THE TRUE COST OF THE VINEYARD LANDSCAPE ENHANCEMENT. FIRST RESULTS IN THE VENEZIA BIODISTRICT

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Abstract:

Context and purpose of the study
The research is part of the "Ecovinegoals" project, financed by Interreg Adrion funds. It aims to encourage the adoption and dissemination of agroecological practices in intensive wine-growing areas. The study focuses on cost analysis of the wine-growing landscape enhancement in an organic winery in order to provide a useful tool for winemakers to direct their investments in green infrastructures. One of the Italian pilot areas of the Ecovinegoals project is the Venezia Biodistrict, characterized by viticulture in a flat reclamation area of 105,800 hectares.

Material and methods
The study area is the organic winery "*La Planitia*" which comprises 106 hectares of vines, including 18 hectares of ancient *Tocai Friulano* vineyards (Lison Classico DOCG appellation), 45 hectares of crop and 12 hectares of woodland, including 5.6 hectares of "*Bosco di Lison*", an old-growth lowland forest. The woodland is a recognized biodiversity site in the middle of vineyards protected by the Natura 2000 network, but currently isolated from other ecological corridors.
In order to preserve biodiversity, increase landscape diversification and attractiveness, we simulated the effects on direct and indirect costs of a solution for a green investment: riparian buffer strips (1,500 m), hedges with melliferous plants (500 m), noise reduction hedges (730 m) and a multipurpose forest (5,000 m^2).
We conducted a cost analysis in order to evaluate the effects on profitability in different scenarios characterized by the sale of grapes, bulk and bottled wine and different vine cultivars. Data of yield, loss by shading, costs of production and processing are collected directly to a sample of 5 organic winemakers. The sample has been selected by organic wine producers with presence of comparable green infrastructure inside the vineyards.
We didn't consider positive externalities such as ecosystem services, widely recognized in bibliography, but currently not internalized by the market. We kept track of winery carbon balance in order to evaluate costs for reaching the goal of carbon neutrality.

Results
Direct and indirect costs were evaluated: the first ones are related to green investments, maintenance and treatments defense, while indirect cost is due to yield reduction, mainly produced by trees shading the vines. Vineyard landscape enhancement showed an increasing production cost, depending on vine cultivar (yield and profitability), vineyard size, shape and surface availability for semi-natural elements and type of product (grape, bulk wine, bottled wine). The impact of costs on profitability is equal to 6.45% (13,043 €/year) in the first scenario, 4.53% (15,263 €/year) in the second one and 1.57% (61,137 €/year) in the third. Obviously, if the whole production were *Glera* (Prosecco DOCG), the convenience to invest in green infrastructures would decrease.
The carbon neutrality target was not reached. A greater area of green infrastructures (1.02 hectares of wood) with an extra-cost of 0.07 €/bottle would have been needed to compensate for CO_2 emissions.
The research shows how costs increase with landscape enhancement interventions in an organic winery. There are different strategies to compensate for the higher costs including environmental certification adoption, new

market penetration and direct sales to tourists. The costs associated with enhancing the green spaces are well established while the potential benefits may be difficult to realize.
Keywords: Ecovinegoals, agroecology, landscape enhancement, green investments, direct costs, indirect costs, carbon neutrality

1. Introduction

Agroecological practices offer a holistic approach to get sustainable food systems in the face of increasing environmental pressures, such as climate change and water scarcity, and socio-economic challenges (Altieri *et al*., 2015; Wezel *et al*., 2020). At landscape level, agroecology integrates ecological principles into the management of agricultural landscapes, including the use of diversified farming systems, conservation of biodiversity (Barbaro *et al*., 2021; Bugin *et al*., 2022), enhancing soil health (Sofo *et al*., 2022) and promoting the use of participatory approaches that involve local communities in the management of these systems (Sinclair *et al.*, 2019). A previous study reported that the most central driver of adoption of agroecological practices by winemakers was the specific pedoclimatic conditions, while aesthetic values and ecological perspective is absolutely a secondary factor (Garini *et al.*, 2017).
"*Ecovinegoals*" is a project funded by the European Union's Interreg program, which promotes the adoption of agroecological best practices in intensive wine-growing areas in different regions of Europe (Interreg Adrion EU, 2023). One of the pilot areas in Italy is the Venezia Biodistrict, characterized by viticulture in a flat reclamation area of 105,800 hectares (BioVenezia, 2023).
Venezia Biodistrict is an association of municipalities, wine-growing producers, tourism and trade operators and it has the purpose to promote organic production methods. In the period 1990-2018, the vineyards area in Venice Biodistrict increased by 4,639 ha, with a rate of 166 hectares per year, almost totally since 2000. Therefore, this is a suitable area for introducing agroecological practices applied to viticulture.
Agroecological practices in vineyards include different techniques at different scales (Teschner & Orenstein, 2022). For instance, green manure and integrated pest management at farm and crop scale. At landscape scale, these practices include integration and management of semi-natural elements, such as hedgerows, rows, buffer strips, woodland and ecological corridors (Wezel *et al.*, 2014).
Among benefits there are several ecosystem services: improved soil health and fertility (Romero *et al*., 2022), improved water quality, conservation of biodiversity (Mo *et al*., 2022), reduced erosion (Prosdocimi *et al.*, 2016), integrated pest management, and diversification of landscape. Although benefits are widely recognised in scientific literature (Winkler *et al*., 2017; Garcia *et al*., 2018; Winter *et al*., 2018), there are also some potential disadvantages to consider: reduced yields in the short term, upfront costs in new plantations, knowledge in managing diversified but more complex agro-ecological systems, limiting the effects of integrated pest management by creating niches favorable to pests (Dumont *et al*., 2021). At farm level, weighing the costs and potential benefits in planning a landscape enhancement should consider costs for planting and managing more species, including pest control (Bolzonella *et al*., 2019), and more labor-intensive activities which require specific knowledge in managing complex agro-ecosystems (Gliessman & Tittonell, 2015; Zanella *et al*., 2018; Jeanneret *et al*., 2021). Potential benefits include improvement in aesthetically pleasing vineyards that distinguish the wineries from their competitors, which attract tourists, promote territorial marketing and increase direct sales (Cargnello, 2017). Another advantage is environmental certification. By pursuing sustainability and environmental stewardship, vineyard owners and wineries could differentiate themselves in the market and reach consumers sensitive to sustainable products (Altobelli *et al*., 2019). While these strategies may offer potential benefits, they are not guaranteed to offset the costs of landscape enhancement interventions. Furthermore, uncertainty in the consumer's willingness to pay a higher price for wines produced with agroecological practices could affect the profitability of vineyards. From a consumer perspective, willingness to pay for agroecological wines can be influenced by a range of factors, including health and environmental benefits, perceived quality, carbon footprint labeling and marketing tactics (Mauracher *et al*., 2019; Hoek *et al*., 2021; Moscovici *et al*., 2022).
The aim of this study is a cost analysis of viticulture landscape enhancement in an organic winery in four scenarios: grape sale, bulk wine sale, wine bottle sale and wine bottle sale in the case of the whole production made with Glera cultivar grapes. Currently, Glera cultivar and Prosecco wine market assure higher yield than other cultivars and higher prices for grapes (Pomarici *et al*. 2019). Regarding environmental certification systems, this research evaluates whether a green investment is sufficient to achieve the company's carbon neutrality.

The study shows how costs increase with landscape enhancement interventions in an organic winery. Although it refers to a specific case study, it represents a tool for assessing the effectiveness of agroecological intensification (Kleijn *et al.*, 2018) in terms practically relevant to a winegrower, who wants to evaluate the trade off between costs and benefits. A first step to implement the doughnut economics model (Raworth, 2017).

Finally, it remains to investigate how these investments, that generate positive externalities, can be compensated with public contributions (Tittonell *et al.*, 2020), through subsidies or incentives to producers that invest in environmental projects to support agroecological transitions. Actions adopted at landscape level, encouraged by economic supports, can be a lever which affects ecosystem services at farm scale also (Palomo-Campesino *et al*., 2018). However, a close multidisciplinary approach among winegrowers, researchers and policy-makers is necessary to define sustainable strategies to actually adapt knowledge about complex agroecosystems to winery and support the landscape enhancement of sustainable viticulture (Pomarici *et al*., 2015; Candiago *et al*., 2022).

2. Material and methods

The study area is Tenuta “*La Planitia*'', an organic winery located in Lison di Pramaggiore in the province of Venice in North-East Italy. The area is composed by 106 hectares of different cultivar vines, with 18 hectares of ancient *Tocai Friulano* vineyards (Lison Classico DOCG appellation), 45 hectares of crop and 12 hectares of woodland, including 5.6 hectares of “Bosco di Lison”, an old-growth lowland forest (Villa Bogdano, 2023) The woodland is an important biodiversity site in the middle of vineyards protected by the Natura 2000 network (Natura 2000 EU, 2023), but isolated from other ecological corridors. The importance of the study area is due to the presence of natural elements such as rivers and woodland, the awareness regarding sustainability, the production of traditional *Lison* variety, through the technique of *cassone padovano*, an ancient cultivation method (Vinix, 2023). It consists of a double cordon grapevine that is spread apart and bent horizontally and parallel to the row, using poles as a support. It is one of vine cultivation methods widespread in Veneto Region and it was lost with viticulture specialization from the mid-twentieth century, while it survives only in the form of relics (Ferrario, 2019; Ferrario, 2021).

Climate conditions are characterized by an average temperature of 13.2 °C, which ranges from 3 °C in January to 23 °C in July and August. Average rainfall is equal to 1,077 mm per year, with average monthly maximum rainfall of 119 mm in September and November. The study area origin is from reclamation interventions done in the second half of the Nineteenth century. It consists of an alluvial plain, characterized by extremely calcareous sediments with a high carbonate content and it forms a particular clay layer called *caranto*.

In order to reach Ecovinegoals purposes at landscape level, we suggest different green investments in the pilot area of Tenuta La Planitia winery, such as riparian buffer strips (1.500 m), hedges with melliferous plants (500 m), noise-reduction hedges (730 m) and a multipurpose forest (5.000 m^2), as practical actions to preserve biodiversity, increase landscape diversification and tourist attractiveness.

On the basis of the proposed solution, we conducted a cost analysis to evaluate the effects on profitability in different scenarios characterized by grape sale, bulk wine sale and wine bottle sale and different vine cultivars. Average data of yield, loss by shading, costs of production and processing, related to 2019-2021, are collected directly by interview of a sample of 5 organic winemakers. The sample has been selected by organic wine producers with presence of similar green areas inside the vineyards.

The cost analysis evaluated direct and indirect costs: the first ones are related to green investments and maintenance for five years. Indirect cost is due to yield reduction, mainly produced by tree shading on vines, and two further passes for fungi treatments, because greater humidity conditions could improve their spread.

For the cost analysis it is considered an average value for shading of 50%. We considered costs for new plantations of 15,000 €/ha and 5,000 €/ha for maintenance in the first five years. Concerning prices, we considered 7 €/ton for white grapes, 6 €/ton for red grapes, 14 €/ton for the *Glera* variety. About wine prices, 1.30 €/l for bulk white wine, 1.25 €/l for bulk red wine and 2.60 €/l for wine from Glera grapes. Regardless of the variety, bottled wine has the average price of 7.5 €/l.

Finally, we considered the average cost of grape production (including depreciation) of 6.3 €/ton and average cost of processing, which includes winemaking (0.21 €/l) and bottling (0.85 €/l).

We didn't quantify positive externalities of ecosystem services, widely recognized in ecological and environmental economic bibliography, but not internalized by the market yet. The possible tools to internalize the ecosystem services produced by green infrastructure are: sustainability certification (Lerro *et al*., 2021)

(Vecchio *et al.*, 2023), increase tourist attractiveness and the wine direct selling or direct public support (Boatto *et al.*, 2013). In this study we kept track of winery carbon balance using bibliography sources data (Chiriacò *et al.*, 2019) in order to evaluate costs for reaching the carbon neutrality certification, which is more interesting for Tenuta La Planita and Venice Biodistrict producers.

3. Results and discussion

In the following chapter we reported the effects in terms of costs of the losses by shading and profitability reduction. Furthermore, we simulated the case of the whole production being made with Glera grapes, the most performing by the economic point of view. Hence, we evaluated if interventions in landscape enhancement and biodiversity improvements are a path to gain company's carbon neutrality, including the extra-cost for a carbon neutral wine.

3.1. *Cost analysis for landscape enhancement and effect on profitability*

Shading of green infrastructure has an important role in the reduction of grape production. In our investigations we found a yield loss produced by linear green infrastructure with more than 5 years old in the first 10 meters respectively of 70 % in the first row, 50 % in the second row and 20 % in the third row. We assumed an average loss of 50% within the first three vine rows, i. e. in the first 10 meters.
As for losses by shading and according to the average yields per hectare of each cultivar and the average price, it is quantified as a loss of € 7,399 in terms of production of grapes, € 9,619 for bulk wine and € 55,493 for bottled wine. Table 1 shows losses in value by shading, depending on the type of product and the type of shaded area (cultivar), while Figure 1 shows value losses per cultivar in the three scenarios.
Vineyard landscape enhancements registered an increasing production cost, depending on vine cultivar (yield and profitability), vineyard size, shape and surface availability for semi-natural elements (5,288 €/year plantation and maintenance), type of product (grape, bulk wine or bottled wine) and additional pest control (357 €/year for two more passes). Indeed, we assumed that shaded areas request on average two more treatments against fungi disease (downy mildew, powdery mildew) because the drying time of the leaves is longer and the probability of germination of fungal spores is higher. We considered an average cost per treatment of 80 euros per hectare.
The impact of costs on profitability is equal to 6.45% (13,043 €/year) in the first scenario, 4.53% (15,263 €/year) in the second one and 1.57% (61,137 €/year) in the third, as reported in Table 2.
In the fourth scenario we assumed that the entire vineyard surface is cultivated with *Glera* (Table 3), that is giving the best economic performance, thanks to the Prosecco wine market. Obviously, in this scenario the cost of lost production increases and the profitability incidence is more contained, as Figure 2 shows. Landscape enhancement is more expensive in areas interested in Prosecco production than other ones, although they are more profitable. For this reason winegrowers may not be willing to invest in introducing semi-natural elements at farm level of which they know about increasing costs, while they do not know when and how much they will gain benefits. It still remains a barrier for winemakers without regulatory instruments or compulsory practices linked to payments for environmental externalities which could support landscape ecological transition in intensive wine-growing areas.
Figure 3 shows the economic results between the real case (*La Planitia*) and the simulation with *Glera* cultivar in both cases with or without landscape intervention.

3.2. *Winery carbon neutrality*

Carbon neutrality certification seems to be the most efficient tool for obtaining a premium price by the investment in green infrastructure (Barisan *et al.*, 2019). In this chapter we quantified the carbon balance with and without green infrastructure using bibliography data. In the carbon balance we kept track of emissions related to the agricultural phase and transformation process and the carbon storage of the multiple elements of green infrastructures (Chiriacò *et al.*, 2019).
The net emissions from the vineyard to the bottle wine are equal to 1.57 Mg CO_2eq per hectare. The agricultural phase produces 0.24 Mg CO_2eq per hectare (15%), the transformation process 1.33 Mg CO_2eq per hectare (85%). In the *La Planitia* company carbon neutrality target is unreached. Emissions are equal to +137.8 Mg CO_2eq per year with a storage of -106.2 Mg CO_2eq per year with a net emission of +31.59 Mg CO_2eq per

year. Concerning the CO_2 emissions compensation, a greater area of green infrastructures is needed (1.02 hectares of wood). In the evaluation the forest "*Bosco di Lison*" is excluded as a carbon sink. Indeed, the eligibility for carbon offset projects requires additionality to what would have happened under a baseline scenario. In forestry, the natural growth of the forest represents a baseline scenario. On the other hand, at the old-growth stage CO_2 emissions could be higher than stocks for cell respiration. In conclusion, higher costs for landscape enhancement generate higher prices for products. We calculated an extra-cost of 0.07 € per wine bottle (+4.43%), as reported in Table 4.

4. Conclusions

The research shows how costs increase with landscape enhancement interventions in an organic winery. Several factors influence the costs of vineyard landscape enhancement: the location and size of the vineyards, the type of vineyard in terms of cultivar and yield and the types of plants used in new green infrastructure. These factors affect direct costs in labor and managing vineyards and their interactions with semi-natural elements introduced. Therefore, costs are a barrier to landscape enhancement investment, but there are different strategies to compensate for higher costs: environmental certification adoption, new market penetration and direct sales increasing through winery touristic attractiveness improvement. However, costs and potential benefits make decision-making process complex, particularly if they require higher initial costs but offer long-term benefits, and this justified the methodology of this analysis.

In conclusion, organic wine producers' attention to environmentally conscious production should be complemented by financial incentives or regulatory support, by involving policy-makers and sharing technical assistance to promote landscape enhancement and encourage sustainable land use practices in viticulture areas. Finally, consumer awareness on organic wines produced in sustainable agro-ecosystems and carbon footprint information could help create demand for such products. Addressing these challenges, landscape enhancement interventions can offer potential benefits for organic wine producers, bridging the gap between costs and potential benefits and supporting their decision-making process based on consumers' target (Capitello & Siriex, 2019), effectively expanding the *production boundary* as defined by CICES (Haines-Young & Potschin., 2012).

It remains to investigate practical solutions to join the profitability of green investments, consumers' choices and environmental sustainability, effectively combining the economic, environmental and social aspects of sustainability. In practice, implementing the doughnut economy model, in which man must take into account the limit of the natural resource in order to continue to prosper, is needed (Raworth, 2017).

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Tables

Table 1: Losses by shading for the proposed landscape enhancements

Plant system*	Length (m) [A]	Width (m) [B]	Surface (mq) [C = A*B]	Planting costs (€) [D = C*1,5 (€/mq)]	Maintenance costs(€) [E = C*0,5 (€/mq)]	Shaded area (mq) [F = A*10 (m)]	Average grape yield (tons/ha) [G]	Grape loss (tons) [0.5*F*G/10,000]	Loss in value of grape production (€)	Loss in value of bulk wine production (€)	Loss in value of bottled wine production (€)
Riparian buffer strip (Pinot grigio)	500	5	2,500	3,750	1,250	5,000	13	3.25	2,275	2,958	17,063
Riparian buffer strip (Chardonnay)	1,000	5	5,000	7,500	2,500	10,000	7.6	3.8	2,660	3,458	19,950
Hedges with melliferous species	500	10	5,000	7,500	2,500	-	-	-	-	-	-
Noise-reduction hedges (Pinot grigio)	380	5	1,900	2,850	950	3,800	13	2.47	1,729	2,248	12,968
Noise-reduction hedges (Tocai)	350	5	1,750	2,625	875	3,500	6.0	1.05	735	956	5,513
Multifunctional forest	50	100	5,000	7,500	2,500	-	-	-	-	-	-
Total	**-**	**-**	**21,150**	**31,725**	**10,575**	**22,300**	**-**	**10.57**	**7,399**	**9,619**	**55,493**

*The cultivated vine cultivar on the shaded area is shown in brackets

Table 2: Economic results comparison between grape, bulk wine and bottled wine scenarios in cases of landscape enhancement intervention and without intervention

Economic results	Scenario 1 - Grape	Scenario 2 - Bulk wine	Scenario 3 - Bottled wine
Net income without intervention (€) [A]	**202,202**	**336,585**	**3,900,411**
Direct cost of landscape intervention (€/year) [B]	5,288	5,288	5,288
Value in loss production (€/year) [C]	7,399	9,619	55,493
Direct cost for additional treatments (160 €/ha per year) [D]	357	357	357
Total costs for landscape enhancement [B+C+D]	**13,043**	**15,263**	**61,137**
Net income with intervention [A-(B+C+D)]	**189,158**	**321,322**	**3,839,274**
Profitability incidence [B+C+D]/[A] (%)	**6.45**	**4.53**	**1.57**

Table 3: Economic results comparison between grape, bulk wine and bottled wine scenarios in cases of landscape enhancement intervention and without intervention if the whole vineyards were cultivated with *Glera* cultivar

Economic results	Scenario 1 - Grape	Scenario 2 - Bulk wine	Scenario 3 - Bottled wine
Net income without intervention (€) [A]	**1,349,398**	**1,827,821**	**6,796,059**
Direct cost of landscape intervention (€/year) [B]	5,288	5,288	5,288

Value in loss production (€/year) [C]	25,757	33,483	102,231
Direct cost for additional treatments (160 €/ha per year) [D]	357	357	357
Total costs for landscape enhancement [B+C+D]	**31,401**	**39,128**	**61,137**
Net income with intervention [A-(B+C+D)]	**1,317,997**	**1,788,693**	**6,689,828**
Profitability incidence [B+C+D]/[A] (%)	**2.33**	**2.14**	**1.50**

Table 4: **Cost comparison of bottled wine between actual scenario without intervention and the carbon neutral scenario**

	Production cost bottled wine (€/l)	**Production cost bottled wine (€/bottle)**	**Percentage difference (%)**
Actual scenario without intervention	1.96	1.47	-
Carbon neutral scenario	2.05	1.54	+4.43

Figures

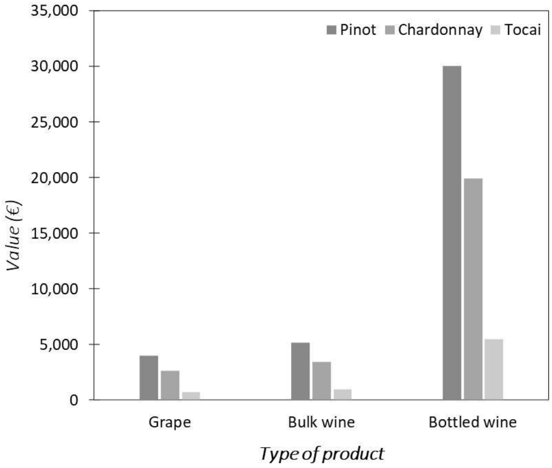

Figure 1: Value for production losses in three scenarios (grape, bulk wine and bottled wine) and type of grape variety. Indirect costs by shading increase as the processing steps move forward. Higher costs for bottled wine is given by the cost of bottling (0.85€/l), while it is more contained in the bulk wine scenario (0.21€/l) than the grape one. For the same product, they vary according to price and cultivar, that means different yields.

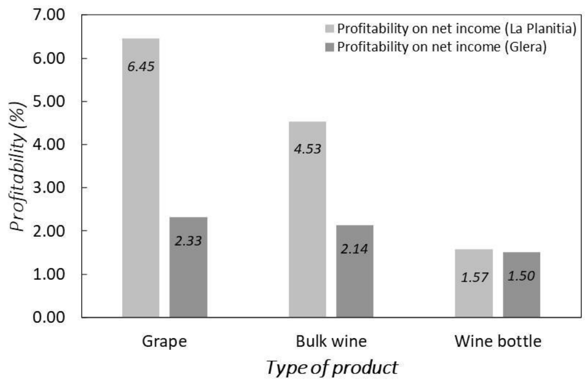

Figure 2: Green investment profitability incidence. Profitability incidence decreases as the processing steps move forward, net income grows faster than costs for green investment. In the Glera scenario profitability is lower than the real case because Glera yield and price are higher than other cultivars, so it is less affected by direct and indirect costs for landscape enhancement.

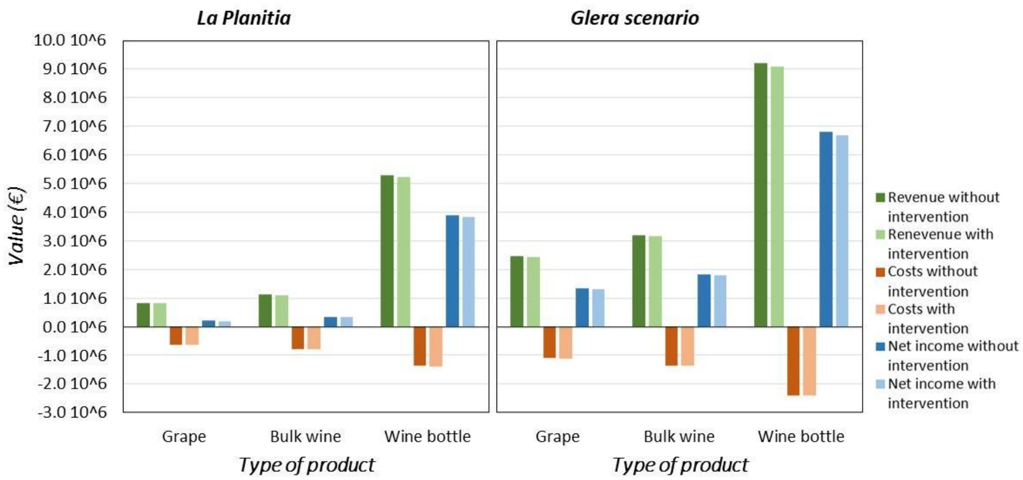

Figure 3: Comparison between the economic results in the three scenarios (grape, bulk wine and bottled wine) for the study case (*La Planitia*) and in case the whole production was made with *Glera* grapes. In both cases, the scenarios are reported with and without landscape enhancement intervention. The *Glera* scenario shows higher costs, although it is more profitable than other cultivars, revenues are higher than others and profitability incidence is less relevant, in particular for bottled wine.