

Sustaining the international wine industry in the midst of climate change: what is Australia doing?

James Turton

PhD Candidate

Department of Business Law

Faculty of Business and Economics

Macquarie University

Sydney, Australia

INTRODUCTION

This paper will examine how climate change will impact the sustainability of the Australian wine industry. Climate change will effect the wine industry in a variety of areas including terroir, timing of grape picking, costs involved in wine production, and the quality of wines produced. In an era where climate change concerns are on the minds of an ever-increasing number of people, developing strategies to mitigate the potential adverse effects on the wine industry has become critical. Consequently, various challenges exist that wineries will need to address in order to remain competitive. Challenges faced by the wine industry in responding to climate change are in area management given the increasing incidences of adverse weather conditions such as drought, flood and fires causing physical damage and smoke taint. Production and marketing approaches (labelling, brands, consumer behaviour etc.) also need to be

addressed. Wineries in Australia have responded to these challenges. New processes for producing wine in a more sustainable way have been implemented. However, while these processes usually result in wines of higher quality, they come at an additional cost that the public struggles to justify paying. These challenges look as if they are going to increase in size and frequency as a consequence of climate change.

CLIMATE CHANGE SCIENCE: SOME BACKGROUND

The Intergovernmental Panel on Climate Change (IPCC) defines climate change as “a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer”. Nicholas Cahill and Field (2008, p. 1) make an important distinction between ‘climate’ itself and climate change noting that “climate is the statistical summary of weather over 10 to 30 years”. Therefore it is crucial to examine changes to the planet’s climate over these time periods, rather than on a year-by-year basis.

The scientific community has reached overwhelming agreement on the key aspects of climate change, namely that global climate warming is already underway, primarily caused by human emissions of heat-trapping greenhouse gases to the atmosphere, and is very likely to warm a further 1.6-4.0°C over the coming century under continued ‘business as usual’ emissions scenarios (Intergovernmental Panel on Climate Change, 2007).

Nicholas Cahill and Field (2008, p. 2 (generally)) point out that the role of greenhouse gases in affecting the earth's climate has been understood for a long time. Swedish scientist, Svante Arrhenius published a paper in 1896 using very simple calculations to show that increasing the concentration of atmospheric CO₂ by 2 to 2.5 times could cause a warming of 3.4°C (6.1°F), a number close to the middle of the current range of projections.

The 2007 reports of the IPCC make it clear that climate has warmed in recent decades and that human actions are a likely cause of most of the warming. The Panel has stated that:

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level... Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic [human-caused] greenhouse gas concentrations.

Nicholas Cahill and Field (2008, p. 7) further claim that even small changes in temperature could have big impacts on the [wine] industry. However, as to what these impacts are exactly, is difficult to determine, due to the unpredictable nature of the Earth's climate. In addition, Schultz (2000, pp. 10-11) states that "an additional

uncertainty lies with the response of grapes to high CO₂ levels". Consequences for grape production throughout the world remain unclear because there is very little data available on how grapevines respond to high CO₂. One point that can be made though is that grapevines have a large adaptive potential to changes in the environment, at least with respect to temperature and possibly to CO₂.

THE PROBLEMS OF CLIMATE CHANGE FOR AUSTRALIAN WINES AND WINERIES

Climate change has the potential to adversely impact the quality of Australian wines. Looking firstly at temperature projections for Australian wineries, we can estimate the regional cost of climate change to the Australian wine industry for the years 2030 and 2050. For example, “the projected warming in McLaren Vale (in South Australia) ranges from 0.3°C to 0.7°C by 2030, and this could result in a 2 to 6% reduction to winegrape quality. However, a projected warming of 0.4°C to 1.7°C by 2050 could reduce quality by 3 to 17%” (Webb et al 2008, p.107-108). Furthermore, “an increasing frequency of extreme events has the potential to affect crops more than high temperatures per se. For instance, a 15-day ‘hot spell’ in South Australia in March 2008 resulted in large quality reductions and fermentation problems” (Webb, et al. in Stokes and Howden (Edts.), 2010 p. 103).

Smoke taint has also become an increasing problem for winemakers as a result of climate change or climate-induced changes to weather, particularly increased temperature, drought, wind and lightning strikes. Grape and grapevine exposure to smoke has been shown to affect the chemical composition and sensory properties of wine. In some cases, fires have occurred in close proximity to wine regions resulting in vineyard smoke exposure and smoke tainted wines. The taint, characterised by objectionable ‘smoky’, ‘dirty’ and ‘burnt’ aromas and a lingering retro-nasal ‘ash’ character on the palate, has caused significant financial loss for grape and wine producers see (Kennison et al. 2008 p. 7379). Smoke taint due to wildfires cost Australian grape growers more than \$7.5 million during the 2003 and 2004 vintages.

In 2003, Victorian growers suffered at least \$4 million losses due to fire in adjoining national parks. Fires again struck Victoria in February 2009, resulting in a loss of wine grapes, and a great decline in quality as a result of smoke taint (Webb, et al. in Stokes and Howden (Edts.), 2010 p. 105).

With the incidence of bushfires projected to increase, Webb et al., in Stokes and Howden (Edts.) p. 105 claim that “the risk of smoke taint is likely to increase”.

Although not a consequence of climate change, arson, too, further exacerbates smoke taint related problems for winemakers, with a number of fires being deliberately lit across Australia each year. Given the above points, it is therefore imperative that steps are taken to mitigate the effects of smoke taint on wine – whether the fires are a result of arson, a changing climate, or controlled burning.

Water management is also a major concern for winemakers given the increase in droughts and floods worldwide due to climate change. The reason for this is that as a consequence of climate change, both floods and droughts will increase, making managing water usage difficult due to the uncertainty of the amount available.

Winemaking can use a great deal of water if the vineyard is not properly managed. Therefore, winemakers need to implement practices so as to minimise the amount of water usage. This is and will continue to be a challenging exercise as the winemakers seek to deliver a quality product in an environment where water is becoming increasingly scarce.

Finally, it is also noteworthy that “in 2006 widespread frost damage decimated vineyards in many parts of Australia’s wine regions. Widespread frost damage also

occurred in 2003, another hot and very dry year (Webb, et al. in Stokes and Howden (Edts.), 2010 p. 105). This illustrates a further adverse effect experienced by Australian winemakers as a result of climate change.

GRAPE QUALITY AND THE CONCEPT OF TERROIR IN THE MIDST OF CLIMATE CHANGE

Wine production is intimately wedded to the concept of terroir: matching premium grape varieties to particular combinations of climate and soils to produce unique wines of particular styles (Webb et al. in Stokes and Howden (Edts.), 2010 p. 102). Ron Laughton from Jasper Hill Vineyards says that wines without chemicals can better express the flavours of the terroir, pointing out that “flavours are created in the vine. The building blocks are the minerals in the soil. If you keep applying synthetic chemicals, you are upsetting the minerals in the soil. So if you wish to express true terroir, you should be trying to keep the soil healthy.” (Morganstern, 2008, in Delmas and Grant, 2010 p. 12)

White et al. (2009 pp. 83-84) argues that:

The current rate of climate change is unprecedented, and is likely to challenge the geographically fixed concept of terroir. If a particular terroir or ‘sense of place’ for a wine is established, and the elements making up that fixed terroir change as climate changes, keeping the concept of terroir in tact will be difficult from both a legal and a marketing perspective.

Given the above points, White (2009 pp. 83-84) therefore further argues that “an increased use of technology and a geographically adaptive sense of place will probably characterise terroir in the twenty-first century, if the concept is to survive”.

Embodied in a wine’s terroir is the quality of grapes produced to make the wine. Winegrapes have four main developmental stages: budburst, flowering, veraison (berry softening and colour change signalling the onset of rapid sugar importation), and maturity (when ripe grapes are harvested) earlier (see Webb et al., in Stokes and Howden (Edts., 2010 p. 102). The most important grapevine compounds contributing to flavour are organic acids, proanthocyanidins (tannins), terpenoids (mono-terpenoids, sesquiterpenoids, and C13-norisoprenoids), and various precursors of aromatic aldehydes, esters, and thiols detectable in finished wines. The relative assortment of compounds in the berries of each grape variety define what is known as ‘varietal character’ to wine enthusiasts. The timing and duration of these stages (phenology) varies with grapevine variety and climate.

Matching developmental phases to climate is an important consideration in vineyard planning. As climates warm, phenology will progress more swiftly and grapes will ripen earlier Webb et al., in Stokes and Howden (Edts., 2010 p. 102). Moreover, this can lead to high alcohol wines with low acidity. This will have both positive and negative effects on the Australian wine industry, depending on the current climate regime, and being able to maintain consistent quality against this background will be critical Webb et al., in Stokes and Howden (Edts., 2010 p. 102). White et al. (2009 p. 83) state that “high-quality wine-grapes may be produced at an average air temperature between 13°C and 22°C during the growing season.” For comparison,

average prices for Cabernet Sauvignon grapes from California's Napa Valley exceeded \$4100/ton in 2006, while those from the Central Valley sold for \$260/ton; the latter region having a 2.7°C higher mean annual temperature than the former (Cahill and Field 2008, in Keller, 2010 p. 63). Consequently, the warming that has occurred as a result of climate change "may affect world wine trading and have effects on global wine prices." (Webb et al, 2008 p. 109). The projected increase in the frequency of hot summer days will undoubtedly exacerbate this problem (Keller, 2010, p. 63).

Pincus (2003, p. 88) raises the important point that it is crucial for winemakers to plan ahead and take precautions against adverse climatic occurrences:

Vines also 'remember' the weather from one year to the next, since the shoots on which berries form begin to grow the year before the flowers bloom. If the fall weather is poor or if an early frost arrives before the shoots mature, the next season's growth will begin in a weaker state. Grape development does not depend on what happens on any particular day, but rather on the accumulation of weather over the course of the growing season, such as overall amounts of precipitation and sunshine.

THE STRUGGLE FOR COMPETITIVE ADVANTAGE IN A WINE INDUSTRY IMPACTED BY CLIMATE CHANGE

Schamel and Anderson (2003,p. 358) argue that "since the quality of a particular bottle of wine cannot be known until it is de-corked and consumed, consumers'

willingness to pay depends on reputations associated with that wine.” This reputation stems from a variety of sources such as advertisements, reviews, and a person’s previous opinion of the wine and/or winery in question.

An important, related concept is that of brand equity. Brand equity is the value of a brand that accrues over a period of time. This value can be tangible as reflected in the price premiums that customers are willing to pay for a particular brand or this value can be intangible in that consumers can develop an affinity for a brand that is difficult to articulate in measurable terms. In the literature, brand equity is the incremental utility or value added to a product by its brand name (Farquher, 1994, in Nowak, 2002, p. 6). Brand equity can therefore be thought of as a type of comparative advantage that is hard to establish but easily lost. A further example of competitive advantage for wineries in light of climate change is “a comparatively lower climate variability making for consistency in vintage quality” according to Keller (2010 p. 60).

ADAPTING TO CLIMATE CHANGE IN THE AUSTRALIAN WINE INDUSTRY

Climate change has meant that winemakers have had to adapt to new and perhaps previously unthought of circumstances such as those illustrated above. Consequently, new practices for winemaking have had to be developed by wineries in Australia and it is not only a question of them being sustainable – it is a matter of survival.

However, adaptation is not a new concept. Howden and Stokes point out that “Australian farmers have always adapted to past changes in prices, technologies and

climate variations as well as institutional factors.” (in Stokes and Howden (Edts.), 2010, p. 2). This ought to give winemakers a degree of confidence as they confront climate change issues. However, it is up to winemakers to act early. Those who do stand to reap benefits that stem from unspoilt vineyards, brand equity, and trust in their winery - factors that increase among consumers when the wineries implement sustainable business practices. Finally, it should be pointed out that while climate change has forced winemakers to adapt, one could argue that it is not just this group that ought to act, but the planet as a whole.

To summarise this section then, climate change may bring opportunities to viticulture as well as potential risks as summarised below:

- New viticultural regions may appear, increasing competition for the old ones.
- A wider choice of cultivars may be necessary in established wine regions, which may change their traditional character.
- Earlier dates of phenological events will accelerate the growth of grapevines, but pests and diseases will increase as well.
- Greater solar radiation will enhance the maturation of grapes but it may also increase sunburn.
- High quality wine produced in good vintages may contrast with serious quality losses in other years and threatens the brand reputation;
- Climatic variability and uncertainties as a result of warming temperatures, drought, floods, smoke taint from fires, etc. may decrease the financial benefits while increasing risks.

RESPONSES BY WINERIES LOOKING TO MAINTAIN QUALITY DESPITE CLIMATE CHANGE

Australian wineries have implemented a variety of processes in order to continue producing quality wine, especially in light of climate change. Two of the most prominent processes used today are Biodynamics and Sustainable Winemaking.

1. BIODYNAMICS

Implementing biodynamic principles has been an alternative practice that wineries in Australia have implemented in an effort to improve the quality of their wines as well as introducing sustainability to counter climate change.

Biodynamic agriculture began in 1924 in Germany and emphasised the role of a healthy, fertile soil. The concept of biodynamics was introduced by Steiner, who took a holistic approach to farming. He felt that because plants germinate, grow and produce fruit and are dependant on the sun, earth, air and water to do so, then literally the whole universe is involved in these processes. Steiner saw each farm as an individual organism that should be as self-sufficient as possible. For example, a biodynamic farm should have a diversity of crops and a certain amount of livestock. Because a farm is a living organism, he reasoned that only life-endowed substances should be applied to it. 'Dead' materials such as chemical fertilizers should not be used. Similarly, synthetic pesticides should not be used either. Therefore only organically derived materials should be used in farming and it is in this aspect that biodynamic farming has a commonality with organic farming. One important practice

that sets biodynamic farming apart from other farming practices is the use of eight specific preparations of materials developed by Steiner to add to composts, to the soil or to spray on plants, depending on the preparation. Each of the preparations is assigned a number from 500 to 508.

Steiner also makes the point that “biodynamic agriculture does not ‘combat’ a disease, rather it promotes an equilibrium, and by this means renders the carriers of disease far less potent. This holistic notion of the agricultural organism is an important one.” (see generally Ohmart, in Striegler, Allen et al. (Edts.), 2009 p. 14). In response to Steiner Joly argues that it “may be a very good idea to sacrifice a little terroir to leave a field, a wood, fallow ground or a tree at the very least” (Joly, 2007 p.77). This is especially important in light of climate change and the effects on the wine industry if the industry is to remain sustainable. While it may appear that biodynamics is the right way to go to achieve sustainability in vineyards, at least one caveat exists: there has been little scientific research into the efficacy of biodynamic farming practices. The results have been mixed, but in some studies it was shown that biodynamic farming systems have better soil quality and lower crop yield when compared to conventional farming systems according to Reganold (1995, in Ohmart, in Striegler et al. (Edts.), 2009 p. 15). Finally, it should be noted that to fully implement a biodynamic system into a vineyard is not an overnight job – it takes a few years.

2. SUSTAINABLE WINEMAKING

Giddens (2009, p. 62) claims that ‘sustainability’ implies continuity and balance, while ‘development’ implies dynamism and change. One of the difficulties in creating

a definition for sustainability is figuring out its boundaries. That is because sustainability involves everything you do on the farm, including economics, environmental impacts, and all aspects of human resources, including not only the farmer and his family but also the employees and the surrounding community. If I were to assemble 50 people in a room, including growers, environmentalists, scientists and government regulators, and ask them to define sustainable farming I would likely get 50 different definitions (see Ohmart, in Striegler et al. (Edts.), 2009 pp. 7-8).

In 2006, FIVS adopted a set of Global Wine Sector Environmental Sustainability Principles (the 'Principles'). This was in recognition that the protection and enhancement of natural assets, such as good water quality, healthy soils, and viable ecological processes, is an imperative of an industry entirely dependent on productive agricultural systems, according to Russell (2007 p. 2). Russell notes that a key consideration in developing the Principles was the integration of wine sector environmental programmes already being developed or implemented in a number of wine-producing countries, including Australia, the United States of America, South Africa and New Zealand. The fact that these Principles have been implemented in the aforementioned countries highlights that the goal of developing sustainable vineyard practices is one shared globally, not just in Australia. There can be little doubt that reaching this goal is paramount given climate change. Some of the Principles are outlined below (see Russell, 2007, pp. 3-4 generally):

- The development of environmental sustainability activities should be based on an

environmental risk assessment. Priority should be given to risks of significance in individual geographic regions where wineries and vineyards are located.

An environmental risk assessment is a standard feature of environmental management systems. Risk assessments allow limited resources to be allocated to those activities that will provide the greatest benefit. This Principle also acknowledges differences between industry programs, because environmental issues will have different priorities across national and regional wine industries.

- Environmental risk assessment should consider, but not be limited to:
 - a) Site selection (for new vineyards/wineries)
 - b) Biodiversity
 - c) Variety selection (for new vineyards)
 - d) Solid waste
 - e) Soil condition
 - f) Energy use
 - g) Water use efficiency
 - h) Air quality
 - i) Wastewater
 - j) Neighbouring land use
 - k) Human Resource Management
 - l) Agrochemical use

The third principle identifies a minimum set of sustainability issues that need to be considered when developing a wine industry environmental sustainability program.

This essentially creates a minimum standard for how comprehensive a program should be to be considered consistent with the global Principles.

- A process of planning for environmental sustainability activities, implementation of the activities, and assessment of their effectiveness and modification of the activity for application into the future should be undertaken as a means of continuous improvement.

Continuous improvement is an essential component of environmental sustainability programs. Current best practices are always being updated, new technologies become available, new risks come to light and economic conditions change. This principle supports the 'plan-do-check-act' management method.

- The improvement of extension and education opportunities about sustainability issues should be undertaken to build awareness within the global vine and wine sector.

Continuous improvement has already been acknowledged as a necessary component of environmental sustainability programs. This is assisted by training and awareness-raising campaigns within the vine and wine sector to ensure that industry remains abreast of best practice developments, market expectations and new technologies.

- The global vine and wine sector should consider partnerships with both industry and natural resource management stakeholders to improve sector sustainability, including the adoption of preferential purchasing policies from suppliers able to demonstrate a similar sustainability ethic.

In 1991 Australia established the Grape and Wine Research and Development Corporation (GWRDC) under the *Primary Industries and Energy Research and Development Act (1989)*. The GWRDC espouses the goal of ‘achieving the sustainable use and sustainable management of natural resources’ used in the wine industry by placing a priority on ‘rural research and development.’ (see Cunningham, 2008-2009 p. 245). In Australia, an ‘organic or biodynamic farm must operate within a closed input system to the maximum extent possible. If an organic vineyard is truly maintained as a closed system, the inevitable depletion of nutrients over a long period will result in unthrifty vines and poor yields, making the enterprise financially non-viable and therefore unsustainable. Furthermore, it should be noted that the operating costs of organic viticulture are generally higher than for conventional viticulture, and organic growers in Australia at least are not paid a premium for their fruit by winegrowers.

EXAMPLES OF AUSTRALIAN WINERY UNDERTAKING SUSTAINABLE WINEMAKING PROCEDURES

Several wineries in Australia have implemented sustainable winemaking practices in their vineyards in order to mitigate the adverse conditions that are likely to occur as a

consequence of climate change. Some of the processes that wineries in Australia have implemented in order to be sustainable are illustrated below.

Western Australia currently produces less than 5% of all Australian wine, but produces about 25% of the wine in the super-premium and ultra-premium categories. Shifting rainfall patterns and drier conditions will change the way vineyards operate and will reduce the wine crop (Wills, in Jubb et al., 2010, p. 148,). The Margaret River region in Western Australia has an ideal climate for growing grapes, due to its location in an area that has relatively high rainfall in winter and warm, dry weather in summer. The soils in Margaret River are very old and most use methods for sustaining the soils so that they will assist in achieving wine quality and sustainability, thus enabling the purest expression of terroir. In the early 1960s detailed climatic studies of various regions in Southwestern Australia revealed that during the winegrowing season, Margaret River's climate was similar to that of Bordeaux, particularly Pomerol. The conclusion that Margaret River was ideal for viticulture was first tested in Wilyabrup in 1966.

As previously mentioned, Western Australian wineries have had to deal with climate change issues, though they have been less severe than those experienced in the eastern states of Australia. Nevertheless, wineries such as Cullen have seen the benefits of striving to be sustainable, thus taking steps to possibly guard itself against adverse future climatic occurrences. Cullen achieved certification by the Biological Farmers Association of Australia as having an organic vineyard in 2003, representatives from Cullen attended a seminar organised by the Biodynamic Association of Australia. This inspired Cullen Wines to adopt a more holistic approach to viticulture and

thereby encouraged the move towards biodynamic farming. Cullen's philosophy is to interfere as little as possible in the winemaking process and thus essentially let the wines make themselves. This approach has resulted in the production of high quality and individual wines from all of the grape varieties that have been planted (see Cullen website).

Several wineries in South Australia have also seen the benefits that operating in a sustainable fashion can have on the quality of the wines they produce, and on the environment. Some of these are outlined below:

1. Paxton Winery in McLaren Vale decided to move to biodynamics as a result of the potential to improve wine quality. Paxton views the biodynamic method as being a smart, well documented organic farming system. Their vineyards are treated as a whole organism rather than a series of problems to be solved individually. Terroir is seen as the interaction between a vine, its environment and the impact of man's management. It is the intention that Paxton vineyards mimic the characteristics of a natural system. In this endeavour Paxton seeks to promote diversity and allow natural balance to counter the effects of pests or disease. (See Paxton website)
2. Henschke in the Eden Valley has used the benefits of mulching and compost to preserve soil moisture and in building the health of soils since 1990. In 2009 Henschke vineyards achieved organic pre-certification status, incorporating biodynamic principles. This has given the vineyard a two-fold benefit – replacement of inorganic fertilizers with compost and the end of using herbicides. (See Henschke website)

3. Elderton in the Barossa Valley has become a leader within the Australian wine industry in its environmental sustainability. The vineyard has proactively implemented a number of initiatives into the day to day operations of the winery, in order to minimise the environmental footprint and to promote a sustainable, clean and environmentally responsible work place. These initiatives include (see Elderton website):

- Elderton was the first winery in South Australia to use Trees for Life's Carbon Neutral program
- In 2007 more than 4,000 trees were planted and this will be an annual commitment.

Increasingly Elderton is turning to bio-dynamic farming techniques in their vineyards. 2007 was the first year that one block of old vine cabernet and one block of old vine shiraz was trialled using these methods. Elderton's winery has recently gained certification from the Australian Certified Organic Organisation.

4. Peter Lehmann Winery also in the Barossa Valley has taken some steps to address biodiversity in its vineyard. Since the winery was built in 1980 7,491 trees and shrubs have been planted to provide windbreaks, prevent soil erosion, provide habitat suitable for birds and reduce the obtrusiveness of the building structures on the landscape. Furthermore, a small bush garden has been established to provide a reliable source of seed for revegetation projects and the preservation of the Barossa Valley's environmental heritage (see Peter Lehmann website).

5. Mitchell Winery's philosophy is that careful soil management and conservative old-style farm and biodynamic practices have proven to be not just sustainable, but to deliver consistently excellent fruit that equates with the same consistency (see Mitchell website).

AUSTRALIAN CONSUMER OPINIONS OF ECO-LABELS

Lockshin, (in Striegler et al. (Edts.), 2009, p. 49) points out that "Australia has been behind in trumpeting environmental credentials, certainly compared to countries such as the United States." Lockshin claims that "the wine sector is in the early stages of consumer recognition of the environmental issues associated with wine making."

(Lockshin, in Striegler et al. (Edts.), 2009 p. 56). Eco-labels signal the environmental attributes of a product to consumers. The goal of eco-labels is to "provide simple and easily interpretable information, and to elicit increased demand for products perceived as environmentally favourable" (Delmas and Grant, 2010, p. 2).

Molla-Bauza et al. (2005, pp. 49-50) argue that "one of the main problems of organic products is their high price, which is a consequence of high production costs, between 25 and 30% above the costs of a conventional wine. Presently, however, there is no evidence that consumers are willing to pay more for these products." Most consumers seem to be unaware of the large amount of waste products wineries produce. They seem to believe wine is a natural and environmentally benign product." Customers will only pay premium prices when they believe that the benefits of purchasing environmentally sustainable products outweigh the costs of such purchases," according to Laroche (Laroche et al., 2001, in Bhaskaran et al. 2006, p. 680).

Winemakers and marketers therefore have the challenge of convincing wine buyers that the additional costs of 'green' wine result in a product that is higher in quality, irrespective of the challenges that stem from a changing climate.

Delmas and Grant (2010, pp. 3-5) argue that eco-certification can provide benefits, such as improved reputation in the industry or increased product quality. Furthermore, green products are credence goods; consumers cannot ascertain their environmental qualities during purchase or use. Customers are not present during the production process of the product and therefore cannot observe environmental friendliness of production. The objective of eco-labels is to reduce information asymmetry between the producer of green products and consumers by providing credible information related to the environmental attributes of the product and to signal that the product is superior in this regard to a non-labelled product. Moreover, green products have been defined as "an impure public good because they yield both public and private benefits. They consist of a private good, such as the pleasure of drinking wine, jointly produced with a public good, like biodiversity protection due to organic farming" (Delmas and Grant, 2010, p. 6).

Bhaskaran et al. (2006 p. 685) point out that Labelling and trade marking food products as green, environmentally sustainable or eco-friendly is unlikely to increase the demand for these products because interviewees:

- could not differentiate between the tacit or implied benefits and attributes of products labelled as green, environmentally sustainable or eco-friendly; and

- indicated that their customers do not perceive food products described as green, environmentally sustainable or eco-friendly as having special attributes that is of value to them.

There is a market for organic wines in Australia, albeit not a very large one. A small proportion of wine consumers (14 % of the sample) are clearly environmentally conscious with eco-friendly claims accounting for almost 40% (30% + 9%) of the decision-making process, when making a purchase for a special occasion. Previous research shows this to be about 25% of wine consumption occasions in Australia see (see Lockshin, in Striegler et al. (Edts.), 2009, pp. 56-57). This low demand for organic wines reflects a low salience of these types of wines. Salience refers to the propensity of the product or brand to be noticed or thought of in buying situations. Finally, implementing environmentally sustainable production and marketing regimes that customers trust, would call for “channel-wide commitment and the capability of channel members to control and monitor the protocols used by other intermediaries in the value-chain,” according to Bhaskaran et al. (2006, pp. 679-680). In light of this it is useful to keep in mind the following passage:

It is likely that no one will ever create a perfectly sustainable vineyard, in part because what is considered sustainable today may not be rigorous enough for tomorrow. Moreover, growing grapes leaves an environmental footprint and there will always be something that can be done to make the footprint smaller. It can be said that the world of sustainable agriculture is one where the horizon is always receding (Ohmart, in Striegler, Allen et al., 2009 (Edts.) p. 22).

CONCLUSION

This paper has examined climate change and its impact on the Australian wine industry. Clear scientific evidence that climate change is something that is happening now, rather than something to worry about in the future, exists and has been outlined in this paper. The problem of climate change is something that all nations have to address if it is to be curbed. Climate change impacts several industries. The wine industry is but one.

As a consequence of climate change global temperatures have and will continue to rise. Droughts and floods will increase. Water is crucial for winemaking and therefore needs to be properly managed. Smoke from fires has the potential to cause serious, sometime permanent damage to vines – the predicted increase in bushfires as a result of drier weather, lightning and arson ought to be a concern for winemakers. All of these factors will influence the quality of wine produced in Australia.

The impact of climate change on the Australian wine industry also has the potential to put the meaning of the concept of terroir as it is currently known in jeopardy.

Furthermore, and also related to quality, wineries will need to find new ways to gain a competitive advantage. This may mean wineries have to find new ways to adapt to the climate as it changes, while keeping the business going. Several Australian wineries have modified their production processes in light of climate change. These modifications broadly come under two headings, namely biodynamics and sustainable winemaking. This paper has outlined both of these concepts. These processes have been implemented by wineries in several States in Australia and the measures taken by six of these wineries have been provided. All of these wineries

share the common goal of producing quality wines for consumers while striving to be environmentally friendly and sustainable, in light of climate change. While wines produced by biodynamic and sustainable methods have been shown, to a certain extent, to be of higher quality, this quality comes at a cost. The wines are more expensive to produce and therefore cost more for the consumer. At this point, most consumers remain unconvinced that the added cost is justified. Therefore, winemakers will need to work harder to demonstrate the benefits that come from biodynamic and sustainable winemaking.

While this paper has concentrated on the Australian wine industry, it is crucial that the global wine industry take steps to mitigate the effects of climate change if it is to remain prosperous and sustainable as the climate continues to change in years to come.

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