

Promoting sustainability in Mediterranean agriculture: insights from the Portuguese vine & wine sector

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Abstract. Agroecology is an integrated approach that simultaneously applies ecological and social concepts and principles to redesign and manage food and agricultural systems, promoting agroecosystems with the necessary biological, socio-economic, and institutional diversity and alignment to support greater efficiency.

The present study aimed at characterising the socio-economic factors that lead farmers to accept and adopt more sustainable practices. Herein, we have addressed technical and economic aspects, in an integrated manner, in order to demonstrate the benefits of sustainable agroecosystems focused on Mediterranean crops. To achieve this, a survey was conducted to map and characterise viticultural practices in Portuguese vineyards, as well as winegrowers' perception regarding the acceptance and implementation of alternative agricultural practices. The questionnaire also identified some barriers and opportunities for the application and adoption of alternative agricultural practices toward sustainable agriculture, considering technical and socio-economic aspects, vineyard characteristics, agricultural practices, and farmers' educational level.

Winegrowers identified climate change adaptation and biodiversity preservation as the most important benefits of implementing alternative practices. Additionally, they demonstrated awareness of the importance of adopting alternative viticultural practices, especially for environmental improvement (biodiversity and natural resources conservation), as well as for increased sustainability of their operations/vineyards and greater profitability (e.g., through wine tourism). It was also possible to perceive that most respondents had a very clear and objective perception of what alternative practices are, even though showing some difficulty in changing habits and work techniques, loss of profitability, and increased production costs. Altogether, our study highlights that Portuguese winegrowers are aware of the importance of agroecological practices, such as sexual confusion, no-till farming, ecological corridors, and the preservation of biodiversity (e.g. insect shelters), reinforcing their position in adopting these approaches for the expansion of agroecology in the context of the ongoing reforms of European Agricultural Policy.

1. Introduction

The challenges faced by modern agriculture are multifaceted, involving not only the need for increasing productivity but also the urgent necessity for sustainable practices that protect and enhance the environment [1]. Agroecology is an integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of food and agricultural systems. This new area has become an emerging topic as a holistic framework that integrates ecological and social concepts to transform food and agricultural systems, promoting

social justice, nurture's identity and culture, and strengthening the economic viability of rural areas [2,3]. By fostering biological, socio-economic, and institutional diversity, agroecology aims to enhance the efficiency and sustainability of agroecosystems. This approach is particularly pertinent in Mediterranean agriculture, where specific crops, such as grapevines, dominate the agricultural landscape, demonstrating a pivotal role in promoting environmental stewardship and economic sustainability [4,7].

Recent studies have increasingly focused on the promotion of agroecological practices among farmers and the broader public, emphasising the importance of soil conservation and health [8-10]. These efforts are crucial in the face of climate change and environmental degradation, which pose significant threats to agricultural sustainability. In this context, understanding the socio-economic factors that influence farmers' decisions to adopt more sustainable practices is essential. Such insights can guide the development of targeted interventions and policies that facilitate the transition to agroecology [11-13].

The Douro Demarcated Region (DDR) is the most well-known Portuguese wine-growing region, renowned for its centuries-old tradition of producing high-quality wines, particularly Port wine. Douro region is at the forefront of adopting new agroecological practices in viticulture. With its steep slope vineyards and unique microclimates, the region faces distinct environmental challenges that are being addressed through innovative agroecological approaches [14,15]. These practices include the use of cover crops, no-tillage farming, and the creation of ecological corridors, which enhance biodiversity, improve soil health, and reduce erosion. The adoption of these practices not only promotes sustainability but also helps the Douro region adapt to climate change, ensuring the long-term viability and productivity of its vineyards while preserving the rich cultural heritage of its winemaking tradition [16-17].

To the best of our knowledge, there are no studies which delve into the socio-economic dimensions of agroecology adoption in Portuguese vineyards by conducting a comprehensive survey of viticultural practices. Building up this information, the current study aimed to map the Portuguese wine-growers perception about the implementation of agroecological practices, highlighting the motivations, barriers and opportunities towards the adoption of alternative agricultural practices.

2. Material and methods

To assess the perception of Portuguese farmers regarding sustainable and alternative practices and their possible implementation on their vineyards, the present survey was performed. The data collected in this survey was strictly anonymous and used only for this research according to the General Data Protection Regulation (GDPR) in European law (EU 2016/679).

In this way, the survey was made up of 3 sections:

- First section - **Characterization of the holding (winegrowers, companies)** - gathering information on the individual characteristics of the winegrowers, i.e. their farms and profile. The objective was to collect data that will allow us to hypothesise on the possible links between the implementation of alternative practices and the profile of the winegrower, particularly concerning their training, sensitivity to the environment and the characteristics of the farm. In addition, information on the types of farms and the implemented

practices, will help to identify alternative practices in Portuguese viticulture context.

- Second section - **Alternative cultural practices** - was focused on the concept of alternative viticultural practices and aimed to assess the knowledge of the winegrowers on the definition of "alternative practices" and thus to find out their level of involvement in these practices. In addition, this section also provides feedback on the implementation of alternative practices and its impact on the economic profitability and workload of winegrowers.
- Third section - **Opportunities and Barriers** - concentrated on exploring the factors that either facilitate or obstruct the implementation of alternative practices. The objective was to identify the key drivers that encourage farmers to adopt these practices, as well as the challenges and barriers that may discourage them to adopt those practices.

The survey, prepared to have an average response time of about 15 minutes, comprised several typologies of responses: single, multiple-choice questions and open questions. When closed questions (yes/no) were made, it was decided to ask an open question afterwards, in order to avoid losing useful information.

To evaluate and quantify the degree of importance of some practices the Likert scale was chosen. This scale comprised five choices and ranged from "not at all important" to "very important", with the possibility of a neutral response "indifferent".

The Google Forms platform was used to prepare and apply the survey due to its practicality and simplicity, either in creating the questionnaire itself or in obtaining responses from the winegrowers.

The survey was carried out in the period between 1st and 30th May 2022. After the response period, the data was collected and analysed.

3. Results

3.1. Characterization of agricultural holdings / farms

The survey received responses from 34 players of the Portuguese Vine & Wine sector. In terms of gender (**Figure 1A**), approximately 21% of respondents were women, demonstrating clearly the predominance of men in the sector (around 74% of the respondents). It can also be observed that the age of the respondents is fairly balanced across the four selected age groups (**Figure 1B**). Furthermore, around 59% of the respondents are farm owners, while 40% are traders or employees (**Figure 1C**).

As depicted in **Figure 1D**, 89% of the respondents have higher education, with 44% holding a degree, 59% of which are related to agriculture (data not shown). This is of the utmost importance, as their educational background directly influences their perception of alternative practices.

This is in agreement with another question, which highlights those activities, such as wine tourism and cultivation of other crops complement their professional roles.

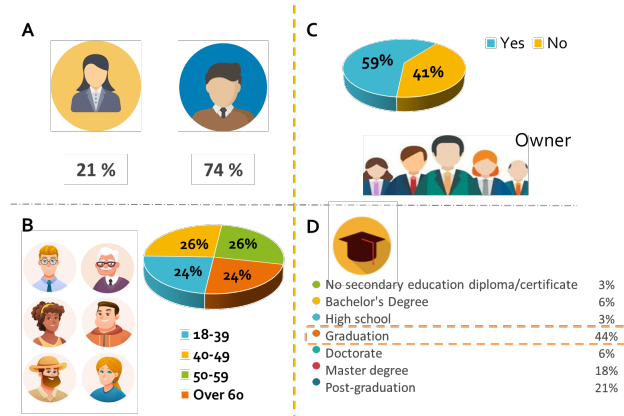


Figure 1. Respondents' characterisation, according to: Gender (A), Age range (B), Company position (C) and Educational level (D).

The present survey also identified the Portuguese winegrowing regions, where respondents have their farms/companies. In fact, most of the respondents are from the Douro region (85%), followed by Trás-os-Montes (12%) and Vinhos Verdes (3%) wine-growing regions. Furthermore, Douro respondents have more vineyards/farms in other regions, particularly in Vinhos Verdes (57%), Távora-Varosa (14%), Bairrada (14%), Dão (14%), Tejo (14%) and Alentejo (29%) wine regions (Figure 2).

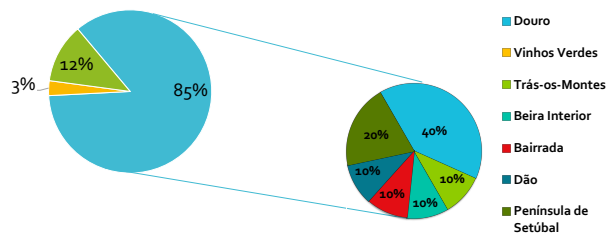


Figure 2. Wine-growing regions of respondents' farms / companies.

The Utilised Agricultural Area (UAA), as well as the vineyard area of respondents' farms/companies, is between 1-10 ha and 10-50 ha. This could be explained since most of the respondents belong to the North of Portugal, where agriculture is characterised by small agricultural areas (Figure 3A).

Furthermore, most of the respondents (21) answered that they use hired labour for the work carried out in the vineyards, followed by temporary workers (19 respondents) and only 11 of respondents have used family labour on their vineyards (Figure 3B).

Regarding wine-growing areas, 38% of respondents develop their activity on Viticulture area. The other activities such as processing, and grape and wine sales are also included within the viticulture sector (Figure 3C). All winegrowers have engaged at least in one of these activities: processing (10%), sales of grapes (29%), sales of wine (10%). Notably, 19% of viticulturists are involved in more than one of these areas simultaneously. According

to the present survey, the production mode most used by the Portuguese winegrowers is Integrated Production (76%), followed by Organic Agriculture (12%) (Figure 3D).

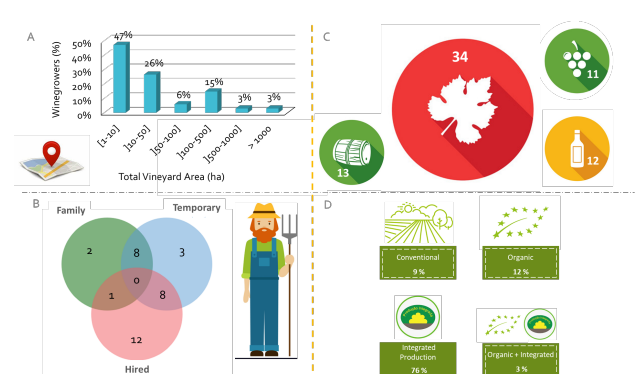


Figure 3. Characterization of winegrowing holdings according to: Total viticultural area (A), work labour (B), wine-growing areas (C) and production mode (D).

3.2. Alternative cultural practices

As mentioned above, this section aimed to assess the knowledge of the winegrowers concerning the definition of “alternative cultural practices” and thus to find out their level of involvement in these practices.

In response to the question “How important are the following characteristics according to ecological and biodiversity issues for your company/farm?”, it was evident that respondents/farmers placed significant importance to all the options presented. This is more pronounced for the option “*biodiversity conservation*”, which was identified as the most crucial topic to ecological and environmental issues, with up to 71% of respondents selecting it as the top priority (Figure 4).

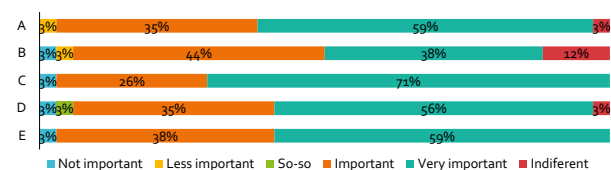


Figure 4. Responses to the question “How important are the following characteristics according to ecological and biodiversity issues for your company/farm?”.

Legend:

- A - Pollination, water quality, culture beneficials, etc.
- B - My farm has as important role on biodiversity conservation
- C - Biodiversity conservation is important to the environment and ecology
- D - Biodiversity conservation is important for outdoor and recreational activities (hiking, hunting, fishing, wine tourism, etc.)
- E - Biodiversity conservation is important since it is part of our heritage (landscapes, local culture, future generations, etc.)

The open question asked in the second section of the survey – “*In your opinion, what are the alternative agricultural practices*” – aimed to find out the degree of perception and/or knowledge that the different agents in the sector have of the concept of alternative practices. For this purpose, respondents were asked to provide their own definition of the concept. The analysis of the responses was conducted using a word cloud graphical

representation, enabling the evaluation of a set of definitions in terms of frequency and value. In this visual representation, the more frequently a word appears across different responses, the more prominently it is displayed in the graph.

Among the key procedures, techniques and behaviours for adoption as alternative agricultural practices, “cover cropping”, “alternative to Conventional” (viticulture), and “eco-friendly agrochemicals” were the most frequently selected by the respondents (**Figure 5**).



Figure 5. Graphical cloud representing the number of times the referenced words, relating to the individual concept of Alternative Cultural Practices.

It is noteworthy that although respondents dissociate alternative practices from conventional agriculture, they do not establish a strong link between organic and biodynamic production modes. On the other hand, respondents clearly expressed their perception about alternative practices, empathising the importance of cover cropping, the use of eco-friendly agrochemicals (with two references to the sexual disruption), and the implementation of ecological infrastructures, such as ecological corridors, establishment of shelter boxes, preference for autochthonous species, preservation and creation of refuges for fauna.

3.3. Opportunities and Barriers

Regarding the alternative cultural practices previously identified, the aim of this section was to assess the opportunities and barriers experienced by the economic agents of the Vine & Wine sector. Thus, the objective was to assess the significance of adopting agricultural alternative practices and to understand the reasons driving farmers to implement them. Additionally, the study aimed to identify the barriers that hinder the adoption of these practices. For this purpose, the Likert scale was chosen, comprising five choices ranging from “not at all important” to “very important” with the possibility of a neutral response “indifferent”.

In the first question (*Rank the factors that would hinder the adoption of an alternative practice according to the degree of importance*), the five main factors that were mentioned as very important, were: *Changing working habits and techniques* (38%), *Loss of income*, *Loss of profitability*, *Increase workload* and *Increase in operational and investment costs*, all with 35% of respondents (**Figure 6**). Also, the factors that would lead winegrowers to adopt alternative practices are mostly related to the economic dimension.

Analysing the answers to the second question (*Rank the factors that would lead you to adopt an alternative practice according to the degree of importance*), the five main factors rated as very important were: *Adapt to climate change* (76 %); *Preserve the environmental and biodiversity* (62%), *Benefit from financial support* (50%), *Working for the good of society (consumers and producers)* (47%) and *Be supported by authorities and policy makers* (44%) (**Figure 6**).

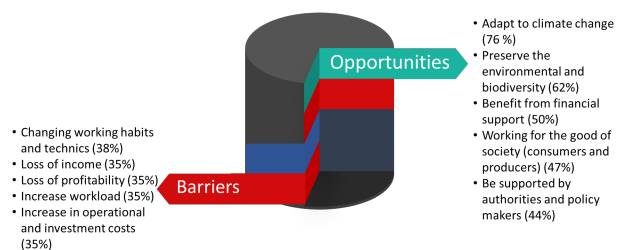


Figure 6. Opportunities and barriers to adopt agricultural alternative practices, identified by winegrowers’ respondents.

These factors show a clear environmental awareness and concern as well as their possible impacts. It is important to emphasise that these responses denote the high educational levels of the respondents as well as their awareness and understanding of today’s most pressing issues. This high level of literacy is further demonstrated by the fact that 32% of respondents indicated “indifferent” to the factor “Accompany/replicate the actions of neighbours”, suggesting a strong confidence in their own management decisions and the strategies they choose to adopt.

4. Discussion

This study provides valuable insights into the adoption of agroecological practices in the Portuguese vine and wine sector, particularly within the context of the Mediterranean agricultural landscape. The data collected illustrates that Portuguese winegrowers have a clear understanding and recognition of the benefits associated with alternative agricultural practices, especially those that contribute to environmental conservation and climate change adaptation. This is aligned with findings reported by Palomo-Campesino *et al.* (2022) and Rizzo (2024), who also emphasised the growing recognition among farmers of the ecological benefits of sustainable practices [9,18]. However, the present study extends the understanding of these motivations by exploring specific practices, such as the use of cover crops, no-till farming, and ecological corridors, which are particularly relevant to the steep-sloped vineyards of the Douro Valley. This region-specific

focus provides a more nuanced perspective of how global environmental concerns are being adapted and addressed within the Portuguese viticulture context. In this way, this awareness is particularly significant, considering the unique environmental challenges faced by the winegrowing regions in Portugal, such as the Douro Valley.

One of the key insights from the survey is the identification of the barriers that hinder the widespread adoption of these alternative practices. Despite the awareness of their benefits, winegrowers reported several challenges, including the difficulty of changing long-standing agricultural habits, the potential loss of profitability, and the increased operational costs associated with new practices. These barriers highlight a critical tension between the desire for sustainability and the economic realities faced by producers. This tension is particularly pronounced in a sector where traditional practices are deeply implemented and where the financial implications of change can be significant. In other words, these barriers suggest that while there is a strong conceptual understanding and acknowledgment of the importance of sustainable practices, practical and economic concerns still play a decisive role in the decision-making process. Therefore, this study is highly impactful due to its focus on the interplay between economic incentives and environmental motivations. While previous works often treat financial support and environmental stewardship as separate drivers, the present study reveals a more complex relationship in which factors are intertwined in farmers' decision-making processes. This finding suggests that policy measures aiming to promote sustainable practices need to address both economic viability and ecological benefits simultaneously to be effective. Wezel *et al.* (2014) and Romero *et al.* (2022) also reported that financial considerations are a primary concern for farmers when transitioning to more sustainable practices [19]. However, the present study adds depth to this understanding by highlighting the cultural resistance to changing long-standing practices, which is less frequently discussed in broader studies but is critical in the context of traditional wine-growing regions like DDR.

On the other hand, the present study also highlights the opportunities and reasons that could influence the adoption of agroecological practices. The most stood out factors include the adaptation to climate change, the preservation of biodiversity, and the availability of financial support. Notably, the high level of education among respondents appears to correlate with their environmental awareness and their willingness to consider adopting alternative practices despite potential economic drawbacks. In fact, the research conducted by Gallardo-López *et al.* (2018) also emphasised the importance of knowledge dissemination for promoting agroecological practices, which, in agreement to our study, suggests that targeted educational initiatives could be effective in overcoming some of the previously identified barriers [4].

Furthermore, the winegrowers who participated in this questionnaire showed awareness in adopting alternative

viticultural practices, especially for an improvement of the environment (conservation of biodiversity and natural resources), but also for an increase in the sustainability of their farms/vineyards, as well as greater profitability (for example, through wine tourism). This is reflected in the high percentage of respondents, who rated biodiversity conservation as the most important factor for ecological and environmental issues. The responses also suggest that Portuguese winegrowers are not only motivated by economic incentives but also by a broader sense of responsibility towards environmental stewardship and the long-term sustainability of their vineyards.

However, it is essential to consider that the survey's methodology, particularly its online format, may have influenced the results. The high literacy level of respondents and the predominance of certain age groups may not entirely represent the broader demographic of the Portuguese Vine & Wine sector, since most of the respondents were from the Douro Region. As such, the findings, while insightful, should be interpreted with caution and could benefit from further validation through more extensive and diversified data collection methods.

5. Conclusions

This study underscores the complex interplay between environmental awareness, economic considerations, and traditional practices in the adoption of sustainable agricultural practices within the Portuguese Vine and Wine sector. While there is a clear recognition of the environmental benefits and a willingness to adopt new practices, significant economic and practical barriers must be addressed. In particular, some opportunities and barriers were identified on the implementation/adoption of alternative practices, especially the difficulty to change work habits and techniques, loss of profitability and increase of income costs. On the other hand, winegrowers have identified that the adaptation to climate change and the preservation of biodiversity are the most important benefits in the implementation of alternative practices.

Future efforts should focus on developing strategies that mitigate these barriers, perhaps through targeted financial incentives, technical support, and education, to facilitate the broader adoption of agroecological practices across the region.

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