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1. Abstract

Currently the production of wine grapes is not a viable business for many growers in inland Australian regions such as the Riverina and is only marginally profitable for others. This project sought to develop understanding of the social and economic drivers of prosperity and profitability for grape production by understanding inputs and outputs across vineyard scales to make grape growing a viable business, attract new entrants and staff, and increase overall profitability in the Riverina. The identification of barriers to practice change derived from evidence based social research will be a key outcome linking the viticultural and spatial data with actionable knowledge specifically targeting wine growers and producers.

2. Executive summary

This report culminates from a co-designed project involving researchers from Charles Sturt University, Wine Australia, New South Wales Wine Industry Association and the Wine Grape Marketing Board in Griffith. The input and guidance of representatives from each of these organisations is gratefully acknowledged. The report is comprised of three components.

- A literature review of important aspects of wine grape production identified by the project advisory committee and where relevant a specific perspective for the Riverina is presented. Some information within this section of the report is compiled from anonymised grower and vineyard information from the Wine Grape Marketing Board.
- A social and ethnographic research investigation to determine and record 'The Lived Experience' of growers in the Riverina. This work has been thoroughly documented using a series of questionnaires and in-depth interviews of grower that represent a cohort of primary producers at varying scales and diversity of production.
- An economic impact analysis of the current production environment for growers in the Riverina. The information in this investigation was derived from in-depth interviews of growers representing varying size and complex grape production enterprises and family business.

The authors of this report are indebted to the generosity and openness of the growers who participated in this research, and we convey our heartfelt thanks to them in providing insights of industry at an uncertain, difficult and challenging time.

Wine grape production like any perennial horticultural enterprise is an inherently risky business and has some unique risk profiles. Long-term investment requirements with timelines typically between 2-3 decades, the substantial capital investment required at establishment phase of the vineyard life, and the lag between planting vines and harvest of a commercial crop typically create a loss-making business in the early stages of vineyard life.

Historically, mitigation of risk for wine grape production in Australia has meant that extensive investment of vineyards and wineries has occurred in warm inland and irrigated regions which have a relatively low disease risk. Corporate and managed agricultural investment schemes in the early to mid 1990's created a substantial increase in vineyard area within some regions of Victoria, New South Wales and South Australia, and many of these vineyards are now reaching the end of their commercial life. Grape over-supply for some varieties coupled with changing consumer tastes and the loss of important export markets though imposition of importation tariffs means the profitability of grape production is seriously challenged, especially within warm to hot regions.

Unlike many other agricultural production systems, grape production is highly inflexible and requires consistent management of vines for optimum crop quality. Managing productive yield in grape vines in response to short- and medium-term climate or market forces is very difficult, unlike other agricultural commodities such as broad-acre cropping, meat or fibre production that enables flexible management of planting and stock management.

Recommendations from this review address grower wellbeing, improving relationships between growers and wineries, improved financial literacy to empower growers' knowledge of business, production, and product knowledge gaps and seek to improve the extension of technology to growers leading to a sustainable and profitable wine grape industry.

Producers identified a strong sense of their own abilities and willingness to seek advice about growing grapes, suggesting that tools supporting evidence-based decision making would be readily adopted.

Importantly any underlying power imbalance between grape growers and wineries needs to be addressed so that producers can benefit from evidence-based decision making.

The recommendations broadly seek to provide better support for growers, improvements to grower and winery relations and to provide the necessary knowledge and skills manage vineyards for sustainable and profitable grape production. Recommendations within the report are summarised as:

1. Mental health and wellbeing support for Riverina grape growers should be an urgent priority. This includes supporting cultural and contractual change in the relationship between wineries and growers.
2. Value chain analysis to improve the understanding and transparency of pricing for wine grapes, discounts and quality penalties. Development of a co-design participatory project, including multiple wineries and grape growers, to inform the value chain analysis is necessary to develop strong, trusting and ethical relationships between grape growers and wineries. A caveat would be that the exiting relational and contractual issues already existing between wineries and grape growers are identified and addressed.
3. Improving trust and engagement between growers and wineries though hosting regular market insights events. Presentations of sector highlights that provide growers with knowledge of winery demand for grapes would empower growers with knowledge on how to provide better value to the final consumer. For these events to succeed, however, it will be necessary for the existing relationships between Riverina grape growers and the wineries to be mediated, with examination of the dimensions of power and respect, to avoid the reinforcement of existing relational and contractual issues and to strengthen reciprocal and respectful partnerships.
4. Development of a suite of financial tools to determine minimum grape prices at varying scales and locations of production to enable break even analysis to be undertaken by individual growers.

5. Improved understanding of emerging mechanisation and digital technologies that improve vineyard productivity and profitability, product traceability, accreditation, and certification for market access. Integration of data capture and reporting for sustainable operations should be incorporated into a digital interface. Articulation with the Vineyard of the Future project at Charles Sturt University is an opportunity to de-risk introduction of innovative solutions and provide demonstration sites for growers to emerging technology.
6. Identify flexible vineyard management practises that can be ceased during periods of expected economic stress, without significant loss of productive capacity in following years to enable adaptable grape production. Potential trial sites could utilise existing aged vines within the Charles Sturt university vineyard and link to the Vineyard of the Future project.
7. Improved understanding of the most effective and economical methods for changing existing grape varieties to alternative varieties (including table grapes) should be explored, along with understanding the confounding factors of rootstocks/own roots and vineyard disease incidence upon outcomes of interventions for vineyard transformation.
8. Synergies to improved understanding of the relationship between plant water use, irrigation timing, water monitoring, scheduling, and delivery options to manage crop yield within grape specifications is a research priority. Objective grape compositional measures linked to price need clear definition. The grape vine yield limits at which grape composition is maintained within specification also require evidence.
9. Optimised groundcover plantings that maximise vineyard biodiversity, beneficial predatory insects and assist in maintaining grape berry composition with an emphasis on complex nitrogen to assist yeast fermentation.
10. Increasing demand for existing grape varieties through new product development targeting reduced and non-alcoholic beverages will address a growing consumer demand for NOLO wines. The gap between market appeal and the time needed for variety changeover, however, needs to be acknowledged, and solutions that reflect an understanding the producers' experience explored and tested.
11. A more thorough understanding of the potential of wine grape varieties from hot Mediterranean climates better suited to the Riverina to produce dry table wines with a goal to reposition the Riverina as a producer of high-quality table wines. The transformation over the past two decades of wineries in the Douro Valley of Portugal from fortified to producers of ultra-high premium could serve as an exemplar, with priority given to practice change approaches that strengthen producer self-efficacy and optimism in the future of grape-growing in the Riverina.
12. Development of industry-wide marketing stories that demonstrate Environmental, Social and Governance (ESG) credentials for water, energy and chemical applications that lead to an improved social license. Great care, however, would be needed to ensure that authentic stories are used and that the current situation in the Riverina grape growing industry is that cultural change will be needed before this recommendation is implemented.

13. The challenges around profitability and sustainability are not confined to the Riverina wine region of NSW. It is further recommended that any future research and projects resulting from this study be expanded to include the Murray Valley and Riverland wine regions alongside Riverina as combined they represent 70% of Australia's grape production.

3. Background

A vibrant and prosperous wine industry is dependent on grape production and supply at many levels of quality across varying climates and geographies. High quality grapes ensure high quality wines that conform to consumer demand and expectations for flavour, style and environmentally sustainable production. With a significant lag between an investment decision for planting a vineyard and productive grape harvests, perennial cropping systems are an inherently risky business with multiple risk factors that are not readily applicable or managed in response to external factors compared to other agricultural commodities. The ability to consistently produce grapes with low inputs that are suitable for wine production has been an attractive value proposition for growers in the Riverine for decades.

The digital world in which we live creates opportunities for rapid exchange of information, data harvesting and more informed consumers. Consumer patterns of consumption are changing to healthy food and beverage options, with consumers demanding choice of supply from production systems reflecting authentic sustainable values. Changing consumer demands has created a requirement for wine producers to be highly responsive to global supply chains and market forces and respond more rapidly than an ever before.

A warming climate with more extreme weather events during the growing season combined with oversupply of some varieties have compounded the demands upon the industry to external pressures. The Riverina produces between 17-19% of the Australian annual grape crush (Wine Australia 2021, 2022). Locations along the Murray River in Victoria, New South Wales and South Australia have been important grape and wine producing regions in Australia for many decades with approximately 70% of the total national crush harvested from these regions (Wine Australia, 2021). These regions have relatively secure water availability for irrigated cropping, and a consistent climate that limits disease risk. It was the lowering of risk that made warm and irrigated inland regions an attractive location in which to grow grapes for wine production. However, the profitability for grape producers has been challenged in recent years, compounded by a record 2021 harvest followed by reduced cropping potential in 2022, loss of important export markets and changing consumer preferences. The 2023 grape harvest will be equally challenging due to substantial rainfall during the growing period that has increased disease pressures. In response to increased disease pressure there is a substantially increased requirement for application of foliar sprays at times when soil moisture and flooding has prevented vineyard access.

This report includes a desktop review of important factors associated with growing grapes, and value chain analysis, with an emphasis on production systems relevant for warm irrigated inland regions. Where information has been identified that is especially relevant for growers in the Riverina this is presented to enable readers to contextualize the production systems specific for that region.

The report also outlines the social research that was undertaken, to explore the lived experience of grape growers in the Riverina, and the social and psychological nuances associated with vineyard practices and decision-making.

The third part of this project report describes a detailed economic analysis for growers located in the Riverina. This section describes the current gross margin position of growers at varying vineyard sizes and can be used to inform and prioritise future research priorities. Findings from this project can be used to inform the development of business cases for research to support the sustainability and profitability of the wider Australian wine industry.

Grape varieties and quality

As with any consumer goods, the concept of wine quality is nebulous and difficult to objectively define. In general, wine quality may be considered features of the beverage that comprise 'fitness for purpose'. Wine consumers are complex and consumer tastes and appreciation for specific wine styles do change over time. Accordingly, the attributes of wines that comprise quality may also change over time. Broadly, quality wines are those that are flavoursome, free from faults and meet consumer expectations of flavour and price within specific market segments. The production of high-quality wines that meet consumer expectations is most easily achieved through the production of grapes that meet minimum standards for ripeness, potential flavour and are delivered to the winery in a timely manner without damage.

Growers need to grow varieties suitable for the intended style of wine as well as being suitable for the environment, and then achieve the quality parameters for that style. Iland et al. (2011) has defined wine styles for red and white varieties in relation to total soluble sugar content, shown in Table 1. Time of harvest in relation to ripeness plays a large role in attaining a suitable quality for the target style of wine. However, the quality of grapes is also influenced by temperatures during ripening, such that the region (cool to hot) in which grapes are grown will influence the flavours of the wine produced.

Table 1. Total Soluble Sugar (TSS) content required for different styles of wine (Iland et al. 2011).

Wine style	TSS °Baumé
Sparkling	9-11
Light-bodied dry red or white	10-12
Full-bodied dry red or white	12-14
Semi-sweet white	13-16
Sweet white	17-22
Dry white fortified	10-12
Sweet red fortified	14-16
Sweet white fortified	17-22

Factors which contribute to grape and wine quality have been reviewed by Jackson and Lombard (1993) and include:

- Soluble Sugars as an estimate of sugar content, which indicate alcohol content in the wine. Measured in Brix, low values indicate unripe grapes, while excess sugar levels above 24°Brix indicate over-ripe grapes.
- Organic acids, measured as total Titratable Acids (TA). High respiration rates in fruit cause a rapid decline in acid content. In warm climates, low acid levels (6-7 g/L TA) result in bland wine while high acid levels (10 g/L TA) result in tart wine.
- pH above 3.6 reduces wine quality. It increases with sugar content, so can indicate the optimal time to harvest.

- Phenolics and anthocyanin. Phenolics are tannins which cause bitterness and astringency, while anthocyanins contribute to the red colour in wine.
- Monoterpenes contribute unique flavour and aroma in white grapes.
- Asynchronous berry development due to variation in ripening reduces wine quality.
- Disease, environmental factors such as smoke, and growing in proximity to eucalypt trees may each also influence the taste and so quality of grapes (Iland et al., 2011)

The price wineries pay for wine grapes is partially dependent on grape quality, with discounts applied or grapes being rejected for suboptimal quality. Quality is determined by vine variety, but also by a range of factors including minimum fermentable sugars at harvest, presence or absence of disease, sunburn and matter other than grapes (MOG), flavour profiles and extractable colour for certain red varieties. The range of quality factors assessed, the method of assessment and the penalty applied can vary between wineries, creating uncertainty for growers (ACCC, 2019). Grape quality can be measured both pre-harvest and at the weighbridge upon delivery to wineries. However, the measurement of phenolics, colour or tannins for red grapes is conducted by few small wineries, and is generally undertaken pre-harvest (AWRI, 2019).

Matching varieties and quality to growing conditions

Terroir is the unique sensory aspects of a wine linked to a location and is a key factor in the marketing of wine and willingness for consumers to pay higher prices for the same variety from different locations. The impact of location on the chemical attributes of grapes appears to be driven largely by differences in water availability and growth ripening conditions (Koundouras, 2022). The management of vines is an important factor in achieving quality grapes, more so than a specific locational aspect within a region (Lock, et al, 2019). Therefore, there is capacity for growers to produce quality grapes in many regions, however not all varieties are suited to all regions. Climate undoubtably influences wine grape composition second only to cultivar selection (Schmidtke et al. 2020), and matching grape varieties to a suitable climate that enables specific wine styles that command a price premium is a challenging task. A balance between growing grapes for wine styles that serve existing markets whilst developing new products and styles that build upon the consumer knowledge base of wines from specific regions creates tension within the grape supply value chain. Juxtaposed to consumer and buyer knowledge of the Riverina as a bulk wine producer is the challenge for quality grape production within a warm to hot climate and emerging competition for water and labour by other high farm-gate value crops.

Site specific factors including water availability either as rainfall or irrigated supply, frost risk, diurnal temperature and growing season temperature and their complex interactions have bearing upon grape composition and therefore potential wine styles. Of these, the most influential factor is temperature during the growing season, with a global band between 12-22°C considered optimum for traditional wine varieties (Jones 2010). Attempts to match climatic indexes based upon heat accumulation,

diurnal temperature changes and frost risk to suitable wine grape varieties has been a goal of viticultural research for decades (Tonietto and Carbonneau 2004). The most common measures of climate suitability for grape production are heat accumulation indexes calculated for the growing season (October to April for southern hemisphere) such as the heliothermal Hughlin index (HI) that adjusted for daylight length at varying latitudes, growing season temperature (GST) and GST with latitude correction (Liles and Verdon-Kidd 2020), Growing Degree Days (GDD) and Biologically Effective Degree Days (BEDD). Each index has specific calculations based upon temperature and associated class limits with broad recommendations associated for optimum wine grape growing. A summary of each index calculations and class is presented in Table 2. As expected from the methodology for calculation of each index, a high correlation between them has been demonstrated (Hall and Jones, 2010) and therefore further discussion in this report will be limited to GST.

Mean values for GST for the Riverina are projected to steadily increase from the current 21.8°C to 23.3°C between 2041-2060, 24.5 between 2061-2080, and reach 25.3°C between 2081-2100 based upon accepted predicted climate models (Remenyi et al. 2019). These projected increases in GST for the Riverina will shift the GST class from very hot to potentially too hot for premium wine grape production. Projected climate index values for the Riverina are presented in Table 3.

Aligning an average growing season temperature to wine grape cultivar requirements for phenological development and optimum grape ripening for flavour is a complex undertaking and a published guide developed in 2006 (Jones 2006) is limited to only the most popularly grown cultivars within a worldwide context as shown in Figure 1. Many wine-grape varieties shown in Figure 1 are grown in regions that possess a GST beyond the depicted groupings and may produce acceptable wines in certain years. In cooler conditions there is a risk that wine typicity is not achieved for a specific variety, and warmer conditions beyond the boundaries of the depicted temperature zones for grape production may be more suited to high-yielding bulk supply or fortified wines (Jones 2010).

Table 2. Derived climate variables applicable to wine grape production. GST: Growing Season Temperature, GDD: Growing Degree Days, HI: Huglin Index, BEDD: Biologically Effective Degree Days. (Hall and Jones, 2010).

Variable	Equation	Months	Class Limits†
Average GST	$\frac{\sum_{d=1}^{n}[T_{max}+T_{min}]/2}{n}$	1 October – 30 April	Too cool < 13°C Cool = 13 – 15°C Intermediate = 15 – 17°C Warm = 17 – 19°C Hot = 19 – 21°C Very hot = 21 – 24°C Too hot > 24°C
GDD‡	$\sum_{d=1}^{n}\max[(T_{max}+T_{min})/2-10,0]$	1 October – 30 April	Too cool < 850 Region I 850 – 1389 Region II 1389 – 1667 Region III 1667 – 1944 Region IV 1944 – 2222 Region V 2222 – 2700 Too hot > 2700
HI	$\sum_{d=1}^{n}\max[(T_{mean}-10+T_{max}-10)/2,0]K$ where k is an adjustment for latitude/day length⁋	1 October – 31 March	Too cool < 1200 Very cool 1200 – 1500 Cool 1500 – 1800 Temperate 1800 – 2100 Warm temperate 2100 – 2400 Warm 2400 – 2700 Very warm 2700 – 3000 Too hot > 3000
BEDD	$\sum_{d=1}^{n}\min[\max([T_{max}+T_{min}]/2-10,0)K+TR_{adj},9]$ where $TR_{adj}=\begin{cases}0.25[Tmax-Tmin-13],[Tmax-Tmin]>13\\0,10<[Tmax-Tmin]<13\\0.25[Tmax-Tmin-10],[Tmax-Tmin]<10\end{cases}$ and K is an adjustment for lattitude/day length	1 October – 30 April	< 1000 1000 – 1200 1200 – 1400 1400 – 1600 1600 – 1800 1800 – 2000 > 2000

† Class names for each variable are not directly comparable i.e. GST cool does not necessarily compare to HI cool

‡ GDD classes are based upon rounded °F which produce non-rounded classes in °C units

⁋ K is a latitude coefficient that accounts for increasing day lengths starting from 1.0 at 34° increasing incrementally pole ward and is based upon day length using Julian day and latitude.

Table 3. Current and projected climate indexes for the Riverina until 2100. Projected GST values are based upon accepted climate models (Remenyi et al 2019) and converted to alternative climate indexes using formula from Hall and Jones 2010).

Year	GST (projected)	Hughlin Index	Growing Degree Days	Biologically Effective Degree Days
Current	21.8 Very hot	2862 Very warm	2426 Region III	1811
2041-2060	23.3 Very hot	3163 Too hot	2740 Too hot	1912
2061-2080	24.5 Too hot	3405 Too hot	2991 Too hot	1969
2080-2100	25.3 Too hot	3565 Too hot	3158 Too hot	1995

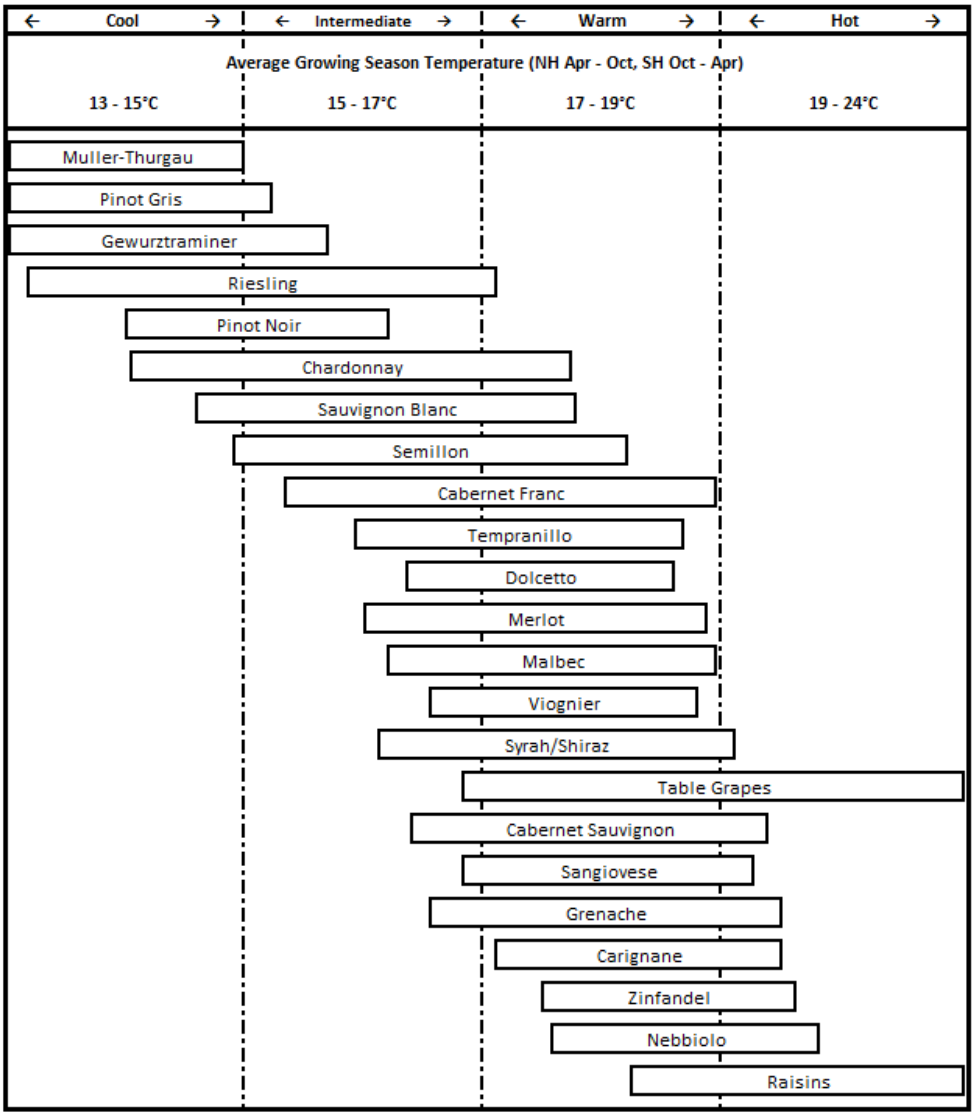


Figure 1. Grapevine climate maturity groupings based on relationships between phenological requirements and growing season average temperatures for high to premium quality wine production for some common cultivars (Jones 2006). Length of rectangle indicates the estimated span of ripening for that varietal.

Notably absent from this guide are wine grape cultivars historically grown in warm to hot climates typical of Mediterranean regions and which may be more suited to the current and projected climate (Remenyi et al., 2019) of the Riverina. Future planting of wine grapes in the Riverina needs to be carefully considered as what specific varieties are desirable from a winery production and marketing perspective, along with climatic suitability.

The median age, size and listed varieties of vineyards in the Riverina is shown in Table 4. With commercial vineyard life typically spanning 25-35 years there exists an opportunity for selection of new varieties for the region that are well suited and more adapted to a changing climate whilst ensuring high quality premium table wines can be produced.

Intriguingly a dilemma similar to that faced by grape growers in the Riverina was experienced by grape growers in the Duoro Valley (Portugal) twenty years ago i.e., grape oversupply for certain varieties, changing consumer demands for lighter style wines and a portfolio of somewhat unfashionable wine styles being mostly fortified wines and heavily extracted table wines. Undoubtably the Duoro is a world-renowned region famous for fortified wine production, and benefits from a stunning geography that readily enables a varied approach to grape production. Over the past 10-15 years a remarkable transformation of wine production has occurred within the Duoro such that the volume of elegant table wines now rivals the quantity of fortified wine production (Asimov, 2019). Historically the Riverina has been a producer of some excellent fortified wines, unfortunately consumer demand for these wines has decreased substantially over the past several decades. With over 1100 commercial wine grape cultivars worldwide (Wolkovich et al. 2018) there is a large pool of varieties that may be better suited for high quality table wines to be produced from warm to hot inland regions of Australia, than those presented in Figure 1.

Review of the Riverina

Riverina vineyard characteristics including cultivars, proportion of vineyard area, and median age are presented in Table 4. A significant diversity of grape varieties is grown in the Riverina, however five varieties dominate the pool of cultivars (Shiraz, Chardonnay, Cabernet Sauvignon, Merlot and Semillon) and comprise over 62% of the total vineyard area. The median vineyard age for each of these varieties is between 21-25 years and this infers that substantial vineyard renewal will become necessary over the next 10 or so years for commercial production. Less commonly planted varieties include some of the more temperature tolerate varieties (e.g. Fiano, Vermentino, Graciano, Durif, Nero d'Avola) typically grown in Mediterranean climates and these also tend to be vineyards with a lower median age. There appears to be a growing demand for varieties well suited to the Riverina for table wine production and early adopter growers have embarked upon planting small areas of selected varieties to meet this demand and in anticipation of climate adaptation.

Any increase to the size and varieties planted in the Riverina need to be considered in consultation with wineries. A planned and co-ordinated campaign to increase consumer awareness of the quality

potential of Mediterranean varietal wines grown in the Riverina and other warm inland irrigated regions involving growers, wineries, The Alternative Wine Show representatives, and influential wine writers could be considered to raise the profile of warm inland regions. Such campaigns tend to be long-term endeavours and would require significant marketing budgets.

In response to increasing consumer demand for alternative varieties more suited for warm climates, product innovation to develop consumer preferred beverages with no or low alcohol using established varieties should be a priority. A rapidly expanding demand for alternative healthy beverages is apparent and ensuring high quality products that meet expectations for flavour, texture and value is a recognised research priority for the Australian grape and wine industries (Wine Australia, 2022)

Table 4. Wine grape vineyard plantings, size and age for the Riverina (Wine Grape Marketing Board, 2022)

Variety	Average Year established	Oldest Vineyard (years)	Median Vineyard Age (years)	Youngest Vineyard (years)	Total hectares	Proportion of Riverina Vineyard	Number of Vineyards	Average Size (Hectare)	Max Size (Hectare)	Min Size (Hectare)	Median Size (Hectare)
Shiraz	1997	69	24	1	4589.86	22.2%	757	6.1	98.2	0.1	2.8
Chardonnay	1999	54	21	0	3848.95	18.6%	581	6.6	240.0	0.1	2.9
Cabernet Sauvignon	1998	62	24	1	1579.42	7.6%	233	6.8	96.1	0.2	3.6
Merlot	2001	47	24	1	1477.97	7.1%	214	6.9	189.9	0.1	3.1
Semillon	1996	62	25	5	1395.59	6.7%	377	3.7	25.0	0.2	2.0
Pinot Grigio	2009	23	16	0	1248.42	6.0%	110	11.3	203.7	0.2	5.7
Sauvignon Blanc	2008	47	14	0	926.58	4.5%	143	6.5	35.0	0.3	4.3
Durif	2008	42	10	1	767.01	3.7%	125	6.1	38.7	0.6	3.8
White Frontignac	2007	46	14	8	673.01	3.3%	58	11.6	68.1	0.5	8.3
Ruby Cabernet	1997	47	24	3	559.06	2.7%	94	5.9	33.8	0.6	4.4
Lambrusco Maestri	2014	16	6	4	512.05	2.5%	28	18.3	88.6	1.3	9.1
Colombard	1997	52	24	1	427.24	2.1%	103	4.1	21.0	0.1	2.6
Traminer	2001	55	20.5	8	407.19	2.0%	94	4.3	39.5	0.4	2.3
Pinot Noir	2003	42	15	1	327.31	1.6%	71	4.6	23.2	0.2	4.0
Muscat Gordo Blanco	1998	62	20.5	8	223.89	1.1%	46	4.9	31.4	0.1	2.3
Petit Verdot	2001	43	23	2	210.5	1.0%	40	5.3	21.9	0.6	3.4
Malbec	2014	13	12	2	208.4	1.0%	13	16.0	38.3	6.6	11.3
Canadian Muscat	2011	14	11	8	206.86	1.0%	16	12.9	50.5	2.0	7.6
Verdelho	1998	32	24	18	196.97	1.0%	24	8.2	47.6	0.5	5.5
Riesling	1998	47	24	14	151.41	0.7%	37	4.1	12.5	0.5	3.3
Viognier	2004	24	17.5	14	124.56	0.6%	16	7.8	21.1	1.6	6.0
Marsanne	1991	57	26.5	23	66.86	0.3%	12	5.6	17.8	0.8	3.8
Nero D'Avola	2011	15	11	8	48.08	0.2%	6	8.0	13.4	1.5	9.7
Tempranillo	1998	42	22	17	45.1	0.2%	7	6.4	20.4	0.3	3.5
Red Frontignac	2002	38	20.5	8	44.72	0.2%	14	3.2	10.3	0.7	2.2

Variety	Average Year established	Oldest Vineyard (years)	Median Vineyard Age (years)	Youngest Vineyard (years)	Total hectares	Proportion of Riverina Vineyard	Number of Vineyards	Average Size (Hectare)	Max Size (Hectare)	Min Size (Hectare)	Median Size (Hectare)
Isabella	2016	7	7	6	43.66	0.2%	3	14.6	33.9	0.4	9.4
Mataro	1994	45	24	24	33.65	0.2%	8	4.2	12.9	0.2	2.1
Dolcetto	2007	22	14	9	27.18	0.1%	4	6.8	11.7	1.1	7.2
Chenin Blanc	1995	37	29	15	25.53	0.1%	9	2.8	7.9	0.7	2.2
Sangiovese	2001	24	23	8	23.29	0.1%	8	2.9	6.0	1.2	2.6
Prosecco	2019	5	4	1	19.33	0.1%	5	3.9	6.9	2.0	3.5
Tyrian	2000	23	22.5	20	19.1	0.1%	4	4.8	8.4	1.3	4.7
Vermentino	2013	14	9.5	1	16.92	0.1%	6	2.8	8.3	0.4	1.2
Fiano	2017	14	1	1	16.01	0.1%	3	5.3	8.1	3.3	4.6
Trebbiano	1980	57	46	23	15.06	0.1%	10	1.5	3.2	0.4	1.5
Barbera	1990	47	29	22	13.05	0.1%	4	3.3	10.4	0.9	0.9
Aglianico	2009	17	11	10	12.82	0.1%	3	4.3	8.8	1.5	2.5
Cabernet Franc	1993	33	33	26	11.48	0.1%	3	3.8	6.2	1.0	4.3
Roussanne	2009	15	13	11	11.33	0.1%	2	5.7	8.6	2.7	5.7
Montepulciano	2013	15	11	2	10.32	0.0%	6	1.7	4.1	0.2	1.3
Palamino	2007	21	18	5	9.78	0.0%	3	3.3	7.2	1.3	1.3
Caverdella	2006	19	16	13	9.28	0.0%	2	4.6	8.0	1.3	4.6
Chambourcin	1989	49	32.5	19	8.89	0.0%	4	2.2	6.8	0.2	0.9
Carmenere	2010	12	12	12	7.25	0.0%	1	7.3	7.3	7.3	7.3
Grenache	1998	26	24	22	6.61	0.0%	2	3.3	3.4	3.2	3.3
Touriga	1999	38	23	8	6.39	0.0%	2	3.2	4.5	1.9	3.2
Tannat	2006	16	16	16	5.29	0.0%	1	5.3	5.3	5.3	5.3
Table Grape	2020	2	2	2	5.25	0.0%	1	5.3	5.3	5.3	5.3
Zinfandel	1997	25	25	25	5.23	0.0%	1	5.2	5.2	5.2	5.2
Arneis	1999	23	23	23	5.02	0.0%	1	5.0	5.0	5.0	5.0
Lagrein	2006	16	16	16	4.69	0.0%	1	4.7	4.7	4.7	4.7

Variety	Average Year established	Oldest Vineyard (years)	Median Vineyard Age (years)	Youngest Vineyard (years)	Total hectares	Proportion of Riverina Vineyard	Number of Vineyards	Average Size (Hectare)	Max Size (Hectare)	Min Size (Hectare)	Median Size (Hectare)
Muscat Giallo	2011	11	11	11	3.6	0.0%	1	3.6	3.6	3.6	3.6
Muscat Hamburg	2004	23	19	11	3.2	0.0%	4	0.8	1.3	0.5	0.7
Pedro Ximenes	2006	16	16	16	2.11	0.0%	1	2.1	2.1	2.1	2.1
Negroamaro	2000	22	22	22	1.97	0.0%	1	2.0	2.0	2.0	2.0
Tokay	2002	20	20	20	1.8	0.0%	1	1.8	1.8	1.8	1.8
Saint Macaire	2013	15	9	3	1.63	0.0%	2	0.8	1.0	0.6	0.8
Aranel	2001	21	21	21	1.4	0.0%	1	1.4	1.4	1.4	1.4
Graciano/Saperavi	2019	3	3	3	0.69	0.0%	1	0.7	0.7	0.7	0.7
Mixed Red	1981	41	41	41	0.63	0.0%	1	0.6	0.6	0.6	0.6
Red Emperor	1972	50	50	50	0.25	0.0%	1	0.3	0.3	0.3	0.3
Sultana	1913	109		109	9.23	0.0%	7	1.3	3.0	0.5	0.8
Palomino	2007	21	3	5	9.78	0.0%	3	3.3	7.2	1.3	1.3
Grillo					2.05	0.0%	1	2.1	2.1	2.1	2.1

Water use and irrigation practices

Supply of water is one of the major costs for warm-climate vineyards (Retallack 2012) since irrigation is required for optimal vine yield, meaning efficient use of water improves profitability. The quantity of water required for irrigation varies between regions and properties depending on climate, rainfall, soil type and vine management strategy. Monitoring of soil moisture and vine condition is essential to efficient water management, and this will increase in importance with the projected increases in temperature and reduction in rainfall across Australia due to climate change (Webb, et al. 2007). A reduced availability of water for irrigation in warm regions can be expected to increase the cost of water, increasing the need for higher efficiencies of use.

Vineyard monitoring (soil and vines) is important to avoid excess moisture stress particularly during the period of flowering to fruit set when it may reduce crop yield, and during the ripening period where stress may delay ripening and reduce berry flavour (Proffit and Campbell-Clause no date). Excess water stress after veraison (ripening) can be associated with longer-term impacts by causing a reduction in grape yields and quality in the subsequent as well as current harvest (Iland, et al. 2011). Irrigation practice is also used to limit vine growth to avoid reductions in yield (Fahey, et al. 2021) and excess shading of berries which can reduce the intensity of flavour in wine (Iland, et al. 2011). Optimally, irrigation is reduced to prevent shoot growth after veraison whilst maintaining a healthy vine.

Regulated Deficit Irrigation is a recommended practice for established vines of red grape varieties (Proffit and Campbell-Clause no date), where some water stress is applied in the period fruit set to veraison with the intent of restricting canopy growth to minimise water requirement and size of berries to maximise grape quality. Another method is Partial Rootzone Drying (Dry and Loveys 1998), which requires a second drip line to allow watering and drying of different parts of the rootzone. This method reduces the risk of reduced grape yield which can occur if the whole root zone dried to a level which created more than a mild water stress to the vine. Partial rootzone drying halves the quantity of irrigation water required compared with full irrigation (Iland, et al. 2011), reducing costs in the longer-term but requiring additional costs during establishment of vineyards. Both restriction methods require an environment which allows soils to dry to an extent which creates water stress. Irrigation practice should also avoid excess water in the period veraison to harvest when splitting of berries may result (Proffit and Campbell-Clause no date), resulting in downgraded or unsaleable fruit.

Practices which increase the efficiency of irrigation include (Proffit and Campbell-Clause no date) use of drip rather than overhead sprinklers, appropriate dripper spacing for the soil type and system, use of under-vine mulch, irrigating at night to minimise losses from evaporation, and protection of water storages to reduce evaporation. Flood (furrow) irrigation is used by some Riverina growers, and at least in one study (Barlow, et al. 2009) used more water than alternative irrigation types on the same soil type.

Pulse irrigation, where the same quantity of water is delivered intermittently, may result in similar fruit yield as continuous irrigation (Zúñiga Espinoza, et al. 2017), but requires automated systems for labour efficiency. Subsurface irrigation systems can substantially reduce water requirements compared with surface drip irrigation, with a 20% reduction reported without adverse effects on grape yield or quality (Pisciotta, et al. 2018). Irrigation at depths of 30, 60 and 90 cm have produced similar grape yields, while placement of the drip line at 1.2 m distant from rather than at the trunk of vines may increase yield (Zúñiga Espinoza, et al. 2017). However, ideal placement may vary on different soil types. Subsurface dripper lines incur higher costs when establishing new vineyards, and infrastructure is protected if installed below the depth of tillage.

While there is a strong positive relationship between available water and grape yield, high yield can also be associated with reduced grape and wine quality, affecting profitability (Romero, et al. 2016). The financial benefit due to restricting irrigation will depend on the cost of water, whether grape yield is reduced, and whether higher prices are received for better quality grapes. The most water-efficient practices may not be the most profitable strategy for vineyards where yield rather than quality drives returns. However, where wineries place a cap on the yields they will receive, creating moderate irrigation restrictions to limit costs may be a viable strategy.

While drip irrigation can increase water use efficiency, it can also lead to higher rates of salinity in the root zone of vines, which at toxic levels will reduce vine productivity. The issue may be increased in drought years when the salinity level in irrigation water increases and lower rainfall prevents natural flushing events. Salt which accumulates during the year has historically been leached out of the root zone by a flushing irrigation post harvest. It is now recommended to avoid this practice, and instead conduct a flushing irrigation at the end of winter if required when the salt content of the irrigation water will be lower and less water is required to move leached salt below the root zone (Biswas, et al. 2008). Monitoring of water and soil salinity levels is required to determine whether they are approaching levels which impact on production.

The levels of salinity in irrigation water may also be important due to restrictions set on mineral concentrations in fruit (Iland, et al. 2011). An historical survey of Australian grape juices indicated that a small proportion contained concentrations of chloride above allowable limits, possibly exacerbated by use of overhead sprinkler systems and growing vines on their own roots rather than rootstocks which restrict the uptake of sodium and chloride (Leske, et al. 1997). Management to maintain acceptable fruit yield and quality therefore minimizes the risk of price penalties or failure of market access.

Under-vine management

The soil area under vines contains the majority of vine roots and so is important to vine health, productivity and water use. Typically, the under-vine area is sprayed with herbicide several times per year to control weeds which compete with the vine for water. However, long-term use of herbicide is undesirable due to selection for herbicide resistant weeds, and deleterious impacts on soil health and potential fertility. Soil

structure is degraded, reducing root penetration and water infiltration. The use of self-regenerating annual clover or medics, perhaps including an annual grass such as ryegrass, as cover crops is a preferable practice to suppress weeds, delay the development of herbicide resistance, contribute nitrogen and improve soil health. It can potentially increase vine yield without reducing grape quality and is intended as a once-only sowing operation, so minimizing costs (Penfold, et al. 2018). This practice has been demonstrated to increase profitability by -5 to +35% compared with standard herbicide use, based on change in vine yield, but assuming no reduction in herbicide or fertilizer costs (Nordblom, et al. 2021). Current studies are evaluating the potential of various under-vine and mid-row prostrate plant species to attract beneficial insects to promote biological pest control without excessively competing for water (Johnson, et al. 2021). Use of perennial grasses which compete for water over summer is likely to reduce vine yield in warm-climate locations, although they may be beneficial in environments where the soil or environment promotes shoot growth which results in excess canopy (Iland, et al. 2011). Mulching with straw may be a profitable alternative in some regions but requires a large initial outlay and more frequent replacement (Nordblom, et al. 2021), and will not provide on-going nitrogen fixation.

Review of wider situation

Warm inland regions of Australia used much more irrigation water (4.5 to 7 ML/ha) than cooler regions (typically 0.5 to 1.5 ML/ha) according to a 2015/16 survey (Australian Wine Research Institute 2019). There is also a wide range in the quantity of water used/ha between individual growers, with the water and drainage cost (excluding cost of water lease), for example ranging from $18 - 2085/ha for growers in the Murray Valley region for the 2010/11 season (Retallack 2012). This suggests large differences in either the source or efficiency of water use between growers within a region.

Australian vineyards predominantly (90%) use either drip or micro-spray systems (Australian Wine Research Institute 2019), which are the most efficient systems. Efficiency of water use can be improved through use of plant or soil sensor systems, but the use of these is < 25% of small growers (< 10ha), increasing with vineyard size to 80% of large growers (>100 ha). In most regions across Australia, less than 50% of growers use the Regulated Deficit Irrigation system (Australian Wine Research Institute 2019), although this method may be less suited to higher rainfall cool-climate regions.

Mulch on the under-vine area was not reported as used by Riverina growers but is commonly used in the Riverland and other regions by between 15 and 40% of growers (Australian Wine Research Institute 2019).

Review of situation in the Riverina

While 84% of Riverina vineyard area is irrigated by drip or micro-spray, approximately 15% is irrigated by flood or furrow. This differs from the Riverland, where spray/sprinkler irrigation is used on 13% of area, with most of the remainder being drip or micro-spray. In the 2015/16 season Riverina growers used less irrigated water (4.4 ML/ha) than Riverland growers (7.05 ML/ha), but the efficiency of use per ton of grape production

was similar. The use of irrigation and various other vineyard practices for the Riverina compared with the Riverland and Murray Darling regions is shown in Table 5. The 2.5 ML/ha greater water use in the Riverland amounts to 2,500 t/ha of extra water, which will have a significant bearing upon the additional grape yield of 8 t/ha compared to the Riverina. The common use of leaching irrigations in the Riverlands further points to better-drained soils than in the Riverina.

The percentage of growers using sensors to monitor water requirements is lower in the Riverina (35%) than the Riverland (71%) or Murray Darling regions (Australian Wine Research Institute 2019). This makes it more difficult for Riverina growers to maximise the efficiency of irrigation practices. Only 27% of Riverina growers use Regulated Deficit Irrigation, similar to the Riverland. Only 17% of Riverina growers use Partial Rootzone Drying, although this is a higher percentage than of Riverland growers (7%), and this strategy was not reported to be used in other regions of Australia in 2016. Riverina growers also did not report using leaching irrigations, although 64% of those in the Riverland did. It is unclear whether this represents differences in levels of salinity or whether root-zone salinity may be reducing productivity in some Riverina vineyards. There is potential for Riverina growers to adopt more efficient irrigation practices.

Under-vine areas in the Riverina are typically managed using herbicides with slashing/mowing on a small percentage of hectares, consistent with most regions in Australia (Australian Wine Research Institute 2019). Adoption of suitable under-vine cover crops would improve the sustainability of Riverina vineyards, while reducing costs and potentially improving profitability.

Wine grapes in the Riverina region require irrigation every year. Irrigation water in the Murray-Darling Basin in Australia is priced in the market daily without special treatment of particular crops. High-security and general security licences are traded separately, with the former most expensive because delivery of water is reliable, and the latter least because of the likelihood of low percentage allocations by the MIA in dry seasons. Growers with vines or tree crops (fruit or nuts) will need to hold high security licences. Permanent high-security water licences enable the sale of temporary water rights when demand and supply disparity arises.

The Murrumbidgee River flows into the region are highly variable from year to year (Figure 2). The excess water flows above the quantities used for the perennial vines and trees have long been used opportunistically by the rice industry and minor areas of other annual cereals; in recent years the cotton industry has expanded rapidly, rivalling rice. Into this picture of competing water uses has been a growing presence of almond plantations, which can be highly profitable. One example is an international company acquiring 9,000 ha of land and high security water rights for on-sale to a Canadian Superannuation Scheme. This adds to the amount of water required by perennial crops with which the wine industry competes. It is most likely that almond production can out-bid most other crops for water in dry years. Notice the low flows of 2007-2008, from which grapevines received constant volumes of water compared with previous and following years. The future droughts and expansion of perennial crops will expand the demand for high security water licenses.

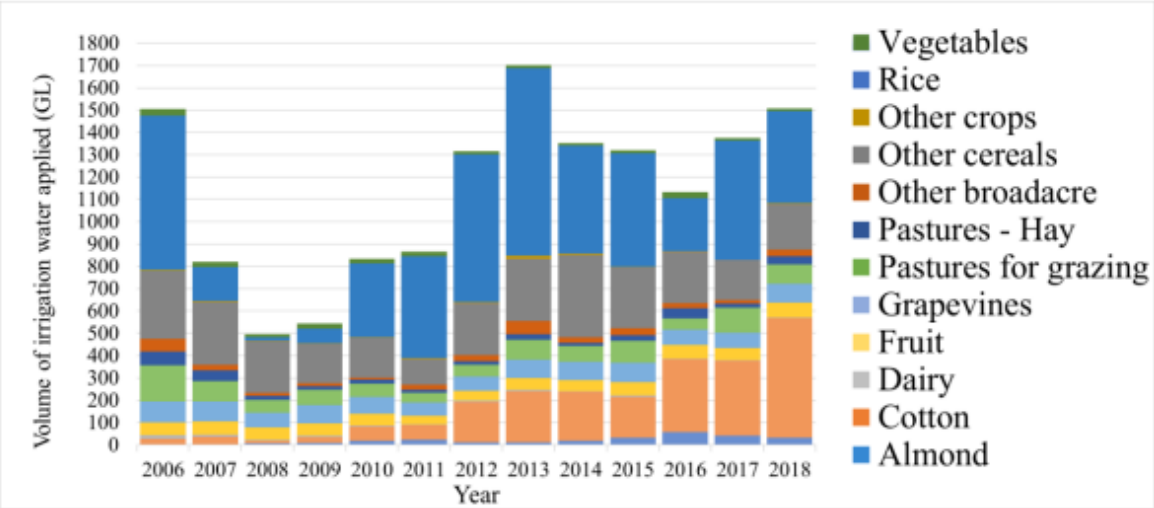


Figure 2. Southern NSW Murrumbidgee catchment 2006 to 2018 volumes of irrigated water applied to different crops. (Godfrey et al. 2022).

Table 5. Comparison of vineyard practices in the Riverina, Riverland and Murray Darling wine growing regions of Australia. Data adapted from Australian Wine Research Institute (2019) based on a survey for the 2016 vintage.

Variable	Riverina	Riverland	Murray Darling
Median yield (t/ha)	16	24	25
Median vine age (yrs)	15	20	15
Median row spacing (m)	3.6	3.3	3.0
Median vine spacing (m)	2.0	2.0	2.3
Median vines/ha† (n)	1390	1515	1450
Median yield/vine‡ (kg)	11.5	15.8	17.2
Median row length (m)	380	250	250
Median row yield (kg/row)	2400	1800	1850
Use of single cordons (% of ha)	85	22	11
Use of multiple cordons (% of ha)	15	78	89
Row direction N-S (% of ha)	61	25	12
Row direction E-W (% of ha)	15	62	83
Uses rootstock (% of ha)	22	52	67
Mechanically pruned (% ha)	92	95	78
Perform de-suckering (% of ha)	91	70	77
Irrigation rate (ML/t)	0.28	0.31	0.30
Mean irrigation rate (ML/ha)	4.5	7.0	7.0
Water use/vine (L/vine) ⁋	3237	4620	4828
Water use/kg grape produced	282	293	281
Use leaching irrigation (% of growers)	0	64	20
Use tissue analyses (% of growers)	45	50	40
Use soil analyses (% of growers)	35	25	32
Mid-row management: cover crop/herbicide/cultivation (% of ha)	59;26;8	57;27;12	41;8;39

† calculated as 10000/(RW x VS) where RW = row width and VS = vine spacing
‡ calculated from median yield and calculated median vine density
⁋ calculated from mean irrigation rate and median vines/ha

In comparing the three regions in table 5, it is evident yield per vine in the Riverina low, and this is somewhat explained through the higher use of double cordon trellising in the Riverland and the Murray Darling regions and a higher planting density. Overall water use per tonne of fruit (or yield per vine) is similar for the Riverina and Murray Valley (282 & 281 L/kg) and modestly higher (293 L/kg) for the Riverland, suggesting that higher overall irrigation in the Riverland translates somewhat into productive plant growth and grape production. Higher usage of drought tolerant rootstock is also evident in the more efficient regions. A more informed understanding of plant water relationships interactions, vine and row spacing, use of water efficient rootstocks, ground covers, irrigation management, plant physiology and crop composition is required to develop a more informed management approach to vineyard irrigation.

Fertilizer and pesticide applications

Fertiliser requirements will vary with soil type and use of fertilisers impacts both vine productivity and wine quality. Observation of vines can detect some mineral deficiencies and toxicities (Iland, et al. 2011) but these situations are better avoided with timely monitoring of petiole tissue samples and use of appropriate fertilizer for the soil type.

Maintaining growth in the post-harvest period is essential to replenish the carbohydrate reserves of vines, which influence the grape yield at the successive harvest. The higher the yield, the greater the need to provide nitrogen post-harvest (Smith and Holzapfel 2015). Insufficient nitrogen restricts growth and may delay berry ripening, while excess nitrogen may also delay ripening through excess shoot growth and shading (Iland, et al. 2011).

Nitrogen (N) fertilizer requirements are recommended to be assessed from petiole tissue samples at the start of and during the growing season (Fahey, et al. 2021). At flowering the optimal range is 0.8 to 1.1 % N (dry weight), whereas at veraison, the minimum for white grape varieties is 0.6 % N (dry weight), with a lower minimum for red varieties. Foliar sprays of N at ≤ 2% N in several applications around veraison are suggested as best practice. The adequacy or toxicity of other nutrients should also be assessed through petiole analysis and through visual monitoring of vine leaves and health, and compared with industry standards (Iland, et al. 2011).

Grape varieties differ in their nutrient requirement. For example, Merlot vines have a high requirement for molybdenum during flowering (Iland, et al. 2011). This highlights the need for growers to monitor different varieties and also regions of their vineyard to achieve optimal provision of nutrients.

A recent survey of producers indicates a wide range of pests and disease impact vineyards, with some variation between regions, but powdery (*Erysiphe necator*) and downy mildew (*Plasmopora viticola*), botrytis/bunch rots, light brown apple moth, birds, mealy bugs/scale and trunk diseases were reported as the issues with the largest impact in warm climate regions (Australian Wine Research Institute 2019). Some

diseases are economically important because they cause off-flavours or other reductions in wine quality. The fungus *Botrytis cinerea* is one example, and when present at an incidence >3% can result in harvested grapes attracting price discounts or rejection (Fahey, et al. 2021). Sauvignon Blanc, Pinot Noir, Pinot Grigio/Gris, Semillon, Chardonnay and Shiraz are varieties which are very susceptible to *Botrytis*. Common commercial wine grape varieties are also highly susceptible to the major pathogens powdery mildew and downy mildew, meaning there is a high risk of crop yields being reduced and/or high chemical costs under environmental conditions that enable these pathogens to proliferate (high rainfall, humidity). Price discounts for grapes infected with powdery mildew may be applied at an incidence of 2%. Control of disease levels is therefore critical in achieving profitable vineyards.

Appropriate control methods vary with the pest or disease. The industry relies heavily on chemical control for some diseases, which increases production costs. Chemicals are one of the major costs in vineyards (Retallack 2012), although requirements will vary between years as some disease risks increase in wet seasons. Chemical use is most effective if a suitable chemical is applied at the optimal times, and adequate penetration of the canopy and vine coverage is achieved (Fahey, et al. 2021). The active constituent in chemicals used as canopy sprays in Australia are most commonly sulfur (40%) and copper (15%) (Australian Wine Research Institute 2019). However, cultural practices will also reduce the risk or impact of many diseases. Practices include adequate biosecurity to prevent introduction to the vineyard; removal of plant material which may harbour disease/pests and carry them to the next season; use of pruning, trellis or other canopy management to optimize air flow and minimise humidity, but also to protect berries from damage (eg sun, hail) which would promote disease; optimizing irrigation to avoid water stress or excess; optimizing vine nutrition to improve resilience to disease; and monitoring strategies to allow early intervention (Fahey, et al. 2021). Breeding of varieties resistant to downy and powdery mildews is underway (Holzapfel, et al. 2020), and release of such varieties with satisfactory yield and grape quality would contribute to a substantial reduction in risk and increase in profitability for producers, however newly developed disease resistant varieties require a long lead time to gain sufficient consumer and commercial interest. Similarly, the development of rootstocks which limit pests and diseases is ongoing (Dry, et al. 2022).

Review of wider situation

An Australian survey showed that both macro and micronutrients were more likely to be applied as the size of vineyards increases, yet only 85% of large growers (> 100 ha) report applying nitrogen (Australian Wine Research Institute 2019). In Australia, the use of soil or tissue analysis increases with size of vineyard, with at least 60% of growers with vineyards > 50 ha using tissue tests at flowering and soil analysis to inform management (Australian Wine Research Institute 2019).

Review of situation in the Riverina

At least 90% of Riverina growers report applying nitrogen to vineyards, which was similar to the Riverland but a larger percentage than for many other regions in Australia (Australian Wine Research Institute 2019). The use of other macro and micronutrients was usually less than 70% of growers across regions.

A separate study including Riverina growers (Barlow, et al. 2009) indicates that nitrogen inputs vary widely between growers (0 to 96 kg N/ha), and that petiole N concentrations at flowering in many of the vineyards monitored were above the recommended range of 0.8 to 1.25% N. Those authors suggested that some growers would be able to reduce N inputs, increasing profits. This highlights the need for effective monitoring to assist with fertilizer decisions, particularly given the high cost of urea fertiliser. Nearly half of growers in the Riverina use tissue analyses to assist decisions, similar to the Riverland region, but fewer growers use soil analyses in both regions (Australian Wine Research Institute 2019).

Growers in the Riverina appear to use a similar number of canopy sprays (8 for the 2015/16 season) as those in the Riverland, consistent with similar diseases being reported as having the highest impact (Australian Wine Research Institute 2019).

Minimising the risk of sunburn

Sunburn of berries occurs in hot climates in Australia and internationally, and its occurrence may increase as ambient temperatures and the intensity of light rise and severe heat periods become more frequent with changing climate. Climate change is also projected to hasten the ripening of grapes by up to 39 days in key grape-growing regions, with an increase in temperature at harvest of 3.5°C by 2050 in the Riverina (Webb, et al. 2007). This will increase the susceptibility of ripening berries to heat and risk of sunburn. The impacts of sunburn and vineyard practices to reduce the risk have been reviewed recently by Gambetta et al. (2021) and are discussed below. Sunburn may occur at ambient temperatures above 30°C and can reduce both the yield of grapes and attract price discounts of up to 50%, clearly reducing profitability.

Vineyard practices which minimise the risk of sunburn are therefore desirable. Avoiding re-planting with more susceptible varieties seems prudent in hot inland regions of Australia. Pino Noir, Semillon, and Shiraz appear to be more susceptible varieties, while less susceptible varieties include Grenache, Pinot Gris, and Sauvignon Blanc. In new plantings, the orientation of rows in Australia is recommended to be E-W and NW-SE to allow shading by the vine canopy to minimise the risk of high berry temperatures and sunburn (Gambetta, et al. 2021). Similarly, spacing rows more closely and with higher canopy heights allows greater shading by vines. Trellis and pruning systems which minimise exposure of berries also minimise the risk, with a sprawl trellis system recommended for high-risk regions (Iland, et al. 2011).

The timing of sunburn influences the level of damage and yield reduction, with grapes being most susceptible at véraison (change of colour of berries), although burn at earlier times can also damage berries (Gambetta, et

al. 2021). Practices which alter canopy shading and bunch temperatures will alter the risk of sunburn. Sudden defoliation will increase the susceptibility to sunburn, while water-stressed vines produce smaller canopies which expose berries to environmental conditions, although such berries are more resilient to burn conditions. Defoliation to control disease therefore risks sunburn of grapes grown in hot regions, and if necessary, may be better performed earlier, to allow grapes to acclimatize to exposure prior to véraison. Unintentional levels of defoliation may also occur after heat-wave events if vines are severely water stressed. It is recommended to irrigate before and during predicted heatwaves to protect vines (Iland, et al. 2011), but noting that depending on the timing, a defoliation event may also risk exposure of berries.

Replacement of bare soil under vines with mulch or living plants can effectively reduce the reflection of light and reduce temperatures (Gambetta, et al. 2021), but needs to be balanced against potential increases in cost of inputs and reduced water efficiency if cover species compete for water.

Netting to provide shade is an effective means of reducing sunburn, with black netting being more effective than white netting (Gambetta, et al. 2021). Netting does, however, incur both purchase and maintenance costs which need to be balanced against the risk of sunburn. Use of water sprinklers to cool the grapes is also an effective option, which would also require investment in infrastructure. An alternative is to spray chemical reflectants onto grapes, with both kaolin and calcium carbonate suitable, although these methods appear to be less effective. A low proportion of Australian vineyard area uses such sunscreen products, possibly because growers manage the canopy to provide protection (Australian Wine Research Institute 2019).

Minimising the risk of frost

Radiant frost occurs on cold nights with no wind when heat from the earth is radiated into the atmosphere, causing temperatures below zero. Advection frost is less common in grape-growing areas and is caused by large masses of below zero temperature air. The risk of frost is increased at low elevation, and frost can cause up to 100% yield loss on affected vines (Gobbett et al. 2020, Poni et al. 2022). Vines are most susceptible to frost damage in the vegetative stage when there are several expanded leaves and when flowering. Cost-effective practices to minimise the risk are therefore needed particularly in inland regions with increased risk of frost.

In new vineyard plantings, placement on elevated land and land where cold air does not pool will reduce exposure to frosts. Planting a range of varieties with differing times of bud-burst including some with late bud-burst may minimise the risk of the entire vineyard being affected (Poni et al. 2022). The time of budburst varies by over 20 days between the commonly-used varieties available, with Cabernet Sauvignon later than Semillon and Shiraz, which are later than Chardonnay (Iland, et al. 2011). Row orientations which promote air flow and trellis systems which keep fruiting wires further above the ground are also effective (Australian Wine Research Institute 2017) but may not be readily achievable in existing plantings. Setting cordons at increased heights can substantially reduce the risk of damage from frost. Trought et al. (1999) cite studies at

various New Zealand locations which show a 0.17 to 0.36°C increase in ambient temperature per 10 cm increase in height above ground level.

In existing vineyards there are several practices which may be suitable to reduce frost risk. A delay in pruning is recommended to delay budburst, so limiting the period of time the most susceptible stages of growth are exposed to the late winter/spring frost period. Pruning can be delayed until a maximum of 2 or 3 unfolded leaves, which may delay budbreak in later nodes by up to 20 days with a low to moderate yield reduction (Poni et al. 2022). A single, late mechanical pruning is the most cost-effective method. Mechanical pruning also retains more buds than hand pruning, allowing some to avoid damage in the event of a frost (Australian Wine Research Institute 2017) while reducing the cost of labour. A light rather than heavy pruning is another option, through retention of additional nodes which can replace shoots lost through frost (Iland, et al. 2011).

The risk of frost can also be reduced by practices which improve radiation of heat from the soil surface at night. Maintaining bare ground through herbicide use can increase minimum temperatures by 0.3 to 0.6°C at cordon height compared with discing or mowing (Donaldson et al. 1993). This may be sufficient to substantially reduce frost damage but is undesirable from a sustainability perspective. Where cover crops or weeds are growing in the inter-row space, mowing or slashing is recommended (Retallack 2012), although use of lower-growing species to limit the need for mowing may reduce costs. Mowing in spring may also reduce seed set which is undesirable where self-regenerating cover crops are used to avoid re-sowing costs. Maintaining a moist soil will reduce frost due to retaining more heat than dry soil (Trought, et al. 1999).

Use of wind machines can be effective to minimise radiation frost (Trought, et al. 1999), but their cost needs to be considered against the risk of frost and size of enterprise. Overhead water sprinkler systems are a reliable means for frost protection. Older systems used large quantities of water (Trought, et al. 1999) which may not be feasible in years with water restrictions and is expensive. Modern systems with micro-irrigation or pulsators use less water. Both wind and irrigation systems require the manager to operate the system in a timely manner. Use of suitable monitoring systems (eg Bureau of Meteorology's MetEye (www.bom.gov.au) and frost alarms) to increase the accuracy in predicting frost events and so allow the system to be turned on when air temperatures reach 1 to 2°C is required for optimal efficiency (Rose 2020). However, these options require considerable capital investment particularly for large vineyards so their use may be uneconomic in warm regions and when the price for grapes is not high.

Vine age

Vine age affects productivity because after initial establishment, vines take 3 years to become productive (Nader, et al. 2019). Vines can remain productive much longer than the typical commercial life of 25 years, with vines > 100 years capable of producing higher yields than those 6-49 years of age when managed to best practice in a mild climate (Barossa Valley) (Grigg, et al. 2018). Older vines (40-60 years) sometimes produce wine with better sensory attributes than that from younger vines (5-12 years) (Riffle, et al. 2022) but often

become less productive and are commercially non-viable. Disease incidence increases with vine age and reduces the productive life of vines which will also limit commercial productive capacity. Incorporation of vineyard management practices to reduce the incidence of disease and spread of pathogens during pruning, especially trunk diseases, are important for maintaining vineyard productivity. Maintaining healthy vineyards in aging vines becomes problematic as increased reservoirs of infection persist in old vine tissue which is readily transmitted during pruning.

Rootstock

Rootstocks have the capacity to influence vine productivity, health and wine quality (Iland, et al. 2011). Rootstocks are chosen to suit soil type, risk of disease and to limit the uptake of sodium and chloride, but also effect the vigour of vines, with Ramsey rootstock known to cause vigorous canopies, which through shading can reduce yield. Ramsey is a highly drought tolerant rootstock with moderate tolerance to salt and high vigour. Use of Ramsey is also an important strategy to reduce the risk from the major insect pest phlloxera and nematodes (Dry, et al. 2022).

Growers report using rootstocks rather than growing vines on their own roots to reduce risks from phylloxera, vigour, nematode, salt and drought (Australian Wine Research Institute 2019). However, the majority of vineyard area in the Riverina (78%) was reported as not grown using rootstock, which differs from the Riverland and Murray Darling regions. Based on grower records (WGMB, unpublished data) 73% of total vineyard hectares in the Riverina are grown without a rootstock, with another 8% of area not declared. Ramsey was the most widely used rootstock (8.5% of ha), followed by Paulsen, with a large variety of other rootstocks used on small areas. The limited use of rootstocks which protect against phylloxera is a key risk to vineyard profitability if this pest were to spread into currently phylloxera free regions.

Trellis system, pruning method and vine maintenance

Maintenance of vines is key to vine productivity and requires significant labour input, with employed farm and contract labour one of the largest expenses in growing wine grapes, although varying widely between vineyards (Retallack 2012). The variation is probably associated with vineyard size and the capacity of the manager to perform operations, and with the method by which vineyard practices are achieved (hand or mechanized). The use of various practices will therefore impact on profitability directly in addition to any impact on the performance of vines.

Trellis systems which increase light interception within vines can increase grape yields, but the optimal level of exposure to light varies with climate (Iland, et al. 2011). In hot regions adequate leaf canopy is needed to prevent excessive berry temperatures, so a sprawl (single cordon with non-positioned shoots) system is appropriate. In cooler regions, systems where the shoots are positioned to achieve higher levels of light interception are desirable, such as the vertically shoot positioned, horizontally divided or vertically divided

methods. Single cordon systems are cheaper to establish, may restrict canopy size so require less fungicide, and may facilitate pruning (Australian Wine Research Institute 2019).

Pruning of vines is a key management practice which influences profitability due to the high cost of manual pruning compared with mechanical methods. Pruning is used to control the number of shoots, and so number and size of fruits (Iland, et al. 2011). Normal practice is to prune once annually, although a double pruning method – a very hard pruning in winter followed by a second late pruning – can be used to delay budburst and flowering, with harvest occurring 2 to 3 months later than normal. The fruit therefore ripens under cooler conditions, improving wine quality.

The method of pruning vines differs between regions. Cool/temperate regions predominantly use spur pruning (63% of ha) with some cane (22% of ha) and relatively little (15% of ha) mechanical pruning. In contrast, in warm regions nearly all pruning is mechanized (Australian Wine Research Institute 2019). Additionally, in warm regions cane pruning is only and minimally used (5% of ha) in small vineyards < 10 ha in size, where spur pruning (42% of ha) and mechanized pruning (53% of ha) are more commonly used. In larger vineyards between 5 and 11% of ha is spur pruned, with the remainder mechanized except in large vineyards (> 100 ha) where 1% of ha receives minimal pruning.

Thinning of shoots either at or after flowering is used to stimulate leaf production to provide the energy required to ripen the fruit, and also to prevent excessive leaf density which would result in shading of fruit (Iland, et al. 2011). Water shoots growing from vine trunks or cordons and resulting from excessively hard pruning may also need to be removed. Thinning of shoots is performed on up to 95% of vineyard ha in some regions of Australia but is not widely conducted in warm/temperate regions and was not reported to be conducted in the Riverina (Australian Wine Research Institute 2019). Positioning of shoots on the trellis system is commonly used in cool-climate regions, but is rarely conducted in warm/temperate regions partly due to the common usage of a sprawl trellis system. In the Riverina and Riverland regions, shoot positioning is rarely performed, possibly due to the limitations of mechanical systems and high cost of labour.

Leaf plucking in the region of fruit bunches by hand or mechanized may be used to alter shading, increase the temperature of berries and so improve grape quality, assist in penetration of chemicals into the canopy and reduce the risk of disease (Iland, et al. 2011). This is relevant to cool regions since exposure to sun in hot regions may result in excessive temperatures and sunburn of berries. Leaf plucking is used on 10% of ha in cool/temperate climate regions, but not in warm regions (Australian Wine Research Institute 2019). Crop thinning may also be practiced achieving a better balance between canopy size and quantity of fruit, and to control the size and so quality of fruit. Crop thinning is usually not mechanized and is performed on 17% of ha in cool/temperate regions but is rarely conducted in the Riverina and Riverland.

Hand-picked grapes can produce higher quality wines than mechanically harvested grapes particularly if processing post-harvest is delayed by 48 hours, leading to fermentation and off-flavours in wine (Sims, et al. 1989). Sensory differences are apparent immediately post-harvest, although these may not impact on wine quality. However, mechanical harvesting is cheaper than hand picking due to the high cost of labour. The ability to employ sufficient labour can also be a limiting factor. The high cost of harvesters means their purchase may only be viable for large producers, with other producers engaging contract harvesting. However, securing harvesters at the time when grapes are ready can be problematic, since many grapes in the region ripen at the same time and wineries having limited capacity to receive grapes, with delays to harvest potentially leading to reduced yield or quality, hence reduced income (ACCC, 2019).

Grape harvesting method varies widely between regions (Australian Wine Research Institute 2019). Growers hand-pick grapes for a variety of reasons, including to obtain high-priced wines, grape processing method, grapes need sorting, when vines are establishing or are very old, vines not in suitable formation for mechanical harvesting and small blocks. In cool/temperate regions approximately 25% of vineyard area is hand-picked, although in specific regions between 65 and 100% of area could be hand-picked. Mechanical harvesting is the norm in warm inland regions, with no hand-picking reported in the Riverina or Riverland, and only about 2% of area in the Murray Darling.

When grapes are mechanically harvested, the addition of sulfur dioxide (SO2) is recommended to minimise deterioration prior to processing (Sims, et al. 1989). This is a common practice in both cool/temperate (83%) and warm inland (90%) regions (Australian Wine Research Institute 2019). For red grapes, the Riverina and Murray Darling growers add SO2 at harvest to around 95% of harvested area, whereas the Riverland is lower at 75%. For white grapes, SO2 is applied to a lower area in the Riverina (78%) than in the other warm regions (88-96%).

Other vineyard management factors

De-suckering is required to remove unwanted shoots from the trunk of vines, which will compete with the fruit-bearing shoots. De-suckering is more widely performed in the Riverina (91% of ha) than in the Riverland (70 % of ha), and approximately 20% larger area uses chemical rather than hand methods (Australian Wine Research Institute 2019).

Vineyard row spacing, while managed at establishment, influences profitability through initial cost, impacts on productivity and impacts on maintenance costs. Wider row and in-row vine spacing reduce the cost of establishment and operating costs (Dry and Loveys 1998) and may allow easier movement of machinery. Lower plant densities allow more shoots per vine to be retained, which similarly achieves the desired reduction in vine vigour as a higher planting density but at lower cost. While both the Riverina and the Riverland regions use slightly wider row spacings than the 3 m used in most other regions, both commonly have a 2 m vine spacing, consistent with other regions (Australian Wine Research Institute 2019).

The length of vineyard rows is also relevant to the efficiency of operations (Australian Wine Research Institute 2019). Long rows are more efficient providing a side-arm discharge harvester is used to allow emptying of bins part-way along the row if on-harvester bins are used. Riverina vineyards typically have longer rows than other regions.

The between-row area of vineyards in cool/temperate regions is typically managed with cover crop or swards, while in warm inland regions cover crops/swards, herbicide or cultivation are all commonly used (Australian Wine Research Institute 2019). Similar areas between-rows in both the Riverina and Riverland are managed using cover crops/swards (58% of ha) or herbicide (26% of ha) with a small percentage cultivated. In the Murray Darling region a much larger area is cultivated, with less use of herbicide. Small vineyards (< 10 ha) use cultivation on a greater percentage of area than larger vineyards, but cover crops are the dominant management across all sizes. Where cover crops are used, across all regions in Australia they are typically managed by mowing/slashing, with many regions also using grazing by livestock. Both the Riverina and Riverland differ from most other areas in zero or minimal use of livestock. They also have a high (25 to 43%) use of cultivation to manage the cover crop, which is not a method used in most regions, including the Murray Darling. All three warm inland regions (Riverina, Riverland and Murray Darling) also have a high use (approximately 30%) of knockdown herbicide, which is not used in the majority of other regions.

Technical innovation

Agriculture is undergoing an accelerating transformation as increased mechanisation and digitation of data flows provide new opportunities to increase profitability and sustainability. In a commercial environment with low margins, continued on-farm mechanisation of processes such as harvesting, pruning and irrigation remain important avenues for maintaining financial viability for wine grape producers (Sun et al. 2022, Wheeler et al. 2022). In addition to ongoing mechanisation, 'Smart Farming', 'Precision Agriculture' and 'Internet of Things (IOT)' based farming approaches which use digital technologies to capture, analyse and act on large amounts of on and off farm data, represent a new frontier in efficient and sustainable farm management (Antle et al. 2017, Islam et al. 2021, Farooq et al. 2019). Current and potential benefits from the adoption of mechanisation and digital technologies include both reduced input costs (e.g. labour, water, diesel, herbicide and pesticide use) and increased product quality, leading to improved product demand and higher prices (e.g. through product traceability, accreditation and certification systems) (Saurabh and Dey 2021).

On farm mechanisation

Wine grape production businesses remain labour intensive enterprises, with labour costs being as high as 60% of total variable expenses (Sun et al. 2022) and a lack of labour availability becoming a significant production constraint (Smedley and Siebert 2021). Within Australia's high costs, low availability labour market, the ability to reduce labour costs through mechanisation, while also retaining product quality, offers significant financial advantages. Grape harvest and leaf removal are the two most common forms of mechanisation for

vineyards and as farmers have become increasingly confident with these technologies, other tasks such as leaf removal and grape thinning have also increased (Kurtural and Fidelibus 2021). Such mechanisation has enabled farmers to reduce the number of workers required, however, total costs savings are mitigated by the need to employ more highly skilled employees with the knowledge and skills to use equipment effectively (Kurtural and Fidelibus 2021). Labour cost savings are still significant though, with the potential to reduce from an average of around 60% of total variable expenses 14%-25% of total variable expenses (Stup and Martinson 2019, Wheeler et al. 2022).

The benefits of vineyard mechanisation have tended to be most available to large growers who can defray the large capital costs against significant reductions in labour costs, however, smaller lower cost machines are also become increasingly available to enable niche growers to adopt labour savings measures as well. In addition to the initial cost of equipment other factors that need to be considered as farmers increase the level of on-farm mechanisation include: the topography of the vineyard, with steep terrain potentially being unsuitable; the need for appropriate vineyard layout, such that machines have sufficient room to operate; as well as adequate drainage to enable machines to access the vineyard when required. Ideally, vineyards are planted with mechanisation in mind, for example by increasing cordon height and row length to ensure machines have sufficient headroom for turning and are working at optimal efficiency (Rieger 2017). As such, new vineyards, or large vineyards which regularly replant sections of their operation, have the greatest opportunity to maximise design efficiency for mechanisation.

While labour cost savings can be significant, not all growers and growing regions have been universally enthusiastic about the continued adoption of vineyard mechanisation. Some traditional wine producers, particularly in Europe, have resisted vineyard mechanisation due to both cultural and product quality concerns. In particular, mechanical harvesting is thought to increase the likelihood of 'matter other than grapes' or MOG entering the wine production process, and also the risk of grape disintegrating and oxidizing before arriving at the vineyard (Hesford 2020). While this issue can be reduced through down-stream quality assurance processes, some European appellation regulators nonetheless prohibit certain types of mechanisation, including mechanical harvesting on these grounds. Conversely, proponents of vineyard mechanisation also suggest there may actually be benefits to wine quality from mechanisation. For example, mechanically pruned vineyards tend to produce smaller fruit, which results in a polyphenolically favourable grape to skin ratio, when compared to hand pruned vineyards (Kurtural and Fidelibus 2021). Ultimately however, the decision to mechanise is most likely to be made on the basis of labour cost savings and/or an inability to reliably obtain sufficient staff, particularly where vineyards operate at large scales. Labour availability and cost pressures are therefore likely drivers of adoption of automation within Australian viticulture enterprises.

On farm digitization

As with other sectors of the economy, agriculture is making increasing use of a range of digital technologies. However, certain fundamental characteristics of agriculture, such as frequently remote work environments that are exposed to the elements, have meant that the introduction of digital technologies has not progressed as rapidly as in some other domains. Despite these challenges, the key components of farm specific digital innovation are largely the same as for other sectors. These are the increased capture of data and the development and use of models to interpret that data for improved decision-making. According to Antle et al. (2017, p.179), "significantly improved data and models can contribute to development of advanced farm-management systems, and […] accelerate the adoption and efficient use of more productive and more sustainable technologies." In the context of Australia's warm climate grape growing regions, the most obvious application for these types of digital enable farm management systems relate to water management, but may also include predictive algorithms for disease outbreaks based on weather events, canopy architecture, cultivar etc, or predictive ripening models and linkage to winery logistics (Wheeler et al. 2022).

The need for continued technical innovation in Australia's warm climate grape production areas is underscored by the fact the majority of growers in these areas are unprofitable or only marginally profitable (Anderson 2019, Wheeler et al. 2022). One of the primary expenses for these growers is the cost of irrigation, particularly for growers in the South Australian Riverland where it made up approximately 20% of total variable costs in recent seasons (Wheeler et al. 2022). Given the tight margin environment and high relative water costs, technology is increasingly important to farm profitability, with recent research in South Australia's Riverland finding a link between the use of more sophisticated irrigation technology and farm profitability (Wheeler et al. 2022).

The use of application-specific digital technologies on farm, such as soil moisture meters linked to irrigation flow meters is only an initial step in terms of what is possible though. In addition, more advanced applications of digital technology are increasingly 'whole of farm' in nature capturing a range of data from both on and off the farm and from both private and public sources and combine those to not only increase the data available to farmers, but increasingly to make recommendations (or even to take automated actions) to the farmer which will increase profitability if followed (Antle et al. 2017).

Farmers may find it difficult to evaluate and choose which digital technologies are likely to be profitable for their enterprise, with the current market for digital agriculture products being described as "fragmented, unregulated and rapidly growing" (Westa et al. 2022). In an attempt to lesson this burden of choice for grape growers, Wine Australia, in partnership with Riverland Wine, has recently made a significant investment with the University of Adelaide to develop and trial a digital farm management platform specifically for the Australian viticulture sector. This system, known as Vitivisor, has been developed to a 'pre commercial' stage, where it is available via an open source licence for further use and development by the community. The Vitisvisor system was designed to capture and integrate diverse data streams from both on and off farm

sources with the goal of increasing farm profitability by enabling grape growers to make more efficient and effective decisions (Westra et al. 2022, Wheeler et al. 2022). Key features of the system include: a geo-located imagery system to capture information about vine health and development; an integrated sensor network to gather information about on-farm (soil moisture, irrigation flow, temperature etc) and off-farm (water and financial market data) factors; the ability to generate growth and yield predictions based upon both real time data and models scenarios; and a financial function to track costs and revenues against benchmarks.

For growers in warm climates such as the South Australian Riverland, irrigation water is a significant part of their cost structure (Wheeler et al. 2022). As such, water use efficiency is a prime application of the Vitivisor system or other similar digital decision support tools. The adoption of this technology is not free though, costing in the order of $10,000 for the initial software and hardware purchases as well as approximately $10,000 in annual labour costs to maintain and implement the system. Analysis by Wheeler et al. (2022), suggest the potential benefits may justify this investment for some growers in the Riverland with the majority of gains coming from increased revenue and production efficiency. Assumptions used in this analysis, determined through a survey of 22 Riverland growers, were a farm size of 57.2 ha, irrigating at a rate of 7.6 ML per hectare, yielding 22.6 tonnes of grapes per hectare, sold at a price of $657 per tonne. Some of these assumptions are highly sensitive to market conditions (e.g. grape prices) and therefore the overall benefit may not extrapolate to current market conditions or to regions of different scale, costs and income. Despite the limitations of this analysis a broader correlation was observed between high levels of digital technology adoption on farm and per hectare gross margin across all farms surveyed regardless of size (Wheeler et al. 2022).

The wine grape supply/value chain and wine grape pricing

Australia's food and beverage market is one of the most highly concentrated in the world, with two retailers, Coles and Woolworths, accounting for nearly 70% of all sales (Devin and Richards 2018, Bakhtiari 2021). This is significant for the Australian wine sector, as around 40% of total wine production is sold into the domestic market (Anderson 2019). International wine markets, especially Australia's traditional wine export markets, the United Kingdom and to a lesser degree the United States, are also dominated by a relatively small number of powerful retailers (Soosay et al. 2012). The survival of suppliers in these markets has traditionally required an unswerving focus on efficiency with the aim of delivering products at the lowest price possible. Retailer outlet concentration has been further exacerbated in the wine sector by a significant increase in supermarket 'own brand' wines that compete strongly on price and which receive advantageous shelf space within store (Soosay et al. 2012). In this environment, margins are driven lower and competitive advantage tends to accrue to firms with significant efficiencies of scale. In contrast, most farm businesses, including many grape producers, continue to be relatively small and research shows that as many of 85% of warm climate wineries made a loss between 2012 and 2015 (Anderson 2019).

While bulk mid and low-priced wine markets remain important within this low-margin environment, the premium and 'low-end premium' export market has been the most successful in terms of profitability over recent years (Anderson 2019). Within these medium and upper-level market ranges domestic and international consumers are increasingly demanding agri-food products, including wine, which incorporate health focused attributes and/or attributes that provide wider social and environmental benefits (Dingwall 2022, Fischer et al. 2009, Soosay et al. 2012). Catering to these more diverse forms of consumer valuation can be a means for firms and supply chains to carve out durable competitive advantage and higher than average returns (Soosay et al. 2012). However, moving away from price-driven commodity markets into more diversified product markets, requires new business models, new ways of working, and new sets of skills (Fisher and Henderson 2010). In the case of the burgeoning non-alcoholic wine market, which grew by just under 40% in the USA in 2021, this may mean adopting different varieties and production methods (Dingwall 2022).

Developing new products with social and environmental benefits are more difficult to achieve requiring supply chains to collaborate intensively over time. An example of this would be investments made by both a winemaker and their grape grower suppliers to understand and then reduce the main environmental impacts of the combined wine production process, and to then communicate the extent and value of these investments to consumers (Soosay et al. 2012). This type of high-functioning value chain is only possible, however, to the extent it can recognise and promote the interests of all participants in the chain, including those who are more distant from end consumers, such as farmers. This is critical to encouraging farmers to make the type of long-term investments required to develop chains with those unique attributes that deliver hard-to-replicate competitive advantage.

Unfortunately, the geographic and economic characteristics of Australia's warm climate grape and wine production supply chains has not always promoted efficient competition and trusting long-term relationships between supply chain partners. In particular, grape growers have suffered the impact of a weak bargaining position relative to their main customers, winemakers (ACCC, 2019). The suppressed bargaining position of grape growers is likely to undermine healthy long-term trading relationships between supply chain participants, both in terms of prices paid and the perception of price fairness. There is a range of structural reasons for this power imbalance. One of the principal characteristics of Australia's wine industry supply chains, including those operating in the Riverina region, is the fact that a small number of very large wine makers purchase grapes from a large number of comparatively small grape producers (ACCC, 2019). In particular, the geographic isolation of Riverina grape producers effectively limits competition from outside winemakers, as transport costs such as fuel and product quality losses are generally too high to justify long-distance transportation of grapes. This situation gives winemakers a significantly stronger bargaining position relative to grape growers and as a result not only limits farm gate prices but also enables behaviours that further stifle competition. These include; multi-year contracts that lock grape producers into selling to a single

winemaker; barriers which limit a grape growers ability to switch buyers between winemakers, such as automatic contract rollovers; and limited transparency about market prices or grape quality determination (Australian Competition and Consumer Competition 2019).

Increased collaboration between grape growers to improve the strength of their bargaining position is one avenue to address the issue highlighted by the Australian Competition and Consumer Corporation (2019). While Australian growers did historically collaborate formally through cooperative business structures, these are now rare in Australia, although not in Europe. One significant exception to this situation is the CCW Cooperative in South Australia, which conducts bulk grape sales for member growers in the South Australian Riverland region (Wheeler et al. 2022). An increased use of cooperative business structures may be one avenue to increase the bargaining power of grape growers in the Riverina. In addition to the formation of cooperatives, another means of increasing buyer power in negotiations with winemakers would be through the Australian Competition and Consumer Corporation's collective bargaining provisions, which provides a process by which competitors (e.g. grape growers) can collaborate to set terms of trade, including prices, with a shared customer.

However, the absolute price that a grower receives for their grapes is not the only consideration determining their satisfaction with the transaction. While a grower needs to achieve a given price in order to cover the costs of production, and this is something that is currently hard to achieve for many growers, other factors are also significant. In particular, there are both financial transaction costs incurred in selling their grapes which must be taken into account, as well as perceptions or psychological factors (Gyau et al. 2010). Where sales are concluded through relatively arms-length means such as spot markets, transaction costs such as the need to investigate claims by both parties are likely to be high relative to transactions that take place between trading partners with high levels of mutual trust. This is because high levels of interpersonal trust acts as an "implicit contract" that minimises the need for "enforceable, legal contracts" (Nyaga et al. 2010, p. 104), thereby minimising transaction costs and presenting opportunities for more dynamic forms of collaboration (Williamson 1993). Thus, efforts that are made to increase trust and commitment between grape growers and wine makers can offer both long-term benefits in terms of opening up opportunities for investments which create sustainable competitive advantage, as well as short-term benefits in terms of reducing search and legal costs associated with specific transactions.

Unfortunately, however, trust seems to be lacking in many Australian grape supply chains. Research by Gyau et al. (2010), which gathered information from 396 Australian wine grape growers, found a lack of trust between grape growers and wineries, particularly in relation to the transparency around price-setting. This research found that in addition to the absolute price received, growers were more likely to be satisfied with a transaction if they perceived that they got a fair price relative to other growers; that the price was fair relative to the quality of their grapes, and that pricing practices were reliable. Addressing these factors gives wineries and grape growers a potential area of discussion around which to improve relationships and hopefully foster

more trusting trading relationship. Such discussions need not begin from the premise that the winery must necessarily raise prices, instead it can centre on actions that can be taken to promote transparency and grape grower trust in the pricing process. An improved pricing mechanism might, for example, involve a real time digital market for grapes in the region that enables buyers and sellers to set prices dynamically according to supply and demand. However, such an outcome should not be viewed as the only option or the most favoured and instead the process of discussion and relationship building required to develop such as system should be viewed as important in and of itself, with the potential to yield different beneficial outcomes.

Another area in which increased collaboration between wineries and grape producers could focus in order to build supplier/buyer trust and promote long-term profitability is varietal selection for new vineyard plantings. The long lead times associated with establishing new vineyards makes investment decisions highly complex and there is a significant risk that aggregate demand may overshoot supply by the time new plantings reach maturity. That is, planting new vineyards to what is currently profitable risks producing an over-supply at the time of maturity. This is particularly true given the trade-exposed nature of the Australian wine industry as varietal gluts can occur on a global scale. The market knowledge of wineries can help minimise this risk because the number of Australian wineries that sell direct to consumers has decreased from 80% in 2000 to 66% in 2016 (Anderson 2019) and wineries are still more likely to have a closer interface with final consumers and/or institutional wine buyers than will the average grape grower. As such, they are in a better position than most grape growers to understand evolving market demands. Encouraging grape growers to consult with winemakers prior to committing new plantings is likely to lead to improved investment decisions in terms of matching new plantings with consumer demand and also improved relations between grape growers and wineries.

A more structured and multi-firm approach that could be adopted by grape growers and wine makers in the Riverina is Value Chain Analysis (VCA), which is a methodology for understanding the strength and weakness of individual value chains. Drawing upon the 'lean' paradigm of supply chain optimisation (Womack and Jones 1996), VCA projects frequently commence with a 'current state' mapping process to understand the chain from an end-to-end for the purposes of identifying activities which; add value for final consumers; do not add value but are nonetheless necessary; or do not add value and are not necessary. (Soosay et al. 2012). The outcome VCA is the identification of opportunities to both add value for the final consumer, thus making the chain more effective and eliminate waste, thereby making the chain more efficient. Such opportunities are frequently found in the space between firms and therefore require significant amounts of inter-firm cooperation if they are to be exploited. The development of cooperation between vertically linked firms used to arms-length, if not outright adversarial, trading relations is not easy and requires that participating actors understand the likely costs and benefits arising from increased cooperation and to develop a clear understanding of how the relationship will be coordinated, including how prices will be set. Finally, in order to be successful, VCA requires expert impartial guidance (usually an academic or consultant), sufficient

time and resources to carry out, and critically, the commitment of senior managers from multiple firms, including a ‘lead’ firm.

4. Project Aims

Over the next decade a significant shift in vineyard stewardship will occur through intergenerational change of asset ownership. This coincides with an aging vineyard asset base that may require re-establishment, thereby providing an opportunity for new cultivars and modern approaches to vine management (Nordestgaard, 2019). Anecdotally, it seems that many Riverina based grape growers are operating in a high stress environment, with challenging relationships with wineries and poor returns on their investments. Consequently, they may prefer to not pass their enterprise on to family due to the financial pressures they find themselves under, and this may result in a loss of experience and industry base. To best support practice change and transition in the agricultural sector, it is important to understand the current daily challenges for Riverina grape growers and reflect on both the challenges they face and the sociopsychological context in which they are living and working (Higgins, et al, 2014). The aim of this part of the project is to use these findings to inform how best to support grape growers through this period of change.

5. Methods

Survey methods for this project are separated into two distinct sections; ***The Lived Experience*** exploring the social and familial environments for grape growing in the Riverina, and an ***Economic Impact Analysis*** to ascertain broad financial outcomes, including gross margin and earnings before interest and tax at varying scales of operations.

The Lived Experience

Human ethics application

An application (LH01869) to the Charles Sturt University Human Research Ethics Committee was submitted on 31st August 2022. The application was considered at the 12/09/2022 HREC meeting and after minor amendments, approved on 23/09/2022 (protocol number H22335). A variation to the ethics approval was submitted on 25/11/2022 requesting approval of the semi structured interview schedule. This was approved on 30/11/2022.

Development of the data collection tools

A mixed-methods approach using a questionnaire and semi-structured interview was used to gather information. The use of this approach to data collection provides in-depth information on the topic researched, allowing for a triangulation of the data obtained that enables the validation of research findings. While the questionnaire provides a broader representation of perspectives, the interviews provide a more in-depth understanding of the area of enquiry and allows for the capturing of information that might not be able to be collected using quantitative approaches and provide more nuanced exploration of the research question.

Contact details were collected (optional) to provide an opportunity for this work to be extended to a longitudinal study to allow for the measurement of changes based on any interventions/workshops/training implemented.

To increase participation and to express the appreciation of the research team, participants were offered an incentive to participate. Those who completed the questionnaire, had the opportunity to go into the draw to win one of 75 $100 Visa prepaid gift cards, whilst all of those interviewed were offered a $100 Visa prepaid gift card.

Questionnaire

The questionnaire collected relevant demographic data, and investigated knowledge, attitudes, and perceptions (KAP) across the following key areas of investigation; challenges (agronomic, social, economic), social connectedness, wellbeing, aspirations (succession planning, future scenarios) and needs (resources, support, guidance). The questionnaire contained 32 questions, the majority of which were closed-ended or rating scales (Appendix 3).

The draft questionnaire was sent to key persons within Wine Australia and the Wine Grape Marketing Board for comment and piloting. After incorporating feedback, a final version was then loaded onto the survey platform, SurveyMonkey (Momentive Inc, San Mateo, California, USA www.momentive.ai). Skip logic was incorporated. The survey was also printed in a paper-based format.

Interviews

The development of the interview schedule (Appendix 3) was guided by the outcomes of the survey and built upon the existing areas of enquiry.

Participants

The study targeted all registered grape growers in the Riverina region of NSW.

Recruitment and distribution

Questionnaire

The invitation to participate was distributed through the Wine Grape Marketing Board. Grape growers were posted an invitation package (Appendix 3) containing the Participant Information Statement (PIS), Consent Statements, copies of the questionnaire and two reply paid return envelopes (one for the questionnaire and the second for the prize draw to ensure that the anonymity of those who do not provide contact details is maintained). A QR code linking to the online questionnaire was printed on the front page of the postal document, should growers choose to complete it in this manner. Instructions in plain English stating that the questionnaire can be completed using the telephone/videoconferencing (Contact details for the research team were provided and any growers interested in using this approach were asked to contact a member of the team to arrange this). There was also provision for the PIS and Consent to be provided verbally.

The online survey was opened on 7th November 2022 and closed on 21st January 2023.

Interviews

Potential interviewees were identified through the questionnaire, with interested individuals ticking a box to indicate interest. Those who agree to participate were re-sent a PIS and consent form and informed that the consent statements were to be read at the commencement of the interview and their consent recorded. Other producers who expressed an interest in meeting with researchers were also provided with the contact details of the researchers, the PIS and consent form. Two members of the research team (JM and JB) travelled to Griffith

between 12th and 16th December 2022 to conduct interviews. Where face to face interviews were not possible, telephone interviews were conducted. Interviews were recorded.

Data analysis

Questionnaire

A total of 38 online responses were received. Data from the online survey were downloaded from the survey platform into Excel (PC/Windows 167 XP, 2007) and cleaned. Following the removal of incomplete/unusable responses (N=10), 28 online responses were included in the analysis. Ten postal responses were received. These data were added to the excel sheet containing the online responses, resulting in an overall total of 38 useable responses.

Descriptive analyses were undertaken to obtain an outline of respondent characteristics and practices, using IBM SPSS Statistics for Windows, Version 169 20.0. Armonk, NY: IBM Corp.

A Bayesian Network modelling approach was used to consider the survey data. This approach allows consideration of the data in a wholistic way, using conditional probabilities from the survey responses. This approach has been used to consider livestock vulnerability to foot and mouth disease in Australia (Manyweathers et al., 2021), and is useful in situations of low response rate, high uncertainty and mixed variable type (categorical, numerical etc) (Chen & Pollino, 2012). The model can then be interrogated using any of the variables to undertake inferential analyses – and ask "what if" questions.

The BN model provides a likelihood estimate of certain variables being represented, relative to others. For example, the model can describe the likelihood of a particular demographic choosing "Market Stability" in their top three business challenges.

The framework used to develop the model considered the interaction of the survey variables aimed to gain an understanding of the lived experiences of grape growers in the Riverina. This included reflecting on the associations between demographic characteristics, identified challenges to their businesses, level of connectivity within the industry and community, succession planning, and self-reported outlook and wellbeing (Appendix 4).

A static version of the interactive BN model can be found in Figure 3.

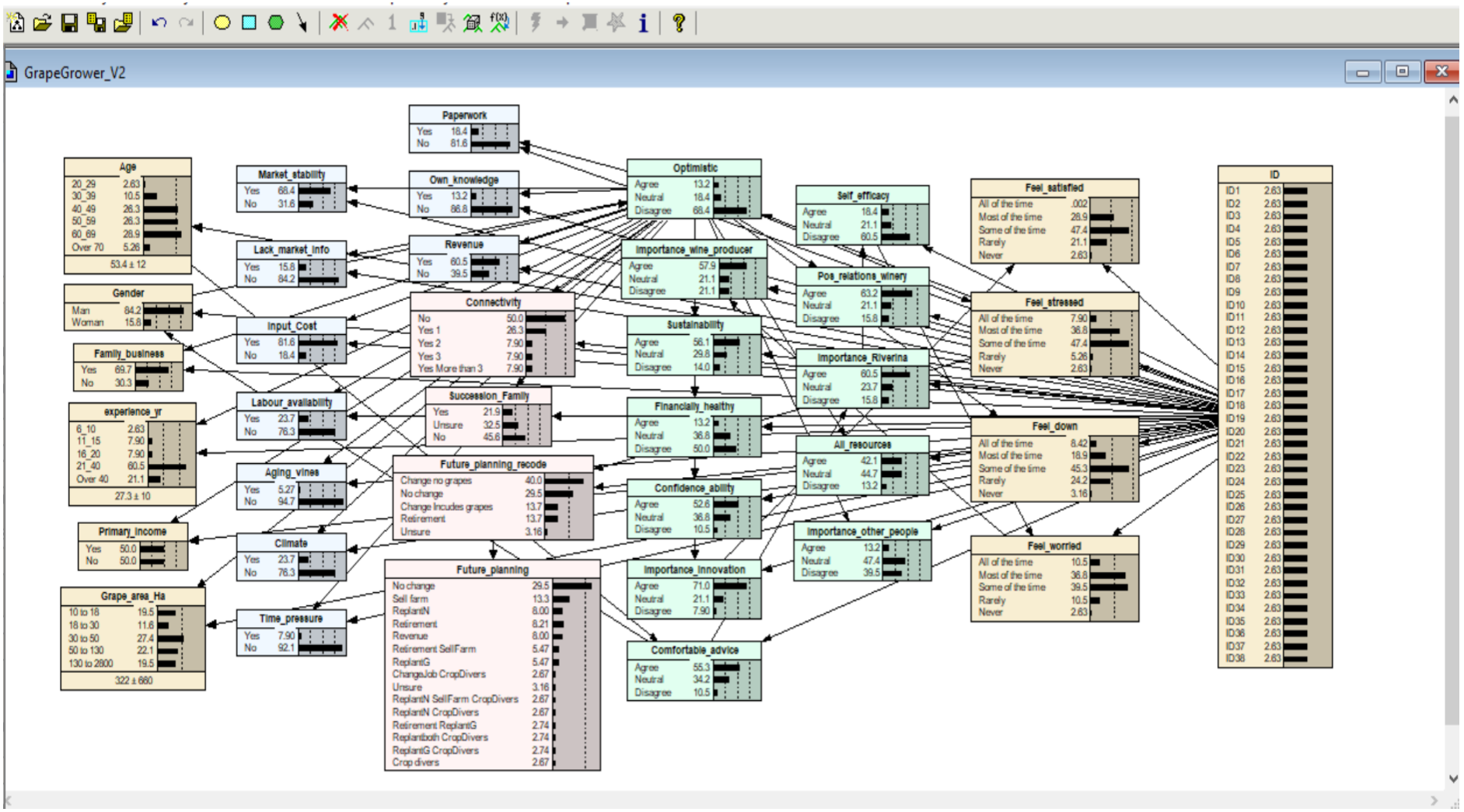


Figure 3. A BN model developed from a questionnaire about the lived experience of grape growers in the Riverina, NSW 2022.

Interviews

Interview data were professionally transcribed, uploaded to qualitative data analysis software NVivo (QSR International Pty Ltd, 2018) and analysed using thematic content analysis (Boyatzis, 1998; Braun & Clarke, 2006). This will allow the identification, examination, and communication of themes.

Economic Impact Analysis

Human ethics application

An application (LH01870) to the Charles Sturt University Human Research Ethics Committee was submitted on 6th September 2022. The application was considered by HREC meeting and after minor amendments, approved on 19/10/2022 (protocol number H22356).

Interview Survey Tool

The interview survey tool was developed with consultation provided by key industry stakeholders including representatives from Wine Australia, New South Wales Wine Industry Association, the Wine Grape Marketing Board (WGMB) and growers from the Riverina for appropriateness and clarity before being revised. The survey tool was designed to seek information on growers' experience, vineyard characteristics, management, production and costs for the 2022 autumn harvest year to allow calculation of gross margins. Growers perceptions on factors influencing the productivity and profitability of wine grape production were sought. All participating growers received copies of the questionnaire in advance of interviews to enable considered preparation of responses applicable for their own vineyards. The final survey questions are provided in Appendix 3.

Wine Grower Interviews

A survey of Riverina wine growers was conducted in November 2022. The aim of the survey was to investigate factors influencing the profitability of wine-grape growing in the Riverina. Vineyard size was considered a key factor describing the types of grower enterprises within the industry. A de-identified list of Riverina wine grape growers was obtained from the WGMB to identify appropriate grower classes to sample. Consultation with the WGMB established vineyard size classes of ≤ 10 ha, 11-20 ha, 21-70 ha, 71-175 ha and >175 ha would represent classes with varying levels of reliance on grape-growing as the sole income, and with varying business structures (family to large corporate). The number of vineyards within each class size varied widely due to the larger number of smaller vineyards. However, since vineyard size rather than representation of grower distribution across the industry was the purpose, the sampling intensity within class sizes differed (Table 12). Additionally, while there was a large percentage of growers with < 10 ha vineyards these managed only 2.7% of vineyard area so an equal sampling intensity across vineyard class size would not have provided an optimal representation of industry.

Growers who had not delivered any grapes within the last 4 years (2019-2022) were excluded from the list. The remaining list of 307 growers was sorted into vineyard size, stratified into appropriate class size and production/ha for the 2022 harvest. A random sample of 5 growers to interview for each size class (total 25 growers) was created by generating a random number to create a ranked list. The list was provided to the WGMB to contact growers on the researchers behalf to invite to interview. Where a grower declined the interview, the WGMB was requested to contact the next ranked grower within the same class size, until all 25 interviewees were secured. The researchers were therefore blinded to the identities of those selected for interview. The WGMB provided a hard-copy list of the interview questions and the participant information statement to potential participants in advance to allow growers to prepare before attending a face-to-face interview with the researchers. In total 20 growers attended interviews, with a further three returning partially completed forms by post. These incomplete responses were included in the results where possible, but were excluded from financial analyses because tonnage of grape harvested and/or costs was not provided.

Survey data was compiled in Excel spreadsheets. Some assumptions were made to fill in missing, incorrectly reported or highly variable data. Where the tonnage of red and white grapes was not separated, tonnages were calculated based on the percentage of total Riverina delivery. Where the price of red and white grapes was not separated or a range was given, the average price for all interviewees was used, or the mid-point from the range given. A standard wine industry levy was applied to all responses based on tonnage: 10 to 3000 t = $180 + 9.20/t; 3000 to 6000t = $27780+ $8.80 per t >3000 (source: https://www.agriculture.gov.au/agriculture-land/farm-food-drought/levies/rates#wine). A standard water cost was applied of $11.30/ML, with an administration fee of $352 plus an increasing number of meter and meter sizes with vineyard size, estimated from those participants who reported these. Where missing, chemical, pesticide and fertiliser costs were estimated from other participant reports. The survey results are presented as descriptive statistics.

Economic Modelling of Grower Data.

Weighted estimates of dollar values of red grapes delivered and white grapes delivered by each grower were calculated, and summed for the grower's weighted total grape sales per hectare. This allowed summaries of weighted average total grape sales per vineyard size class and average per hectare grape sales. Charts comparing within-size class average total grape revenues per vineyard and per hectare were prepared.

Each grower was queried on operating costs in the categories of Labour, Harvest and cartage totals, Wine industry levies, total Chemicals costs, Fertilizers, Water delivery, Electricity, Fuel, and Machinery and repairs. In most cases these costs were expressed across each grower's whole vineyard. As with sales revenues per vineyard and per hectare in a vineyard size class, each of the operating costs was similarly summarised and charted.

Gross margins were defined as total grape sales revenues minus total operating costs, per vineyard and per hectare in a vineyard size class. Of course, average vineyard gross margins would be expected to rise with

vineyard size class while per hectare gross margins were expected to be directly comparable across size classes. The charted summaries of these values generally support our expectations but the reader will see some surprises.

Readers will see positive gross margins across the vineyard size classes, but should be cautioned that these are not measures of profits because we have not included all overhead costs, interest payments, tax liabilities nor opportunity costs of asset ownership, such as land, physical plant and values of water licences which are largely costs of a personal nature and we are not reporting on returns on investment.

In order to give a more complete financial picture, an estimate is also made for Earnings Before Interest and Taxation (EBIT). EBIT is a measure of profitability that goes beyond gross margin to take into account both operating and overhead costs. As data on overhead costs was not collected directly from respondents, overhead costs were inputted using data collected by Wheeler et al (2022) using Australian Taxation Office returns for grape growers in the South Australian Riverland region for the years 2019/20 and 2020/20.

While EBIT produces a fuller of picture of how vineyards of different scales have performed economically over the study period, this report does not include a 'Break-Even' analysis for individual class sizes or the sector as a whole. This analysis was omitted for two reasons. Firstly, an accurate breakeven analysis would require gathering knowledge about individual farm debt levels and interest payments. This information was not collected as it was deemed overly sensitive, however, individual farm debt levels are likely to be both variable and significant in terms of determining ultimate farm level profitability, particularly, in an environment of rising interest rates. Secondly, due to the relatively small number of respondents and the potential large amounts of variability in levels of farm debt, with newer farmers more likely to be highly leveraged, breakeven analysis has the potential to be highly skewed by individual responses and as such was deemed to be less useful.

6. Results and Discussion

The Lived Experience

The descriptive results from the social questionnaire and the interviews are outlined below, followed by the findings from the Bayesian Network Analysis. In reference to the questionnaire, (n) refers to the number of respondents to each question.

Descriptive results from the questionnaire and interviews

Grape grower /Household characteristics

Table 6 shows that most questionnaire participants (growers) were male (84.2%), with a median age of 55 years (IQR 17.0), ranging from 28 to 78 years. Whilst the highest level of education for more than half of growers was high school, a number reported that they had completed further studies.

For most questionnaire participants, a long history of involvement with grape growing was evident, with 70.3% reporting having grown up in a grape-growing family business and over 80% working more than 24 years in the grape and/or wine industry. Over two-thirds of growers were owner-operators working full-time in the vineyard business. This long history of involvement in the industry also characterised the interviews, where only one respondent was a first-generation farmer.

Table 6. A description of demographic and property characteristics of grape growers completing questionnaire in 2022-2023 exploring the lived experience of grape growers in the Riverina.

Highest level of education (n=38)		
	n	(%)
None	0	(0)
Primary school	0	0
High School (e.g., HSC)	22	57.9
Certificate III	3	7.9
Certificate IV	5	13.2
Undergraduate degree	6	15.8
Postgraduate degree	2	5.3
Did you grow up in a grape-growing family business (n=37)		
No	11	29.7
Yes	26	70.3
How many years have you been working [as an adult] in the grape and/or wine industry? (n=38)		
6-10	1	2.6
11-15	3	7.9
16-20	3	7.9
24-40	23	60.5
More than 40	8	21.1
Current role within the vineyard business (n=38)		
Owner/operator – full time in the business	26	68.4
Owner/operator – part time in the business only	5	13.2
Owner/operator – work outside the business also	5	13.2
Employee	2	5.3
Retired family member who helps out sometimes	0	0.0

The questionnaire asked participants to indicate their level of agreement with a series of statements. While a number of these were standalone, others could be grouped into themes. Selected results are described below with all results reported in Table 7.

Table 7. Level of agreement with statements exploring current and future factors related to grape growers completing questionnaire in 2022-2023 exploring the lived experience of grape growers in the Riverina.

Please indicate your level of agreement with the following statements: (n=38 *n=37)					
	1. Strongly Disagree	2.	3.	4.	5. Strongly Agree
I feel optimistic about the future of my business	12 (31.6)†	14 (36.8)	7 (18.4)	3 (7.9)	2 (5.3)
Being a wine grape grower is important to me	2 (5.3)	6 (15.8)	8 (21.1)	16 (42.1)	6 (15.8)
I think the Australian public views wine grape growers in a positive way	3 (7.9)	6 (15.8)	16 (42.1)	12 (31.6)	1 (2.6)
The Riverina is very special to me	0	3 (7.9)	6 (15.8)	9 (23.7)	20 (52.6)
I am confident I can access market information when I need to	1 (2.6)	7 (18.4)	13 (34.2)	13 (34.2)	4 (10.5)
It is important to me that I grow grapes in an environmentally sustainable way*	3 (8.1)	2 (5.4)	11 (29.7)	14 (37.8)	7 (18.9)
It is likely that my children or grandchildren will take over my business	16 (42.1)	4 (10.5)	10 (26.3)	4 (10.5)	4 (10.5)
I feel that my vineyard business is currently in a financially healthy position	11(28.9)	8 (21.1)	14 (36.8)	3 (7.9)	2 (5.3)
I think Australian government views wine grape growers in a positive way	12 (31.6)	16 (42.1)	9 (23.7)	0	1 (2.6)
I am very attached to the natural environment in the Riverina	1 (2.6)	3 (7.9)	14 (36.8)	11 (28.9)	9 (23.7)
I am confident in my ability to manage my business into the future	2 (5.3)	2 (5.3)	14 (36.8)	11 (28.9)	9 (23.7)
It is important to me to continuously innovate in my business	2 (5.3)	1 (2.6)	8 (21.1)	20 (52.6)	7 (18.4)
I think media coverage of the Australian wine industry is mostly positive	5 (13.2)	5 (13.2)	19 (50.0)	7 (18.4)	2 (5.3)
I feel comfortable in turning to other grape growers for advice regarding my grape growing business	3 (7.9)	1 (2.6)	13 (34.2)	13 (34.2)	8 (21.1)
I feel that operating a profitable grape growing business is within my control	12 (31.6)	11 (28.9)	8 (21.1)	5 (13.2)	2 (5.3)
I have positive relationships with the wineries that I sell my grapes to	3 (7.9)	3 (7.9)	8 (21.1)	15 (39.5)	9 (23.7)
What other growers in the Australian wine industry think about how I run my business is important to me	4 (10.5)	11 (28.9)	18 (47.4)	4 (10.5)	1 (2.6)
Doing my activities in the Riverina is more important to me than doing them in any other place	2 (5.3)	4 (10.5)	9 (23.7)	10 (26.3)	13 (34.2)
I have all the resources I need to manage my vineyard business profitably	4 (10.5)	1 (2.6)	17 (44.7)	13 (34.2)	3 (7.9)
I think the Wine Grape Marketing Board view wine grape growers in a positive way	1 (2.6)	2 (5.3)	6 (15.8)	16 (42.1)	13 (34.2)
I am confident I can access agronomic information when I need to	0	1 (2.6)	8 (21.1)	14 (36.8)	15 (39.5)

† numbers in parenthesis represent % responses

Overall, the findings show growers currently perceive their industry negatively. Several factors contribute to these negative feelings, including crop loss concerns due to severe wet weather in the 2022 growing season, low grape prices from wineries, increased input costs, poor relationships with wineries, uncertain outlook of the future of the industry and a lack of rewards from their efforts. These issues will be explored further in the following sections.

As a summary of the general mood of participants, respondents stated:

> *"It's not a real positive one at the moment, no. Because you just don't know what's going on. There's no clear indication. We're getting a lot of mixed messages from the wineries… There's so many contributing factors to it too. We're all blaming the wineries, but there's other things, there's the freight and logistics of it all. There's so much stuff going on out there that to look at, that all contribute to it. China was definitely a big one."*

> *"Oh well I am a glass half full person, but I've never seen it as bad as these last three years."*

> *"Look, we don't know. Honestly, we're in a spot where none of us know what the future's going to be for anyone, for all the grape growers, because the industry is at its knees really, as far as growers are concerned, a lot of them."*

Change in the industry over time

Many interview respondents explored the changing nature of their industry. Over time farm sizes have increased for economies of scale but the number of growers and number of wineries in the region have reduced. The average age of growers has increased. Farm profitability has reduced as whole families in the past could be supported by smaller farm sizes and maintain a good standard of living. In the current climate, many farmers supplement their farm income with off-farm work of a spouse or themselves.

> *"Well, when things started to get tough, first of all there was a wife or partner working at the farm. And they were only doing part-time work off the farm. And then that wasn't probably enough because they weren't making enough money on the property. Things were getting tighter. So what they used to do, a lot of the farmers actually went out and bought trucks, mainly semis. A lot of them did that and doing carting, whether they're carting grapes, carting grain or whatever they have to. And that's what a lot of them did. Some got work off farm."*

> *"So a lot of the guys gone working off farm. A lot of the trucks started to come in probably in 20 years ago or so, started buying trucks to make extra money. That was started around then, about 25, 30 years ago it would've started. Before that, no. Only a few people were doing it then. Yeah. It was a lot more physical work back then too. We*

picked a lot by hand. A lot of the grapes were picked by hand. Everything was all manual labour. You relied on manual labour and manual labour was available. Now, labour's hard to get, so they're trying to make it more mechanical. And well, the grape industry is all mechanical. The only physical side is when people are sitting in the steering wheel., that's the only physical side. And when you're pruning, just tidying up. A couple people walking around just tidying up after you've pruned it. Yeah. And that's all."

The composition of tasks of a farmer have reportedly changed also. Where in the past farmers spent the majority of their day outside or in the tractor, the proportion of work that is office-based has increased.

"I'd like to see like it was when I first come on the farm, walked out the door, did a hard day's work, drank five litres of water, and got sunburn. It's not that anymore. Farmers don't farm anymore."

The rise of corporate farms was also noted by respondents, and their ability to operate with lower profit margins due to shareholders, than is manageable for a family farm that has to support dependents.

"But they [corporate farms] just need to keep money turning. They don't need to make a profit. They don't need to live off what they make."

"The industry at the moment is grasping at straws. The industry is drowning. And so if something doesn't change, the industry will drown. Yeah. Obviously it'll change, it'll evolve… it'll become like America where it's just a corporate entities and the family farm will die. Yeah. The family farms will become hobby farms, and you will have your full-time job in town, or you will buy a truck and you will work for a corporate, or your children will not come back at all."

Farmers noted that the industry is currently in a state of turmoil, and this brings uncertainty which plays on their minds.

"The uncertainty is probably the worst. Okay, markets are down, and then prices are probably down, but the uncertainty's the biggest issue at the moment. When you talk to growers, that's what everyone would say. "Do we have a home for our fruit? What price are we going to get from our fruit? Are we going to make money or lose money? Are we going to break even?"

"It will change. When it'll change, and who survives the change, is the key thing."

Farm characteristics

There was a broad range in terms of the number of hectares that growers had planted to vine, with a mean (S.D) of 143.5 (462.1) and a median (IQR) of 40.0 (70.38).

Diversification was evident, with over half of growers (52.6%) reporting that the vineyard business was not the only farm-based activity occurring on the property. However, within this group, vineyard-based activities were still dominant, accounting for more than half of farm income for over two-thirds of participants. Whilst prunes and citrus accounted for the majority of other farm-based activities, growers also described cropping, contracting, and water trade as contributing to their overall farm income.

Interview respondents discussed how in previous generations, growers were considered more "fruit salad" farmers where they would grow a range of horticultural products on their smaller sized farm. This diversification can also be seen today, but perhaps with fewer horticultural crops and diversification into other agricultural commodities and off-farm employment.

> *"I mean, there's been what you call your fruit salad growers from 40, 50 years ago, say from my father's year. But that's how they started, they knew no better. They had three acres of oranges, three acres of peaches, five acres of grapes, four acres of veggies and such and such, and such and such."*

> *"Yeah, if not more in the 70s. Right. You're talking people that had peaches, they had apricots, they had market grapes, they had grapes, they had naval oranges, they had Valencia oranges, they had mandarins… As time went on to cut back out that work, grape prices were okay. So they used to pull out their peaches and apricots, because there's a lot of work, because it was all manual labour. So they put in grapes or they put in citrus, because citrus were doing very well. So they're putting in citrus. And then grapes do well, they're putting in grapes. So we've gone away from the peaches, the apricots and all that, and only diversity in oranges and grapes. And oranges were doing well, very well."*

> *"Diversity is probably the only way that we [children if they choose to come onto the farm]…, it'll be diversity that brings up the farm. It will not be grapes, wholy and soul. And we've always been diverse, but it'll be diversity."*

Farm management

While most growers responding to the questionnaire believed in *their* ability to manage their business, as evidenced by over half agreeing (28.9%) or strongly agreeing (23.7%), with this statement, a feeling of *lack of control* was present, with over 60% of growers indicating that operating a profitable grape growing business was not their control.

A key component of recent growing seasons has been weather. The 2022 wine grape season in the Riverina (Griffith Airport AWS) has been characterised by above average rainfall in both autumn and spring (BOM, 2023) which resulted in widespread flooding. These weather conditions increased the incidence of mildew but also posed physical barriers to farmers being able to spray. This may also have implications for subsequent growing seasons.

> *"Yeah. Just rain. Yeah. Flooding. No. Well, flooding in other areas, yes. Where water's been laying in the bottom of a paddock and growers can't get in to spray, yeah. But just generally wet weather, humid weather, very heavy dews in the morning. And it's just a haven for the powdery of the downy mildew that's kicking off at the moment. And downy mildew is one of those disease that will die if it gets about 38 degrees or higher. It will automatically just die 'cause it doesn't like the heat. But then you've got the other one where you've got powdery mildew that can come set in then."*

> *"I think the flow on effects for next year's crop will probably be the guys that haven't looked after their vineyards. They're going to probably be in a bit of strife and how... Don't get me wrong, no offense to any of them, because some of them physically couldn't do anything. They were either underwater or every time they could get on to spray it, rain again. They're delayed so they keep getting disease. Because I have heard, I don't know how true it is, that disease can cause you some dramas for next year, with your bud setting and all that sort of stuff."*

However, climate change wasn't highlighted by growers as a major issue they are facing. More pressing barriers to farm management are input costs. Within the questionnaire, in a ranking question of pre-defined challenges (Table 8), where '1' was the most significant for the profitability of the vineyard business, input costs (n=11) market stability (n=9), and revenue/yields (n=8) were ranked highest by the largest number of growers, also having the highest number of top 3 rankings. By contrast, own knowledge/skill (n=7) climate (n=5), and aging vines (n=4) received the lowest rankings. Interestingly, this changed slightly when the bottom three rankings were considered with a lack of market information moving into this group and climate dropping out to equal 5th position. A lack of branding of the region was described by one grower in free text as an additional challenge.

Table 8. Ranking of challenges related to profitability by grape growers completing questionnaire in 2022-2023 exploring the lived experience of grape growers in the Riverina.

Please rank the following challenges in terms of most significant for the profitability of your vineyard business.											Combined top 3 rankings	Combined bottom 3 rankings
	1	2	3	4	5	6	7	8	9	10		
Market stability	9	10	4	2	1	1	0	1	0	1	23	2
Lack of market information	1	0	4	2	5	0	2	3	5	2	5	10
Input costs	11	10	7	3	0	0	0	0	1	0	28	1
Labour availability	0	1	4	3	5	5	4	1	0	0	5	1
Aging vines	0	0	0	1	0	4	3	6	4	4	0	14
Climate	3	1	3	4	4	3	3	0	0	5	7	5
Time pressures	0	0	2	3	5	5	3	3	1	1	2	5
Government regulations/'paperwork'	2	2	2	3	1	4	3	4	2	0	6	6
Own knowledge/skill	2	0	1	1	0	0	1	4	6	7	3	17
Revenue/yields	8	7	4	2	2	0	1	0	2	0	19	2

Respondents noted that freight, chemical and labour costs in particular have skyrocketed compared to previous years, perhaps exacerbated by COVID-19. Labour availability is an issue as growers lamented the change in labour laws moving from payment based on output to an hourly minimum wage. This often resulted in poorer returns on their labour costs.

> *"Because this year, everyone knows, it's ridiculous what we're spending. We're doing it just to prove a point that we can do it. Just pure passion to say that I can get a crop off this year where it looks like a lot of people won't. It's costing a lot of money, but that's just what we do. We just want to grow grapes."*

> *"We're spending lots of money on systemic chemicals. We normally don't need… these expenditures. And as you're aware, the chemicals are going up. I just spotted one the other day that I bought last March and it cost me 145, and this year it's 225."*

> *"And chemical prices have gone up about 40% compared to last year. And that's extra cost they have to put out. A year like this year, they're doing probably at least almost twice as many chemical sprays that they would normally use. And they've had to use a lot more expensive, they have to use systemics rather than just preventatives. So that's a cost that they never thought they would've had to put up with…In this year of all years. If the prices were good, you'd say, "Well, instead of making a net profit of 200, I'll make a profit 100." But you're losing 200 rather than anything else. "*

> *"That's something you've got to think about every day. Do you have to buy water? Can you sell it? All those sorts of things. Yeah."*

"The cost of labour and cost of everything… This year, we paid them twice as much as we paid them last year."

These higher input costs combined with low grape prices mean that overall farm profitability is much less than it has been in previous years. Rising interest rates is also an issue and this is particularly significant for those growers who are older and carrying debt.

"The amount of capital we have tied up for the return we're getting, we're going backwards fast"

"Farmers don't want to be millionaires. Farmers don't want to make 100% or 200% on a product like these, like these companies that are selling a chair or selling a phone or this, farmers just want to be rewarded for doing a good job and just make a decent living."

"It's because I've been doing it for a long time and got me own machines and stuff. There's no mortgage on the property. But if there was, I don't know how I would survive."

"You'd think after 40 years of doing something, you would say, "Well, I'm debt free." Like a wage earner that buys a house after 40 years would own their house. But we don't. And there'd be a lot in my situation, very few could actually say that they're debt free because you are constantly upgrading machinery and bettering your farm, changing varieties, chasing trends, and you don't get rewarded. You are constantly worried."

The time burden that farmers have to endure in managing their vines is a challenge. Long days at particular times of the year are common and night harvesting for certain varietals is disruptive. There is an extra layer of administrative burden that growers have to undertake which further exacerbates their long hours. This time burden then has flow on effects to family life.

" It's not unusual to do 16 hour days this time of the year. No. It's not unusual at all"

"I'd love to see the grape harvesting at night go. It's too dangerous, as far as I'm concerned. I know the wineries want it because it's cooler, but we've had years going by where we've picked grapes at midnight and it was still 39 degrees. So where's the logic in that? And yet, like just last year, for instance, we had days that were, like today, 22 degrees. Why couldn't they pick white grapes during the day? I mean, the human body's designed to work in the daylight hours. I reckon it's too dangerous, all this harvesting at night and that. And their argument to all of us is that you need to employ a second shift. What farmer and contractor in their right mind can employ a second shift"

"It just seems every time you walk out your door, you're trying to negotiate with someone. There's always a form of red tape somewhere that you can't go and do that because that

has to be met and that has to be met, and you got to ring this person to get that sorted and ring that person. It can be a disaster."

"There's a lot of pressure. Yeah, it affects probably time, your time. I think now time. Probably because of the farmers struggling for profitability, the emphasis then to go and have other income streams is quite good. Yeah, time with family life, and that has probably impacted a lot at the moment. I think a lot of growers would say that, just probably at home and home life. Yeah. Yeah, I don't know. That's probably what they'd say."

Industry characteristics

Most (80%) growers sold their grapes to one winery only, with the remainder selling to two wineries. Growers lament that they are price receivers, cannot pass their costs on to others in the value chain and have very little power to alter their place in the market.

"Obviously, for pricing-wise it's been getting worse and worse. So yes, we've been losing money as we go along. That's what we're doing off-farm to fund our hobby or... You nearly want to call it at this stage, or I'll call it a hobby because you're losing everything you make on it. You're just working for the enjoyment of working on it, and you got an off-farm income to even pay to do it. So yes, it's been getting worse, and this year, the prices of the winery that we're with is really ridiculous, and they pretty well told us they're probably not going to take it anyhow because all they've got to do is find the slightest mark on a... Residue of disease and they're not going to take it."

"It doesn't matter whether citrus, grapes, what have you, contracts aren't worth the paper they're written on in this industry."

"Most businesses would probably argue, "But we are no different." All right? And true. But they are different in the sense that, I mean, like last night we were looking at, saw the toilet paper there. The guy was saying the gas prices have got through the roof. He says, "Well, the only thing I can do is either go offshore or pass the cost onto consumers." And good on you, mate that you've got that luxury. What do I do as a farmer? Farmers don't have that luxury. We can't pass on a bill to say, "Hey, it's costing me so much more to grow my grapes, you can't give me 300 bucks a ton. You've got to give me 600." They say, "Oh no, no, it's got to do with supply and demand."'"

However, respondents did acknowledge that different actors in the value chain also have challenges and costs that they need to manage. Supermarkets are seen at the top of the chain.

> *"Look, the wineries have their drums as well. Of course. They're getting screwed by the supermarkets. They're getting screwed by the exporters, the people they're selling to because if we don't buy it off, you will buy it off Argentina, we'll buy it off South Africa. We'll buy it off Chile. Understand that. But instead of making 100% profit, if you make 88% profit, give us a little bit that say we are getting above cost of production. Everybody's happy."*

> *"It is a huge challenge. Just trying to, I suppose, educate the public a bit better would be the number one thing. Not to listen to what the bloody supermarket's say all the time."*

> *"Supermarkets do have a hand in what the wineries do in a sense because they're taking their products."*

While Table 7 shows that over 60% of questionnaire respondents agreed with the statement that they have positive relationships with the wineries that they sell to, the responses from interview respondents was more mixed. Some interview respondents reported that they have long-standing, amicable relationships with their wineries based on trust, others have fraught relationships with the wineries they deliver to. In fact, some growers are in the precarious position of being owed payment for the previous year's delivered grapes and while preparing to deliver the next harvest to that same winery.

> *"The relationship with the winery's not too bad. Like I said, it's because we've kind of been loyal to them, they've been loyal to us."*

> *" I wouldn't say it's an all-time low. I think it's always been like that. It's always been a "them and us", it always has been. Right. And depending on years, the relationship gets better. Sometimes gets worse, but it's always been there. It's never been an equal part."*

> *"They [wineries] know they can manipulate us because we can't go anywhere else."*

> *"There's only one winery in the area that pays within 30 days of delivery, 30 days after the month of delivery. Only one winery. But yeah, we can't work with that winery in any shape or form. His attitude is that you are the scum under the boot. And the only reason people deliver is because they know he pays him 30 days, he pays less, but he takes it in. We get paid in 30 days. The three wineries we deliver to, only one has kept their terms of payments. The other two haven't."*

"There's been a few incidents happened over the years, if you look over 20, 30 years, there's been a few incidents where people haven't been paid, wineries have gone under, been bankrupt, and they've lost all their money."

"It's exactly the same as the two wineries that are paying late and haven't paid at all. As in only two and a half payments. The contract actually states that if they're two weeks late with payment, I can actually call that contract in and call it null and void. Where am I going to go? No other winery's going to touch me because every other winery in the area is in the same boat in that their tanks are still full of red wine and they all talk, and this is the problem."

"Those same growers now have got their vineyards, their grapes at the point of harvest and where do you go? Do you deliver them to the same winery and then they'll be two years without paying. So, that's one fellow's got a million dollars that needs to be paid."

Respondents see the reduced number of wineries in the region a problem for competition and even perceived collusion amongst the local wineries.

"When there were more wineries in the area that played the game, it was okay, but the wineries don't play the game. Now the wineries, and they tell you it's not true, but they have a monthly meeting, dinner date where they all get together and they all talk and they're all best mates… There's no collusion. No collusion at all between the wineries and what they're prepared to pay. And this is the problem… And then one winery follows the other. And then the growers, obviously you say, 'right, I've got Jack of this. I'm going to leave this winery'. You've got what a couple to choose from, and once you put a cross against your name, one winery, that's one less availability. And if there was more, obviously this is in a perfect scenario, if there was more around they, they would all be bidding on fruit, looking for fruit."

"And the collusion that's in the collusion that is out there to keep the farmer under their thumb, under their boots, is to the point where they are ruining their own business."

In terms of growers banding together to negotiate prices or greater power within the market, this seems limited by the differing perspectives and aspirations of different growers (i.e. those that undertake grape growing as a lifestyle activity alongside off-farm work, and those whose families are dependent on grape income). While growers acknowledged that the Grape Wine Marketing Board are active in this space, they are also limited in what they can achieve.

" And the other problem we have as growers is we're only as strong as our weakest link. And I'm not sure of the exact number, but there used to be about 600 growers in the area.

I'm sure there's a lot less than that now, but there used to be. But you get the older generation, even older than me, who've always had their own little farm and they've got no debt, and it's a garden to them. And it doesn't matter what they get as long as they get something. And that doesn't work for someone who treats it as a business, it doesn't work. But if Joe Blog is going to sell me grapes for $150 a ton, well, why do I need to give you 300, which is cost of production, bare minimums, 300 cost of production. Why do I have to give you 300? He'll give to me for 150. And this is where we're fighting a losing battle with one hand and one leg tied behind our backs. And then we're our own worst enemies because we get bigger, we buy the best possible machinery we can buy to make life easier for ourselves. So we buy better machinery so we can run a few more acres, and yeah, we cause a rod for our own backs."

"The government in their wisdom, took away their vesting powers. All the wine grape marketing board can do is talk to government and can advise growers on issues. But they can't set a price and they can't negotiate a price and they can't negotiate terms. So they're a toothless tiger. You still need them there in one form or another because to deal with all the government issues. But as far as being able to support the grower and work as a union, which is what they basically were, the growers had a union that's gone. But the rice growers kept theirs, but we didn't but the rice growers did."

Engagement with industry and community

Whilst, awareness of Wine Australia was high (89.5%) amongst questionnaire respondents, over half (54.5%) of the growers could not, if asked, describe what the organisation does (Table 9). Most growers (62.5%) either disagreed or were neutral when asked to indicate their level of agreement with the statement that Wine Australia views wine grape growers in a positive way.

Table 9. The engagement with industry and community of grape growers completing questionnaire in 2022-2023 exploring the lived experience of grape growers in the Riverina.

Are you aware of Wine Australia? (n=38)	n	%
No	4	10.5
Yes	34	89.5
If someone asked you, could you describe what Wine Australia does? (n=33)		
No	18	54.5
Yes	15	45.5
Please indicate your level of agreement with the following statement: Wine Australia views wine grape growers in a positive way (n=32)		
1. Strongly disagree	1	3.1
2.	5	15.6
3.	14	43.8
4.	9	28.1
5. Strongly agree	3	9.4

Membership of other industry groups was described by 42.1% of questionnaire respondents, most of whom (75%) were only involved with one such group. Most of these groups related to their grape-growing business. Much lower numbers (24.3%), indicated that they were members of a community group with the types of groups described including Rotary, church and special interest groups. One interview respondent noted that he had withdrawn recently from much of his community and industry work and took this as a sign of his overall feelings about the state of the industry:

> *"So for the first time in probably 40 years, I'm not involved apart from [a group] in any community or any government based community or industry based organization in a official capacity. And that's a very sad state of affairs. But that's how disillusioned I have become with everything."*

Whilst there was a strong sense of the importance of being a grape grower (57.9% agreed or strongly agreed, Table 7), it was the attachment to the Riverina region and its natural environment that appears to have the strongest pull. Over three-quarters of growers agreed that the Riverina was special to them with most (52.6%) expressing an attachment to the natural environment in the Riverina.

Responses from interview participants showed slightly more nuance, where some growers were very attached to grape growing as a career, others put more stock in attachment to their farm, some to the point that if they sold their farm they stated that they would have to leave the region so they didn't have to see the farm being owned by someone else.

"I suppose growing up in this region and being familiar with it probably goes a long way. In saying that, working in other regions within Margaret River for a bit and across Australia, it's... Yeah, I love this region, and I love what we can produce here."

"Oh, I just enjoy being a farmer in general, because it's just all I've known since I was a kid. I've known no different. I never got a trade. I just love being outdoors. Trying to be your own boss is good. Yeah, and hopefully, the more you put in into something, the more you can get out of it, so reaping the rewards. So it's satisfying to know that you've done a good job and it's turned out well, that you have been able to go and buy that new ute or splurge and buy yourself a motorbike or take your family on a holiday or know that you're sustainable for next year. That's probably the best part about, well, farming, not so much wine grape growing."

"No, I won't stay here. I will go somewhere where nobody knows me. Yeah, so yeah. No, yeah, it's just like that. It's not rewarding. Hasn't been rewarding ever. The only reason we are all still here is that we are into the banks and they might be driving around the flash car, but do they own it? You see it all the time… I don't want to be in the area, because I just don't want to see farms anymore. I'm over it. I just want to go somewhere where I just don't see farms, you know what I mean?"

Very different perspectives were evident in relation to how growers felt that they were perceived by others. Overall, growers felt that the Australian public viewed them positively, with only 23.7% of growers disagreeing with this statement. A very different picture was presented in relation to government with only 2.6% agreeing that the Australian government views wine grape growers in a positive way. Interview respondents highlighted that the general public probably doesn't understand the challenges they face and efforts should be put towards public education to improve their perceptions of grape growers.

"I think the way farmers are being treated, it's horrible at the moment. We've had issues with a few things and I can tell you just in this last week, people have no consideration for what we are doing."

"Supermarkets are controlling everything. And I said it to them too, this is where the general public needs to be educated better because they... How do you say? I personally feel that the supermarkets, the media and the government's all tied in together… It is a huge challenge. Just trying to, I suppose, educate the public a bit better would be the number one thing. Not to listen to what the bloody supermarket's say all the time."

Grower wellbeing

The group of questions related to well-being are presented in Table 10. Across these questions there is an undeniably concerning theme, with a degree of stress (92.1%) and worry (86.8%) and low mood (72.9%) reported by most growers. This can perhaps be juxtaposed against the finding that over three quarters of growers still feel a level of satisfaction in relation to their business.

Table 10. Perception of aspects related to well-being of grape growers completing questionnaire in 2022-2023 exploring the lived experience of grape growers in the Riverina.

Please indicate your perception of the following in relation to your vineyard business over a typical week: (n=38 *n=37)					
	Never	Rarely	Some of the time	Most of the time	All of the time
I feel stressed (related to my business)	1 (2.6)	2 (5.3)	18 (47.4)	14 (36.8)	3 (7.9)
I feel down (related to my business) *	1 (2.7)	9 (24.3)	17 (45.9)	7 (18.9)	3 (8.1)
I feel worried (related to my business)	1 (2.6)	4 (10.5)	15 (39.5)	14 (36.8)	4 (10.5)
I feel satisfied (related to my business)	1 (2.6)	8 (21.1)	18 (47.4)	11 (28.9)	0

Interviews also found that there is currently a negative outlook in the industry and this has implications for growers' mental health. While some growers acknowledge that the Grape Wine Marketing Board is trying to make a positive impact on this aspect of the industry, this can have the reverse outcome as growers getting together to talk about grapes can reinforce negative feelings and wellbeing.

> *"But really grapes can go get fucked. Right?"*
>
> *"And there are some days the attitude is not good. I do have some very negative thoughts sometimes which I've never had before, so is that partly age or is that just partly the fact that two and two aren't making four?"*
>
> *"Well, there is a wine marketing board and they said that's what the biggest concern is for them is the mental illness of a lot of their growers. Which also then filters down to the family and stuff, so it's not just the one person. It can affect a lot of people. When people are down it's just, yeah, the black dog can really step in and make a mess of things and... Well I've had to sort out myself, people I hang with. But bloke I do talk to, he says there's a lot of blokes out there, yeah, just doing it pretty tough."*

"Sometimes you go in the meeting at the moment like those, yeah, industry get-togethers. Everyone's probably a bit down and out, and it probably rubs off on you slightly. Yeah, get a group of people together, and they're negative, well, it sort of compounds it a bit. Yeah, yeah. It's just our outlook at the moment… Probably there's been a overload out of the Wine Grapes Marketing Board in the last few months. There's a lot going on. Yeah, yeah. It's at a time when growers aren't positive about the industry, and they don't want to be… they don't want to go in technical things and whatever. Yeah, they don't want to talk about grapes. It's what… It's all they read, so they don't want to talk about it really. Yeah. I think, yeah, they get over talking about it. That's understandable. I mean, yeah, then their grape... Yeah, if they had an event where, oh, we just catch up a bit, and we aren't talking- Yeah, no talking about grapes. Not allowed to talk about grapes. Everyone would come."

Succession planning and future outlook

With the option of selecting more than one response in the questionnaire, over two-thirds of growers planned on removing/selling grape production assets in the next 10 years (Table 11). Of this group, a third intended on selling their farm, with a quarter indicating that they would be retiring. Similarly, a quarter planned on diversifying their crops, and just over 20% planned on replanting a new wine crop.

Table 11. Succession planning and future outlook of grape growers completing questionnaire in 2022-2023 exploring the lived experience of grape growers in the Riverina.

Do you plan on removing/selling grape production assets in the next 10 years? (n=37)	n	%
No	12	32.4
Yes	25	67.6
Why do you plan on removing/selling grape production assets? (n=24)		
Retirement	6	25.0
Leave for employment in another sector/industry	1	4.2
Replant new wine crop	5	20.8
Replant non wine crop	6	25.0
Selling the farm	8	33.3
Crop diversification	6	25.0
Other reason (please specify)	4	16.7

Despite growers describing enterprises that supported partners/spouses (86.8%), children (55.2%) and parents (26.3%), in terms of succession planning, almost half did not intend on passing on the vineyard business to family members. A further 32.4% reported being unsure. Statements related to future outlook (Table 11) and viability generally presented a negative picture. Optimism was low, with very few either agreeing (7.9%) or strongly agreeing (5.3%) that they felt optimistic about the future of their business. Similarly, very few growers agreed (7.9%) or strongly agreed (5.3%) that their vineyard business is currently in a financially healthy position**.** These results may provide some context to the finding that very few agreed (10.5%) or

strongly agreed (10.5%) that it is likely that their children or grandchildren will take over the business. For all statements, there was, however, a degree of neutrality with 18.4%, 36.8%, and 26.3% respectively selecting the arguably uncommitted score of three on the scale.

Several interview respondents stated that they did not want their children to come back on the farm, at least not straight after school, and others suggested that their children could come back on the farm in the future, but as a hobby rather than being reliant on the farm for a living wage.

> *"At the moment, no. I don't really want them [children] to, as into farming at all, unless I can see major improvements in the common sense, the paperwork, the red tape, and all that stuff being changed."*

> *"They reckon the best form of child abuse is letting your son come home on the farm. Well, I'm guilty, but it wasn't always like this wasn't always like this, interest rates weren't supposed to go through the roof, you are beholding not only to the winery but to the weather. We've got one property that we got wiped out by frost last year and this year we've been wiped out by the disease. It doesn't make it very much fun."*

While interview respondents were hesitant to have their children come onto the farm, they did lament the lack of young people within the industry.

> *"It's just got to turn around because I don't see too many young ones going to come forward and take over... since I've been involved with the industry, I'm still seeing the exact same faces. There's no new ones coming through, no younger ones. I mean there's the odd younger one, but when I say the odd young one, they're coming back to it from something else at like 34, 35. And they only got into it just before the downturn. But yeah, you don't see any young teenagers or 20 year olds coming straight onto the vineyard, that's for sure."*

One respondent claimed that part of the issue is that grape growing isn't attractive for younger generations to come into, as they see their parents dealing with tough times and that discourages them.

> *"And you've got to think that the kids nowadays, kids, as they're growing up in a family, and we were all no different, we saw our parents, what they were going through. If they were having arguments on money, and they were arguing about the industry the way it is, and if you're coming through and you're listening. And kids listen. You think they're not. They're there, So they're thinking, 'They're having an argument over the farm. They're having arguments. I don't want to come on the farm. Do I want to go through that relationship?'"*

Growers are discouraged about the future due to the range of factors presented in this results and discussion section. Various factors have reduced the profitability of grape growing in the Riverina region and that has flow on effects to farmers and their families more broadly. One respondent stated that part of the real difficulty is that much of the problem within industry at the moment is "man-made". He stated "I don't have a problem with that because that's beyond, and that's God, that's beyond anyone's control. But what we are going through at the moment is manmade, right? It's just greed." What the implications are for the industry moving forward are unclear. Interview respondents reflected on this, suggesting that the future landscape of the industry would be different, with more corporate farms in the Riverina and many current growers exiting the industry.

> *"I guess for the multinationals who've got vineyards out there who use other people's money, I guess they'll always keep farming because they've got investment to do. Growers who are family owned, yeah, I really don't know what's... For some people also who have got a mortgage over it, I don't know. Because the industry the last two or three years has been sort of flat. Because last year wasn't a good year either because it did rain and a lot of blocks were condemned from mildew. And this year some blocks are gone totally abandoned. Yeah, I don't know, I think they need more and more people, particularly the smaller grower. Same, I say smaller grower 50 acres or less. I reckon they'll probably end up walking away and just ripping their vineyard out and then just having an empty block."*

> *"There's only about a third of the growers that are in business at the moment, that have a younger sibling coming along. Whether there is the odd one of two daughters coming through, but not many, most of them are sons. But that's all there is. So there's a third of the growers, or two thirds of the growers going to have to either do one thing, walk away from their property as they get older, or if someone's willing to buy it, they'll sell it. So that's where we are with the industry at the moment."*

BN model findings

The following inferential analyses were undertaken using the BN model, to consider the following questions.

1. What are the characteristics of the producers that self-report as feeling down, stressed and worried all or most of the time? What about those that report high levels of satisfaction?
2. What are the characteristics of the producers who report no intended change in the next 10 years, and those that intend to retire, replant, or diversify out of wine grapes?

The producers that self-reported that they are satisfied most of the time are characterised by the model in the following way.

- They are likely to be aged 50-69, be experienced grape growers (21-40 years' experience) and identify 'Market Stability' and 'Input Cost' in their top three challenges.
- While they are likely to not feel optimistic about the future of their business, they are likely to report a high sense of self efficacy and high confidence in their ability to manage their business into the future and have all the resource they need to manage their business profitably.
- They are likely to report a strong identification of themselves as a wine grape grower and identify that the Riverina is Important to them for grape growing.
- They are very likely to report positive relationships with the winery, and while they are likely to be ambivalent about the current financial health of their business, they are comfortable in asking advice from other growers.
- They are likely to have lower levels of connectivity with industry and community groups (between 0-1 connections).
- They are likely to feel stressed and worried some of the time and are almost equally likely to feel down some of the time or rarely.
- They are likely to not be planning any change in the next 10 years and are ambivalent about passing the farm onto family members.

The producers that rarely feel satisfied can be characterised by the model in the following way. They are likely to:

- Be 40-59 years old, experienced grape growers (21-40 years' experience) and have an alternative source of income.
- Identify 'Market Instability', 'Input Cost' and 'Revenue' as the top three challenges in their business.
- Report a lack of self-efficacy, not identify Grape growing as important to themselves and be ambivalent about the Riverina.

- Be divided between positive and negative relationships with the winery, and have variable connectivity with industry and community groups, from 0 (37.5% likely) through to 3 connections (25% likely) and more than 3 (12.5% likely).
- Undertake change of some sort in the next 12 months including retirement or replanting non-grape crops, unlikely to pass the farm onto family, with selling the farm being the most likely option.

The grape growers who reported no intended change over the next 10 years can be characterised in the following way. They are likely to:

- Be aged 50-59, or 30-39. They are likely to be experienced growers (21-40 years' experience), on 30-50 ha.
- Report higher satisfaction levels and report feeling stressed, down and worried some of the time.
- Strongly identify as grape growers and be attached growing grapes in the Riverina.
- Have positive relations with the winery and confidence in their own ability to manage the business in the future but lack a sense of control over running a profitable business.
- Have between 0-1 connections with industry and the community, be unsure about a family succession plan.
- Identify 'Input Cost', 'Market Stability' and 'Revenue' as the top three challenges to their business.

Findings from Part 2 of the project illustrates a community of growers under strain, who are generally lacking optimism and a sense of control over their capacity to operate a profitable business. Producers are not strongly connected to industry/community groups, which can indicate a lack of supportive network and potential for respite from the concerns of their business.

In the context of the whole project, it is important to utilise the impact of participants' lived experience and wellness to inform any further research and action taken within the grape growing industry in the Riverina.

Economic Impact Analysis

Vineyard size and grower characteristics

The median size of participants vineyards in each size class was similar to that in the Riverina region (Table 12). The distribution of participants, however, was biased towards the 71 to 175 ha class size, with only 2 to 4 responses in each of the other class sizes. These responses should not be considered representative of the wider industry, although they do provide a benchmark. A summary of key responses by size class is shown in Table 13.

Table 12. Description of vineyard size (ha) classes and sampling used in the survey of Riverina growers.

	Vineyard size (ha)				
	≤ 10	11 - 20	21 - 70	71 - 175	>175
Median size (ha)	7	16	38	106	254
Total area in Riverina (ha)	545	943	3854	2989	12215
Percentage of Riverina vineyard area (%)	2.7	4.6	18.8	14.5	59.5
Number of growers in Riverina (n)	90	59	100	26	32
No. surveyed	4	2	11	3	3
Median vineyard area of those surveyed (ha)	5	15	42	125	300

All except one participant were the owners of their vineyard, with the other a manager. The highest level of formal education attained was completion of Year 10 (10/23) followed by completion of a trade certificate (7/23). A degree or higher degree was held by 3/23 participants. The participants were very experienced in wine grape production, with 22/23 having between 22 and 40+ years experience. Those with vineyards ≤ 10 ha had at least 40 years experience, while those with 21 to 175 ha vineyards also included owners with fewer years experience. The small numbers sampled mean it is not possible to determine whether small vineyards are generally only owned by older growers. A lack of profitability in recent decades could be expected to result in a reduction in vineyard size where diversification to alternative on-farm enterprises is possible, or to off-farm employment.

The intentions of participants to remain in the industry were not closely associated with vineyard size, with some growers intending to remain in all size classes. Only 11/23 participants stated a clear intention to remain in the industry, 7/23 intended to retire or leave, 3/23 were unsure whether they would remain, while 2/23 intended to diversify on-farm. Within the 21 to 70 ha class size, only 5/11 participants intended to remain in the industry. When asked later in the survey whether they were actively preparing to leave the industry, 9/23 agreed. For the future 2022/23 harvest, 91% of participants were not expecting to generate a financial profit due to the low prices for grapes. Over the 2021/22, 2020/21 and 2019/20 harvests, a declining percentage of growers (43%, 36%, 27%, respectively) reported having made a financial profit, and this was consistent across vineyard size classes. Participant intentions to leave the industry were linked to the low profitability of wine grape production. Several successive years of not making a profit results in growers not seeing a future in the industry, and younger generations needing to find off-farm employment.

The majority of participants (17/23) reported sourcing a proportion of household income off-farm. The method for this and number of dependants per vineyard/farm was not recorded, but included off-farm employment of self and/or partners. Vineyards ≥70 ha sourced 0 to 30% of income off-farm, while those ≤ 20 ha sourced 40 to 100% off-farm. Those between 21 – 70 ha sourced 0 to 100%. The reporting of 100% of

income suggests some participants were not considering farm income before costs. The reports do suggest that the requirement for off-farm income will increase below a vineyard size of 70 ha.

Vineyard management

None of the participants responding owned a winery nor a cellar door, meaning they relied on grape sales. Grapes were commonly only sold to a single winery (17/22), with only 5/22 participants selling to more than one winery. Only participants with ≥21 ha vineyards sold to more than one winery. The sale method for grapes was a concern for many growers, with some growers not able to obtain contracts with wineries, some growers considering contracts would not be honoured or not worthwhile, and some growers considering contracts essential to enable sale of grapes. The majority (13/23) of participants used contracts, and this was consistent across large and small vineyards. A further three participants used a contract plus handshake or handshake/verbal agreement, while 7/23 growers sold grapes using spot price. The lack of contracts, and particularly contracts agreed well in advance of harvest, indicates a lack of security for growers in determining appropriate costs of production for the tonnage able to be sold and the income generated. Participants also commented on the restriction caused by wineries capping the tonnage they would buy, making it impossible for growers to increase tonnage to overcome the impact of low prices on income.

The production of other crops in addition to a vineyard was common (13/23 participants). It occurred across most size classes, although the small sample size prevents determination of any trend across vineyard sizes. The area of other crop ranged from 3 to 128 ha but was usually (9/13 participants) less than 21 ha. Large areas (> 21 ha) of other crop were only reported for the 21 to 70 and ≥176 ha size classes.

New vines had been planted across all vineyard size classes within the last 1.5 years. However, the youngest vines on individual properties were 8 to 25 years old on 32% (7/22) of vineyards, with two vineyards where the youngest vine was 15 to 25 years. The oldest vine was reported as 10 years by only one participant. All other participants reported oldest vine ages between 14 and 60 years, with 8/23 reporting ages ≥35 years, and these were present across all vineyard size classes. Where the commercial lifespan of a vine is about 20 years, this indicates that the productivity of some vineyards may be less efficient than agronomically possible, that a large number of vines are at or nearing their productive life and that replanting is desirable. The low profitability of vineyards for some years is probably the reason many growers have aging vines and is also preventing the large capital outlay required for replanting. Aging growers whose intent is to leave the industry in coming years without succession of a family member may also have little incentive to outlay scarce capital to renew vines.

When replacing vines, participants generally sourced vines from nurseries or the vine improvement association. The question did not clarify whether these were grown on own roots or with a selected rootstock. Only 4/18 participants indicated they would use cuttings. If growers are replanting using rootstock, this indicates a change in practice, as historical records indicate that at least 73% of vineyard hectares have been

grown on their own roots (WGMB, unpublished data) potentially exposing growers to a higher level of production risk. A change in practice is supported by 10/16 participants indicating that if they were to replace vines in future, they would use rootstock, rather than cuttings. However, our survey may also be biased by more progressive growers than the average for industry.

Inter-row management of vineyards was variable with individuals often reporting several methods, and there were not sufficient responses to determine trends between size classes. Mowing was widely used (9/22), but the question did not clarify whether this was used only with volunteer weeds, or also with cover crops. Cover crops were used by 5/22 participants although some stated they were only used if the season was favourable. Herbicide was used by 6/22 participants, with some cultivation by 3/22.

All vineyards sourced water from a water provider (MIA). While drip irrigation was the most common practice (14/23), 39% (9/23) of participants used flood (including furrow), or flood in addition to drip irrigation. Flood irrigation occurred across all vineyard class sizes. Some participants reported using flood at specific times (spring to prevent frost damage) or on small areas, with most irrigation by drip. While less efficient than drip irrigation, the cost of converting to drip irrigation in established vineyards may be one reason for the continued used of flood irrigation. Visual/manual (eg vine condition, shovel, soil auger, weather forecast) methods were generally used to determine irrigation requirements. Only 6/21 participants reported using technologies such as soil moisture meters or gypsum blocks, and use of technology did not appear to increase with vineyard size. It is noteworthy that several participants reported dis-adoption of technologies to determine irrigation requirement. Reasons given included a high cost relative to the benefit over visual methods, and also ineffectiveness – water stress to vines had already occurred by the time the technology indicated irrigation was required.

Table 13. Participant survey responses based on vineyard size (ha) classes used in the survey of Riverina wine grape growers.

	Vineyard size (ha)					Total
	≤ 10	11 - 20	21 - 70	71 - 175	>175	
No. surveyed	4	2	11	3	3	23
Intend to remain in industry, not diversify	1	2	5	3	0	11
Sell grapes on contract	3	0	6	2	2	13
Grow other crops	3	1	5	3	1	13
Maximum area other crop (ha)	20	13	91	20	128	
Number using flood/furrow irrigation	3	1	3	1	1	9
Use technology to determine irrigation	1	1	3	0	1	6
Number of red varieties (mode)	1	2	3	5	3	-
Number of white varieties (mode)	1	2 or 3	2	7	3	-

Most vine management practices were mechanised (mowing, spraying, pruning, harvest) across all vineyard size classes. The only practices usually conducted manually were de-suckering, tidying vines post-pruning and training of young vines. Vineyard row spacing varied between 3 and 4 m, while vine spacing along rows

ranged from 0.9 m to 2.7 m. A single cordon trellis was the dominant system (16/21 participants), although some growers had a percentage of double cordons.

Overall, the most frequent number of grape varieties grown per participant was 3 red or 2 white. Although the low sample number limits accuracy, while vineyards ≤ 10 ha most commonly grew only one variety of red and/or white grape, larger vineyards commonly grew 2 or 3 varieties of red and/or white. The 5 or 7 varieties grown in the 71 – 175 ha class (Table 13) may be biased due to only 3 participants in that category although a percentage of growers (26 to 35%) for the survey overall did produce ≥ 4 varieties of red and/or white. Diversification of varieties may reduce production risk due to differing susceptibility to disease or environment, variation in maturity date, and change in winery demand for particular varieties. A larger number of varieties may also reflect trialling of new varieties or small areas for specialist varieties. These activities would be more difficult to achieve at commercial scale on vineyards ≤ 10 ha. A larger number of varieties would, however, lead to more complicated management, which may be why very large vineyards do not grow a wide range of varieties.

The red varieties grown by the largest number of survey participants were Shiraz, Cabernet sauvignon, Merlot and Durif (Table 14). The most common white varieties were Chardonnay, Sauvignon blanc and Semillon. These are consistent with the key varieties based on area grown in the Riverina (WGMB, unpublished data), and the most common varieties were grown across all vineyard classes. Of the 29 varieties grown, there was a large number (12) of varieties of grapes only grown by one participant, and these were usually only grown in the 21 – 70 ha size class. The reason for this is unclear, but may reflect greater trialling of new varieties or retention of old varieties, or perhaps specialist growing for a winery.

Table 14. The number of participants growing particular red and white grape varieties based on vineyard size (ha) classes in the survey of Riverina wine grape growers.

	Vineyard size (ha)					Total
	≤ 10	11 - 20	21 - 70	71 - 175	>175	(n)
Red varieties						
Cabernet sauvignon	1	1	7	1	2	12
Durif			4	2	1	7
Lagrein			1			1
Lambrusco			1		1	1
Malbec			1			1
Merlot		1	5	3		9
Montepulciano			1			1
Petit verdot			1	2	1	4
Pinot noir		1	3		1	5
Raison			1			1
Ruby cabernet			3	2	1	6
Shiraz	2	1	8	3	3	17
White varieties						
Aranel			1			1
Chardonnay	1	1	7	3	3	15
Colombard			2		2	4
Dourado			1			1
Gewurztraminer			3	2		5
Muscat (probably gordo)	1					1
Muscat gordo blanco			3	3		6
Pinot grigio			2	2		4
Riesling			1			1
Sauvignon blanc		2	6	3	2	13
Semillon	2	2	4	3	2	13
Trebbiano	1					1
Verdelho			1			1
Viognier				2		2
White frontignac				1	1	2

Grape production reported for the 2022/2023 harvest is shown in Table 15. A decline in grape yield as vineyard size class exceeded 20 ha may be due to the small sample size. Yields for both participants in the >175 ha class were low, and both crops were reported as impacted by disease. Disease and grape quality also caused some grapes to be sold at a discount on 5 vineyards in the 21 to 70 ha size, and low Baume resulted in discounted price on one < 10 ha vineyard. The price for red grapes averaged $419 (range $320 to $550) and was $400 (range $330 to $500) for white grapes sold at full price. Grapes discounted for disease or quality sold at $150 to $330 (red) or $225 to $350 (white). While the majority of participants did not sell grapes at discounts, for those that did between 4 and 50% of total crop yield was impacted, leading to significant reductions in income. The 2022 season was one of extreme disease challenge due to high rainfall. This resulted in higher than normal use of chemicals for disease control, but some growers were also unable to spray at the appropriate times due to the soil being too wet for vehicle access. The use of vine varieties which are resistant to the major pathogens would reduce the dependence on chemical inputs for disease control and

substantially reduce costs in challenging years. The traditional varieties commonly are often less disease resistant.

The use of water to produce the grape crop was higher for the ≤ 10 and > 175 ha size classes (Table 15). The high water use in the smallest class may be associated with a larger percentage of participants using flood/furrow rather than drip irrigation. The reason for the higher water use in the > 175 ha class is unclear, but there were only 2 participants so the result may not be representative. The efficiency of water use for grape production was similar for classes between 11 and 175 ha. Water efficiency was reduced in the ≤ 10 ha class, but also in the > 175 ha class, possibly because both vineyards in this class were impacted by disease and produced very low grape yields.

Table 15. Grape production for red and white grapes for the 2022/2023 harvest based on vineyard size (ha) classes in the survey of Riverina wine grape growers.

	Vineyard size (ha)				
	≤ 10	11 - 20	21 - 70	71 - 175	>175
Number of responses	3	2	9	2	2
Grapes sold (t/ha) Average	17.1[A]	20.3	15.5[A]	16.2	8.5[B]
Range	14.4-20.3	18.4-22.2	9.8-19.8	15.4-16.9	5.4-11.6
Percentage of crop sold at discount price	0-50	0-10	0-32	0	0-8
Water use (ML/ha)	6.3	4.7	3.6	4.0	5.8
Water efficiency (ML/t grapes sold)	0.30	0.24	0.23	0.26	0.82

[A]Excluded one grower report of 37.5 t/ha or 28.6 t/ha in the ≤ 10 and 21 – to 70 ha classes, respectively.
[B]Includes one report of 5.4 t/ha affected by disease.

Participant perceptions of factors limiting productivity and profit

The high cost of inputs (eg labour, fertiliser, chemicals, water) was the most common factor participants identified as limiting the productivity of vineyards (Table 16). For example, the price of urea increased from under $300/t in 2020 to over $900/t in 2022 (https://tradingeconomics.com/commodity/urea). The increasing cost of inputs where income is declining due to low grape prices results in growers minimising costs where possible, which can result in lower production. Such impacts included insufficient cash flow to replace vines, resulting in aging vines with an increased risk of disease, reduction in fertiliser use which restricts yield, and 'not testing things' which may result in sub-optimal levels of inputs. However, participants also recognised that short-term cost-cutting could have adverse long-term impacts on production due to the perennial nature of vines eg "not fertilising in bad years is false economy." Good management of vines with monitoring and early actions was stated as important in avoiding production losses.

Environmental conditions were also a major factor identified as limiting the productivity of vineyards. Weather was linked to disease risk, water requirement, grape quality and timely management of vines. Soil type was reported to limit production by three participants.

The third most frequently identified factor limiting productivity was winery practices and pricing. Wineries are currently capping the yields they will receive due to oversupply and advising growers to manage vines to achieve lower yields. The price wineries offer for grapes is not provided well in advance of harvest, so growers reported limiting inputs to reduce the risk of eroding profitability e.g. “uncertainty about price limits investment in the crop.”

The high cost of inputs and low prices for grapes were the most cited factors limiting vineyard profitability. Grape growers are price-takers, with prices being set by the market (wineries). Some participants perceived a lack of competition between retailers as a factor reducing grape prices. Others had a wider view and considered the current oversupply relative to demand, along with changing consumption patterns eg “young people don’t drink wine”.

Participants reported a very strong link between market forces and profitability. The fact that growers are price-takers was the most identified factor. The inability to obtain contracts with wineries or contract limitations to sell grapes was also reported as a serious obstacle to profitability. The lack of security of future price limited investment in crop management and low prices made production unprofitable. Other reasons covered a range of responses, including wineries not being responsible for the current market conditions, wineries delaying payment to growers up to 12 months, growers lacking financial literacy, and an excess number of growers causing oversupply of grapes.

Participants identified a wide variety of possible changes to increase the profitability of wine grape production. Product differentiation and marketing strategies was the most frequent factor. This included the development of low or non-alcoholic wines for new markets (e.g. Islamic countries, underage), a modern style of wine or a unique product or wine to provide differentiation and increase demand for Riverina grapes. Better marketing was suggested to increase demand in both domestic and export markets.

The second most frequent potential change to improve profitability was improving the winery/grower relationship and pricing. Increased transparency in winery requirements, and so price, may be achieved with improved communication to growers throughout the growing season. This would allow growers to make more informed decisions about vine management and choice of variety, thereby optimising input costs relative to price received. Several participants suggested a need for regulation or a code of conduct to protect growers. The ACCC (ACCC, 2019) has previously identified that there is a power imbalance between wineries and growers and that while a voluntary code exists, it may not be effective.

Other suggested changes to improve profitability were variable. The implementation of a standard in grape quality parameters was suggested, which addresses the concerns of growers that the standards and resultant discounts are not transparent. This was a recommendation from the ACCC (ACCC, 2019). While one participant suggested increased use of technology (e.g. automated equipment) to reduce labour and increase

efficiency, others did not view this as beneficial. A review of technologies and their cost-benefit may clarify the potential to improve profitability. Two survey participants indicated a need for younger growers to succeed and to bring new ideas to the industry. While attracting young growers to the industry while it is unprofitable would be difficult, there may be opportunity for the development of grower group activities to assist in sharing of industry developments and to provide a collaborative community support.

Table 16. Participant identified causes of low productivity and profitability, market impacts on profit and possible changes to improve profitability in the survey of Riverina wine grape growers.

Question	Number of responses
Factors limiting productivity (t/ha)	
cost of inputs	20
weather or soil type	13
winery practice and pricing	11
disease	5
vine management	3
other	2
product differentiation/marketing	1
Factors limiting profitability ($/ha)	
cost of inputs	20
low grape prices	19
supply vs demand	6
yield and quality	4
product differentiation	2
winery practice	2
long-term production impacts	1
How does the market impact profit?	
grower is price-taker	15
other	14
lack of contracts/restrictions	11
supply vs demand	9
late pricing impacts production decisions	3
What changes could increase profitability?	
product differentiation/marketing	26
improve winery/grower relationship/pricing	25
other	13
increase on-farm production/quality/new varieties	4
reduce cost of production	4
diversification on-farm	2

Financial Information Derived from Interviews

This section of the report summarizes the financial information shared by a sample of 20 farmers, all being members of Riverina Winegrape Growers association, on their production practices, costs and outcomes in terms of grape quantities and prices of their 2022 crush.

The results of this research have a number of limitations that should be considered when interpreting them. Firstly, the data presented has been gathered from a relatively small sample comprising 20 farmers. This sample represents approximately 7% of the total population of Riverina wine grape growers and includes a cross section of farm scales, however, the total number of farms is still small. As such, data provided by individual farmers may have a significant impact on averages at the class level. Another limitation of this study is the fact that data was not gathered from respondents on overhead costs such as depreciation, owner drawings and administration costs and therefore these costs were estimated using secondary data (Wheeler et al 2022).

Grape sales

Total grape sales shown in Figure 4 shows a significant difference in total grape sales between farms with the largest farms averaging more than $1m in grape sales per annum as compared to less than $50,000 for the smallest farms of 10 hectare or less. Most farm size classes had a relatively even split between red and white varieties except for the 71 ha -175 ha class that had a significantly larger share of white grape varieties. The split between red and white grapes is likely to have a bearing on the economic performance of producers due to the relatively strong declines in prices for red grapes in recent years (Appendix 5

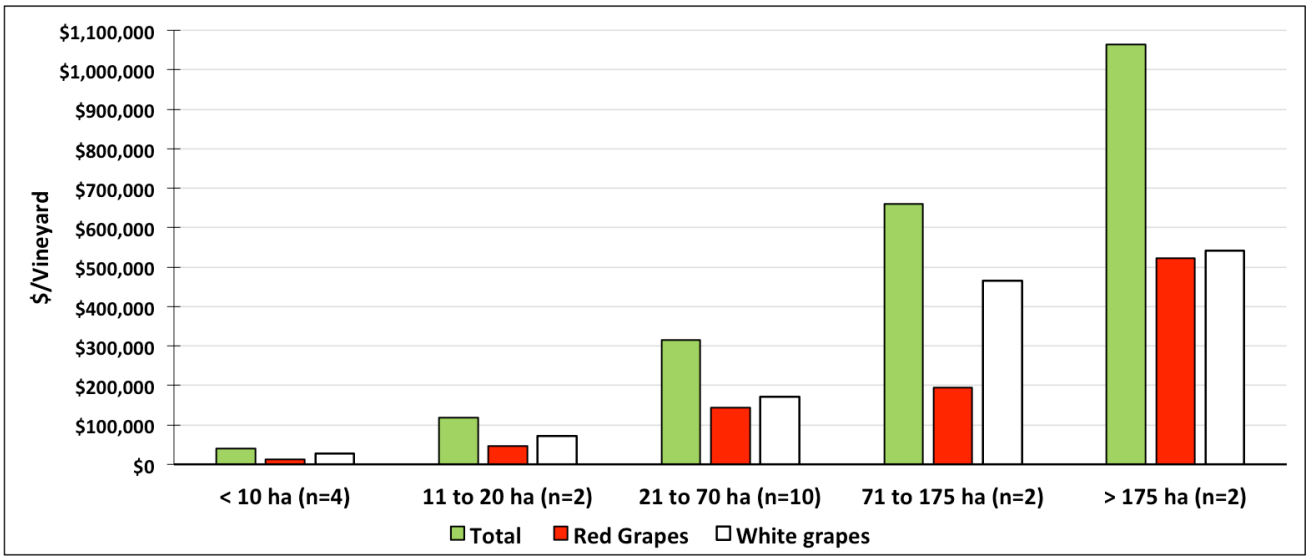


Figure 4. Mean value of grape sales by farm size class reported by survey participants for the 2022 vintage.

However, when viewed from the per-hectare level, we see an inverse relationship between scale and grape sales, with smaller farms achieving a much larger return per hectare. This difference is likely due to a

combination of factors, including higher per tonne earnings due to higher quality grapes on smaller farms as a result of greater management intervention (to control vine health issues etc), as well as higher hectare yields, again due to increased management intervention such as rate of fertiliser application.

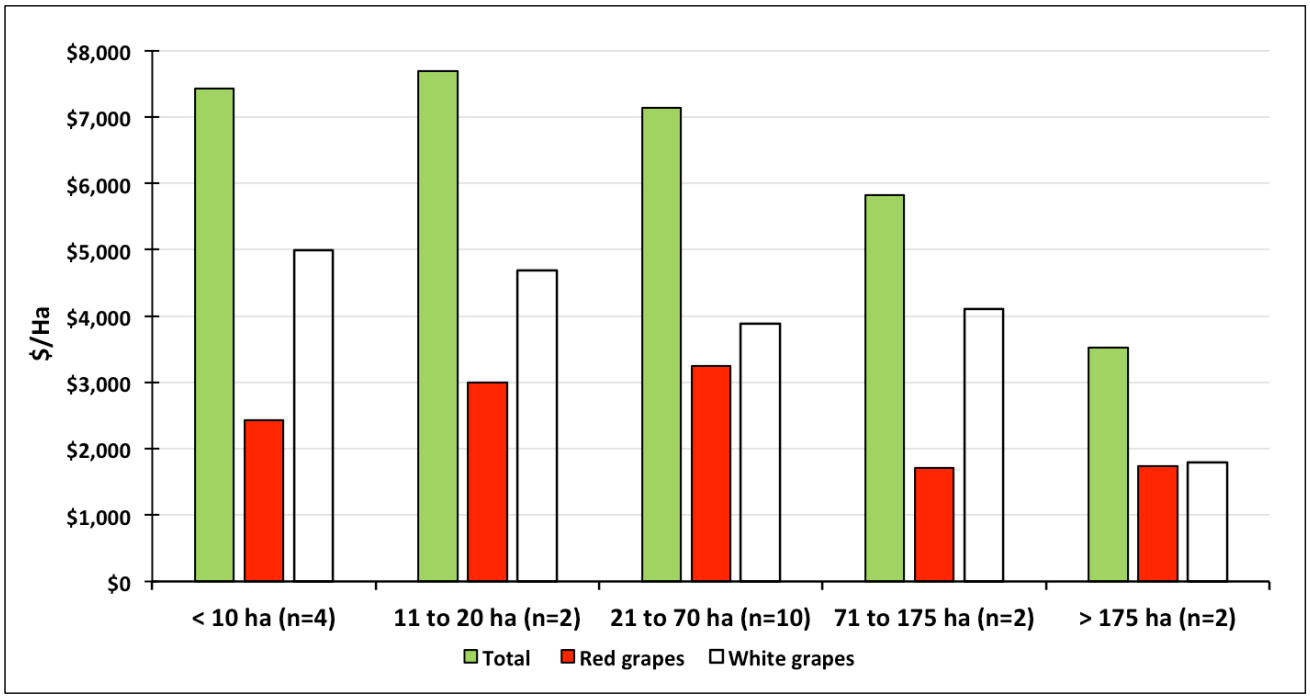


Figure 5. Mean value of grape sales per hectare by farm size class reported by survey participants for the 2022 vintage.

Production costs

However, while smaller farms tend to achieve higher per hectare income, the corollary is higher per hectare operating costs for small farms. While total operating costs are obviously higher for larger operations, at the per hectare level we see significant economies of scale accruing to larger operations. Interestingly, however, labour costs do not follow a linear downward trend as scale grows. This can perhaps be explained by the fact that owner operators perform a larger share of labour tasks on the smallest operations, while on the largest farms as well as employing general laborers, an additional tier of higher skilled managerial staff may be employed, thus increasing per hectare total labour costs. After labour costs, chemical and machinery costs were the next most significant, with growers in the middle of the size scale carrying the highest per hectare costs for these items.

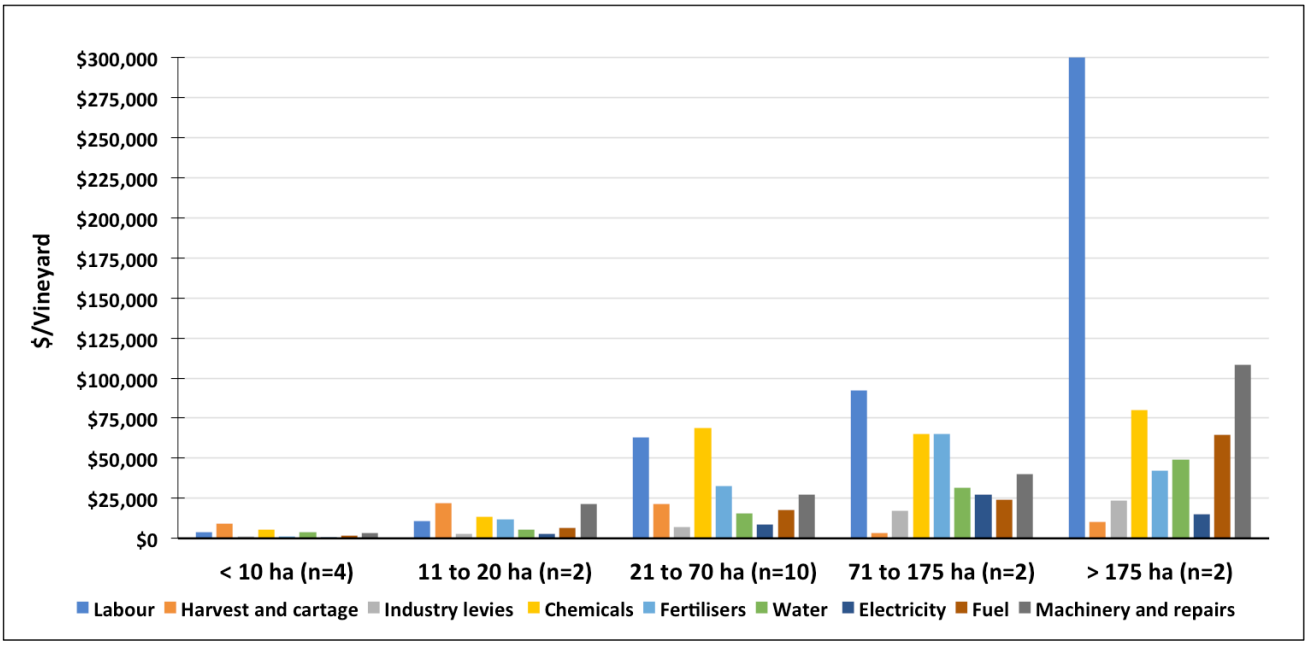


Figure 6. Mean annual operating costs per vineyard by size class reported by survey participants for the 2022 harvest year.

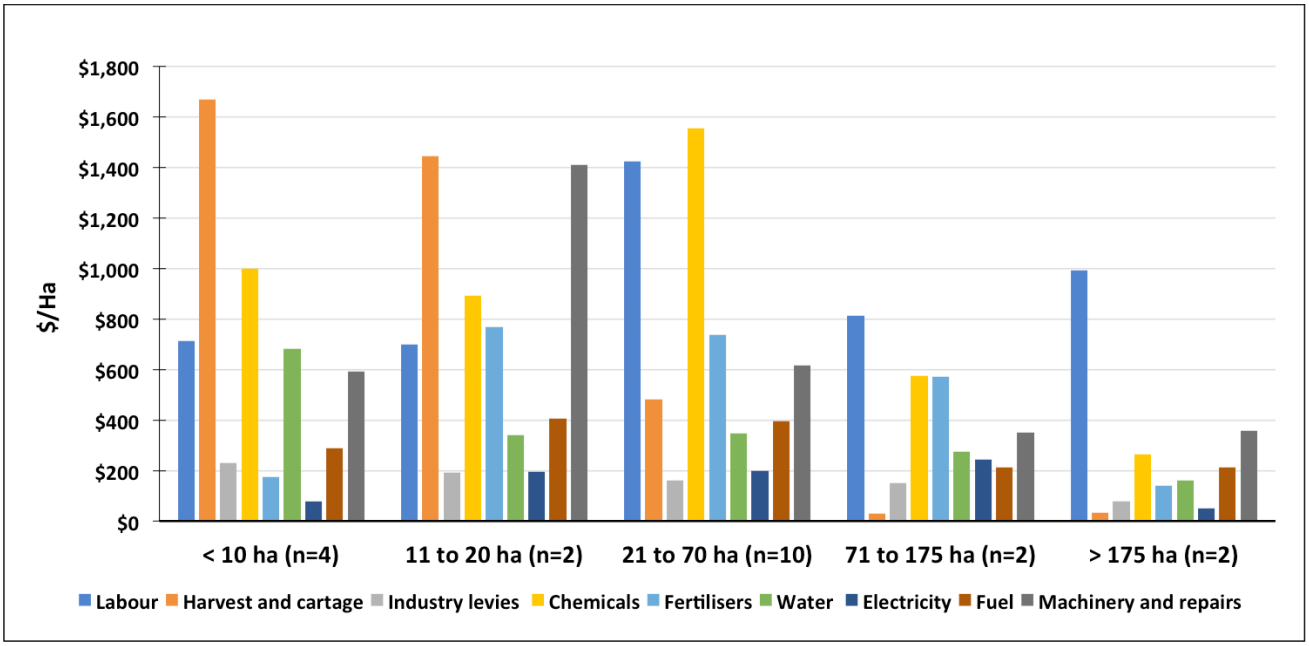


Figure 7. Mean annual operating costs per hectare by vineyard size class reported by survey participants for the 2022 harvest year.

Gross Margin Analysis

When operating costs are deducted from grape revenue to show gross margin per vineyard we see clear benefits to scale, with larger operations producing significantly larger gross margin. However, this relationship is less clear at the per hectare level, with the smallest farm size class (<10 ha) and second largest class (71 – 175 ha) achieving the highest gross margin per ha.

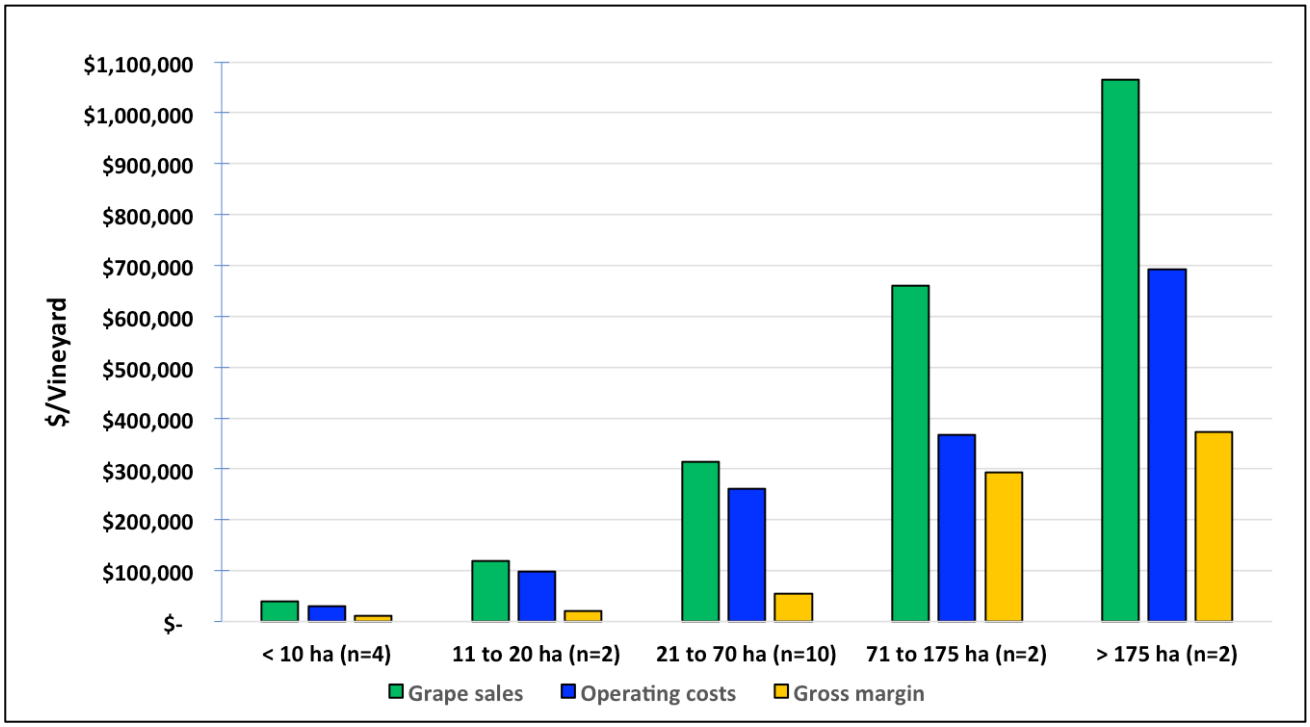


Figure 8. Mean gross margin per vineyard by size class for the 2022 harvest year.

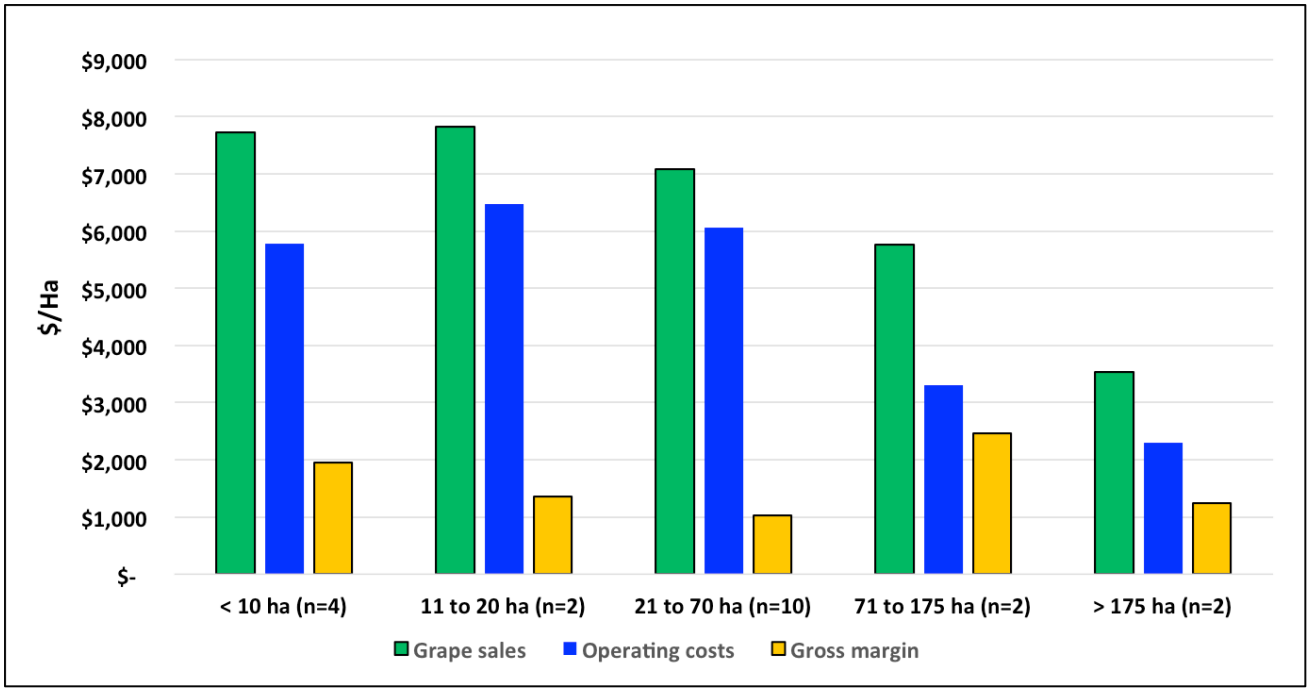


Figure 9. Mean gross margin per hectare by vineyard class size for the 2022 harvest year.

Overhead Costs

While operating costs are the most flexible in terms of being able to be reduced in the face of unprofitable operating conditions, all farms will also incur a range of overhead costs that must be met regardless of seasonal output. This includes an allowance for drawings to cover farmer household expenses, depreciation on

capital equipment, as well as administrative costs such as rates, insurance and office expenditure. While direct data was not captured on these overhead costs from survey respondents, estimates have been derived from data collected by Wheeler et al 2022 using Australian Taxation Office data on South Australian Riverland grape producers for the years 2019/20 and 2020/21.

As such, depreciation was set at $400 per hectare; estimated drawings at $1143 per hectare (departing from Wheeler et al we cap assumed drawings at $100k p.a. once they reached that level); while administration costs are set at 43%, of overheads (drawings and depreciation). This approach has the benefit of showing per hectare economies of scale for larger growers, which is to be expected, and places a realistic burden on small vineyards in terms of the expected drawings. That is because small vineyards are likely to represent a smaller time impost on the managers, which makes a $100k drawing unrealistic – instead these farmers are likely to work off-farm regardless of grape price.

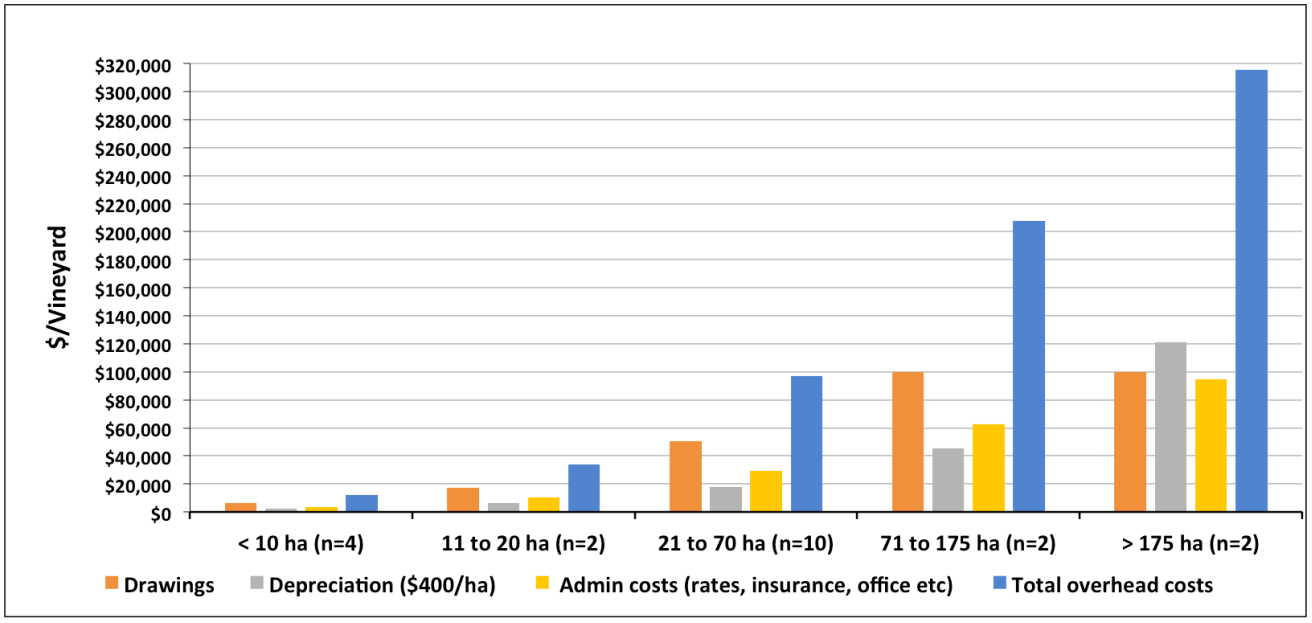


Figure 10. Estimated mean overhead expenses per vineyard by size class for the 2022 harvest year.

The class level data provided in Figure 10 shows that the first three class levels do not sustain a drawings level of $100k per annum, and also incur significantly smaller total levels of depreciation, as is likely to due to smaller inventories of machinery and shedding. At the per hectare level however, we see that the economies of scale accrue to the two largest scales of operation, particularly for drawings (Figure 11).

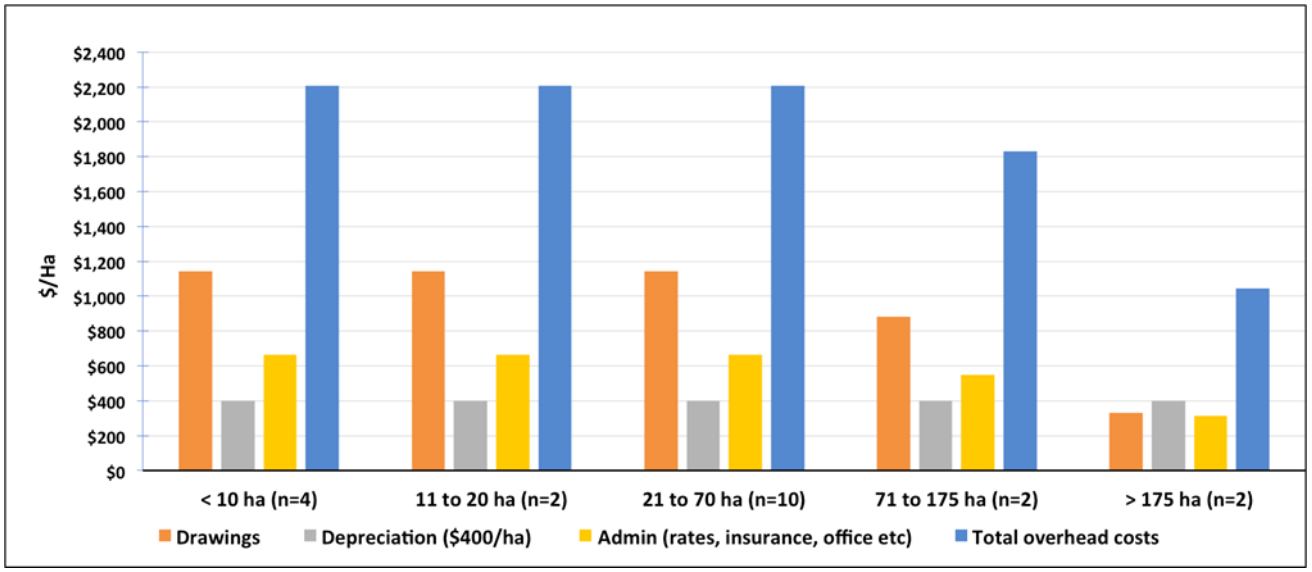


Figure 11. Estimated mean overhead costs per hectare by vineyard size class for the 2022 harvest year.

Earnings before interest and taxes (EBIT)

The results of the EBIT analysis show that levels of profitability are low for all growers but are particularly difficult for growers in the middle tiers of production. This likely reflects the fact they do not enjoy the economies of scale that larger vineyards do, while still being large enough to require significant levels of owner labour input, thus necessitating significant levels of assumed drawings. Regardless of whether these assumed drawings are taken, these farmers are likely to be squeezed between the management load associated with the farm and the need to acquire off farm income.

The EBIT analysis shown in Figures 12 and 13 below uses a per hectare drawings figure ($1143 per Ha) derived from Wheeler et al (2022) up to a total level of $100K per annum. That is, drawings are not assumed to be higher than $100k for large farms. We believe this to a be a realistic assumption given Australian median household incomes, and the financially constrained operating environment for grape producers. Nonetheless we have further modelled the impact of a linear application of the per hectare drawings rate to all farms. In addition to increasing assumed drawings this modified approach also increased assumed administration costs, which are a multiple (43%) of combined drawings and depreciation. The results of this modified approach are broadly similar to those shown in Figures 12 and 13, with the exception that the largest farms are significantly less profitable with a loss of around $1000 per hectare, which is broadly in line with farms in the 21-70ha range.

Finally, while the EBIT analysis depicted here shows low levels of profitability, the lived experience of farmers is likely to be significantly worse, as these figures do not take into account the cost of debt (interest). Interest payments are likely to vary greatly between farms, depending on how long they have been held, and business strategy around machinery ownership etc. Farms that have been more recently purchased, and or, that

maintain significant inventories of up-to-date machinery are likely to face significant additional financial pressure.

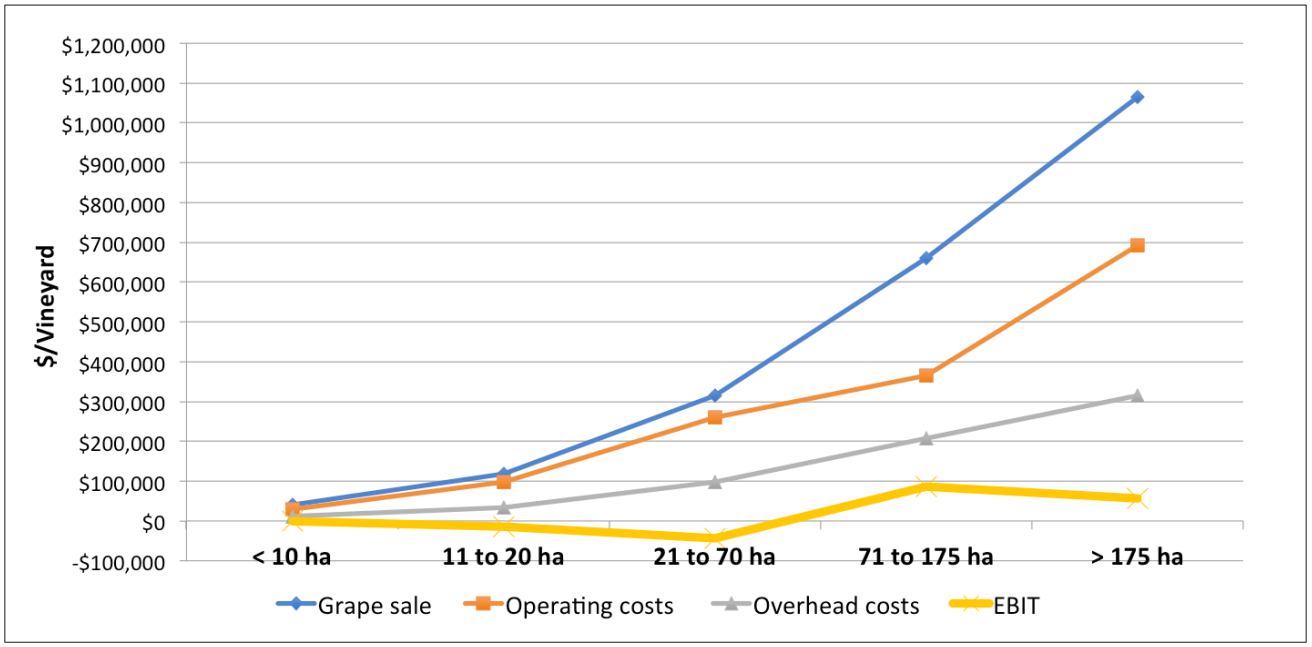


Figure 12. Mean revenue from grape sales, operating and overhead costs and earnings before interest and taxes (EBIT) by vineyard size class for the 2022 harvest year, using $1143/ha drawings rate capped at $100,000/vineyard.

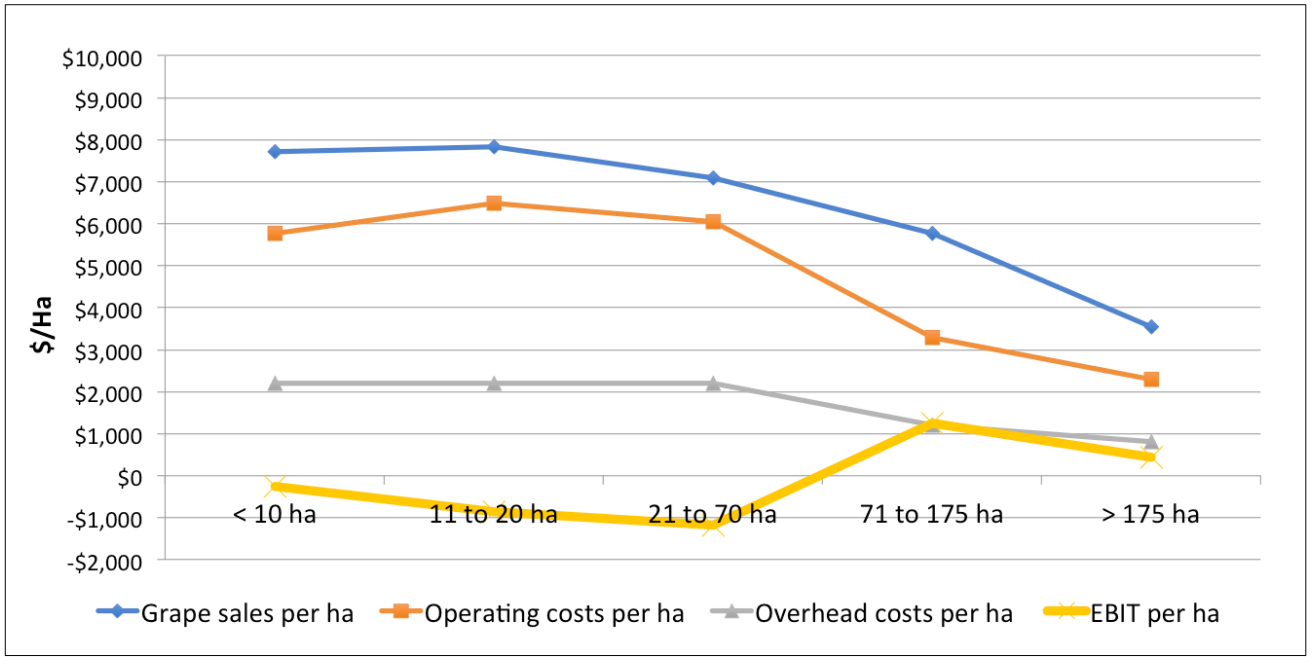


Figure 13. Mean revenue from grape sales, operating and overhead costs and earnings before interest and taxes (EBIT) per ha by vineyard size class for the 2022 harvest year, using $1143/ha drawings capped at $100,000/vineyard.

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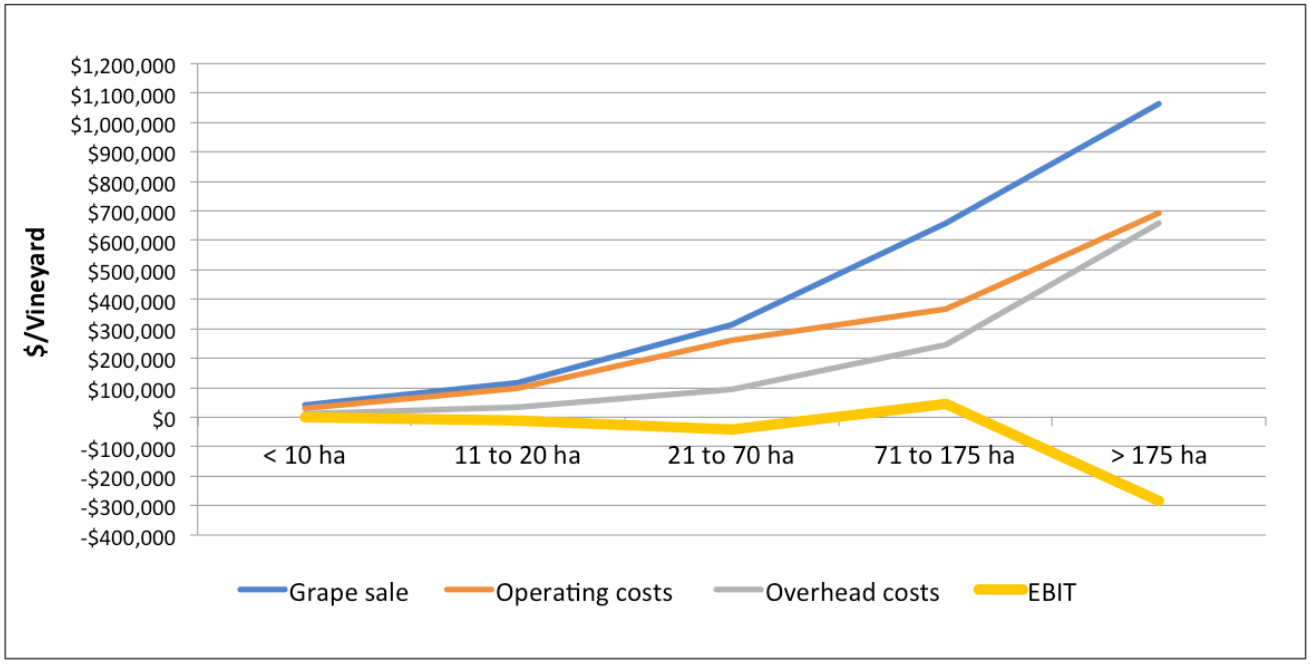


Figure 14. Mean revenue from grape sales, operating and overhead costs and earnings before interest and taxes (EBIT) by vineyard size class for the 2022 harvest year with assumed drawings held constant at $1143ha.

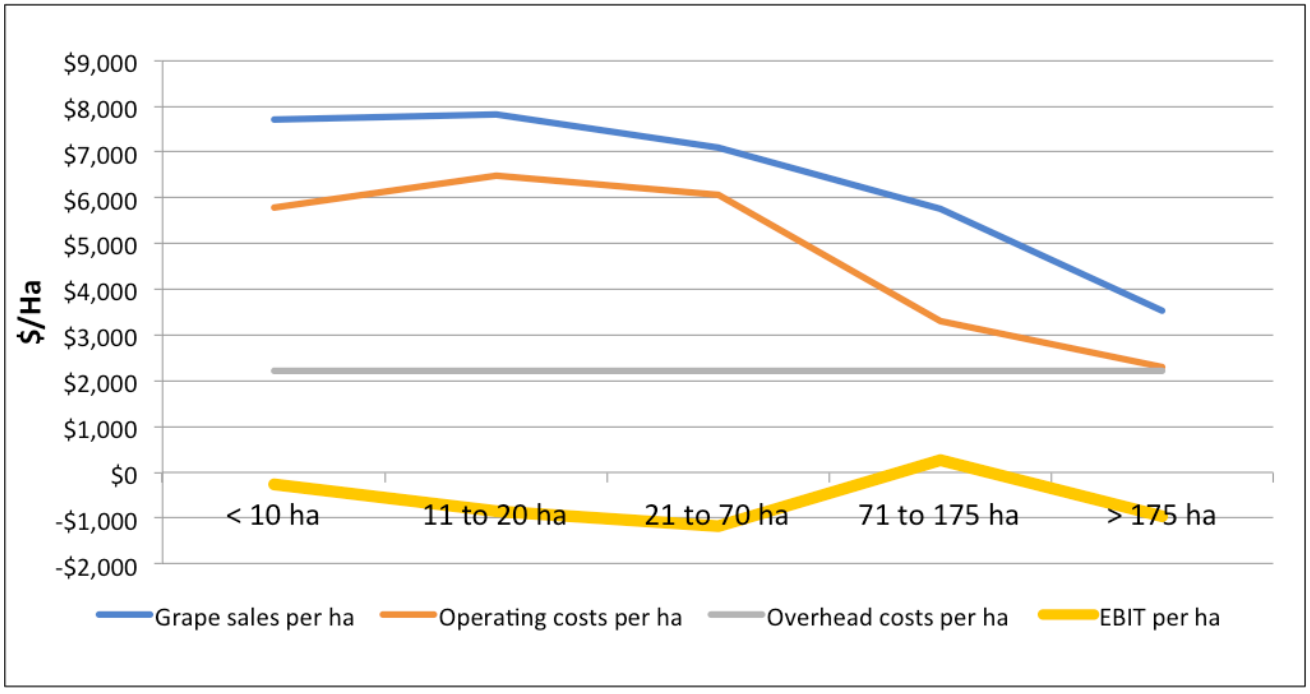


Figure 15. Mean revenue from grape sales, operating and overhead costs and earnings before interest and taxes (EBIT) per ha by vineyard size class for the 2022 harvest year with assumed drawings held constant at $1143ha.

Recommendations

Recommendation from this project have been identified from the desktop research and through feedback gathered from grower interviews conducted as part of the 'Lived Experience' and 'Economic Impact' and work packages. Some recommendations have caveats which are informed by the social research survey tools. The following recommendations address knowledge gaps and extension of technology concepts to growers in the Riverina to improve the long-term profitability and sustainability of the industry and strengthen producer wellbeing and longevity within the industry. Importantly the health and well-being of growers must be considered as the most pressing priority to ensure a long-term sustainable future for grape and wine production.

Recommendation 1

Mental health and well-being support needs to become an urgent priority. The current struggles for grape growers are unpinned by power imbalances between producer and wineries, resulting in a loss of sense of control over farm profitability and optimism in the future. Climate uncertainties play a role in this, and while remaining out of producer control, contribute to the stress producers are experiencing. Participants identified strongly as wine growers and were attached to the Riverina as a place to grow grapes, but this connection to place will not be sufficient if producers are not able to have more autonomy and power within the market, to manage their revenue and achieve success, which include profitability but is also connected to provision for family and contributing to intergenerational wealth, success and wellbeing.

Recommendation 2

Value chain analysis of grape and wine production will enable a higher level of price transparency between grape producers and wineries. Growers in the Riverina have identified a lack of transparency in wine grape pricing as a significant problem. One potential approach to addressing this problem would be to instigate a Value Chain Analysis project that brings together one or more winemakers with grape growers and researchers, with the aim of better understanding the current process of setting prices and how this might be improved, for example through the development of a real-time pricing dashboard. Growers would be motivated to participate in this process if it was likely to lead to more timely information about grape pricing as well as a clearer basis for assessing quality discounts. Active participation from one or more winemakers would be critical to the success of such a project, with winemakers potentially being motivated to participate on the basis that it may foster supplier loyalty and also lead to improved grape quality due to improved communication of quality parameters. In addition to the core focus on improving grape price transparency, the development of a digital dashboard between growers and winemakers would likely reveal other potential use cases for such a dashboard, in the course of conducting the Value Chain Analysis exercise.

The outcomes from the social research of the project strongly support this recommendation. Development of a co-design participatory project, including multiple wineries and grape growers is needed to develop strong, trusting and ethical relationships between grape growers and wineries. Underlying relational and contractual issues identified in the social research project, however, would need to be addressed prior, or at least during, a value chain analysis project for such a project to result in real and lasting change for both grape growers and wineries.

Recommendation 3

To build trust between grape growers and winemakers, the Riverina Wine Grape Marketing board could consider hosting a regular set of events that bring together grape growers and winemakers. Depending on resourcing and winemakers' willingness to participate, these events could be held with multiple winemakers in attendance or with individual winemakers. Such events would enable senior managers within the winemaking sector to provide growers with market insights, such as projected demand for new varietals, that would help growers better understand how they can provide value to the final consumer. In addition, such events should ideally provide an opportunity for multiple staff from the winemaking enterprise to engage with growers in a relaxed and non-confrontational setting such that interpersonal relationships are fostered.

The relationship between grape growers and wineries needs to be examined and mediated, with careful consideration of power allocation and how this power is used. Findings from the project strongly suggest that more work will need to be done in managing the existing relationship before this recommendation can be of benefit to the industry, and to avoid the reinforcement of existing relational and contractual issues. Activities undertaken without a clear acknowledgement of the structural barriers currently at play may be disingenuous and risk further damage to the relationships within the grape growing industry in the Riverina.

There may also be an opportunity for Riverina grape growers to become more familiar with the work of Wine Australia through this process, through sponsorship of events.

Recommendation 4

Development of a suite of financial tools, with a focus on determining minimum grape pricing for breakeven analysis at varying scales and locations of production and improved financial literacy for growers is important. Improved understanding of fixed and variable costs associated with crop production will empower growers with decision support tools that allow more informed business operations.

Recommendation 5

Improved understanding of emerging mechanisation and digital technologies that improve vineyard efficacy, product traceability and certification for market access is required at all levels of the value chain. Integration of automated digital data capture, storage and reporting systems that address governance and claims of sustainable grape production are required. Trial vineyards to showcase new technologies to growers in the

Riverina should be developed in partnership between research providers and grower groups. Partnerships between research institution, funding organisations and grower groups could seek funding to develop a testing facility that provides a demonstration site and research opportunities for technology companies to trial new technologies designed to drive efficiency gains for grape growers in the Riverina. Cross sector support from other perennial horticultural industries (pome fruit, stone fruit etc), could be sought as production pressure points and technology solutions are broadly similar to the viticulture industries. Trial sites remove the financial risk from growers otherwise needing to trial practices themselves, or rely on sales-driven advice.

Examples of potential technologies include driverless robotic tractors which reduce labour costs on farm; automated irrigation applications linked to soil moisture probes and data capture technology. Articulation with the Charles Sturt University Vineyard of the Future in the Global Digital Farm (VF-GDF) is an obvious synergy. Additional activities that improve understanding and demonstrate efficient methods to change vine cultivars within an existing vineyard to expedite production of a commercially viable crop could be included in a suite of projects targeting vineyard renewal and regeneration.

The potential for innovation and new technologies to support Riverina grape growers is supported by the survey and interview responses, which suggest that producers value innovation and that they acknowledge the need for change. This recommendation, however, needs to be considered within the other findings of the social research project - that grape growers currently do not view their enterprises as financially healthy, which means their capacity to invest in innovation is limited at best.

Recommendation 6

The results of the economic analysis demonstrate that medium sized growers are some of the most strongly impacted by the current downturn in the sector. This is likely due to the fact that their farms are sufficiently large such that they require significant management time input to remain productive, while at the same time not being large enough to enjoy the economies of scale, which accrue to the largest operations. Interventions aimed primarily at these mid-sized growers may produce relatively large positive returns in improved financial wellbeing. For example, additional research could be undertaken to determine which vineyard management practices could be reduced or even paused during periods of unprofitability, without significantly undermining the long-term health and productivity of the vineyard. The goal of such as process would be to free up time so that mid-sized growers could take off farm income without damaging the medium or long-term productivity of their vineyard. Such knowledge would in effect allow growers to idle up and idle down their vineyard operations and their off-farm income in order to respond to market conditions.

Recommendation 7

Vineyard management interventions that enable the most effective, rapid, and economical change over from one cultivar to another, including table grapes should be explored. Understanding the limits of vine top work within the confounding constraints of vineyard disease incidence, rootstock/ own roots and winery demand for

specific cultivars requires is required along with development of cost-benefit analysis tools for growers to use for decision support.

Recommendation 8

Research addressing the relationship between plant water use efficiency, irrigation timing, water delivery options, fertiliser use, crop yield, grape and wine composition should be prioritised to provide evidence for decision support related to the productive limits for wine grape growing in the Riverina. Defined objective quality parameters for grape production should be clearly and firmly defined by wineries. Viticultural production inputs that impact upon grape composition for key varieties need to be determined to support yield limits related to quality parameters.

The findings from the social research aspects of this project support the need for decision making tools, with producers identifying a strong sense of their own abilities and willingness to seek advice. However, one caveat would be that if the underlying power imbalance between grape growers and wineries is not addressed, producers will not be able to benefit from evidence-based decision making.

Recommendation 9

Selection and optimising ground cover plantings for mid row management that maximises biodiversity, increases beneficial predatory insects and where possible, stimulates higher levels of yeast assimilable nitrogen in grape berries at harvest should be a priority. Potential for groundcover crops as an additional income stream could be incorporated into this project. Integration of vine nutrition and agroecology projects will leverage outcomes to the industry through reduced pesticide applications, mitigation of disease risk and potentially grapes that possess higher levels of YAN produce more sensory complex wines.

Recommendation 10

New product development research to determine appropriate viticultural inputs targeting consumer preferred wine styles made with lower alcoholic levels should be a priority. Current wine production in the Riverina is heavily orientated to full bodied, full flavoured and high alcoholic level wines that have lost some market appeal. Integrating viticultural and wine production techniques to develop novel products that utilise existing varieties in the Riverina will potentially increase the demand for grapes and provide better price support for growers.

'Market Stability' was consistently identified as one of the top three challenges by participants in Part 2 of the project. The challenge for the wine making industry is this disconnect between market appeal and the time needed for variety changeover. This gap and its impact on producer optimism and self-efficacy needs to be acknowledged, and solutions that reflect an understanding the producers' experience explored and tested. The BN model suggests that producers who identified 'Market Stability' as one of their top three challenges are

more likely to consider moving away from grape production in the next 10 years, including retirement and growing non-grape crops.

Recommendation 11

A more thorough search for grape varieties suited for growth in hot climates and which retain acidity and flavour is a priority. Varieties, particularly those grown in Mediterranean environments, with lower water demands may prove to be more suited for full flavour wines in a climate predicted to substantially warm over the next several decades. Most varieties grown in the Riverina are those that are grown in most Australian wine regions and were planted many decades ago. Whilst demand for traditional varieties will continue, newer wine styles made with selected cultivars with an origin from hot climates could be used to reposition the Riverina and inland wine grape growing regions as a producer of high-quality table wines. A similar production and marketing strategy was successfully undertaken by wine companies in the Douro Valley and could serve as a model for transitioning an industry from less popular wine styles to a commercially acceptable style.

This priority could commence with literature and climate model research to identify wine grape producing areas of high repute from Mediterranean regions with broadly matching climate indices to enable selection of potential cultivars of interest. Noting the considerable time taken for new varieties to gain market acceptance, this research priority must be developed in close consultation with existing wineries, to ensure wine styles are targeted that match existing and future market opportunities, and grape growers to strengthen their sense of self efficacy and optimism in the future of grape growing in the Riverina.

Recommendation 12

The wine industry could increase grape production and winery social licence to operate through the development of mature storylines and marketing that demonstrate well connected land stewardship and resource use (especially fertilizer, water, and energy) to produce grapes and wine. Wine is increasingly being viewed as a luxury product with younger consumers who have a high engagement with Environmental, Social and Governance (ESG) values.

Whilst plant water use efficiency is important, Riverina grape producers are amongst the lowest water users for crop production in the region. The value of water used for agriculture is broadly measured at farm gate value, however a considerable value transformation arises in the wine industry through the production process to produce a higher value product. Arguably the value addition of grapes made into wine post farm gate is substantially more than most other agricultural commodities, with value addition occurring in the regions that grapes are grown. Consequently, regional communities with long standing links to grape production have a high level of economic and social dependency for the ongoing success and prosperity of the wine and grape industries.

One caveat of this approach is that, within the findings of the project, most participants are struggling and do not have optimism in the financial future of their enterprises. It is important, that if producer stories are to be used, that this is done in an environment where producers are cared for and supported, and that the stories used are authentic. This recommendation, therefore, would need to be accompanied by cultural change within the Riverina grape growing industry.

Recommendation 13.

The challenges around profitability and sustainability are not confined to the Riverina wine region of NSW. It is further recommended that any future research and projects resulting from this study be expanded to include the Murray Valley and Riverland wine regions alongside Riverina as combined they represent 70% of Australia's grape production.

7. Appendix 1: Communication

Publications

N/A

Industry presentations and extension activities

Television and radio news broadcasts.

8. Appendix 2: Intellectual property

N/A

9. Appendix 3: Questionnaire and Interview tools and ethics forms

The Lived experience

Cover letter

Charles Sturt University

Dear Householder,

Invitation to participate in a survey regarding the Riverina wine industry

If you would like us to give you a call to explain the project rather than reading the information below, please contact Lynne Hayes lhayes@csu.edu.au or call 02 6933 2802.

You are invited to participate in a research study being undertaken to understand the current context of Riverina grape growing and how farming families perceive their challenges and opportunities. This invitation is being sent to Riverina grape growers registered with the Wine Grape Marketing Board. As this survey is focused on perceptions, more than one person within the household is able to participate.

This invitation package includes:

An Information Sheet regarding what the research is about and what your participation involves
Questionnaires
Reply-Paid envelope/s to return the completed questionnaire to the researcher

Please read the Information Sheet before deciding whether to participate in this research. There are a few ways that you can complete the questionnaire (it will take approximately 20 minutes). You can either:

Complete the attached questionnaire(s) and returning it to the researcher in the Reply-Paid envelope. Multiple questionnaires can be sent back in the one envelope. There is second Reply-Paid envelope that you can use to return your prize draw entry (if you haven't provided your contact details in the questionnaire).

OR

Complete the online version by going to https://www.surveymonkey.com/r/RiverinaGrape or

OR

We can complete it together over the phone. Please contact Lynne Hayes lhayes@csu.edu.au or 02 6933 2802 to arrange this.

All participants who complete the questionnaire (and provide contact details) will go into the draw to win one of 75 $100 VISA cards to thank you for your time.
Kind regards,

The Research Team
Locked Bag 588, Wagga Wagga, NSW, 2678, Australia T: +61 2 6933 2802 | E: lhayes@csu.edu.au | csu.edu.au/
CRICOS Provider Number for Charles Sturt University is 00005F. ABN: 83 878 708 551

Participant Information – Questionnaire

Charles Sturt University
Gulbali Institute
Agriculture Water Environment

Using the lived experience of grape growers in the Riverina to inform plans for sustainable and profitable viticulture – Questionnaire

Principal Investigator

Dr. Jennifer Manyweathers, Senior lecturer in Ruminant Health and Epidemiology. School of Agricultural, Environmental and Veterinary Sciences Charles Sturt University. Gulbali Institute.

Co-investigators

Dr. Jen Bond, Lecturer in Human Geography, School of Agricultural, Environmental and Veterinary Sciences Charles Sturt University. Gulbali Institute.

Professor Leigh Schmidtke, Professor of Oenology, Charles Sturt University. Gulbali Institute.

Ms. Lynne Hayes, Research Assistant, School of Agricultural, Environmental and Veterinary Sciences Charles Sturt University. Gulbali Institute. Email lhayes@csu.edu.au P: 02 6933 2802

You are invited to participate in a research study that is investigating how growing and how farming families perceive their challenges and opportunities Please note that to participate in the research you must be over 18 years old.

The study is being conducted by the researchers listed at the top of this document who are affiliated with Charles Sturt University and the Gulbali Institute.

Before you decide whether you wish to participate in this study, it is important for you to understand why the research is being done and what it will involve. Please take the time to read the following information carefully and discuss it with others if you wish. If you would like to contact the research team for more information, please contact Lynne Hayes (details above).

What is the purpose of this study?

The project will contribute to our understanding of the lived experience of grape growers in the Riverina. This will help us to better understand the knowledge, skills, business management, and vineyard practices of growers in the Riverina region.

Why have I been invited to participate in this study?

We are interested in hearing from grape growers in the Riverina region of NSW. If you have other members of your household involved in grape growing, please feel free to give this information to them so they can participate also.

What does this study involve?

Participation will initially involve the completion of a questionnaire (survey). It is expected that this will take approximately 20 minutes and will cover the following areas: challenges, social connectedness, well-being, aspirations, and needs.

At the end of the questionnaire, you will be given the opportunity to indicate your interest in participating in an interview to provide us with more in-depth information on the topics of interest. This is entirely optional, with further information on this part of the study provided at the end of the questionnaire.

We may extend this into future research (longitudinal study) that will allow us to measure changes based on any interventions/workshops/training implemented as part of the business plans. If this happens, we will be conducting similar research activities over the coming years and would love to hear from you again to see how things are progressing. For this reason, we will be asking for names and contact details to allow us to follow respondents over the course of the study. You do not have to provide your details for this purpose.

Are there any risks and benefits to me in taking part in this study?

Participation in this study should involve no physical or mental discomfort. However, if because of participating in this research you feel you need support, please contact your usual health professionals. Support is also available from Beyond Blue http://www.beyondblue.org.au/, Rural Financial Counselling Service (RFCS)

the https://nema.gov.au/#/map or, for crisis counselling and support, please contact Lifeline 13 11 14.

How is this study being paid for?

This study is funded by Wine Australia.

Will taking part in this study cost me anything, and will I be paid?

Other than your time, there are no costs associated with participating in this research. After the questions, you will have the opportunity to enter a draw to win a $100 pre-paid Visa gift card (75 available). If you have provided your contact details on the questionnaire you are automatically entered into the prize draw. You can also provide your contact details separately if you prefer to keep your responses anonymous.

What if I don't want to take part in this study?

Participation in this research is entirely your choice. Only those people who give their informed consent will be included. Whether or not you decide to participate is your decision and will not disadvantage you. There are no consequences for those who decide not to participate.

What if I participate and want to withdraw later?

If you have provided your contact details, we are able to remove your data within 2 weeks of when you submitted your responses. Please contact Lynne Hayes at lhayes@csu.edu.au to arrange this. If we do not have your contact details, your questionnaire will be anonymous and as such, we will not be able to remove your individual data.

How will my confidentiality be protected?

All participants will be allocated a survey ID code and any contact details removed from the questionnaire and stored separately. Please be assured that you will not be named or individually identified in any reports or publications related to all research activities. We will be reporting broad categories of participants so please consider this before deciding whether you would like to participate. You can choose to skip questions that you think may identify you.

All contact details collected separately as part of the prize draw will be deleted once the prizes have been allocated.

All information collected from you will be stored securely and only accessed by the researchers unless you consent otherwise. Data will be retained for at least 5 years after final publication at Charles Sturt University.

What will happen to the information that I give you?

While results will not be returned to individual participants, aggregated (combined) research findings will be shared through the communication channels of Wine Grape Marketing Board and Wine Australia (newsletter, social media, direct email). The outcomes will be published in relevant reports associated with this project. The outcomes will also be published in an appropriate scientific journal and/or presented at relevant conferences.

Who should I contact if I have concerns about the conduct of this study?

Charles Sturt University's Human Research Ethics Committee has approved this project. If you have any complaints or reservations about the ethical conduct of this project, you may contact the Committee at (02) 6933 4213 or ethics@csu.edu.au. Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

Charles Sturt University
Gulbali Institute
Agriculture Water Environment

Using the lived experience of grape growers in the Riverina to inform plans for sustainable and profitable viticulture.

Participant consent

Please read through the following Consent Statements

- I agree to participate in the above research project and give my consent freely.
- I understand that the project will be conducted as described in the Participant Information Statement, a copy of which I have retained.
- I understand I can withdraw from the project at any time and do not have to give any reason for withdrawing
- I understand that my personal information will remain confidential to the researchers
- I have had the opportunity to have questions answered to my satisfaction.

We will assume consent if you have returned a questionnaire.

Charles Sturt University's Human Research Ethics Committee has approved this project. If you have any complaints or reservations about the ethical conduct of this project, you may contact the Committee on (02) 6933 4213 or ethics@csu.edu.au.
Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

Before we get started, we just need to check that the majority of your vineyard business operates in the Riverina Geographic Indication (GI) region?

If no, thank you for your interest but currently, the research is focusing on the Riverina GI. We may expand to other regions in the future so you may hear from us again.

If yes, please continue.

As mentioned previously, we may be conducting similar research activities over the coming years and would love to hear from you again to see how things are progressing. For this reason, we will be asking for names and contact details to allow us to follow respondents over the course of the study. You do not have to provide your details for this purpose and can skip any questions that you feel may identify you. Please note that we are only collecting address information to distinguish between multiple respondents within the same household

Name	
Address	
Email	
Phone number	

1. **What is your age in years?**

2. **Which gender do you identify with?**

Man	Woman	Non-binary	Prefer not to say	Prefer to self-describe
☐	☐	☐	☐	☐ _____

3. **What is your highest level of education?**

None	Primary school	High School (e.g., HSC)	Certificate III	Certificate IV	Undergraduate degree	Postgraduate degree
☐	☐	☐	☐	☐	☐	☐

4. **Did you grow up in a grape growing family business?**

No☐ Yes☐

5. **How many years have you been working [as an adult] in the grape and/or wine industry?**

0-5	6-10	11-15	16-20	21-40	More than 40
☐	☐	☐	☐	☐	☐

6. Are you aware of Wine Australia?

No☐ Please go to Q 7 Yes ☐ Please answer Q6a and Q6b

6a) If someone asked you, could you describe what Wine Australia does?

No☐ Yes☐

6b) Please indicate your level of agreement with the following statement:

	Strongly Disagree				**Strongly Agree**
	1	**2**	**3**	**4**	**5**
Wine Australia views wine grape growers in a positive way	☐	☐	☐	☐	☐

7. What is your current role within the vineyard business? Please select one.

☐Owner/operator – full time in the business

☐Owner/operator – part time in business only

☐Owner/operator – work outside the business also

☐Employee

☐Retired family member who helps out sometimes

8. Is the vineyard business the only farm-based activity that is operated on the property?

No☐ Please go to Q8a Yes☐ Please go to Q9

8a) Please estimate the % of your overall farm income that the following activities make up. If you don't do a particular activity, just leave that option blank.

Activity	**%**
Vineyard	
Citrus	
Grazing	
Livestock	

Poultry	
Other – please describe and provide %	

9. How many hectares (HA) of your property is planted to vines? ☐

10. How many wineries do you sell your grapes to?

1☐ 2 ☐ 3☐ 4 or more ☐

11. How many people (besides yourself) does this vineyard business support and what is their relationship to you? [Please include children currently living away, i.e., boarding school, university, who are still dependent].

People	**Number**
Partner/spouse	
Dependent children	
Parents	
Other (describe and provide number)	

12. Please rank the following challenges in terms of most significant for the profitability of your vineyard business: You can number everything, where '1' is the most significant through to 10 (or 11 if you have included 'other') or just give us at least your top 3.

Challenge	**Rank (enter number)**
Market stability	
Lack of market information	
Input costs	
Labour availability	
Aging vines	
Climate	
Time pressures	
Government regulations/'paperwork'	
Own knowledge/skill	

Revenue/yields	
Other (describe and rank)	

13. Are you a member of any industry groups? We are using the term industry to include all industries, not just those that are related to grape growing.

No☐ Please go to Q14 Yes ☐ Please answer Q13a and 13b

13a) How many industry groups are you a member of? ☐

13b) Please provide the name/s of the industry group/s below (up to 5).

Group 1	
Group 2	
Group 3	
Group 4	
Group 5	

14. Are you a member of any community groups?

No☐ Please go to Q15 Yes ☐ Please answer Q14a and 14b

14a) How many community groups are you a member of? ☐

14b) Please provide the name/s of the community group/s below (up to 5).

Group 1	
Group 2	
Group 3	
Group 4	
Group 5	

15. Do you plan on removing/selling grape production assets in the next 10 years?

No☐ Please go to Q16 Yes ☐ Please indicate your reason/s why from the list below.

☐Retirement
☐Leave for employment in another sector/industry
☐Replant new wine crop
☐Replant non wine crop
☐Selling the farm
☐Crop diversification
☐Other reason

16. Do you plan to pass on your vineyard business to your family? (no time limit on when that might be).

No☐ Yes☐ Unsure☐

17. Please indicate your level of agreement with the following statements:

Statement	Strongly Disagree				Strongly Agree
	1	2	3	4	5
I feel optimistic about the future of my business	☐	☐	☐	☐	☐
Being a wine grape grower is important to me	☐	☐	☐	☐	☐
I think the Australian public views wine grape growers in a positive way	☐	☐	☐	☐	☐
The Riverina is very special to me	☐	☐	☐	☐	☐
I am confident I can access market information when I need to	☐	☐	☐	☐	☐
It is important to me that I grow grapes in an environmentally sustainable way	☐	☐	☐	☐	☐
It is likely that my children or grandchildren will take over my vineyard business	☐	☐	☐	☐	☐
I feel that my vineyard business is currently in a financially healthy position	☐	☐	☐	☐	☐
I think the Australian government views wine grape growers in a positive way	☐	☐	☐	☐	☐
I am very attached to the natural environment in the Riverina	☐	☐	☐	☐	☐
I am confident in my ability to manage my business into the future	☐	☐	☐	☐	☐
It is important to me to continuously innovate in my business	☐	☐	☐	☐	☐

I think media coverage of the Australian wine industry is mostly positive	☐	☐	☐	☐	☐
I feel comfortable in turning to other grape growers for advice regarding my grape growing business	☐	☐	☐	☐	☐
I feel that operating a profitable grape growing business is within my control	☐	☐	☐	☐	☐
I have positive relationships with the wineries that I sell my grapes to	☐	☐	☐	☐	☐
What other growers in the Australian wine industry think about how I run my business is important to me	☐	☐	☐	☐	☐
Doing my activities in the Riverina is more important to me than doing them in any other place	☐	☐	☐	☐	☐
I have all the resources I need to manage my vineyard business profitably	☐	☐	☐	☐	☐
I think the Wine Grape Marketing Board view wine grape growers in a positive way	☐	☐	☐	☐	☐
I am confident I can access agronomic information when I need to	☐	☐	☐	☐	☐

18. Please indicate your perception of the following in relation to your vineyard business over a typical week:

	Never	Rarely	Some of the time	Most of the time	All of the time
I feel stressed (related to my business)	☐	☐	☐	☐	☐
I feel down (related to my business)	☐	☐	☐	☐	☐
I feel worried (related to my business)	☐	☐	☐	☐	☐
I feel satisfied (related to my business)	☐	☐	☐	☐	☐

19. Please tell us what resources (if any) you think would be useful to your business into the future:

Thank you for participating. All respondents have the opportunity to go into the draw to win one of 75 $100 pre paid-VISA cards. If you have provided your contact details, this will be automatic.

If you did not provide your details at the start of the questionnaire, please complete the attached prize draw slip, remove it from the questionnaire and return it in the separate reply-paid envelope. This will ensure that your responses are not identifiable.

Follow-up interview expression of interest

The next phase of the research will involve follow-up interviews to provide us with more in-depth information on the topics that have been covered in this survey.

Please tick yes if you would like to participate in a follow-up interview.
Yes □

We will provide you with a copy of the Participant Information related to the interview and obtain separate consent when this phase of the project commences.
Please note that we may not be able to interview all those who have expressed an interest. If we do not contact you, please know that we sincerely appreciate your willingness to be involved.

We will contact you using the details provided at the start of the questionnaire. If you have not provided this information but would like to participate in the interview, please provide your details below. Note that your questionnaire responses will no longer be anonymous.

Name	
Phone number	
Email	

Prize draw

If you have not included your contact details at the start of the questionnaire or for the interviews, please remove this page and send back in the separate reply-paid envelope.

Name	
Phone number	
Email	



Charles Sturt University

Gulbali Institute
Agriculture Water Environment

Participant Information

Using the lived experience of grape growers in the Riverina to inform plans for sustainable and profitable viticulture – Interviews

Principal Investigator

Dr. Jennifer Manyweathers, Senior lecturer in Ruminant Health and Epidemiology. School of Agricultural, Environmental and Veterinary Sciences Charles Sturt University. Gulbali Institute.

Co-investigators

Dr. Jen Bond, Lecturer in Human Geography, School of Agricultural, Environmental and Veterinary Sciences Charles Sturt University. Gulbali Institute.

Professor Leigh Schmidtke, Professor of Oenology, Charles Sturt University. Gulbali Institute.

Ms. Lynne Hayes, Research Assistant, School of Agricultural, Environmental and Veterinary Sciences Charles Sturt University. Gulbali Institute. Email lhayes@csu.edu.au P: 02 6933 2802

You are invited to participate in a research study that is investigating how growing and how farming families perceive their challenges and opportunities Please note that to participate in the research you must be over 18 years old.

The study is being conducted by the researchers listed at the top of this document who are affiliated with Charles Sturt University and the Gulbali Institute.

Before you decide whether you wish to participate in this study, it is important for you to understand why the research is being done and what it will involve. Please take the time to read the following information carefully and discuss it with others if you wish. If you would like to contact the research team for more information, please contact Lynne Hayes (details above).

What is the purpose of this study?

The project will contribute to our understanding of the lived experience of grape growers in the Riverina. This will help us to better understand the knowledge, skills, business management, and vineyard practices of growers in the Riverina region.

We may extend this into further research (longitudinal study) that will allow us to measure changes based on any interventions/workshops/training implemented.

Why have I been invited to participate in this study?

We are interested in hearing from grape growers in the Riverina region of NSW. You indicated that you were interested in taking part in an interview and provided your contact details at the end of the project questionnaire.

What does this study involve?

Participation will involve taking part in a semi-structured interview. This will provide us with more in-depth information on the areas that were covered in the questionnaire.

The interview will be conducted via telephone or a video/teleconferencing platform, depending on your preference. It is expected that the discussion will take up to 60 minutes, noting that this may vary depending on the level of detail provided in the responses

Data gathered from the interviews will be recorded on an audio recording device or using the record function video/teleconferencing platform and transcribed following the interview. If you prefer to not have the interview recorded, written notes will be taken. You will have the opportunity to decide which option you would prefer prior to participating in the interview.

Please note that we may not be able to interview all those who have expressed an interest. If we do not contact you, please be assured that we sincerely appreciate your willingness to be involved.

Are there any risks and benefits to me in taking part in this study?

Participation in this study should involve no physical or mental discomfort. However, if because of participating in this research you feel you need support, please contact your usual health professionals. Support is also available from Beyond Blue http://www.beyondblue.org.au/, Rural Financial Counselling Service (RFCS)

the https://nema.gov.au/#/map or for crisis counselling and support please contact Lifeline 13 11 14.

How is this study being paid for?

This study is funded by Wine Australia.

Will taking part in this study cost me anything, and will I be paid?

Other than your time, there are no costs associated with participating in this research.

All participants will receive a $100 pre-paid Visa Gift card.

What if I don't want to take part in this study?

Participation in this research is entirely your choice. Only those people who give their informed consent will be included. Whether or not you decide to participate is your decision and will not disadvantage you. There are no consequences for those who decide not to participate.

What if I participate and want to withdraw later?

At the time of the interview, you will have the opportunity to request that information you have provided be removed from the data set. Once the interview has been completed you will have up to two weeks to request that your data be removed, should you choose to no longer participate in the research. Please contact Lynne Hayes at lhayes@csu.edu.au to arrange this.

How will my confidentiality be protected?

All participants will be allocated an ID code (the same as the one we have used for the questionnaire) and no contact details will be stored with the interview data. Please be assured that you will not be named or individually identified in any reports or publications related to all research activities. We will be reporting broad categories of participants so please consider this before deciding whether you would like to participate.

All information collected from you will be stored securely and only accessed by the researchers unless you consent otherwise. Data will be retained for at least 5 years after final publication at Charles Sturt University.

What will happen to the information that I give you?

While results will not be returned to individual participants, aggregated (combined) research findings will be shared through the communication channels of Wine Grape Marketing Board and Wine Australia (newsletter, social media, direct email). The outcomes will be published in relevant reports associated with this project. The outcomes will also be published in an appropriate scientific journal and/or presented at relevant conferences.

Who should I contact if I have concerns about the conduct of this study?

Charles Sturt University's Human Research Ethics Committee has approved this project. If you have any complaints or reservations about the ethical conduct of this project, you may contact the Committee at (02) 6933 4213 or ethics@csu.edu.au. Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

Charles Sturt University
Gulbali Institute
Agriculture Water Environment

Participant Consent

Using the lived experience of grape growers in the Riverina to inform plans for sustainable and profitable viticulture.

Principal Investigator

Dr Jennifer Manyweathers, Senior lecturer in Ruminant Health and Epidemiology. School of Agricultural, Environmental and Veterinary Sciences Charles Sturt University. Gulbali Institute.

Co-investigators

Dr Jen Bond, Lecturer in Human Geography, School of Agricultural, Environmental and Veterinary Sciences Charles Sturt University, Gulbali Institute.

Professor Leigh Schmidtke, Professor of Oenology, Charles Sturt University. Gulbali Institute.

Ms Lynne Hayes, Research Assistant, School of Agricultural, Environmental and Veterinary Sciences Charles Sturt University. Gulbali Institute.

- I agree to participate in the above research project and give my consent freely.
- I understand that the project will be conducted as described in the Participant Information Sheet, a copy of which I have retained
- I consent to participating in an interview, the content of which will be documented either by audio or audio visual recording and transcription. The type of recording will depend on the interview platform used. Please select which form/s of recording you consent to-

  Audio only oAudio and Video o
- I understand I can withdraw from the project at any time and do not have to give any reason for withdrawing
- I understand that my personal information will remain confidential to the researchers
- I have had the opportunity to have questions answered to my satisfaction.

Name:_ Signature: Date:

NOTE: Charles Sturt University's Human Research Ethics Committee has approved this project. If you have any complaints or reservations about the ethical conduct of this project, you may contact the Committee on (02) 6933 4213 or ethics@csu.edu.au. Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

Locked Bag 588, Wagga Wagga, NSW, 2678,
Australia T: +61 2 6933 2802 | E:lhayes@csu.edu.au |
csu.edu.au/

CRICOS Provider Number for Charles Sturt University is 00005F. ABN: 83 878 708 551

Interview schedule

Using the lived experience of grape growers in the Riverina to inform plans for sustainable and profitable viticulture

Interview guide:

Name:

Date/time:

Location:

Interviewer:

Interview notes:

- **Please tell us what you really enjoy about being a grape grower in this area.**
  - Prompt: profitability, connection to the environment, sense of pride in product, family business, sense of wellness
- **Please tell us about the challenges of being a grape grower in this area.**
  - Prompt: seasonal/climate challenges, aging vines, succession challenges, profitability, vineyard relationships, pests and diseases, sense of wellness, support, information
- **Please tell us where you see yourself in 5 years' time.**
- **Please tell us what you would do for work if you could do anything.**
- **Is there anything else you would like to tell me that you think is important about being a grape grower in this area?**

Economic Impact Analysis Ethics Forms

Participant Information

Charles Sturt University
Gulbali Institute
Agriculture Water Environment

Project title: Profitable Vineyards for New South Wales: Package 2 Economic studies

Principal Investigator
Adjunct Associate Professor Tom Nordblom. Gulbali Institute. BSc (Hons) Ag Management, Cal-Poly; MSc & PhD, Ag & Resource Econ, Oregon State U.; served in Research & Training 16 yrs ICARDA-Aleppo; 14 yrs NSW DPI-Wagga; 8 yrs Charles Sturt University; Gulbali Institute.

Co-investigators
Dr Susan Robertson B. App. Sc. (Ag) (Hons), PhD, Senior Lecturer in Ruminant Production, School of Agricultural, Environmental and Veterinary Sciences Charles Sturt University. Gulbali Institute.

Professor Leigh Schmidtke. B. App. Sc (MLS), M. App. Sc (Research), PhD, Grad. Dip. Uni. Teach & Learning., Professor of Oenology, Gulbali Institute, Charles Sturt University.

Invitation
You are invited to participate in a research study that is investigating the drivers of financial performance for inland wine grape growers. You have been invited to participate in an interview as representing the diversity of Riverina wine grape growers as determined through a process of stratified random sampling, designed to ensure representation of the smaller vineyard areas to the larger. Please note that to participate in the research you must be over 18 years old.

The study is being conducted by the researchers listed at the top of this document who are affiliated with Charles Sturt University and the Gulbali Institute.

Before you decide whether you wish to participate in this study, it is important for you to understand why the research is being done and what it will involve. Please take the time to read the following information carefully and discuss it with others if you wish. We do expect that, if required, you will discuss your involvement in this research with your organisation/employer and obtain any necessary approvals.

What is the purpose of this study?
The project will contribute to our understanding of the drivers of financial performance for inland wine grape growers, aiming to identify opportunities to increase the profitability of growers.

Why have I been invited to participate in this study?
This is a pilot study and we are inviting participation only from Riverina wine-grape growers

What does this study involve?
Participation will involve the completion of a face to face interview or an interview via zoom. It is expected that the interview will take approximately 60 minutes to complete and will cover the following areas:

Inputs and quantity of grape production
Costs and prices received
Vineyard practices
Perspectives on limits to profitability

You will be provided a list of the questions to be covered in the interview before-hand so you know what to expect and come with as many of the questions answered as possible. For example, questions on grape yield and price, the number of applications of fertiliser and chemicals, water use, etc. and overhead costs, for example, depreciation, plant maintenance, etc. Grape yields and prices vary considerably from year to year and the financial risks caused by this to growers are a key area of focus of this study.

Are there any risks and benefits to me in taking part in this study?

The research aims to define the practices used and financial performance of wine-grape growing. Participation in this study should involve no physical or mental discomfort. However, if as a result of participating in this research you feel you need support, please contact your usual health professionals. Support is also available from the Centre for Rural and Remote Mental Health 1800 011 511 or for immediate support, Lifeline 13 11 14.

How is this study being paid for?

The study is funded by Riverina Wine Grape Growers, Wine Australia, Charles Sturt University, NSW Department of Primary Industries, and Food Innovation Australia Ltd.

Will taking part in this study cost me anything, and will I be paid?

Other than your time, there are no costs associated with participating in this research, nor are there any direct payments. Each participant will be entered into a draw for the opportunity to win a $100 voucher.

What if I don't want to take part in this study?

Participation in this research is entirely your choice. Only those people who give their informed consent will be included. Whether or not you decide to participate is your decision and will not disadvantage you. There are no consequences for those who decide not to participate.

What if I participate and want to withdraw later?

Participants will have 2 weeks after the interview in which to notify the research team if they wish to withdraw their data. After this time, it will not be possible to withdraw data.

If you **do** wish to remove your data within 2 weeks of your interview, please contact Tom Nordblom tnordblom@csu.edu.au to arrange this.

How will my confidentiality be protected?

Interview data will be compiled as aggregated data. Individual property identity will be anonymised, and no identifying information will be stored with the interview data. You will not be identifiable in any reports, presentations or publications.

Once we have completed the data analysis, contact details will be deleted. Please be assured that you will not be named or individually identified in any reports or publications related to all research activities. We will be reporting broad categories of participants so please consider this prior to deciding whether you would like to participate.

All information collected from you will be stored securely and only accessed by the researchers unless you consent otherwise.

Data will be retained for at least 5 years after final publication at Charles Sturt University.

What will happen to the information that I give you?

The outcomes will be published in relevant reports and may also be published in appropriate scientific journals and/or presented at relevant conferences. You will not be individually identified.

What should I do if I want to discuss this study further before I decide?

If you would like further information, please contact:
Tom Nordblom Email: tnordblom@csu.edu.au P: **04192 90428**

Who should I contact if I have concerns about the conduct of this study?

Charles Sturt University's Human Research Ethics Committee has approved this project. If you have any complaints or reservations about the ethical conduct of this project, you may contact the Committee on (02) 6933 4213 or ethics@csu.edu.au. Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

Charles Sturt University
Gulbali Institute
Agriculture Water Environment

NOTE TO HREC- INFORMATION ON THIS PAGE WILL BE READ AT THE START OF THE INTERVIEW, CONFIRMED AND BECOME A PART OF THE INTERVIEW RECORD.

Participant Consent

TITLE Profitable Vineyards for New South Wales: Package 2 Economics case studies

Principal Investigator

Associate Professor Tom Nordblom. Gulbali Institute.

Co-investigators

Dr Susan Robertson Senior Lecturer in Ruminant Production, School of Agricultural, Environmental and Veterinary Sciences Charles Sturt University, Gulbali Institute.

Professor Leigh Schmidtke. Professor of Oenology, Gulbali Institute, Charles Sturt University.

Dr Benjamin Wills. Research Fellow, Gulbali Institute, Charles Sturt University.

- I agree to participate in the above research project and give my consent freely.
- I understand that the project will be conducted as described in the Participant Information Sheet, a copy of which I have retained
- I consent to participating in an interview, the content of which will be documented in writing and/or either by audio or audio visual recording and transcription. The type of recording will depend on the interview platform used. Please select which form/s of recording you consent to-
  In writing ☐ Audio only ☐ Audio and Video ☐
- I understand I can withdraw from the project at any time and do not have to give any reason for withdrawing
- I understand that my personal information will remain confidential to the researchers
- I have had the opportunity to have questions answered to my satisfaction.

Name:_____**Signature:**_____**Date:** _____

NOTE: Charles Sturt University's Human Research Ethics Committee has approved this project. If you have any complaints or reservations about the ethical conduct of this project, you may contact the Committee on (02) 6933 4213 or ethics@csu.edu.au. Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

Participation in this study should involve no physical or mental discomfort. However, if as a result of participating in this research you feel you need support, please contact your usual health professionals. Support is also available from the Centre for Rural and Remote Mental Health 1800 011 511 or for immediate support, Lifeline 13 11 14 or BeyondBlue 1300 224 636 (www.beyondblue.org.au).

Charles Sturt University
Gulbali Institute
Agriculture Water Environment

Interview questions: Vineyard practices for profitability

Question	Circle correct answer or write relevant answer on dotted line
1. Business ownership	Owner / Manager / Corporate
2. Location	Postcodes: …….
3. Highest level of education	< Yr 10 / Yr 10 / Yr 12 / Trade certificate / Degree / Higher Degree
4. Number of years growing grapes?	
5. Intent in next 5 years	Remain in industry / Diversify on or off-vineyard / Retire / Leave industry
6. How do you sell your grapes (tick those that apply)?	Sell grapes off-farm to wineries ..... How many wineries do you sell grapes to ..... Have own winery ...Yes/No Have cellar door Yes/No
7. Wine grapes sold on contracts to winery	Yes / No / Spot price only / Combination contract and spot price Reason for sale method……
8. Farm area (ha) (to convert acres to hectares divide by 2.47 ie 10 acres ÷2.47=4.05 ha)	Your vineyards for wine grapes…….ha Other crops (specify) ie citrus, cotton , nuts …….ha……..ha……..ha…….ha Other (specify)…… ha……..ha
9. Vineyard description	Age of youngest ....., oldest .....vines (years) Year vines last replaced/grafted or changed……. Replacement vines sourced from:……@ $...../vine

	Inter-row management: mowing / cover crop./ herbicide /.cultivation./.other (specify).....
10. Source of water	Private bore .....River.....Water provider.....Dam.....None.....
11. Type of irrigation	Flood.....Drip.....Sprinkler.....Channel.....Other.....None..... How do you determine irrigation requirement? .....
12. What activities are mechanised on your farm?	Pruning / Desuckering./ Canopy management/trimming./ Under vine/floor management / Spraying / Harvest Other (please list).....
13. Number of wine grape varieties grown?	List Red varieties……. …….. List White varieties……. ……..

The following questions relate to farm income.

14. Does your household obtain income from off farm employment/activities	Yes / No / Sometimes If yes, what % of household income from off farm activities.....%
15. Did your wine grape production generate a financial profit in the previous three financial years?	2021 – 2022 Yes / No 2020 – 2021 Yes / No 2019 – 2020 Yes / No
16. Do you expect your wine grape production activities to be profitable in the next financial year?	Yes / No
17. Are you making active preparations to exit the wine grape production business due to low profitability?	Yes / No

18. **Please indicate your wine grape production for your vineyard for the <u>autumn 2022</u> harvest, and reasons for any discounts or unsold production.**

	Vineyard Total
Area (ha)	
Number of blocks	
Row spacing (m)	
Vine spacing (m)	
Trellis system (i.e. # of cordons)	
Grapes sold at full price(t)	
Full price ($/t)	
Grapes sold at discount (t)	
Discount price ($/t)	
Reason for discount	
Grapes not harvested/sold (t)	
Reason for unsold grapes	

19. Please indicate wine grape production costs ($) for your vineyard for the autumn 2022 vintage.

Variable Costs	**Vineyard Total**
Labour - permanent employees	
Casual labour	
Contract labour	
Harvesting cost	
Fruit cartage to winery	
Wine Industry Levies	
Chemicals: Herbicide	

Fungicide Pesticide	
Fertiliser type	…….T
Water	……ML @
Electricity for pumping water	
Fuel	
Machinery/equipment expenses	
Repairs and maintenance	
Soil/plant testing	

The next questions allow producers to indicate what they believe is limiting profitability

20. What are the most important factors limiting the productivity of wine grape production (t/ha)?	
21. What are the most important factors limiting the profitability of wine grape production ($/ha)?	
22. How does the current marketing system (contracts, quotas, discounting) impact on profit?	
23. What might be changed that would increase the profitability of wine grape production?	

11.Appendix 4: Bayesian Network framework

Wine profitability BN conceptual model

Research project Summary

The project aims to work with growers to identify any gaps in knowledge, skills, business management and vineyard practices relating to profitability. This will be achieved through a survey and interviews conducted with grape growers in the Riverina.

We will investigate knowledge, attitudes and perceptions (KAP) across the following key areas of investigation; challenges (agronomic, social, economic), social connectedness, wellbeing, aspirations (succession planning, future scenarios) and needs (resources, support, guidance).

A key outcome will be to develop a better understanding of the lived experience of grape growers in the Riverina. This will be used to inform business cases for research to address the aforementioned issues and support the sustainability and profitability of the wider Australian wine industry.

We may extend this work to a longitudinal study to allow us to measure changes based on any interventions/workshops/training implemented as part of the business plans.

Target audience

Participants in the survey are registered grape growers with the Wine Grape Marketing Board, based in the Riverina.

BN model

A BN model will be developed to undertake an exploratory segmentation based on respondents' demographics, their long-term industry intentions, connectivity with community, reflections on the industry and self-reported stress levels.

The following categories will be used in the BN model to identify respondent clusters.

Demographics

- Gender
- Age
- Intergenerational grape growing
- Primary income source
- Property size (ha) (Continuous)

Identified challenges, including

- Market stability
- Lack of market information
- Input costs
- Labour availability

- Aging vines
- Climates
- Time pressures
- Government Regulations
- Own Knowledge
- Revenue

Connectivity (how many industry/community groups are they part of)

- No,
- Yes_1,
- Yes_2,
- Yes_3,
- Yes_More than 3)

Future planning

    - Removal of grape assets (Y/N)
    - If yes
        - No_Change
        - Retirement
        - Change_includes_grapes
        - Change_no_grapes
        - Unsure

Outlook (Disagree/Neural/Agree)

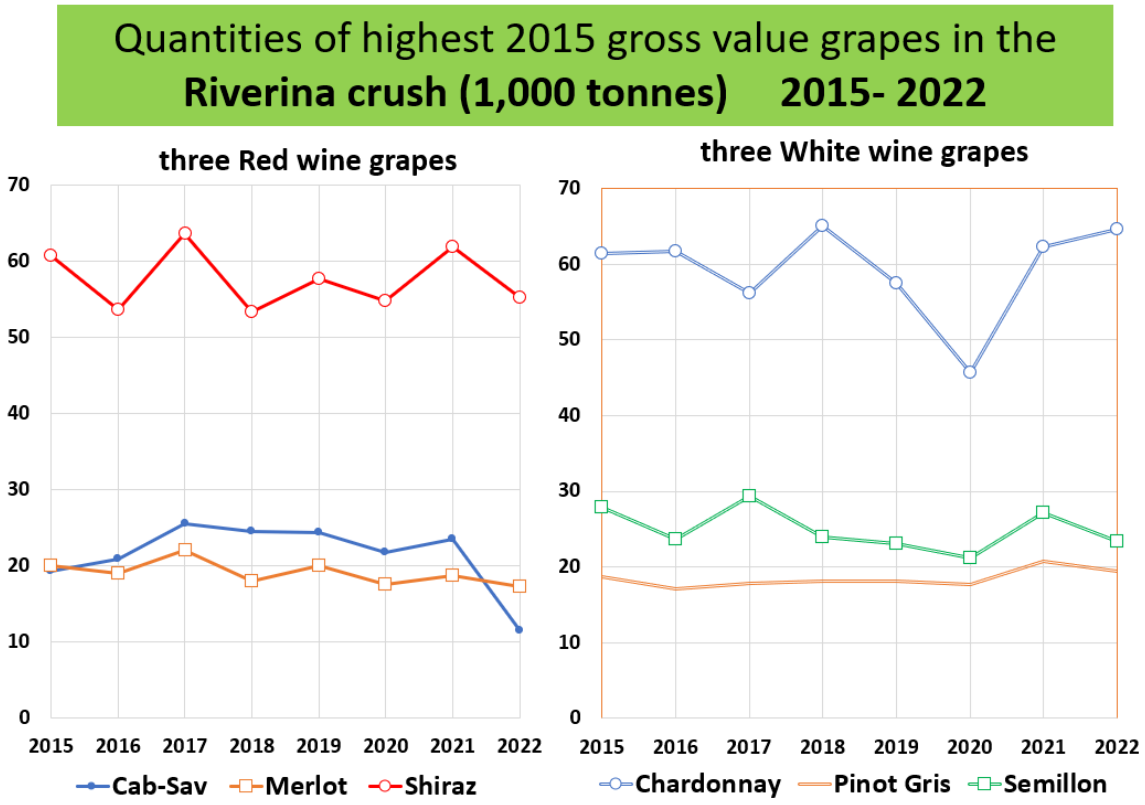
- Optimistic
- Importance of being a grape grower to self
- Importance of sustainable practices
- Current healthy situation
- Confidence in ability for future profitability
- Importance of innovation
- Comfortable in getting advice
- Self-efficacy for profitable business
- Positive relationship with wineries
- Importance of Riverina to grape growing
- All resources needed

Wellbeing in a typical week (Never/Rarely/Sometimes/Mostly/Always)

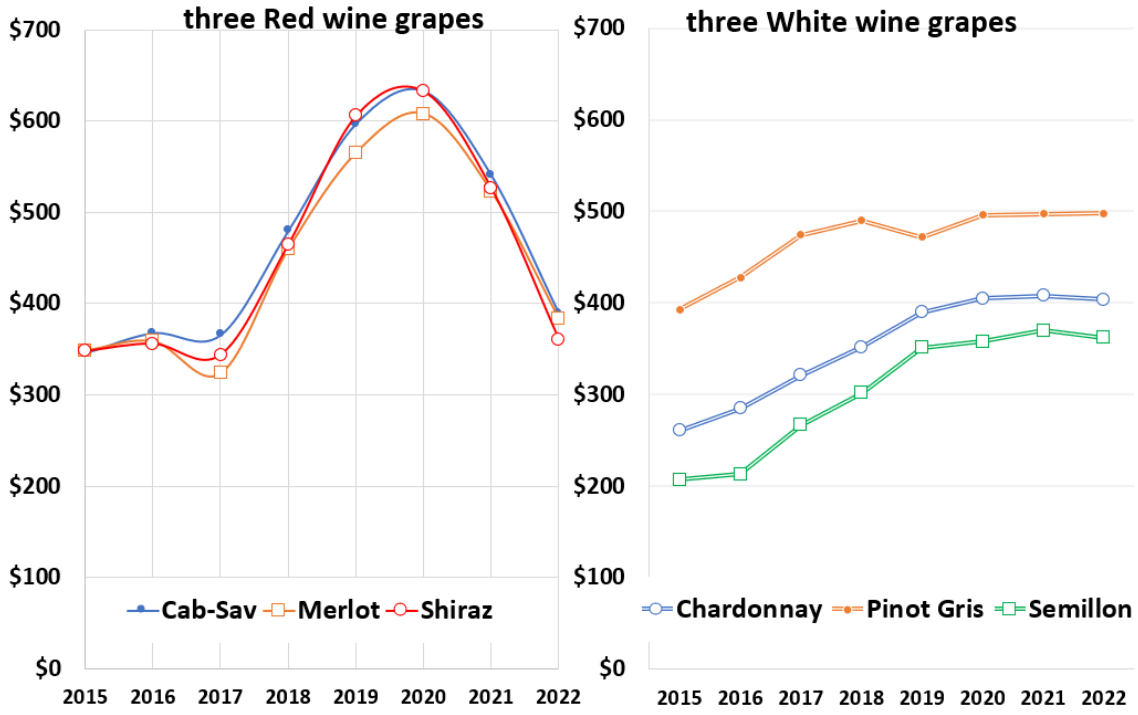
- Feeling stressed/down/worried/satisfied

12. Appendix 5. Comparing Quantities, Prices and Gross Values of Red and White grape crushes in the Riverina and Lower Murray-Riverland Regions 2015 – 2022

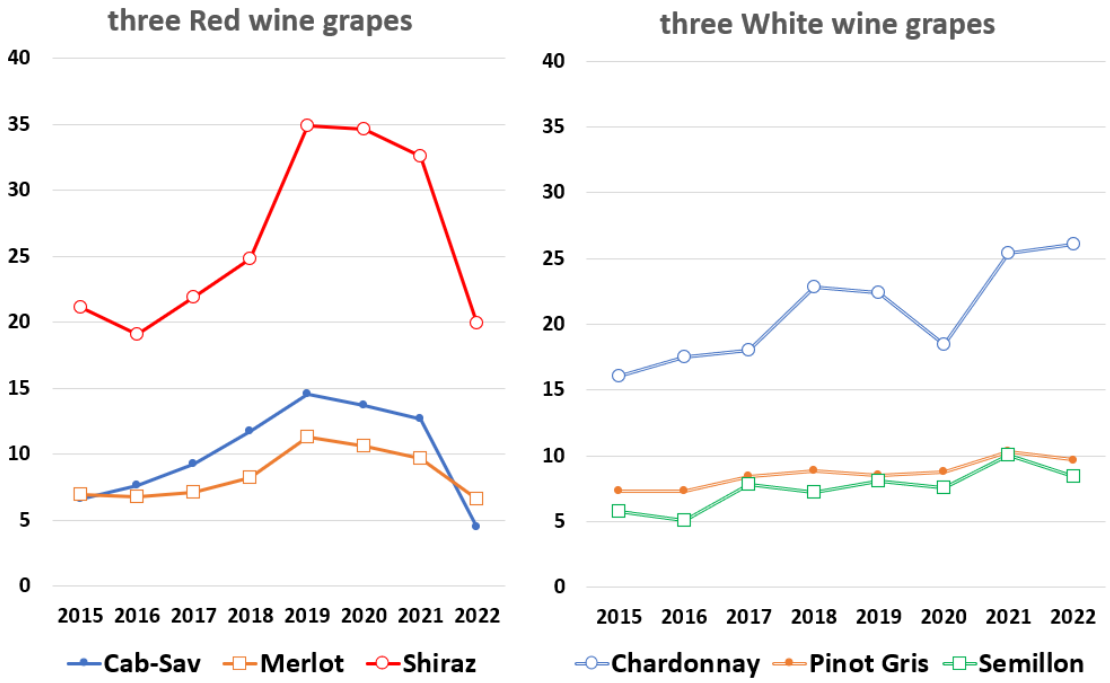
Data source: https://marketexplorer.wineaustralia.com/vintage-survey



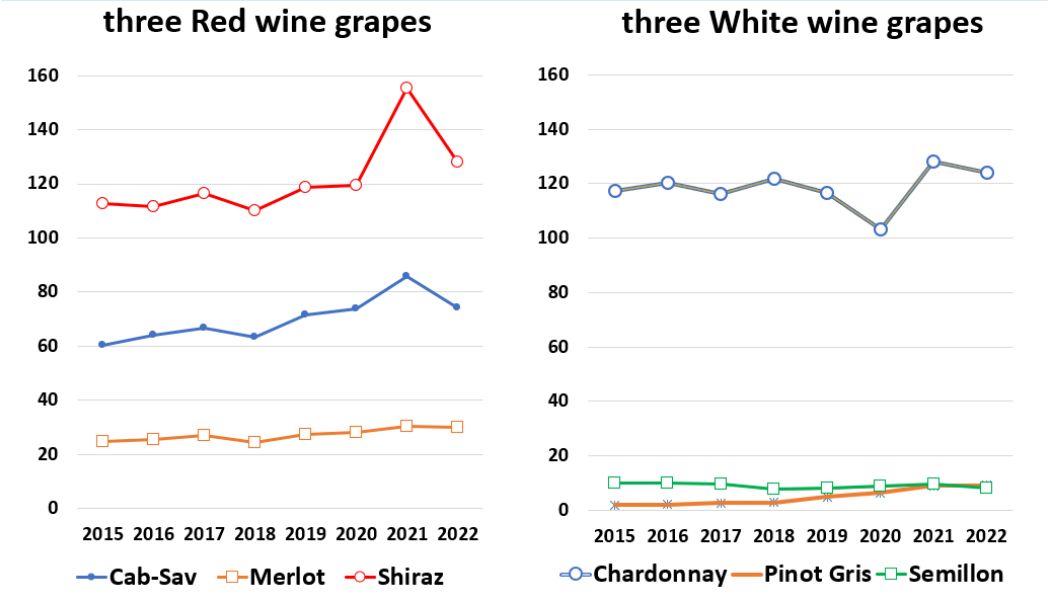
Average prices of three **RED** and three **WHITE** grapes in **the Riverina crush ($/tonne) 2015- 2022**



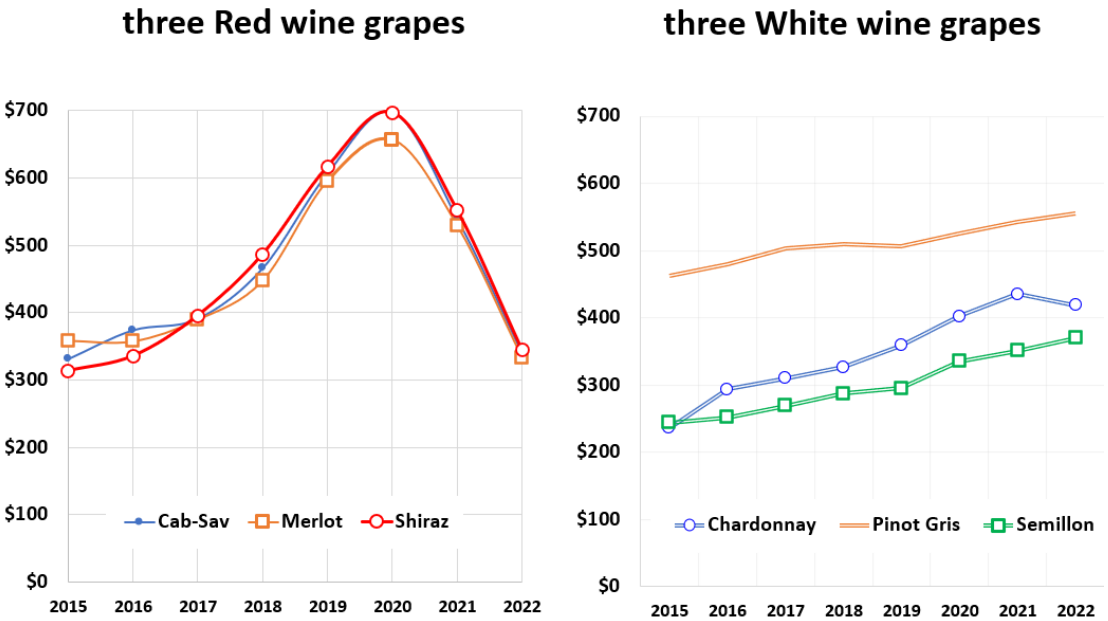
Gross values of three RED and three WHITE grapes in the **Riverina crush ($ millions/yr) 2015-2022**



Quantities of highest 2015 gross value grapes in the Lower Murray & SA Riverland crushes (1,000 tonnes)

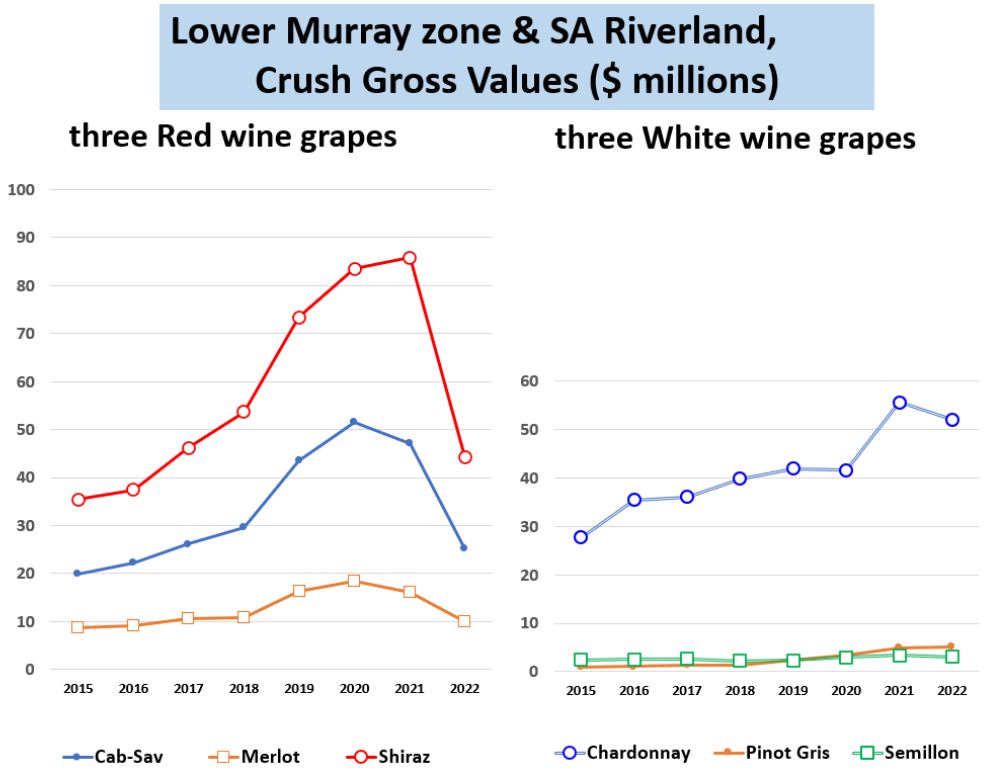


Harvest values of grapes, Lower Murray zone & SA Riverland crush ($/tonne)



Data source: https://marketexplorer.wineaustralia.com/vintage-

Source: https://marketexplorer.wineaustralia.com/vintage-survey



Comparisons of regions,

Riverina and Lower Murray-SA Riverlands

The three Red wine grape varieties with the highest gross values of production in 2015 were the same in both regions: Shiraz, Cabernet Sauvignon and Merlot

Likewise for the three White wine grape varieties: Chardonnay, Pinot Gris and Semillon

The tonnes of Shiraz and Cab-Sav grapes crushed in 2022 were noticeably less than 2020 production in both regions, based on trends of the other grapes and growers reports that wineries could not accept all grapes produced. Across the 2015-2022 span of time, crushes of the two red grapes in the larger LM-SA Riverlands region were about double those of the Riverina. Likewise for Chardonnay.

Prices of the three red grapes strongly peaked in 2020 but fell by half in 2022 in both regions, partly attributed to an embargo by China.

White grape prices showed steady increases in both regions.

It is clear the red grape price crash has caused much of the disruption felt by growers in both regions in 2022.

RIVERINA			https://marketexplorer.wineaustralia.com/vintage-survey						
Colour/ Variety	VINTAGE YEAR	Tonnes purchased	Total value purchsased	Average purchase value per tonne	% change in average value	Winery grown fruit, (tonnes)	Winery grown share of crush	Total crushed (tonnes)	Total value all grapes
RED									
Cabernet Sauvignon	2015	14,118	$ 4,880,008	$ 346	-9%	5,066	26%	19,183	$ 6,631,048
	2016	14,071	$ 5,176,260	$ 368	6%	6,709	32%	20,780	$ 7,637,193
	2017	16,791	$ 6,206,479	$ 366	-1%	8,482	33%	25,452	$ 9,308,494
	2018	16,544	$ 7,938,756	$ 480	31%	7,935	32%	24,478	$ 11,744,331
	2019	16,430	$ 9,810,698	$ 597	24%	7,952	33%	24,383	$ 14,559,150
	2020	15,672	$ 9,925,323	$ 633	6%	6,009	28%	21,680	$ 13,730,664
	2021	16,365	$ 8,854,243	$ 541	-15%	7,049	30%	23,414	$ 12,668,262
	2022	8,809	$ 3,438,553	$ 390	-28%	2,628	23%	11,437	$ 4,464,351
Merlot	2015	13,545	$ 4,720,706	$ 349	1%	6,399	32%	19,944	$ 6,950,875
	2016	14,270	$ 5,122,140	$ 359	3%	4,725	25%	18,995	$ 6,799,382
	2017	13,235	$ 4,286,638	$ 324	-10%	8,767	40%	22,002	$ 7,127,590
	2018	12,288	$ 5,647,532	$ 460	42%	5,639	31%	17,927	$ 8,224,357
	2019	13,030	$ 7,367,287	$ 565	23%	6,968	35%	19,998	$ 11,306,823
	2020	11,571	$ 7,038,579	$ 608	8%	5,959	34%	17,529	$ 10,663,189
	2021	12,428	$ 6,495,219	$ 523	-14%	6,203	33%	18,631	$ 9,737,198
	2022	11,972	$ 4,594,324	$ 384	-27%	5,311	31%	17,285	$ 6,632,072
Shiraz	2015	48,929	$17,050,879	$ 348	-1%	11,763	19%	60,692	$ 21,150,060
	2016	45,429	$16,184,893	$ 356	2%	8,170	15%	53,599	$ 19,100,630
	2017	48,953	$16,857,002	$ 344	-3%	14,665	23%	63,617	$ 21,906,768
	2018	41,485	$19,299,074	$ 465	35%	11,777	22%	53,262	$ 24,820,612
	2019	42,968	$26,024,038	$ 606	30%	14,692	25%	57,660	$ 34,922,595
	2020	39,443	$24,973,296	$ 633	5%	15,302	28%	54,746	$ 34,662,017
	2021	45,495	$23,992,824	$ 527	-17%	16,370	26%	61,865	$ 32,626,209
	2022	41,126	$14,849,104	$ 361	-32%	14,065	25%	55,191	$ 19,927,442

RIVERINA			https://marketexplorer.wineaustralia.com/vintage-survey						
Colour/ Variety	VINTAGE YEAR	Tonnes purchased	Total value purchsased	Average purchase value per tonne	% change in average value	Winery grown fruit, (tonnes)	Winery grown share of crush	Total crushed (tonnes)	Total value all grapes
WHITE									
Chardonnay	2015	46,289	$12,089,229	$ 261	-5%	15,130	25%	61,419	$ 16,040,733
	2016	47,400	$13,490,360	$ 285	9%	14,229	23%	61,630	$ 17,478,703
	2017	36,958	$11,880,980	$ 321	13%	19,161	34%	56,119	$ 18,035,571
	2018	43,623	$15,339,758	$ 352	9%	21,486	33%	65,110	$ 22,857,091
	2019	38,382	$14,919,364	$ 390	11%	19,201	33%	57,483	$ 22,402,390
	2020	31,391	$12,703,039	$ 405	4%	14,275	31%	45,666	$ 18,479,844
	2021	43,080	$17,584,085	$ 408	1%	19,253	31%	62,333	$ 25,442,874
	2022	49,735	$20,092,493	$ 404	-1%	14,803	23%	64,539	$ 26,072,964
Pinot Gris/ Grigio	2015	15,159	$ 5,963,915	$ 393	8%	3,488	19%	18,646	$ 7,336,065
	2016	13,615	$ 5,820,727	$ 428	9%	3,539	21%	17,153	$ 7,333,593
	2017	9,946	$ 4,714,009	$ 474	11%	7,832	44%	17,779	$ 8,426,142
	2018	10,520	$ 5,157,681	$ 490	3%	7,610	42%	18,130	$ 8,888,597
	2019	10,792	$ 5,090,292	$ 472	-4%	7,292	40%	18,084	$ 8,529,547
	2020	9,723	$ 4,821,228	$ 496	5%	7,976	45%	17,700	$ 8,776,276
	2021	13,890	$ 6,906,876	$ 497	0%	6,825	33%	20,715	$ 10,300,918
	2022	12,221	$ 6,080,862	$ 498	0%	7,207	37%	19,428	$ 9,667,066
Semillon	2015	21,109	$ 4,362,347	$ 207	-13%	6,781	24%	27,890	$ 5,763,772
	2016	18,761	$ 3,997,884	$ 213	3%	4,912	21%	23,673	$ 5,042,234
	2017	22,911	$ 6,122,725	$ 267	25%	6,469	22%	29,380	$ 7,849,403
	2018	18,535	$ 5,588,868	$ 302	13%	5,358	22%	23,893	$ 7,199,009
	2019	17,580	$ 6,165,986	$ 351	16%	5,495	24%	23,075	$ 8,093,348
	2020	16,791	$ 6,013,367	$ 358	2%	4,442	21%	21,232	$ 7,604,088
	2021	21,713	$ 8,040,855	$ 370	3%	5,510	20%	27,223	$ 10,081,274
	2022	18,802	$ 6,798,798	$ 362	-2%	4,600	20%	23,401	$ 8,462,088

Lower Murray zone and Riverland sample of wine crush and values 2015-2022									
Colour/ Variety	VINTAGE YEAR	Tonnes purchased	Total value purchsased	Average purchase value per tonne	% change in average value	Winery grown fruit, (tonnes)	Winery grown share of crush	Total crushed (tonnes)	Total value all grapes
RED									
Cabernet Sauvignon	2015	46,494	$15,382,240	$ 331	-2%	13,845	23%	60,399	$ 19,962,634
	2016	49,433	$17,134,939	$ 374	5%	14,729	23%	64,162	$ 22,240,352
	2017	50,921	$19,907,026	$ 391	13%	15,852	24%	66,773	$ 26,104,219
	2018	49,489	$23,062,915	$ 466	19%	13,968	22%	63,457	$ 29,572,518
	2019	54,529	$33,079,334	$ 607	30%	17,097	24%	71,626	$ 43,450,999
	2020	55,429	$37,968,074	$ 698	15%	19,310	26%	73,739	$ 51,437,914
	2021	66,343	$35,729,362	$ 539	-23%	19,244	22%	85,587	$ 47,093,008
	2022	53,262	$18,033,923	$ 339	-37%	21,023	28%	74,285	$ 25,152,070
Merlot	2015	16,776	$ 6,030,450	$ 359	2%	7,764	32%	24,540	$ 8,821,274
	2016	18,744	$ 6,719,805	$ 358	0%	6,693	26%	25,437	$ 9,119,192
	2017	18,630	$ 7,269,944	$ 390	9%	8,449	31%	27,079	$ 10,567,001
	2018	17,001	$ 7,608,993	$ 448	15%	7,316	30%	24,317	$ 10,883,233
	2019	17,871	$10,644,131	$ 596	33%	9,519	35%	27,390	$ 16,313,804
	2020	17,487	$11,486,191	$ 657	10%	10,699	38%	28,186	$ 18,513,594
	2021	21,054	$11,113,377	$ 529	-20%	9,424	31%	30,479	$ 16,087,822
	2022	17,715	$ 5,903,800	$ 333	-37%	12,322	41%	30,037	$ 10,010,185
Shiraz	2015	87,167	$27,400,131	$ 314	-9%	25,585	23%	112,752	$ 35,442,576
	2016	88,485	$29,726,348	$ 336	7%	23,051	21%	111,536	$ 37,470,287
	2017	91,880	$36,424,712	$ 396	18%	24,621	21%	116,501	$ 46,185,473
	2018	86,072	$41,883,788	$ 487	23%	24,213	22%	110,286	$ 53,666,244
	2019	91,611	$56,538,963	$ 617	27%	27,255	23%	118,866	$ 73,359,644
	2020	89,555	$62,640,636	$ 697	13%	30,085	25%	119,641	$ 83,443,761
	2021	121,626	$67,160,684	$ 552	-21%	33,795	22%	155,470	$ 85,814,401
	2022	90,183	$31,134,859	$ 345	-37%	37,989	30%	128,172	$ 44,250,034
Data abstracted from: https://marketexplorer.wineaustralia.com/vintage-survey									

Lower Murray zone and Riverland sample of wine crush and values 2015-2022									
Colour/ Variety	VINTAGE YEAR	Tonnes purchased	Total value purchsased	Average purchase value per tonne	% change in average value	Winery grown fruit, (tonnes)	Winery grown share of crush	Total crushed (tonnes)	Total value all grapes
WHITE									
Chardonnay	2015	104,031	$24,539,817	$ 236	0%	13,417	11%	117,449	$ 27,704,801
	2016	106,159	$31,236,652	$ 294	25%	14,207	12%	120,366	$ 35,417,086
	2017	96,701	$30,017,055	$ 310	5%	19,654	17%	116,355	$ 36,117,781
	2018	101,989	$33,345,987	$ 327	5%	19,929	16%	121,918	$ 39,861,931
	2019	97,102	$34,897,314	$ 359	10%	19,521	17%	116,623	$ 41,912,841
	2020	82,867	$33,336,544	$ 402	12%	20,510	20%	103,377	$ 41,587,500
	2021	105,138	$45,702,836	$ 435	8%	22,867	18%	128,005	$ 55,642,979
	2022	97,430	$40,846,014	$ 419	-4%	26,769	22%	124,199	$ 52,067,390
Pinot Gris/ Grigio	2015	1,516	$ 701,492	$ 463	3%	462	23%	1,979	$ 915,421
	2016	1,677	$ 805,487	$ 480	4%	467	22%	2,143	$ 1,029,713
	2017	1,995	$ 1,004,381	$ 503	5%	665	25%	2,661	$ 1,339,334
	2018	2,225	$ 1,134,167	$ 510	1%	556	20%	2,781	$ 1,417,378
	2019	3,970	$ 2,012,485	$ 507	-1%	874	18%	4,844	$ 2,455,651
	2020	5,059	$ 2,657,621	$ 525	4%	1,284	20%	6,343	$ 3,332,242
	2021	6,890	$ 3,731,813	$ 542	3%	2,199	24%	9,088	$ 4,922,525
	2022	6,898	$ 3,837,413	$ 556	3%	2,387	26%	9,284	$ 5,165,214
Semillon	2015	5,914	$ 1,442,579	$ 244	-3%	3,969	40%	9,883	$ 2,410,862
	2016	4,826	$ 1,216,310	$ 252	3%	5,081	51%	9,907	$ 2,496,991
	2017	4,787	$ 1,287,573	$ 269	7%	4,968	51%	9,755	$ 2,623,751
	2018	4,014	$ 1,153,062	$ 287	7%	3,658	48%	7,672	$ 2,203,982
	2019	4,790	$ 1,414,790	$ 295	3%	3,298	41%	8,088	$ 2,388,774
	2020	3,979	$ 1,331,719	$ 335	13%	4,773	55%	8,752	$ 2,929,200
	2021	5,191	$ 1,821,567	$ 351	5%	4,435	46%	9,626	$ 3,377,685
	2022	4,437	$ 1,641,774	$ 370	5%	3,875	47%	8,312	$ 3,075,788
Data abstracted from: https://marketexplorer.wineaustralia.com/vintage-survey									

13.Appendix 6: References

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14.Appendix 7: Staff that have been engaged on the Project.

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