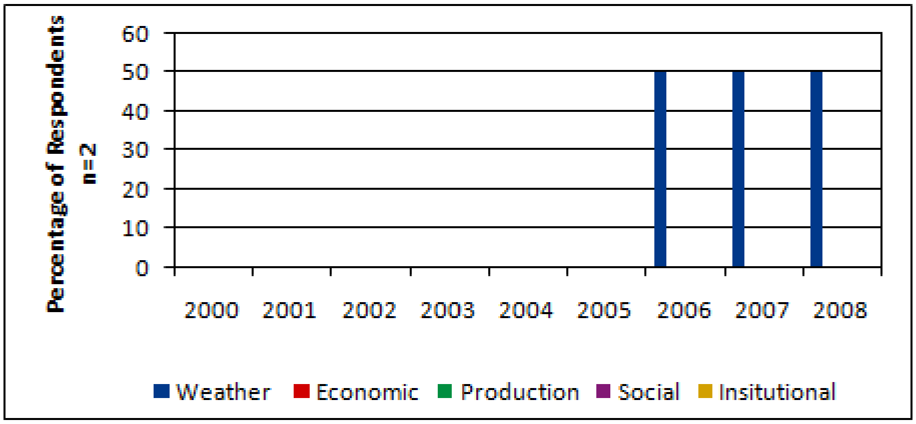


Figure 5.3: Good Years Identified By Wine Producers (WPs)

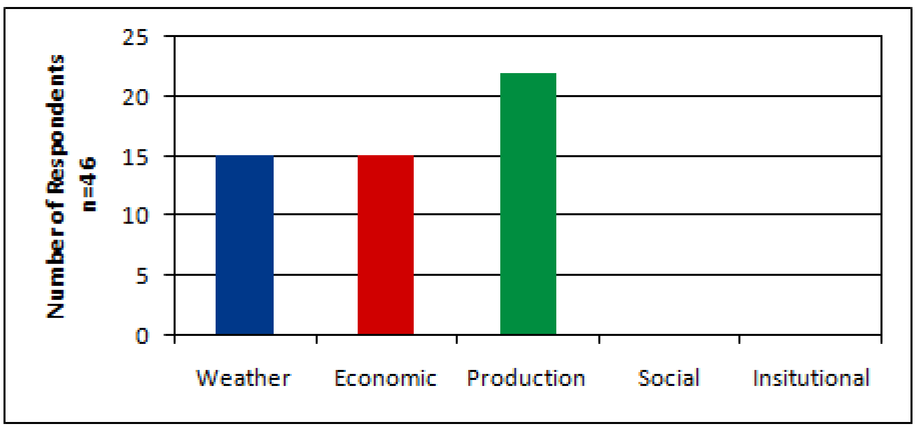


Figure 5.4: Forces Identified By Interviewees as Creating Above Average Conditions

Economic forces contribute greatly to above average years for the GG group (see Figure 5.5). Over the past ten years 7 of 13 (54%) GGs identified economic forces as having played an important role in their success. The GG group is also sensitive to production and weather forces in above average years.

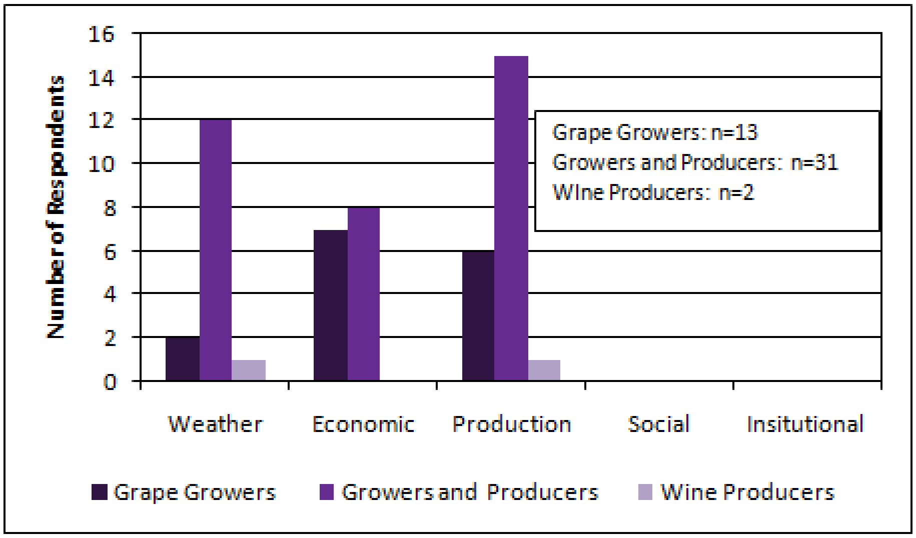


Figure 5.5: Forces Creating Above Average Conditions By Operation Type

The GW group is most sensitive to production forces in above average years. This group is also sensitive to weather and economic forces. The WP group is sensitive to both weather and production forces.

The forces described in this section create opportunities, and for the most part, positively influence the success of grape growers and wine producers in the Maule Region. The following subsection further investigates the results described above and the adaptive techniques employed to manage these forces.

5.2.1.1 Production

Production forces create significant opportunity for interviewees. Figure 5.6 illustrates the two production forces –high yields and high quality—playing an important role for growers' and producers' success, as well as the number of interviewees indicating each. High yields were reported by 9 of 13 (69%) GGs and 5 of 31 (16%) GWs (Figure 5.7). The majority of GGs, especially those producing lower quality grapes, aim to produce high yields because wineries pay them paid by the kilogram; higher yields result in greater income generation and lead to better financial security.

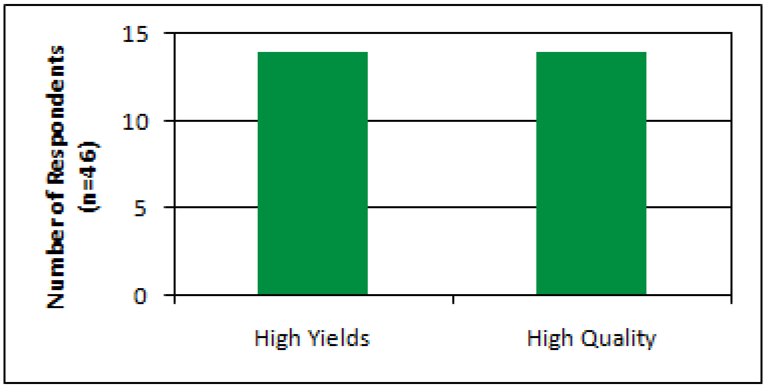


Figure 5.6: Production Forces Creating Above Average Conditions

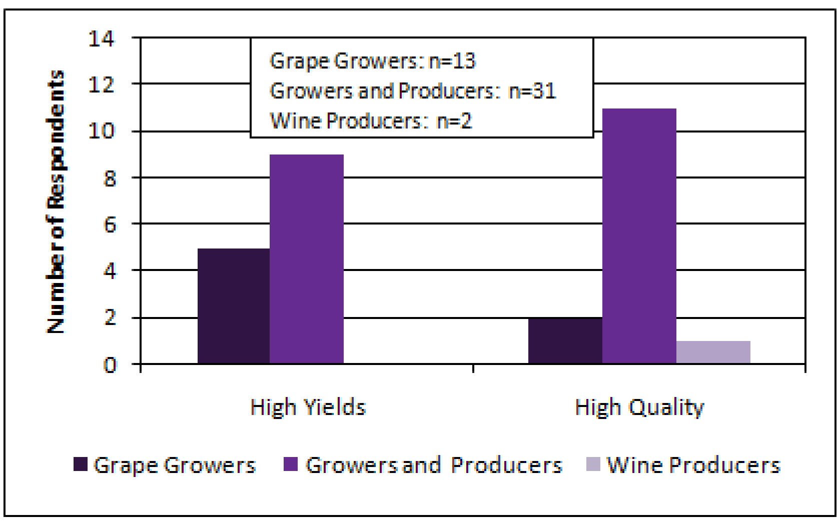


Figure 5.7: Production Forces Creating Above Average Conditions By Operation Type

The years 2000, 2001, 2007 and 2008 were mentioned as above average in terms of production by GGs, and the years 2000, 2001, 2003, 2005, 2006 and 2008 by GGs. Figure 5.8 illustrates the amount of wine produced for export in the Maule Region from 2002 to 2007. Export data were used as a surrogate for yields because the majority of the wine produced in Maule is exported. Over the past 6 years, 2004, 2006 and 2007 stand out as years with the highest production, although all years since 2002 have exceeded the total amount of wine produced for export in 2002.

Figure 5.8: Litres of Wine Produced for Export in the Maule Region (Data Source: ODEPA, 2008b)

"*You know it's a good year based on the quality of your wine, which is based on climate, how the producers manage their land, and the winemakers and what grapes they pick*", commented a WP. A total of 2 of 13 (15%) GGs and 11 of 31 (35%) GWs noted high quality grapes as contributing to above average years (Figure 5.7). The production of high quality grapes and wine creates significant opportunities because it permits viticulturalists and viniculturists to demonstrate their abilities. Many consider viticulture and viniculture an art, and high quality grapes are the perfect canvas for the production of outstanding and diverse wines. Many growers receive a higher price for their high quality grapes, and wineries are able to market a higher quality product, potentially drawing more buyers and earning them widespread recognition for their wines.

Linkages were commonly made between the two production forces described above and weather. Weather is an important determining factor, besides individual skill sets and vineyard management, in the production of quality grapes and wine (Jones et al, 2005; Jackson and Schuster, 2007). Rain, for example, during grape maturation facilitates the onset of botrytis, potentially decreasing yields and quality. The alignment of phenological stages of all grapevines of the same variety in a vineyard is essential to producing high quality grapes, as is the uninterrupted maturation of grapes, two processes in which weather interferes with considerably. Figure 5.9 provides a summary of the adaptive responses employed by growers and producers to manage the production forces described above.

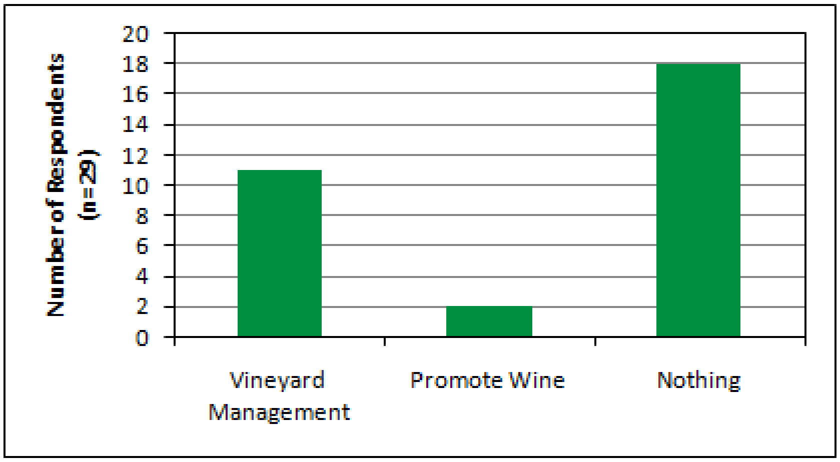


Figure 5.9: Adaptive Responses to Above Average Conditions Resulting From Production Forces

Vineyard management, a tactical, responsive management strategy, was the primary adaptive response to achieve high yields and high quality grapes. Irrigation schedules were adjusted, if the weather conditions permitted and sufficient water was available, in order to permit a large crop. Pruning and thinning techniques are employed to facilitate preferred ripening of grapes, while the application of fungicide and pesticide is used to prevent unwanted pests and disease, contributing to consistency among phenological stages. Wine producers are diligent in the vineyard during harvest, constantly tasting the grapes to make sure they are harvested at the optimal time.

While some producers took a proactive approach, many opted to do nothing; that is, 18 of 46 (39%) interviewees do nothing to take advantage of the opportunities in years with good production. Investigation into the variations in responses among operation types shows that both GGs and GWs use vineyard management to manage production opportunities, and GGs more often do nothing than GWs (Figure 5.10). Of course GGs do not promote wine because they do not produce it.

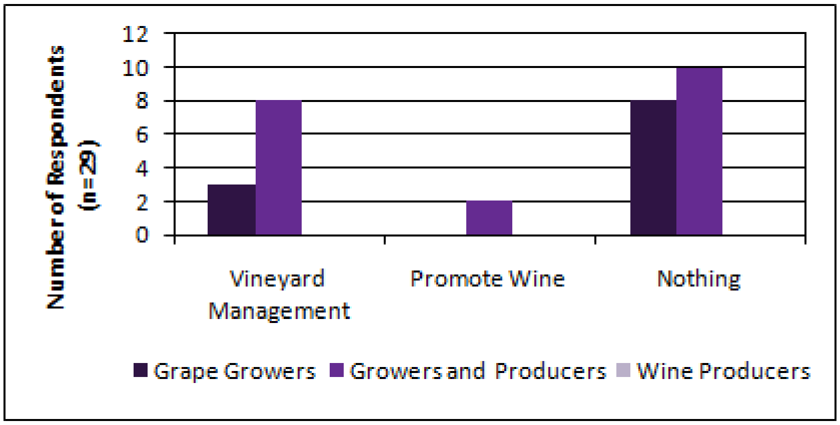


Figure 5.10: Adaptive Responses to Above Average Conditions Resulting From Production Forces By Operation Type

5.2.1.2 Economic

High grape and bulk wine prices are an economic force to which interviewees are sensitive, as they greatly increase operations' profitability. When prices are high, interviewees feel they are paid a reasonable price for their grapes and/or wine, allowing them to cover their input costs and make a decent profit and living.

Figure 5.11 illustrates grape prices from 2003 to 2008. There was a drastic increase in grape prices in 2005, followed by a sharp drop in 2006, gradual increases in 2007/2008, and a slow drop at the end of 2008. Table grapes did not increase in price to the same degree as wine grapes. Table grapes are used to produce low quality wine, while wine grapes are used to produce higher quality wine.

Prices for three varieties of bulk wine from 2000 to 2008 are shown in Figure 5.12. Cabernet Sauvignon prices were high in 2000 – triple that of Sémillon and País. Cabernet Sauvignon experienced a drastic drop in 2001, the other two varieties experienced also dropped in price but not to the same degree. Prices were highly variable but generally increasing between 2004 and the end of 2005. During this time Sémillon surpassed Cabernet Sauvignon. The price of bulk wine fell drastically at the end of 2005, when there was a drastic drop in the price of all three varieties. Prices began to recover at the end of 2007 and early 2008, and began dropping again at the end of 2008.

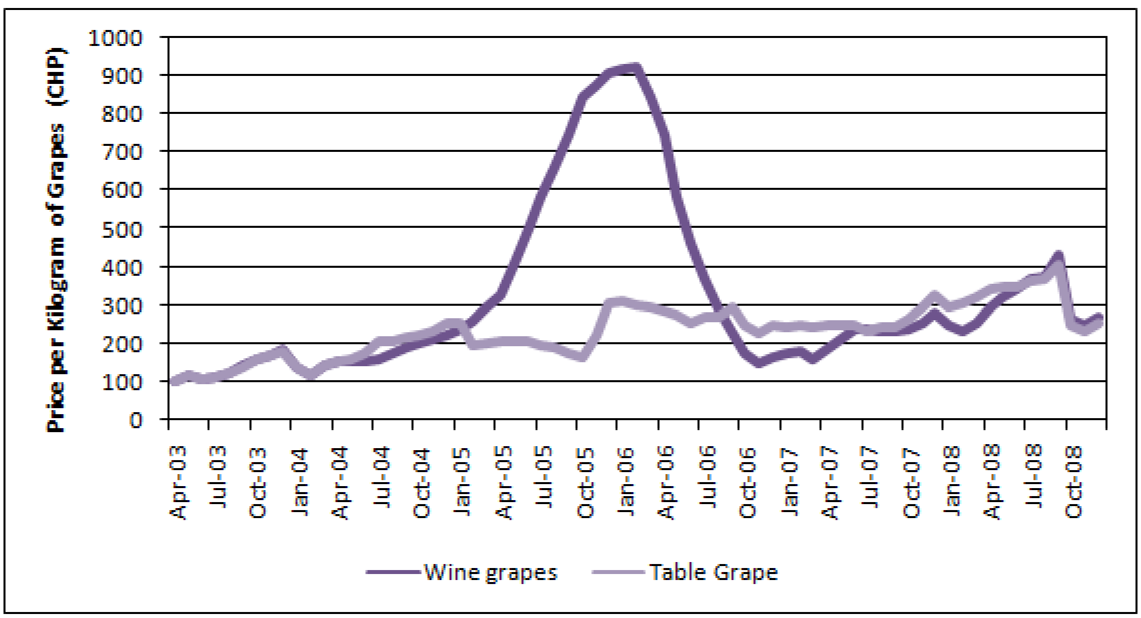


Figure 5.11: Average Table and Wine Grape Prices (April 2003-December 2008) (ODEPA, 2008b)

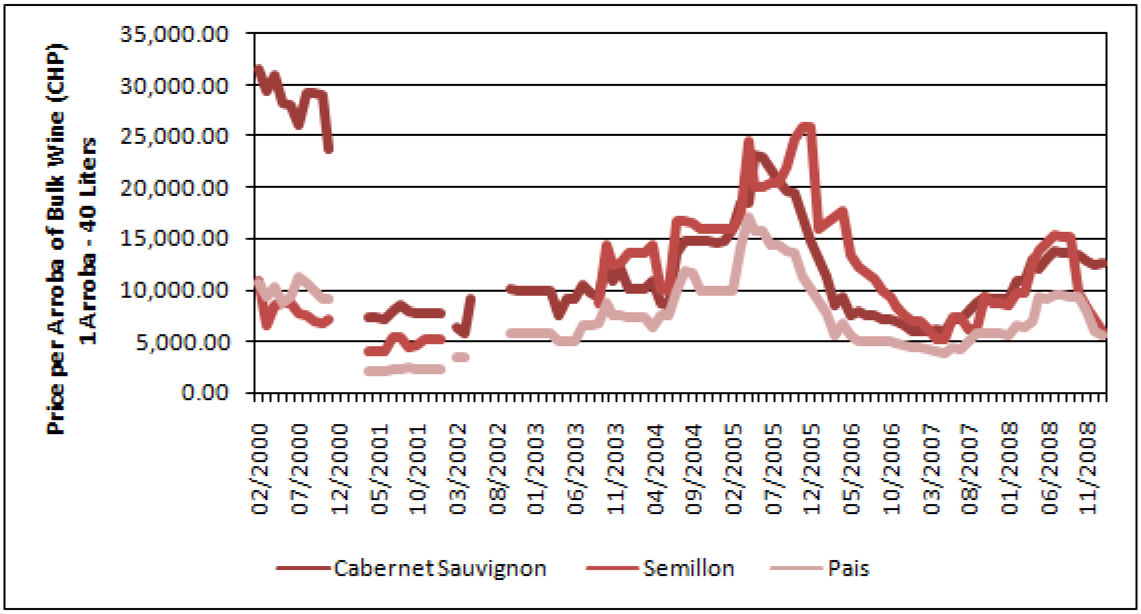


Figure 5.12: Average Price Per Arroba of Bulk Wine: Cabernet Sauvignon, Sémillon and País (January 2000-December 2008) (ODEPA, 2008b)

The years 2000, 2007 and 2008 were identified by GGs as being above average as a result of economic forces, while 2002, 2004 and 2008 were identified by GWs. Although no data were available for 2000, grape prices began to recover in 2007 and 2008 after a dramatic drop (Figure 5.11). Bulk wine prices began increasing in 2002 after a large drop in 2000-2001; they peaked in 2004, and were in the process of recovering, along with grape prices, in 2008 following a drastic plunge (Figure 5.12). These data support interviewees' recollection of years.

One commonly noted problem with high prices is that they are usually accompanied by low production (or grape yields); that is, generally, when prices are high, demand is high and production is low. This is reflected in Figure 5.8 above, which shows a significant decrease in the volume of wine produced in

2005, accompanied by high grape and bulk wine prices (Figures 5.11 and 5.12). Ideally growers and producers would have high grape and wine yields when prices are high. "*That's agriculture, when there's a small amount [of grapes] the price is good, and when there's a lot the prices are low*", a small GG stated. Many interviewees noted their inability to take advantage of high prices because their production fell.

Various adaptive techniques are employed by growers and producers in order to take advantage of the opportunities created by high grape and bulk wine prices. These adaptive techniques are shown in Figure 5.13 and further characterized in Table 5.2. A variety of anticipatory-strategic and responsive-tactical strategies are adopted at the farm-level to maximize opportunities created by high prices. Strategies include financial management, business management, vineyard management and winery management. Business management, the most widely used technique, involves expanding the operation, an anticipatory-strategic technique. Grape growers acquire more productive land when they experience a financial surplus, which typically accompanies high prices. They expand their operations to encompass new terroirs and microclimates so they can produce a multitude of varieties. Having a wide array of varieties spreads risk, primarily weather-related risk, and provides them with an opportunity to boost financial returns. Wine producers often expand their winery's vinification abilities by increasing potential production volumes. Investments are made in winery equipment; concrete holding and fermentation tanks are replaced with stainless steel ones (see Figure 5.14) and labourers are replaced with automated harvesters, pre-pruners, wine labellers and bottlers, and cooling systems are upgraded. "*We are always trying to modernize our winery*", stated one small winery operator. Grape growers installed weather and/or vineyard monitoring systems to aid them with future vineyard management and decision making because they felt their decisions would be better informed if they had as much information surrounding the vineyard available to them.

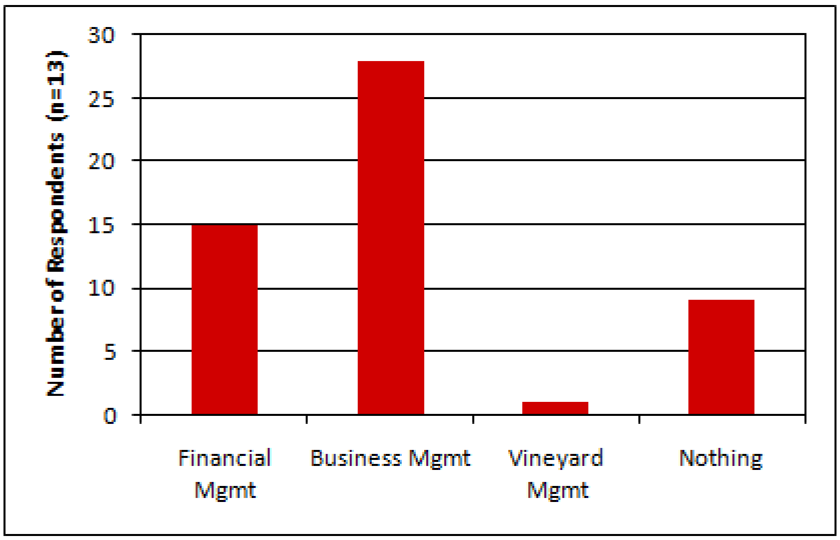


Figure 5.13: Adaptive Responses to High Grape and Bulk Wine Prices

Table 5.2: Characterization of Adaptive Responses to High Grape and Bulk Wine Prices

	Anticipatory	**Responsive**
Strategic	• Invest in operation (7) • Pay debt (4) • Save (4) • Expand (8)	
Tactical		• Irrigate (1) • Sell grapes (18) • Sell wine stock (2)

Figure 5.14: Stainless Steel Fermentation Tanks in a Medium Sized Winery

Selling grapes, rather than processing them, is one business management strategy used by interviewees, if the facilities are available, with the hopes of obtaining a better price for the primary product rather than selling wine. Some wine producers sell whatever wine they have in stock in order to maximize their profits when bulk wine prices are high. Both selling grapes and bulk wine stock are responsive-tactical techniques. Selling grapes and bulk wine has implications for the market; prices could potentially increase because wineries need to replenish their stocks, causing demand for grapes to increase, but if the following year is a high production year, grape prices may drop because supply is plentiful. The majority who opt to sell their grapes are producing average quality wine and mostly selling on the bulk wine market, because those producing high quality wines obtain a much better price for their bottled wines than their bulk wines. They also might sell the grape varieties that are paying well and process the ones that are not, with hopes of obtaining a better price for the wine. This optimizes financial returns. One winery owner commented:

> *Sometimes I sell the high priced varieties and keep the ones that are low, process them and then sell the juice. There are years where I've sold almost all [grapes] and other years where I've only sold the varieties that are paying well. Other years I've sold them all.*

Financial management strategies are necessarily anticipatory-strategic and involve paying off debts and putting money away in savings. Vineyard management involves modifying irrigation in order to increase yields and maximize profitability. Quite a few growers and producers also noted doing nothing in years where prices are high.

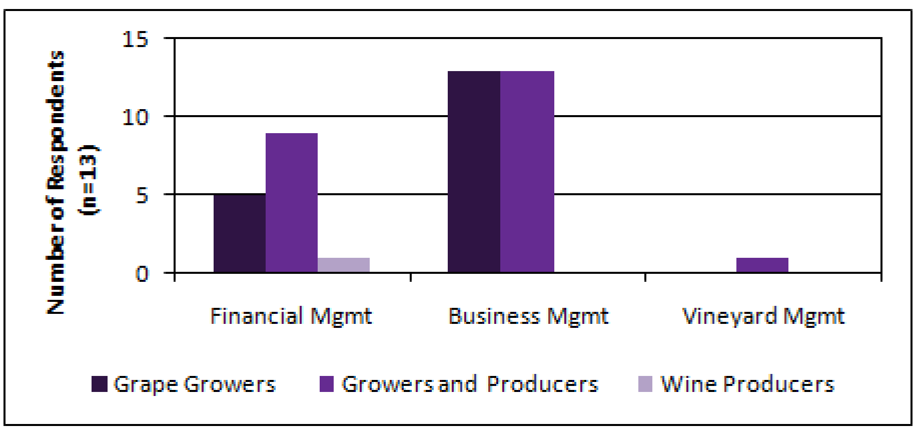


Figure 5.15: Adaptive Responses to High Grape and Bulk Wine Prices By Operation Type

According to Figure 5.15, GGs, GWs and WPs engage in financial management when prices are high. GGs and GWs engage in business management, and just GWs engage in vineyard management. Investigation into differences among operation types reveals no considerable differences, except that GGs always use business management strategies, largely because it includes selling grapes, and they have few options in terms of business management besides selling their grapes. GWs have more management strategies available to them because they have the option of either selling or processing their grapes.

Although high grape and wine prices are beneficial to growers and producers selling their grapes and bulk wines, they are problematic for buyers (e.g. wineries that purchase grapes). High prices significantly increase their input costs and result in lower profit margins. Operations in this situation employ management strategies such as lowering inputs costs by reducing personnel and energy costs, and signing contracts with growers to guarantee price and reduce price uncertainty.

5.2.1.3 Weather

What interviewees deemed 'good weather' generates opportunities, primarily in the way in which weather contributes to the preferred development of grapes (see Figure 5.16). The majority of interviewees noted 'overall' climate as generating better than average conditions; climate manifests as weather on a short-term basis (i.e. less than 30 years), and is discussed as such in this section. The specific weather conditions noted as being beneficial, along with the number of interviewees identifying each, are shown in Figure 5.17. All forces identified significantly influence grape production and were largely the forces opposite to those creating risks described in section 5.2.2.1.

Figure 5.16: Organic White Grapes Ready for Harvest After A Year With What is Considered 'Good Weather' (Photo Credit: Carlos Correa)

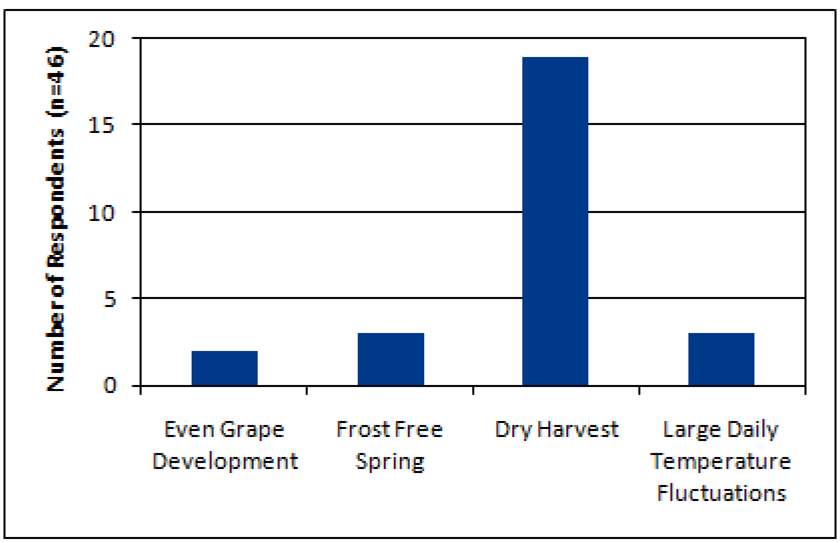


Figure 5.17: Weather Forces Creating Above Average Conditions

The following represent what growers and producers mean by 'good weather': absence of frost in spring during bud burst, absence of rain in spring to promote even flowering, large daily temperature fluctuations during the growing season and a dry harvest; the presence of all of these conditions during the growing season facilitate preferred grape maturation.

Further investigation into differential exposures among operation types (Figure 5.18) divulge that GGs find a dry harvest and frost free spring beneficial, while just GWs find large daily temperature fluctuations and even grape development as beneficial. Perhaps these differences stem from training, as many GGs tend to lack formal training in viticulture, although they have extensive practical training.

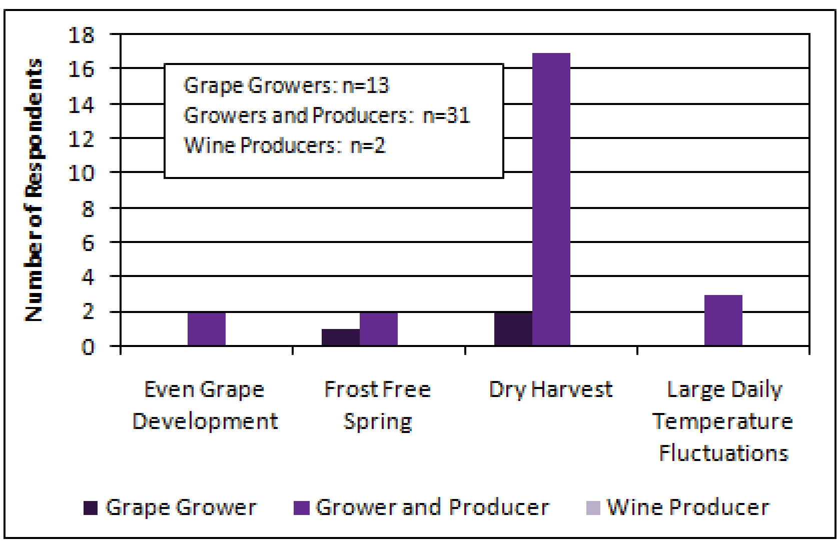


Figure 5.18: Weather Forces Creating Above Average Conditions By Operation Type

Even grape development facilitates higher quality grape production because all grapes are mature when they are harvested and made into wine, as opposed to having some that are mature and others that are not. Flavour, aroma, taste and colour are compromised when grapes mature unevenly.

Intense frosts during bud burst kill the primary bud, the most fruitful of the three buds present in grapevines, initiating secondary bud growth, which is less fruitful and produces inferior quality wines (Jackson and Schuster, 2007). Frost-free springs are desired to optimize grape and wine quantity and quality.

Harvests with minimal rainfall tend to create significant opportunity for interviewees, as the potential for botrytis is eliminated, ensuring a higher quality, fungi-free crop. Large temperature fluctuations are also preferred as fine wine grapes are known to produce high quality fruit if nights are cool and days are warm, but not too warm.

Response strategies were limited as growers and producers identified good weather in relation to bad weather and when asked what strategies they utilize when weather conditions are above average, the majority responded with "nothing", because the weather is uncontrollable and largely unpredictable.

5.2.2 Forces Creating Risks

The years in which interviewees indicated as 'bad' and the important forces influencing bad years are shown in Figures 5.19, 5.20 and 5.21. GGs noted the past nine years as bad. All years excluding 2003 and 2005 constituted bad years for GWs. WPs mentioned 2001 and 2008 as bad years. All interviewees highlighted economic, weather and production forces as contributing to bad years. It is also important to note that many years identified as being good were also identified as bad, which highlights that both risks and opportunities can be experienced simultaneously.

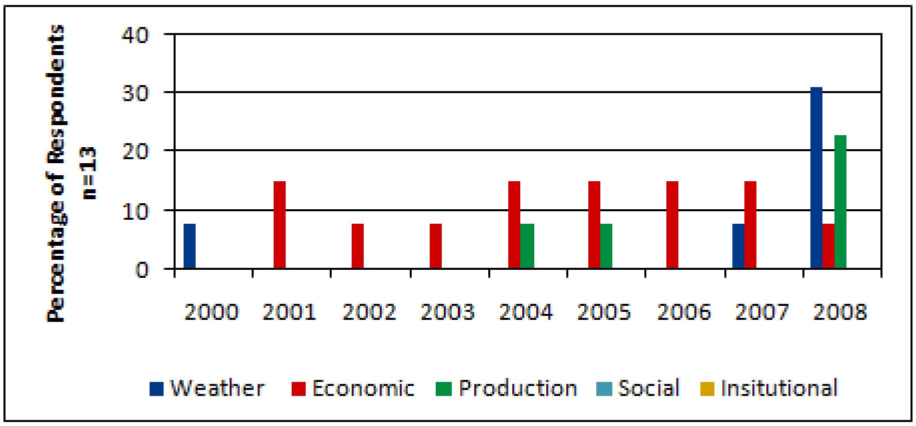


Figure 5.19: Bad Years Identified By Grape Growers (GGs)

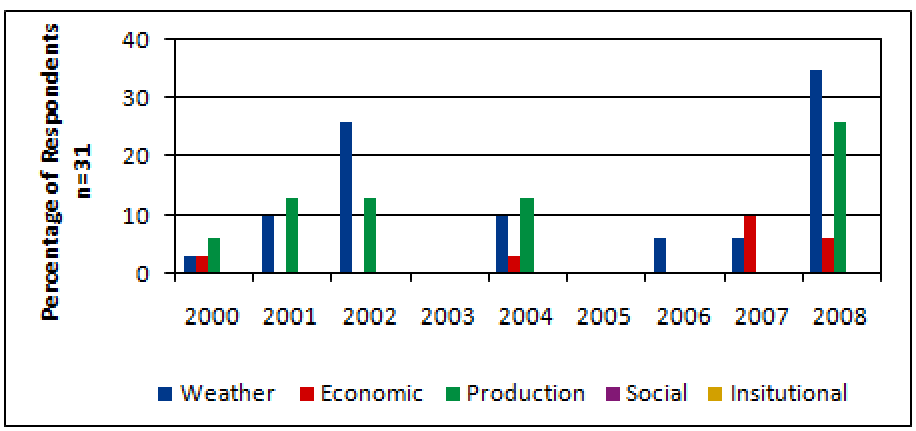


Figure 5.20: Bad Years Identified By Grape Growers and Wine Producers (GWs)

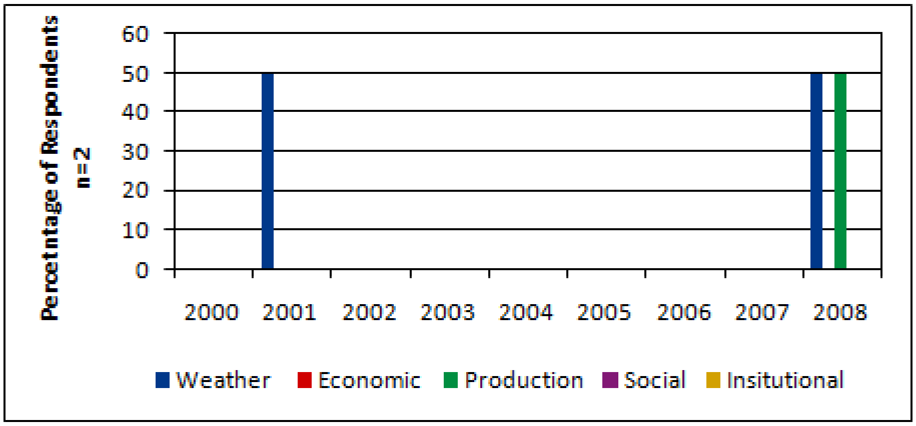


Figure 5.21: Bad Years Identified By Wine Producers

The broad forces creating risks are related to those creating opportunities. A summary of the broad forces creating risks is found in Figure 5.22. Interviewees are most sensitive to weather forces, followed by economic, production, social and institutional. When broken down by operation type (Figure 5.23), the forces identified in Figure 5.22, for the most part, preserve their degree of sensitivity. These forces negatively influence the success of grape growers and wine producers in the Maule Region, although management strategies are employed to help cope with or manage these forces. Both the forces and management strategies will be investigated in the following subsections. It is important to note again that the majority of exposures lead to income losses.

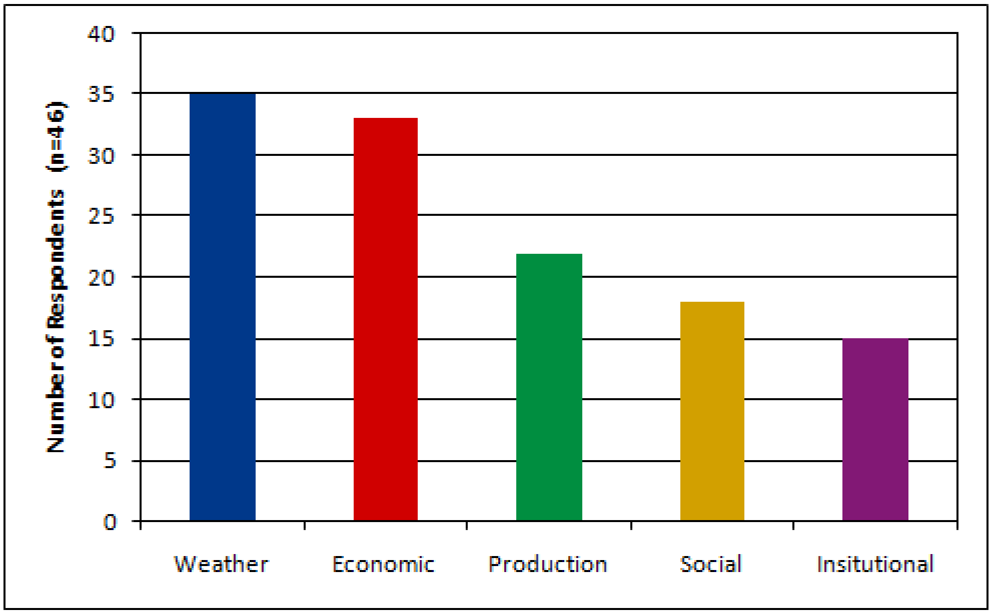


Figure 5.22: Forces Identified By Interviewees as Creating Below Average Conditions

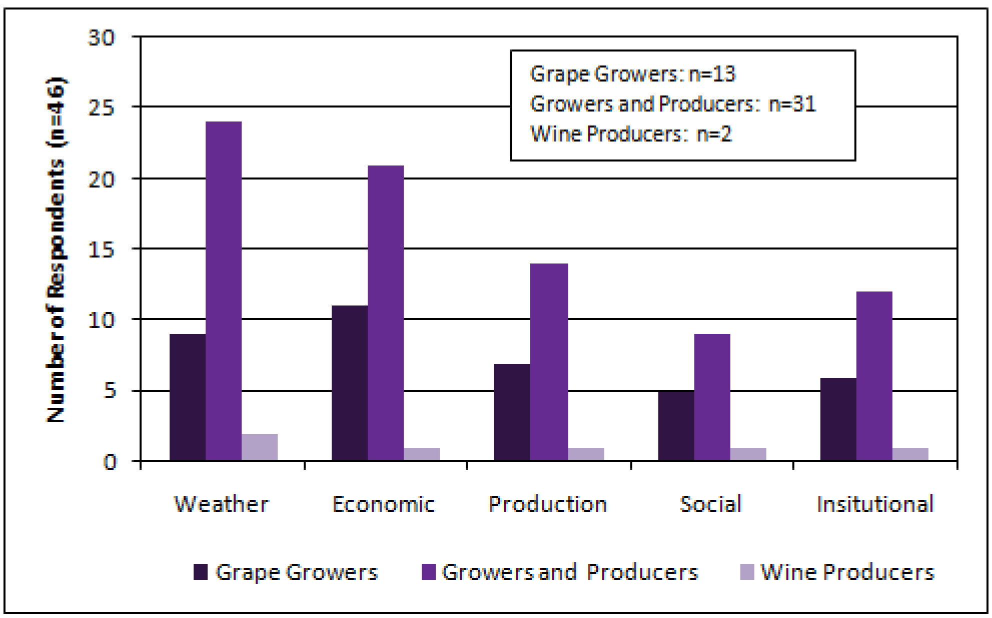


Figure 5.23: Forces Creating Below Average Conditions By Operation Type

5.2.2.1 Weather

The main force impeding the success of grape growers and wine producers is weather. Various attributes of weather were identified as problematic (Figure 5.24), including wet fall, wet spring, spring frost, drought and high temperatures during grape maturation. These attributes are problematic during different times throughout the growing season and create different risks.

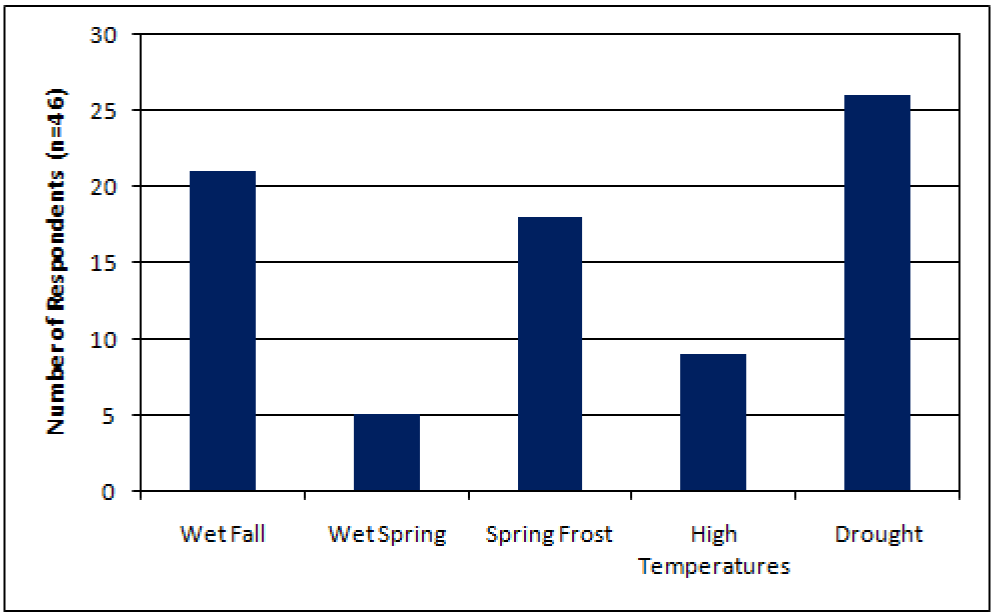


Figure 5.24: Weather Forces Creating Below Average Conditions

Further investigation, shown in Figure 5.25, reveals similar results as in Figure 5.24. Growers and producers are most sensitive to drought, wet fall and spring frost. Perhaps drought was a prevalent issue for growers and producers because at the time of the interviews the Maule Region had just experienced a severe drought which had significant impacts on the agricultural sector.

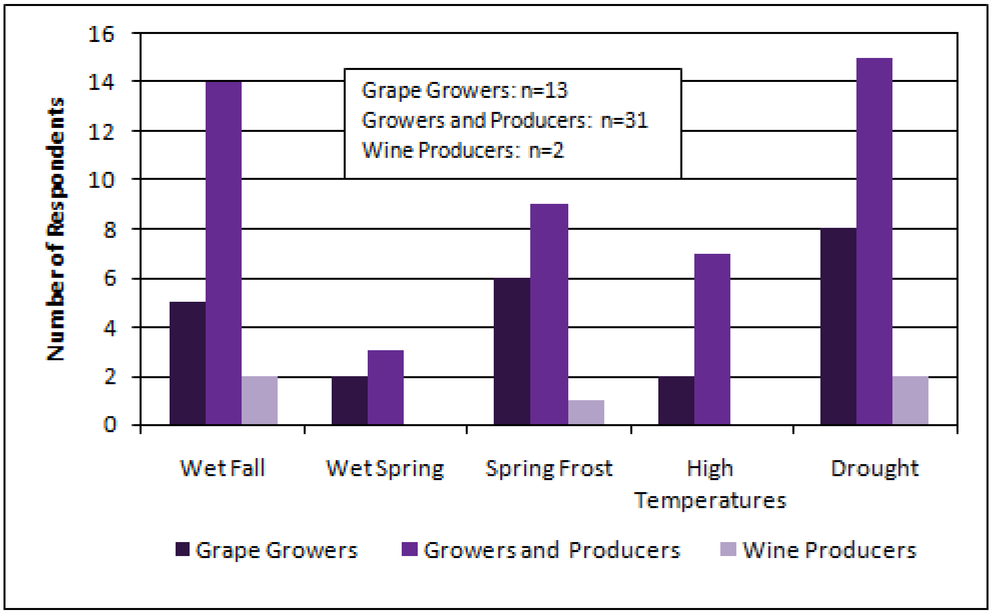


Figure 5.25: Weather Forces Creating Below Average Conditions By Operation Type

5.2.2.1.1 Wet Fall

Identified by 21 of 46 interviewees (46%), rain during grape maturation (February, March, April and May), otherwise referred to as a 'wet fall', is extremely problematic for growers as it facilitates the onset of botrytis (Figure 5.26), a problematic fungal disease which causes grapes to rot. Botrytis, if not controlled, can result in reductions in grape and wine yields and quality. Infected bunches are typically deemed unacceptable for winemaking, and if they are accepted, fermentation and other vinification processes become complicated. Wines made with infected grapes are known to possess undesirable tastes and colour as well as a high alcohol content, all of which compromise wine quality;

reds suffer from a decrease in tannins, colour and taste, and whites from a decrease in flavour, aroma and taste.

Figure 5.26: Botrytis on Wine Grapes (Photo Credit: A. Haenni)

Rain itself is not challenging, but when rain is heavy and concentrated over the span of a few days during maturation, it becomes a challenge. One grower stated that in 2002 there was "*a lot of rain in March, which is unusual. There was about 100-200 millimetres of rain in a space of 7 days. Everything rotted*". The year 2002 was noted by 8 of 31 (26%) GWs as being a below average year, largely due to precipitation during maturation. Another grower noted that between 100 to 300mm of rain fell between March 5th and 10th, chaos ensued after that. Figure 5.27 illustrates 2002 precipitation anomalies for nine stations in the Maule Region, using 1990 to 2007 as the normal period, for the months in which a wet fall is problematic. In 2002, all stations (their locations shown in Figure 5.28) experienced above normal precipitation in February, March and May and below normal precipitation in April, which is consistent with grower and producer recollection. There is a high degree of variation from station to station, with some experiencing small variations, and others experiencing a great deal of variation.

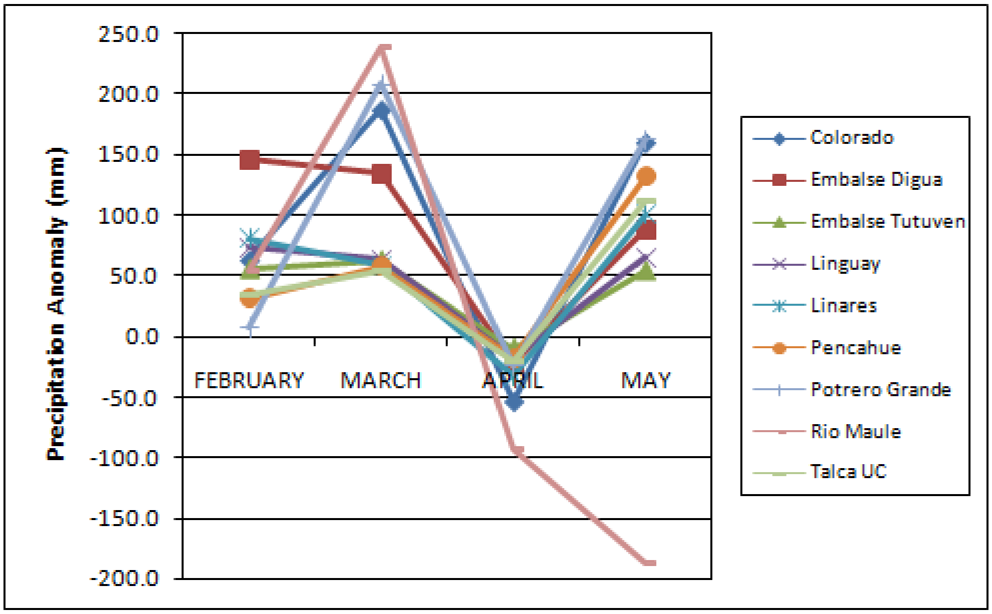


Figure 5.27: 2002 Precipitation Anomalies for the Grape Maturation Period for 9 Stations in the Maule Region

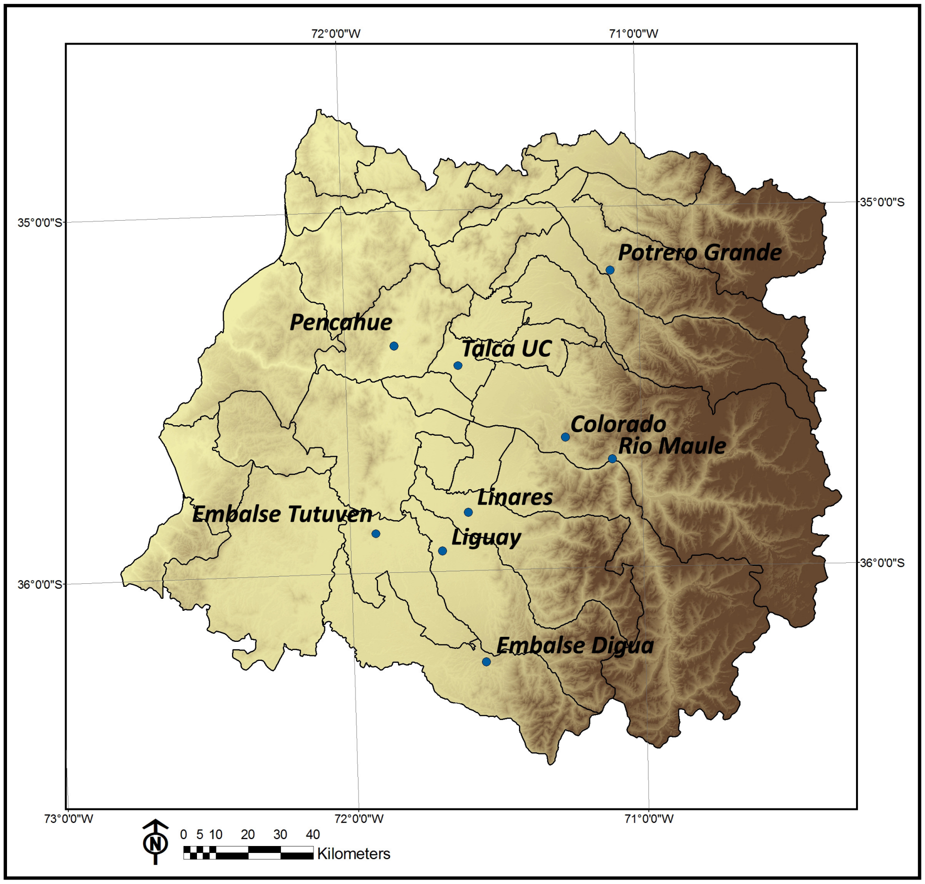


Figure 5.28: Location and Names of the Selected Climate Stations in the Maule Region

Both growers and producers use a range of adaptive strategies to respond to a wet fall (see Figure 5.29). These strategies can be grouped into vineyard management, business management and winery management. Vineyard management, the most common response, includes anticipatory-strategic techniques such as replanting with higher quality varieties, replanting with varieties less susceptible to rot such as early maturing varieties and engaging in a preventative spray program to reduce the risk of a wet fall. Vineyard management also includes responsive-tactical techniques, such as rapidly harvesting to avoid a reduction in grape yield and quality, applying fungicide, leaf thinning to facilitate air circulation, shaking plants to remove rotten bunches and sorting grapes after harvest to remove rotten bunches.

A few business management strategies are used by GWs. GWs take out loans to cover costs, they export the good quality wines and sell the poor quality wines domestically, they buy grapes and wine to offset a reduction in yields, and some try to find a niche (e.g. high quality bulk wine market) to secure sales and reduce market risks associated with wet fall. Winery management techniques are also used. These involve the manipulation of wines, including macerating less prior to fermentation, mixing wines to mask undesirable traits and adding colour to red wines to brighten its colour. The vineyard, business and winery management adaptive strategies noted above are described in more detail below.

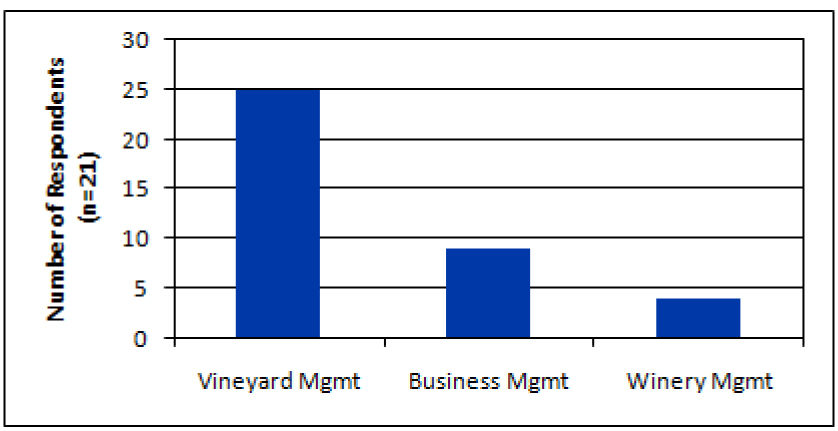


Figure 5.29: Adaptive Responses to Wet Fall

Growers generally harvest their crop as soon as the threat of botrytis becomes a reality. "*Rain a lot during harvest is problematic. The worst is that* *you have to harvest faster. You lose quality because of botrytis*", one GW stated. Although grape growers are unable to accomplish preferred maturity in their vineyard, which decreases the quality of their crop, harvesting enables them to salvage the portion of the crop not yet infected with botrytis, which allows them to earn some financial return, rather than losing the entire crop to botrytis. When botrytis infects a vineyard, white grape harvest and red grape harvest overlap, and many wineries are not set up to process both their white and red grapes at the same time. A GW explained:

> *Harvest gets complicated, requiring more labour because the whites are usually harvested first and the reds second, but when it rains, both need to be harvested around the same time. It's craziness. Many wineries are not set up to process the juices of all their grapes at once; they rely on the weeks between white maturity and red maturity to process whites, put them in cubes and then get reds in*.

Investigation into variations in responses among operation types reveals some differences in adaptive responses (Figure 5.30). All operation types engage in vineyard management, just GGs and GWs engage in business management and just GWs engage in winery management. WPs do not produce their own grapes but they do have considerable control over vineyard management, this is why WPs identified vineyard management strategies as a coping mechanism for wet fall. A characterization of the strategies employed in a wet fall is found in Table 5.3.

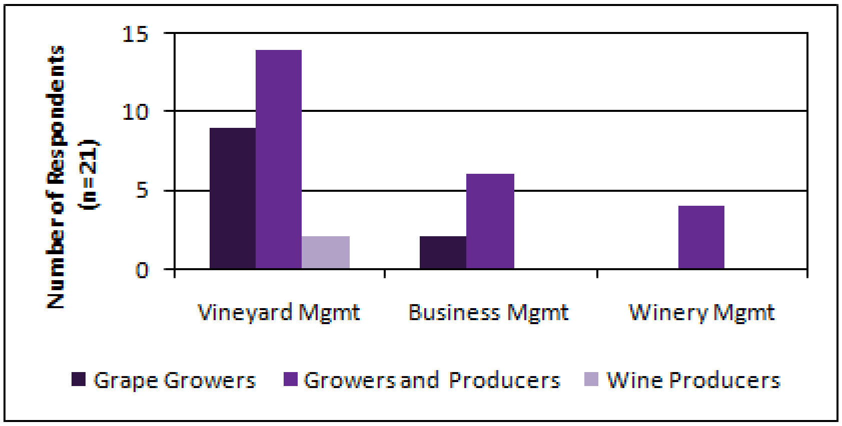


Figure 5.30: Adaptive Responses to Wet Fall By Operation Type

Table 5.3: Characterization of Adaptive Responses to Wet Fall

	Anticipatory	**Responsive**
Strategic	• Replant with new varieties (6) • Diversify operation (3) • Find a niche market (1) • Promote product (1)	• Buy fruit (2) • Loans (1)
Tactical		• Harvest (17) • Leaf thinning (3) • Spray fungicide (10) • Remove or sort botrytis grapes (8) • Macerate less prior to fermentation (1) • Mix wine (3) • Add colour to red wine (1) • Add sulphur and enzymes to wine (1) • Target a different market (e.g. make bulk wine) (1) • Buy wine (1)

Some growers replanted their vineyard with varieties that are appropriate to the vineyard's climate and soil. This strategic, anticipatory strategy is very costly but many growers noted its effectiveness. One grower switched from Syrah to Pinot Noir because Syrah is the last variety to be harvested, and Pinot Noir is one of the first. Syrah is more susceptible to a wet fall, and by grafting Malbec onto Syrah, the grower reduced his exposure to wet fall, and because he chose to graft, the vine started to produce fruit in two years, rather than in four years, the typical time it takes for vines to establish when they are planted. Other growers have diversified into higher-value crops such as blueberries and avocadoes.

Once botrytis has infected grapes, a number of techniques are used besides harvesting. A tactical, reactive strategy utilized by many growers is the application of fungicide after heavy amounts of rainfall during grape maturation. Fungicide is expensive and many growers noted they opt to not spray because rain is not common during maturation, which significantly lowers their input costs as they do not purchase fungicide, but they do take a risk if they chose not to spray and it does rain, because the possibility of losing part or their entire crop remains. Leaf thinning is another strategy utilized by growers. The purpose of this vineyard management strategy is to reduce the amount of leaves on the vine, allowing for air to circulate and reducing the spread of the fungus. Botrytis grapes can also be separated from non-infected grapes either in the vineyard by removing affected bunches during harvest or in the winery prior to vinification usually via a sorting table. Producers are able to attain higher quality wines when botrytis grapes are removed. Others choose to keep the not-so-affected bunches, which are typically used to make bulk wine, while the non-affected grapes are used to make bottled wine. Labour costs are greater in years with botrytis because more labour is required to quickly harvest the crop, spray the crop with fungicide, or sort the grapes. Income significantly decreases in a wet fall because input costs increase and usually a portion of the crop is lost, which is more income lost.

In the winery, producers modify the fermentation process and mix wines in order to mask the undesirable effects botrytis has on wine. For example, *Tintorero*, a red wine grape variety with bold colour, is added to red wines to balance the colour taken away by botrytis. Other winery management strategies involve reducing maceration times prior to fermentation and adding enzymes and sulphur after crushing to increase free juice volumes and help break down the fungus. Wineries buy grapes if they are anticipating being short prior to harvest, and they buy wine if they are short wine after vinification and are in need of greater volumes to meet demand. They also try to find a niche market and travel abroad to promote their wines. One winery, for example, found a market in high quality bulk wine and has experienced great success.

5.2.2.1.2 Wet Spring

Of the 46 interviewees, 5 (11%) noted a wet spring as being problematic. A threshold of 30mm of rainfall when the vine has 50% of its flowers was noted by a GW as disastrous. Excessive rainfall during flowering can cause uneven grape development and powdery mildew. Uneven grape development creates complications at harvest because the same varieties in the vineyard are at different stages of phenological development (i.e. some are mature and ready to be harvested and others are not). Growers experience increases in labour costs because labourers need to assess each bunch to determine which ones are ready to be harvested. The grower may harvest mature grapes, wait until the unripe grapes ripen and then do a second harvest, or harvest both mature and immature grapes all at once and compromise grape and wine quality if the mature and immature grapes are processed together. Powdery mildew, shown in Figure 5.31, is a fungus that coats the grapes and leaves and acts to prevent grapes from ripening. It destroys the grape skins, essential for quality wine making. In wine, powdery mildew usually negatively affects tannins, colour and taste in reds, and aroma and taste in whites.

Figure 5.31: Powdery Mildew on White Wine Grapes (Photo Credit: Simone Quentin de Manson)

Little can be done once the grapes have begun developing unevenly. Growers try their best to monitor the vineyards. Chemicals are applied to shield the flowers and make them more resilient when it rains, but this is ineffective and very expensive. Growers apply sulphur to combat powdery mildew. Some growers do this to prevent powdery mildew, while others spray after it appears. Growers also remove the affected bunches to reduce spread. Both of these vineyard management strategies result in higher input costs because they require additional labour and chemical.

5.2.2.1.3 Spring Frost

Another problematic force affecting 18 of 46 (39%) interviewees is spring frost. Frosts occur when ambient temperatures are below 0^0C, causing significant damages to grape vines during the bud burst and early shoot growth stages of development (i.e. late August, September, October and November). Buds and primary shoots are damaged and may be killed if frosts are severe or last for a long period of the night. Secondary shoots will then grow, and although fruit may form, yield will be reduced and grapes may not ripen before late autumn (Jackson and Schuster, 2007). Lower yields result in reduced profits for growers and reduced wine volumes for producers. Frosts largely affect the early budding varieties such as Pinot Noir, Merlot and Chardonnay.

Many growers are unaware frost has damaged their crop until they harvest a low yielding crop. One grower identified 2006/2007 and 2007/2008 as being below average due to spring frost. "*The frost really affected the whites, production fell substantially* ", one grower stated.

Various adaptive techniques have been adopted by growers and producers to manage spring frosts (see Figure 5.32), and they do not differ too much based on operation type (Figure 5.33). The techniques are characterized in Table 5.4 and primarily involve vineyard management. The most common technique involves increasing ambient temperatures in the vineyard, a responsive and tactical approach to battling frosts. This can be done using a variety of methods. Many growers use pruning remnants or garbage as fuel. Using this method, the bark or garbage is spread along each row and lit on fire in an attempt to increase temperatures. Some growers have trucks with fuel tanks that are lit and driven up and down the vineyard until the frost passes. One large winery hires a helicopter to mix the cold air with warmer air higher in the atmosphere. These strategies are not always effective, as one grower noted, "*We burned whatever we could to avoid the frost, but we were significantly affected anyway*".

Growers also irrigate their vines in order to provide frost protection. When temperatures are at dangerous levels, water is applied to the vines and, although it will freeze the grapes, the constant addition of water will prevent the temperature from falling below 0^0C and reduce the potential for frost damage.

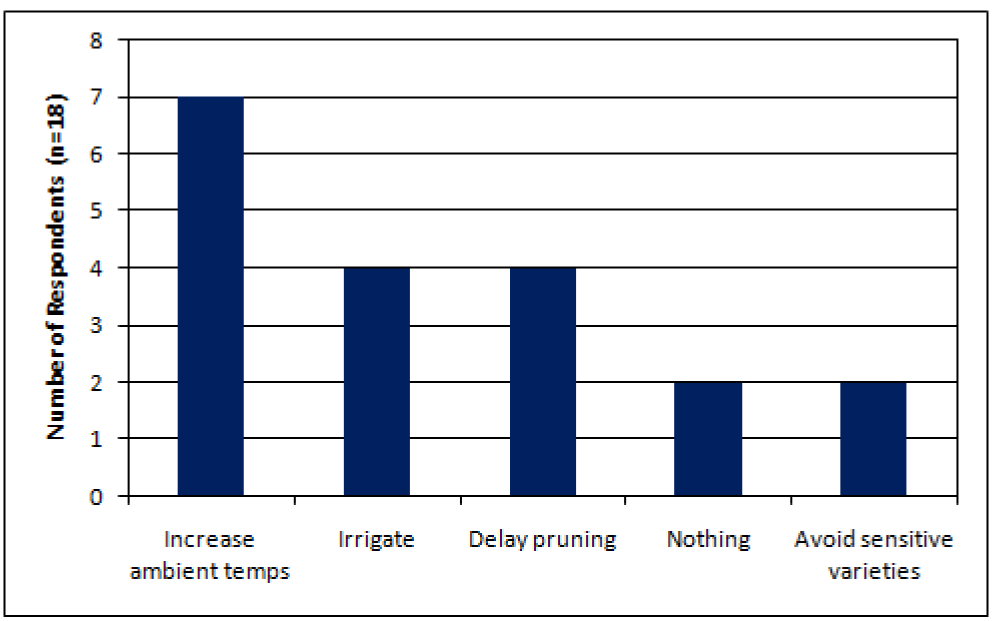


Figure 5.32: Adaptive Responses to Spring Frost

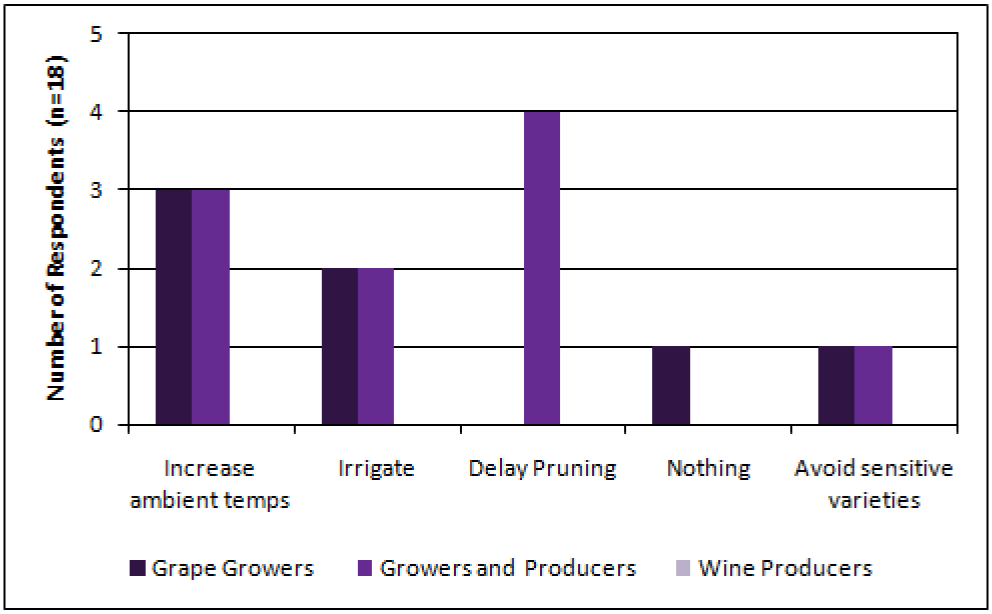


Figure 5.33: Adaptive Responses to Spring Frost By Operation Type

Table 5.4: Characterization of Adaptive Responses to Spring Frost

	Anticipatory	**Responsive**
Strategic	• Avoid sensitive varieties (2)	
Tactical	• Delay pruning (4)	• Increase ambient temperatures (7) • Irrigate (4)

One vineyard management technique noted as alleviating the impacts of spring frosts involves pruning. Growers delay pruning following harvest for as long as they can, as this strategy is known to delay bud burst in the next growing season because it alters the hormonal balance of the grapevine. It essentially ‘tricks’ the vine into initiating its developmental stages later than it normally would.

A strategic, anticipatory approach to spring frosts is to refrain from planting frost-sensitive varieties where spring frosts are known to be an issue. A couple growers who have experienced one too many frosts decided to either graft late bursting varieties onto early bursting varieties or rip out the frost-sensitive varieties and replant with late bursting varieties. This, however, is an extremely costly endeavour, for which most growers do not have the capital to invest.

5.2.2.1.4 High Temperatures

High summer temperatures during maturation were identified by 9 of 46 (20%) interviewees as creating risk. High temperatures cause dehydration in certain wine grape varieties (e.g. Merlot) which results in lower yields in terms of grape bunch weight. This is problematic for growers because most are paid per kilogram, so they receive lower financial returns because their grapes weigh less than normal. Similarly, wine producers process fewer kilograms of grapes, resulting in reduced wine volumes, also lowering financial returns.

High solar radiation combined with high temperatures creates the risk of sunburnt grapes, if vineyard management does not accommodate these conditions. Many growers revealed their struggles surrounding sunburnt white grapes, particularly because the skins become discoloured (see Figure 5.34), negatively affecting grape quality and the colour and taste of wine. One grower detailed his experience, "*Where I removed too many leaves, the grapes dried up, before harvesting they dried up, the sun burnt them. The warmer the sun the more harmful it is for agriculture*".

Figure 5.34: Dehydrated and Sun-Damaged White Grapes (Photo Credit: Through the Wine Glass)

Vineyard management, always responsive and tactical, is used to manage the effects of high temperatures and high solar radiation (Table 5.5). Growers and producers reduce the amount of leafing and thinning carried out in the vineyard and are extremely cautious when using this technique, keeping in mind the potential for dehydration and sun damage. Growers and producers also remove the affected bunches at harvest to avoid reductions in wine quality.

Table 5.5: Characterization of Adaptive Responses to High Temperatures

	Anticipatory	Responsive
Strategic		
Tactical		• Reduce leafing and thinning (4) • Remove affected bunches (6)

5.2.2.1.5 Drought

Drought and water shortages were identified by 26 of 46 (57%) interviewees. The 2007/2008 season was identified as being below average as a result of drought by 3 of 13 (23%) GGs, 12 of 31 (39%) GWs, and 1 of 2 WPs. "*We always have problems with respect to water but never anything like what we experienced last year [2007-2008]*", a grower stated during the interview. Figure 5.35 illustrates yearly precipitation anomalies for 1990 to 2007, using the 1997-2007 as the normal period. It highlights the years 2002 and 2005 as abnormally wet years and 2003 and 2007 as abnormally dry years. Yearly precipitation is highly variable in the Maule Region, as is evident from Figure 5.35. Consistent with grower and producer recollection, 2003 and 2007 were dry years and 2002 a wet year (see section 5.2.2.1.1), hence why drought and wet fall were noted as stressors these years.

Drought leads to decreased water availability for irrigation. A few growers noted increases in grape quality, primarily increases in juice concentrations, if the grapevine experienced a small amount of water stress during the growing season. A consequence of drought is smaller grapes because grapes are unable to produce the same volume of juices under water stress, which subsequently decreases the volume of grapes harvested. This reduces financial returns for those selling grapes because they have fewer kilos to sell and for those making wine because the volume of juice extracted from the grapes decreases and therefore less wine is made.

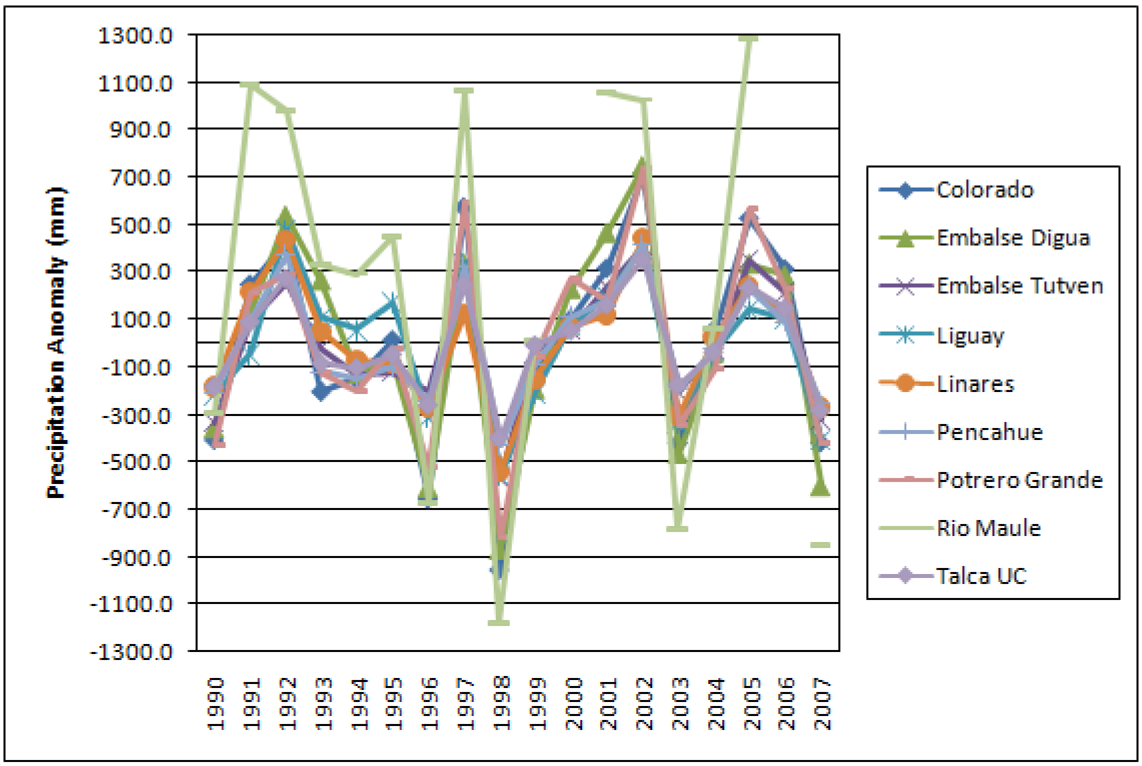


Figure 5.35: Precipitation Anomalies for 1990-2007 for 9 Stations in the Maule Region

The location of growers' and producers' irrigation canal relative to the mother canal significantly influenced exposure to drought. The irrigation canals closer to the mother canal receive water first, while those furthest away receive water last. The growers who receive their water last are much more affected by drought than those who receive their water first, largely because those upstream do not adhere to the rationing rules agreed to by growers through the Canal Association (*Asociaciones de Canalistas*). Those who did not have access to groundwater via deep wells or high water tables to exploit groundwater were significantly impacted by drought.

Adaptive techniques employed to manage drought are found in Figure 5.36. As is shown is Table 5.6, responsive- tactical strategies are more often utilized in response to droughts than any other strategy. Water management techniques were the most frequently cited by growers and producers as ways of managing droughts. Storing water in preparation for a drought is one anticipatory, strategic technique. Responsive, tactical techniques include modifying irrigation schedules to allow for more irrigation hours, tapping a variety of water sources (e.g. canals and groundwater), hiring watch guards to ensure no one is stealing water out of irrigation canals, and rationing or prioritizing irrigation water (e.g. reducing the volume of water applied by reducing the number of times grapevines are irrigated and prioritizing irrigation of higher value crops such as blueberries or high quality wine grapes over lower quality crops such as beans and lower quality wine grapes).

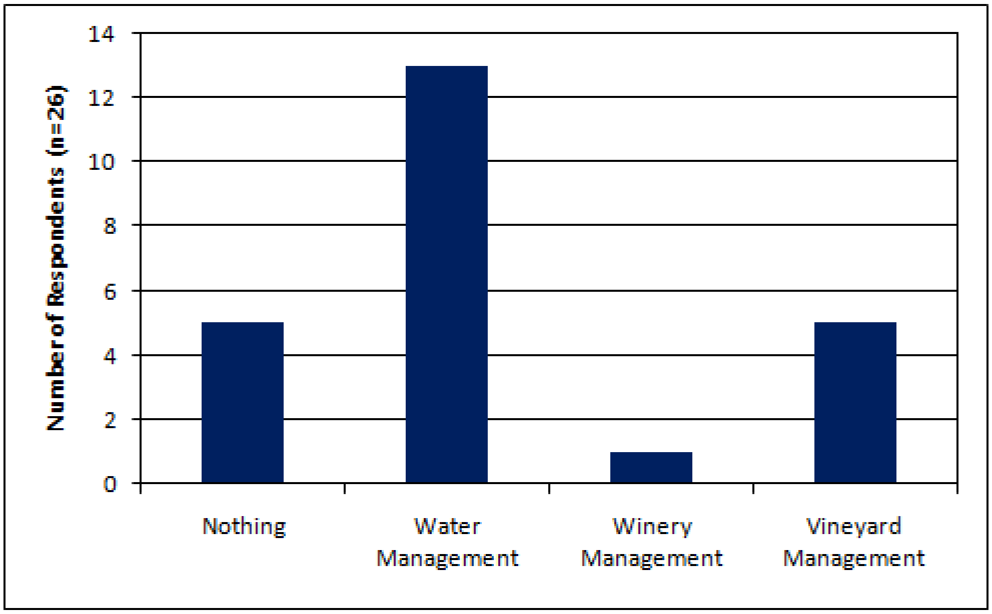


Figure 5.36: Adaptive Responses to Drought

Table 5.6: Characterization of Adaptive Responses to Drought

	Anticipatory	Responsive
Strategic	• Store water (1) • Plant in lowlands (natural drainage) (3)	• Pump groundwater (1)
Tactical		• Irrigate (9) • Hire watch guard (1) • Ration/prioritize irrigation water (8) • Harvest (2) • Add nitrogen to wine (1)

Vineyard management techniques include a responsive, tactical strategy— harvesting when the effects of drought become a serious threat to the crop, and an anticipatory, strategic strategy – planting the vineyard in fertile lowlands that offer natural water drainage and reduce the need for irrigation. One winery management technique was noted by a grower and producer, "*We measure the free nitrogen in the [wine] juices. This is a slow process but we do it,* *and if it's low, we add nitrogen. This year [2007-2008] the nitrogen content in the grape was low and we think it was due to the drought*". Meanwhile, 5 of 26 (19%) of the interviewees identifying drought as problematic do nothing to reduce the risks associated with drought.

Closer examination of response strategies among operation types uncovers some differences (Figure 5.37). GGs tend to manage water resources and not use the vineyard management techniques described above; perhaps because they do not have the financial capital to carry out these strategies.

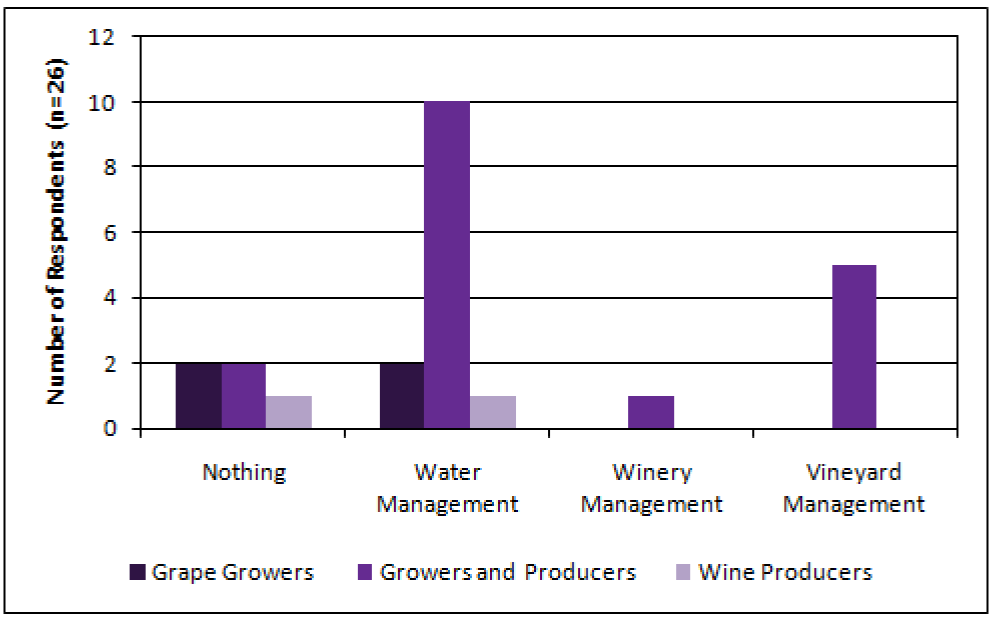


Figure 5.37: Adaptive Responses to Drought By Operation Type

5.2.2.2 Economic

Economic forces were identified by 33 of 46 (72%) interviewees as creating risks. Figure 5.38 provides a breakdown of the specific forces identified by interviewees. Interviewees are sensitive to a low United States dollar (USD) exchange rate relative to the Chilean Peso (CHP), noted by 25 of 46 (54%). Interviewees are also sensitive to low grape and bulk wine prices (18 of 46 – 39%), high input costs (17 of 46 – 37%) and contracts (8 of 46 – 17%).

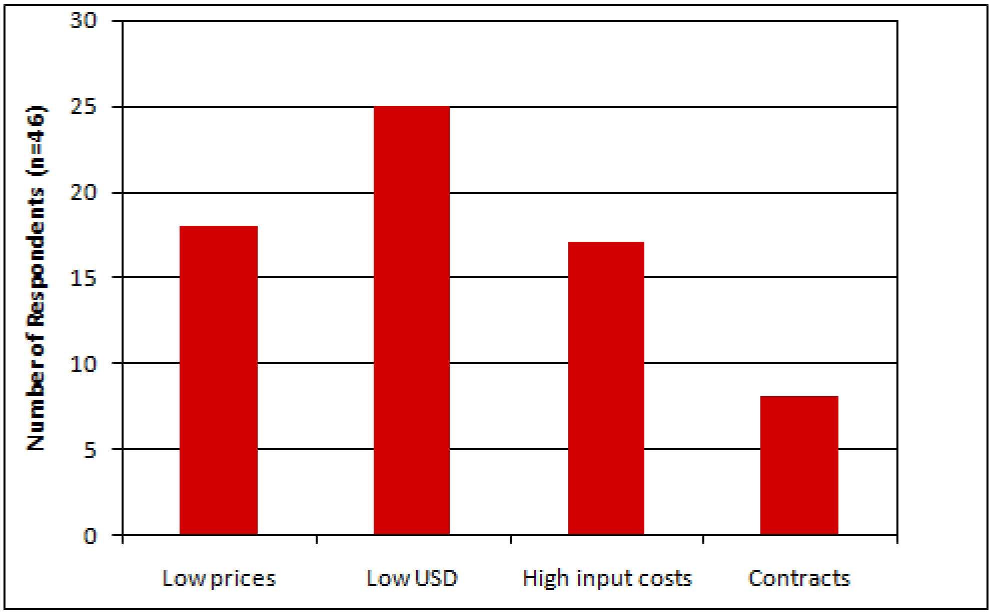


Figure 5.38: Economic Forces Creating Below Average Conditions

Additional investigation into differential exposures among operation types uncovers no major differences except that GGs noted contracts more often than wine producers (39% versus 9%) and low prices were not noted by WPs (Figure 5.39). A low USD and high inputs costs remained important to all three operation types. The four forces discussed in this introduction will comprise the following discussion.

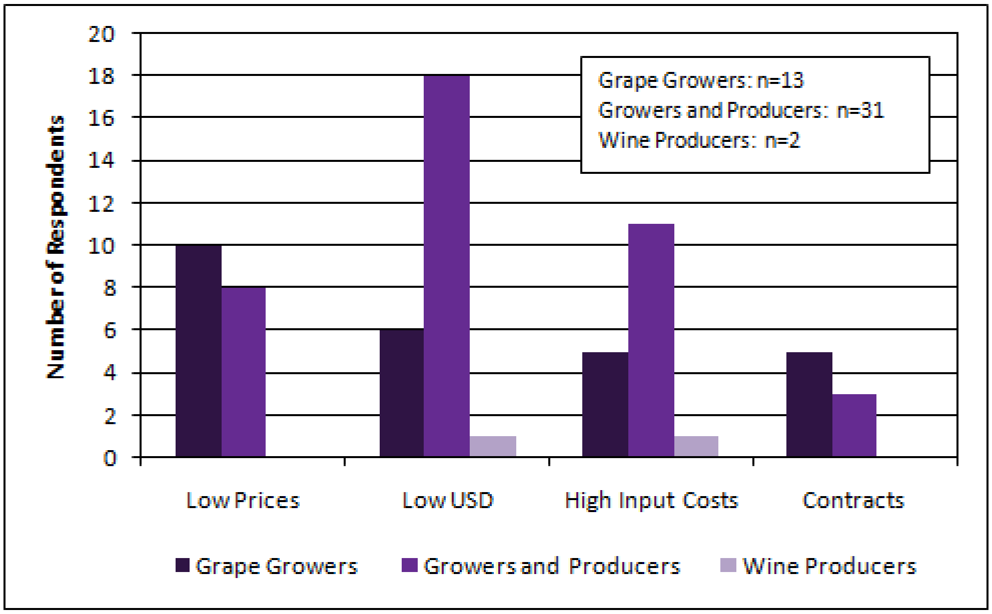


Figure 5.39: Economic Forces Creating Below Average Conditions By Operation Type

5.2.2.2.1 Low USD

A low USD exchange rate relative to the CHP is problematic for growers and producers. The USD influences many aspects of their operations; many inputs (e.g. fertilizer and pesticides) are purchased in USD by the wholesaler and the wholesaler increases the prices when the exchange rate from USD to CHP decreases; bulk wine is sold on the international market in USD, and a low exchange rate results in lower financial returns. Lower financial returns means growers and producers have less capital to work with than they do when the exchange rate is high, and the exchange rate is unpredictable, so financial planning becomes a trying task. Figure 5.40 provides a daily record of the USD exchange rate relative to the CHP from 2000-2008 and reveals a steady drop since 2003, followed by a recovery at the end of 2008.

Figure 5.40: Exchange Rate From USD to CHP from 2000-2008

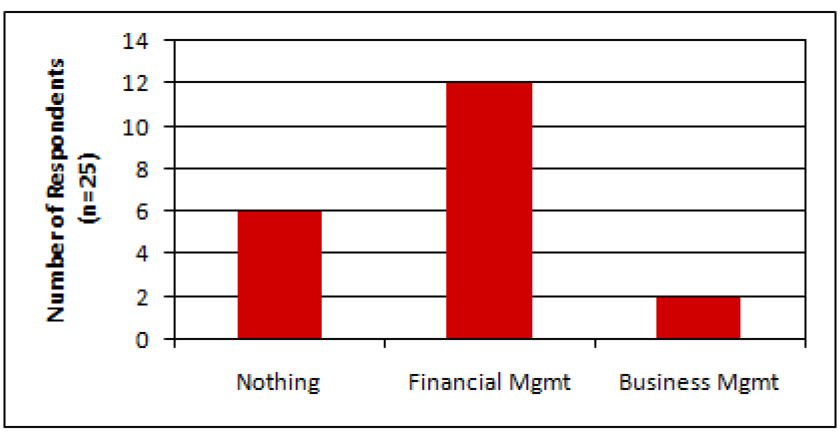


Figure 5.41: Adaptive Responses to Low USD Exchange Rate

The majority of interviewees, both growers and producers, either do nothing (24%) or use financial management strategies such as reducing input costs when the USD exchange rate is low (Figure 5.41). Anticipatory responses, whether strategic or tactical, are preferred by both growers and producers to reduce the risks of a low USD. As is shown in Table 5.7 below, lowering input costs can be anticipatory-strategic or anticipatory-tactical. An anticipatory-strategic technique adopted involves efficiency. In one winery, for example, the winemaker is also the business manager and promoter. By reducing the amount of hired personnel, and hiring staff with multiple skills, the winery is able to cut costs. An anticipatory-tactical technique involves profit margins. When the exchange rate is low, growers choose not to fertilize and reduce the amount of fungicide applied. Essentially, growers and producers try to save as much money possible by reducing costs and budgeting their expenses. Entering contracts to ensure financial returns and account for fluctuations in USD is another anticipatory-strategic financial management technique used by each operation type. However, growers and producers identified significant drawbacks surrounding contracts (discussed in section 5.2.2.2.3). Business management was not as widely used as the other techniques but involves wine producers' differentiating themselves in the marketplace in order to hopefully capture a more stable market.

Upon further investigation into the variations in responses among operation types, Figure 5.42 shows that both GGs and GWs do nothing to reduce the risk associated with a low USD. All three operation types use financial management, and just GWs use business management.

Table 5.7: Characterization of Adaptive Responses to Low USD Exchange Rate

	Anticipatory	Responsive
Strategic	• Lower input costs (2) • Save (2) • Enter contracts (4) • Differentiate themselves (2)	
Tactical	• Lower input costs (3)	

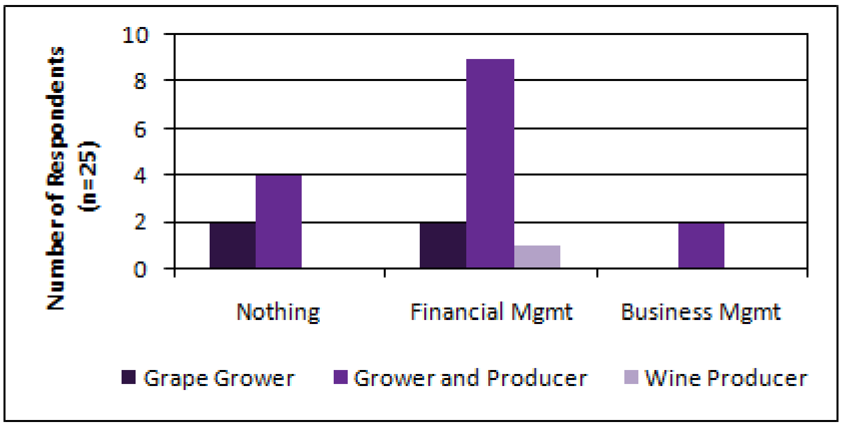


Figure 5.42: Adaptive Responses to Low USD Exchange Rate By Operation Type

5.2.2.2.2 Low Grape and/or Bulk Wine Prices

Low grape and bulk wine prices were highlighted by 18 of 46 (39%) interviewees because they reduce profitability and financial security. As is expressed by one GW, "*Bad years are always bad because the prices are low. The market is very unstable. From one year to the next a producer has little security as to what is going to happen in the market*". Comparatively, GGs seem to be more sensitive to low prices than GWs. Most interviewees attributed low grape and bulk wine prices to the low US dollar as well as market saturation, which generally stems from the presence of preferred growing season conditions, which facilitates harvesting higher yields and therefore more bulk wine is produced. When wineries have an excess of stock or inventory, prices drop (for both grapes and bulk wine) because there is less demand.

The years 2001 through 2008 were noted by interviewees as problematic due to economic forces. In particular, interviewees noted 2000, 2004, 2007 and 2008 as being years when prices were low, claims supported by Figure 5.43. According to Figure 5.43, there was a sharp increase in grape prices during 2005 and 2006; the prices in all other years since 2003 have been relatively low. A similar trend can be seen in bulk wine prices; bulk wine prices gradually increased from 2003 until 2005, when they experienced a sharp drop, followed by a gradual recovery in 2007-2008 and then a sharp drop at the end of 2008.

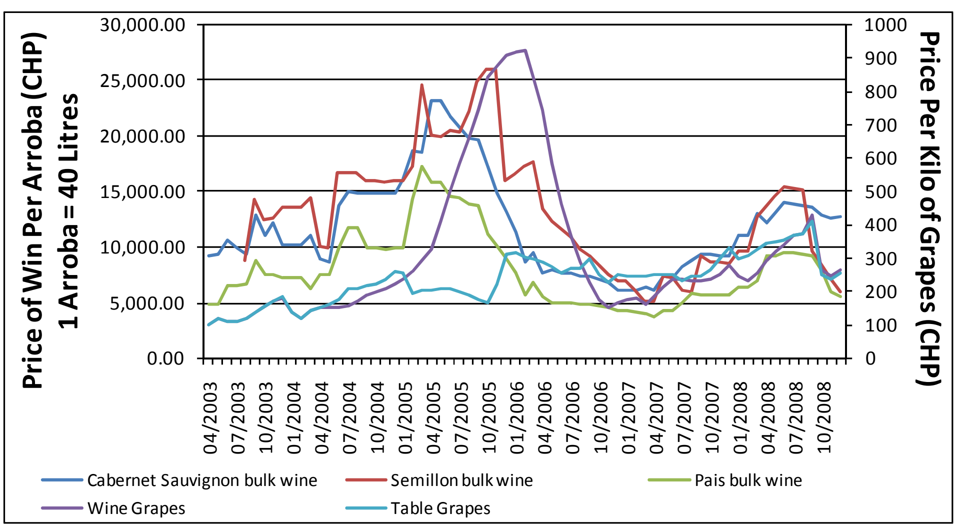


Figure 5.43: Average Bulk Wine and Grape Prices (April 2003-December 2008)

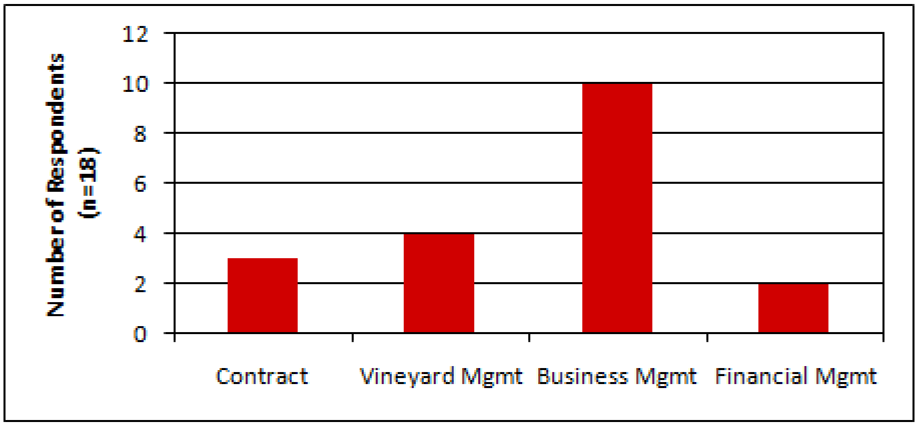


Figure 5.44: Adaptive Responses to Low Grape and Bulk Wine Prices

The majority of interviewees identifying low prices as an exposure (56%) employed business management strategies in response to low grape and bulk wine prices (Figure 5.44). A characterization of the response strategies can be found in Table 5.8. All business management strategies are responsive-tactical and include selling grapes at the low price, holding back bulk wine until the prices go up, finding an alternative market (e.g. selling organic wine grapes to organic grape juice makers) and vinifying grapes either in their own winery or in a rented space. Each of these strategies is undertaken with the aim of increasing financial returns. However, vinifying grapes has repercussions for the following year because there will be more bulk wine on the market than anticipated, which is reflected in its price. Generally, when growers are processing their grapes due to low grape prices, the price of bulk wine decreases because the market becomes saturated.

Table 5.8: Characterization of Adaptive Responses to Low Grape and Bulk Wine Prices

	Anticipatory	**Responsive**
Strategic	• Change varieties (3) • Join cooperative (1)	• Take out loan (1)
Tactical	• Enter contracts (3)	• Reduce inputs (e.g. fertilizer and labour) (2) • Sell at low price (5) • Hold bulk wine until prices go up (2) • Rent space in a winery (1) • Find alternative market (e.g. organic grape juice) (1) • Process grapes and sell bulk wine (7)

Vineyard management is another commonly undertaken adaptive response. It includes anticipatory-strategic techniques such as changing varieties, and responsive-tactical techniques such as reducing input costs by reducing fertilizer application and the amount of hired labour, or not harvesting because input costs exceed market price. One grower explained the situation:

> *The prices were bad so we didn't fertilize because we couldn't afford it. When the prices are bad the work in the vineyard is bad. The low prices affect us the following year because you don't have the money to do the vineyard work the next year due to low income obtained the previous year.*

Interviewees realize that higher quality grapes, although they demand higher input costs, tend to pay a better price than low quality grapes. A technical assistant affirms:

> *When you are not producing quality the market is more variable because the market is massive, there are so many people competing out there and so many producers out there that there is almost a demand to sell, not to buy. When one large producer is willing to pay,*

> *they all pay, when no one is paying high, then the price maintains itself or drops*.

Switching to higher quality varieties has become more common among growers, as they see the benefits and relative stability in the high quality grape market. Growers are beginning to switch from wild grape trellising systems (Figure 5.45) to upright trellising systems (Figure 5.46) because it reduces input costs, namely labour. The upright trellising system also facilitates the production of higher quality grapes, whereas the wild grape trellising system yields exceptionally high but produces lower quality grapes, and is exceptionally labour intensive. The conversion from wild to upright trellising systems requires significant initial investment, and many growers are not capable of bearing the financial burden.

Growers noted the input costs associated with harvesting, in addition to the inputs already devoted to the vineyard throughout the growing season, sometimes surpass the price they receive for their crop, so they simply do not harvest when this is the case. Contracts are entered to fix pricing, helping to alleviate potential uncertainty surrounding pricing, and to secure a buyer, because when prices are low, buyers are scarce, usually due to low demand.

Financial management involves securing loans to secure income and joining cooperatives to provide more bargaining power in the marketplace. Interestingly, Figure 5.47 highlights that just GGs utilize contracts and financial management techniques, while both GGs and GWs utilize vineyard management and business management techniques.

Figure 5.45: Wild Grape Trellising System

Figure 5.46: Upright Trellising System

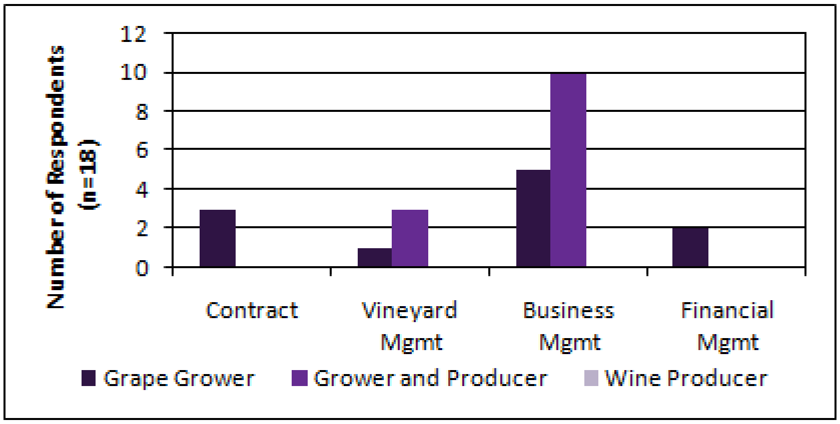


Figure 5.47: Adaptive Responses to Low Grape and Bulk Wine Prices By Operation Type

Although low prices are terribly problematic for all growers selling grapes, wineries purchasing grapes benefit from low grape prices because they have the opportunity to maximize their profits by buying the raw material at a low price, while still maintaining the market price; they buy low and sell high. Prices tend to remain low for a while because wineries stock up when the price is low, effectively lowering demand and price in subsequent years.

<u>5.2.2.2.3 Contracts</u>

Contracts, as mentioned in the previous subsection, are a way for growers to secure price, but they were also noted by 17% of interviewees as being problematic. More GGs (38%) identified contracts as an exposure than GWs (10%), possibly because the majority of GGs do not have the option of processing their grapes, increasing their need to fix price. GGs enter contracts with wineries to ensure their grapes are sold at harvest and to secure their financial situation. However, quite a few issues regarding contracts arose during the interviews. GGs find they succumb to buyers because contracts generally imply handing over control of the vineyard to the wineries, meaning they are unable to make vineyard management decisions without first consulting with the winery. Conversely, one of the benefits of the contract lies in the technical assistance some growers receive. The technical assistant, available only if the grower is producing higher quality grapes, visits the vineyard once a week to observe and make changes, if necessary. Growers producing lower quality grapes do not have access to technical assistants. Similarly, some wine producers find contracts problematic because they often do not work in their favour; the USD rate could drop after the contract is signed, resulting in unnecessary overspending.

GGs who have entered contracts declare that wineries do not take ownership of the decisions undertaken at the vineyard level, particularly when their decisions result in a reduction in grape quality or quantity. Often the winery does not accept the grapes because the conditions of the contract are not met (e.g. the grapes are delivered to the winery with botrytis), but if the conditions are not met as a result of a decision made by the winery's technical assistant, the grower suffers the consequences –he/she finds himself/herself without a buyer at harvest. The grower, in this case, seeks out other wineries to buy his/her grapes. Typically they would sell to a winery whose standards are not as stringent or to one who is not planning on making a premium quality wine with the grapes (e.g. Concha y Toro). However, the grower receives a lower price than expected for his/her grapes because quality has often been compromised and suffers the stress of frantically trying to find a last minute buyer.

The conditions of the contract are often very stringent (e.g. if one grape bunch in a load has botrytis, the whole load is not accepted and sent back) and they usually do not take into account fluctuations in the USD—input costs increase and grape prices remain the same, which reduces returns, or input costs decrease and grape prices remain the same, which increases returns. Sometimes this stipulation works to benefit growers and producers, most of the time is does not.

No adaptive to contracts exist, besides not entering contracts and taking the risk of finding a buyer during the growing season, which leaves many in an uncomfortable and uncertain situation.

5.2.2.2.4 High Input Costs

Of the 46 interviewees, 17 (37%) discussed high input costs as negatively influencing their operations. Approximately the same percentage of GGs (38%) and GWs (35%) identified high input costs. Rising input costs are negatively affecting both growers and producers, as it reduces financial returns and hinders their ability to take advantage of opportunities (e.g. high grape prices).

Fertilizer, pesticide and other chemicals used in the vineyard, as well as labour costs, have increased greatly over the past few years. While chemical purchases account for approximately 5% of grape growers' annual expenses, labour accounts for between 70 and 95% (SMA, 2007). Prices for four different types of fertilizer are illustrated in Figure 5.48, highlighting a drastic increase in fertilizer costs from 2000 to 2006. Fertilizer has almost tripled within this six year period. Similarly, minimum wage, the average price growers pay labourers, has almost tripled from 1997 to 2009 (Figure 5.49). The 300% increase in labour costs that account for 75-95% of grower expenses has considerably reduced the profitability of wine grape growing because growers' income has not increased proportionately.

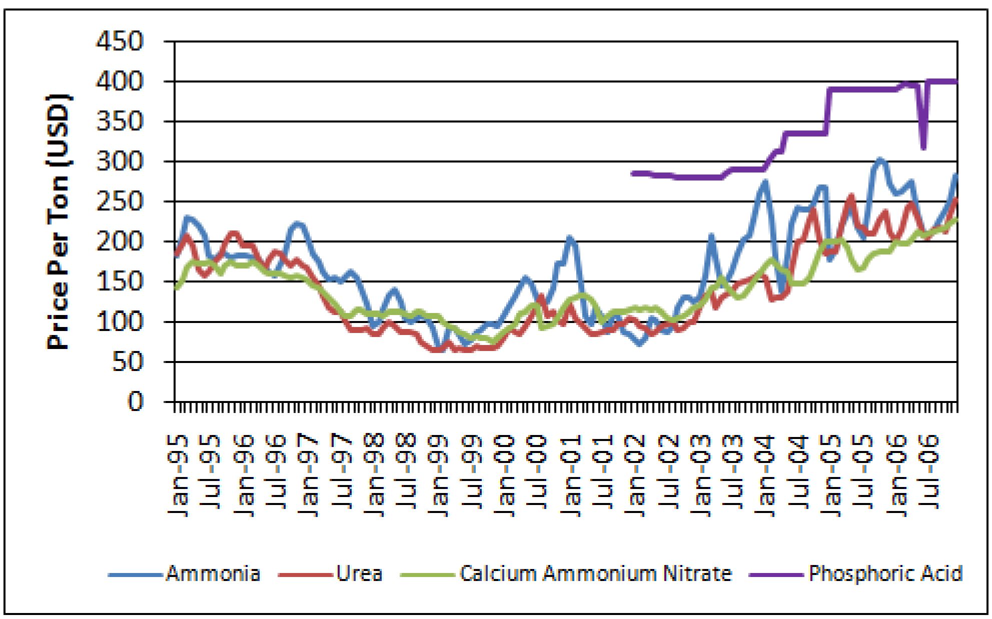


Figure 5.48: Market Prices for Four Commonly Used Fertilizers from 1995-2006

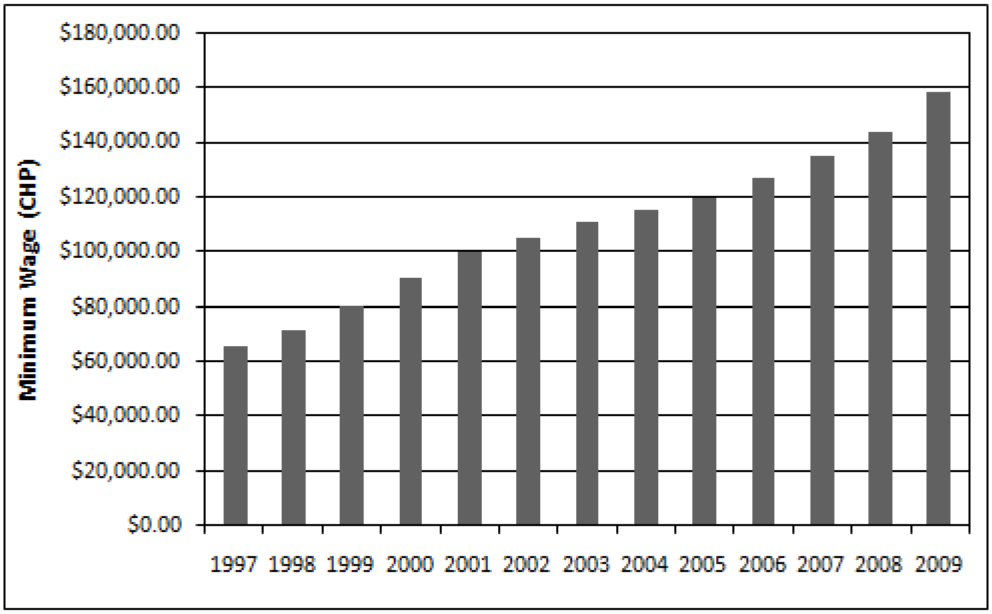


Figure 5.49: Minimum Wage in Chile from 1997-2009 (Data Source: BCC, 2009)

Adaptive responses to rising input costs include doing nothing and using business and vineyard management strategies (Figure 5.50). The majority of interviewees (41%) do nothing, while 29% employ vineyard management techniques and 18% employ business management techniques. Vineyard management techniques include reducing the inputs by decreasing chemical application and labour and shifting the vineyard's focus towards quality wine grapes. Business management techniques include investing in technology (e.g. automatic pre-pruners and harvesters) and establishing a good reputation for the operation. Almost all adaptive techniques are anticipatory-strategic in nature, meaning interviewees are planning ahead and focusing on the long-term rather than short-term (Table 5.30).

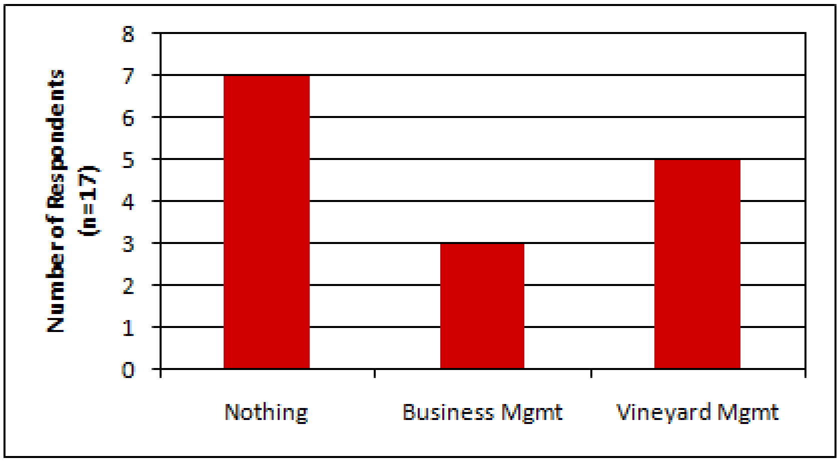


Figure 5.50: Adaptive Responses to Rising Input Costs

Table 5.9: Characterization of Adaptive Responses to Rising Input Costs

	Anticipatory	**Responsive**
Strategic	• Enter contracts (1) • Focus on quality (2) • Invest in technology (1) • Establish a good reputation (1)	
Tactical		• Reduce inputs (3)

Closer analysis indicates no substantial differences in the responses adopted by the three operation types (Figure 5.51). GGs and GWs carry out the adaptations described above, while WPs focus on business management.

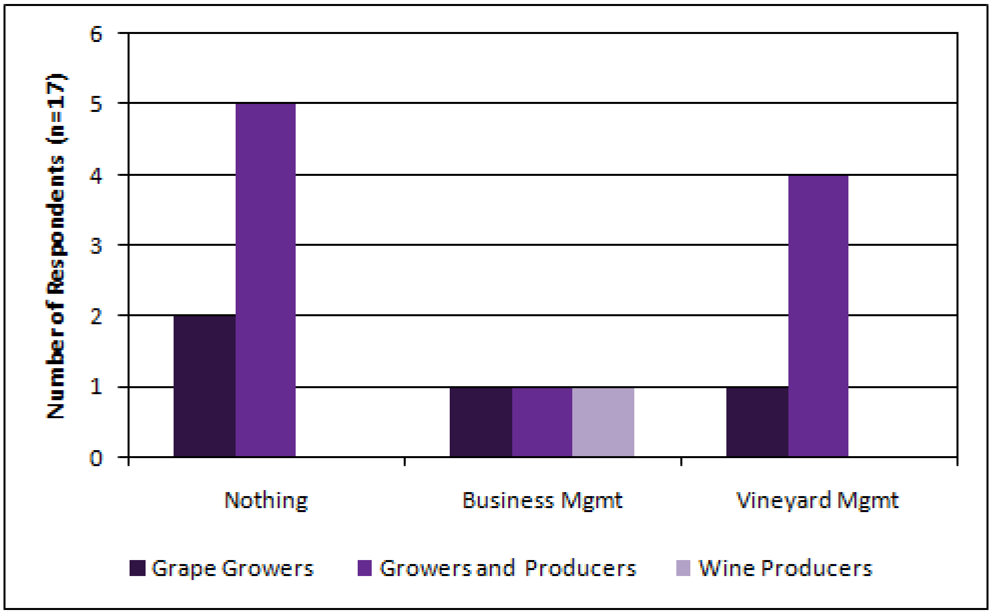


Figure 5.51: Adaptive Responses to Rising Input Costs By Operation Type

5.2.2.3 Production

Low yields and poor grape and wine quality were production risks highlighted by many interviewees (Figure 5.52). Low yields were noted by all operation types, and poor quality by just GGs and GWs (Figure 5.53). Low yields are problematic for all because they result in income losses. GGs have fewer kilograms of grapes to sell, GWs harvest fewer grapes and make less wine, and WPs have fewer options on the grape market when yields are low (i.e. there is more demand and less supply). Poor quality is largely averted by WPs because they do not produce their own grapes and are in a position to select their grapes from growers. They simply do not buy poor quality grapes and therefore poor quality wine is not an issue for them.

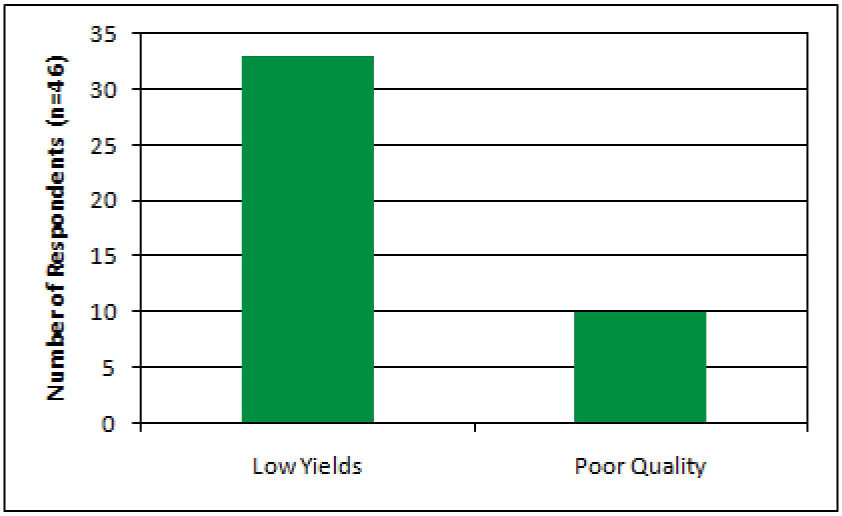


Figure 5.52: Production Forces Creating Below Average Conditions

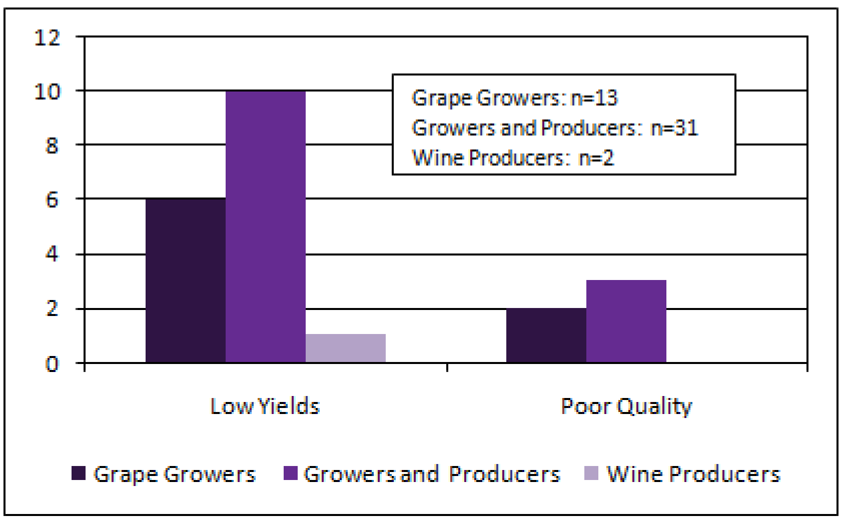


Figure 5.53: Production Forces Creating Below Average Conditions By Operation Type

Adaptive responses to production forces are reflected in section 5.2.2.1, as the primary reason for low grape and wine yields as well as poor quality grapes and wine is undesirable weather conditions throughout the growing season. Refer to this section of the thesis for an overview of the adaptive responses used by interviewees to reduce production risks.

5.2.2.4 Institutional

Institutional rules and regulations were identified as risks by 15 of 46 (33%) interviewees. Within institutional rules and regulations, interviewees documented both international and national rules and regulations as forces to which they are sensitive (Figure 5.54). National rules and regulations were more frequently cited (33%) than international ones (11%). GGs cited just national rules and regulations as problematic; GWs cited both international and national; WP cited just international (Figure 5.55). A simple explanation for these differences: GGs do not do business internationally, GWs have an interest in the grape and wine industry both nationally and internationally, and WPs are generally involved in just export and are therefore more concerned with international rules and regulations.

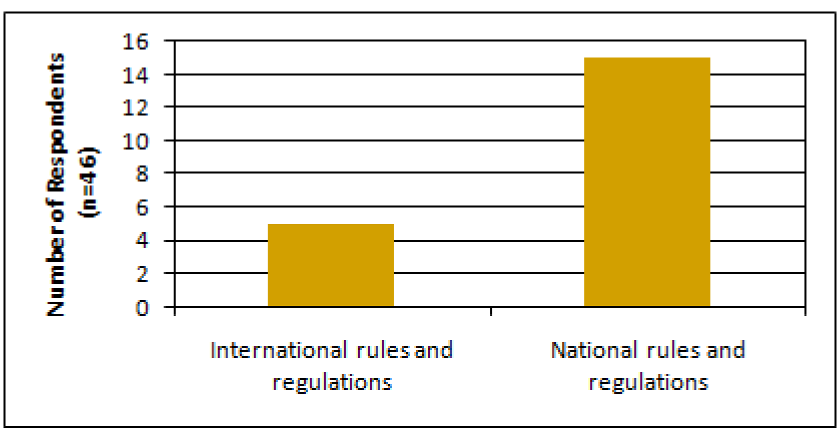


Figure 5.54: Institutional Forces Creating Below Average Conditions

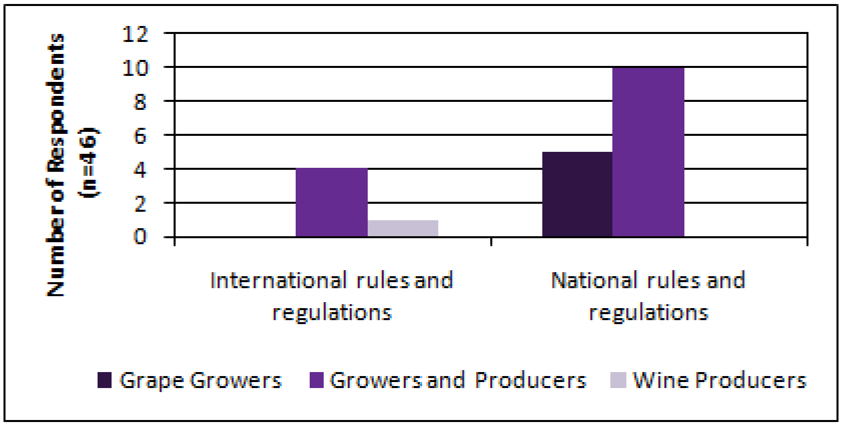


Figure 5.55: Institutional Forces Creating Below Average Conditions By Operation Type

5.2.2.4.1 International Rules and Regulations

The ways in which international rules and regulations treat quality assurance are problematic for growers and producers. Most countries have strict guidelines as to what is acceptable for import. Certain chemicals, for example, acceptable in Chile are not acceptable in other countries, and documentation of vineyard and winery management practices are becoming increasingly necessary. Grape growers, some of which are illiterate or have basic literacy skills, are now being required to maintain detailed records of vineyard management. This new way of doing business is unfamiliar to many interviewees and many do not have the skills to carry out the tasks requested of them. Similar to grape growers, wine producers are required, either by contract or international law, to adhere to certain production guidelines; for example, some buyers want wine shipped at certain temperatures, or a screw cap instead of a cork. These demands require modifications to the operation and financial investment, and they are imposed with no financial support.

The adaptive responses to institutional rules and regulations are few because producers fear losing buyers. A few producers attempt to negotiate import-export terms with buyers, with little to no success.

5.2.2.4.2 National Rules and Regulations

Chilean labour laws have recently become more demanding, requiring heavy financial investment to remain in compliance, and they are also often very difficult to adhere to. A few examples of recently developed labour laws are: 1) the construction of a lunch room in each vineyard; 2) workers must be able to access a washroom within 100 meters of their work space; 3) chemicals have to be under lock and key in a shed; 4) chemical baths have to placed in each vineyard; and 5) out-of-town workers must ride seated while being transported to the vineyard. "*Workers have to be seated when we transport them by bus from their town to the vineyard, something that doesn't even happen in Santiago, Chile, because there they're treated like animals, but the government still demands it*", a GW expressed with a frustrated tone in his voice. The overarching issues with these laws are that growers and producers are not provided with guidance or suggestions as to how to go about incorporating them, there is no financial support from the government to help implement these changes, and many believe the laws are extreme and nearly impossible to carry out.

Environmental laws have begun changing as well. Grape growers are no longer able to manage their vineyard or winery the way they did ten or twenty years ago; they are unable to apply certain chemicals that were previously acceptable and for some growers this requires an adjustment period.

Similar to the discussion in the international rules and regulations section, adaptive responses to national rules and regulations are scarce. Growers and producers must adhere to the labour laws or suffer the consequences, which include fines and the potential closing of the vineyard or winery. They must follow environmental laws and rules or take the risk of their crop not being accepted by buyers. Some members of cooperatives have access to training programs that provide them with the knowledge and background to successfully implement labour and environmental laws. There are also government training programs available to ease the transition. This still, however, requires major investment and a change in mentality.

5.2.2.5 Social

A social force to which interviewees are sensitive is labour shortages (18 of 46 – 39%). Vineyard labour is increasingly scarce because people are migrating to the city, leaving fewer labourers in the countryside, resulting in growing competition for labourers among fruit operations in the Maule Region. In addition to wine grapes, blueberries, cherries, pears, kiwis and apples are all grown in the region, each demanding labour, many simultaneously. Labour shortages, especially during harvest, are extremely problematic, grapes are not harvested when they are mature and quality is compromised, resulting in reduced financial returns.

In response to labour shortages, growers have begun investing in technology (e.g. automatic harvester) to reduce reliance on human labour, an anticipatory-strategic technique. However, wine grapes are delicate and require delicate treatment, so complete reliance on machinery is not possible. Human labour is still required, for example, to harvest white wine grapes, otherwise growers risk oxidization, which reduces quality. One anticipatory-tactical technique used by growers is the recruitment of workers from poor rural towns, usually a far distance from the vineyard, where agricultural work is welcomed. The grower provides transportation for the workers to and from the vineyard, resulting in rising input costs and reduced profitability. Often workers demand higher wages, threatening to instead work with other fruit producers, and growers have no choice but to pay them what they demand because the alternative –a shortage of labour—is seen as a greater risk to their operation.

5.2.3 Adaptations in Response to Multiple Risks and Opportunities

Grape growers and wine producers in the Maule Region highlighted a number of adaptive strategies they employ in response to a combination of the stresses described above. Many growers have revamped their vineyard and replaced varieties that are not suitable to the location, rather than planting the varieties that are paying well at the moment. Exposure to spring frost, for example, is often greater if frost-sensitive varieties are planted in frost-prone areas. A technical assistant remarked:

> *Many people plant their vineyards without the proper knowledge of where to plant, what to plant and how to manage their vineyards. For example, Carménère and Cabernet Sauvignon in Molina and higher are not good. They don't mature properly and they know they have to harvest early.*

However, people still plant these varieties, some knowing the variety will never reach full maturity, others unaware. Figure 5.56 illustrates the change in hectares planted in white wine grapes in Maule from 2000 to 2006, and Figure 5.57 illustrates the change in red wine grapes. Chardonnay, Sauvignon Blanc, Cabernet Sauvignon, Tintorero, Syrah and Carménère plantings have grown in hectares planted in Maule. Conversely, Semillón and País plantings have diminished.

Although revamping the vineyard is a huge and costly undertaking, many growers have opted to do this in order to reduce the risks associated with weather, market instability, institutions, and many other forces influencing their operations. Experimental plots are often used to test which varieties will thrive and produce the best wines. A shift towards producing quality grapes and wine is the next step once the appropriate varieties are selected. Quality grapes and wine are what interviewees want the region to be recognized for. Producing good quality grapes and wine is what some interviewees find most rewarding in the business, and they see financial opportunity in building a good reputation for Maule.

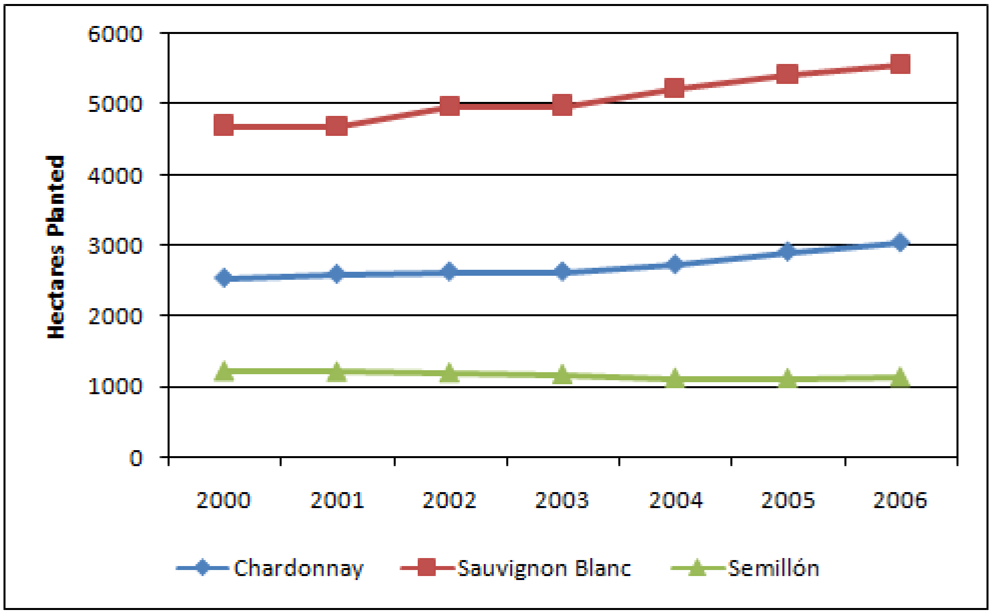


Figure 5.56: Number of Hectares of White Wine Grapes Planted in the Maule Region (2000-2006)

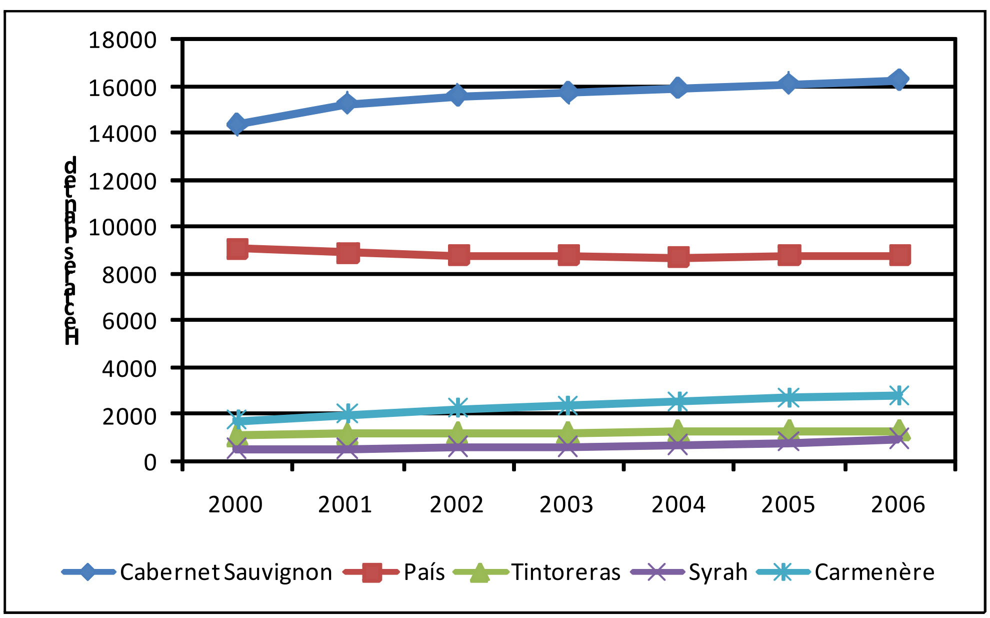


Figure 5.57: Number of Hectares of Red Wine Grapes Planted in the Maule Region (2000-2006)

5.2.4 Summary of Current Vulnerability

Growers and producers in the Maule Region are faced with a multitude of risks and opportunities stemming from the farm-level to the international level in scale. Figure 5.58 offers a diagram of the interactive forces creating risks and opportunities in the Maule Region grape and wine industry. Generally, it is not one force alone that is problematic or beneficial but rather a combination of forces acting together to create multifaceted risks and opportunities. Growers and producers were found to be sensitive to weather, economic, production, institutional and social forces, all of which contribute greatly to the success or failure of Maule's grape and wine industry, and all of which are intricately connected. Low grape and/or bulk wine prices, for example, have significant implications for growers and producers, particularly in terms of financial return, but can be managed; when combined with rising input costs, a low USD and unfavourable contracts, they are extremely problematic. A wet fall, for example, decreases grape and wine quantity and quality, but when a wet fall is experienced along with labour shortages, the situation becomes critical. Exposures vary according to location, size, operation type, experience, age of vineyards, participation in other business endeavours, access to capital and knowledge, and many others.

Exposures prompt adaptations which then create new exposures and/or serve to hinder adaptive capacity. Contracts, for example, are an adaptive strategy used to reduce the risks associated with low grape and bulk wine prices, as well as fluctuations in the USD exchange rate. However, contracts often create a new exposure for GGs in that contracts often result in income losses—the opposite of what they are intended to do, which is provide financial security—as wineries often do not take ownership of the decisions they make regarding GGs' vineyards when quantity or quality is compromised due to a management decisions they themselves (the winery) employed. Contracts also restrict growers from making their own management decisions, effectively reducing their adaptive capacity.

Adaptive strategies often serve to alleviate more than one exposure, but at the same time, may create new ones. Reducing input costs, not only reduces exposure to rising input costs, for example, but it also reduces the risks associated with low prices. However, they may be more exposed to weather-related risks, for example. Planting varieties that are suitable to the location seem to reduce exposure to a variety of the identified risks.

Risks are experienced with opportunities, and risks can also be opportunities. It was common for interviewees to identify forces as being both problematic and beneficial. Drought, for example, reduces water availability for irrigation during the growing season, which decreases yields and subsequently financial returns, creating significant risks for grape growers, but at the same time drought tends to increase grape and wine quality, an opportunity for wine producers. Similarly, high-yielding growing seasons create opportunities for growers because they offer the potential to increase financial returns, but these years tend to be accompanied by low prices due to market saturation, an opportunity for grape buyers.

GGs and GWs experience similar risks and opportunities. What differs among these two operation types are the response strategies employed, and those available to them. GGs have fewer options than GWs, although both predominately employ responsive-tactical adaptive strategies. Those that employ anticipatory-strategic adaptive strategies tend to be GWs and WPs, as these strategies are typically not available to just GGs for many reasons, including access to financial capital and a lack of education. WPs have managed to reduce many sources of risk by not producing their own grapes. Essentially they have eliminated many of the risks associated with weather and production.

Various adaptive responses have been developed to reduce risks and capitalize on opportunities. The majority are directed towards vineyard, winery and business management and are anticipatory-strategic and reactive-tactical in nature. However, numerous growers and producers noted they do nothing, placing them in a high risk environment, and significantly increasing their vulnerability. Growers and producers either plan ahead with long-term goals, scramble to respond for the short-term, or do nothing and struggle to make ends meet.

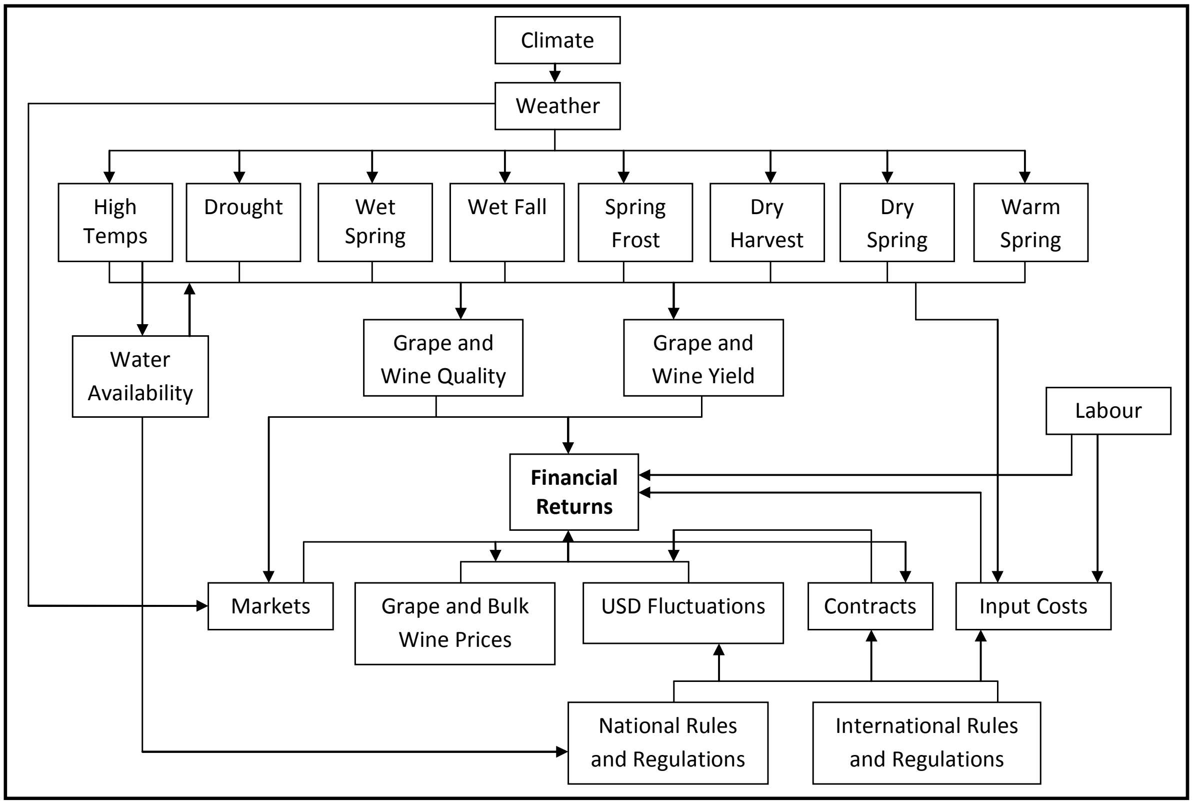


Figure 5.58: Relationships Among Exposures Creating Risks and Opportunities in the Maule Region Grape and Wine Sector

One major issue in the industry that contributes to vulnerability is that there exists a serious disconnect between grape growers and wine producers; grape growers tend to focus on producing quantity rather than quality because they are paid per kilogram of grapes, wine producers tend to focus on quality because the market demands quality wines. This disconnect exacerbates exposure to a multitude of risks because the wine producers do not compensate for what they want, and the growers do not grow what the producers want because they are not compensated accordingly.

Another major issue in the industry is that rarely are varieties suited to the characteristics of the vineyard planted. Many growers and producers are working with grapes that are not adapted to the conditions in which they are planted. This greatly increases exposure and limits the options available for adaptation.

Most interviewees believe there has been consistency in the climate and therefore have not developed an extensive suite of adaptive strategies to manage climate and other risks and opportunities. Grape growers and wine producers currently manage the risks and opportunities created by a changing climate sufficiently, some better than others depending on an array of factors. It is not average temperatures and precipitation that pose a great challenge for grape growers and wine producers, but variability in weather, particularly temperature and precipitation and their impacts on grape and wine quantity and quality, as well as market fluctuations and uncertainty. Climate change has the potential to create both risks and opportunities for Maule's grape and wine industry. The subject of climate change and the factors influencing the industry's ability to adapt are explored in the following chapter.

CHAPTER 6: FUTURE VULNERABILITIES

The previous chapter on current vulnerability highlighted climate, manifested as weather from year-to-year, its influence on production, and economic conditions as the predominant forces currently creating risks and opportunities for grape growers and wine producers in the Maule Region. This chapter investigates the future vulnerability of Maule's grape and wine industry to climate change, combining the knowledge of the forces identified in Chapter Five with predictions of future climate change. The vulnerability approach suggests future changes in social, political, institutional and economic forces be taken into consideration in order to gain realistic insights into the nature of future potential exposures and adaptive capacity. While it is acknowledged that changes in social, political, institutional and economic forces are likely to occur, assessing their likelihood of change is beyond the scope of this thesis; for the purposes of this thesis, future exposures will relate to climate, as this is one area not yet considered in the literature. The analysis is based on trends observed in the field and in relevant literature, on climate scenarios, and on the interviewee responses to the fourth section of the interview guide which investigates future risks and opportunities. Future adaptive capacity is assessed based on the utility of current adaptive strategies to reduce the risks and maximize opportunities created by future exposures and the results obtained in the third section of the interview guide investigating factors facilitating and/or hindering adaptation.

6.1 Changing Climate

One major future climate change assessment has been conducted in Chile by CONAMA. It is specific to particular zones in Chile, not towards regions, and uses a spatial resolution of 25km. The scenarios are derived from the Special Report on Emission Scenarios A2 and B2 models used by the IPCC for 2071-2100. The scenarios are described in this section, and all show current seasonal situations followed by future seasonal projections under the two scenarios (A2 and B2). A2 represents a scenario with a moderate reduction in greenhouse gases, while B2 represents a scenario with aggressive future reductions of greenhouse gases.

Average temperatures are projected to increase between 1 and >5^0C over the next century (see Figure 6.1). The most pronounced change is to be experienced in spring and summer. This may be beneficial for some grape varieties planted in Maule but also problematic in that high temperatures are already beginning to burn and dehydrate grapes, and further increases in temperatures during grape development could increase the incidence of sunburn and dehydration, causing a reduction in yields and quality, and subsequently grower and producer income. With 61% of interviewees noting changing temperatures over the past 10 years, many noted extreme variability in yearly weather—summers are much warmer than in the past. Water supplies could diminish as a result of high temperatures and increased evaporation, and the number of pest breakouts could also increase with higher temperatures. However, higher temperatures may create opportunities to explore new varieties. The cultivation of new varieties may be facilitated by warmer temperatures, perhaps creating a market advantage.

Investigation into future average maximum (Figure 6.2) and minimum (Figure 6.3) temperatures reveals an increase of 2 to 5^0C and 1 to 3^0C, respectively. Again, the most pronounced change is in spring and summer, during which grapes are developing and susceptible to sunburn and dehydration. However, growers and producers may benefit from an extended growing season resulting from increasing temperatures. The number of warm days (>25^0C) are projected to increase by 50-300% during the grape growing season (Figure 6.4), further supporting the notion that sunburn and dehydration may be a more likely occurrence in the future. A summary of the temperature scenarios generated by CONAMA can be found in Table 6.1.

Figure 6.1: Average Seasonal Temperatures Currently and in the Future Under A2 and B2 Scenarios for the Central Chile Zone. Maule is Delineated By the Dark Purple Square (CONAMA, 2006)

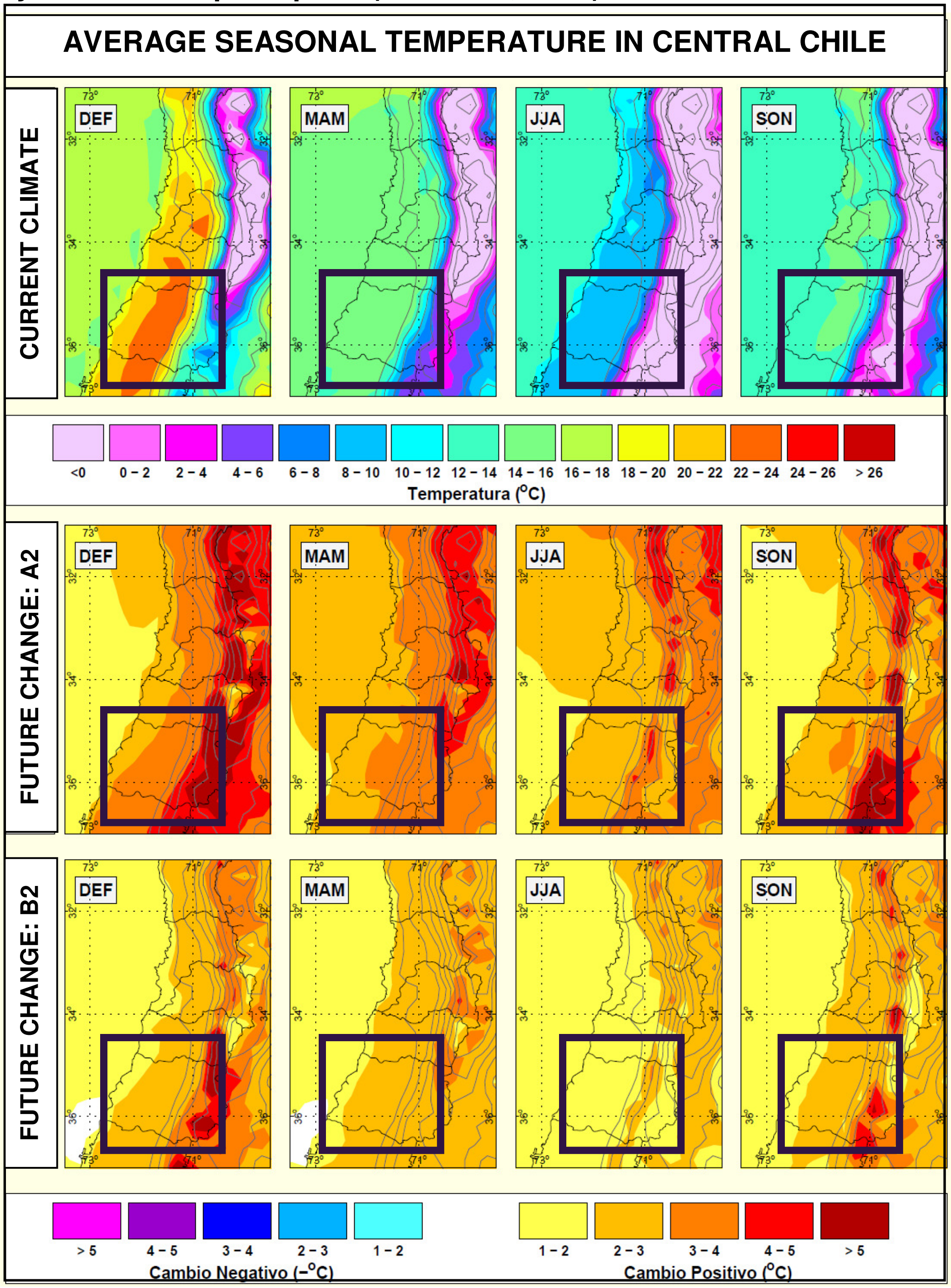


Table 6.1: Summary of Projected Changes in Temperature for the Maule Region Using the A2 and B2 Scenarios Generated By CONAMA (2006) '+' Indicates an Increase, '-' Indicates a decrease. All Values are in ^{0}Celsius.

	Average Temperature	Average Maximum Temperature	Average Minimum Temperature
Summer	A2: +2 to >5 B2: +1 to 5	A2: +1 to >5 B2: +1 to 5	A2: +1 to >5 B2: +1 to 5
Fall	A2: +2 to 4 B2: +1 to 3	A2: +1 to 5 B2: +2 to 4	A2: +2 to 4 B2: +1 to 3
Winter	A2: +2 to 4 B2: +1 to 3	A2: +2 to 5 B2: +1 to 4	A2: +1 to 4 B2: +1 to 3
Spring	A2: +2 to >5 B2: +1 to 5	A2: +3 to >5 B2: +2 to >5	A2: +2 to 5 B2: +1 to 3

Figure 6.2: Average Maximum Temperatures Currently and in the Future Under A2 and B2 Scenarios for the Central Chile Zone. Maule is Delineated By the Dark Purple Square (CONAMA, 2006)

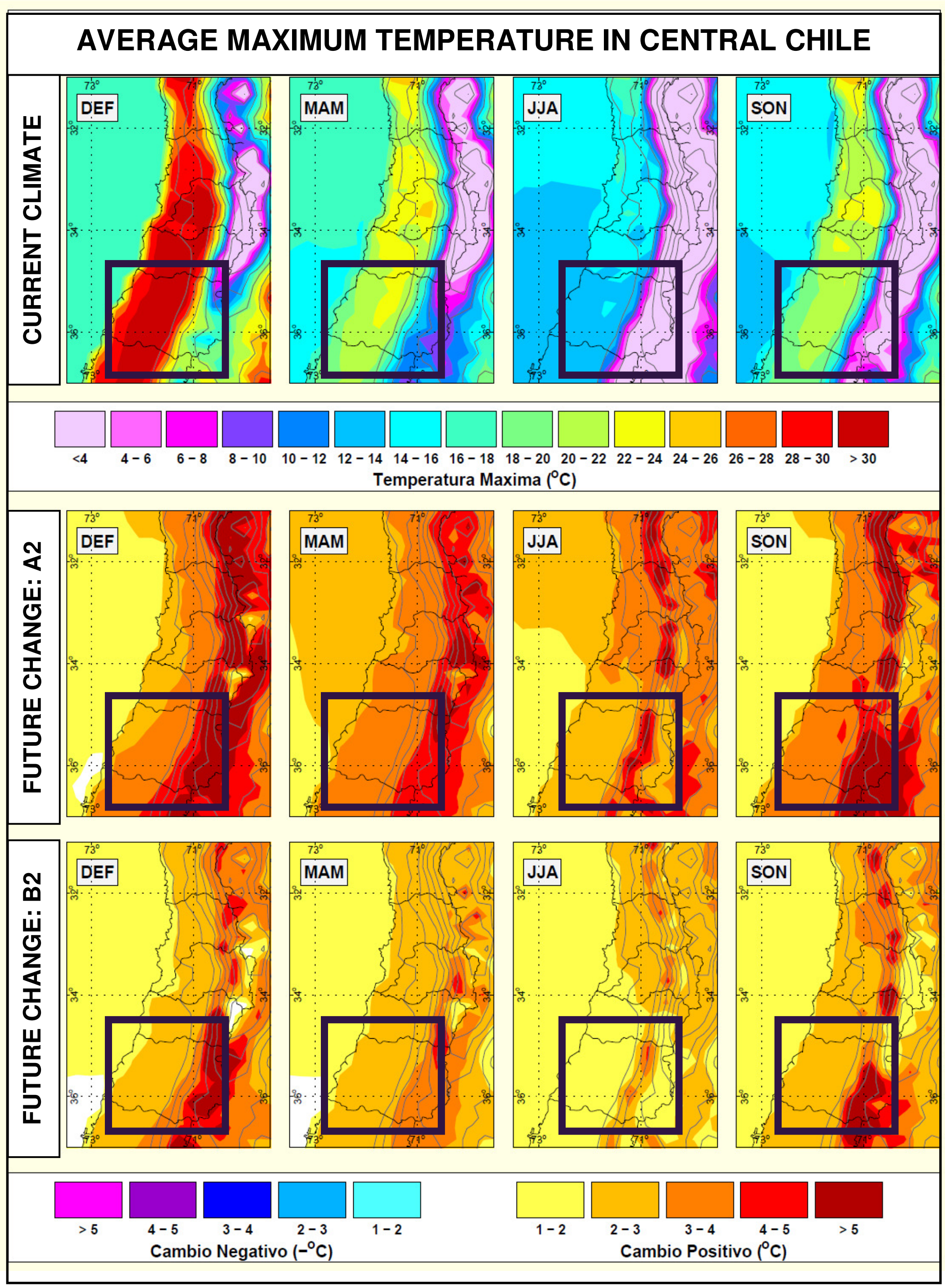


Figure 6.3: Average Minimum Temperatures Currently and in the Future Under A2 and B2 Scenarios for the Central Chile Zone. Maule is Delineated By the Dark Purple Square (CONAMA, 2006)

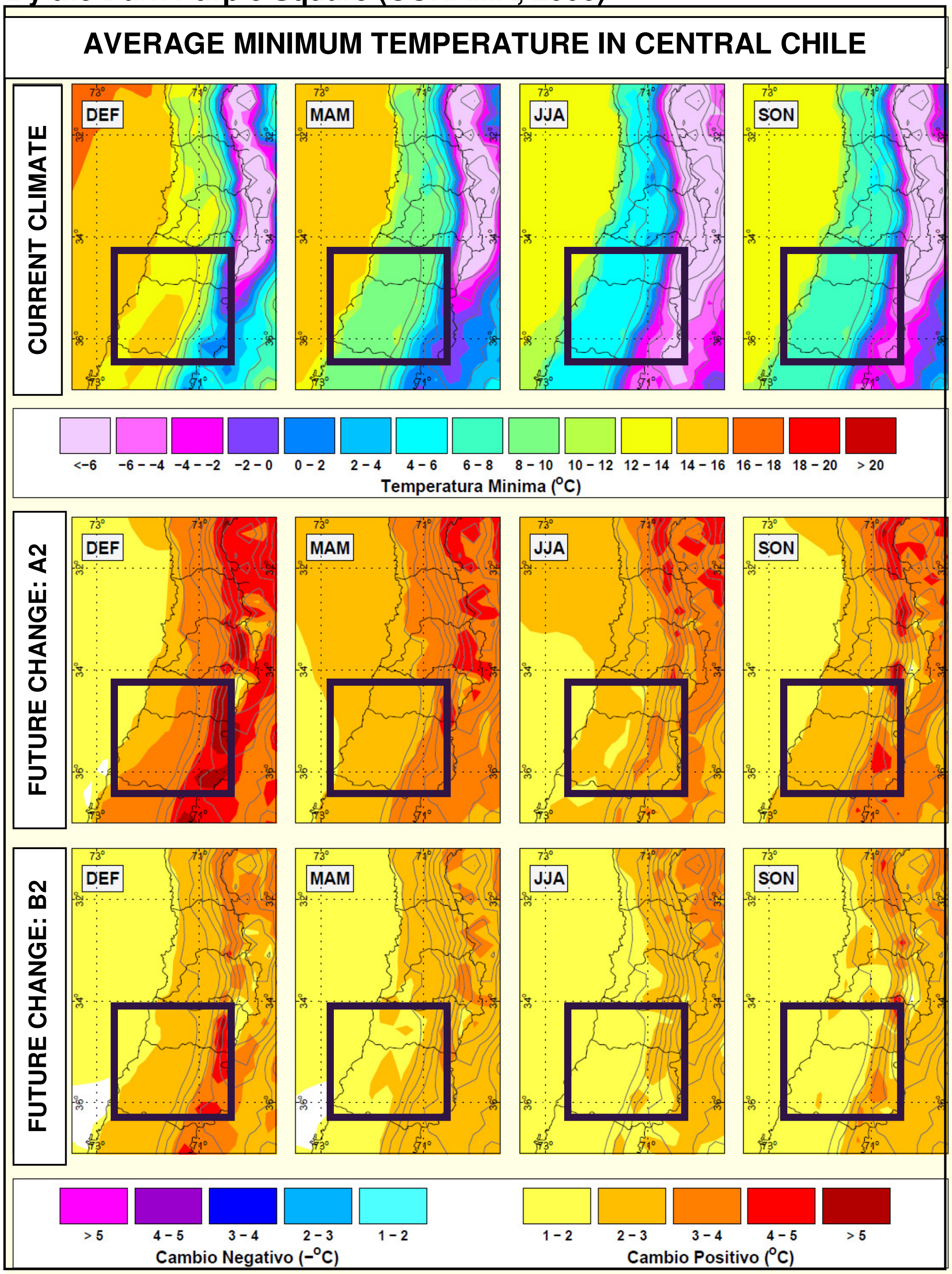
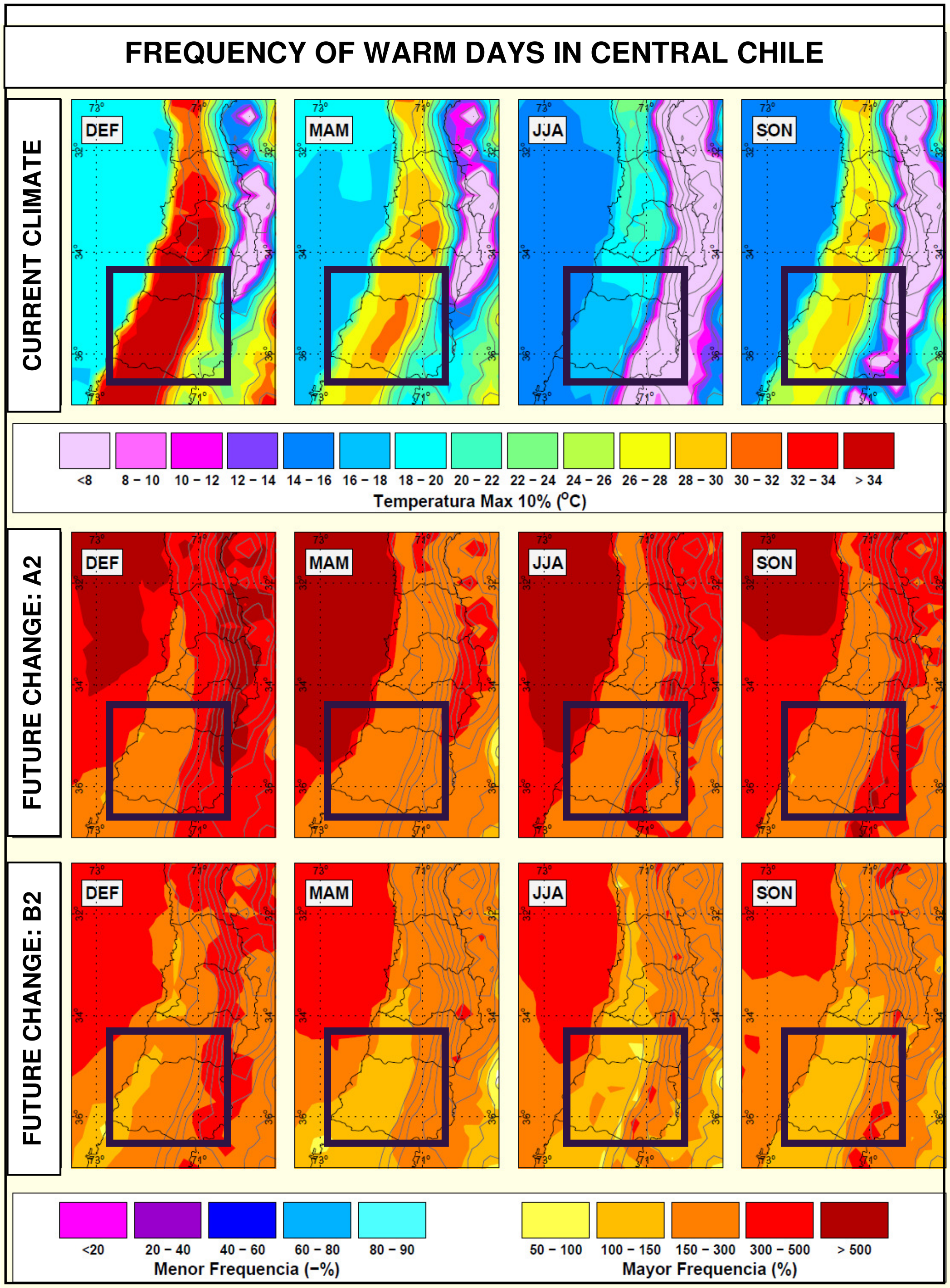


Figure 6.4: Frequency of Warm Days (>25^{0}C) Currently and in the Future Under A2 and B2 Scenarios for the Central Chile Zone. Maule is Delineated By the Dark Purple Square (CONAMA, 2006)



Seasonal precipitation is projected to decrease in the Maule Region by 25 to 90%, depending on the season of interest and the scenario examined (see Figure 6.5). Rain in the spring and fall are problematic because they cause uneven flowering and an increased probability of fungus and disease outbreaks. According tothe scenarios (Figure 6.5), the most pronounced decrease in precipitation is in the fall and winter, with 50-90%. Decreasing rainfall in fall is beneficial for growers and producers, as it may allow grapes to reach preferred maturity with a reduced risk of botrytis outbreaks, contribute to future increases in grape and wine quality, and lead to increased income security. However, decreases in precipitation during the winter could be extremely problematic. The region relies on winter precipitation for water resources to recharge for use during the growing season. Less precipitation in winter may result in irrigation water shortages and reduced yields and quality.

Precipitation is difficult to project, hence the large range in projected decreases in precipitation offered by CONAMA, because there are large scale oceanic and atmospheric circulation processes such as the El Niño-Southern Oscillation (ENSO) whose interactions with regional and local climate in Maule are not yet fully understood (Montecinos and Aceitunos, 2003). During the warm phase of El Niño, the country receives above average precipiation, sometimes up to 2 or 3 times the annual average, and during the cold phase of El Niño, known more commonly as La Niña, the country receives below average precipitation and colder than average winter temperatures (Vuille and Keimig, 2004).

Montecinos and Aceituno (2003) found that central Chile, where the Maule Region is located, also tends to receive above average rainfall in the spring during the warm phase of El Niño.

The magnitude and frequency of ENSO is projected to increase in the future, creating greater variability in precipitation patterns than is currently being experienced by growers and producers in Maule (IPCC, 2007). In any case, variability in precipitation poses a risk to the Maule grape and wine sector, even 24% of interviewees have noticed increasing variability in precipitation, and with the intensification of ENSO, rainfall during flowering in spring and grape maturation in fall could occur more frequently.

The combination of increases in temperatures and decreases in precipitation lead to diminishing surface and ground water resources. Reductions in water resources has direct implications for irrigators. Less water may be available for irrigation, potentially creating conflicts and competition among users, and potentially causing decreases in yields and quality. The effects of drought and diminishing water resources are already being felt, with 39% interviewees noting a considerable change in the frequency and magnitude of drought, and many expressing concern surrounding the negative implications drought has production. Future water shortages are sure to be problematic for the industry.

Figure 6.5: Seasonal Precipitation Currently and in the Future Under A2 and B2 Scenarios for the Central Chile Zone. Maule is Delineated By the Dark Purple Square (CONAMA, 2006)

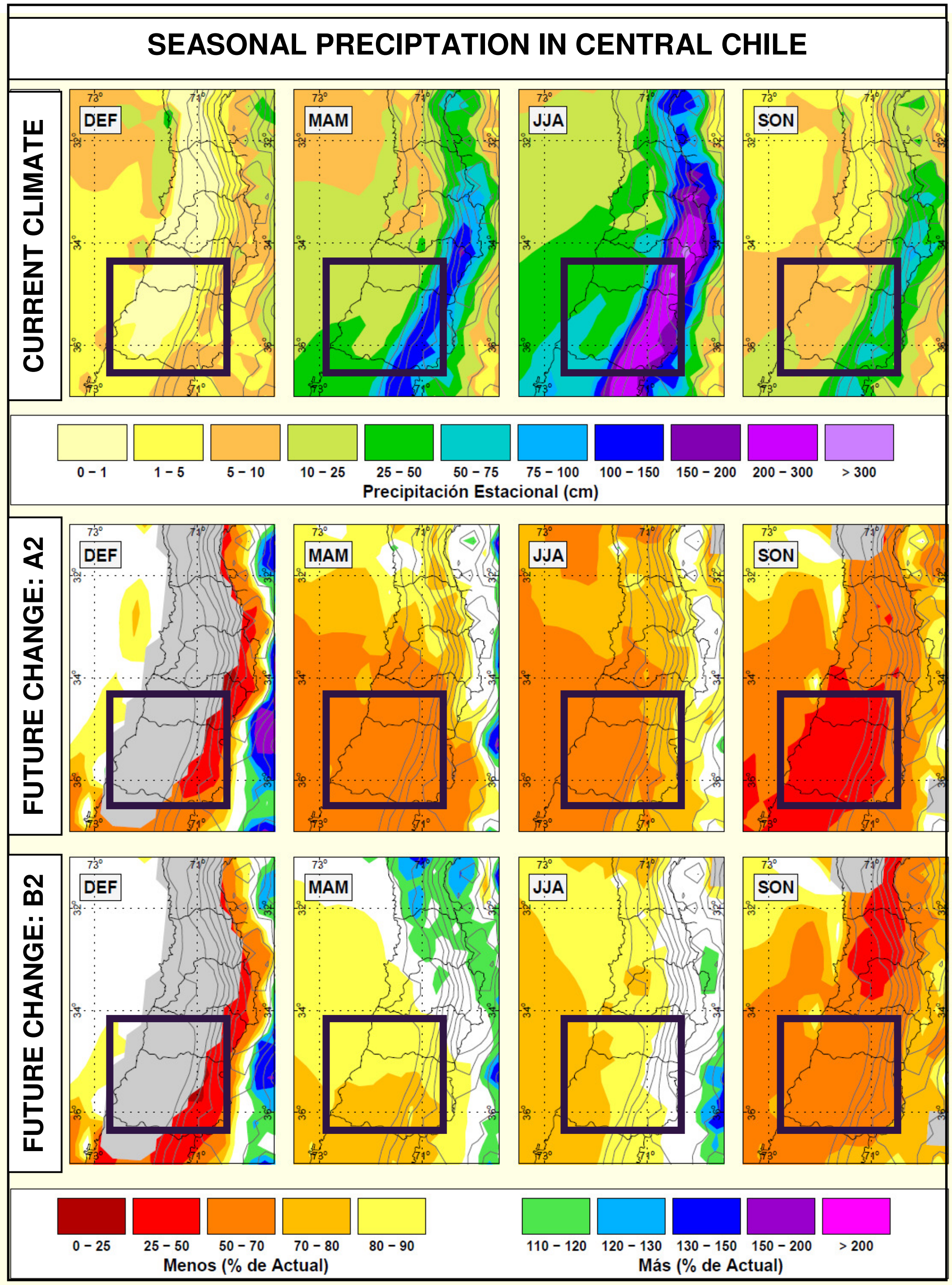
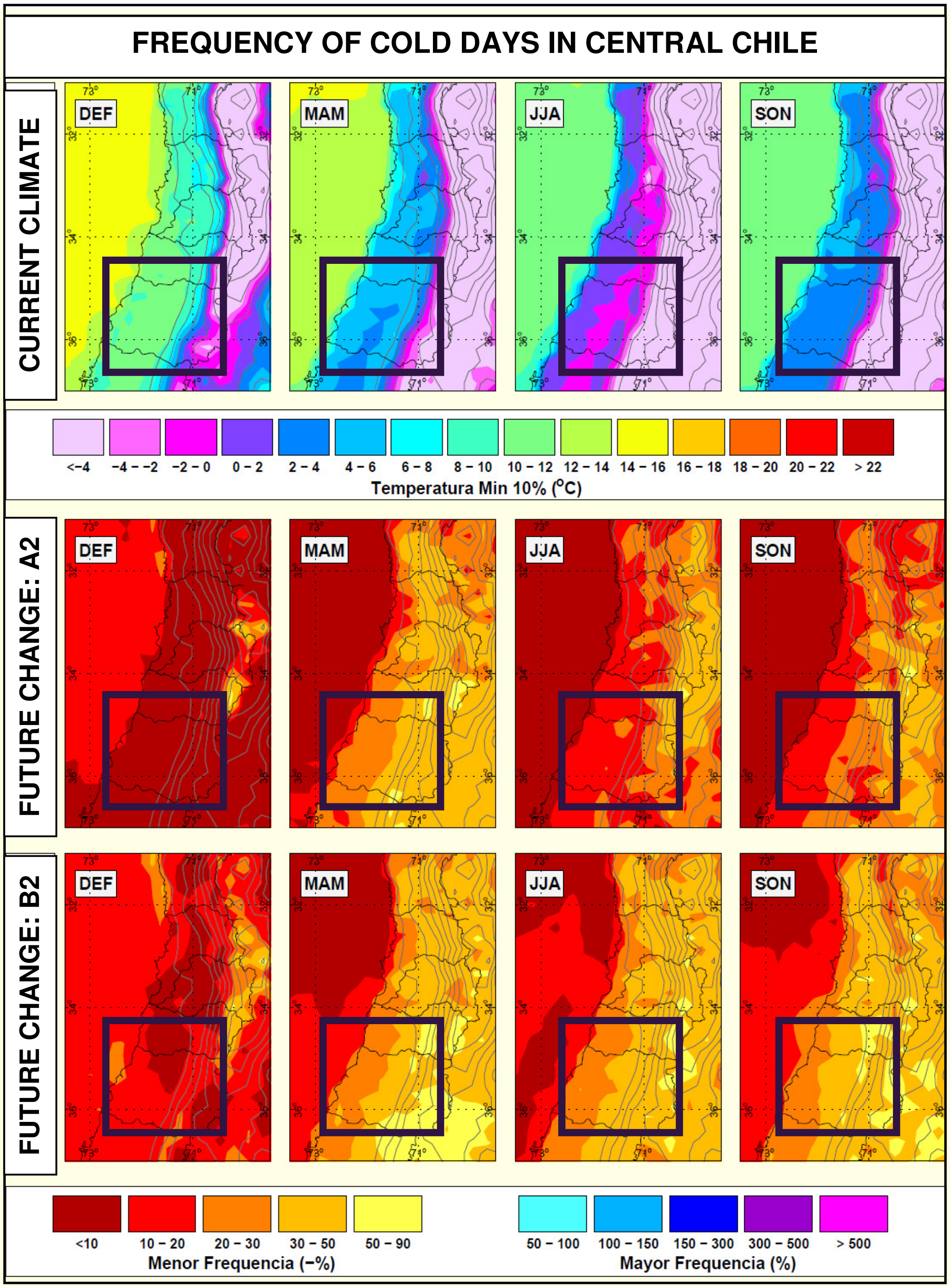


Figure 6.6: Frequency of Cold Days (<0^0C) Currently and in the Future Under A2 and B2 Scenarios for the Central Chile Zone. Maule is Delineated By the Dark Purple Square (CONAMA, 2006)



Spring frosts were another risk identified by growers and producers. Figure 6.6 shows the current and expected future frequency of cold days (<0^0C). In all cases the frequency of cold days is projected to decrease, particularly in the spring, when cold days have the potential to damage crops. Fewer incidences of spring frost serves to benefit growers and producers in Maule, as their crops will be less suceptible to cold snaps in spring. Although CONAMA's scenarios indicate a decrease in the frequency of frost during spring, AGRIMED's scenarios (Santibañez et al, 1999) indicate an increase, creating significant risks for growers and producers. Consistent with CONAMA's scenarios, 39% interviewees observed a decreasing trend in the frequency of frosts.

Projections suggest there will be future increases in average, maximum and minumum temperatures, an increase in the number of warm days, a decrease in preciptiation and either an increase or decrease in the frequency of frost events, depending on the scenario. A summary of the scenarios generated by CONAMA (2006) and explored in this chapter can be found in Table 6.2. Future increases in temperature coupled with decreases in precipitation can result in decreases in water availability for irrigation, potentially increasing but more likely reducing grape and wine quantity and quality given the high degree of projected changes. The potential for frost during budburst is uncertain, as the scenarios examined projected both a decrease and an increase in frost frequency during the spring.

Table 6.2: Summary of Climate Change Scenarios Generated by CONAMA (2006). '+' indicates an increasing trend, '-' indicates a decreasing trend

	Temperature (^oC)			Precipitation	Frequency of Warm Days (>25^oC)	Frequency of Cold Days (<0^oC)
	Avg.	**Max.**	**Min.**			
Summer	+ 2-5	+ 3-5	+ 2-4	- 25-70%	+ 150-300%	- 0-20%
Fall	+ 2-4	+ 2-4	+ 1-3	- 50-90%	+ 100-300%	- 20-50%
Winter	+ 1-3	+ 1-4	+ 1-3	- 50-90%	+ 100-300%	- 20-50%
Spring	+ 2-4	+ 2-5	+ 1-3	- 25-70%	+ 100-300%	- 10-50%

The industry's ability to respond under a changing climate will be an important determinant in its success or failure. The following section delves into the factors influencing growers' and producers' ability to adapt under changing climatic conditions and estimates the utility of current adaptive strategies under future climate change.

6.2 Future Adaptive Capacity

6.2.1 National Government Programs and Policies

The Chilean government both facilitates and constrains adaptation. The government offers training programs to certify wine quality and landuse practices in order to meet certain environmental standards; however, the more programs a grower or producer is enrolled in, the more intensely they are monitored. Government representatives show up unexpected, demand to see proof that the grower or producer is in compliance, and do not offer any leeway. Growers and producers find they are punished for trying to better their operations because even if something minor is not in compliance the government can close down their operations.

Irrigation project subsidies are available via government agencies. These subsidies, however, are not available to all growers. One small grower who has, without success, applied several times for subsidies to upgrade his irrigation system explained:

> *They make these irrigation projects to free water that another person could use, but if you occupy few water rights, the amount of water you will be able to free for others is small; they take points off your evaluation form. If you're too small or too big, or you're location is poor, they take points off your application*.

These projects are available, but those who need it most (i.e. small growers with little capital) cannot access them. The government also offers subsidies to wineries who are travelling abroad to promote their wines, but most medium and small wineries cannot take advatage of them because the government funds just a small portion of expenses; for example, the government funds 30% of a trip abroad, but the winery has to come up with 70%, which is not realistic for some small and medium wineries.

The government has played a role in helping agriculturalists become more competitive in the marketplace. However, programs are often abandoned midway through and improperly planned. A few years ago the government funded growers in Cauquenes (Figure 3.5) to convert their vineyards to olive tree plantations. Now these growers have olive trees, but there is no market for olives, so growers find themselves in a position where they cannot sell their product, and there is no government support or recommendations as to how these growers should proceed. An interviewee stated angrily, "*The government promotes planting something and then abandon the producers, Olive trees, for example. There are people planting olive trees but there is no place for the oil to be produced. People are stuck with olives and no market*".

Labour laws are not only a significant exposure for growers and producers but also a factor constraining adaptation. They were implemented to set working standards for all Chileans; however, labour, the most costly input for growers, is increasingly more expensive, and the infrastructure needed to employ labourers is very high, reducing the amount of capital available to spend on other aspects of the operation, effectively reducing growers' and producers' ability to respond to risks and opportunities. An interviewee expressed:

> *There is no help from the government. More than helping they create more problems. They have created more difficulties than they have helped. There are all these norms and regulations, which are good, but they require investment and cost money and the small business owner is spent*.

6.2.2 Market

Interviewees feel the large wineries in Chile (i.e. Concha y Toro, San Pedro, Santa Rita and Santa Carolina) have a monopoly over the grape and wine industry in Maule, and all of Chile. These large wineries control the market for grapes and wine because they essentially set the price (Gwynne, 2008). Other wineries, for example, wait for the large wineries to set their prices for the growing season, and then they set their own prices. This impedes growers' and producers' abilities to manage price, the main determinant of their income; if the large wineries are paying a low price, there is no alternative for growers and producers or opportunity to obtain a better price.

Contracts are a response to market fluctuations but they also hinder adaptive capacity because growers are limited as to what they can do in their vineyard. When growers sign a contract with a winery, they essentially sign over control of their vineyard, and they are unable to freely make decisions surrounding their vineyard. In the case of a wet fall, for example, growers might disagree with the decisions the winery makes in the vineyard; however, the contract stipulates that vineyard management lies in the hands of the winery. If the winery mismanages the vineyard and compromises quality, the winery retracts the contract and the grower struggles to find a buyer. Contracts provide security in terms of income, but the ability of growers to manage their vineyard the way they want is compromised. The fact that growers who have entered contracts serve just as labour in their own vineyard lessens the effort needed to succeed because they do not have to acquire the knowledge needed to manage their vineyard in the same way the winery does—most wineries send agronomists who have formal training in vineyard management; most growers who enter into contracts have far less formal training. This can be beneficial, as many growers are older and have no desire to obtain formal training in agronomy, and/or problematic, as growers become dependent on wineries to manage their vineyard.

Many GGs recognized and acknowledged their need to organize and work together to manage market risks. Cooperatives are the primary way GGs have attempted to organize, because they consider it an opportunity to both occupy a greater proportion of the marketplace and have a more important voice in the grape and wine industry. Unfortunately, cooperatives in Maule have had little to no success. Many of the GGs interviewed (77%) were once involved with one or more co-ops, but withdrew, or more commonly, the co-op went bankrupt because of poor/unfair management. There exists mistrust within the industry and people find it difficult to unite and fight for collective interests. Interviewees attributed the inability to organize to both the individualistic mentality that many growers, and other agriculturists, possess, and the fears instilled by the military regime that violently restricted the formation of cooperatives in the 1970s and 1980s. The majority of GGs, as well as many others interviewed, view the inability of the industry to organize as a serious limitation to their adaptive capacity.

6.2.3. Education

Many interviewees did not receive a formal education in viticulture and/or viniculture—they were trained through experience, others received extensive formal training. Those without formal training seem to be at a disadvantage, which is reflected in the adaptive strategies they adopt. Their lack of education, in many cases, is hindering their adaptive capacity because they are unaware of certain management strategies that exist, or they do not have the scientific background required to make informed decisions with respect to their operations. An example where this lack of education is reflected involves a wet fall. Many growers spray fungicide in response to a wet fall, which substantially increases input costs, without realizing there is a threshold in which the fungicide is no longer effective. Many of the adaptive strategies employed are responsive and tactical, in part, because they do not have the information and education necessary to make effective decisions.

The issue of canal cleaning came up quite often. Many growers in the countryside do not understand, or care, that when they throw their garbage into the irrigation canal, or neglect to maintain their portion of the canal, the amount of water available for irrigation is reduced through seepage and other processes. This lack of education is very problematic in times of drought because people downstream receive less water as a result of the actions of persons upstream.

Many growers and producers cannot read or write, which significantly reduces the information and potential knowledge available to them. This creates problems when contracts, for example, are negotiated and signed; many growers cannot read the terms and conditions of the contracts and thus are put in a position where they can be taken advantage of. Modern information sources, such as the internet, are simply not accessible in the countryside, where vineyards and wineries tend to be located, as there is no infrastructure to develop these information networks, further reducing the amount of information available.

6.3 Future Vulnerability

As is reflected in Chapter Five, weather, economic, production, social and institutional forces create risks and opportunities for growers and producers in Maule, and play a significant role in the success or failure of the region's grape and wine industry. The problematic climatic risks identified in the previous chapter may be exacerbated into the future, requiring adaptation to remain viable. Current response strategies are largely responsive-tactical and may not be effective in the future under climate change. Growers and producers are not well-prepared to manage the risks associated with climate change. Many interviewees actually noted that a changing climate will create just opportunities for the region, a naive perspective given the high degree of variability projected, particularly during times where they are accustomed to receiving what they consider fairly consistent weather. This perception that future climate change will create just opportunities will likely hinder their future adaptive capacity in that they will be anticipating opportunity and be ‘surprised’ by risks. The primary future concern of interviewees related to economic forces, and included markets, competition and changing consumer preferences. Market uncertainty creates income uncertainty, and increasing competition from emerging wine producing countries such as China were seen as a threat in that they have the potential to take over a portion of Maule’s market share, but they were also seen as an export opportunity if these populations begin to consume more wine.

Future climate change combined with other changing conditions may create unforeseen opportunities and/or risks. The factors discussed in the adaptive capacity section above generally hinder adaptive capacity and serve to increase vulnerability. The shortfalls of government, market uncertainty and instability, and a lack of education and access to resources need to be addressed in order to reduce the grape and wine industry’s vulnerability to future climate change. Adaptation to climate change should be mainstreamed into existing policy in order to increase the industry’s adaptive capacity. Growers and producers are already responding to changes in climate and other conditions, although these strategies may not be effective in the future.

CHAPTER 7: CONCLUSION

This chapter highlights the key findings of the study and its scholarly and practical contributions. It concludes with suggestions for future research.

7.1 Summary of Key Findings

The majority of the climate change and agriculture scholarship focuses on impact assessments, which tends to assume future risks for the agricultural sector will relate to climate alone, namely changes mean temperatures and precipitation, and pay little attention to the role of adaptation in managing risk. This is particularly the case for developing world agriculture (e.g. Conde et al, 2006), and in assessments of climate change and quality wine production (e.g. Jones and Goodrich, 2008). This study employed a vulnerability approach, which has been successfully applied in other agricultural contexts and has been responsible for uncovering a multitude of risks and opportunities faced by the agricultural sector (e.g. Belliveau et al, 2006; Thomas et al, 2007; Tarleton and Ramsay, 2008; Paavola, 2008). This approach seeks to understand all the forces creating risks and opportunities from the impacted system itself, in this case grape growers and wine producers, the strategies adopted to manage these conditions, and the factors facilitating or constraining adaptation.

The results from this study reveal that growers and producers are sensitive to weather, production, economic, institutional and social forces. Exposures are not experienced in isolation, they are experienced along with other risks, as well as with opportunities; a wet fall, for example, creates risk for grape growers, while high prices resulting from a decrease in the supply of grapes when a wet fall is experienced creates opportunity. Risks and opportunities often compound to create greater or new risk and/or opportunity; when a wet fall, labour shortages and the implementation of strict labour laws are experienced together, for example, the operations' success may be threatened. These results emphasize the need to place climate in the context of other risks and opportunities, rather than assuming the exposures of importance.

Interviewees tend to adapt to the exposures they face. However, often the adaptations employed to manage exposures actually end up becoming exposures, and may even affect adaptive capacity. In order to obtain a higher price for their grapes, for example, many growers switch varieties, but rather than switching to a variety appropriate for their vineyard's climate and soil, they plant what the market is demanding at the time. Thus, the varieties chosen are often not appropriate for the location of the vineyard, resulting in increased exposure to weather in some cases; some growers find themselves more exposed to frost because they plant early budding varieties in low lying areas. Inappropriate planting of wine grape varieties hinders their adaptive capacity because they have reduced capital in the event of a spring frost due to the great financial investment involved in replanting, and fewer management options available.

Growers and producers do not have a wide array of adaptive strategies to manage exposures, for many reasons. The first is that the forces affecting them lie within their coping range, and therefore do not necessitate extensive adaptive strategies; the second is that most do not have the capacity to adapt in the ways they would like; and the third is that many growers and producers have endured serious hardships in their lifetime and their perspective reflects this in that they take one day at a time and they try not to stress about things they see as being beyond their control (e.g. climate and markets), because they know they will make it, whether they get rich doing it is not necessarily a priority. These factors coupled with the fact that many interviewees perceived climate in the region as being fairly consistent, may explain why the adaptive strategies they do utilize are, for the most part, reactive and tactical.

This study found that while future climate change may create opportunities for both existing and new varieties in the Maule Region, it has the potential to considerably exacerbate the climatic risks that are currently problematic. Current adaptive strategies may not be sufficient or effective in the future, and adaptive capacity is primarily constrained by government, market instability and both a lack of education and access to resources. Thus, growers and producers in the Maule Region are not well-prepared to manage the risks associated with future climate change.

7.2 Research Contributions

7.2.1 Scholarly Contributions

This research enriches three bodies of scholarship: 1) vulnerability assessment; 2) climate change and wine; and 3) climate change and Chilean agriculture. Vulnerability assessments have tended to focus on broad-scale systems, such as Latin American and South American agriculture (e.g. IPCC, 2007). This research provides a complimentary perspective via the empirical application of the vulnerability approach to a particular agricultural sector in a developing world context. It emphasizes the need to consider exposures and adaptive capacity as interconnected components of vulnerability and highlights the presence of a multitude of risks and opportunities.

The climate change and wine scholarship is in its infancy and has tended to focus on the impact climate change will have on global wine quality (e.g. Jones et al, 2005; Jones and Goodrich, 2008; Battaglini et al, 2008). This research contributes to this scholarship, as it sought to understand the nature of the wine industry's vulnerability to climate change via a case study in the Maule Region of Chile. It documented the risks and opportunities currently faced by the wine industry and the management strategies the industry uses, and it assessed how future climate change might impact the industry under changing climatic conditions, while highlighting its adaptive capacity. This research is an example of how farm-level decision making influences vulnerability to climate change, something that has been excluded in climate change and wine scholarship to date.

There are few studies seeking to understand how climate change will affect Chilean agriculture. The impact assessment perspective has dominated the studies that have investigated climate change and Chilean agriculture, and the forces affecting agriculture are typically assumed to be average temperature and precipitation. For this study, agriculturalists themselves identified the forces important to them and the management strategies they employ. The contribution here is similar to that of the climate change and wine scholarship in that adaptation and its importance in managing risk and opportunity are incorporated into the assessment, and the forces important to producers are not assumed.

7.2.2 Practical Contributions

There are numerous practical contributions of this study. Collaborative arrangements with academics and industry stakeholders allowed for the development, implementation and execution of a project that is of relevance and importance to the grape and wine industry in Maule. These arrangements also ensured there was significant interest in the industry to conduct the research.

This research has perhaps enhanced the utility of vulnerability assessments for decision makers by identifying processes hindering adaptive capacity, effectively providing a starting point for policy and decision making intervention. The results from this study— the industry's current and future vulnerability— were summarized and disseminated to interviewees and other industry stakeholders. This information will hopefully assist growers and producers in the management of their operations, and be mainstreamed into future policy and decision making structures, such that the industry's adaptive capacity can be enhanced, and its vulnerability reduced. Mainstreaming is a mechanism in which vulnerability assessments can be transferred from theory into practice in order to ensure the insights gained from the vulnerability assessment have both policy and practical implications. For example, many interviewees noted the negative ramifications associated with strict labour laws, while others noted the need for investment into alternative energy and research into the grape varieties appropriate for Maule's climate and soils. These all provide entry points for decision makers.

Within Chile's National Climate Change Action Plan, which was developed in 2008 by CONAMA, there is a call for 1) an analysis of vulnerability and adaptation in Chile's silvoagricultural sector to climate change; and 2) the systematization of national and international adaptation to climate change policies and strategies. Although further research will be necessary, this research directly addresses the needs identified by CONAMA.

The dissemination of the results will allow stakeholders to examine the nature of the industry's vulnerability to climate change and perhaps shed light as to the future direction of the industry. There is an understanding among small growers, for example, that they have a stronger voice if they join together. However, this has been very difficult because most growers have an individualistic attitude and have a hard time sharing control. There also exists a disconnect between grape growers and wine producers with respect to what is actually produced and what is desired. The results from this research will hopefully motivate organization and unification within the industry.

7.3 Future Research Opportunities

As is described in the previous section, this research contributes to three related bodies of scholarship. These bodies of scholarship are growing, and therefore there are areas still necessitating further research. The risk perception scholarship played a minor role in the design and implementation of this research. A better understanding of risk perception and the factors that influence it may help to understand and explain why certain adaptive strategies are chosen instead of others.

Another direction for future research involves mainstreaming, described previously in this chapter. Although this research attempted to identify some ways in which decision makers could increase adaptive capacity, the industry would benefit from research that explicitly sought to identify ways to mainstream adaptation to climate change. This research provides the building blocks for these types of analyses. Future research could also build on the assessment of future vulnerability provided by this study and incorporate changes in political, economic and social forces.

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APPENDIX A

INTERVIEW GUIDE
GUIA DE ENTREVISTA

Section 1: Grape and Wine Production Characteristics

a) What is your position here?
Cual es su posición?
b) How long have you held this position?
Por cuánto tiempo ha celebrado esta posición?
c) How long have you/the farm/the winery been farming/been in business?
Por cuánto tiempo ha (n) estado en operación?
d) Has it always been grapes?
Ha sido siempre las uvas?
e) How many hectares of grapes do you farm?
Cuántas hectáreas de uvas tiene(n)?
f) What varieties of grapes are produced?
Qué variedades de uvas se producen? Qué variedades?
    i. How many hectares of each do you produce?
    Cuáántos hectáreas de cada variedad produce(n)?
g) Are grapes your only crop?
Uvas son su(s) único cultivo?
    i. How many hectares of other crops do you farm?
    Cuántas hectáreas de otros cultivos tiene(n)?
    ii. What crops did you start with?
    Con cuales cultivos empezó(aron)?
h) Are you involved in processing the juice and/or making wine?
Esta(n) involucrado(s) en el procesamientoo del jugo de las uvas y/o la producción del vino?
    i. How much wine do you produce?
    Cuánto vino produce(n) por año?
    ii. Do you buy grapes from other producers? Do you sell all your grapes to one company?
    Compra(n) las uvas procedentes de otros productores? Vende(n) todas sus uvas a una empresa?
    iii. Is the wine sold domestically or internationally?

    El vino se vende en el país o internacionalmente?
    iv. What percentage of your wine is sold domestically?
    Qué porcentaje de su(s) vino se vende en el país?
    v. What percentage of your wine is exported?
    Qué porcentaje de su(s) vino se exporta?
    vi. What countries is it exported to?
    A qué países se exportan?
i) Ownership structure (national or foreign)?
j) Get into production characteristics? (e.g. tones of grapes, litres of wine)

Section 2: Adaptation

1.

a) Over the past 10 years, which years were really good? What has positively affected your production system? Why?
En los últimos diez años, que años fueron realmente buenos? Que ha tenido efectos positivos para su operación? Por qué?

b) What conditions led to these years being better than average?
Qué condiciones dado lugar a este año están mejor que la media?

c) How did this affect you?
Esto cómo le(s) afectó?

d) Did you do anything differently?
Hizo (hicieron) algo diferente este año?

e) Did you do anything differently in subsequent years?
Hizo (hicieron) algo diferente en los años siguientes?

f) Were there factors that served to facilitate or constrain 'c &d'?
Existen factores que sirven para facilitar o limitar lo que hizo (hicieron) o que quería(n) hacer?

g) If the same event happened again, how would it affect you now? Why?
Si el mismo caso ocurrió de nuevo, cómo afecta a usted(es) ahora? ¿Por qué?

h) Would you respond in the same way
Haría (an) lo mismo que hizo (hicieron) en el pasado?

2.

a) Over the past 10 years, were there years that were really bad? What has negatively affected your production system? Why?
En los últimos diez años, que años fueron malos o peores que otros? Que ha tenido efectos negatives para su operación?

b) What conditions led to these years being worse than average?
Qué condiciones dado lugar a este año están peor que la media?

c) How did this affect you?
Esto cómo le(s) afectó?

d) Did you do anything differently?
Hizo (hicieron) algo diferente este año?

e) Did you do anything differently in subsequent years?
Hizo (hicieron) algo diferente en los años siguientes?

f) Were there factors that served to facilitate or constrain 'c &d'?
Existen factores que sirven para facilitar o limitar lo que hizo (hicieron)o que quería(n) hacer?

g) If the same event happened again, how would it affect you now? Why?
Si el mismo caso ocurrió de nuevo, cómo afecta a usted(es) ahora? ¿Por qué?

h) Would you respond in the same way
Haría (an) lo mismo que hizo (hicieron) en el pasado?

3.

a) Over the past 10 years how has your operation been influenced by:
En los últimos diez años qué influencia ha tenido:

i. Government policies

Políticas gobermentales

ii. Industry representation (e.g. wine association)
Representación industrial (e.g. asociacion de productores, CCV)

iii. Economic conditions (market, trade)
Condiciones económicos

iv. Technology (GIS, wind machines)
Tecnología

v. Availability of material (rootstocks, trellising)
La disponibilidad de materiales

vi. Environment (pollution, soil quality, water availability, pests)
El medio ambiente

vii. Climate (variability, extreme events, temperature shifts)
El clima

viii. Other influences?
Otros

- For each influence identified, explore the conditions and response using questions 1, c-f
Para cada uno de influencia identificados, explorar las condiciones y la respuesta usando las preguntas
    i. How did this affect you/the operation?
    Cómo afecto a su(s) operación?
    ii. What have you done about it? Did you do anything differently this year?
    Qué ha(n) hecho sobre esta tema? Hizo (hicieron) algo diferente este año?
    iii. Did you do anything differently in subsequent years?
    Hizo (hicieron) algo diferente en los años siguientes?
    iv. Were there factors that served to facilitate or constrain 'a, b, & c'?
    Qué le(s) ayudo con esto? Que le(s) restringio? Que factores ayudaron o restringieron en estos años?en las respuestas?

Section 3: Nature of Climate Change

a) Has the incidence of drought changed over the past 10 years?
La incidencia/frecuencia de la sequía ha cambiado en los ultimo diez años?

b) Has the incidence of heavy rain changed over the past 10 years?
La incidencia/ frecuencia de lluvias fuertes ha cambiado en los ultimo diez años?

c) Have summer temperatures changed over the past 10 years?
Las temperturas en el verano han cambiado? En invierno?

d) Has there been a change in winter injury/frost incidence over the past 10 years?
Han observado cambios en la incidencia/frecuencia de daño invernal o la incidencia/frecuencia de heladas en los ultimo diez años?

e) Has the length of the growing season changed?
La duración de la temporada de crecimiento?

f) Has anything else changed related to the weather or climate changed?
Algo más ha cambiado en relación al tiempo o el clima?

- For each influence identified, explore the conditions and response using questions 1, c-f
    i. How did this affect you/the operation?

Cómo afecto a su(s) operación?

ii. What have you done about it? Did you do anything differently this year?
Qué ha(n) hecho sobre esta tema? Hizo (hicieron) algo diferente este año?

iii. Did you do anything differently in subsequent years?
Hizo (hicieron) algo diferente en los años siguientes?

iv. Were there factors that served to facilitate or constrain 'a, b, & c'?
Qué le(s) ayudo con esto? Que le(s) restringio? Que factores ayudaron o restringieron en estos años?en las respuestas?

Section 4: Future Risks and Opportunities

a) What do you see as the major risks facing your operation over the next 20 years?
Cuales piensa Ud. que son los mayores riesgos para su (la) operación?

b) What do you see as the major opportunities over the next 20 years?
Cuales piensa Ud. que son las mayores oportunidades para su (la) operación?

c) If maximum temperatures increase, how will grape and wine production or the industry be affected? What can be done for this?
Si la temperatura máxima aumenta, como le(s) afectara? Que hará(n) en este caso?

d) If minimum temperatures increase, how will grape and wine production or the industry be affected? What can be done for this?
Si la temperatura mínima aumenta, como le(s) afectara? Que hará(n) en este caso?

e) If the amount of solar radiation decreases how will grape and wine production or the industry be affected? What can be done for this?
Si la cantidad de radiación solar disminuye, como le(s) afectara? Que hará(n) en este caso?

f) If the amount of precipitation decreases…
Si la cantidad de precipitación disminuye, como le(s) afectara? Que hará(n) en este caso?

g) If the amount of UV reaching the earth's surface increases…
Si la cantidad de UV disminuye, como le(s) afectara? Que hará(n) en este caso?

h) If water consumption increases…
Si el consumo de agua aumenta, como le(s) afectara? Que hará(n) en este caso?

i) If there is a high seasonal variation in weather…
Si hay alta variación temporal, como le(s) afectara? Que hará(n) en este caso?

One last thing, do you know of anyone who I should talk to or who would be interested in talking to me?
Ultima pregunta, conozca a alguien con quien debería hablar o incluir en este estudio o que quizas le interesaría hablar conmigo?

APPENDIX B

INFORMED CONSENT TO PARTICIPATE IN A RESEARCH STUDY

The University and those conducting this study to subscribe to the ethical conduct of research and to the protection at all times of the interests, comfort, and safety of subjects. This form and the information it contains are given to you for your own protection and full understanding of the procedures. Your signature on this form will signify that you voluntarily agree to participate in this study, which asks you to respond to a series of open-ended questions regarding the management of your farm and/or winery in light of numerous risks and opportunities.

The purpose of this research is to identify the various risks and opportunities facing grape and wine producers in the Maule Region. We wish to gain an understanding of the conditions that create risk, and the subsequent responses that reduce risk or seize opportunity. The end-goal of the research is to become better informed on farm-level adaptations that you feel are advantageous and to gain insights into how decisions are made in the face of multiple risks.

As a participant in this research study, I understand that my identity can be kept confidential if I so chose, but my responses will be used in the analysis. While direct quotations may be used, I can choose if my identity will be attached to my comments. The interview will be audio taped for the purpose of ensuring all commentary is considered in my analysis. During the 30 to 60 minute interview I may choose not to answer any questions. Further, I understand that I may withdraw my participation in this study, including my response, at any time.

I understand that I may register any complaint or compliment I might have about the project with Ms. Monica Hadarits, Dr. Barry Smit, Professor of Geography, University of Guelph, Guelph, ON, Canada; phone: (519) 824-4120, ext 53279; email: bsmit@uoguelph.ca, or with Dr. Fernando Santibanez, Vice-Dean of Agronomy, University of Chile, Santa Rosa 11315, La Pintana, Santiago, Chile; phone: 56 2 6785734; email: fsantiba@chile.cl.

I may obtain copies of the results of this study upon its completion by contacting: Dr. Barry Smit, Professor of Geography, University of Guelph, Guelph, ON, Canada; phone: (519) 824-4120, ext 53279; email: bsmit@uoguelph.ca.

NAME (please print clearly):____

ADDRESS: ____

Please keep my identity confidential when reporting results (circle one): YES NO

SIGNATURE: ____________________________________

DATE: ____

APPENDIX C

CONSENTIMIENTO DE PARTICIPACIÓN EN EL PROYECTO

Título del proyecto: Adaptación e Innovación el Sector del Vino del Maule Bajo Cambios en el Medio Ambiente y el Mercado

El propósito del proyecto: es identificar los riesgos y oportunidades que enfrentan los productores de uva y vino, frente a cambios en el medio ambiente y el mercado, entendiendo las condiciones que crean riesgos y oportunidades para los productores, y las soluciones disponibles en la industria del vino. Además, identificar estrategias innovadoras que sean beneficiosas para productores de la región del Maule frente a cambios ambientales y del mercardo. Agradecemos mucho su partcipación en este proyecto.

Investigador en el proyecto:

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Número de teléfono: Chile – 99 499 2342; Canadá – 519 824 4120 ext. 54174
Dirección de correo eléctronico: mhadarit@uoguelph.ca

Elija uno por favor:

☐ Quiero ser anónimo – mi identidad y la información que yo doy es confidencial

☐ Yo doy mi permiso para usar mi nombre y quiero que la información que doy sea atribuida a mi

☐ Doy mi permiso para la grabación de audio

Declaración de sus derechos:
He sido informado y tengo conocimiento de los objetivos del proyecto, por lo que doy consentimiento para ser entrevistado(a), y me compromento a propocionar información verdadera. Tengo claras las medidas que se llevarán a cabo para garantizar que esta entrevista será confidencial, a menos que consienta para ser identificado(a). También, tengo conocimiento que si deseo retirarme del estudio, se me permite hacerlo sin repercusiones.

Nombre:____

(Escriba en letra de imprenta por favor)

Dirección: ____

Dirección de su correo eléctronico:_______________________________

Firma: ______________________________ Fecha:_______________