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IN ACADEMIC AFFILIATION WITH THE EMIRATES ACADEMY OF HOSPITALITY MANAGEMENT

The Effects of climate change on Maltese wine production.

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Abstract

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This research focuses on the effects of climate change on Maltese wine production. The reason behind it is to explore further how viticulturists and wine producers are working around these climatic changes that affect wine production, with particular focus on how such changes affect the vineyards and terroir in the Maltese Islands. Moreover, there are two other secondary objectives in this study: one investigates the techniques being used in the vineyards to adapt to climate change for quality wine making, whilst the other explores the level of knowledge that consumers have in relation to climate change and its effect on wine making.

Through secondary research, online peer reviewed articles published with a focus on the three main questions and based on countries with similar climates, were reviewed; all articles being sourced primarily from ProQuest, Google Scholar and periodicals.

The primary research was conducted using qualitative methodology through four semi structured interviews with two viticulturists and two wine makers in Malta, from which different views were elicited and with all interviews being digitally recorded and transcribed. The contributions of two viticulturists, and two wine makers, helped to limit the bias in this research. From the interviews it resulted that currently, drip irrigation is counteracting the dry weather brought about by climate change. Consequently, expenses are increasing as lower yields on the vines are being obtained due to vine stress resulting from shorter dormancy and drastic decrease in precipitation during the winter months. Apart from hefty water and electricity costs, pest control costs are also contributing to an increase in the cost of production.

Quantitative methodology through the implementation of a semi-structured survey was also applied. The main scope of the survey was to find out how knowledgeable wine consumers are about the effects of climate change on the Maltese wine production. The results stated that the majority of wine consumers are familiar with the issue of global climate change. However, it also transpired that there is the need to educate furthermore about the relationship of climate change

and wine production and on the increasing challenges that viticulturists are facing in the vineyards. This will eventually lead to consumers empathising and understanding why the local wine prices are increasing. Consequently, they will be more willing to purchase organic or more sustainable local wines.

In conclusion, at present, climate change is still controllable in Malta through the use of various irrigation methods. However, if temperatures continue to soar, Malta will eventually experience desertification which will create a greater challenge to local wine production. This study should be re-evaluated in 20 to 50 years' time.

Keywords

Climate change, viticulture, and consumer knowledge, techniques used.

Declaration of Authenticity

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Research Title : The Effects of climate change on Maltese wine production.

Declaration:

I hereby declare that this research study is based on the outcome of my own research. I, as the author, declare that this research study is my own composition which has not been previously produced for any other qualification.
The research study was conducted under the supervision of Aaron Rizzo.

02/06/2025

Date

Student's Signature

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1. Introduction

The global community has been advocating greater emphasis on the deteriorating climate crisis through both governmental and corporate initiatives over the past twenty years (Iglesias, *et al*., 2011). Despite its non-essential function in human existence, wine is a significant example of human ingenuity. All agricultural activities, including viticulture, are inextricably linked to climate and weather. Grapes are cultivated worldwide; however, a small number of locations are suitable to produce high-quality wine grapes. The production of winegrapes is more vulnerable to both short-term and long-term climate change than other crops, as certain varieties of winegrapes require climates that are highly restricted to achieve optimal quality and productivity (Jones & Webb, 2010).

The Intergovernmental Panel on Climate Change (IPCC) anticipated a 1.5 ◦C rise in the average global temperature in 2021, which would have a significant impact on agroecosystems due to the increasing concentrations of greenhouse gases. Additionally, it is anticipated that the frequency of severe weather events and rainfall patterns will change. The current environment necessitates that agroecosystems adapt to both gradual and abrupt changes (Tosato , *et al*., 2023). This issue has contributed to an increase interest in this area, and this research focuses particularly on the effects of climate change on Maltese wine production.

Environmental influence affect how grapes grow and ripen. Not all grapes grow in all types of climates; vines have preferred climates in which they adapt and consequently achieve their full potential. Climate is influenced by latitude, altitude, seas, air, slopes, soil, weather, frost and hail. With climate change, these features are being affected and thus vineyards are facing serious problems such as drought, soil erosion and increase in temperature amongst others (Wine and Spirit Education Trust, 2019). For example, warming during the growing season has been observed in all studied wine regions on several continents over the past 50-60 years (Hofmann, *et al*., 2022). Malta, being in the middle of the Mediterranean is suffering from these effects especially drought and hot weather. Therefore, the aim of this research is to analyse what is happening in Malta and how this issue is being dealt with.

1.1 Research Aim, Objectives and Hypothesis or Question

This research is mainly focused on three main research questions:

The central research question: How can climate change affect the vineyards and terroir of the Maltese Islands?

Sub research question 1: What techniques are being used in the vineyards to adapt to climate change for quality wine making?

Sub research question 2: How knowledgeable are wine consumers regards to climate change and its effect on wine making?

2. What is the relation of climate change with wine production?

The production of quality wine is predicted to be impacted by climate change (Matters, 2021). One of the agricultural products most sensitive to fluctuations in temperature and precipitation is wine grapes. Premium wine grapes can only be grown in areas that can maintain a delicate balance of heat and precipitation. Extreme heat waves, severe precipitation, sudden spring frosts, and drought are some additional climate change challenges to wine production. Insects and other grapevine pests are also living longer due to shorter and milder winters (Germanier & Moricciani, 2023).

2.1 Disadvantages of climate change on wine production

In this section the disadvantages of climate change on wine production will be covered. With the effects of climate change, the quality of wine is changing, and some countries might not manage to produce wine in the future if temperatures continue to rise. Also, expenses are increasing to accommodate the vines' needs such as a constant water supply and effective pest control to ensure healthy plant growth.

2.1.1 Ozone Effects

The Troposphere, the lowest part of the atmosphere on Earth, contains most of the atmosphere's mass (about 75–80%). It is where most clouds are situated, and it is where practically all weather takes place. The Tropospheric ozone is created by chemical reactions between oxides of nitrogen and volatile organic compounds. Southern Europe has rising tropospheric ozone levels, which is associated with more frequent hot summers and heatwaves (Ascenso, *et al*., 2021). According to modelling findings referred to in this paper, climate change alone will cause Tropospheric Ozone (O_3) concentrations to rise in many parts of the world. It was estimated that the yield of grapevines was brought down, and it will continue to decrease throughout the years. Also, grape quality will be affected due to the loss of polyphenols, (a substance that is found in many plants and gives some flowers, fruits, and vegetables their colour) (Gama *et al.,* 2021).

2.1.2 Precipitation levels

The observed climatic changes are characterised by an increase in air temperature, but not in rainfall, which results in an increase in plant water requirements. A study in Bydgoszcz, Northern Poland, was conducted to determine the grapevines' water requirements from 2021 to 2050. As Jagosz *et al.,* (2022) assert, understanding the impacts of precision irrigation systems on plant and soil physiology in vineyards, as well as on fruit yield and quality, is essential for managing these systems for grapevines. The results showed that water requirements will rise by 6–10% between the years 2021 and 2050. It was also argued that since the start of the 20th century, soil moisture has declined throughout Europe (Hanel, et al., 2018), and in the past ten years, southwest Germany has experienced more severe drought occurrences (Erfurt, *et al*., 2020). This was in part a consequence of observed recent increases in potential evapotranspiration and the natural variability of precipitation. Water scarcity puts economic pressure on vineyards as the application of irrigation systems are expensive and in some cases access to water is problematic. Precipitation levels in steep slope regions were less than other regions (Hofmann, *et al*., 2022). The situation in Malta, as pointed out by the CEO of Marsovin Winery Jeremy Cassar, indicates that indigenous grapes are dying as precipitation levels have decreased drastically. These varieties are not surviving with only drip irrigation as they still need rainwater, and some locations are not accessible to irrigation systems. Marsovin has seen a 20-25% less volume production due to this excessive heat and lack of rainfall (Orland Schembri, 2016). The Maltese Islands experienced their second-driest year on record in 2024, with a mere 249.8 mm of precipitation, which is nearly 300 mm below the annual average (Bonello , 2025).

2.1.3 Change in temperature

Pal-Fam *et al. (*2022) provide a summary of the effects of climate change, particularly the rise in air temperature, on the development of vineyards in Europe indicating that a great number of vines are being destroyed. Moreover, there were studies which examined how climatic warming affected the progression of the phenological stages of grapevines in France. They investigated how climate change affected the earlier ripening of fruit that happens in hot climates. The yield and fruit quality have been severely impacted by the acceleration of the phenological stages of grapevines in central Poland because of climate change. Atilgan *et al., (*2022) stated that simulation on grapevine growth will be expanded into some sections of the Italian Alps where new vineyards have not yet been planted in Italy

because of global warming. One of the most frequently cultivated fruits in the world is the grapevine *Vitis vinifera*, largely for the manufacture of wine. Temperature increases during the ripening process brought on by the global warming phenomena have recently led to variations in wine quality and varietal typicity in numerous growing regions. Different models project a likely temperature rise of between 1.8 and 4ºC by the year 2100 using the data currently available. In the upcoming years, this temperature rise may considerably restrict the areas suitable for growing grapevines for wine production (Drori, *et al*., 2022). The Maltese islands are having higher temperatures each year during the winter season with December registering temperatures high as 21ºC. It was also forecasted that January will be missing storms and having higher temperatures (Vella, 2022). Due to high temperatures, new terroirs are already being tested. For instance, cooler grasslands in the UK are being converted into vineyards for the manufacture of sparkling wine by French Champagne firms. To combat warm vintages at home, they have also resumed employing the long neglected Arbane, Fromentot, Blanc Vrai, and Petit Meslier varieties, which are inherently tarter (Meekers, 2016). Malta experienced a brief dormancy period in 2024, as the temperature was not particularly cold, and the vines awoke early to progress through the spring season. The yield was at a low level by the time of harvest, as it had been harvested weeks prior due to high temperatures. Especially for international white grape varieties, production significantly decreases by 25-40% (Bonello , 2025).

2.1.4 Pests and diseases

A range of parasites and diseases, called "bio aggressors," threaten winemakers. These pests and diseases may reduce productivity and quality, making wine production difficult (Leeuwen , *et al*., 2024).

These changes may affect viticulture positively, negatively, or neutrally. Negative effects include disease vector immigration, better conditions for diseases and pests, quicker plant growth, and higher plant sensitivity. Meanwhile benefits include enhancing the plant's defences, decreasing its vulnerability time, favouring the bio aggressor's natural foes, and adversely affecting the pathogen. All these interactions may be affected simultaneously and to variable degrees, making it difficult to determine how climate change affects bio aggressors (Banga , *et al*., 2012).

Thirteen well-known insect pests that have become pests in the Ontario province (Canada) present substantial challenges to its vineyards. These parasites encompass both native species such as *Pseudococcus maritimus* and *Paralobesia viteana* and invasive species such as *Popillia japonica.* They pose a substantial threat to the health of vineyards and the yield of crops, as they have the potential to cause significant harm to fruit, leaves, blooms, short branches, and other vine components. The frequency and severity of these insect incursions are influenced by a variety of factors, but temperature is the most significant. It is anticipated that variations in climatic patterns will result in the emergence of new parasites and vectors, including the spotted lanternfly (*Lycorma delicatula)* (Tosato , *et al.*, 2023).

According to simulations of the European grapevine moth *(Lobesia botrana*), its distribution range is expected to migrate 11 degrees northward by 2055. Additionally, it is anticipated that the distribution range of tropical and Mediterranean insect species will extend into temperate regions in response to future climatic conditions. Increased temperatures and extended growing seasons may lead to an increase in the number of offspring produced annually (Svobodova, *et al.,* 2014).

In addition to temperature, fungus and their illnesses are sensitive to humidity and precipitation. Powdery and downy mildews are the most serious fungal problem in several wine-producing countries with diverse weather circumstances. The growth season weather is crucial for polycyclic infections, which cause these two illnesses. *Plasmopara viticola,* which causes downy mildew, needs leaf wetness and rainfall to infect grapevines at all stages. Due to precipitation uncertainty in many mid-latitude zones, downy mildew threats are forecast inconsistently. Reduced leaf wetness and temperatures over the infection threshold are expected to make northeastern France less suitable. In contrast, rising temperatures in northern Italy and other wine areas of Europe may worsen the condition. Another mystery is *Erysiphe necator*, which causes powdery mildew. (Leeuwen , *et al*., 2024) Malta is one of the grape-growing regions in Europe where the European grapevine moth is present. It has the potential to cause damage to grapevines, particularly when the larva penetrates the grapes as they grow. It is referred to as *Susa tal-Għeneb* in Maltese (Dandria, 2010).

2.2 Advantages of climate change on wine production

Apart from disadvantages, climate change provides some advantages as well, such as the improvement of scent of wine through irrigation. Also, countries or regions that were not considered to have the right conditions to produce wine will manage through the climate changes, particularly in cold countries. In France before 1980, it was not common to get drought and have an early harvest. With recent temperature increase and early harvests becoming more common, is proving to be highly beneficial for regions such as Burgundy and Bordeaux (Alastair, 2016).

2.2.1 Improvement of scent of wine through irrigation

Wine quality factors like the scent can be altered by grape variety, cultural methods, soil, and climate. Additionally, other elements like irrigation, leaf clearance and vine burden, influence the ripening of grapes (Delgado, *et al.*, 2022). The impact of vine irrigation on the scent composition and sensory qualities of La Mancha Chelva wines was investigated. It transpired that wines made with grapes from irrigated and non-irrigated vineyards in the Chelva region had 75 different fragrance components that were all recognised and measured. The findings indicate that minor changes in the concentration of wine volatile compounds were created using irrigation during grape cultivation. However, it generally boosted the qualities of the primary aroma sensory profile of the wines (Gonzalez-Vinas *et al.,*2022). A factor to consider when forecasting the quality of grapes and wines, is grape sugar content. However, in recent years, climatic change has increased the sugar concentration in grapes, which has led to an increase in the alcohol percentage of wines. Instead, it is possible that today's high sugar contents at harvest are related to efforts to maximise technical, polyphenolic, and aromatic ripeness. Local wine producers Marsovin are changing second class water into first class through reverse osmosis and using it to irrigate their Marnisi vineyards. This helps significantly with the aroma of the wine and its quality (Orland Schembri, 2016).

2.2.2 New wine producing regions

A major effect of climate change is the rise in temperature. This is a negative factor for regions which have moderate to warm climate such as Malta, but it gives an opportunity to cold climate regions to start producing wine. For example, Michigan (USA) went from growing edible grapes to *Vitis vinifera* grapes, such as Riesling, Chardonnay and Pinot Noir.

Also, Northern France, Canada, Germany, Luxembourg and Switzerland. In a study on Michigan, it was noticed that the region endures routinely severe winter temperatures and potentially hazardous spring temperatures. This is as post-budburst frost may occur but if it can be avoided, summer temperatures are hot enough to proceed to grape clusters and the rest of the process. It was concluded that in the future the temperatures will get higher, but the frost still might occur, and the growing season might change from April to October to March to September (Schultze & Sabbatini, 2022). Malta does not suffer from winter freeze. Due to this it has less energy expenses than other countries as it is not needed to warm the vineyards.

Atilgan together with a group of scientists investigated how climatic change affects the progression of the phenological (the cycle of growing grapes) stages of grapevines in France. They show that climate change affected the earlier ripening of fruit that happens in warmer climates. (Atilgan *et al.,*2022). One of the first vineyards to be harvested in Europe, Marsovin began its 2021 grape harvest on July 19 by taking its first Chardonnay grapes from the Wardija Valley Estate. To ensure that grape bunches are handled with care, these Chardonnay grapes were entirely hand-picked and used for Marsovin's Cassar de Malte - Brut. Cutting the grapes earlier than usual is necessary since this sparkling wine requires chardonnay grapes with high acidity. For age development of high-quality sparkling wine, the high degree of acidity in a sparkling wine created using the conventional method is essential. The mild temperature of the Maltese islands makes picking possible as early as July, whilst other northern countries must wait until later in the summer for the grapes to be at the right stage of ripeness (Times Of Malta , 2021).

2.2.3 Lower Vine Yields

Due to the numerous variables involved in cultivating grapes, it is challenging to forecast how climate change would affect how many grapes the plant produces. For instance, increased atmospheric carbon dioxide levels may be beneficial for plant growth in general, but heat, dryness, and sun radiation can also be harmful to plants. While yields are likely to rise in places that are presently below the comfort zone for vines to grow, lower yields can be anticipated in areas that are becoming hotter and drier such as Malta. Although less wine will be produced, the fact that it is at a low yield the wine will have better quality (Falzon, 2013).

2.2.4 Richer Biodiversity

With Climate change and global warming, viticulturists are turning to organic ways and removing the use of pesticides which can harm the environment. When producing wine, biodynamic techniques are used for both fruit cultivation and post-harvest processing (refer to figure 1). In order to produce biodynamic wine, organic agricultural techniques are used (such as using compost as fertiliser and avoiding most pesticides), as well as soil additives made in accordance with Rudolf Steiner's formulas and a planting calendar based on astrological configurations (*Masotti, et al.*, 2022). For organic grape production, Malta adheres to EC Regulations 834/2007. Some of the different techniques are mechanical or manual de-weeding, spring pruning to increase grape ventilation, no synthetic plant protection products used and frequently mowing of inter row grass to increase soil organic matter. Spinosad and mineral oil are harmless alternatives to pesticides. The first of several estates held by Marsovin that were designed with the intention of producing wines of the greatest standard was the Marnisi Estate. Over 50,000 Cabernet Sauvignon, Merlot, and Cabernet Franc vines are present in the vineyard. In 2013, the winery started a thorough three-year journey to implement organic farming and vinification methods. The 2016 vintage went on to become the first premium wine from Malta to receive EU certification and the designation of "Organic Wine" (Maltese Pantry, 2020).

When biodynamic soil was tested next to non-organic soil, the result was that the biodynamic had a greater disease suppression and a decrease in compaction.

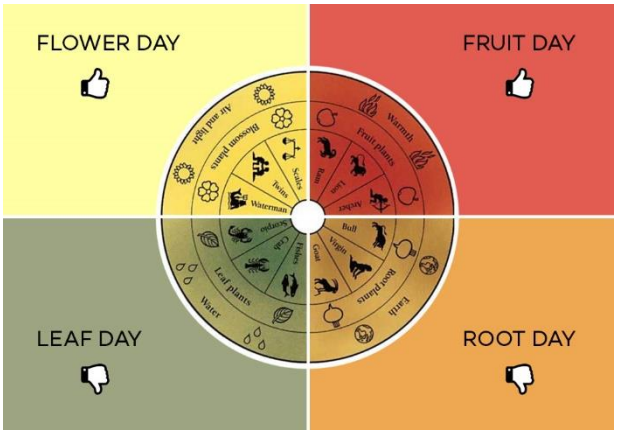

Figure 1 Diagram of the Biodynamic calendar Cited from winefolly.com (Puckette, 2023)

2.3 Techniques used in the vineyards to adapt to climate change

Different grape varieties need particular weather conditions to grow. Malta's climate is a Mediterranean climate where summers are very hot and have a mild winter. In Malta the grapes that are grown are Girgentina which is the indigenous grape, Chardonnay, Moscato, Zibibbo, Trebbiano, Pinot Bianco, Vermentino, Chenin Blanc, Viognier, Sauvignon Blanc. For the black grape varieties Ġellewża which is the indigenous grape, Cabernet Sauvignon, Cabernet Franc, Merlot, Grenache, Syrah, Mourvèdre, Sangiovese, Tempranillo, and Carignan (Wines of the Maltese Islands, 2023). All these grape varieties love heat and can survive in Malta but sometimes the temperature increase is too much and that is where the location of the vineyard is effective. Locations of high altitude, such as Wardija, gives more air circulation to the wine, and the local Marsovin Cheval Franc, which is derived from this area, is a case in point. This also gives better quality wine. The sea current and the wind help wine to keep its acidity and valleys such as Ramla Valley offer better drainage, all factors that help the grapes to achieve higher acidity. Moreover, vineyards which are located right next to the sea are exposed to the sea breeze during the night and provides shelter from hot winds (Wines of the Maltese Islands, 2023).

2.3.1 Irrigation techniques

Irrigation treatments in vineyards can boost fruit output by up to 58%. However, it is important to consider a variety of biotic and abiotic elements that affect fruit output and quality while supplementing irrigation of the grapevine. It was discovered that in addition to climate, leaf surface to yield ratio, and training systems, cultivar, exposure duration to water limits, rootstocks, and climate also have a significant impact on the composition of must and wine (Sadan *et al.,*2022).

This concept was also argued by (Drori *et al.,*2022), which stated that those vines that receive initial deficit irrigation later in the growing season, tend to have lower midday stem water potential even after irrigation commencement. Reduced bunch production and smaller fruit sizes on these vines also contribute to lower yields. Increased amounts of catechin and epicatechin in the wine made from the late-irrigated treatments contributed to its higher phenolic content. In contrast to caffeic acid levels, which showed an inverse tendency as irrigation start dates were moved back. Due to increased concentrations of most

anthocyanins, late watering also produced more intense colorations than irrigation at early phases.

In Gozo, the Eco-Gozo department of the Gozo Ministry, are currently conducting a trial of a distinctive irrigation system that has the potential to significantly reduce the quantity of water required to irrigate plants and trees. The clay-based approach involves the positioning of clay components in close proximity to the crop's root zone. Water is extracted from the clay components as a result of a pressure differential that arises when the water in the soil in the vicinity evaporates. The clay's special porosity, which regulates the rate of water release, guarantees a steady and gradual flow of water to meet the requirements of the crops. Researchers in Għarb are employing low-water emitters to irrigate vegetation, discharging less than one litre of water daily. The technique, a variation of a Self-regulating, Low Energy, Clay-based Irrigation (SLECI) system that is currently being investigated in Portugal and Morocco. SLECI technology irrigation employs approximately half the quantity of water as conventional drip irrigation, as indicated by preliminary data. In addition, SLECI systems improve nutrient retention by supplying water directly to the roots, assist in controlling vegetation growth through precise water delivery, and reduce unnecessary water discharge and evaporation (Busuttil , 2024).

2.3.2 The use of Shading Nets on Vines

Vineyards are increasingly experiencing hot weather events, water shortages, and high levels of irradiance. Long-term exposure to UV rays and high temperatures can have detrimental effects on the physiology of the vine and the makeup of the berries (Villalabos Soublett, *et al*., 2021). Sunscreen substances including calcium carbonate, kaolin (a clay mineral), and potassium silicate that form an inert particle coating on the leaves have been examined to boost reflecting capacity, allow leaf cooling, and reduce leaf and cluster sunburns under extreme summer stress.

Similar results are achieved by shading nets, which are recommended as an adaptation strategy to lessen the effects of global warming on the wine industry since they reduce the effects of high temperatures and evapotranspiration. Comparing overhead shade to full canopy shade, bunch shade, soil shade, and side canopy shade, overhead shade generally looks to be the most effective strategy to reduce temperatures and water stress. With a technical and financial choice, more research should be done on the timing and length of

shading, colour, kind, and specific canopy portion shading. Research was done on Muscat of Alexandria vineyard and the average solar radiation in vines shaded by nets was lower in all phenological stages evaluated, as expected, according to the data, which were attenuated by the nets' reflection and absorption of solar radiation. The shade nets were set on the row of vines without covering the edges, which would account for the minor variations in temperature and relative humidity that were seen (Balbontin, *et al.,* 2021).

2.3.3 Different yeast usage in fermentation

Warmer weather frequently has unfavourable impacts on fruit development and maturity, resulting in wines with altered physicochemical properties, such as high alcohol concentration and low acidity, as well as altered aromatic profiles, which are frequently unwelcome on the market. Studies on *Bombinonero* and Minutolo in Southern Italy where made and it was found that the joint fermentation of *Saccharomy cerveciae* and non-*Saccharomyces* yeasts can lead to improved freshness and aromaticity, features that can be easily cooperated with the rise in temperatures (Paradiso, et al., 2022).

2.3.4 Creating Clones, Hybrids and using Indigenous grapes

The countries in Europe are some of the most countries being affected by heatwaves and hot weather. Some countries need to divert back to their indigenous grapes as they are more adapted to the location rather than imported grapes. Malta's indigenous varieties being the Girgentina and Ġellewża. Some of the imported grape varieties might not be suitable anymore on our local terrain as they require a colder climate to grow and with climate change this is not possible anymore (Cellar Hand, 2016). This return to planting indigenous varieties is also beneficial due to this method being more water efficient as indigenous varieties require less watering. Additionally, the use of clones or rootstock-scion combination with a higher Water Use Efficiency would help to overcome the water shortage issue (Gisbert, *et al*., 2022).

Wang *et al.,* (2021), also argue that high quality, cold-resistant burial-free cultivars must be bred. By selecting seedlings and breeding hybrids, cold-resistant types can be created, and better varieties can be chosen depending on the local climate, such as: Brianna and Frontenac Grapes (Alastair, 2016).

Scientists have also recently discovered the potential of developing new hybrid grape varieties to replace traditional ones as a novel approach to climate change adaptation. These grape varieties are referred to as "fungus resistant grape varieties" or PIWI (Pilzwider standsfahige) (Krauss, *et al*., 2010).

2.4 Knowledge of Wine consumers regards to Climate change effects on vineyards

During the past twenty years there has been a surge in environmental awareness since the effects of climate change are brought by humans themselves. Some consumers nowadays are willing to pay more for environment friendly products such as organic wine. This comes down to how well does the wineries marketing team promotes their product. Through this study it was found that people are opting for organic wines and environmentally friendly wines mainly due to environmental consciousness and not because they are aware of the struggle that viticulturists and wine makers go through to produce their products (Barber, *et al*., 2023). In agreement, Wiedmann, *et al.,* (2021) state that efficient use of Eco-conscious branding and sustainability driven marketing will increase customer loyalty and will to purchase organic wine.

In the wine industry, there has been an increase in consumer interest in sustainability. Companies have indicated that market expectations are transitioning towards more conscientious and active consumption. Currently, consumers evaluate the product value and the manufacturing chain composition. Consequently, demand matures and gains empowerment, acknowledging its capacity to impact company decisions (Sgroi, *et al*., 2023). Businesses are granted a competitive edge over their competitors by establishing sustainable standards for wineries. This has the potential to generate financial benefits. The brand reputation will encourage customers who prioritise environmental sustainability to make more frequent purchases, thereby enhancing their propensity to pay for sustainable wines and their perception of their value. When sustainable practices are implemented, the business framework for wine development becomes more sustainable (Beaumelle, *et al*., 2023).

Consumers are evolving, modifying their purchasing habits, acquiring knowledge, and becoming increasingly concerned with the sustainability of the products and services they acquire. The present crisis amplifies this change, leading customers to be more selective and engaged in the decision-making process (Sgroi, *et al*., 2023). Consumer perceptions of

sustainability on wine production are significantly and profoundly affected by digital marketing strategies. This is consistent with the notion that customer loyalty is enhanced by social media marketing and environmentally responsible branding. It implies that the advantages of digital engagement transcend those of conventional marketing strategies (Usmonova, 2025).

The aforementioned studies, indicate that customers are enthusiastic about purchasing wines that are organic or have a lower level of pesticide use. A study was conducted to ascertain the existence of a market for wineries produced using innovative rootstock, PIWI cultivars, plant growth regulators, and kaolin. The results indicate that customers are more inclined to purchase wines treated with kaolin and vines with innovative rootstock. This could be more favourable as previously viticulturists adopted new rootstock to combat *phylloxera*. Customers do not favour this topic as much as they do for organic wine since it is a new subject and wine consumers require additional information and education (Di Vita , et al., 2024).

The Australian wine industry could switch to new wine grape types that are more resilient to the effects of climate change to survive this challenge. Sensory profiles were created, and information regarding Australian wine consumers preferences for domestic and foreign wines. Particular red wine grape varieties, that are drought resistant and currently not being cultivated in Australia, are better suited to change in climate. After some wine consumers tried the new wines all the feedback was positive, and the top-rated ones were the ones which had characteristics like Grenache and Shiraz grapes. The consumers understood the need for change since the vines that were planted before were not adapting to climate change (Mezei, *et al*., 2021).

Maltese viticulturalist Carmel Cortis notes that there is a large market for wine locally. Twelve to fourteen million bottles of wine are typically consumed yearly in Malta. The availability here is insufficient as every year, Malta produces between two and four million bottles of wine. He also points out that local market should strive for expensive wines rather than inexpensive ones (A Maltese Pantry, 2020).

3. Methodology

The methodology used for this research was mixed methodology (qualitative and quantitative). "Qualitative" is frequently used as a synonym for any data gathering method (like an interview) or data analysis operation (like categorising data) that utilises non-numerical data. Meanwhile the quantitative method is more for open subjects where you need a lot of different opinions to find a result and conclude (Thornhill *et al.,* 2016). There are different research instruments to conduct data. Themed semi structured interviews and surveys where adopted. Focus groups weren't used since it is not easy to get everyone together at the same time.

3.1 Interviews

Semi structured Interviews were used to elicit information on techniques implemented by viticulturalists and to assess the effects of global climate change on grape yield. This methodology being chosen especially since the topic under investigation is highly technical and experts in the field were needed. Both open ended and close ended questions were asked to gather additional information about the subject matter and to avoid losing focus from the main research questions. The interview questions where mainly covering the central research question and sub research questions one. Three questions were asked during the interviews regards the second sub research question, but some of the interviewees did not have enough knowledge regarding the questions put forward on this issue.

3.1.1 Justification of interviews

The interviewees consisted of two viticulturists and two wine makers. The reason behind this decision being that this study focuses on the effects of climate change on Maltese wine production. Wine production consists of both the viticulturist (the person that cultivates the grapes) and the wine maker (the person that turns grapes into wine). Their contribution was important as each participant explained the struggles that are being encountered in wine production and its management. The reason behind choosing four participants was to eliminate bias as much as possible, leading to a more reliable outcome. This ensured that answers given during the interviews were credible, authentic, and reliable.

The interviewees were:

- Carmel Cortis, Viticulturist
- Carmel Borg, Viticulturist
- Anton Mangion, Wine maker
- Gerald Vella, Wine maker

The justification table was created to make the results of the interviews more credible, authentic and reliable. Permission was given by the interviewees for their name to be used in this study. Consent forms can be found from Appendices 4 through 7. Please see table 1 below.

Table 1. Justification of participants for interviews.

Name	Expertise	Background/ years of experience	Location of Vineyard
Carmel Cortis	Viticulturist at Cortis Vineyards	• Went abroad and saw the different techniques used in other countries. • Started planting international grapes before EU funds, 43 years of experience. • Has around 15,000 vines.	Mdina and Żebbuġ
Carmel Borg	Viticulturist	• No qualifications but self- studied viticulture and is well read on this subject area. • 28 years of experience. • Has approximately 3000 vines	Burmarrad

Name	Expertise	Background/ years of experience	Location of Vineyard
Gerald Vella	Viticulturist / Oenologist	• Qualified from MCAST on Viticulture and Oenology. • 22 years of experience. • Viti Malta's Administrative Secretary.	Between Siġġiewi and Żebbuġ
Anton Mangion	Viticulturist / Oenologist	• Qualified in Brewing and distilling, Edinburgh. • Worked at Farson's and Meridiana for 7 years. • Has around 300 vines. • Lectures at MCAST and University about viticulture and wine making. • Formed part of the wine regulation board in 2004	Marsascala

(Refer to Appendix 1 for a detailed interview questions research matrix.)

3.2 Surveys

An online survey was conducted which focuses mainly on the sub research question (How knowledgeable are wine consumers regarding climate change and its effect on winemaking?) Since the viticulturists and winemakers lacked a clear understanding on the degree of knowledge of their customers, the researcher could not rely solely on their biased response. Consequently, an online survey was conducted with 109 respondents, this being a reliable instrument to get multiple responses and have a clear idea without being biased. It is also free to conduct and will have a quicker response rate from conventional survey modes. (Fricker & Rand , 2002) The survey was created through google forms and was sent to different social media platforms such as Facebook and Outlook. At least one hundred respondents were expected to reply for research purposes. The answers given from the surveys were credible, authentic, and reliable.

3.2.1 Justification of Surveys

The participants for the survey were wine consumers and sommeliers working in the industry. The survey was sent to multiple Facebook groups such as the Xara collection employee members page, where hotel workers have basic knowledge on wine. It was also posted in the Wine Lovers Malta page having followers from the wine industry and other people who are wine enthusiasts. Course lecturers who have wine connoisseurs as friends helped in the dissemination of the survey on their page. An email via Outlook was sent to lecturers and students from different course groups who had a wine course as part of their studies. (Refer to Appendix 2 for the survey questions and Appendix 3 for the Survey Research Matrix).

3.3 Pilot Study of Survey Questions

Once the initial draft of the survey was ready, the researcher forwarded the survey to ten lecturers all with a master's degree to review the survey and to take note of any changes that could be applied to ensure clearer question structure that would lead to relevant and accurate responses. Whilst acquiring an 80 percent response rate for the pilot study, one of the feedback items that proved useful was that of numbering the questions as this would make reference to survey questions easier during discussion. Furthermore, an additional question was set to determine the respondent's level of expertise on wines as this had a direct bearing on the credibility to the responses given. Following this process, the final draft of the survey was disseminated to all the participants.

3.4 Ethical Considerations

The Institute of Tourism Studies' (ITS) ethical principles were applied throughout the entire process of this research. The survey's participants were provided with all the information needed, and all survey respondents were kept anonymous. This ensured the acquisition of more honest answers from respondents.

Before the interviews, the viticulturists and wine makers were briefed about the general outline of the study in particular the research questions under investigation. They were also provided with the questions beforehand prior to the actual interview. The permission letter, information letter, consent form and consent for name usage form were also sent to be signed beforehand.

3.5 Limitations

A major limitation to this research centred mainly on the fact that the response rate was low in the beginning and the researcher had to approach individuals directly to encourage them completing the survey questions. This proved to be time consuming and the possibility of some respondents giving hasty responses without due reflection could have been higher. Having only a few open-ended questions, the semi structured questionnaire format might have limited the depth of insight on certain research areas. With surveys, the data provided might not be as genuine, as respondents might provide responses that follow trends (Example: buying organic wines which are more expensive), whilst in reality, they adhere more to mainstream practices, such as going for more economically affordable wines.

Another limitation when conducting interviews revolves around the number of participants. Since interviews are time intensive, the participants are either a handful of individuals or small groups. Consequently, the views expressed cannot be extrapolated.

Since the interviewees provided their responses in the Maltese language, to ensure fluent expression of ideas, some points might lose clarity through the process of translation for transcription purposes.

4. Results, Analysis and Discussion

In the Results, Analysis and Discussion section, the interviewees responses are reported, analysed, transcribed and discussed.

When reading through the analyses of the interviews, reference should be made to the Thematic Analysis (Braun and Clark, 2013) as outlined in the matrix hereunder and relate it to the Research Matrix in Appendix 1 to link outlined themes with the literature review.

4.1 Thematic Analysis Matrix of Interviews

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Precipitation levels	Question 1	Due to water stress, yields decrease. The vines would also have aged by 10 years, this being another contributing factor in decreasing the yield. In agreement with Jagosz *et al.*, (2022)	The Vines are taking too long to initiate their dormancy stage due to high temperatures and lack of rain. Therefore, the vines are under stress and have lower yields. In agreement with Jagosz *et al.,(*2022)	There is not a huge difference. It is true that the temperatures are rising, and precipitation levels have decreased, but one cannot say that there is a substantial reduction in the quantity of grapes produced by each vine. Even the quality of the grapes being produced is not diminishing. Assertions that contradict findings by Jagosz *et al.,(*2022)	Yes, there are less grapes, but the reason is not only precipitation. The most vines suffering from this are the older ones as they are already old, and the water stress does not help either, therefore they die as they do not have enough energy to counter this stress. All claims in agreement with Jagosz *et al.,(*2022)

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Precipitation levels	Question 2	Our vineyards are affiliated within a scheme offered by water services corporation with funds from the European Union. They have sensors which calculate the soil's humidity to detect the right water volume requirement for the vines.	A schedule was constructed from an agronomist. Different fertilizers are given each week which irrigates the vines once a week at the rate of 15L per 2 hours.	Sometimes there is the use of tensiometers. However, once the vines' pattern of water requirement is established, irrigation is implemented when necessary to ensure that terroir remains humid.	Humidity sensors are not present. Irrigation occurs on own experience gained and by referring to previous years' records. The irrigation schedule is also determined by weather patterns.
Irrigation Systems	Question 3	Irrigation costs are a big issue especially during heatwaves, as the vines need to be irrigated even more frequently. Obviously, there are further expenses other than the ones directly related to irrigation. Agreed with Hofmann *et al.,(*2022)	During spring and summer irrigation is a must, even if the winter season is wet, as the soil does not sustain the water for future use. Therefore, the expenses are always there but if the winters are dry, expenses soar as more irrigation is needed to sustain the vines. Agreed with Hofmann *et al.,(*2022)	Vineyards do not have direct water access. Rainwater is collected through a particular system. As a backup, recycled water is accessed. When situations get dire, brackish and fresh water is mixed. Therefore, if it rains this is seen as a godsend as costs are consequently reduced. Agreed with Hofmann, *et al.,(* 2022)	By irrigating, the expenses increase. However, the main issue is that due to high temperatures, the vines are not going into dormancy stage immediately and the vines end up under stress and do not produce the quantity needed. At the end of the day, the wine makers pay per kg, so it is a struggle. Agreed with Hofmann *et al.,(*2022)
Irrigation Systems	Question 4	Drip irrigation once a week, drippers set at the rate of 4L per hour for 8hrs during summer.	Drip irrigation once a week at the rate of 15L per 2 hrs	Drip irrigation is used. 4-5L per hour	Drip Irrigation is used.

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Irrigation System	Question 5	It prevents diseases, reduces weed growth and labour costs.	The best system, as one can determine the distance between vines and the amount of water being utilised. Fertilizers can also be released in a uniform way and therefore, it is the best system to ensure minimal wastage of water and nutrients.	4-5L per hour is the ideal irrigation rate as this does not flood the soil and it is the perfect amount to reach the roots slowly so that the maximum uptake of nutrients is ensured.	Most efficient system that reduces excessive consumption. It also stimulates the roots to search for water and convenient for leaving ample room for large equipment usage to treat vines.
Irrigation System	Question 6	Water extracted from water table through borehole system. The fact that the vineyards are in the middle of Malta the water has less salinity.	Borehole and a well is used, but it is not enough as a lot of water is needed. Energy used for extraction is more environmentally friendly. Instead of pumping the water with diesel fuel, energy from solar power is used.	Collection of rainwater is done in a particular system and if it rains the average of 600mm it is enough for his vineyards. Since the required amount is not being reached, lee water is used. If this does not suffice, the brackish and freshwater mixture is used.	Pumping of water from a borehole. The quality is good as his vineyard location is not close to the sea.

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Irrigation System	Question 7	No difference was observed as even when precipitation levels were higher during summer, irrigation was still needed. Not in agreement with Gonzalez-Vinas *et al*., (2022).	If irrigation is stopped, the brick level will stop increasing as well. Hence, irrigation is important for the grape maturation. In agreement with Gonzalez-Vinas *et al*., (2022).	Malta's water does not improve the aroma of wine as Malta's water is brackish (contains a lot of salt). The quality of water abroad might be of better quality. Not in agreement with Gonzalez-Vinas *et al*., (2022).	It is subjective, as not every viticulturist irrigates with the same amounts and not every year has the same temperatures. Hence it is hard to determine if it is really resulting from irrigation. But through irrigation the vine will keep hydrated and works at its optimum, so it gives good aroma. Only agrees to a certain extent with findings Gonzalez-Vinas *et al*., (2022).
Irrigation System	Question 8	Irrigation does decrease the yield, but lower yield means better quality. This conforms with Driori *et al.,* (2022).	If the right irrigation quantity is used, the quality will improve as the yields will be lower. But if a lot of water and fertilizer is applied to the vine, it will grow a lot of leaves, and the fruit will be compact and colourless as not a lot of sugar will be produced. This conforms with Driori *et al*., (2022).	Yields are decreasing due to stress on the vineyard. With the right vineyard technology and irrigation, the quality of grapes is still good, and the quantity is still maintained. In disagreement with Driori *et al*., (2022).	Irrigation lowers yields but gives better quality. This conforms with Driori *et al*., (2022).

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Change in Temperature /different yeast used.	Question 9	By using the refractometer, the bricks level is monitored and when it reaches 21-22 brix, the grapes are harvested.	By using the refractometer to measure the desired brix levels. Once this is achieved, harvesting is carried out.	Due to high phenological stages, there might be the case where vines do not mature properly and mixed grapes (ripened and unripen grapes) might be present. Hence the unripen ones are discarded resulting in less grape mass being sold.	The 20-year-old vines in the vineyard yield less due to age, and all the sugar will be spread in 2kg instead of 5kg. Therefore, high sugar levels result. For red wines it is still not a problem but as for white wines, grapes need to be monitored regularly and harvested earlier. If not, flat wines will result. If high sugar level grapes enter the winery, these will be blended with other grapes to lower alcohol levels.

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Change in temperature	Question 10	The high temperatures are still controllable with irrigation. The larger issue is that the temperatures are taking a longer time to drop, and the vines are not going into dormancy stage, thus causing an increase in stress on the vine. Also, due to high temperatures, harvest is being applied up to 14 days earlier than before. In agreement with Bonello (2025).	During heatwaves, if the temperature is above 37^0C, although the vines are still hydrated, they shut down and the sugar level does not increase.	During heatwaves the vines are irrigated more. If there is a period with constant high temperature the vines will shut down hence the grapes might not mature properly. But apart from this there are no further effects on the grapes.	Vines are still surviving during heatwaves. The worst is when *lupa* (hot dry wind) passes through the vineyards as this dries all the fruit and the production of the year is lost. Another issue is that the temperatures are not dropping a lot, and vines are not receding into a long dormancy stage. Hence the vine will not store enough energy to produce enough grapes. Agreed with Bonello (2025).
Change in temperature	Question 11	Due to high temperatures new pests are increasingly attacking the vines. None of the vines were damaged due to vines temperature increase as these have been watered regularly way before any heatwaves being experienced. In disagreement with Pal-Fam *et al., (*2022).	The vines are getting destroyed only due to pests such as the powdery mildew, botrytis and sour grape rot. The most problematic is the sour grape rot as it is not noticeable at the onset. In disagreement with Pal-Fam *et al., (*2022).	Did not comment on this question.	Vines are not getting destroyed but if *lupa* occurs, the grapes for that season are lost but the vine still survives to bear fruit the following year. Fires might occur in fields as temperatures soar mainly due to shards of glass left in poorly maintained fields. Intense heat from this glass reflecting the hot sun's rays on fry grass, is the major cause for field fires. In agreement with Pal-Fam *et al., (*2022).

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Change in temperature	Question 12	Due to the geographical location, the water from the water table is of good quality. Comparing the grapes grown in both locations, the ones in Żebbuġ, being flat land, produce higher levels of brix in the same grape variety than the ones grown in Mdina. In Mdina, due to its altitude, the grapes there retain more acidity.	Summer cool breeze during the evening helps the vineyards more than does the hot sun during the day. With regards to water supply, there is the problem that all the fields around the vineyard are being used for vegetable produce that require vast water supplies to be pumped from the borehole.	'Terra rossa' soil is present but underneath there is a backfilling of *turbazz*, a layer of stones which helps the soil to keep its humidity. The location of the vineyard is very close to San Tumas, Marsascala. It is not close to the sea but situated on a North facing slope and is exposed to North Northwest and North Easterly winds. These winds are beneficial as they ventilate the vines thus minimising incidents of disease. Malta being an island, frequency of windy days is not much of an issue.	The vineyard is located between Siġġiewi and Żebbuġ on a flat land in sandy soil. The vines face a North Westerly wind which is the most ideal as it is neither too humid, which causes fungus growth nor too windy, which can lead to leaf burn. The fact that the vineyard is situated on deep soil helps to give good soil storage and a greater potential for the roots to search for water.

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Richer Biodiversity	Question 13	The government is not providing financial compensation for organic fertilisers, but rather for non-organic ones, which are prohibitively expensive to purchase. Consequently, Cortis Vineyard is unable to transition to organic production. Additionally, he is of the opinion that the organic principle should be implemented, as if his vines are organic and the vines adjacent to them are not, the pests will ultimately infiltrate his vines because of the wind. Additionally, he is of the opinion that the general public does not appreciate organic wine, as it is slightly more expensive, and the number of vines will be reduced at the end of the year because of parasites. Although, sulphur is utilized in the vineyards.	Most pesticides that are found on the market are organic and the vineyard utilises this form of pest control. Through a scheme in collaboration with the agricultural department IPM is being implemented. (IPM is an ecosystem-based strategy that employs several techniques to prevent pests or the long-term damage they cause. It includes also biological management, habitat change, modifying cultural practises and the adoption of resistant cultivars). It will be introduced into the vineyard if the strategy proves to reap the desired outcomes.	Applies organic products such as organic compost, *sovexxo* (nitrogen producing rose plants) ensuring a good nitrogen supply in the soil. Preferably vines are not treated, however this is not always possible due to drifts of pesticides coming from nearby vineyards. Therefore, practice is not 100 % organic. Leaving the vineyard without treatment next to neighbouring pesticide treated vineyards can result in pests migrating from one vineyard to the other. Thus, organic practices should be enforced across the country.	Copper and sulphur are beneficial to vines, as they are susceptible to three primary diseases. That is why they can easily transition to organic cultivation. He is of the opinion that the organic cultivation of grapes would be beneficial since sulphur is utilised in vineyards. Pests would pose a challenge. However, organic pesticides and sulphur on their own serve to repel them. The disadvantage of this is that there is no market for organic grapes. Therefore, if the wine producers are provided with organic grapes, they will combine them with non-organic grapes. Consequently, the awards should be increased to account for the increased risks associated with the viticulturist's decision to adopt organic farming practices. This is since if the surrounding fields are not organic, parasites will infiltrate the vineyard. Thus, it is not a worthwhile endeavour to purchase organic grapes, as the wine producers are not paying higher prices for them. This is because some grapes will be lost, resulting in a lower weight and a lower profit for the viticulturist. He employs organic techniques; however, they are not entirely organic.

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Shading	Question 14	Netting of vines is utilised more as prevention purposes against birds eating the grapes but at the same time it provides shade to the grapes. Also, when a heat wave is approaching the vines are watered more.	He does not employ any shading nets because he lacks the necessary storage space and the process of attaching them to the vines is time-consuming.	He primarily employs netting to safeguard the vines from birds, but he also employs it to provide shade from the intense sun. Additionally, the vines are irrigated. He is sceptical of the sprinkler system, as it is causing water to be directed at the vines, which will result in a high level of humidity in the vineyard and a danger of mildew growth on the fruits.	The primary purpose of shading netting is to safeguard them from animals. They typically irrigate more frequently to ensure that the vines are consistently hydrated. They safeguard the grapes by pruning the leaves on the eastern side, as the sun rises from the east, exposing them to the intense sunlight. This is more effective than protecting the vines.

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Clones, hybrids and indigenous	Question 15	Sometimes lack of trimming of leaves is done to protect the grapes.	Only black grape varieties are grown in his vineyard and those can withstand heat and had no problems until now.	Did not comment on this question.	Most international grapes are performing well. However, Cabernet Sauvignon produces high-quality fruits in limited quantities. In the interim, the indigenous grapes are thriving, as they require less irrigation than their international counterparts due to their greater adaptation to our climate. In agreement with Cellar Hand 2016.

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Clones, hybrid and indigenous	Question 16	The viticulturist should always consider the winemaker's preferences when it comes to clones. As a result of their adaptation to the high temperatures, specific clowns produce an increased quantity of grapes. However, it is pointless to acquire them if their quality is lacking. The vines are imported from France, Italy, and Sicily due to their similar climates.	The humidity was not as prevalent when he acquired his vines, which are now 20 years old. His Syrah is grafted onto a Ruggeri rootstock, and the vines are Vitis vinifera. This is since Ruggeri is more resistant to lime. The French clones are incompatible because of the production of Testa Grossa. Consequently, he opted for an Australian clone, as it was the superior alternative. He is unaware of any individuals who have acquired clones for the purpose of mitigating the effects of climate change; rather, they are used for insect control against powdery mildew, botrytis, and Downey mildew.	He is still uncertain about whether he wishes to begin cultivating clones, as there is insufficient scientific evidence to determine which clones are most suitable for Malta's climate. In all candor, all of the vines are hybrids, as they have a specific rootstock that is optimal for the soil, rather than Vitis vinifera, which is susceptible to roots that are rapidly attacked.	He does not possess such clones. He is of the opinion that investing in clones from locations with similar climates is a wise decision if the situation continues to deteriorate. Additionally, it would be prudent to allocate additional resources towards our indigenous grape varieties. Since we have invested in international varieties, some of which are from northern Europe, the climate is not the same. In consideration of the fact that these plants have been in place for two decades.

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Knowledge of wine consumers	Question 17	It is crucial that viticulturists become a member of an organisation such as Viti Malta, as business owners and winemakers are now more aware of the issue. The advantage of being a member of an organisation is that it assists in the identification of new collaborators in the event that the winemaker is unable to comprehend the organization's requirements.	He is of the opinion that the elderly generation is not as knowledgeable as younger generations, as a result of the era in which they lived. However, he is of the opinion that there is a growing interest in the study of wines and the acquisition of knowledge about them. Additionally, they are more environmentally conscious.	Wine consumers are not knowledgeable enough.	Wine consumers do not have a clue.

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Knowledge of wine consumers	Question 18	Nowadays vineyards have decreased drastically as field owners are not growing vines, and the viticulturists are not finding empty fields to plant vines. In Malta there is an average of 14 million wines which are drank yearly. Therefore, no they are not managing with the high demands and there is the need for importation of wine.	Did not comment on this question.	Did not comment on this question.	According to the statistics office, the number of vineyards has decreased by over 1400 *tumoli* between 2010 and 2020, resulting in a 35% decrease in the amount of land under vines in a decade. This is due to the fact that grape farmers are not receiving sufficient compensation and viticulturists are forsaking their vineyards. Despite the fact that the majority of viticulturists are around 60 years old and a vine requires a minimum of 25 years of investment, they are being compelled to plant additional vines. Consequently, it is not beneficial for them to begin planting new vines.

Themes	Interview Questions	Response of Interviewee 1 Carmel Cortis Viticulturist	Response of Interviewee 2 Carmel Borg Viticulturist	Response of Interviewee 3 Anton Mangion Oenologist	Response of Interviewee 4 Gerald Vella Oenologist
Knowledge of wine consumers	Question 19	It is important that the knowledge about climate change is spread. Nowadays people are getting more interested about wine knowledge as well therefore they will acknowledge the information given.	Awareness is always important especially through social media.	Did not comment on this question.	Knowledge should be provided the first thing that the country needs to understand is that viticulture and wine making is one thing not two. Many people focus on wine making and do not realise that the wine cannot be produced without the grapes. Creating an interest in viticulture has the potential to sell more wine.

4.2 Survey Analyses with the Target Market being knowledgeable wine consumers.

The survey yielded 109 responses, which were sufficient to ascertain the level of knowledge that wine consumers possess regarding climate change for the purposes of this research. The survey includes nineteen questions, of which six are demographic inquiries designed to ascertain the respondent's background. There were two social media groups to which this survey was distributed. Consequently, a total of 400 surveys were distributed, resulting in a response rate of 27.25%.

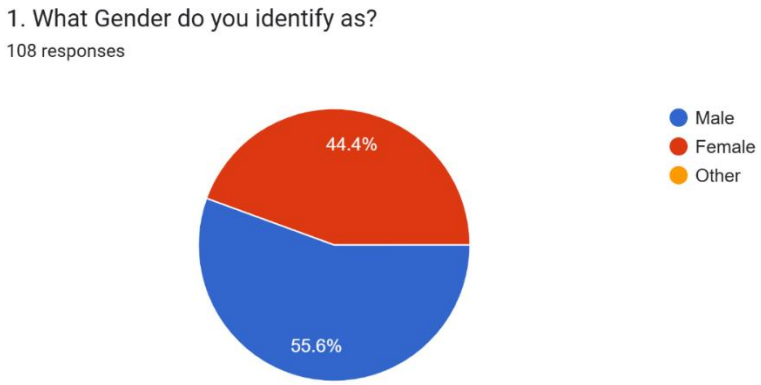

Figure 2

The first question was a demographic question, and its aim was to identify the gender of the participants: 48 being female (44.4%) and 60 male participants (55.6%).

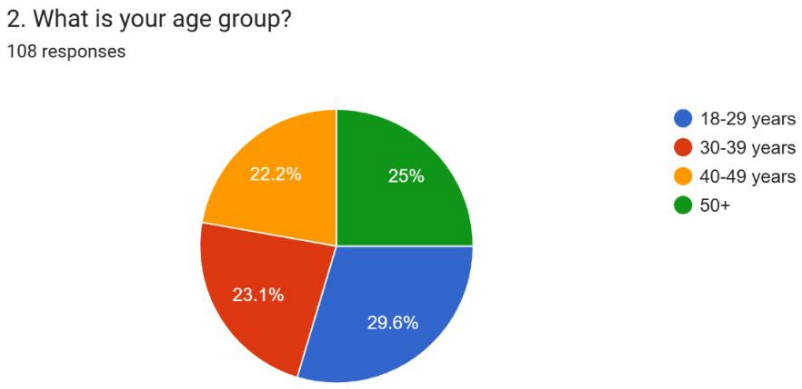

Figure 3

Question two was also a demographic question as it aims to understand the different age categories that the participants fall under. From 108 respondents, a total of 31 fall under the 18-29 category, 25 respondents fall under 30-39 category, 24 respondents fall under 40-49 category and 27 respondents fall under the 50+ category. From the above distribution the researcher could identify which responses from the survey were being derived from particular age groups.

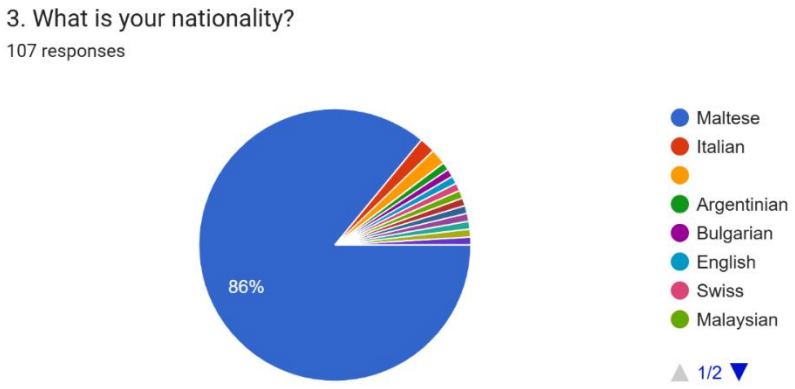

Figure 4

Another demographic question to understand the nationality of the respondents. Since one of the sub research questions referred to the level of knowledge that wine consumers have on the effects of climate change on Maltese wine production, getting a picture of the nationality of the respondents could have indicated the level of knowledge on the subject that respondents from particular countries are exposed to. 92 respondents were Maltese, 2 respondents were Italian, 2 respondents did not respond this question, 1 respondent was Argentinian, 1 respondent was Bulgarian, 1 respondent was English, 1 respondent was Swiss, 1 respondent was Malaysian, 1 respondent was Italian and Maltese, 1 respondent was Belgian, 1 respondent was French, 1 respondent was Indian, 1 respondent was Hungarian, and 1 respondent was Spanish.

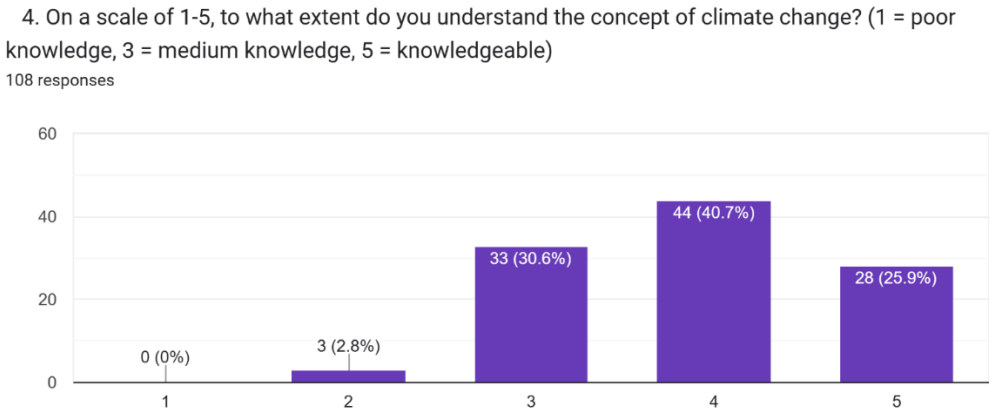

Figure 5

Question four is aimed to better understand the level of knowledge that the respondents have about climate change. A Likert scale was utilized to better measure the level of knowledge of the respondents, with 1 being poor knowledge, 3 being medium knowledge and 5 being knowledgeable. This question was asked as it is crucial that the respondents are knowledgeable about climate change as much as they are about wines. 28 respondents voted 5 which means that they are knowledgeable, 44 respondents voted 4 which is in between knowledgeable and medium knowledge, 33 respondents voted 3 which was medium knowledge, 3 respondents voted 2 which is between medium knowledge and poor knowledge. This signifies that the majority of respondents are knowledgeable on the subject.

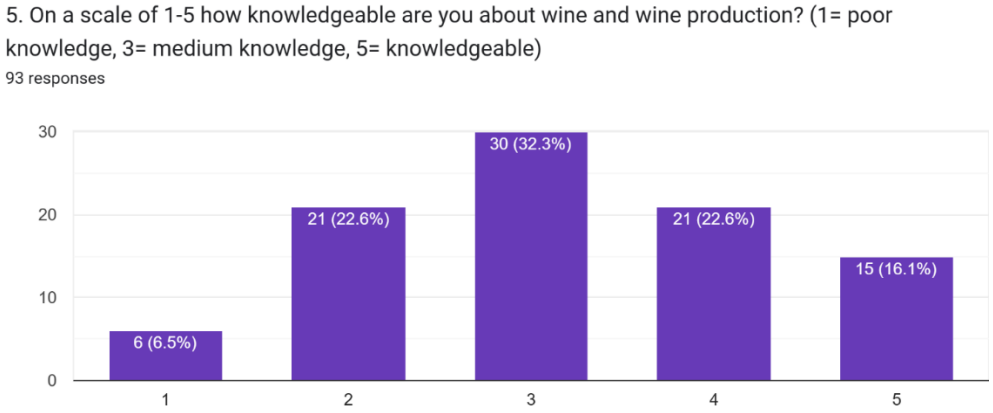

Figure 6

The aim of this question was to better understand how knowledgeable the wine consumers are about wine and its production. This question was important as it might affect some results of the following questions. A Likert scale was utilized to better measure the level of knowledge of the respondents, with 1 being poor knowledge, 3 being medium knowledge and 5 being knowledgeable. 6 respondents voted poor knowledge, 21 respondents voted 2 which is in between poor knowledge and medium knowledge, 30 respondents voted medium knowledge, 21 respondents voted 4 which is in between medium knowledge and knowledgeable and 15 respondents voted knowledgeable.

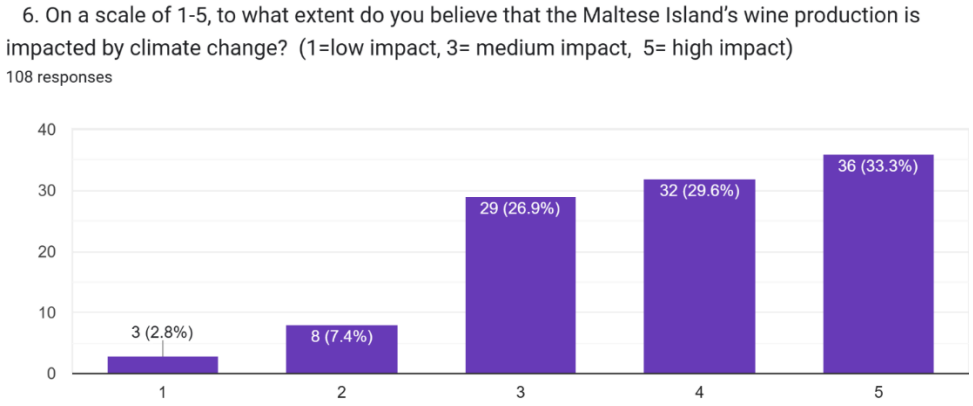

Figure 7

The intention of this question was to find out how much the respondents think that climate change impact wine production in Malta. 3 respondents (2.8%) voted 1 which means low impact, 8 (7.4%) responded 2 which is between low impact and medium impact, 29 respondents (26.9%) voted 3 which is medium impact, 32 respondents (29.6%) voted 4 which is between medium and high impact and 36 respondents (33.3%) voted 5 high impact.

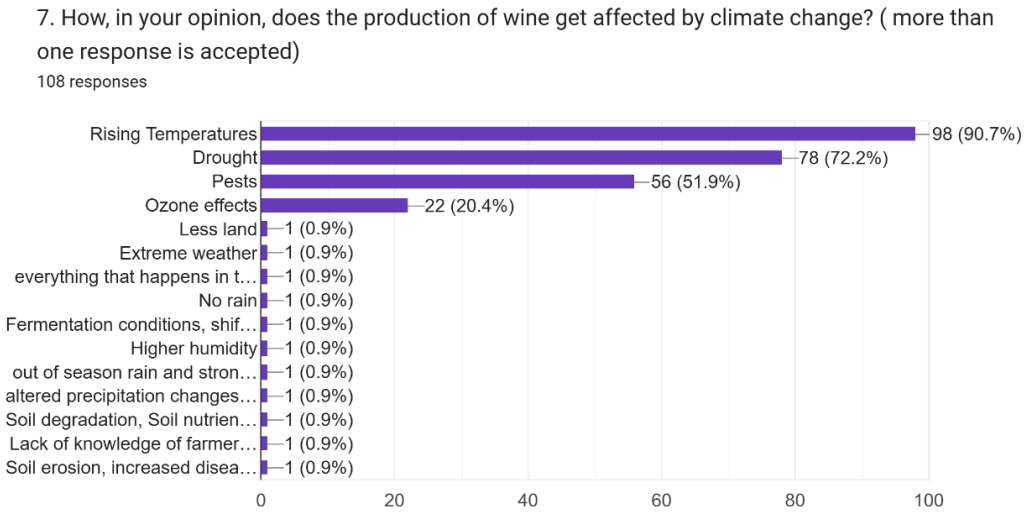

Figure 8

The purpose of this question was to understand how many factors of climate change respondents consider when thinking on what is affecting wine production. 98 respondents (90.7%) responded rising temperature, 78 respondents (72.2%) voted drought, 56 respondents (51.9%) voted pests, 22 (20.4%) voted ozone effects. Some respondents added another response which are listed in the image above.

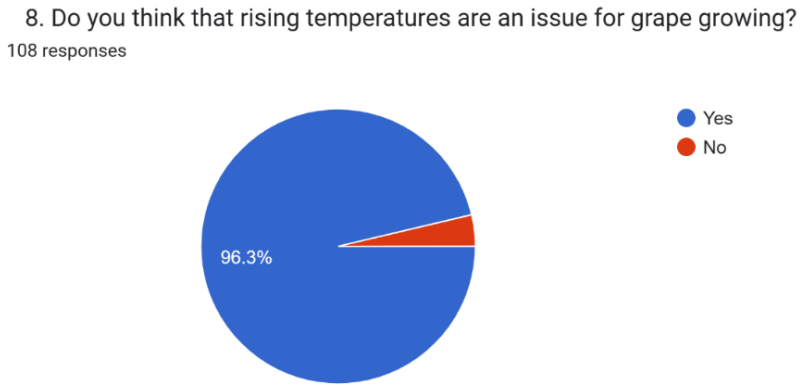

Figure 9

The purpose of this question was to understand the number of people who perceive that the increase of temperature has an effect on wine production. 104 respondents (96.3%) agree with this, whilst 4 respondents (3.7%) did not. The majority of respondents agree that there

is an increase in climate temperature and this supports what Drori *et al.,* (2022) stated which was that this temperature rise may considerably restrict the areas suitable for growing grapevines for wine production.

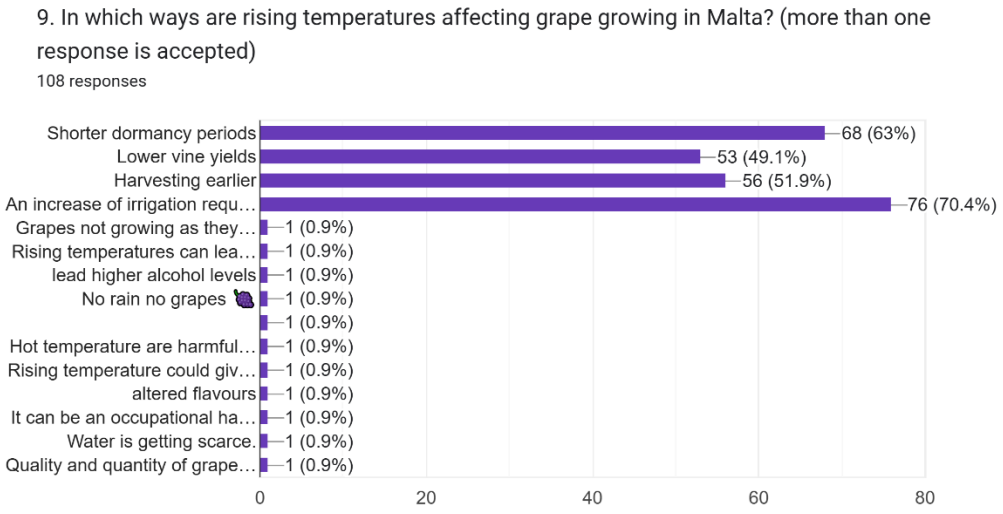

Figure 10

The purpose of this question was to understand if the respondents have knowledge on the effects of rising temperatures on grape growth. 68 respondents (63%) responded shorter dormancy periods, which is in agreement with (Bonello, 2025) 53 (49.1%) lower vine yields, which is in agreement with (Atigan *et al.,* 2022) 56 (51.9%) voted harvesting earlier and 76 (70.4%) responded an increase of irrigation requirement.

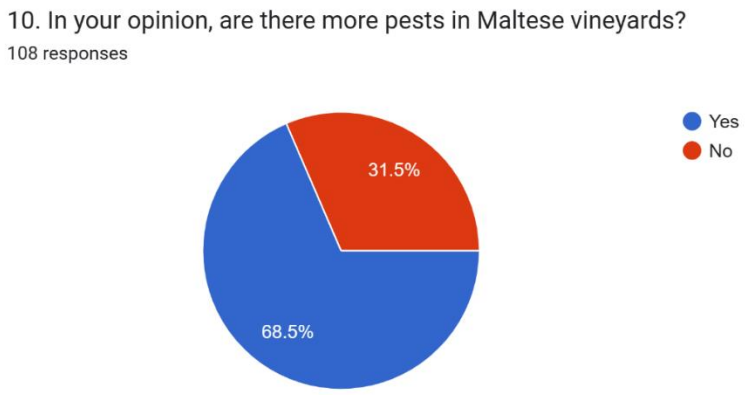

Figure 11

This question was asked to understand if the respondents think that there was an increase of pest Malta due to climate change. 74 (68.5%) responded yes and 34 (31.5%) responded no.

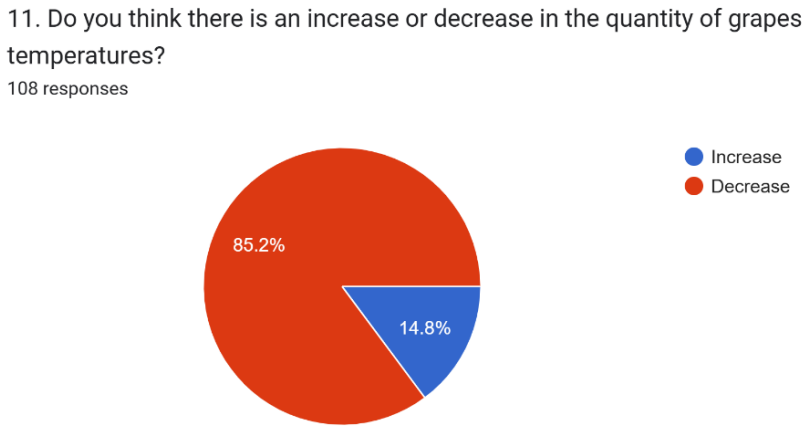

Figure 12

The purpose of this question was to see if the respondents new that there is a decrease in the quantity of grapes with the increase of temperature. 92 (85.2%) respondents said that there was a decrease, while 16 (14.8%) responded an increase. This mirrors findings by Falzon (2013), claiming that higher temperatures result in lower yields of a better quality and those by Bonello (2025) that claims lower yields in Maltese vineyards ranging from 25- 40 % especially for the white grape variety, due to rising temperatures.

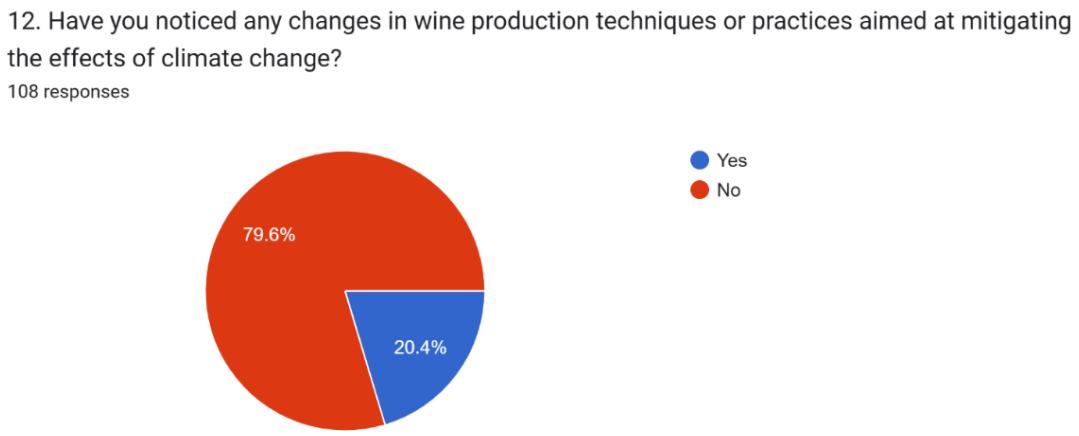

Figure 13

The purpose of this question was to see if the respondents have heard about any techniques aimed at mitigating the effects of climate change. 86 (79.6%) of respondents were not aware whilst 22 (20.4%) were aware of practices to mitigate effects of climate change as outlined in the following question. This reflects to what Barber, *et al.,* (2023) stated, that consumers are purchasing organic wines out of consciousness for the environment, not for the knowledge of viticulturists efforts.

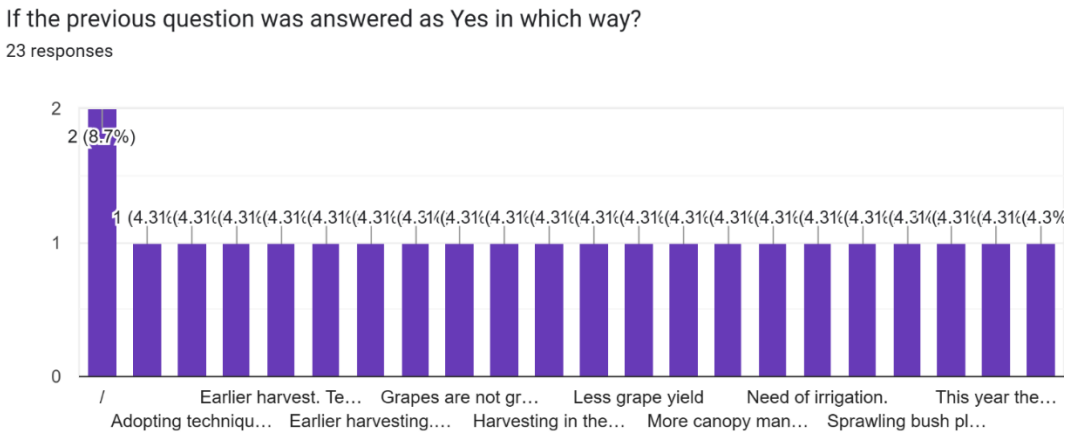

Figure 14

Respondents agreeing that mitigation techniques for the effects of climate change are being used during the production of wine, explained further their assertions as follows: Two of the respondents answered that wineries are adjusting fermentation temperatures. Five mentioned earlier harvesting of grapes, three mentioned planting new heat-resistant grape

varieties; three claimed that more irrigation is being applied and one mentioned the use of different vine training systems and techniques. Another mentioned the use of canopy management. The introduction of sprawling bush vines and late harvest were also mentioned. The responses given reflected techniques already explored earlier with Bonello (2025) referring to early harvesting as a mitigation technique whilst Drori *et al.,* (2022) and Sadan *et al.,* (2022) all refer to irrigation as a solution. Mezei *et al.,* (2021) also refers to employing heat resistant grape varieties as a solution to climate change effects in Australia.

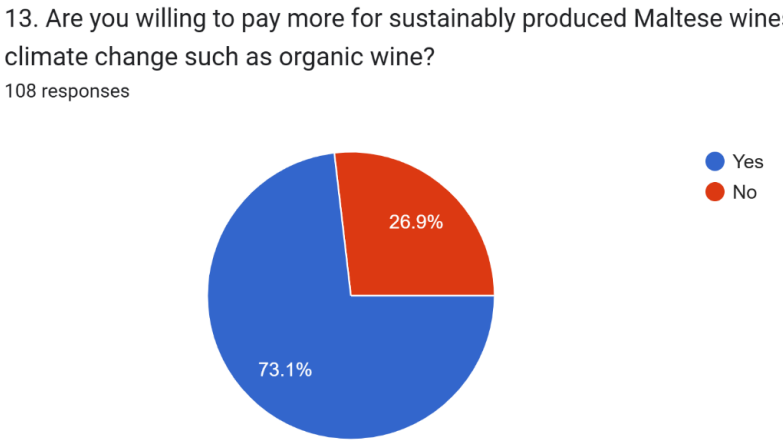

Figure 15

This question was asked to find out if there is a market for more sustainable or organic wines, with the majority agreeing that a market exists. In fact, 79 responded in the affirmative whilst 29 disagreed. This result agrees with Barber, *et al.,* 2023 which state that there is a market for organic wine. Although the volume of organic wines locally is relatively low, with Marsovin championing the first organic wine in 2018, as cited in the Maltese Pantry (2020), and other viticulturalists, such as Marc Casar wines (marccasar.com) following suit, respondents are aware that such a niche market could strive and have the competitive edge as stated by Beaumelle, *et al.,* (2023).

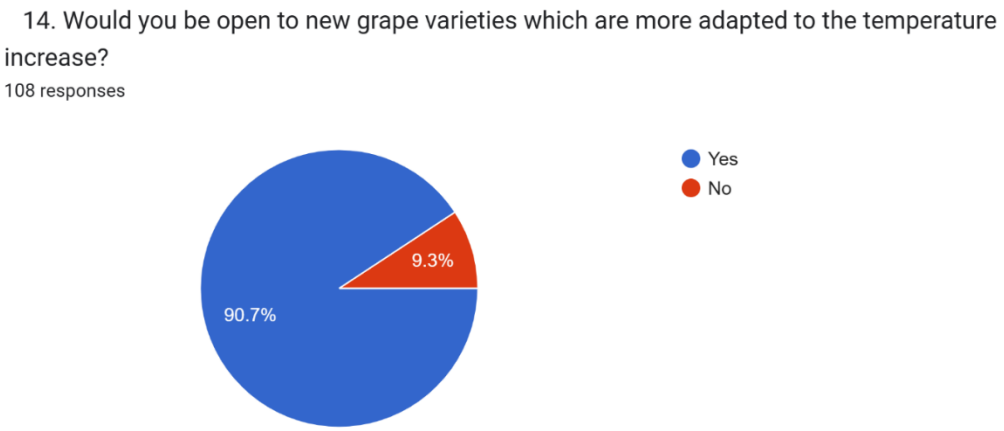

Figure 16

This question tried to explore if the respondents would consider buying wine with grape varieties that adapt better in the Maltese climate. 98 respondents (90.7%) agree whilst 10 (9.3%) prefer not to. Same approach was noticed in Australia by Mezei *et al.,* (2021) where consumers adapted to new wines produced from more resilient vines that adapted better to changes in weather patterns.

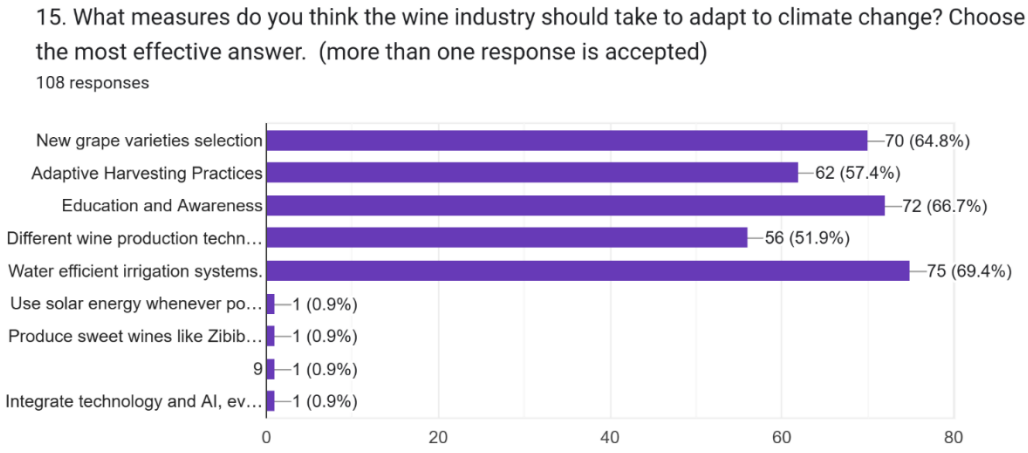

Figure 17

This question was asked in order to explore how knowledgeable the respondents are on the measures that can be taken from the wine industry. 70 (64.8%) opted for new grape varieties selection, 62 (57.4%) for adaptive harvesting practices, 72 (66.7%) for education and awareness. 56 (51.9%) for different wine production techniques and 75 (69.4%) for water

efficient irrigation systems. One respondent mentioned the introduction of solar energy, and another mentioned to produce more sweet wines like Zibibbo in Pantelleria. Finally, one mentioned to integrate technology and AI evidence-based practices.

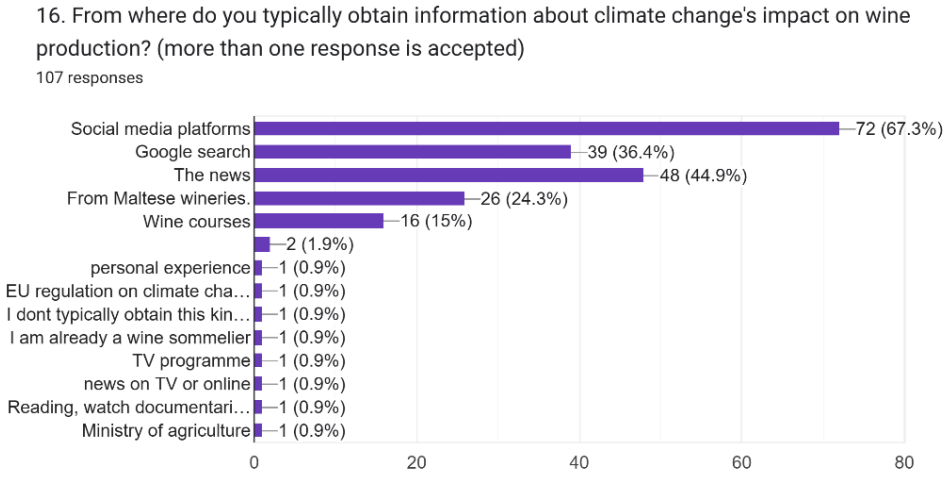

Figure 18

The purpose of this question was to discover from where the respondents get knowledge about climate change and its effects on wine production. 72 (67.3%) referred to social media platforms, 39 (36.4%) mentioned Google search, 48 (44.9%) the news, 26 (24.3%) from Maltese wineries, 16 (15%) got this knowledge through wine courses. One respondent obtained such information through EU regulations on climate change, and another respondent claimed that he does not obtain this information, and it is not communicated enough. Two mentioned through tv programmes, one mentioned through reading, documentaries and podcasts. One mentioned Information from the Ministry of Agriculture. This result mirrors findings by Usmonova, (2025) stating, customer loyalty is enhanced through social media marketing and education.

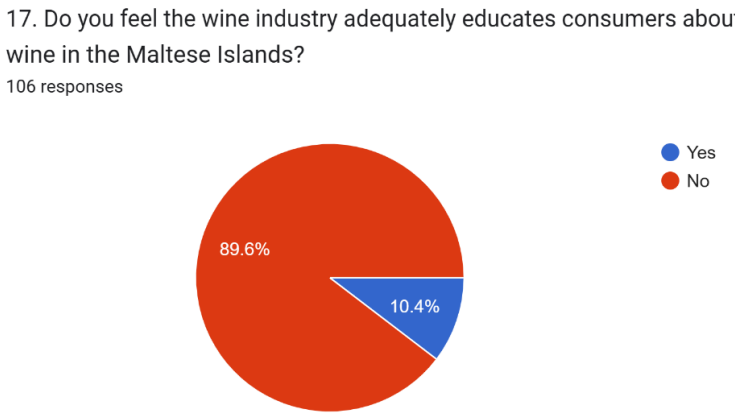

Figure 19

This question explores if the local wineries are educating the Maltese population with the struggles that they are facing when producing wine or if they are getting the knowledge from another research abroad. 95 respondents (89.6%) do not agree, whilst 11 (10.4%) think that this kind of knowledge is being disseminated. This shows that there is the need for more information relayed to the public to better understand the struggles they are facing such as increasing costs of production.

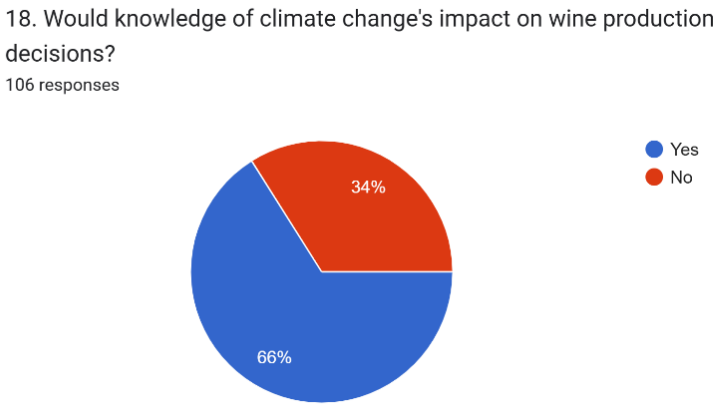

Figure 20

This question identifies if knowledge about climate change's impact on wine production would influence the respondent's purchasing decisions. The majority, 70 (66%) agree whilst 36 (34%) do not think that this does not affect consumer decisions. Same approach was

noticed by Sgroi *et al.,* (2023) stating that wine consumers are acquiring knowledge leading to more selective purchases.

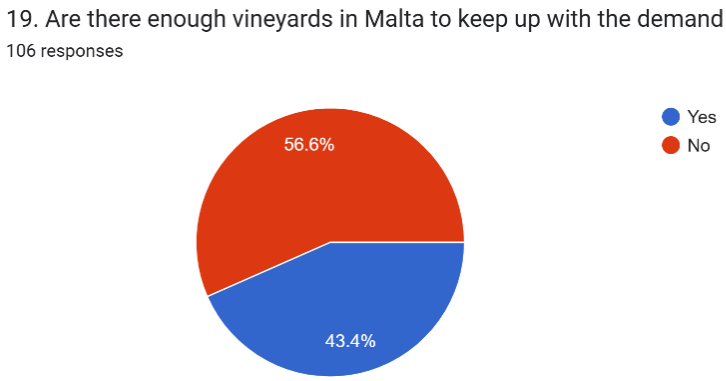

Figure 21

This question was asked to see if the respondents have an idea on how many vineyards are needed to supply for the demand. 60 (56.6%) think that Malta does not have enough vineyards to sustain local demands for wine whilst 46 (43.4%) think otherwise. Local viticulturalist Carmel Cortis also agrees with this outcome and comments that local demand for wine exceeds the local capacity for production, as reviewed in *Pantry*, (2020).

4.3 Discussion

In this chapter the results obtained both from the surveys and interviews will be triangulated with the literature review by eliciting common themes which aim to answer the three research questions. It is important to note that the survey conducted in this study reflects the opinions of only 107 respondents, hence certain outcomes of this exercise cannot be extrapolated and attributed to the wider population

4.3.1 Discussion to cover the central research question

With climate change there is an increase in air temperature but not in precipitation levels which results in plant water requirements and stress. Research shows that in 30 years' time; water requirements will increase by 6-10%. *(*Ptach *et al.,*2022*)* Interviewee one argued that vines are under a lot of stress and the yields are decreasing. He also argued that the vines would have aged by ten years and yields decrease through age. The older vines are dying as they cannot manage the water stress. Interviewees four and two also agree with this assertion. Moreover, due to the high temperatures, the vines are taking longer to achieve dormancy, and this creates further stress on the vine, a view that is shared also by Bonello (2025). Interviewee three although arguing that temperatures are rising and precipitation is decreasing, he does not believe that there was a substantial reduction of grapes and quality. Results from respondents in survey question seven and eight also reflect the views expressed above, as the majority attribute rising temperatures and drought as the main contributing factor that is affecting wine production.

To overcome this issue, viticulturists are measuring the amount of water needed for the vines to stay hydrated. Interviewee one uses sensors that calculates humidity, interviewee two uses a schedule that was provided by an agronomist and fertilizes each week, interviewee three uses tensiometers but mostly irrigates through experience and interviewee four also irrigates through experience and by following previous years records.

Multiple vines are getting destroyed due to higher temperatures. The yield and fruit quality have been impacted with high phenological stages *(*Pal-Fam *et al.,*2022*).* In Malta, higher temperatures are being experienced each year during Winter and during December, temperatures can reach as high as 21^{o}C, with January missing storms *(*Vella, 2022*).* Interviewee one believes that the high temperatures can still be counteracted if irrigation is applied. Harvest is being moved forward by 14 days since brix levels are increasing rapidly.

The largest issue is that temperatures are taking long to drop, and vines are not experiencing a long dormancy stage. Agreeing to this was interviewee four which believes that the vines are not storing a lot of energy during their dormancy stage and consequently resulting in attaining lower yields. The worst cases are being observed in grape varieties such as Chardonnay which can adapt to all climates. Since temperatures are not dropping lower than 7^{o}C, dormancy in vines occurs only for a week or two. Interviewee four also stated that the worst is *lupa*, as it dries all the produce of that particular year. Hence, all the grapes are lost. Meanwhile interviewee two and three argued that if temperatures stay above 37^{o}C for a few days, the vines will shut down and stop producing sugar, consequently, the grapes might not mature properly. Likewise, grapes do not mature properly due to high phenological stages and when harvesting, there is a mix of ripened and unripen grapes. This situation, eventually, will lead to an increase on costs of production as less grapes are sold. Responses from survey question nine also reflect these assertions especially when referring to irrigation frequency, length of dormancy and timing of harvesting.

Interviewees one and two did not lose vines through high temperatures and fires, but certain pests are repopulating, and they have lost vines through pest attacks or bio-aggressors as termed by Leeuwen *et al.,* 2024. Responses to question ten of the survey also see pests as being on the increase. Interviewee four said that his vines were not destroyed by fires but only the grapes were affected by *lupa*. He also states that certain fields and vines are catching fire since the fields around them are abandoned and damage can be caused by spontaneous fires.

Delgado *et al.,*2022*,* researched about the impact of vine irrigation on the scent and sensory qualities and was found that it boosted the qualities of the primary aroma sensory profile of the wines. Interviewee one and two stated that they haven't seen any difference since irrigation is always needed during summertime. Hence, they never grew grapes without irrigating through summer and cannot compare both results. Interviewee three does not believe that Malta's water improves the scent as it is brackish, and the quality of water abroad is better as it comes from mountains or natural springs. Interviewee four believes that it is subjective as not every viticulturist irrigates the same and not every year has the same temperatures. If the vines keep hydrated, they will achieve optimum performance and give good primary aromas. Hence to a certain extent this is in agreement with the primary research.

With Climate change and global warming viticulturists are turning to organic ways and removing the use of pesticides which can harm the environment. Agricultural techniques are used to create biodynamic wine (such as using compost as fertiliser and avoiding most pesticides), as well as soil additives made in accordance with Rudolf Steiner's formulas and a planting calendar based on astrological configurations (Masotti, *et al.*, 2022). In Malta, the Marnisi Estate started producing organic wine (Maltese Pantry, 2020). Interviewee one stated that the use of sulphur is used but cannot go fully organic since the government is not compensating money on organic fertilizers. Interviewee two states that he prefers using organic pest control through his affiliation with the IPM scheme issued by the Agricultural Department. If this succeeds, he will be considering introducing it in his vineyards to start producing organic wines. Interviewee three uses organic compost, nitrogenous plant in the rose and treats the vines to a minimum. Interviewee four believes that vines are most suitable to respond to organic methods as the main diseases can be cured organically with the use of copper and sulphur. There are also organic pesticides and sulphur repels certain pests. Although there is agreement among all interviewees that one should adopt organic practices, enforcement is needed to ensure that neighbouring vineyards follow suit.

Interviewee four also believes that presently wine producers are not opting for organic grapes as they pay by mass, and grapes are being mixed from different vineyards. Since the organic grapes are getting mixed with non-organic ones, cultivating organically would not be economically viable. Although respondents from survey question 13 indicate that there is a market for organic wines locally, this is not being reinforced by wine producers.

4.3.2 Discussion to cover sub research question 1

Vines that receive initial deficit irrigation later in the growing season contribute to reduced yields, as stated by Drori *et al*. (2022). Drip irrigation is implemented by each interviewee. This irrigation method was selected for its ability to prevent diseases and reduce vegetation growth, as well as its ability to regulate the quantity of water, fertilisers that are released together with ensuring proper distance between vines. Additionally, it encourages the roots to seek water. It is the most cost-effective irrigation procedure because it guarantees minimal water waste. The research provided agrees with interviewees one, two, and four. They asserted that while the yields are lower, the quality is superior, and winemakers prioritise both quantity and quality. However, if an abundance of water is provided, the vine will produce an abundance of leaves, resulting in grapes that are compact and lack colour

due to a lack of sugar. In contrast, Interviewee three disputes this assertion and asserts that the vines are experiencing stress, which is resulting in a decline in yields. The quality and quantity of fruits are preserved through the implementation of appropriate vineyard technology and irrigation. Their business is significantly impacted by irrigation costs, particularly during heatwaves. Additionally, irrigation is necessary during arid winters. The quantity of grapes is diminishing due to the rising temperatures, and winemakers are compensated based on their production volume. This presents a challenge for viticulturists.

Shading nets are recommended as an adaptation strategy to mitigate the effects of global warming, as they mitigate the effects of high temperatures and evapotranspiration. The most effective approach to mitigate water stress and temperatures is to implement overhead shade (Balbontin, *et al.,* 2021). The shading netting are utilised by interviewees one, three, and four; with their primary function being to safeguard the grapes from birds. However, it also serves as a protective barrier against the intense sunlight. Interviewee two does not utilise them due to a lack of storage space. Consequently, he, like the other interviewees, increases the irrigation of the vines during periods of high temperatures.

The elevated alcohol levels and minimal acidity are a consequence of the high temperatures. Additionally, the market is unwelcoming of the altered aromatic characteristics. It was discovered through research that the joint fermentation of Saccharomyces cervesiae and non-Saccharomyces yeast can result in enhanced freshness and aromaticity (Natrella *et al.,* 2022). The viticulturists are utilising the refractometer to measure the brix level prior to harvesting in order to contend with high temperatures. Interviewee three stated that there are occasionally mingled grapes, as not all of them would have ripened. Interviewee four stated that his vines are approximately 20 years old, which results in significantly reduced yields and elevated sugar levels. Consequently, the sugar is concentrated in fewer grapes. Currently, there is no issue with red wines. Viticulturists blend wines to reduce the alcohol volume if the wine they extract has elevated sugar levels compared to the winery.

Due to rising temperatures, some of the grapes might not be suitable anymore as they require colder climate to grow. This is also done as there is the need for more water use efficiency (WUE) so indigenous grapes might not need as much water as others. Also, the use of clones or rootstock-scion combination with a higher WUE (Gisbert *et al.,*2022).

The interviewees believe that presently, the international grapes are still surviving in Malta. Interviewee four mentioned that the Cabernet Sauvignon is giving good quality but not in abundance. Interviewee one invested into the indigenous grapes and put them on trellis instead of leaving them on a bush vine as this helps prevent diseases. Also, with the trellis system the quantity is controlled and have better quality. Meanwhile interviewee three does not believe that the Ġellewża and Girgentina grapes are even indigenous as they do not manage to produce enough alcohol, and they usually need to be blended. To further sustain interviewee three's argument there is no scientific proof of them being indigenous either. Interviewee one stated that when it comes to clones the viticulturist needs to see what the wine maker wants. It is useless to invest in clones which produce more quantity but have less quality. Interviewee three stated that there wasn't enough research regards to which clones are the best for Malta. Hence, he is hesitant to invest in them. They all mentioned that if clones should be bought, they need to come from similar climates to us such as Sicily, Italy and France. They all have hybrids as the rootstock is different since the vitis vinifera roots used to get attacked from *phylloxera* and that was its cure.

4.3.3 Discussion to cover sub research question 2

The second research method; survey, was employed to determine the level of knowledge among wine consumers regarding the impact of climate change on wine production in Malta in order to address the second sub research question. Additionally, the respondents were asked a limited number of questions during their interviews.

The first three questions of the survey were demographic questions to understand the background of the respondents. There was a good mix of age categories, this makes the research more reliable as you have different aspects from different age groups.

The primary objective of questions four, five, and six was to determine whether the respondents primarily possess knowledge about climate change or on both climate change and its relationship to wine production. The results indicate that the respondents possess a greater understanding of climate change, as the majority indicated that they possess medium to high levels of knowledge. However, when asked about their level of expertise in wine production, the majority responded that they possess medium levels of knowledge. It was observed that most respondents provided the correct answer to queries seven through eleven, indicating that they possess a comprehensive understanding of the subject matter. The result from question twelve indicates that the respondents are aware of the challenges

posed by climate change; however, they are unaware of the strategies employed by viticulturists to address the issue, as also observed by Barber *et al.,* (2023). Specifically, 76% of the respondents reported that they had not observed any modifications to wine production methods that were intended to mitigate the effects of climate change.

People are currently seeking wines that are more environmentally favourable and are willing to pay higher prices, according to Barber *et al*. (2023) and Sgroi, *et al.,* (2023). Regrettably, the Marnisi Estate is the sole organisation in Malta that has made an investment in organic wines. Interviewees three and four are of the opinion that the Maltese population is unaware of the impact of climate change on Maltese wine production. Furthermore, interviewees one and two are of the opinion that the younger generation is becoming more knowledgeable about the impact of climate change on vineyards and is beginning to comprehend its implications. The wine makers and business proprietors are beginning to comprehend the challenges. The survey revealed that 73.1% of respondents are prepared to pay a premium for Maltese wines that are sustainably produced or organic.

The consumers comprehended the necessity for change, as the vineyards that were previously planted in Australia were not able to adjust to the changing climate (Mezei, *et al.,* 2021). Therefore, one of the enquiries was to determine whether the Maltese populace would be amenable to the introduction of new grape varieties that are more adaptable to the new climate. This presents a potential opportunity for viticulturists in the immediate future, as 90.7% of respondents responded in the affirmative.

In terms of managing wine demand, secondary research has indicated that Marsovin has experienced a 20-25% decrease in volume production (Orland Schembri, 2016). Additionally, Bonello (2025) reported that production of international white grape varieties has decreased by 25-40%. According to interviewee one, vineyards have experienced a significant decline in recent years since field proprietors are not cultivating vines and viticulturists are unable to locate suitable fields for the planting of new vines. The average demand for wine in Malta is 14 million, necessitating the importation of wine. Additionally, interviewee four stated that grape farmers are not receiving sufficient compensation and viticulturists are forsaking their vineyards, resulting in a 35% decrease in the amount of land under vines within the next decade. This is a result of the lower yields, the increase in product expenses, and the need for irrigation. The viticulturists are being compelled to cultivate additional vines, even though the majority of them are already around 60 years old

and vines require a minimum of a 25-year investment. In the survey, 56.6% of respondents responded negatively to the question of whether there are sufficient vineyards to meet the demand for wine in Malta, while 43.4% responded positively. This indicates that there is a lack of awareness regarding the situation.

The interviewees are of the opinion that the public should be informed, and since there is a growing interest in wines, they may be more inclined to accept the information provided. Interviewee four is of the opinion that the public must first comprehend the distinction between viticulture and winemaking, as there are no grapes to be pressed in the absence of viticulture. Therefore, wine is sold by generating knowledge about viticulture. The surveys revealed that 66.7% of respondents believed that the industry should increase its education and awareness to adapt to climate change. It was also noted that social media (67.3%) and the news (44.9%) are the primary sources of their knowledge. Additionally, 89% of the respondents do not believe that the wine industry in Malta is adequately educating consumers. 66% of the respondents indicated that their purchasing decisions would be influenced by the provision of adequate information regarding the methodologies employed and the subject matter, as they would be inclined to spend more on the wine. This agrees with Sgroi, *et al.,* (2023).

5. Conclusions

Following analyses of the information obtained from the set research questions, the following conclusions were elicited; experienced viticulturalists claim that the effects of climate change on Maltese wine production are not as drastic as predicted. Wine production can still operate with increased irrigation despite being a costly measure. However, most participants still view the rise in temperature as the primary climatic effect that is harming the vineyards, which is being counterbalanced by increasing frequency of irrigation. Shorter dormancy periods enhance levels of water stress on the vines resulting in less grape yields. Although this is a positive outcome with regards to grape quality, it is causing a great deal of financial constraints to the viticulturist, as local wine producers purchase by volume. Since irrigation is the main technique being implemented to combat the effects of climate change on wine production, the costs of wine production are increasing. Although viticulturalists use shading nets as a technique to repel birds from vines, this is also proving to be effective in reducing heat stress on grapes, mirroring findings from the study by Balbontin, *et al.,* (2021).

The second sub research question was also explored mainly through the surveys. The findings demonstrate that respondents have knowledge about the effects of climate change on wine production but are not as knowledgeable on how the viticulturists in Malta are tackling this issue. Another outcome was that the respondents would be interested in more education about the subject on social media to further expand their knowledge, resulting in the purchasing of more sustainable wines such as organic wines.

If temperatures continue to increase in the coming years, Malta might experience desertification, and serious problems will result for the local wine industry. Viticulturists will have to invest in clones from areas with similar climatic conditions. This research should be re-evaluated in 20-50 years' time to investigate how viticulturalists and wine producers are dealing with a possible further increase in global climate temperatures.

5.1 Recommendations

Viticulturists should invest in large rainwater reservoirs since this allows for the collection of greater volume of rainwater, especially when rain is diminishing both in frequency and intensity. Such measure would assist viticulturalists in maintaining adequately vine health in general and simultaneously minimising irrigation costs.

The experts in this study all implement the drip irrigation system as it is one of the most efficient irrigation systems available presently. Clay-based irrigation technology could be a future possibility, as Busuttil (2024) notes when referring to the trial study conducted in Gozo. This technique is expected to be more efficient as it can significantly reduce the quantity of water used for irrigation with improved nutrient retention. Viticulturists should implement this method if trials prove successful.

Better understanding and communication are needed between viticulturists and wine makers as they need to understand each other's challenges and expenses to produce wine. Winemakers can further use this information to educate their wine customers so that they can understand better why prices must be on the high end, mainly due to the challenges that both viticulturalists and wine makers face to deliver good quality wines to the table.

Moreover, when customers have more informed knowledge about the effects of climate change on wine production, they can be more selective in buying more sustainable wines, a view that is shared by both Barber *et al.,* (2023) and Sgroi, *et al.,* (2023). As a result of this reasoning, wineries should invest more in organic wine production. Surveys showed that there is a potential market locally and with reflection to Wiedmann *et al.,* (2021), if the right marketing strategies are implemented, more wine consumers will opt for organic wines. Marketing should be mainly distributed through social media as it proved to be the most efficient way both from the surveys and literature reviewed. If good quality organic wine is produced, this will have a competitive edge on other wine producers as it would be offering a trendier product. The local *Marnisi* wine being a case in point. Getting a wider perspective on this issue is advisable and therefore, research that targets a larger representative sample of participants will give a clearer and more realistic picture on whether there is a good market for organic wines.

If more wineries are to invest in organic wines, wine makers should renegotiate payment rates to viticulturists who are growing organic grapes due to their higher production costs. Adequate legislation should also be in place to ensure the protection of organic vineyards by giving incentives to neighbouring non-organic growing farmers by changing their wine growing practices. This would also minimise the transmission of pesticides from neighbouring vineyards that would contaminate organic vineyards.

Finally, interviewees recommended that viticulturists should join organisations such as Viti Malta, to ensure more economic safeguarding and market stability.

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7. Appendices

Appendix 1: The Interview Research Matrix.

The research matrix was created to link the interview questions to the themes of the literature review and the research objectives. With this method one reassures that all interview questions that are being mentioned are not out of point. The themes chosen are the subchapters from the literature review and in this way all the objectives are covered.

- CRQ: How can climate change affect the vineyards and terroir of the Maltese Islands?
- SRQ1: What techniques are being used in the vineyard to adapt to climate change for quality winemaking?
- SRQ2: How knowledgeable are wine consumers regards to climate change and its effect on winemaking?

Objectives:
- CRQ = central research question
- SRQ = Sub research question

Themes	Interview Questions	Objectives CRQ and SRQ	How is it related to the Literature Review.
Precipitation levels	1) How much difference do you see in the grape quality from ten years ago when the precipitation levels were higher?	CRQ	(*Jagosz, et al.2022)* Effects of the forecast Air temperature change on the water needs of vines on the region of Bydgoszcz, Northern Poland.
Precipitation levels	2) In what ways do you measure when the vines need more water?	CRQ	(*Ptach et al, 2022)* Effects of the forecast Air temperature change on the water needs of vines on the region of Bydgoszcz, Northern Poland.
Irrigation Systems	3) How are the irrigation costs affecting your business?	SRQ1	
Irrigation Systems	4) Which irrigation system is being used on the vineyards?	SRQ1	
Irrigation System	5) Why did you adopt such an irrigation system?	SRQ1	

Themes	Interview Questions	Objectives CRQ and SRQ	How is it related to the Literature Review.
Improvement of scent of wine through irrigation	6) Which class of water are you using and in what ways do you find the water required?	CRQ	(*Delgado, et al., 2022)* Effects of the irrigation of Chelva grapevines on the aroma composition of wine.
Improvement of scent of wine through irrigation	7) In what way does irrigation improve the scent of wine?	CRQ	*(Gonzalez-Vinas et al., 2022)* Effects of the irrigation of Chelva grapevines on the aroma composition of wine.
Irrigation System	8) How does the quality of wine change through irrigation? (Example: lower yields)	SRQ1	(*Drori et al.,2022)* The effects of irrigation -initiation timing on the phenolic composition and overall quality of cabernet sauvignon wines grown in a semi-arid climate.
Change in Temperature /different yeast used.	9) How are you controlling the high sugar levels in the grapes? (i.e. high alcohol levels).	CRQ/SRQ1	(*Pal -Fam et al.2022)* *(Natrella et.al,2022)* Cultivar-Dependent Effects of non-saccharomyces yeast starter on the oenological properties of wine produced from two autochthonous grape cultivars in Southern Italy.
Change in temperature	10) What ways are your vines being affected by hot temperatures?	CRQ	*(Pal-Fam et al.,2022)* Effects of the forecast air temperature change on the water needs of vines on the region of Bydgoszcz, Northern Poland.

Themes	Interview Questions	Objectives CRQ and SRQ	How is it related to the Literature Review.
Change in temperature	11) How many vines are getting destroyed yearly because of climate change?	CRQ	*(Pal-Fam et al.,2022)* Effects of the forecast air temperature change on the water needs of vines on the region of Bydgoszcz, Northern Poland.
Change in temperature	12) How does your vineyard location help to reduce hot temperatures? (Sea breeze, altitudes.)	SRQ1	
Richer Biodiversity	13) In what ways can organic techniques be used to help fight climate change? (i.e. compost or reducing the use of pesticides)	CRQ	*(Masotti, et al., 2022)* Environmental impacts of organic and biodynamic wine produced in Northeast Italy.
Shading	14) In what ways do you protect the vines from the harsh summer temperatures? Example: Shading nets	SRQ1	*(Balbontin, et al., 2021)* Effects of shading nets on yield, leaf biomass and petiole nutrients of muscat of Alexandria vineyards growing under hyper arid conditions.
Clones, hybrids and indigenous	15) How are the grape varieties adapting in the vineyards? (International and Indigenous)	SRQ1	*(Gisbert et al., 2022)* Characterization of Local Mediterranean Grapevine Varieties for Their Resilience to Semi-Arid Conditions under a Rain-Fed Regime

Themes	Interview Questions	Objectives CRQ and SRQ	How is it related to the Literature Review.
Clones, hybrid and indigenous	16) How can clones of grape varieties be useful to adapt to hot rising temperature? and which countries do we import such clones?	SRQ1	*(Gisbert et al., 2022)* Characterization of Local Mediterranean Grapevine Varieties for Their Resilience to Semi-Arid Conditions under a Rain-Fed Regime
Knowledge of wine consumers	17) How knowledgeable are wine consumers and business owners about climate change and wine?	SRQ2	(Barber *et al.,* 2023) Wine consumers environmental knowledge and attitudes. Influence on willingness to purchase.
Knowledge of wine consumers	18) How are you managing with high demand and how are you approaching it?	SRQ2	*(Mezei, et al.,2021)* Meeting the demands of climate change. Australian consumer acceptance and sensory profiling of red wine produced from non-traditional red grape varieties.
Knowledge of wine consumers	19) How can the general public be informed about the effects of climate change?	SRQ2	*(Mezei, et al.,2021)*

Appendix 2: Survey Questions

The effects of climate change on Maltese wine production.

My name is Jael Ellul, and I am currently pursuing a bachelor's degree in international hospitality management (Hons) at the Institute of Tourism Studies (ITS) Malta. In fulfilment of the dissertation research, a study entitled "The Effects of climate change on Maltese wine production." will be conducted. It appears that climate change is having a significant impact on wine production, as indicated by prior research. Therefore, the primary objective of this study is to examine the extent of wine consumers' awareness of climate change and its impact on winemaking, the various methods employed in the vineyard to adapt to climate change in order to produce high-quality wine, and the impact of climate change on the terroir and vineyards of the Maltese Islands. This dissertation will be beneficial to wine producers and viticulturists, as it will help them to demonstrate to the public the challenges, they are encountering due to climate change. It may also provide them with insights on how to enhance their vineyard techniques and further educate customers on the situation. You are invited to participate in this online survey, which is expected to require approximately 10 minutes to complete. Your participation in this research is entirely voluntary, and you are free to withdraw at any time without the necessity of providing justifications. You have the ability to modify your responses at any point during the questionnaire; however, they cannot be altered after it has been completed. No identification details will be solicited, ensuring that all responses remain anonymous. I am grateful for your willingness to participate in this survey. If you have any concerns or have any further inquiries, please do not hesitate to contact me at jaelellul13@gmail.com

1. What Gender do you identify as?

Mark only one oval.

- ◯ Male
- ◯ Female
- ◯ Other

2. What is your age group?

Mark only one oval.

- ◯ 18-29 years
- ◯ 30-39 years
- ◯ 40-49 years
- ◯ 50+

3. What is your nationality?

Mark only one oval.

- ◯ Maltese
- ◯ Other: _____

4. On a scale of 1-5, to what extent do you understand the concept of climate change? (1 = poor knowledge, 3 = medium knowledge, 5 = knowledgeable)

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

5. On a scale of 1-5 how knowledgeable are you about wine and wine production? (1= poor knowledge, 3= medium knowledge, 5= knowledgeable)

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

6. On a scale of 1-5, to what extent do you believe that the Maltese Island's wine production is impacted by climate change? (1=low impact, 3= medium impact, 5= high impact)

Mark only one oval.

	1	2	3	4	5	
	◯	◯	◯	◯	◯	

7. How, in your opinion, does the production of wine get affected by climate change? (more than one response is accepted)

Tick all that apply.

- [ ] Rising Temperatures
- [ ] Drought
- [ ] Pests
- [ ] Ozone effects
- [ ] Other: _____

8. Do you think that rising temperatures are an issue for grape growing?

Mark only one oval.

- ◯ Yes
- ◯ No

9. In which ways are rising temperatures affecting grape growing in Malta? (more than one response is accepted)

Tick all that apply.

- [ ] Shorter dormancy periods
- [ ] Lower vine yields
- [ ] Harvesting earlier
- [ ] An increase of irrigation requirement
- [ ] Other: _____

10. In your opinion, are there more pests in Maltese vineyards?

Mark only one oval.

- ◯ Yes
- ◯ No

11. Do you think there is an increase or decrease in the quantity of grapes on vines with increased temperatures?

Mark only one oval.

- ◯ Increase
- ◯ Decrease

12. Have you noticed any changes in wine production techniques or practices aimed at mitigating the effects of climate change?

Mark only one oval.

- ◯ Yes
- ◯ No

If the previous question was answered as Yes in which way?

_____

13. Are you willing to pay more for sustainably produced Maltese wines that mitigate the effects of climate change such as organic wine?

Mark only one oval.

- ◯ Yes
- ◯ No

14. Would you be open to new grape varieties which are more adapted to the temperature increase?

Mark only one oval.

- ◯ Yes
- ◯ No

15. What measures do you think the wine industry should take to adapt to climate change? Choose the most effective answer. (more than one response is accepted)

Tick all that apply.

- ☐ New grape varieties selection
- ☐ Adaptive Harvesting Practices
- ☐ Education and Awareness
- ☐ Different wine production techniques
- ☐ Water efficient irrigation systems.
- ☐ Other: _____

16. From where do you typically obtain information about climate change's impact on wine production? (more than one response is accepted)

Tick all that apply.

- [ ] Social media platforms
- [ ] Google search
- [ ] The news
- [ ] From Maltese wineries.
- [ ] Wine courses
- [ ] Other: _____

17. Do you feel the wine industry adequately educates consumers about climate change's impact on wine in the Maltese Islands?

Mark only one oval.

- ◯ Yes
- ◯ No

18. Would knowledge of climate change's impact on wine production influence your purchasing decisions?

Mark only one oval.

- ◯ Yes
- ◯ No

19. Are there enough vineyards in Malta to keep up with the demand of wine consumption?

Mark only one oval.

- ◯ Yes
- ◯ No

Appendix 3. Survey Research Matrix

The research matrix was created to link the survey questions to the themes of the literature review and to link with the objectives and the literature review. With this method one reassures that all survey questions that are being mentioned are not out of point and relates to the literature review. The themes chosen are the subchapters from the literature review and in this way all the objectives are covered.

- CRQ: How can climate change affect the vineyards and terroir of the Maltese Islands?
- SRQ1: What techniques are being used in the vineyard to adapt to climate change for quality winemaking?
- SRQ2: How knowledgeable are wine consumers regards to climate change and its effect on winemaking?

Survey Question	Reason / Theme	Objectives linked to the central research question and sub research questions	Connection to the literature review
1. What gender do you identify as? Male Female Other	Finding out the gender of the respondent	Identify gender group	Knowing the wine consumers
2. What is your age group? 18-29 30-39 40-49 50+	Demographic Question	Age target group	Identifying the respondents age
3. What is your nationality? Maltese Other	Demographic Question	Nationality	Identifying the nationality of the respondents
4. On a scale of 1-5, to what extent do you understand the concept of climate change? (1 = poor knowledge, 3 = medium knowledge, 5 = knowledgeable)	Knowledge question	CRQ/SRQ2	Understanding if the respondents have knowledge on the subject to better understand their background.

Survey Question	Reason / Theme	Objectives linked to the central research question and sub research questions	Connection to the literature review
5. On a scale of 1-5 how knowledgeable are you about wine and wine production? (1= poor knowledge, 3= medium knowledge, 5= knowledgeable)	Knowledge question	CRQ/SRQ2	Understanding if the respondents have knowledge on the subject to better understand their background.
6. On a scale of 1-5, to what extent do you believe that the Maltese Island's wine production is impacted by climate change? (1=low impact, 3= medium impact, 5= high impact)	Knowledge question	CRQ/ SRQ2	Understanding the respondent's perspective about the severity of the effects of climate change on wine production. By analysing questions 4,5,6 the results would mirror Barber *et al.,* (2023) 's findings.
7. How, in your opinion, does the production of wine get effected by climate change? (more than one response is accepted) Rising Temperatures Drought Pests Ozone effects Others	Rising Temperatures Precipitation levels Pests Ozone effects	CRQ/SRQ2	
8. Do you think that rising temperatures are an issue for grape growing? Yes No	Rising Temperatures	CRQ/SRQ2	The effects of irrigation-initiation timings on the phenolic composition and overall quality of Cabernet Sauvignon wines growth in semi-arid climate (Drori *et al.,* 2022).

Survey Question	Reason / Theme	Objectives linked to the central research question and sub research questions	Connection to the literature review
9. In which ways are rising temperatures affecting grape growing in Malta? (more than one response is accepted) Shorter dormancy periods Lower vineyard yields Harvesting earlier An increase of irrigation requirements	Rising temperatures Irrigation	CRQ/SRQ1/SRQ2	Effect of the forecast air temperature change on the water needs of vines in the region of Bydgoszcz, Northern Poland (Atigan *et al.,* 2022) and Scarcity breeds and distinction: Grape harvest 2024 (Bonello, 2025).
10. In your opinion, are there more pests in Maltese vineyards? Yes No	Pests and diseases	CRQ/SRQ2	Climate change impacts and adaptations of wine production (Leeuwen *et al.,* 2024).
11. Do you think there is an increase or decrease in the quantity of grapes on vines with increased temperatures? Increase Decrease	Lower vine yields	CRQ/SRQ2	Sustainable management on the main two indigenous grape varieties for wine making (Falzon 2013) and Scarcity breeds and distinction: Grape harvest 2024 (Bonello 2025).

Survey Question	Reason / Theme	Objectives linked to the central research question and sub research questions	Connection to the literature review
12. Have you noticed any changes in wine production techniques or practices aimed at mitigating the effects of climate change? Yes No	Techniques used in the vineyards to adapt to climate change	SRQ1/SRQ2	-Wine consumers environmental knowledge and attitudes: Influence on willingness to purchase (Barber *et al.,*2023) - Scarcity breeds and distinction: Grape harvest 2024 (Bonello 2025). -The effects of irrigation-initiation timings on the phenolic composition and overall quality of Cabernet Sauvignon wines growth in semi-arid climate (Drori *et al.,*2022). -Meeting the demands of climate change. Australian consumer acceptance and sensory profiling of red wines produced from non-traditional red grape varieties (Mezei *et al.,*2021).

Survey Question	Reason / Theme	Objectives linked to the central research question and sub research questions	Connection to the literature review
13. Are you willing to pay more for sustainably produced Maltese wines that mitigate the effects of climate change such as organic wine? Yes No	Richer Biodiversity	CRQ/SRQ2	Biodiversity conversation, ecosystem services and organic viticulture; A glass half full (Beaumelle *et al.,* 2023) and Wine consumers environmental knowledge and attitudes: Influence on willingness to purchase (Barber *et al.,* 2023).
14. Would you be open to new grape varieties which are more adapted to the temperature increase? Yes No	Different use of grape variety	SRQ2	Meeting the demands of climate change. Australian consumer acceptance and sensory profiling of red wines produced from non-traditional red grape varieties (Mezei *et al.,* 2021)
15. What measures do you think the wine industry should take to adapt to climate change? Choose the most effective answer. (more than one response is accepted) New grape varieties selection Adaptive harvesting practices Education and Awareness Different wine production techniques Water efficient irrigation systems other	Different use of grape variety Earlier harvesting Education and Awareness Different wine production techniques Irrigation practices	CRQ/SRQ1/SRQ2	

Survey Question	Reason / Theme	Objectives linked to the central research question and sub research questions	Connection to the literature review
16. From where do you typically obtain information about climate change's impact on wine production? (more than one response is accepted) Social media platforms Google search The news From Maltese wineries Wine courses Other	Knowledge of wine consumers	SRQ2	Sustainable marketing strategies: a guide for viticulture companies (Usmonova, 2025).
17. Do you feel the wine industry adequately educates consumers about climate change's impact on wine in the Maltese Islands? Yes No	Knowledge of wine consumers	SRQ2	
18. Would knowledge of climate change's impact on wine production influence your purchasing decisions? Yes No	Knowledge of wine consumers	SRQ2	Exploring consumer behaviour and willingness to pay regarding sustainable wine certification (Sgroi *et al.,* 2023).
19. Are there enough vineyards in Malta to keep up with the demand of wine consumption? Yes No	Knowledge of wine consumers	SRQ2	From soil to vine, meeting a Maltese vigneron (A Maltese Pantry, 2020).

Appendix 4. Consent of Name usage, Interviewee 1

I have read this consent form and am giving the researcher the opportunity to carry out the research at my company. I hereby grant them permission to use the information provided as data in the above-mentioned research project, knowing that it will be kept confidential and anonymous.

CARMEL CORTIS		27/04/23
Participant's Name	Participant's Signature	Date
JAEL ELLUL		27/04/23
Researcher's Name	Researcher's Signature	Date

I give Permition for the use of the Company's name

Appendix 5. Consent of Name usage, Interviewee 2

ITS INSTITUTE OF TOURISM STUDIES

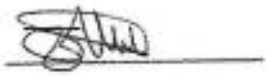
Consent for Name usage.

Dear Sr/ Madam,

I, Jael Ellul, a student at the Institute of Tourism Studies am currently in the final year of my Higher National Diploma, I am carrying out research on the effect of climate change on the Maltese islands.

I had already sent you the information letter about my research and you had provided me with a signed information letter. If you have any further questions for clarification, please do not hesitate to ask me.

By signing this document, you are giving me your consent to use your name in the research.

CARMEL BORG		14/5/25
Participant's Name	Participant's Signature	Date
Jael Ellul		7/06/23.
Researcher's Name	Researcher's Signature	Date

Appendix 6. Consent of Name usage, Interviewee 3

ITS INSTITUTE OF TOURISM STUDIES

Consent for Name usage.

Dear Sr/ Madam,

I, Jael Ellul, a student at the Institute of Tourism Studies am currently in the final year of my Higher National Diploma, I am carrying out research on the effect of climate change on the Maltese islands.

I had already sent you the information letter about my research and you had provided me with a signed information letter. If you have any further questions for clarification, please do not hesitate to ask me.

By signing this document, you are giving me your consent to use your name in the research.

A. MANGION		07/06/2023
Participant's Name	Participant's Signature	Date
Jael Ellul		7/06/23
Researcher's Name	Researcher's Signature	Date

Appendix 7. Consent of Name usage, Interviewee 4

INSTITUTE OF TOURISM STUDIES

Consent for Name usage.

Dear Sr/ Madam,

I, Jael Ellul, a student at the Institute of Tourism Studies am currently in the final year of my Higher National Diploma, I am carrying out research on the effect of climate change on the Maltese islands.

I had already sent you the information letter about my research and you had provided me with a signed information letter. If you have any further questions for clarification, please do not hesitate to ask me.

By signing this document, you are giving me your consent to use your name in the research.

Gerald Vella		16/05/2025
Participant's Name	Participant's Signature	Date
JAEL ELLUL.		16/05/2025
Researcher's Name	Researcher's Signature	Date

Appendix 8. Information Letter provided to Interviewees one to four

Information Letter

Name and Surname of Researcher: Jael Ellul.

ID number of researcher: 98500L

Email address of researcher: jael.ellul001@its.edu.mt

Mobile number of researcher: 79254783

Course: HND in Food and beverage Management.

Tutor name and surname: Aaron Rizzo

Tutor office telephone number:

Title of the Long essay/Dissertation: The effects of climate change on Maltese wine production.

Aims of the research:

1) How can climate change effect the vineyards and terroir on Maltese Islands?

2) What techniques are being used in the vineyards to adapt to climate change for quality wine making?

3) How knowledgeable are wine consumers regards to climate change and its effect on wine making?

Dear Sir / Madam,

I, Jael Ellul, a student at the Institute of Tourism Studies am currently in the final year of my Higher National Diploma, I am carrying out research on the above-mentioned title.

My research is about the effects of climate change on wine production. The method of data collection will be interviews. The data collected from the interviews will be used for the sole purpose of this research. The data will be collected by asking questions in a audio recorded face-to-face interview at your esteemed company. The data will be collected in a Thematic analysis and will be transcribed. The data will be thoroughly analysed to collect the answers

to the above-mentioned aims of the research. I am kindly asking for your consent to have a face-to-face interview with you. The purpose of this letter is to provide you with information so you can decide whether to participate in this study. Any questions you may have will be answered by the researcher.

There are no known risks related with this research project other than possible discomfort with the following:

- You will be kindly asked to be honest when answering questions.
- Any audio recorded data will be used for transcription purposes, after which it will be destroyed.

The information collected will be kept strictly confidential. All data will be stored securely and will be made available only to researcher. No reference will be made in oral or written reports that could link you to the study. Your identity will not be revealed in any publications that result from this study.

You can terminate your participation at any time without prejudice. Participation is voluntary. You do not have to answer individual questions if you do not want to. Your name or the name of your company will not be attached to the analysis of the results. and will ensure that your participation remains confidential. Kindly, contact me if you have any queries or require any further clarification.

Participant's declaration

I have read this consent form and am giving the researcher the opportunity to carry out the research at my company I hereby grant them permission to use the information provided as data in the above-mentioned research project, knowing that it will be kept confidential and anonymous.

Appendix 9. Consent Form provided to Interviewees one to four

Consent Form

ITS INSTITUTE OF TOURISM STUDIES

Name and Surname of Researcher:

ID number of researcher:

Email address of researcher:

Mobile number of researcher:

Course: HND in Food and Beverage Management

Tutor name and surname: Aaron Rizzo

Tutor office telephone number:

Title of the Long essay/Dissertation: The effects of Climate change on Maltese wine production.

Dear Sir / Madam,

I, Jael Ellul, a student at the Institute of Tourism Studies am currently in the final year of my Higher National Diploma, I am carrying out research on the above-mentioned title.

I had already sent you the information letter about my research and you had provided me with a signed information letter. If you have any further questions for clarification, please do not hesitate to ask me.

By signing this consent form, you are giving me your consent to use the data collected through the Interview for the analysis of the results. I will send you a list of questions before the Interview so you can prepare yourself beforehand.

The information collected will be kept strictly confidential. All data will be stored securely and will be made available only to those individuals conducting the study. No reference will

be made in oral or written reports that could link you to the study. Your identity will not be revealed in any publications that result from this study. Unless approved.

You can terminate your participation at any time without prejudice. Participation is voluntary. You do not have to answer individual questions if you do not want to. Your name will not be attached to the Interview and will ensure that your participation remains confidential. Kindly, contact me if you have any queries or require any further clarification.

Participant's declaration

I have read this consent form and am giving the researcher the opportunity to carry out the research at my company. I hereby grant them permission to use the information provided as data in the above-mentioned research project, knowing that it will be kept confidential and anonymous.

Appendix 10. Permission Letter provided to Interviewees one to four

Permission Letter

INSTITUTE OF TOURISM STUDIES

Name and Surname of Researcher: Jael Ellul

ID number of researcher: 98500L

Email address of researcher: jael.ellul001@its.edu.mt

Mobile number of researcher: 79254783

Course: HND in Food and Beverage Management.

Tutor name and surname: Aaron Rizzo

Tutor office telephone number:

Title of the Long essay/Dissertation: The effects of climate change on Maltese wine production.

Aims of the research:

1) How can climate change effect the vineyards and terroir on Maltese Islands?

2) What techniques are being used in the vineyards to adapt to climate change for quality wine making?

3) How knowledgeable are wine consumers regards to climate change and its effect on wine making?

Type of participants: Viticulturists and Winemakers.

Number of participants required: 4

Dear Sir / Madam,

I, Jael Ellul, a student at the Institute of Tourism Studies am currently in the final year of my Higher National Diploma, I am carrying out research on the above-mentioned title.

I have read this consent form and am giving the researcher the opportunity to carry out the research at my company. I hereby grant them permission to use the information provided as data in the above-mentioned research project, knowing that it will be kept confidential and anonymous.

There are no known risks related with this research project other than possible discomfort with the following:

- Everyone will be asked to be honest when answering questions.
- Any audio recorded data will be used for transcription purposes, after which it will be destroyed.

The information in the study records will be kept strictly confidential. All data will be stored securely and will be made available only to those individuals conducting the study. No reference will be made in oral or written reports that could link you to the study. Your identity and the identity of the participants will not be revealed in any publications that result from this study.

Participants can terminate their participation at any time without prejudice. Participation is voluntary. Participants do not have to answer individual questions if they do not want to. Your name and the participant's names will not be attached to the interviews, and this will ensure that everyone's information remains confidential. Please, kindly contact me if you have any queries or any further information or clarification.

Participant's declaration

I have read this consent form and am giving the researcher the opportunity to carry out the research at my company. I hereby grant them permission to use the information provided as data in the above-mentioned research project, knowing that it will be kept confidential and anonymous.