Journal of Agriculture and Environment for International Development - JAEID 2024, 118 (2): 181-202
DOI: 10.36253/jaeid-15126

Exploring perceptions of sustainability and its indicators in grape and wine production in South Africa

OMAMUYOVWI GBEJEWOH[1], SASKIA KEESTRA[2,3], WILLEM HOFFMAN[4], ERNA HAILEY BLANCQUAERT[1*]

[1] *South African Grape and Wine Research Institute, Department and Viticulture and Oenology, Stellenbosch University, Stellenbosch, South Africa*

[2] *Soil, Water and Land Use Team, Wageningen University and Research, Wageningen*

[3] *Civil, Surveying and Environmental Engineering, The University of Newcastle, Callaghan, Australia*

[4] *Department of Agricultural Economics, Stellenbosch University, Stellenbosch, South Africa*

**Correspondence details: ewitbooi@sun.ac.za*

Submitted on: 2023, 11 September; accepted on 2024, 2 August. Section: Research Papers

Abstract: Sustainability has always been a divided term due to the individuality linked to it. Just like the sustainability concept, measuring sustainability has been difficult because selecting indicators is just as subjective. In the South African grape and wine industries, this is even more so given the urgency and need to be sustainable. However, research on what sustainability means and what to measure is limited and mostly one-dimensional. This research adds to the current knowledge by taking a multi-dimensional approach to sustainability and its indicators. A mixed-method design was used comprising of a questionnaire with stakeholders and a Delphi Technique. The results show that different stakeholders interpreted sustainability meaning subjectively and the environmental dimension dominated most perceptions of sustainability. Respondents noted the near-constant trade-offs between the three pillars but deemed the environmental as the most important but the social as the most difficult to achieve. Furthermore, grape/wine demand and prices, brand value and production/quality consistency were deemed relevant for economic sustainability, soil health, chemical/water use efficiency for environmental sustainability and living wage, safe work environment and children's welfare for social sustainability. This research showed the difficulty respondents had with balancing the three pillars in the economic production condition of the country that constrains their effort to do more.

Keywords: sustainability, pillars, dimension, Delphi, wine grape, South Africa

Introduction

Ever since sustainable development and sustainability was emphasized by the Brundtland Commission, it has always been a contentious topic (Espinosa, Harnden & Walker, 2008). This is mainly because sustainability as a concept is subjective and rooted in various personal ideologies and perceptions (Rinne, Lyytimäki & Kautto, 2013). As such, even though they are many accepted definitions of sustainability over the years, there has never been one definition that has drawn universal consensus (Wei, Davidson, Chen, & White, 2009). However, they are a few explanations of sustainability that have drawn

significant acceptance, one of which being the "triple bottom line" or "three pillars" concept proposed by Elkington (1998). This concept expanded from the Brundtland Commission's definition, proposes that sustainability is only possible when businesses show effort towards the economic, environmental, and social aspects of their production process.

Just as there are a plethora of perceptions and definitions of sustainability, there has also been a cascade of sustainable indicators to be assessed and measured (Santiago-Brown, Metcalfe, Jerram & Collins, 2015a). Furthermore, given that sustainability is believed to be multidimensional, it involved measurement and approximation of disparate indicators, there is not a universally accepted methodology for measurement of these indicators (Escribano, Diaz-Caro & Mesias 2018). In agriculture, this dilemma is exacerbated by the choices between practice-based indicators and performance-based indicators as there is a lack of consensus between on which type of indicators to select and use (de Olde, Sautier & Whitehead, 2018).

The importance of sustainability for agriculture generally and grape and wine production cannot be overemphasized (Christ and Burritt, 2013; OIV, 2020; Wagner, Stanbury, Dietrich, Döring, Ewert, Foerster, Freund, Matthias, Kamman, Koch, Owtram, Schultz, Voss-Fels & Hanf, 2023). Agriculture and vinivitculture has major concerns such as ecosystem pollution, significant water usage, organic and inorganic waste production, land use change, energy usage, and greenhouse gas emissions. For context, research has shown that some wineries use over eight litres of water to produce a bottle of wine, with over 70% of this water use destined for wastewater (Christ and Burritt, 2013; Flores et al., 2018; Merli, Preziosi & Acampora, 2018). In addition, climate change impacts are exacerbating these sustainability issues. For example, increased temperatures associated with climate change has increased the incidence of pest and disease pressure on crops necessitating the need for more synthetic chemical usage (Gbejewoh, Keestra & Blancquaert, 2021). While unpredictable rainfall coupled with droughts, wildfires and heatwaves has put pressure on grape and wine producers to rely less on precipitation and more on irrigation. Lastly, the possibility of vineyard relocation to cooler areas may worsen the land use change patterns associated with agriculture and grape production (Gbejewoh et al., 2021; Wagner et al., 2023).

The grape and wine industry has become attuned to its concerns such as climate change, water, chemical and energy use, workers' welfare amongst other things (Gilinsky, Newton & Vega, 2016). Furthermore, consumers are becoming knowledgeable of the sustainability concerns of grape and wine production and are open to spending more for sustainable products, despite limited knowledge of what sustainability means or how to measure them (Schaufele and Hamm, 2017). In a recent Deloitte millennial report, climate change and protecting the environment ranked 3rd most important parameter (Deloitte, 2023).

These concepts of sustainability and its indicators are important for the grape and wine sectors in South Africa because it is a significant contributor to the South African economy. South Africa is one of the largest grape and wine exporters in the world, contributing significantly to the Gross Domestic Product (GDP) of the country and employing thousands of workers (Gbejewoh et al., 2021). In addition, South Africa is one of the first wine producing regions to roll out environmental sustainability initiatives for wine production, exemplified by the Integrated Production of Wine (IPW) framework in 1998, followed by the Biodiversity and Wine Initiative (BWI) in 2005. South Africa also has social sustainability initiatives exemplified by Wine and Agricultural Ethical Trade Association (WIETA) and Fair-Trade certifications (McEwan and Bek, 2009).

However, despite these various initiatives research on what sustainability means for grape and wine stakeholders in South Africa is practically non-existent, while research on sustainability indicators has been based on a number of wine-producing regions without specific focus on South Africa (Santiago-Brown et al., 2015a; Gbejewoh et al., 2021). Even

more so, research on sustainability in South Africa has been one-dimensional (Santiago-Brown et al., 2015a; Hamman, Smith, Tashman & Marshall, 2016; Devereux, 2020) without any effort to collate various dimensions into a coherent picture. This research contributes to the current state of knowledge and fills the gap by (i) exploring what sustainability and its three pillars mean to stakeholders of grape and wine production and (ii) identifying indicators that can be used for the assessment of economic, environmental, and social dimensions of sustainability.

Methodology

Study area

Grape cultivation in South Africa primarily takes place in the Western Cape with its Mediterranean climatic conditions. The Western Cape is in the southwest of South Africa and covers approximately 129,370 km^2 (Winter, 2002). The Western Cape is bordered by the Indian Ocean, Atlantic Ocean in the south and west respectively. The province of Western Cape is composed of 6 district municipalities which are West Coast, Eden, Cape Winelands, City of Cape Town, Overberg and Central Karoo. Western Cape accounts for about 11.3% of the country's population which translates to over 6.3 million people (Fanadzo, Ncubo, French & Belete, 2021). The topography is varied and complex and ranges from valleys to coastal plains and mountain ranges. The three obvious climatic regions are the South Coast, Karoo and the Mediterranean. The Mediterranean climatic region (of interest to viticulture) found in the southwestern and western part of the Western Cape, gets most of its precipitation during winter (May to August/September) (van Niekerk and Joubert, 2006). Even though the region has an average annual rainfall between 500mm and 150mm, higher than the average for South Africa, it is still a water-scarce region due to increasing urbanization and high-water demand for irrigation (Saldias, Speelman, van Huylenbroeck & Vink, 2015). The average temperature ranges from 5°C to 22°C in the winter and 15°C to 27°C in the summer. The agricultural sector in the Western Cape is an important industry for the nation which includes wine grapes, deciduous fruits and vegetables. Western cape directly contributes about 3% to the national Gross Domestic Product (GDP), which is closer to 8% when the entire value chain is considered (Greyling, 2012). It accounts for over 60% of the country's agricultural exports. It is also a significant employer and seasonal and permanent labour in farming communities (Murray, 2019).

Study Design

This research employed a mixed-method research design. To explore the perceptions of stakeholders regarding sustainability, a structured online questionnaire with open-ended questions was used (see Appendix I). This is because as a study population of the stakeholders of grape and wine production in South Africa has not been studied, explanatory theories cannot be created for this study. Consequently, an exploratory methodology is required. Given that so many factors are unknown, it is pertinent to acquire many varieties and complexity of opinions within the population of the study as is possible. As such, a questionnaire allows respondents to answer in their own words and give voice to their experiences (Du Plessis, 2019).

To identify sustainability indicators, a Delphi technique was used. It is a methodology employed in the sciences to collect views of stakeholders of a particular research area for decision making and in reaching consensus (Carrera and Mack, 2010). The Delphi technique is usually carried out in an array of questionnaires sent in "rounds, with at least two rounds deemed sufficient" (Belanger, Vanasse, Parent, Allard & Pellerin, 2012). In

this research, two rounds of the Delphi technique process were used. When it comes to consensus or agreement, different degrees of subjective consensus scores can be found in previous research, from 50% to 80% consensus (Ahmad and Wong, 2019). Here, a subjective consensus score of 80% was used. Consequently, all indicators with a below the 80% consensus score were rejected. The Delphi technique expert is a person with appropriate knowledge and skill, demonstrated in various ways via education and/or experience. Previous research has found a minimum size of 7 or 8 experts to be sufficient. However, sizes from 9 to 13 have been deemed sufficient for the practical and timely development of a Delphi technique (Labuschagne and Brent, 2008). In relation with other Delphi technique research (Escribano, Diaz-Cruz & Mesias, 2018), a 5-point Likert scale (from 0 – not important to 4 – very important) was used in the questionnaire to assess the level of importance of the various sustainability indicators as decided by the Delphi experts (see Appendix II). The initial list of sustainability indicators to be used for the Delphi process was chosen from an extensive review of previous literature on sustainability in the grape and wine production in South Africa (Gbejewoh et al., 2021).

Convenience and snowball sampling procedure was employed for this research study. The recruited participants were asked to recommend others that might be willing to participate in the study. The same list of research participants was used for both the online questionnaire and the Delphi technique process. This study was conducted between March 2021 and July 2021 via online questionnaires. However, before the research commenced, ethical clearance was obtained from the Social, Behavioural and Education Research (SBER) Committee at Stellenbosch University.

Data Analysis

Qualitative research data were analysed thematically using both deductive (theory-driven) and inductive (data-driven) methods to produce themes (Fereday and Muir-Cochrane, 2006). This method of data analysis is a general and convenient approach in examining qualitative data as its approach is recognizing patterns or themes in the data set. The use of the thematic data analysis method has been deemed appropriate when analysing exploratory qualitative data (Naude, 2019). We used the concepts of economic, environmental, and social sustainability as a lens to approach the data. However, we also looked out for other themes that materialized from the study (Fereday and Muir-Cochrane, 2006). Quantitative data was analysed using descriptive statistics, mean and standard deviation.

Results and Discussion

Research Participants/Delphi Experts

The full list of the stakeholders in the grape and wine industry that participated in the study is described in Table 1. The list of stakeholders of the grape and wine industry that participated in this study are diverse from academic researchers, wine grape farmers, winemakers and cellar masters, industry professionals at VinPro and sustainability certification personnel at Integrated Production of Wine (IPW), Wine and Agricultural Ethical Trading Association (WIETA), Sustainability Initiative of South Africa (SIZA) and government officials from the National Agricultural Marketing Council (NAMC). The research participants all had sufficient experience in the grape and wine industry of South Africa with over half of the research participants having over 15 years of experience. Furthermore, all but two of the research participants had a bachelor's degree which shows a group of highly educated research participants.

Table 1: Description of stakeholders of the grape and wine industry who participated in the study.

No	Highest Academic Qualification	Years of Experience	Job Title	Affiliation
1	Bachelors	18	Head of Wine and Viticulture	Farm
2	Masters	11	Junior Lecturer	Academia
3	Bachelors	6	Winemaker	Farm
4	Bachelors	6	Assistant winemaker	Farm
5	Bachelors	37	Cellarmaster	Farm
6	Masters	25	Technical Manager	Industry
7	Diploma	20	Marketing Assistant	Industry
8	Diploma	22	General Farm Manager	Farm
9	Bachelors	11	Winemaker	Farm
10	Bachelors	31	Group Viticulturist	Farm
11	Bachelors	20	Viticulturist/Senior Farm Manager	Farm
12	Masters	4	Environmental specialist	Farm
13	Diploma	26	General Farm Manager	Farm
14	Bachelors	15	Wine Accountant	Industry
15	Masters	16	Wine Merchant	Industry
16	Bachelors	15	CEO	Industry
17	Bachelors	20	PR, Wine judge and educator	Industry
18	Masters	15	Senior Economist	Government
19	Doctorate	13	Chief Economist	Government

Perceptions of Sustainability

Although different stakeholders participated in this research, there was still conformity concerning the responses. This section summarizes the results of the online questionnaires using similar themes to show common answers. Sustainability has always been a contentious concept, largely because its meaning and importance is persona and open to various interpretations depending on the views, beliefs, and ideations of the respondents (Rinne et al., 2013; Bebbington, Brown & Frame, 2007). Our research shows that is the case as the participants all defined sustainability differently. A word cloud that was created from a word frequency is shown in figure 1 below.

"(Sustainability is) something (that) is able to be maintained at a certain rate or level" (Participant 6)

"To put it in simple terms, that we can still be farming in 50 to 100 years from now" (Participant 10).

Ohmart (2011) said that if you put 50 farmers in a room and ask them what sustainability means to them, you are going to get 50 different answers and our research confirmed this point of view. Sustainability is a complex concept, and this complexity seems to be the point of contention in defining it and therefore the lack of a universal and consensual definition (Dantsis, Loumou & Giourga, 2009). Gabzdylova, Raffensperger & Castka (2009) found that in New Zealand individual interests has a hand in how sustainability is perceived and eventually practised. While Szolnoki (2013) found sustainability to be a very peculiar and subjective term. Furthermore, there is no clear-cut way of saying what specific practice is sustainable or not. In that sense, what we believe is sustainable is what we think will be beneficial for the planet years from now. Regardless of the various definitions of sustainability given by the research participants, it was found that the environment was at the forefront of the perceptions of sustainability.

"Sustainability towards our natural resources. using little to create a lot" (Participant 3)

"Farming for the next generations to come, ticking all the boxes of being beyond green. Striking the balance between nature and product" (Participant 5)

This confirmed the findings of previous research that sustainability perceptions have focused on the environment (Santiago-Brown, 2015a). The environmental dimension has always been the focus of sustainability and sustainability practices (Saltiel, Bauder & Palakovich, 1994). This focus largely came about because of the inherent conflict between finite natural resources and sustainable development (Darnhofer, Fairweather & Moller, 2010). For example, early instances of sustainability efforts like the Low Input Sustainable Agriculture (LISA) in the 1980s that focused on the limited use of synthetic inputs by using environmentally based practices (Brouwer and Crabtree, 1999) and carbon footprints assessments which involves reducing carbon emissions with regards to climate change and the scarcity of natural resources (Koohafkan, Altieri & Gimenez, 2012).

Figure 1 - A word cloud of word frequency for the three pillars of sustainability.

With increased criticism about the focus on only the environmental pillar of sustainability, other dimensions were gradually being recognized. Consequently, Elkington (1998) defined the three-pillar concept of sustainability. As stated earlier, this widely accepted concept of sustainability espouses the view that sustainability is only possible when an effort is put towards the economic, environmental, and social dimensions of sustainability. However, respondents that defined sustainability using all three pillars were few and far between.

"Considered use of a finite resource with a long-term vision - looking at environmental, economic, and social systems" (Participant 15).

"Meeting the social, environmental, and economic resource needs of the present without compromising those three needs for future generations" (Participant 16).

This agrees with the findings of Santiago-Brown et al. (2015a) explained that perceptions that involved all three pillars of sustainability are rare. Consequently, regardless of the increased recognition of the economic and social dimension of sustainability, the environmental dimension is still the more prominent dimension. This is largely because the Brundtland report (United Nations, 1987) that popularized the concept of sustainability and form which every other definition of sustainability came from, focused mainly on the environmental pillar. As a result, this perception of the outsized importance of the environmental dimension of sustainability has been hard to shake.

Elkington (1998) defined the three-pillar concept of sustainability and explained that all three pillars are equally important for achieving sustainability. However, this has not been the case as some pillars have been deemed more important than others with regards to the push for sustainability (Santiago-Brown, Jerram, Metcalfe & Collins, 2015b).

"Environmental sustainability is the largest of the three and sustains the other two pillars. In an ideal world, with considered and responsible environmental management, social and economic sustainability should follow" (Participant 15).

"As a winemaker, we are asking a lot from the soils, and we need to work accurately to preserve the resources given to us. once the soils are drained of nutrients and the ecosystem is removed, production of anything will be difficult" (Participant 3).

Our research confirmed these findings but interestingly, the research participants regarded the environmental dimension as the more important pillar. As explained earlier, the outsize importance of the environmental pillar is hardly new. However, this importance of the environmental pillar over the others is noteworthy because it contrasts with research by Santiago-Brown et al., (2015b) that found the economic dimension of sustainability to be deemed most important by research participants. While the research by Santiago-Brown et al., (2015b) involved only wine farmers, ours is more diverse and wide-ranging and involves other stakeholders of grape and wine production. This perhaps accounts for the contrasting results as producers may be more economically inclined, but other stakeholders not directly involved in grape and wine production may be more environmentally or socially inclined.

Just as contentious as defining sustainability, balancing and/or reconciling the three pillars of sustainability have always been rife with difficulties because the three pillars are interdependent and usually at odds with each other (Peterson, 2013) Regardless, the majority of the research participants believed in the possibility of achieving all three pillars of sustainability in a farm or cellar.

"A paradigm for development, moving away from the current sectorial approach where social, economic, and ecological development are seen as separate parts. A transition toward a world logic where the economy serves society so that it evolves within the safe operating space of the planet. We have to redefine what we mean by growth. Instead of deriving this purely from the conclusion that the present global economy is flawed, we must make it possible to trace some historical trajectories which could emerge from the current poly-crises, culminating, possibly, in the evolution of a sustainable long-term development cycle" (Participant 6)

"Producers need to realize the importance of this balance and how their employees can also benefit i.e., that everything is not just about the farm, but also its people. The circle of interaction between the 3 pillars needs to be made clear producers - everything is interlinked and by just watching Rands and cents you will not necessarily benefit the most. There is a deeper, philosophical link between the 3P's. Realising this requires a mind-shift - this will be the difficult part" (Participant 2).

Even though most research respondents believed in the possibility of achieving all three pillars of sustainability and deemed the environmental pillar is most important, it is obvious that the participants believed that economic sustainability is crucial in any push to achieving all three pillars of sustainability. Santiago-Brown et al. (2015b) found that producers believed that environmentally friendly practices and social investments are contingent on the economic viability of vineyards. In this regard, our research agrees with that of Santiago-Brown et al. (2015b).

Given the intrinsic interrelationships and conflict between the three dimensions of sustainability, it is without note that there is bound to be trade-offs made regularly in trying to balance/reconcile all three dimensions.

"It is thought to be difficult to sustain all 3 pillars at once, as it is believed that ending world-hunger could come at a cost to the environment, whereas the "overprotection" of natural resources, could delay or reduce economic growth. It is also possible that ending poverty and increasing living standards could come at a cost of economic growth" (Participant 12).

"Trade-off between financial and environmental sustainability - less harmful products (organic/biodynamic/newer developed chemicals with lessened impacts on environment) are often more expensive than conventional products. Social sustainability is very often traded off for financial sustainability - reducing team size, only using contract labour in critical times and therefore limiting permanent staff. Investing in training of staff is also considered from a financial point of view and not in terms of what it could mean for the individual" (Participant 2).

Santiago-Brown et al. (2015b) believed that trade-offs as an inherent part of sustainability encourage incessant conflicts between the economic, environmental, and social dimensions of sustainability. Our research confirmed these findings that producers have to deal constantly with these trade-offs between the three dimensions of sustainability. Sustainability involves complex variables such as the time of farm management decision, relevant context and perceptions of the stakeholder. Just as reasons for engaging in sustainable practices differ, farm management decisions also differ greatly. As such, bargains in decision making are hard to capture using a single time frame of reference. Advancements in a particular dimension may or may not have a deleterious effect in another dimension that did not receive attention during the same time (Santiago-Brown et al., 2015b). For example, a producer may forgo a wage increase for a new tractor in a particular growing season. Later, improved productivity due to improved mechanization may bring about an increase in the wages of workers. At the same time, the improved productivity due to the use of a tractor may bring about soil compaction and carbon emissions and thus reduced environmental sustainability.

Regardless of the trade-offs present in achieving all three pillars of sustainability, our research found that some pillars are indeed more difficult to achieve than others. Strikingly, the social dimension of sustainability was regarded by the respondents as the most difficult to achieve.

"Measuring social sustainability in metric terms is quite difficult, as there are many qualitative factors that have an impact on it. As the Profit and Planet pillars have "key performance indicators", it is much easier to set targets for improvement and to track progress on the journey to sustainability. The "human element" in social sustainability makes it very difficult to measure and plan for improvement, and to ascertain when sustainability has been reached" (Participant 12)

"Producers are well aware of environmental sustainability and financial sustainability, but social sustainability is too often overlooked. There are industry bodies, such as WIETA, who are trying to address this, but many producers only comply by means of "tick-box" exercises for audits. It should be much more important than just window-dressing for a certificate. Producers need to BELIEVE in the principles of these compliance certificates and commit to DOING something about the problems in the industry" (Participant 2).

The social dimension of sustainability has always been the more overlooked dimension of sustainability and years of criticism from social scientists has brought this dimension increasing recognition, (Missimer, Karl-Henrik & Bromann, 2017) even more so in South Africa due to the history of the country and labour relations that has characterized the relationships between farm owners and farm workers (Ewert and Hamman, 1999; Ewert and Du Toit, 2005; Kritzinger, Barrientos & Rossouw, 2004) South Africa has a storied history with regards to the relationship between the farm owner and farm workers and research has shown that agricultural workers are among the poorest and most discriminated workers of any sector (Linton, 2012). Research has found that amongst other things, the labour rights of farmworkers are still being violated irrespective of labour laws and various social certifications in place to prevent these types of violations (Devereux, 2020). The acknowledgement of the difficulty in achieving social sustainability in South African vineyards and cellars by stakeholders, while encouraging is just the first step in a very long way to redeeming the pilloried image of the treatment of farmworkers in South African vineyards and cellars.

Table 2 - List of Sustainability Indicators.

Dimension	Indicator	Consensus score (%)	Mean score (Out of 4)	Standard Deviation
Economic	Grape Yield	85%	3.4	0.6
	Grape and Wine Prices	90%	3.6	0.6
	Vine Health	90%	3.6	0.6
	Farm Net Income	89%	3.56	0.51
	Input costs	89%	3.56	0.72
	Financial Autonomy (Freedom from debts)	83%	3.31	0.60
	Labour Costs	81%	3.25	0.68
	Grape and Wine Demand	88%	3.5	0.52
	Grape and Wine Quality	90%	3.6	0.48
	Brand Value	88%	3.5	0.79
	Production and Quality consistency	93%	3.7	0.6
	Labour Productivity	93%	3.7	0.6
Environmental	Soil Health	99%	3.94	0.25
	Water use efficiency	97%	3.88	0.34
	Plant and Microbial biodiversity conservation	89%	3.56	0.63
	Environmental Record Keeping	83%	3.31	0.79
	Integrated Pest Management	92%	3.69	0.6
	Carbon Footprint	80%	3.2	0.91
	Soil Organic Matter content	88%	3.5	0.52
	Water Footprint	86%	3.44	0.81
	Precision Agriculture	86%	3.44	0.73
	Wastewater Management	83%	3.31	0.87
	Air and Water Quality	88%	3.5	0.52
	Organic and Inorganic Waste Management	83%	3.31	0.6

	Soil Conservation/Erosion Control	92%	3.67	0.48
	Energy Use Efficiency	88%	3.5	0.52
	Fertilizers, Pesticides and Chemical Use Efficiency	92%	3.69	0.48
	Soil Cover	89%	3.56	0.51
Social	Workers' education, training, and skills development	91%	3.63	0.62
	Safe and Healthy Work Environment	94%	3.75	0.45
	Workers' Welfare	91%	3.63	0.5
	Labour laws compliance	91%	3.63	0.89
	Farming Community's health and welfare	89%	3.56	0.51
	Workers' productivity	95%	3.81	0.54
	Labour Costs	86%	3.44	0.73
	Right to a Living Wage	97%	3.88	0.34
	Farming Community's benefits	81%	3.25	0.77
	Workers children's education, health, and welfare	95%	3.81	0.54
	Consumers' health and welfare	89%	3.56	0.63

Sustainability Indicators

The final list of the selected sustainability indicators that showed an 80% consensus or higher are shown in Table 2. The first round of the selection of the sustainability indicators yielded an initial list of 60 indicators in total (20 for each pillar of sustainability). The list for the second and final round of selection of indicators that showed an 80% consensus or higher was 39 indicators (12 for the economic dimension, 16 for the environmental dimension and 11 for the social dimension). The full list of indicators is included in the Appendix III.

Economic Indicators

For the economic dimension, production quality/consistency and labour productivity were the indicators with the highest mean values and level of agreement as both indicators averaged a value of 3.7 (out of 4) with a consensus score of 93%. This was followed by grape/wine quality, vine health and grape/wine prices which averaged a score of 3.6 with a consensus value of 90%. Meanwhile, indicators with a consensus score below the accepted threshold were environmental and social certifications (78%), non-capital expenditures (78%), break-even price (78%), capital expenditure (75%), credit access (69%), income from off-farm activities (68%), age of vines (58%) and government subsidies (50%). A spider graph of the economic indicators is shown in Figure 2. Interestingly, there was very high consensus for the indicators of production/quality consistency, grape/wine quality, grape/wine prices and brand value as extremely relevant. This speaks to the dilemma that wine producers face in South Africa. The focus of the country was on bulk wine as result of the export ban during the Apartheid era which set the country on a path and reputation of having "cheap and cheerful" wines which have been hard to shake ever since. As a result, South Africa wine has always been priced cheaply and branded wines in the country are few and are far between unlike other wine-producing countries (Ewert and Henderson, 2004). The relevance of these indicators for economic sustainability speaks to the knowledge of farmers and other stakeholders in the grape and wine industry even though research has shown that other indicators like input costs and labour productivity were ranked as also highly relevant and have been steadily increasing over the past decade (VinPro, 2020).

It is also noteworthy that environmental and social certifications were not regarded as particularly economically relevant. This is maybe because even though these certifications are required for access to important export markets, factors like the high cost of compliance mean that producers are not exactly seeing any economic returns for having these certifications. Research has shown that farmers weigh the costs of compliance and in many cases are only compliant because of export contracts (Moseley, 2008). Our results contrast research by Santiago-Brown et al. (2015a) on wine production where experts found grape yield and profitability to be among the most relevant indicators for economic sustainability. However, the differences in sample size and research respondents may account for the different results as Santiago-Brown et al. (2015a) had a significantly larger sample size than ours and employed only wine farmers as research respondents while ours employed various actors in the entire value chain of grape and wine production. This is noteworthy because previous research has shown that farmers usually favour profits over other indicators Santiago-Brown et al. (2015b).

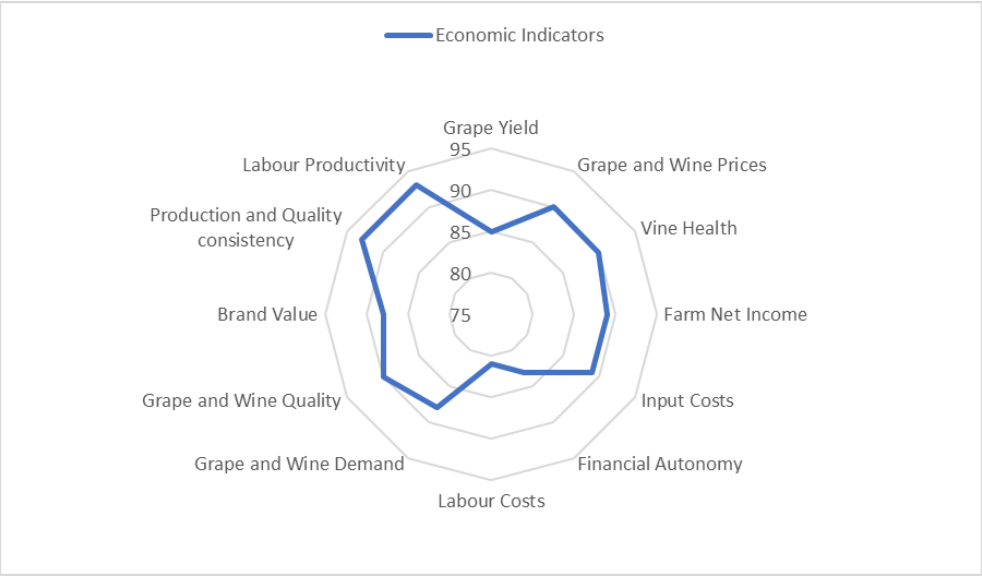

Figure 2 - A spider graph of the economic indicators ranked by relevance levels.

Environmental Indicators

With regards to the environmental dimension, soil health averaged the highest value with a mean score of 3.94 and a consensus score of 99%. This was closely followed by water use efficiency with a mean score of 3.88 and a consensus score of 97% and integrated pest management, soil conservation/erosion control and fertilizers/pesticides/chemical use efficiency with a consensus score of 92%. Indicators that scored below the threshold were environmental certifications (78%), percentage of a natural (untouched) area on the farm (75%), minimum soil disturbance (72%) and off-farm environmental impacts from farm/cellar (70%).

A spider graph of the environmental indicators is given in Figure 3. Even though environmental indicators like water use efficiency, wastewater management and water footprint were regarded as highly relevant by the experts, research has shown that farms still use more water than is necessary for grape and wine production or underestimate the quantity of water used in vineyards and cellars (Sheridan, Bauer, Burton & Lorenzen, 2005). Recent research on the water footprint by the table grape and wine industry in South Africa shows that wine production has an average water footprint of 484L/kg while table grapes had an average water footprint of 619L/kg with the global average being 707L/kg for wine grapes and 607L/kg for table grapes (Jarmain, 2020). While these figures show that the water use in South African vineyards and cellars is on par with international levels, it belies the deeper statistics. The water footprint in the coastal region was 842L/kg for wine and 714L/kg for table grapes, higher than the global average (Jarmain, 2020). The cognitive dissonance here is striking as experts agree on the relevance of these indicators for environmental sustainability but in practice, do something different. While this may be true, it should be noted that higher than average water demand in the coastal regions is due to different viticultural practices – vertical shoot positioning (VSP), which has been shown to increase water demand – which may account for the higher water use of these regions (Lebron, Pellegrino, Louarn & Lecoeur, 2006). The same situation applies to fertilizers/pesticides/chemical use efficiency and organic/inorganic waste management as these indicators were judged as highly relevant in our research, but limited research available has shown that indiscriminate use of these chemicals has been documented in vineyards (Forbes, Cullen, Cohen,Wratten & Fountain, 2011) and inconsiderate disposal of organic/inorganic waste is a feature of vineyards and cellars (Musee et al., 2007; Devesa-

Rey, Vecino, Varela-Alende, Barral, Cruz & Moldes, 2011) but differences in pest population pressures in various regions play a role in the quantity of pesticides used. Even though there are sustainability frameworks like IPW in South Africa to monitor sustainability in grape and wine production, the high use of water and external inputs coupled with the self-evaluation of sustainability efforts leaves a lot to be desired. Furthermore, independent self-audits of wine farms are few and far between (McEwan and Bek, 2009).

The low level of agreement for the indicator of a protected and untouched area of a farm is hardly interesting. Research has shown that most vineyards in South Africa are small to medium scale and even though conserving biodiversity is relevant, keeping an area of the farm completely natural and untouched is a step too far (Hussain, Cholette & Castaldi, 2008). Besides, the small and medium scale nature of vineyards in South Africa means that the conserved area is usually spotty and scattered (Kemper, Cowling & 1999; Reyens et al., 2001). This probably explains the low level of relevance afforded to biodiversity conservation. In addition, regardless of sustainability schemes like BWI to protect the biodiversity in the Cape Floral Kingdom (CFK) of South Africa, research has shown that the membership and compliance in the scheme is not strictly enforced (Hamman et al., 2016).

It is striking that experts deemed soil conservation/erosion control as highly relevant but minimum soil disturbance as not particularly relevant. This probably shows that minimum soil disturbance is not regarded as a particularly relevant option for soil conservation/erosion control. This could also be why soil cover was regarded as highly relevant as it provided a more practical option for soil conservation/erosion control than minimum soil disturbance. Regardless, soil conservation/erosion control in vineyards is worryingly limited as research has shown that soil loss in vineyards is above what is considered as manageable soil loss (Verheijen, Jones, Rickson & Smith, 2009). Environmental record keeping is an interesting indicator. Even though there are adequate records on water use, fertilizers/pesticide/chemical use generated by farms and experts agree on the relevance of this indicator for environmental sustainability, previous research has shown that the presence of these records does not necessarily improve or change production practices (Christ and Burritt, 2013) What this means, remains to be researched.

Although it is not the first thing that comes to mind concerning environmental sustainability, grape and wine production uses a considerable amount of energy and emit a sizeable quantity of greenhouse gases (Smyth and Russel, 2009). This does not even consider the quantity of energy used, and carbon emitted in bottle production, packaging, and distribution (Barber, 2010) given that previous research has shown that this stage of the value chain accounts for about 50% of the carbon produced (Point, Tyedmers & Naugler, 2012). It is also noteworthy that these indicators were regarded as relevant given that although they are tools for calculating greenhouse gas emissions, (James, 2012) whether these calculations are used or even brings about change remains to be seen (Christ and Burritt, 2013). In terms of environmental sustainability, our research agrees with Santiago-Brown et al. (2015a) where soil health and water use were found to be the most relevant indicators for environmental sustainability.

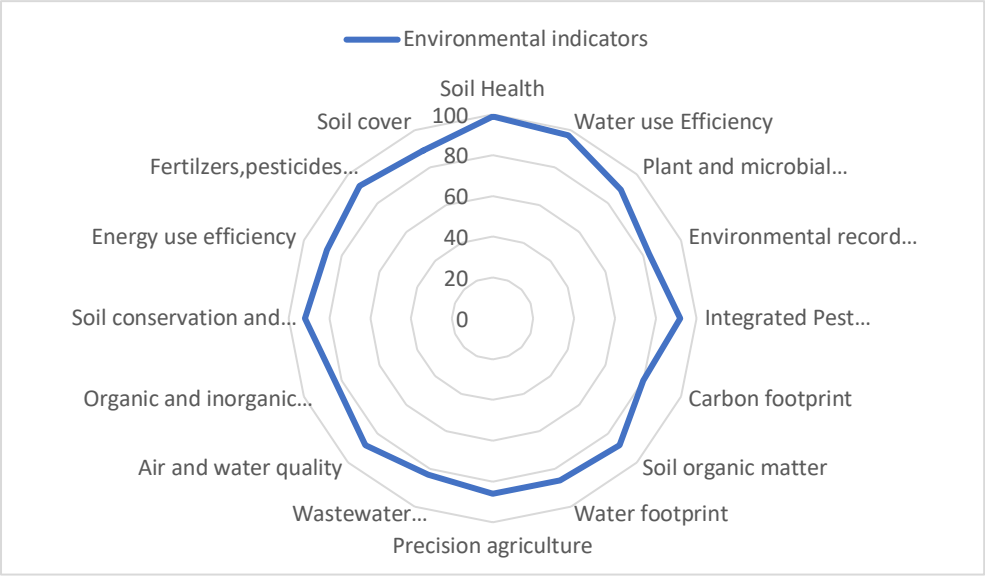

Figure 3 - A spider graph of the environmental indicators ranked by relevance levels.

Social Indicators

Lastly, for the social dimension, the right to a living wage averaged the highest score with a value of 3.88 and a consensus score of 97%. This was followed by workers' productivity and workers children's education, health, and welfare with a mean score of 3.81 and a consensus score of 95%. Indicators below the consensus score were workers' complaints (79%), workers' retention rate, workers' housing/tenure security and work-related benefits with (78%), gender equality (75%), social certifications (74%), the ratio of permanent to temporary workers (72%), off-farm/cellar activities (67%) and aesthetics (66%).

A spider graph of the social indicators is shown in Figure 4. Strikingly, the right to a living wage was deemed as highly relevant with near-universal consensus because previous research has documented that farmworkers especially in the Western and Northern Cape are paid below the living wage and sometimes even below minimum wage (Devereux et al., 2020). This shows that even though experts agree on the principle of the need to pay workers a living wage, the economic situation of most farms precludes farms from doing so. Research has shown that the majority of wine farms in South Africa are barely profitable (VinPro, 2020). Consequently, even though farmers believe in the need to pay a living wage, for financial reasons, most cannot. It is also noteworthy that social indicators like safe/healthy work environment and labour laws compliance were rated as highly relevant even though research has shown that farmworkers are not working in a particularly safe work environment or that farmers comply with all the labour laws (Devereux et al., 2020). Again, the financial situation of most farms precludes farmers from carrying out full health and safety precautions, which are usually expensive and have to be done regularly.

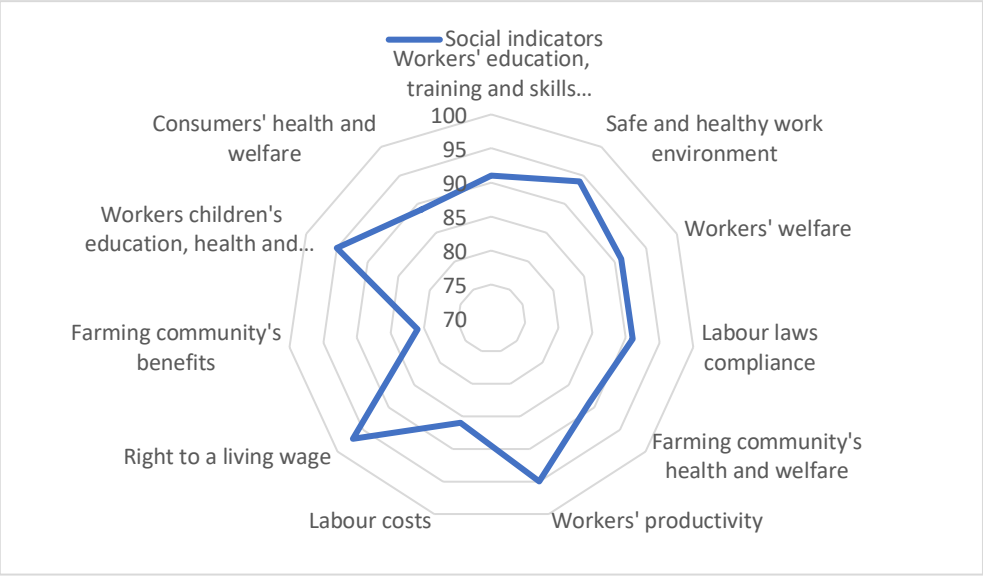

Figure 4 - A spider graph of the social indicators ranked by relevance levels.

The low levels of relevance with regards to the indicators of workers' retention rate and the ratio of permanent to temporary workers are hardly noteworthy. Previous research has shown that a high turnover rate and the higher percentage of temporary workers are all efforts of producers to keep production costs down, costs that have been push down on them from retailers (Ponte and Gibbon, 2005). As such, it is not striking that experts do not rate keeping a fairer ratio of permanent to temporary workers or high retention rate as particularly relevant as farm workers have always been regarded as expendable (Barrientos and Kritzinger, 2003) Even though are there are South African context-specific social sustainability schemes like WIETA, research has shown that the cost of compliance is high, wine farms are rarely compliant after the initial audit and the cost of corrective measures are prohibitively expensive (McEwan and Bek, 2009). Finally, it is important to note that in comparison to the economic and environmental dimensions, the social dimension received higher mean scores and consensus for its indicators. While this may mean the high relevance attached to these social indicators, it may also imply social desirability bias where respondents under or over report depending on what they perceive as being socially or culturally acceptable.

Conclusion

This study, a first of its kind in South Africa has aimed to understand the concept of sustainability, its three dimensions and identify indicators that can be used to measure these dimensions. Consequently, we define sustainability in agriculture as "the continuous effort in trying to balance and/or reconcile the economic viability, environmental stewardship and social responsibility of a farm in the different economic, environmental and social context of the farm, farming region and country in any given period". This definition of sustainability, we believe is apt because it is not just enough to consider the three pillars of sustainability, one must consider these pillars in the context where they exist. Furthermore, sustainability is defined as a "continuous effect to balance and/or reconcile" because the three pillars will always be conflicting. The effort, therefore, is to strive for a set of practices and decisions that tries to bring the best of out all three pillars. Lastly, the definition also considers time because any consideration of sustainability must consider the time frame in which sustainability is considered as the concept of improved or diminished sustainable practices is only as good as when it was considered.

The indicators selected by the Delphi experts yielded interesting results as experts rated economic indicators like production/quality consistency, grape/wine prices, quality and demand and brand value as relevant for economic sustainability. This speaks to the untenable situation of bulk wine that the country majorly exports and to the fact that some sort of intervention is needed in the wine sector. What that will be, whether it be in form of government subsidies or financial assistance from foreign retailers remains to be seen. Furthermore, there appears to be some sort of theory and practice discrepancy with regards to the environmental dimension as indicators related to water and chemical use shows a high degree of relevance but practices on farms tell a different story. However, region contexts may preclude producers from certain viticultural practices. Finally, the high relevance of the social indicators shows that although stakeholders believe in the importance of these social indicators, they are limited in what they can do to improve this dimension due to the economic situation of many grape and wine farms.

References

Ahmad, S., & Wong, K. (2019). Development of weighted triple-bottom-line sustainability indicators for the Malaysian food manufacturing industry using the Delphi method. *Journal of Cleaner Production*, 229, 1167-1182. https://doi.org/10.1016/j.jclepro.2019.04.399

Barber, N. (2010). "Green" wine packaging: targeting environmental consumers. *International Journal* of *Wine Business Research,* 22, 423-444. https://doi.org/10.1108/17511061011092447

Barrientos, S., & Kritzinger, A. (2003). Squaring the circle: Global production and the informalization of work in South African fruit exports. *Journal of Cleaner Production*, 16, 81–92. https://doi.org/10.1002/jid.1064

Bebbington, J., Brown, J., & Frame, B. (2007). Accounting technologies and sustainability assessment models. *Ecological Economics,* 61: 224–236. https://doi.org/10.1016/j.ecolecon.2006.10.021

Belanger, V., Vanasse, A., Parent, D., Allard, G., & Pellerin, D. (2012). Development of agri-environmental indicators to assess dairy farm sustainability in Quebec, Eastern Canada. *Ecological Indicat*ors, 23, 421-430. https://doi.org/10.1016/j.ecolind.2012.04.027

Brouwer, F., & Crabtree, B. (1999). *Environmental Indicators and Agricultural Policy*, (CABI, New York, USA).

Carrera, D.G., & Mack, A. (2010). Sustainability assessment of energy technologies via social indicators: results of a survey among European energy experts. *Energy Policy*, 38 (2), 1030-1039. https://doi.org/10.1016/j.enpol.2009.10.055

Christ, K.L., & Burritt, R.L. (2013). Critical environmental concerns in wine production: An integrative review. *Journal of Cleaner Production*, 53, 232–242. https://doi.org/10.1016/j.jclepro.2013.04.007

Dantsis, T., Loumou, A., & Giourga, C. (2009). Organic agriculture's approach towards sustainability; its relationship with the agro-industrial complex, a case study in Central Macedonia, Greece. *Journal of Agricultural and Environmental Ethics.* 22: 197-216. https://doi.org/10.1007/s10806-008-9139-0

Darnhofer, I., Fairweather, J., & Moller H. (2010). Assessing a farm's sustainability: Insights from resilience thinking. *International Journal Agricultural Sustainability,* 8: 186–198. https://doi.org/10.3763/ijas.2010.0480

Deloitte, The Deloitte Global. (2021). Millennial and Gen Z Survey. Retrieved 25th July 2023 from https://www2.deloitte.com/xe/en/pages/about-deloitte/articles/millennialsurvey.html

de Olde, E.M., Sautier, M., & Whitehead, J. (2018). Comprehensiveness or implementation: Challenges in translating farm-level sustainability assessments into action for sustainable development. *Ecological Indicators,* 85, 1107-1112. https://doi.org/10.1016/j.ecolind.2017.11.058

Devesa-Rey, R., Vecino, X., Varela-Alende, J.L., Barral, M.T., Cruz, J.M., & Moldes, A.B. (2011). Valorization of winery wastes vs. the costs of not recycling. *Waste Management,* 31, 2327-2335. https://doi.org/10.1016/j.wasman.2011.06.001

Devereux, S. (2020). Violations of farm workers' labour rights in post-apartheid South Africa. *Development Southern Africa*, 37: 382–404. https://doi.org/10.1080/0376835X.2019.1609909

du Plessis, H.P. (2019). *Mapping the contours of organic agriculture: an exploratory study of an under-served population in South Africa*. (Unpublished MSc dissertation) Stellenbosch University, South Africa, P.O Box X1, Matieland, 7600).

Elkington, J. (1998). Partnerships from cannibals with forks: The triple bottom line of 21st-century business. *Environmental Quality Management* 8(1): 37-51. https://doi.org/10.1002/tqem.3310080106

Escribano, M., Diaz-Caro, C., & Mesias, F.J. 2018. A participative approach to develop sustainability indicators for dehesa agroforestry farms. *Science of the Total Environment,* 640-641, 89-97. https://doi.org/10.1016/j.scitotenv.2018.05.297

Espinosa, A., Harnden, R., & Walker, J. (2008). A complexity approach to sustainability: Stafford Beer revisited. *European Journal of Operational Research,* 187: 636-651. https://doi.org/10.1016/j.ejor.2007.03.023

Ewert, J., & Hamman, J. (1999). Why paternalism survives: Globalization, democratization and labour on South African wine farms. *Sociologia Ruralis*, 39(2): 202-221. https://doi.org/10.1111/1467-9523.00102

Ewert, J., & Henderson, J. (2004). *How globalisation and competition policy inhibit poverty reduction: the case of the South African wine industry*. 3rd International Conference of the Centre for Competition and Regulation, Cape Town, September 7th – 9th, 2004).

Ewert, J., & du Toit, A. (2005). A deepening divide in the countryside: Restructuring and rural livelihoods in the South African wine industry. *Journal of Southern African Studies,* 31(2): 315-332. https://doi.org/10.1080/03057070500109524

Fanadzo, M., Ncubo, B., French, A., & Belete, A. (2021). Smallholder farmer coping and adaptation strategies during the 2015-18 drought in the Western Cape, South Africa. *Physics and Chemistry of the Earth, Parts A/B/C*, 124(1): 102986. https://doi.org/10.1016/j.pce.2021.102986

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods,* 5(1): 80–92. https://doi.org/10.1177/160940690600500107

Flores, S. S. (2018). What is sustainability in the wine world? A cross-country analysis of wine sustainability frameworks. *Journal of Cleaner Production,* 172, 2301-2312. https://doi.org/10.1016/j.jclepro.2017.11.181

Forbes, S.L., Cullen, R., Cohen, D.A., Wratten, S.D., & Fountain, J. (2011). Food and wine production practices: an analysis of consumer views. *Journal of Wine Research,* 22, 79-86. https://doi.org/10.1080/09571264.2011.550763

Gabzdylova, B., Raffensperger, J.F., & Castka, P. (2009). Sustainability in the New Zealand wine industry: drivers, stakeholders and practices. *Journal of Cleaner Production*, 17(11): 992-998. https://doi.org/10.1016/j.jclepro.2009.02.015

Gbejewoh, O., Keesstra, S., & Blancquaert, E. (2021). The 3Ps (Profit, Planet, and People) of sustainability amidst climate change: A South African Grape and Wine Perspective. *Sustainability,* 13: 2910. https://doi.org/10.3390/su13052910

Gilinsky, A., Newton, S.K., & Vega, R.F. (2016). Sustainability in the Global Wine Industry: Concepts and Cases. *Agriculture and Agricultural Science Procedia,* 8, 37–49. https://doi.org/10.1016/j.aaspro.2016.02.006

Greyling, J.C. (2012). *The role of the agricultural sector in the South African economy*. (Unpublished MSc dissertation), Stellenbosch University, PO Box X1, Matieland, 7600).

Hamann, R., Smith, J., Tashman, P., & Marshall, R.S. (2016). Why Do SMEs Go Green? An Analysis of Wine Firms in South Africa. *Business & Society,* 56: 23–56. https://doi.org/10.1177/0007650315575106

Hussain, M., Cholette, S., & Castaldi, R.M. (2008). An Analysis of Globalization Forces in the Wine Industry. *Journal of Global Marketing,* 21, 33–47. https://doi.org/10.1300/J042v21n01_04

James, K. (2012). An investigation of the relationship between recycling paper and card and greenhouse gas emissions from land use change. *Resources, Conservation and Recycling,* 67, 44-55. https://doi.org/10.1016/j.resconrec.2012.07.003

Jarmain, C. (2020). Water Research Committee (WRC). Water Footprint as an indicator of sustainable table and wine grape production. Retrieved at 27 August 2021 from
http://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/2710%20final.pdf

Kebreab, E. (2013). *Sustainable Animal Agriculture*. (CPI Group Ltd, Croydon, United Kingdom).

Kemper, J., Cowling, R.M., & Richardson, D.M. (1999). Fragmentation of South African renosterveld shrublands: Effects on plant community structure and conservation implications. *Biological Conservation,* 90, 103–111. https://doi.org/10.1016/S0006-3207(99)00021-X

Koohafkan, P., Altieri, M.A., & Gimenez, E.H. (2012). Green agriculture: Foundations for biodiverse, resilient and productive agricultural systems. *International Journal of Agricultural Sustainability*, 10: 61–75. https://doi.org/10.1080/14735903.2011.610206

Kritzinger, A., Barrientos, S., Rossouw, H. (2004). Global Production and Flexible Employment in South African Horticulture: Experiences of Contract Workers in Fruit Exports. *Sociologia Ruralis,* 44: 17–39. https://doi.org/10.1111/j.1467-9523.2004.00259.x

Labuschagne, C., & Brent, A.C. (2008). An industry perspective of the completeness and relevance of a social assessment framework for project and technology management in the manufacturing sector. *Journal of Cleaner Production,* 16 (3), 253-262. https://doi.org/10.1016/j.jclepro.2006.07.028

Lebron, E., Pellegrino, A., Louarn, G., & Lecoeur, J. (2006). Branch Development Controls Leaf Area Dynamics in Grapevine (Vitis vinifera) Growing in Drying Soil. *Annals Botany,* 98(1), 175-185. https://doi.org/10.1093/aob/mcl085

Linton, A. (2012). Growing Fair Trade in South Africa. *Globalizations,* 9(5): 725-740. https://doi.org/10.1080/14747731.2012.732440

McEwan, C., & Bek, D. (2009). The political economy of alternative trade: Social and environmental certification in the South African wine industry. *Journal of Rural Studies*, 25(3), 255-266. https://doi.org/10.1016/j.jrurstud.2009.03.001

Merli, R., Preziosi, M., & Acampora, A. (2018). Sustainability experiences in the wine sector: toward the development of an international indicators system. *Journal of Cleaner Production*, 172, 3791-3805. https://doi.org/10.1016/j.jclepro.2017.06.129

Missimer, M., Karl-Henrik, R., & Bromann, G. (2017). A strategic approach to social sustainability - Part 1: exploring the social system. *Journal of Cleaner Production*, 32–41.

Moseley, W.G. (2008). Fair trade wine: South Africa's post-apartheid vineyards and the global economy. *Globalizations*, 5(2), 291–304. https://doi.org/10.1016/j.jclepro.2016.03.170

Murray, M. (2019). *Key trends in the agricultural economy of the Cape Winelands District Municipality: Implications for farm workers and dwellers*. Retrieved on 27 July 2023 from http://www.phuhlisani.com/oid%5Cdownloads%5C20100619CWDMAgricTrends V04f%20edited.pdf

Musee, N., Lorenzen, L., & Aldrich, C. (2007). Cellar waste minimization in the wine industry: a systems approach. *Journal of Cleaner Production,* 15, 417-431. https://doi.org/10.1016/j.jclepro.2005.11.004

Naude, R. (2019). Impact of Climate Change and Extreme Weather Conditions on wine growing within the Stellenbosch region. *Journal of Contemporary Management,* 16: 111–134. https://doi.org/10.35683/jcm19041.0029

Ohmart, C. (2011). View from the vineyard: A practical guide to sustainable winegrape growing. San Francisco, CA: Wine Appreciation Guild.

OIV (Organisation Internationale de la Vigne et du Vin), 2020. Guide for the implementation of principles of sustainable vitiviniculture. Retrieved on 16 June 2024 from https://www.oiv.int/standards/oiv-guide-for-the-implementation-of-principles-of-sustainable-vitiviniculture-)

Peterson, H.C. (2013) *Sustainability: A wicked Problem*. In: Kebreab E (ed.), Sustainable Animal Agriculture. CPI Group (UK) Ltd, Croydon, United Kingdom. pp 1-9.

Point, E., Tyedmers, P., & Naugler, C. (2012). Life cycle environmental impacts of wine production and consumption in Nova Scotia, Canada. *Journal of Cleaner Production,* 27, 11-20. https://doi.org/10.1016/j.jclepro.2011.12.035

Ponte, S., & Gibbon, P. (2005). Quality standards, conventions and the governance of global value chains. *Economy and Society,* 34, 1–31. https://doi.org/10.1080/0308514042000329315

Rinne, J., Lyytimäki, J., & Kautto, P. (2013). From sustainability to well-being: Lessons learned from the use of sustainable development indicators at national and EU level. *Ecological Indicators*, 35, 35–42. https://doi.org/10.1016/j.ecolind.2012.09.023

Saldias, C., Speelman, S., van Huylenbroeck, G., & Vink N. (2015). Understanding farmers' preferences for wastewater reuse frameworks in agricultural irrigation: lessons from a choice experiment in the Western Cape, South Africa. *Water SA* 42 (1). https://doi.org/10.4314/wsa.v42i1.04

Saltiel, J., Bauder, J.W., & Palakovich, S. (1994). Adoption of sustainable agricultural practices: Diffusion, farm structure, and profitability. *Rural Sociology,* 59: 333–349. https://doi.org/10.1111/j.1549-0831.1994.tb00536.x

Santiago-Brown, I., Metcalfe, A., Jerram, C., & Collins, C. (2015a). Sustainability assessment in wine-grape growing in the New World: Economic, environmental, and social indicators for agricultural businesses. *Sustainability,* 7(7): 8178-8204. https://doi.org/10.3390/su7078178

Santiago-Brown, I., Jerram, C., Metcalfe, A., & Collins, C. (2015b). What does sustainability mean? Knowledge gleaned from applying mixed methods research to wine grape growing. *Journal of Mixed Methods Research,* 9(3): 232-251. https://doi.org/10.1177/1558689814534919

Schaufele, I., & Hamm, U. (2017). Consumers' perceptions, preferences and willingness-to-pay for wine with sustainability characteristics: a review. *Journal of Cleaner Production,* 147: 379-39. https://doi.org/10.1016/j.jclepro.2017.01.118

Sheridan, C.M., Bauer, F.F., Burton, S., & Lorenzen, L., 2005. A critical process analysis of wine production to improve cost, quality and environmental performance. *Water Science and Technology,* 51, 39-46. https://doi.org/10.2166/wst.2005.0005

Smyth, M., & Russell, J. (2009). 'From graft to bottle' - analysis of energy use in viticulture and wine production and the potential for solar renewable technologies. *Renewable and Sustainable Energy Reviews,* 13, 1985-1993. https://doi.org/10.1016/j.rser.2009.01.007

Szolnoki, G. (2013). A cross-national comparison of sustainability in the wine industry. *Journal of Cleaner Production,* 53: 243-251. https://doi.org/10.1016/j.jclepro.2013.03.045

United Nations (UN). *Our common future: Report of the World Commission on Environment and Development*. Retrieved on 22 May 2021 from http://conspect.nl/pdf/Our_Common_Future-Brundtland_Report_ 1987.pdf

van Niekerk, A., & Joubert, S.J. (2006). Input variable selection for interpolating high-resolution climate surfaces for the Western Cape. *Water SA*. 37(3).

Verheijen, F., Jones, R., Rickson, R., & Smith, C. (2009). Tolerable versus actual soil erosion rates in Europe. *Earth Science Reviews,* 23–38. https://doi.org/10.1016/j.earscirev.2009.02.003

VinPro, VinPro Cost Guide. Retrieved on 27 June 2021 from https://portal.vinpro.co.za/wp-content/uploads/2020/05/Vinpro-Kostegids-2020-Online_DPS.pdf

Water Research Commission. (2020). Water Footprint as an indicator of sustainable table and wine grape production. Retrieved on 27 August 2021 from http://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/2710%20final.pdf

Wagner, M., Stanbury, P., Dietrich, T., Döring, J., Ewert, J., Foerster, C., Freund, M., Matthias, F., Kamman, C., Koch, M., Owtram, T., Schultz, H.R., Voss-Fels, K., Hanf, J. (2023). Developing a Sustainability Vision for the Global Wine Industry. *Sustainability*, 15(13), 10487. https://doi.org/10.3390/su151310487

Wei, Y., Davidson, B., Chen, D., & White, R. (2009). Balancing the economic, social and environmental dimensions of agroecosystems: An integrated modeling approach. *Agriculture, Ecosystems & Environment,* 131: 263-273. https://doi.org/10.1016/j.agee.2009.01.021

Winter, K. (2002). Oxford Intermediate Atlas of Southern Africa (in Afrikaans), (Oxford University Press, Cape Town).