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Unveiling the Motivations Behind Cultivating Fungus-Resistant Wine Varieties: Insights from Wine Growers in South Tyrol, Italy

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Abstract: A significant amount of fungicides consumed in European agriculture are used in viticulture, despite vineyards only occupying a very limited percentage of the cultivated area. Cultivation of disease-resistant hybrid grape cultivars can reduce vineyard treatments by half, with a significant decrease in climate-altering emissions, farmer costs, occupational injury risks, and excessive soil compression. The objective of this study is to investigate the motives and barriers that winegrowers in South Tyrol, Italy face when considering the conversion to fungus-resistant grape varieties (PIWI) farming. We conducted a qualitative study using in-depth interviews and participant observation with winegrowers to gain insight into their perspectives on the reasons for and challenges in adopting or practicing PIWI viticulture. The paper tests two hypotheses: the environmental commitment and concerns of producers with their personal values and environmental ethics in adopting PIWI varieties and relational and social influences, leading producers towards the consideration of social sustainability. The results present a picture aligned with the existing literature, emphasizing a stronger commitment to environmental sustainability while also considering economic and legislative constraints in the cultivation of a niche wine variety, which still has a limited market presence and distribution.

Keywords: sustainable viticulture; social sustainability; PIWI; farmers' motivations



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1. Introduction

The current expectations outlined in the Green Deal [1,2] emphasize that agriculture must not only meet the challenge of feeding a growing global population but also ensure the broad expectation of sustainability. This entails the ability to compete economically in a liberal market while simultaneously safeguarding the environment and enhancing the social well-being of farmers, workers, communities, and society at large. This holistic perspective necessitates a comprehensive approach along the entire production and distribution chain, encompassing farmers, processors, wholesalers, retailers, and consumers [3–6].

Within this agricultural framework, it is essential to recognize that it is a social arena shaped by roles and regulations across the supply chains, engaging all stakeholders in structured processes within physical and social frameworks. These interactions, whether formal or informal, may adhere to norms, traditions, and legal frameworks at various levels. The winegrowing sector has a long history of commitment to promoting more sustainable development, and several initiatives are under way worldwide [7]. Over the past 20 years, various approaches to implementing sustainability in the wine industry have been developed and applied, including voluntary standards and management systems with associated certification processes [8]. Among these, a significant increase in the Protected Designation of Origin and Protected Geographical Indication wines has been

registered in the past years in line with Article 93 of the Regulation (EU) 1308/2013 [9]. The orientation towards sustainability has been primarily embraced by organic and biodynamic producers because these approaches are inherently aligned with sustainable practices. Organic farming prohibits the use of synthetic chemicals, focusing instead on natural inputs, which reduces environmental impact and promotes biodiversity. Biodynamic farming goes a step further by incorporating holistic practices that consider the farm as an interconnected ecosystem, emphasizing soil health, crop rotation, and the use of natural preparations [10,11], and, as a reflection of Rudolph Steiner's thoughts, today biodynamic certifications are usually issued by the Demeter Association with specific attention to minimizing the use of sulfur dioxide [12].

This paper will focus on the decision to cultivate fungus-resistant grape varieties by analyzing motivations or drivers behind wine growers' choices to cultivate these particular grapes, which offer unique advantages, such as the ability to significantly reduce or eliminate the need for pesticides beyond what is required for organic or biodynamic farming [13]. By exploring the reasons behind this choice, involving the totality of PIWI (PilzWiderstandsfähige Rebsorten—fungus-resistant grape varieties) wine producers of South Tyrol (IT), the paper seeks to shed light on the intricate factors that influence the adoption of PIWI varieties, starting from the decision to adopt an organic or biodynamic approach or to cultivate together traditional and fungus-resistant grapes. It is important to highlight that PIWI varieties are often cultivated using an organic approach, as organic wine growers are already committed to sustainable production. Notably, when comparing the number of treatments required, PIWI varieties demand fewer interventions than traditional organic wines.

This study is part of an interdisciplinary research project, titled "Towards sustainable viticulture: a case study on wines from resistant grape varieties in South Tyrol", aimed at understanding the implications of sustainability within the production of fungus-resistant wines (from now on PIWI—from the German Pilzigwiderstandsfähig Rebsorten) in South Tyrol (Italy), considering economic, agronomic, oenological, and social aspects. The viticultural sector in the region counts 4800 producers, with a vinery extension of 5800 hectares located between 200 and 1000 m above sea level and an average farm size of 1 hectare, representing less than 1% of Italian vinery area. A total of 98% of wines have a geographical identification label (DOCG—Denominazione di Origine Controllata e Garantita, controlled and guaranteed origin denomination); the overall production is about 40,000,000 bottles, 65% red and 35% white wines [14]. Viticulture is highly grounded in the culture and tradition of the land: archeologists have revealed that wines have been produced in the area since 500 B.C.E. PIWI vines cover approximately. In the last two centuries, however, pathogens have been increasing in number and danger. Grapes are, in fact, susceptible to several pests and pathogens, including gray mold (*Botrytis cinerea*), downy mildew (*Plasmopara viticola*), powdery mildew (*Uncinula necator*), and grape moth (*Lobesia botrana*). To combat these pests, the agrochemical industry has developed fungicides and insecticides, including potential alternatives to synthetic pesticides in wine production, such as biopesticides and biological agents [15]. Fungus-resistant varieties have a relevant potential in naturally contrasting pests. The high level of agrochemicals in vineries is no longer suitable under the European Green Deal and the Farm to Fork strategy, and PIWI vines are recognized as a possible solution to environmental impact reduction in agriculture [16].

Cultivating these wines, which are inherently more resistant to fungi and thus require fewer pesticides, already positions growers on the path toward more sustainable agriculture. However, the reasons behind their choice can be varied and sometimes contradictory. This paper investigates the specific motivations of wine producers by exploring their understanding of sustainability in its main senses, the environmental and the social. While

there is extensive literature on sustainability in agriculture (among others, [17–19] and numerous studies on sustainability in viticulture, some studies cover the topic of the motivations and drivers of wine growers [10,11,20–24], but no studies pertain to PIWI wine growers.

The SUWIR project adopted an interdisciplinary approach to understand the implications of integrating such varieties into the wine sector from the social, environmental, and economic perspective. Specifically, against the framework proposed by the existing literature, we aimed to analyze the case of South Tyrolean PIWI wine producers, drawing on two key hypotheses, which focus on understanding the motivations for such choices in this region. We sought to determine whether the primary drivers for these South Tyrolean wine growers are predominantly environmental or relational-social in nature. This approach helps clarify whether the decision to adopt PIWI grapes is rooted in ecological concerns—such as reducing chemical use and fostering sustainability—or in the growers' relationships with their peers, networks, and communities. We attempted to identify the main drivers by testing the following hypotheses, aligning with broader discussions in the literature, providing context-specific insights into the dynamics behind sustainable viticulture choices:

Hypothesis 1. *Environmental commitment.*

This hypothesis posits that wine growers adopt PIWI wine varieties primarily due to environmental concerns. The expectation is that wine growers are motivated by a desire to engage in more sustainable agricultural practices, which include reducing the environmental impact of their cultivation methods. This commitment reflects a broader ethos of preserving the natural environment and promoting biodiversity, aligning with personal values and environmental ethics.

Hypothesis 2. *Relational-Social Influences.*

This hypothesis suggests that the adoption of PIWI wine varieties is significantly influenced by relational and social factors. These factors include maintaining family traditions, strengthening community ties, and preserving the cultural heritage associated with wine growing in South Tyrol. The context of South Tyrol is an internationally renowned geographical area to produce high-quality wines. Situated in northern Italy, the Autonomous Province of Bolzano—South Tyrol boasts a unique mountainous terroir, with a wide range of exposures, altitudes, and soil types contributing to the diversity of its wines. The grape varieties range from classic international varieties such as Pinot Noir, Chardonnay, and Sauvignon Blanc to indigenous varieties like Gewürztraminer, Lagrein, and Schiava. The PIWI wines studied in the project, produced from disease-resistant grape varieties, indeed represent a niche segment in South Tyrol's wine production landscape, but in recent years, there has been growing interest among winemakers in experimenting with and incorporating disease-resistant grape varieties into their vineyards.

In the article, we are offering a conceptualization of environmental and social sustainability, deepening the relationship between PIWI wines and these concepts. A methodological paragraph describes the context of South Tyrol and the adopted approach. Finally, in Sections 5 and 6, the hypothesis offers an understanding of the motivations of the PIWI wine growers.

2. Conceptualizing Environmental and Social Sustainability in Agriculture

The United Nations Commission on Environment and Development provides the most widely accepted definition of sustainability as the capacity of human actions to ensure present livelihoods without compromising the ability of future generations to meet their own needs [5]. Despite the pervasive use of the term sustainability today, there is often a lack of precise definition, particularly concerning its social dimension [25]. Sustainability encompasses three key pillars: environmental, social, and economic [26]. The definition of sustainability is shaped by the context and cultural perspectives of stakeholders [6] and is inherently context-dependent [4]. Moreover, moral conflicts can disrupt the functioning of social agricultural systems, potentially conflicting with the notion of agricultural sustainability within specific contexts.

The discourse on environmental sustainability has generally prevailed both in the literature studies and in cultivation practices, often making social sustainability a sometimes-neglected concept. Social sustainability emerged prominently in academic debates following the Millennium Summit in September 2000 [27]. One of the major challenges lies in the definition [5]. Hale et al. [28] propose three overarching orientations: firstly, social changes that facilitate environmental sustainability; secondly, the preservation of socio-cultural structures and practices threatened by social and economic shifts; and thirdly, values related to social justice and the mitigation of inequalities. The intrinsic connection between individual and collective well-being and the specific cultural context of individuals and communities [6] makes sustainability contingent upon a particular time and challenging, even at the policy level [29], to determine the resources future generations will require to satisfy their needs.

Various scholars tend to narrow social sustainability to the labor dimension, focusing on aspects such as fair wages, working conditions, security, and inclusion, despite acknowledging the complexities of these working conditions [30]. A further conceptualization of social sustainability is provided by Anastasova-Chopeva [31], who proposes five dimensions: (1) equity, (2) diversity, (3) social cohesion, (4) quality of life, and (5) democratic governance. Conversely, Nicli et al. [32] introduce five principles of social sustainability: (1) empowerment and integration of disadvantaged people, (2) promotion of ecological farming practices, (3) protection of nature and landscape resources, (4) support for the local community, and (5) education for sustainable development. Janker et al. [25] advocate for examining interactions at a broader interpersonal level to comprehend the formation of sustainability concepts. They emphasize understanding how these interactions shape individuals' perceptions and, consequently, which indicators may be appropriate for measuring sustainability, underscoring the importance of viewing farms as complex systems intricately linked to the broader social macro-system. The complexity of the system makes it not only difficult to assess its ability to be sustainable in its various aspects [33], but also to propose alternative solutions and adjustments to the failures it presents, especially in the agricultural sphere [34], measuring quantities such as food safety, animal welfare, and landscape quality [35] and the ability to provide social, environmental, and economic sustainability through multifunctionality [36]. Medland [37] noted, for example, a greater capacity of organic agriculture to offer spaces for social sustainability, while other authors tend to find a systemic social unsustainability in agriculture when it involves migrant labor [38–40], while Prause [41] denounces the risks inherent in the forced digitization of the agricultural sector in terms of labor exploitation, farmers' autonomy loss, and power dynamics among the food value chain.

The process of assessment of social sustainability itself remains challenging and sometimes conflicting with economic or environmental sustainability [42,43]. Achieving

social sustainability in agriculture is particularly arduous, although there are instances where greater economic sustainability can provide a foundation for enhanced social and environmental sustainability [44]. Assessing social sustainability in agriculture, as well as the social objectives agriculture might pursue, necessitates considering both individual and collective welfare aspects, transcending agriculture's role as mere food production [45]. Small-scale farmers exhibit greater sensitivity, prioritize worker welfare, and demonstrate better environmental stewardship in their working and living environments, although they may struggle to realize economic benefits from these practices due to a lack of marketing and communication skills. Conversely, large-scale producers often prioritize economic sustainability and profitability over social sustainability, relegating it to a secondary concern or dismissing it altogether if it conflicts with economic imperatives [46].

2.1. Fungus-Resistant Varieties, Organic and Biodynamic Wines: Different Steps Towards More Sustainable Agriculture

In agriculture, the question of sustainability is first read from the environmental perspective and often linked to diminishing the use of pesticides and/or adapting to climate change, which poses major challenges for viticulture and agriculture in general. Pomarici et al. [47] note, however, that in the adoption of sustainability practices in agriculture, the economic benefits, both directly from reduced costs and indirectly from increased revenues, far outweigh the costs involved in adopting the practices. Already, Pilgeram [44] had identified a disconnection between the environmental and social ideals of farmers on the one hand and a lack of market response so that producers often find themselves in a dilemma between moral ambitions and self-exploitation.

Both organic and biodynamic farming share key elements that contribute to sustainability: organic farming avoids synthetic fertilizers, pesticides, herbicides, and genetically modified organisms (GMOs); focuses on natural processes to enhance soil fertility, crop health, and biodiversity; and furthermore, biodynamic farming emphasizes minimizing external inputs and enhancing the self-sufficiency of the natural ecosystem. Biodynamic farms often aim to produce their own feed, fertilizers, and seeds, reducing dependence on external resources and preserving the fertility of the soils in a natural way [20,21,48].

In this picture, fungus-resistant varieties come as a forward level in sustainable practices: resistant vines are a step toward more regenerative viticulture, where farming practices restore and enhance ecosystems rather than deplete them. By enabling grape growers to reduce or eliminate chemical inputs, these varieties contribute to soil health, biodiversity, and the overall sustainability of wine production. Länn and Wikholm [49] offer an interesting perspective, reporting how in Sweden many vine growers use resistant varieties and undertake organic production, partly due to the very strict regulatory restrictions on the use of pesticides. In Sweden, copper, which is allowed in organic farming throughout Europe, is prohibited. In general, the authors note that among Swedish winegrowers there is a strong inclination towards organic practices, first and foremost for ideological reasons linked to the protection of the environment and people's health, and that these practices are strongly favored by the choice of resistant grape varieties. The authors go on to highlight the economic benefits of adopting PIWI varieties, considering the amount of spraying required by conventional varieties, with the consequent consumption of time and hydrocarbons, as well as the cost of plant protection products.

The reduction in pesticide use, in particular fungicides, in the cultivation of PIWI varieties is considered an essential innovation to promote environmentally sustainable cultivation, the only reliable one currently available according to the study by Thiollot-Scholtus et al. [50] in the perception of producers. Nesselhauf et al. [13] point out that 70% of fungicides in Europe are used in viticulture compared to only 7 percent of the agricultural area devoted to grape production. This fact, according to the authors, is

strongly criticized by the public, and consumers are increasingly sensitive to the issue, rewarding those initiatives that favor pesticide reduction. Galletto et al. [51] also claim that the ecological benefits of reduced spraying in the vineyard due to the fungal resistance of PIWI vines also have a considerable economic effect. The study shows that the net gain from the production of PIWI wines is between 40 and 80% due to the reduction in costs, not to mention the reduction in water consumption and subsequent costs. Already Basler and Pfenninger [52] had noted that the reduction in the use of fungicides, including copper in organic farming, meets with great favor among consumers, in return for substantial organoleptic equivalence, and produces a reduction in farm costs. Vecchio et al. [53] further pointed this out in a recent study, highlighting the limitations of organic farming in the massive use of copper. While there is, however, a strong consumer demand for ecologically sustainable products, it should be noted that PIWI wines are not always favored by the public, nor are they so widely supported by public and private regulators so far.

Borrello et al. [54] clearly show how a strong reason for hostility towards PIWI wines stems from the mistaken belief of many consumers that they are GMO (genetically modified organisms) products, even if they are not, given the fact that the new varieties are obtained through natural pollination and not genetic engineering. In this case, the environmental relevance of the product takes second place, and even when informed of the reduced impact of these crops on the environment, the negative judgment remains. A second motivation highlighted by the authors lies in the hostility to change and an attachment to tradition. In this case, even correct information on the differences between resistant varieties and GMOs does not increase the propensity to buy. In another study, Pomarici and Vecchio [55] in fact emphasized the importance of a correct communication of environmental aspects as well as of the way in which these resistant varieties are obtained to foster public knowledge that overcomes barriers due to lack of awareness.

Although there is a concern regarding the product's recognizability in wine consumption due to the low 'historicity' of PIWI varieties [56], the choice to cultivate resistant varieties seems to be related to how the product is marketed. Research by Krauss, Legrand and Sloan [57] indicates that 71.3% of PIWI wines in Germany are sold directly to the final consumer, 22.5% through retailers, and 6.2% to the restaurant trade, although with significant differences from winery to winery. The study shows how direct sales are functional in appropriately communicating information about the product and its specificities, offering the possibility of trying and getting to know varieties that are still largely unknown and therefore little accepted, primarily by the retailers themselves. The same study also highlights how many farmers who produce resistant varieties recognize a greater economy in terms of reducing production costs compared to conventional varieties. This would allow a lowering of prices, which is, however, not the preferred line of producers who can thus obtain a higher margin, also counting on the increased demand for organic wines. Lower production costs are attributable to lower costs of raw materials such as pesticides and fuels, as well as lower labor costs in treatments.

2.2. Ideological and Values-Based Assumptions in the Choices of Winegrowers

The motivations related to the possibility of pursuing more sustainable agriculture can be framed in different ways, from the choice of making environmentally friendly cultivation a way of life with a very strong personal and political commitment to the somewhat opportunistic and 'reformist' rather than revolutionary choice [58]. In some cases, there is also a retro-innovative tendency, which sees, for example, organic farming as a way of returning to ancient practices, tradition, and pre-industrial habits, paradoxically held back by a strong resistance to change and a fear of assuming risks [59]. In this vein, McCarthy et al. [33] emphasized how Irish farmers value the farmer's lifestyle, being

outdoors, being free to self-organize, but also carrying on the family business, valuing the knowledge and skills they have inherited, while at the same time showing fear of land abandonment and social decline in rural areas. Knowledge transmission is a key element in sustainability practices, as argued by Trigo et al. [60], who highlighted how awareness in the transition to a more sustainable approach is closely related to the degree of personal and emotional involvement, not just technical skills.

McCarthy et al. [33] have also highlighted in the agricultural sector the relevance of relational values and reciprocal influences between actors in an area in determining the behavior deemed virtuous, which can outweigh the economic benefits in regulating the behavior of individuals. The “behavioral factors synonymous with psychological factors are those cognitive, emotional, personal, and social processes or stimuli underlying human behavior” [61] can be subdivided into cognitive factors (perceived control, perceived costs and benefits, expected consequences, perceived risks), social factors (prescriptive norms, descriptive norms, social positioning, and status), and personal predispositions (resistance to change, productive goals, tolerance to risk, personality, environmental, and moral concerns).

3. Materials and Methods

Studying PIWI wines in South Tyrol is valuable due to the existence of a distinctive and engaging niche of producers in the region [14]. Even though they are a small group, the 27 PIWI producers in South Tyrol provide a rich source of data, as their motivations, practices, and outcomes can offer deep insights into the adoption of sustainable agriculture practices. Considering the small dimension of the target population, a qualitative approach has been privileged to grasp in-depth details. Data collection was conducted in spring 2023 through typical qualitative methods: farm visits with direct observation, collection of field notes, semi-structured in-depth interviews with producers, and a multiple-response and open-ended questionnaire through an online survey to the wineries (Table 1).

Table 1. Stakeholders involved in the study and timing.

Method	Number	Timing
Documental analysis (Website)	27	January–March 2023
In-depth interviews	7	March–April 2023
Online survey	6	May–June 2023
Participant observation	2	September 2023
Interview with the director of the Südtirol Association	1	April 2023

A second step of the data collection has been made through document analysis [62], specifically analysis of the wineries’ public communication through different media channels, namely websites and social media posts. This cross-references is at the base of triangulation to obtain higher reliability in a qualitative study [63]. Through the document analysis, we have identified the organic, biodynamic, or conventional approach to agriculture and the typology of wines cultivated (if just PIWI varieties or also traditional ones). Finally, the presence of certifications or self-declarations related to the sustainability of the wineries.

The analysis of the study was carried out in two phases, each focusing on different data sources to explore the motivations behind the adoption of PIWI varieties by South Tyrolean wine growers. The first phase involved a qualitative analysis of data gathered from interviews, observations, field notes, and other forms of direct interaction with wine growers. Using thematic analysis [64,65], the research aimed to identify recurring patterns

and themes related to the motivations and attitudes of these farmers. By systematically coding and analyzing the transcripts, this phase explored how growers perceive PIWI wines, their views on sustainability, and how these new practices fit into their broader agricultural strategies.

The data collected in the second phase (document analysis) have been cross-referenced with the insights from the first phase to verify the growers' predisposition toward sustainable practices. Specifically, it sought to establish whether these wine growers had already adopted organic or biodynamic farming practices before introducing PIWI varieties, providing a clearer understanding of their commitment to sustainability.

In the following section, we refer to the interviews by identifying quotes with I and to the survey with Q; the subsequent number refers to the producer ID as listed in Table 2.

Table 2. Source of information, approach, type of cultivation, and certifications.

ID	Data Collection Method	Organic Certified	Only PIWI	Other Labels
1	Survey + website	Yes	No	Bioland ¹ + Vegan ² + 'Vignaioli indipendenti' ³ + Demeter ⁴
2	Website	No	No	
3	Survey + website	No	Yes	
4	Survey + website	Yes	Yes	Bioland + Vignaioli indipendenti
5	Website	Yes	No	Bioland + Vignaioli indipendenti
6	Website	No	No	
7	Interview + web	Yes	No	Bioland + Vignaioli indipendenti
8	Website	No	No	
9	Survey + website	Yes	No	Natural wine ⁵
10	Website	Yes	No	Bioland
11	Website	No	No	
12	Survey+ website	No	No	
13	Website	Yes	No	Tyrolensis ars vini ⁶
14	Website	Yes	No	
15	Website	No	No	
16	Interview + web	No	No	
17	Interview + web	Yes	No	
18	Interview + web	Yes	No	Bioland + Vignaioli indipendenti
19	Website	No	No	
20	Interview + web	Yes	No	Demeter
21	Website	Yes	No	Bioland + vignaioli indipendenti
22	Website	Yes	Yes	Natural wine
23	Website	Yes	No	Bioland
24	Interview + web	Yes	No	Natural wine + bioland
25	Website	No	Yes	
26	Survey+ website	Yes	Yes	BioWeis (Bio-Wein-Valle d'Isarco) ⁷
27	Interview + web	Yes	No	Demeter

¹ www.bioland.de (accessed on 28 November 2024): a German-based network of producers; ² several organizations offer this certification related to avoiding animal exploitation and animal ingredients in foods and beverages; ³ www.fivi.it/ (accessed on 28 November 2024): a local network of wine producers not affiliated to cooperatives; ⁴ www.demeter.de (accessed on 28 November 2024): a globally diffused third-party certification without legal recognition concerning biodynamic production techniques, related to Rudolf Steiner's teachings and anthroposophical philosophy; ⁵ it is not a certification but a self-declared way of production avoiding any chemicals even in the cellar; ⁶ www.tyrolensis-ars-vini.it (accessed on 28 November 2024): a local network of wine producers in South Tyrol; ⁷ <https://radoar.com/it/gruppo-bioweis/> (accessed on 28 November 2024): a local wine producers network.

4. Results

4.1. The Understanding of Sustainability for PIWI Producers in South Tyrol

From the qualitative data, a clear understanding of the term sustainability as associated primarily with environmental sustainability emerges. For farmers, this concept can be interpreted in three main ways. First, there is a view that adheres to the classic definition: sustainability in agriculture has to do with preserving resources for the future. In particular, farmers who refer to this aspect are concerned with the preservation of soil fertility, but also water and air health and biodiversity:

“We also work biodynamically and there it is a question for us not only how to keep the land fertile, but also how to make it more fertile, for future generations. And there also the tractor rides don’t, if you only do 8 passes with the tractor on the soil or if you do 25 that also makes a difference [...] we don’t want to consume what we already have, you know, air, soil fertility, bridges, materials. For us sustainability is respect for the environment and for other people, but above all, as I said before, trying to carry on what we have for the future” (I20).

Second, sustainability is recognized as a holistic approach, bringing together a whole series of business choices. In addition to the careful use of resources, they go so far as to consider the materials used, e.g., by using wooden poles instead of concrete ones, to favor renewable energy sources by achieving 100% locally produced energy using biomass and photovoltaics, or even the use of animals for weed control and the preservation of biodiversity. One producer goes so far as to speak of sustainability as an epistemological question:

“It is a matter of epistemology, that is, how you observe reality. So taking care of yourself is the first key ... it is the only key to, let’s say, increasing or having environmental sensitivity. Why? Because we are used to having or thinking about a boundary. I mean, between us and the environment. I mean, physics says that even if we see 3 to 50, at 700 nanometres physically the boundary is not there between me and what is outside. This means that if I see myself as part of the environment, and if I feel emotionally part of the environment, I should care about the environment. So sustainability means breaking this vision where I’m outside the environment and not part of it” (I7).

A third understanding of sustainability limits this issue in agriculture to a question of reducing inputs, both in terms of pesticides and greenhouse gases from tractor rides. A producer who has been working with resistant varieties for years, not only in grape production but also in the selection of new varieties and seedling production, reports:

“[Sustainability] is first and foremost about keeping our soil healthy, because every chemical ends up in the soil. Keeping the water table healthy, and that is perhaps the most important thing even. Keeping the air healthy as well. [...] With PIWI wines] we talk about the 50% reduction of possible applications. We are also talking about a certain CO₂ footprint” (I17).

Sustainability, for producers of wines from resistant vines, is therefore a matter of reducing the use of chemicals on the farm, a commitment to preserve soil, water, and air for future generations. Some producers testify to using a holistic approach to farming and life, of greater reconnection with the natural environment.

The argument of heroic viticulture—often framed as a practice that respects and works in harmony with nature—has become the flagship narrative of the PIWI Association.

“Viticulture is highly dependent on crop protection products in the form of chemical or biological agents (fungicides). Without the regular use of these ‘repellents’, high quality wine production would not be possible. This applies to both conventional and organic viticulture. PIWI are the true heroes among vines. They do not need these constant

fungicides because they are natural robust against fungal diseases we are. They are sustainable and environmentally friendly because they require very few ecological crop protection agents and crop care products to produce excellent wines with an exciting variety of flavours. This directly protects the environment because few pesticides enter nature.” (PIWI Südtirol website).

In fact, the producers themselves, without significant differences, recognize the cultivation of resistant varieties as a way of reducing environmental impact and thus as an important step towards greater environmental sustainability precisely due to the radical reduction in treatments on the plants and, consequently, passages with agricultural equipment.

“The planting is 10 years old and we have not done any treatment on either the vines or the soil” (Q12).

Regarding social sustainability, we encountered challenges in defining *“what social sustainability is”*. Many interviewees described it as a *“complex question”* (Q9), *“difficult to answer”* (I7), or admitted, *“I have never thought about it”* (I20). However, upon further exploration, two key themes emerged: the quality of life for workers and their human development and self-fulfillment. Quality of life is broadly described as *“enhancing the living conditions”* (Q1) and *“ensuring people feel good”* (Q4). One respondent encapsulated well-being as the satisfaction of continuing to work in the same company—a notable sentiment in South Tyrol, where job opportunities are abundant.

“For me, if the worker does his job well, and in the morning when we start he is punctual and laughs then it means that he likes what is going on during the day. And we try to make the work comfortable” (I20).

Some producers go a step further by better declaring what well-being represents and going as far as talking about *“personal development”* (Q3), involving people in decisions:

“Applying a very simple concept, ethics in daily work, respect for people, involving them in decisions, training them and giving them the chance to develop” (Q9).

The role of resistant wines in promoting social sustainability is first and foremost related to less exposure to pesticides, less work, and therefore a lower risk of accidents. The issue of toxic substances inhaled by farmers is largely present in all the interviews and questionnaires, and so the resistance of PIWI wines allows for a significant reduction in the use of fungicides so that these plants contribute to *“keeping us who work every day among the wines healthy and ultimately having a non-polluted product”* (I17).

Fewer treatments also translate into less work, as PIWI vines do not need any treatment, unlike organic crops, albeit with less impactful substances. This is of particular benefit to the so-called second farmers, those who have another main job and being a farmer is a second job:

“Many small producers who have another job, it’s like that here in general, who have little land, maybe taken from dad or granddad, there logically for them it would be a big advantage if they can plant PIWI, because there is less work, then those people have to do it on their days off no, if they have another fixed job” (I20).

Less work also means fewer accidents at work, a very relevant topic in agriculture. Particularly in South Tyrol and mountainous areas, where soils are often steep and there is an increasing tendency to cultivate in inaccessible areas, less treatment means a lower risk of overturning and often fatal accidents:

“Also the fact that you don’t have to risk it, we are in the hills so there is always a risk of tipping over, it is really job security. So yes, [the cultivation of resistant vines] does influence in a very positive way” (I7).

4.2. A Light on the Motivations to Plant Resistant Varieties

Our study aimed to understand the motivations of PIWI growers by examining their choices through the lens of their understanding of sustainability and the attitudes and approaches to agriculture. Here, the information coming from the document analysis is crucial in order to distinguish between those who cultivate only PIWI varieties and those who combine PIWI with traditional, organic, or biodynamic methods. The reasons behind the choices appear to be controversial and sometimes contradictory, with economic factors playing an increasingly significant role.

The desire to reduce pesticide use and minimize the need for field treatments is a sentiment echoed by all producers surveyed and confirmed in most of the individual interviews. However, the underlying motivations are more nuanced: for some, planting resistant grapes is a necessity due to regulations within nature parks where treatments are prohibited (Q1), or because the high-altitude location of their fields makes other varieties unviable (Q12), with PIWI varieties offering the necessary resilience and robustness (Q9).

The financial aspect appears to be a significant component of the choice: fewer treatments mean cost savings for pesticides and sprayers and diesel:

“[I realised that] we always needed more treatments, bigger ones, or even new products to combat these infections, especially fungal ones, because to have a good product you have to have healthy leaves and healthy bunches. And it also became a great economic effort, because the chemical industry clearly takes advantage of the great need for these products and always evolves new ones to replace the others, but I bet they will always be more expensive. Otherwise, the discourse of the genuineness of products was also born; fifty years ago no one asked a big question about the genuineness of the elementary sector as far as products are concerned, but as the number of products also became more varied, this discourse was emerging. And it is only right that this discourse was born. Then the whole thing brought me more interest” (I17).

However, very few producers make only and exclusively wines from resistant varieties because the market demand for PIWI wines is struggling to establish itself and economic sustainability is faltering:

“However, I have to say the truth that there is no market, . . . it is a market that needs to be developed. According to what I see, as an oenologist and also as a trader of this wine, I have to say that it is difficult...” (I16).

Even if the market for PIWI wines was not the subject of this work, one of the obstacles to focusing exclusively on PIWI wine is the small production volume, which corresponds to limited market demand. Because wine growers produce PIWI wines based on their personal convictions, there is a noticeable gap in how they communicate these beliefs to consumers.

Another group of reasons can be traced back to the concerns for workers' conditions of safety, since PIWI is often cultivated in rough and steep terrain:

“Another part [of the vineyard planted with PIWI] is, let's say, quite steep hillsides and it's about treatments, i.e., if you have to do five, four, one, two treatments, it's already better than doing ten or more. The reasoning is just that: you have less work, the quality is fairly good, and also the philosophy of the farm is to go organic and to make as little impact as possible on its surroundings. So you say 'why not?'" (I16).

Moreover, concerns about the health impacts and the potential consequences that traditional cultivation methods with pesticides can have on inhabited areas or the farm, which is often owned by the growers, are among the reasons for choosing PIWI varieties:

“When we took over the farm, we said ‘around the farm—because we also have a farmhouse—when we have guests on the pool we don’t want to spend every week with the sprayer’. That’s how the idea came about. And we got on well from the first moment, or rather, our first wine we made was good so we decided to go ahead and plant other quantities and other varieties” (I20).

“part of the vineyard is right next to the house, they made the choice to make two rows next to the house because they did not want to treat their lawn, garden and house” (I16).

A last argument for deciding to adopt organic farming first and then the PIWI approach is rooted in family traditions, in some cases following the enlightened decision taken by the previous generation, which grew up with the use of chemicals in agriculture in the 1960s and 1970s, to start organic production:

“Dad was already very active in the 1980s in a group that I don’t know what it’s called in Italian: Umweltschutzgruppe [...] He never liked this farming he was doing, in the sense, he liked nature, agriculture in general but to use these poisons as they used in the ‘60s-’70s, until the 80s, it was done like this because nothing else was known; but he confronted a lot [...] And then already in the ‘80s he stopped using herbicides, then also mineral salts until he said ‘yes, the only sustainable way is to work organically” (I24).

In other cases, this transition constituted a break between generations, where the radical choices of those who took over, which questioned the abundance brought by the agro-industry, were often misunderstood. However, these choices had to translate into financial success:

“My father didn’t know what bio is. [... after the war] there was little to eat, there was little money. And that’s when fertiliser came, everything grew, no, but then with fertiliser also comes disease, because if it grows more, the disease has more room to develop. But that’s also when the chemical pesticides came, and then there was no problem. And my father says ‘eh now we have found a method that brought Wellbeing [...] Now you don’t want to have any risks, to lose all [the crop]” (I17).

The second generation opted for organic production, accepting the challenge of economic sustainability.

“But I explained that I don’t want [chemicals], because maybe after 20 or 50 years you can’t produce any more, no you don’t know at that time what will happen. When I started I thought ‘if we continue like this, like our parents did, maybe the land is dead’. And I told my father that if I can live off the farm I received, at that time when I had already started to do organic, if I can live I’ll do organic, if not, I’ll go back to conventional. Because my grandfather was able to live here on the farm with seven children, my father too, and I said ‘I have to live here too’. And the luck was that I also had apples. We sold the apples to Germany and they asked for organic ones.” (I27).

Environmental motivations were largely centered on preserving resources, reducing pesticide use, and maintaining a holistic view of agriculture. On the other hand, economic motivations were tied to factors such as cost reduction, market demands, and the long-term viability of PIWI adoption. The accompanying figure (Figure 1) provides concrete examples of these responses (marked by codes in the thematic analysis), offering a qualitative snapshot of the growers’ perspectives. This clustering approach respects the complexity of the data while offering a clear framework for understanding the motivations behind PIWI adoption. It also highlights the inherent tensions between environmental ideals and economic pragmatism, which are central to farmers’ decision-making processes.

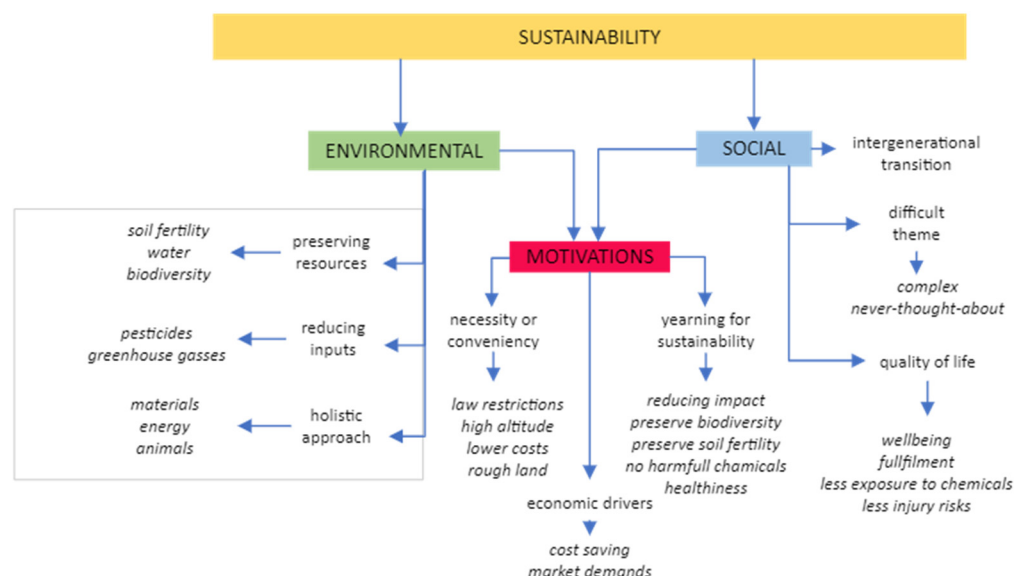


Figure 1. Thematic analysis flow.

5. Discussion

The evidence gathered in the research reveals a spectrum of propositions [66] in the adherence of PIWI wine producers to the demands of sustainability, from the most radically convinced to those who adopt this practice for utilitarian purposes [23,49].

The testing of the hypotheses has provided a clear result indicating that environmental sustainability (first hypothesis) is the main concern of PIWI wine growers and refers to the preservation of resources, the reduction in pesticides and impact, and, in some cases, a holistic view of agriculture (Figure 1). However, by cross-referencing the qualitative data with the result of the document analysis, a more nuanced picture of the South Tyrolean PIWI wine producers' commitment to sustainable agriculture emerges. Out of the 27 wine growers analyzed, 17 are already organic farmers, i.e., the majority, 6 exclusively cultivate PIWI varieties, and 21 mix traditional grape varieties with PIWI varieties.

These findings help highlight the emergence of a small group of “pioneers” (6) who are fully dedicated to sustainable agriculture, demonstrating a significant reduction in pesticide use through their exclusive cultivation of PIWI varieties.

The majority of PIWI wine producers, however, are mixing PIWI with traditional grape varieties, suggesting a partial contradiction to the claim of wanting to significantly reduce the use of pesticides. The primary reasons for this mixed approach appear to be rooted in economic concerns and the perceived insufficiency of relying solely on PIWI varieties. While these producers recognize the ecological benefits of PIWI, many continue to cultivate traditional grape varieties due to market demand or economic viability. This tension between environmental ideals and economic pragmatism reflects the complexity of transitioning entirely to non-conventional practices. In some cases, the combination of PIWI and non-PIWI is related to a conscious strategy to keep the business going; in other cases, it is a matter of slow transition, as vineyards have a long life cycle [67]. As related to the market, the majority of PIWI producers seem to refer to niche markets, somehow nested in trust-based relationships, even if not properly alternative [68].

Despite these challenges, the motivations behind adopting PIWI grapes are notable. Among the six “pioneers” who exclusively grow PIWI varieties, four are also organic farmers, and three hold organic certifications. This group of pure PIWI producers exhibits an authentic, ethically driven commitment to sustainability, with a strong orientation toward social sustainability principles. Their approach goes beyond mere environmental

considerations, showing a more holistic view, reflecting a deeper sense of responsibility toward the community and future generations [5], and integrating the social concerns into their discourse [25]. They see the choice of PIWI crops as a stance related to caring for the natural and human environment.

Conversely, most growers who mix PIWI and traditional grapes are also inclined toward environmental sustainability. Of these, 20 out of 27 are already organic producers, and seven of them hold certifications. This suggests that while their approach may not be purist, they are still moving in the direction of more sustainable practices, largely due to their involvement in organic farming because of their personal beliefs [21].

Still close to a widespread vision of sustainability is the search for the reduction in pesticides and impact. We find direct evidence of this in the literature, in the works of Vecchio et al. [53] and Nesselhauf et al. [13], which show significant values of such reduction. The commitment in the Italian wine sector to a less impactful form of agriculture is also noted by Pizzol et al. [69] and is clearly found in the interviews, as is the concern for adaptation to climate change [70]. A critical observation from these results is the relatively slow adoption of certifications within the sector. PIWI cultivation itself does not come with a specific certification, and this lack of formal recognition may explain why certification uptake remains limited. While the growers are embracing sustainability in practice, the absence of certification highlights an area where further progress can be made.

As far as the concept of social sustainability is concerned, it is often regarded as a secondary aspect, indicating that it is not yet fully conceptualized or acknowledged as part of farm management. However, some of the practices adopted by these farmers inadvertently cover key elements of social sustainability [31]. For instance, activities aimed at improving the quality of life for the workers and collaborators are part of the vision of these farmers. This suggests that, while there may be limited awareness or discourse around the formal term, the practical implementation of such principles is already taking place.

The economic dimension is always present in the discourses, even if it is often not explicitly referenced. It is clear from the interviews that there is an awareness of the economic benefits in terms of reduced costs, both direct (pesticides, fuel) and indirect (working hours, risk of accidents), as highlighted in the literature by Länn and Wikholm [49] and Galletto [51]. Additionally, the problem of a market that is too limited for this type of wine is admitted and seen as problematic [53,54].

The point of view of the PIWI wine producers is therefore highly instructive about possible ways towards more sustainable viticulture as well as about the integration of social sustainability into the green transition debate. The willingness of farmers to question the economic benefits of conventional viticulture in favor of a greater concern for environmental impact shows how they can be primary agents of change, rather than having to consider themselves as objects of education.

Having clearly understood the need to frame the analysis in a clear but flexible theoretical context [23] and applying a behavioral theory that highlights the interaction between values, collective imagery, and economic needs [71,72], we kept the focus on the farmer's point of view [73]. From here, we can understand how the contribution of resistant wine growers is not limited to agronomic practice but can be extended to a broader vision of agriculture anchored in a world and life view that recalls values and traditions. This becomes particularly clear for those farmers who are willing to give up a share of profit in order to practice a more sustainable approach.

Nevertheless, it is important to recall that the adoption of PIWI grape varieties faces several obstacles, with legislative issues being a major factor. Unlike organic farming, PIWI are not a cultivation method but specific grape varieties that growers choose. This

specificity means that many wine producers aiming for sustainability may prefer alternative approaches, such as organic or natural wine production, or recognized sustainability labels.

A key hurdle is that resistant grape varieties are registered in Italy with marginal limitations. Legislative Decree no. 61/2010 declared these grapes “unsuitable for wines with a denomination of origin”, limiting their use to IGT wines. However, the EU’s Official Journal of 6 December 2021, under the new Common Agricultural Policy, approved the use of resistant varieties in designated denominations.

Despite this, Italian DOC wines still do not permit wines made from PIWI grapes due to differing interpretations between EU law and Italian legislation (Law 238/2016). In Italy, regional authorities are responsible for legislating grape variety classifications, based on the guidelines from the 25 July 2002 agreement, in contrast to what happens in other European countries like France, Germany, Austria, the Czech Republic, Slovakia, and Hungary that consider PIWI grapes equivalent to *Vitis vinifera*.

6. Conclusions

In the present study, we have tried to account for the privileged point of view of wine producers from resistant grape varieties (PIWI) based in a rural region in the northeast of Italy, with respect to the motivations that guide farmers in adopting agronomic practices with a lower impact. We have formulated two hypotheses; the first one relates to environmental commitment and concerns, aligning producers with their personal values and environmental ethics; the second one refers to relational and social influences, including maintaining family traditions, strengthening community ties, and preserving the cultural heritage associated with wine growing. Both the understanding of environmental and social sustainability aspects was examined and related to the motivations themselves, making farmers ‘talk’ in the first person with a bottom-up approach rather than identifying a priori and top-down parameters to be applied. The result was a picture consistent with the literature concerning drivers and motivations for converting the production towards more sustainable practices (like in the case of organic productions) but made distinctive by the social and cultural context of South Tyrol and the emergence of a small group of purists of the PIWI varieties. Results show that commitment to maintaining soil fertility is strongly felt, although less so for biodiversity, while the concern for the health of the environment for both workers and those who live nearby is the key to their understanding of the intersection between environmental and social sustainability. The intertwinement between social and environmental concerns, emerging through the study, is the most original result in the area of investigation.

Recalling the one element that is often combined with PIWI varieties, the capacity to combat climate change challenges, it is an element that deserves attention. Climate change is expected to intensify the prevalence of fungal diseases due to rising temperatures and increased rainfall across Europe. While PIWI varieties, with their natural resistance, could offer a valuable strategy for farmers to mitigate these risks, it is important to recognize that the impacts of climate change cannot be generalized across all regions. Specific studies tailored to local contexts are essential to better understand how regional climatic shifts, soil conditions, and ecological factors interact with the adoption and performance of PIWI varieties.

Our findings suggest that growers prioritize environmental sustainability, which aligns with the potential of PIWI varieties to reduce reliance on chemical pesticides, lowering both environmental harm and financial costs. However, the adoption of PIWI varieties outside South Tyrol would depend heavily on localized microclimatic conditions, soil compatibility, and cultural acceptance. Additionally, regional differences in agricultural policies, market

structures, and consumer preferences may significantly influence their adoption. This underscores the importance of site-specific research even with small samples.

As for the cost of establishing new PIWI varieties, this is a critical factor influencing farmer decisions. While PIWI varieties offer long-term economic benefits, such as reduced pesticide costs and lower labor demands, the upfront costs of vineyard conversion can be significant. These costs include purchasing new plants, modifying vineyard infrastructure, and potential market adaptation efforts (e.g., consumer education or marketing campaigns). This economic trade-off may explain why some farmers in South Tyrol mix PIWI with traditional varieties, balancing innovation with economic viability.

A last factor affecting the motivations of the wine growers is the time it takes for PIWI vines to mature and produce viable crops. For most grape varieties, it typically takes 3–5 years before significant yields can be harvested. This delay in productivity represents a critical period where farmers face sunk costs without immediate financial returns. Such delays can discourage growers from fully committing to PIWI varieties.

Last but not least, the Italian legislation's constraints on PIWI varieties still represent an obstacle in boosting their cultivation.

This study is clearly limited by the narrow geographical focus of the data and the small sample of PIWI vine growers. As such, the study is a case analysis of particular interest serving as a valuable starting point for broader and more comprehensive evaluations regarding the use of resistant crop varieties. This issue is likely to become increasingly significant as genetically modified (GM) and genetically engineered (GE) varieties gain traction in response to climate challenges, as mentioned before. PIWI varieties are still naturally obtained by crossing different varieties without treating the genes directly. As the aversion to engineered food, crops, and animals manifested by consumers and civil society has to be seriously taken into consideration, these resistant varieties could be a critical alternative to face climate changes and multiple environmental crises. In such a future scenario, understanding farmers' motivations for adopting or rejecting these varieties will be critical.

A limitation of our study is that a more comprehensive investigation into the motivations for adopting PIWI varieties by asking non-PIWI growers why they decided not to adopt PIWI varieties has not been performed due to resource constraints. However, exploring other Italian regions where the legislation has already been authorized could bring more insights, as the legislation is one of the main obstacles in South Tyrol, representing a control-group analysis.

The scalability of this study is feasible at the regional level, provided that similar wine production conditions are taken into account. Moreover, conducting comparative studies on PIWI adoption in different European regions to evaluate how climate, soil, and market dynamics influence motivations and outcomes will be of great interest. Further investigation merits a better understanding of the current lack of support from policymakers and regulators at local, national, and EU levels for PIWI varieties, coupled with consumer reluctance, particularly from those who favor traditional varieties. These elements have been marginally detected by this study and deserve specific in-depth analysis, especially given the imminent technological advancements in this field related to genetically engineered crops and ongoing political support for the forced digitalization of the primary sector. What would be equally valuable would be a broader discussion among stakeholders regarding the reasons for promoting or resisting the adoption of resistant varieties produced through non-invasive techniques, as compared to the potential deregulation of varieties created through genetic engineering methods.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data supporting reported results are stored by the authors in the Bolzano university data storage.

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