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Evaluating Sustainability Practices in Viticulture Through a Comprehensive Study of Environmental, Social, and Economic Factors: A Case from Batman Province, Türkiye

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ABSTRACT

This study aims to assess the sustainability level of viticulture farms in Batman province and identify the factors that hinder their sustainability. The data used for the study were collected in the 2021 production year through surveys of 94 farms. A composite sustainability index was developed to measure the sustainability level of viticultural activities. Positive or endogenous weighting methods, such as Principal Component Analysis (PCA), were used to reduce the number of sustainability indicators and determine their weights. The index values for economic, environmental, and social sustainability were found to be 0.40, 0.44, and 0.53, respectively. The overall sustainability index value for the farms was calculated as 0.43. The study also highlighted that 46.81% of the farms are at risk in terms of sustainability, with larger farms showing better sustainability performance compared to smaller ones.

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Introduction

Grapevine, due to its non-selective nature in terms of climate and soil requirements, ease of propagation, and versatile utilization, is one of the most widely cultivated crops in the world. As of 2021, global viticulture covers a vast area of 6 729 198 ha, resulting in a substantial grape production of 73.52 million tons (FAO, 2023). In Türkiye, viticulture has a long and well-established cultural tradition due to its favorable climate zone and being the center of origin for grapevine (Kök et al., 2018; Korkutal et al., 2018a; Yılmaz et al., 2020; Teker, 2021). In 2021, Türkiye ranks 5th among the world countries with a vineyard area of 390 221.1 ha (FAO, 2023). Grape production is widespread across almost all provinces of Türkiye, with Manisa, Mardin, Denizli, and Mersin being among the leading ones (Akdemir and Candar, 2022). Batman province, the focus of this research, is also a significant region for viticulture, ranking 16th with a vineyard area of 5 888.6 ha in 2021 (TURKSTAT, 2023).

Despite the high potential for viticulture in both Türkiye and Batman province, there has been a decline in vineyard areas in recent years (Table 1). Batman province is losing its current position in terms of vineyard area and agricultural production. The increasing attractiveness of pistachio cultivation due to rising prices has led to the conversion of many vineyards into pistachio fields. Moreover, most existing vineyards are old, unproductive, and degenerated. The rapid decrease in vineyard areas and grape production in the region is a clear indication of the severe decline of viticulture. Additionally, producers face numerous challenges throughout the entire process, from establishing vineyards to marketing the final product, resulting in insufficient income from their produce.

Previous studies conducted to determine the potential, challenges, and solutions related to viticulture in Türkiye have revealed several key findings. Firstly, the majority of grape producers are elderly (Eşitken et al., 2012; Yener and Cebeci, 2013; Özatak et al., 2018; Gazioğlu Şensoy et al., 2020), and the level of education among them tends to be moderate to low

(Yener and Cebeci, 2013; Çakır et al., 2015; Özatak et al., 2018; Gazioğlu Şensoy et al., 2020). Additionally, land holdings in the viticulture sector are typically small-scale and often passed down through inheritance (Doğan et al., 2007; Eşitken et al., 2012; Çakır et al., 2014; Çakır et al., 2015; Özdemir et al., 2015; Korkutal et al., 2018b). A concerning trend observed is the conversion of vineyard areas into residential zones due to urbanization (Doğan et al., 2007; Uyak et al., 2011; Kiracı et al., 2018). Furthermore, grape producers commonly face a lack of knowledge about cultivation and cultural practices (Doğan et al., 2007; Uyak et al., 2011; Eşitken et al., 2012; Kızılaslan and Somak, 2013; Gözener et al., 2014; Öztunç, 2015; Korkutal et al., 2019; Gazioğlu Şensoy et al., 2020), as well as limited access to technical support (Doğan et al., 2007; Uyak et al., 2011; Eşitken et al., 2012). The absence or limited effectiveness of organizations like unions or cooperatives also poses challenges in the industry (Eşitken et al., 2012; Çakır et al., 2014; Çakır et al., 2015). Producers tend to cultivate locally suitable standard grape varieties (Doğan et al., 2007; Uyak and Gazioğlu Şensoy, 2009; Uyak et al., 2011; Eşitken et al., 2012) but struggle to achieve the expected yield (Uyak and Gazioğlu Şensoy, 2009; Uyak et al., 2011) and face difficulties in marketing their products (Kiracı, 2006; Akaalp, 2007; Çakır et al., 2014; Göksu et al., 2015; Özdemir et al., 2015; Çakır et al., 2017; Bingölbali, 2019).

Upon reviewing other studies conducted on a global scale, it has been observed that vineyard managers worldwide are increasingly dealing with the issue of invasive species. This has led to the adoption of innovative strategies, including the use of new insecticides, semiochemicals, and molecular techniques, to promote sustainable viticulture (Daane et al., 2018). Additionally, Climate change poses a significant threat by altering grape phenology and quality, necessitating adaptive strategies such as the use of drought-resistant plant materials, modified viticultural techniques, and potentially irrigation (Van Leeuwen et al., 2019).

The presence of these diverse challenges underscores the critical need to undertake an extensive investigation into the potential threats that may impede the sustainability of viticulture activities (Kiracı et al., 2018). Within the framework of sustainable agriculture, three separate perspectives are taken into account: environmental, social, and economic dimensions (Yıldız, 2015). Sustainable agriculture is a holistic approach that seeks to achieve environmental health, economic profitability, and socio-economic equity. Its overarching goal is to preserve agricultural productivity while minimizing environmental impact, ensuring long-term economic viability, enhancing the well-being of those involved in farming, and continuously improving sustainable practices (Şengül, 2020). Sustainable viticulture, according to the International Organisation of Vine and Wine (OIV, 2008), is a global strategy that encompasses grape production and processing systems to produce high-quality products, taking into account structural and regional economic sustainability. It emphasizes precise agricultural requirements, considers environmental risks, ensures food safety, and prioritizes consumer health while appreciating cultural, historical, ecological, and landscape elements.

Given this information, it is of utmost importance for the future of the region to ensure the healthy and planned development of grape production, which holds a significant share in Batman province's economy, and to make it sustainable. To achieve this goal, a comprehensive understanding of the current state of grape production in the region, along with the identification and resolution of its challenges, is essential. Hence, this study aims to assess the sustainability level of viticulture farms in the province and identify the barriers hindering their sustainability.

Material and Method

Research Area

Batman province, situated in the Southeastern Anatolia Region's Dicle section, is one of Türkiye 's prominent viticulture areas. Its geographical coordinates fall between 41° 40' and 41° 10' east longitudes and 37° 50' and 38° 40' north latitudes, while its elevation stands at 550 meters. The province shares borders with Diyarbakır to the west, Bitlis and Siirt to the east, Mardin to the south, and Muş to the north (Figure 1). The climate of Batman is characterized as continental, featuring hot and dry summers and cold winters with accompanying snowfall. The annual average temperature is recorded at 15.9°C, with an average annual maximum temperature of 23.7°C and an average annual minimum temperature of 8.9°C. The region experiences an average annual sunshine duration of 2873 hours, and the number of rainy days averages around 81.1 days per year. The average annual precipitation measures 494 mm, while the highest recorded temperature reaches 48.8°C and the lowest drops to -24°C (Anonymous, 2021).

Table 1. Changes in vineyard areas and grape production quantities in Türkiye and Batman province

Year	Türkiye		Batman	
	Area (ha)	Production (thousand tons)	Area (ha)	Production (thousand tons)
2013	468 792.20	4 011.41	7 495.00	29.49
2014	467 092.90	4 175.36	7 318.30	30.72
2015	461 955.70	3 650.00	6 463.00	25.21
2016	435 226.90	4 000.00	6 383.00	31.59
2017	416 906.80	4 200.00	6 397.40	27.06
2018	417 041.00	3 933.00	6 491.20	33.25
2019	405 438.70	4 100.00	6 037.80	21.81
2020	400 997.90	4 208.91	5 976.60	28.49
2021	390 221.10	3 670.00	5 888.60	21.17
2022	384 536.50	4 165.00	5 755.30	22.57
AARC	-2.18	0.42	-2.89	-2.93

AARC Average annual relative change (%); Source: TURKSTAT, 2023

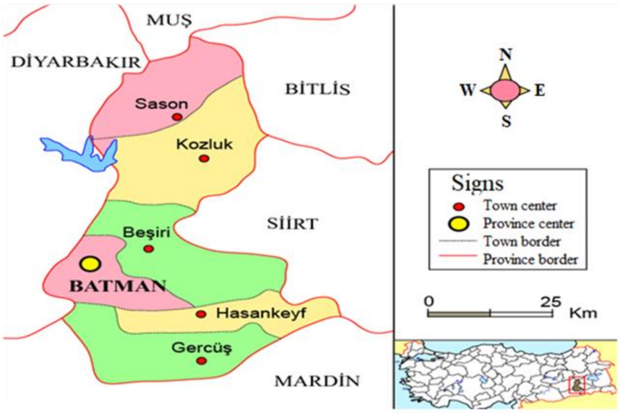

Figure 1. Geographical location of Batman province (Anonymous, 2022)

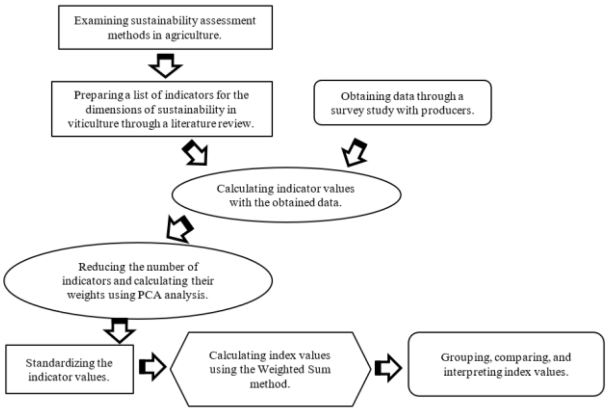

Figure 2. Methodology used in the study

Table 2. Indicators of sustainable viticulture activities

The dimension	The indicator.	Description.
Economic	Sales rate	The sales rate of grapes sold by the producer
	Marketing potential	The marketing status of the produced grapes by the producers
	Profitability status	The profitability of grape sales according to the producer's perception
	Land size	The size of the vineyard area (in hectare)
	Access to consultancy services	The utilization of technical support during the establishment of vineyards.
	Use of certified saplings.	The use of certified saplings during the establishment of vineyards
	Selection of saplings	Paying attention to factors such as suitability to soil, climate, etc. when purchasing saplings
	Yield	Yield of grapes per hectare (kg/ha)
	Access to financial support	Utilization of financial support when establishing vineyards
Environmental	Fertilizer usage	The type of fertilizer used in vineyard activities.
	Irrigation method	The irrigation method used in vineyard activities
	Tillage	The number of soil tillage applied in vineyard activities
	Disease and pest control	The method used for controlling diseases and pests in vineyard activities.
Social	Education	The education level of the producer.
	Age	The age of the producer

Batman province has a total land area of 465 921.0 ha, with different land use classifications. Approximately 34% of the land is designated as agricultural land, 9% as pastureland, 17% as forest land, and 40% as unsuitable for agriculture (Aydın, 2019). Within Batman Central, Kozluk, and Beşiri districts, a diverse range of agricultural and industrial crops are cultivated.

Data Collection

The data for this study were obtained through face-to-face surveys conducted with vineyard farms in Batman province. Also; Ethics committee permission was given by the board members at the meeting of the Siirt University Ethics Committee dated 24/11/2020 and numbered 2020/100. As of 2021, there were 3 231 vineyard farms registered in the Farmer Registration System (FRS) in Batman province, constituting the main target population for the research. The number of producers to be interviewed within the scope of the study was determined as 94, employing the proportional sample size formula (Newbold et al., 1995), with a 95% confidence level and a 10% margin of error.

$$n = \frac{N.p(1-p)}{(N-1)\sigma^2_{p_x} + p(1-p)}$$

n= Sample size, N= Number of producers engaged in viticulture in the research area, σp_x^2 = Variance, P= Proportion of producers adopting sustainable practices in viticulture (P is taken as 0.50 to achieve the maximum sample size.)

Development of the Sustainability Index

In this study, a Composite Sustainability Index was developed to measure the sustainability level of vineyard enterprises (OECD, 2008). The stages of developing the relevant index are provided in Figure 2.

In this study, a comprehensive review of various sustainability assessment tools such as MESMIS, RISE, SAFE, SAFA, IDEA, and indicators used for measuring sustainability in crop production, along with relevant studies related to viticulture, was conducted to prepare a comprehensive list of indicators covering the Economic, Social, and Environmental dimensions of sustainability.

The number of indicators calculated from the survey data was then reduced using the Principal Component Analysis (PCA) method. The resulting indicator list obtained through PCA is presented in Table 2.

In this study, the weighting of obtained indicators was carried out using the positive or endogenous weighting technique known as PCA analysis. Positive or endogenous techniques determine the weights of fundamental indicators through statistical procedures (Fallah-Alipour et al., 2018). Subsequently, the indicator values were standardized using the Min-Max method (Freudenberg, 2003), and then the weighted summation was employed to calculate the sustainability index values for each dimension of sustainability and the overall sustainability. The calculated indices were categorized based on their average and standard deviation, allowing for the determination of sustainability levels (Şengül, 2020). As a result, producer profiles were developed according to these categories.

A. Unsustainable : A < (Mean - Standard Deviation)
B. Relatively Unsustainable : (Mean - Standard Deviation) ≤ B ≤ Mean
C. Relatively Sustainable : Mean <C ≤ (Mean + Standard Deviation)
D. Sustainable : (Mean+Standard Deviation) < D

Table 3. Categorization of farms According to Land Size

	Number of farms	Average farm size (hectare)
0.1-0.699 hectare (small)	30	0.39
0.7-1.499 hectare (medium)	30	1.01
1.5+ hectare (large)	34	3.35
Total	94	1.66

Table 4. KMO and Bartlett test results

The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy		0.703
Bartlett's Test of Sphericity	Approximate Chi-Square	372.754
	Degrees of Freedom	105
	Significance Level.	0.00

Table 5. Explained variance percentages of components

Component	Eigenvalue	Variance Ratio	Cumulative Variance Ratio
1	3.28	21.89	21.89
2	2.17	14.44	36.33
3	1.25	8.36	44.68
4	1.21	8.08	52.76
5	1.15	7.68	60.44
6	0.97	6.50	66.93
7	0.83	5.52	72.45
8	0.78	5.20	77.65
9	0.72	4.82	82.47
10	0.68	4.54	87.01
11	0.66	4.37	91.38
12	0.49	3.27	94.65
13	0.46	3.09	97.75
14	0.20	1.30	99.05
15	0.14	0.95	100.00

Furthermore, the vineyard farms have been categorized into three groups based on their land sizes, and their sustainability status has been analysed accordingly (Table 3).

Results and Discussion

In order to assess the sustainability level of viticulture farms, the appropriateness of the selected key indicators for conducting PCA analysis was examined using The Kaiser-Meyer-Olkin (KMO) and Bartlett test statistics. As presented in Table 4, both the KMO (with a value greater than 0.5) and the Bartlett test results (significant at $p<0.001$ level) confirmed that the data is suitable for PCA analysis.

In the process of PCA analysis, the components with eigenvalues greater than 1 were taken into account to determine the number of components. As depicted in Table 5, these 5 components account for 60.44% of the total variance.

Table 6 presents the loadings of the components obtained from PCA analysis. The 1st and 2nd components are closely related to the economic sustainability of the farms, capturing crucial indicators such as grape sales rate, marketing potential, and yield per hectare, among others. On the other hand, the 3rd and 4th components are associated with the environmental sustainability of the farms, encompassing indicators such as fertilizer usage and irrigation method. Lastly, the 5th component is attributed to the social sustainability of the farms and includes two key indicators: education and age.

In the PCA analysis, the load values of the indicators, as explained in the Rotated Component Matrix, were utilized to assess the variance explained by each component and its contribution to the total variance. Based on these findings, the weights of the three dimensions of sustainability, along with the weights of the fundamental indicators corresponding to each dimension, were calculated. According to Table 7, the most crucial dimension in assessing the sustainability of viticulture farms is the economic dimension, with a weight value of 0.560. It is followed by the environmental dimension, with a weight value of 0.306, and the social dimension, with a weight value of 0.134.

Table 8 presents the weights of the fundamental indicators related to the sustainability dimensions, both within each dimension and overall. Utilizing the within-dimension weight values, the sustainability index for each dimension was calculated, while the overall sustainability index was determined using the overall weights.

Table 9 displays the sustainability values of viticulture farms categorized by their size groups. The economic sustainability index is calculated as 0.40, the environmental sustainability index is 0.44, the social sustainability index is 0.53, and the overall sustainability index is 0.43.

Table 6. Principal Component Matrix

Rotated Component Matrix					
	Component				
	1	2	3	4	5
Sales rate	0.914	0.175	-0.063	0.032	0.010
Marketing potential	0.904	0.047	0.064	0.022	-0.106
Profitability status	0.870	0.137	0.009	0.068	-0.063
Land size	0.550	-0.168	-0.032	0.216	0.235
Access to consultancy services	0.132	0.714	-0.057	0.256	-0.064
Use of certified saplings.	0.003	0.658	0.129	0.129	0.085
Selection of saplings	0.114	0.636	-0.143	-0.137	0.335
Yield	0.201	0.534	0.283	-0.177	-0.132
Access to financial support	-0.259	0.522	0.273	0.145	-0.168
Fertilizer usage	-0.084	-0.027	0.808	-0.079	0.158
Irrigation method	-0.069	-0.242	-0.682	-0.193	0.070
Tillage	-0.054	-0.137	0.116	-0.836	0.126
Disease and pest control	0.162	0.062	0.259	0.643	0.148
Education	-0.294	0.015	0.020	-0.011	0.743
Age	0.182	0.024	0.059	0.018	0.597

Table 7. Weights of Sustainability Dimensions obtained from PCA analysis

Criteria	Economic	Environmental	Social
Weight	0.560	0.306	0.134

Table 8. Weighting Sustainability Indicators using the PCA Method

Dimension	Indicators	Within Dimension	Overall
Economic	Sales rate	0.182	0.102
	Marketing potential	0.179	0.100
	Profitability status	0.166	0.093
	Land size	0.066	0.037
	Access to consultancy services	0.109	0.061
	Use of certified saplings	0.093	0.052
	Selection of saplings	0.087	0.048
	Yield	0.061	0.034
	Access to financial support	0.058	0.033
Environmental	Fertilizer usage	0.297	0.091
	Irrigation method	0.211	0.065
	Tillage	0.309	0.094
	Disease and pest control	0.183	0.056
Social	Education	0.608	0.082
	Age	0.392	0.053

Table 9. Composite Sustainability Index values by farm groups

Sustainability Index	Small (30)	Medium (30)	Large (34)	Overall (94)	p-value
Economic Sustainability Index	0.21	0.42	0.54	0.40	0.00**
Environmental Sustainability Index	0.44	0.45	0.44	0.44	0.99
Social Sustainability Index	0.53	0.50	0.57	0.53	0.47
Overall Sustainability Index	0.33	0.44	0.51	0.43	0.00**

**According to the Kruskal-Wallis test results, it is significant at the $p<0.01$ level.

These values range from 0 to 1, with higher values indicating greater sustainability. An analysis based on farm size groups reveals that as the vineyard area increases, both the economic and overall sustainability of the farms show significant improvements ($p<0.01$) (Figure 3). This suggests that larger vineyard areas are associated with higher levels of sustainability.

Based on the indicators that constitute the economic sustainability index, it is evident that approximately 45.48% of grapes produced by farms are sold. Unfortunately, 35.11% of producers face marketing challenges, resulting in unprofitable viticulture endeavors. Additionally, a significant portion (33%) of producers do not make any sales, while only a meager 6.4% successfully sell their entire grape yield. These findings raise concerns about the farms' economic sustainability. Based on the findings of a study conducted in Gaziantep, it has been reported that grape producers encounter several challenges in marketing their products. These challenges include a scarcity of buyers and grape varieties, inadequate market knowledge among producers, subpar quality of processing facilities, and a limited number of processing facilities (Seçer and Yener, 2017).

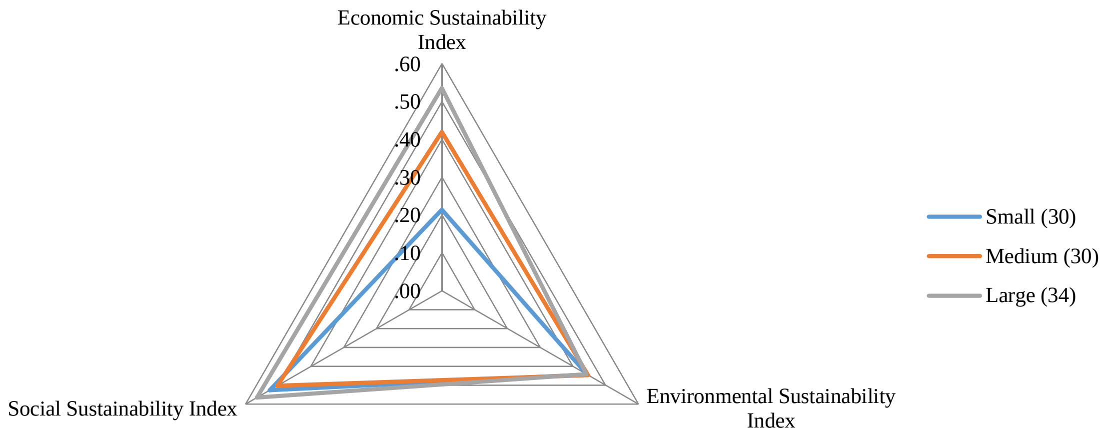

Figure 3. Sustainability Dimensions by farm groups

Another indicator affecting economic sustainability is land size. The average land size in the farms is 1.66 hectares, with 26.60% having an area below 0.5 hectare, 27.66% between 0.5 and 1.0 hectare, and 45.74% with an area larger than 1 hectare. According to a study conducted by Tapkı et al. (2020) in the Tarsus district, the average size of grape-producing farms is 1.77 hectare, with 70.8% of them having an area between 1.1 and 2.0 hectare. Previous research has suggested that factors such as input usage, productivity, and agricultural income could be closely related to the size of the farms (Doğan Öz and Saner, 2022). The indivisibility of capital inputs like machinery can increase average input costs per area for small-scale farms. Conversely, larger farms with lower fixed costs per managed area can lead to increased production efficiency (Ren et al., 2019). These factors directly impact economic sustainability.

In the examined farms, around 65.96% of the producers did not avail of technical support offered by agricultural engineers while establishing their vineyards. Farmer consultancy, which involves professional assistance related to rural development, is a vital service (Tamulienė et al., 2017). Utilizing technical support and agricultural consultancy can lead to enhanced productivity, improved quality, cost reduction, better disease control, and efficient marketing strategies, thereby increasing income and profitability. Moreover, technical support aids in elevating farms' competitiveness and sustaining their market position. However, the absence of such support can result in unfavorable outcomes like reduced productivity, quality deficiencies, increased costs, and weakened economic sustainability. Regrettably, over half of the examined farms' inability to benefit from technical support has negatively impacted their economic sustainability.

The use of certified vine saplings is a crucial factor affecting the economic sustainability of the farms. These saplings play a pivotal role in modern viticulture by ensuring the production of healthy and high-quality grapevines, as they are free from viruses, virus-like diseases, and pests (Söylemezoğlu et al., 2010; Çelik, 2014). The adoption of certified vine saplings offers significant economic benefits during vineyard establishment and farm operations. With healthy plants, farms experience reduced costs and prevent losses from diseases and pests, ultimately enhancing their profitability. Furthermore, the longer lifespan of certified saplings leads to lower maintenance and renewal expenses in the long term, thereby improving overall cost-effectiveness. Additionally, the careful selection of appropriate rootstock and variety among certified vine saplings enables better adaptation to environmental conditions, promoting environmental sustainability. Therefore, integrating certified vine saplings not only strengthens the economic sustainability of the farms but also becomes a pivotal factor for their long-term success. Despite these advantages, the usage of certified vine saplings remains low, with only 9.57% of the producers in the examined farms opting for them. This limited adoption negatively impacts the overall sustainability of the farms.

The study's findings highlight the significance of yield per hectare in grape vineyards as a crucial indicator influencing economic sustainability. Higher yields contribute to increased farm income and profitability, lower unit product costs, enhanced competitiveness, and greater investment potential. Moreover, it promotes sustainable agricultural practices by optimizing the use of natural resources. The examined farms reported a yield per hectare of 3 971.3 kg. In comparison, TURKSTAT's 2021 data shows the average yield of different grape varieties in Türkiye to be 9 404.9 kg/ha, while in the Batman province during the same period, it is 3 594.9 kg/ha (TURKSTAT, 2023). The calculated value for the examined farms closely aligns with TURKSTAT's regional figure but falls below the national average, which has a negative impact on economic sustainability. Notably, in a study conducted in Kalecik district, Ankara province, the yield per hectare was found to be 9 280.7 kg for table grape varieties and 6 829.1 kg for wine grape varieties (Bayramoğlu et al., 2010).

The utilization of financial support during the establishment of grape vineyards is a critical factor that can significantly impact the farms' sustainability. By reducing initial costs and supporting technological advancements, financial support enhances farms' productivity. Additionally, it improves income and cash flow, providing the necessary resources for smooth operations. Well-designed financial assistance can contribute to the long-term success of farms and foster sustainable agricultural practices. However, in the examined farms, only 25.53% of them took advantage of financial support during the establishment of their vineyards. In contrast, a study conducted in Siirt province found that none of the vineyard producers benefited from agricultural support (Gazioğlu Şensoy et al., 2020).

When analyzing the sub-indicators of environmental sustainability, the study revealed that 46.81% of grape producers do not use any fertilizers, while 17.02% opt for chemical fertilizers, 3.19% choose commercial organic fertilizers, and 32.98% rely on farmyard manure. These varying fertilizer usage practices have significant implications for the sustainability of grape farms. Some producers abstain from using fertilizers to preserve soil and environmental health. However, this approach can pose challenges in terms of productivity and income. Those employing chemical fertilizers may experience increased yields and product quantity, but improper or excessive use can raise the risk of environmental pollution. On the other hand, utilizing commercial organic fertilizers can promote soil health and environmental sustainability, despite their higher costs potentially affecting economic sustainability. In contrast, using farmyard manure can improve soil quality, supporting environmental sustainability, and is often considered a viable economic option. Therefore, achieving a balanced impact of fertilizer usage on sustainability requires farmers to make appropriate fertilizer choices and adopt suitable practices.

When examining irrigation methods, it was found that 6.38% of grape producers prefer flood irrigation, 11.70% opt for drip irrigation, while a significant majority of 81.91% reported not using any irrigation. The proper selection of irrigation methods holds paramount importance for the economic and environmental sustainability of grape farms. Efficient techniques like drip irrigation contribute to the optimal utilization of water resources, prevent water wastage, and promote environmental sustainability. On the other hand, traditional methods such as flood irrigation may lead to water wastage and have adverse long-term impacts on economic and environmental sustainability. The decision to forgo irrigation can be environmentally sustainable in regions with adequate natural rainfall, yet it may have negative consequences on economic sustainability due to a shortened vineyard lifespan and reduced yields and product quality, particularly for table grape varieties.

In the studied farms, soil tillage practices vary, with 12.77% of grape producers performing it once a year, 17.02% twice a year, and the majority, 70.21%, engaging in soil tillage three times a year. However, excessive soil tillage can disrupt the soil structure, leading to increased soil erosion and adversely affecting productivity. This can result in reduced farm yield and profitability in the long run. On the other hand, adopting less frequent soil tillage practices can help preserve soil health and water retention capacity, leading to more efficient water resource utilization and reduced erosion risks. Moreover, it contributes to both environmental and economic sustainability by lowering energy consumption. Thus, reducing the frequency of soil tillage is a crucial step toward achieving long-term agricultural success while safeguarding environmental and economic sustainability.

The choice of disease and pest control methods in grape vineyards has significant implications for the farms' sustainability. Among the studied farms, 19.15% of grape producers prefer not to conduct any disease and pest control measures, which can have adverse effects on environmental sustainability. Diseases and pests can lead to reduced yield and product quality, resulting in income loss. On the other hand, 75.53% of producers opt for chemical pesticides, while 5.32% choose organic pesticides. Those using chemical pesticides may achieve faster and more effective results, but this can also contribute to negative environmental effects, such as soil and water pollution and the disruption of the natural balance. Conversely, those who opt for organic pest control methods support environmental sustainability by avoiding the adverse impacts of chemical pesticides.

The education level and age of producers in grape vineyard farms are crucial factors that influence the farms' social sustainability and long-term success. Among the farms examined, 5.32% of grape producers are illiterate, while 51.06% have completed primary school, 13.83% have completed middle school, and 29.79% have completed high school or higher education. Producers with higher education levels have easier access to agricultural knowledge and skills, enabling them to embrace modern farming practices and increase productivity. This not only strengthens the farm's economic sustainability but also fosters social responsibility and environmental awareness, thus promoting environmental sustainability. On the other hand, the average age of producers is 51.82 years, with only 21.28% being 40 years old or younger. Younger producers possess traits such as agricultural entrepreneurship, leadership potential, openness to innovation, and the ability to introduce fresh ideas and approaches to the farm, enhancing its competitive advantage. Additionally, young producers can have a significant impact on countering rural population decline and migration by continuing the farming profession. However, the experience and traditional knowledge of older producers are also invaluable, providing a solid foundation for the farms' sustainability.

The overall sustainability of vineyard farms was evaluated based on their average and standard deviation, leading to the establishment of four distinct sustainability categories: unsustainable (0.00-0.27), relatively unsustainable (0.28-0.43), relatively sustainable (0.44-0.58), and sustainable (0.59-1.00). As shown in Table 10, 17.02% of the studied farms are categorized as unsustainable, 29.79% as relatively unsustainable, 40.43% as relatively sustainable, and 12.77% as sustainable. The majority of small-scale farms are at risk in terms of sustainability, whereas a significant proportion of large-scale farms are considered sustainable. When compared with a study conducted in Qazvin, Iran, the results of this research show some similarities. In the Qazvin study, approximately 62.3% of vineyard farms were classified in the unsustainable and relatively unsustainable categories, while 30% were relatively sustainable, and 7.7% were deemed fully sustainable (Ghazvini et al., 2012). Thus, there is a certain level of resemblance between the findings of the two studies.

Table 10. Sustainability status of producers based on farm groups

Category	Small (30)		Medium (30)		Large (34)		Overall (94)	
	no	%	no	%	no	%	no	%
Unsustainable	12	40.00	4	13.33	0	0.00	16	17.02
Relatively Unsustainable	12	40.00	10	33.33	6	17.65	28	29.79
Relatively Sustainable	4	13.33	12	40.00	22	64.71	38	40.43
Sustainable	2	6.67	4	13.33	6	17.65	12	12.77
Total	30	100.00	30	100.00	34	100.00	94	100.00

Table 11. Profile of producers according to sustainability levels

Category	Producer profile
Unsustainable (16)	The producers have an average age of 56.63 years, and the average family size is 7.94 people. Among them, 37.5% have completed education up to middle school or higher. Only 12.50% of them conducted soil analysis before establishing the vineyard. None of them have agricultural insurance. Additionally, a mere 12.50% of the producers possess knowledge about organic farming.
Relatively Unsustainable (28)	The producers' average age is 51.61 years, with an average family size of 6.39 people. Nearly 46.43% of them have received an education up to middle school or beyond. Around 17.86% of the producers conducted soil analysis before establishing their vineyards, while only 3.57% have agricultural insurance. Additionally, 28.57% of the producers are knowledgeable about organic farming.
Relatively Sustainable (38)	The average age of the producers is 51.71 years, and the average family size is 6.34 people. About 42.11% of them have completed middle school or higher education. Approximately 15.79% of the producers conducted soil analysis before establishing their vineyards, and only 7.89% have agricultural insurance. Moreover, 26.32% of the producers possess knowledge about organic farming.
Sustainable (12)	The producers have an average age of 46.25 years, and the average family size is 5.67 people. A significant portion, approximately 50.00%, have completed middle school or achieved higher education. Before establishing their vineyards, about 41.67% of the producers conducted soil analysis, and only 16.67% have agricultural insurance. Additionally, 41.67% of the producers possess knowledge about organic farming.

The characteristics of producers in different sustainability categories are presented in Table 11. Producers in the relatively unsustainable group share some similarities with those in the relatively sustainable group. However, the sustainable group stands out with younger producers, smaller family sizes, and a higher proportion of education beyond middle school compared to the unsustainable group. Furthermore, producers in the sustainable group are more inclined to have agricultural insurance as a risk management tool and possess greater knowledge of organic farming as an example of sustainable agriculture.

Conclusion

This study aimed to assess the sustainability level of vineyard farms in Batman province and identify the obstacles hindering their sustainability. Surveys were conducted with 94 farms, resulting in the calculation of various sustainability indices. The economic sustainability index was found to be 0.40, the environmental sustainability index 0.44, the social sustainability index 0.53, and the overall sustainability index 0.43. These findings indicate that the farms' economic and environmental sustainability levels are below average, while their social sustainability level shows an average value.

The results of this study indicate that the economic sustainability of vineyard farms is negatively affected mainly due to low sales rates and a lack of technical support. The farmers also show weaknesses in using certified saplings and enhancing productivity. These factors have a detrimental impact on the farms' income and profitability, consequently reducing the sector's competitiveness. Therefore, it is essential to provide grape producers with technical support and consultancy services, encourage the use of certified saplings, and improve productivity to strengthen economic sustainability. Additionally, effective utilization of agricultural financial support will also support the long-term success and sustainability of the farms. This way, the sector can achieve a more competitive and sustainable structure. In light of the challenges faced in product marketing, which have contributed to a decline in economic sustainability, it is recommended that the establishment of cooperatives or producer associations be considered. Such organizations could benefit producers by enhancing their marketing capabilities and improving market access.

In this study, indicators affecting environmental sustainability were examined. It was determined that farmers have various preferences regarding fertilizer usage. While some producers refrain from using fertilizers, others opt for chemical, organic, or farmyard manure. Among the irrigation methods, drip irrigation is preferred, but many farmers do not practice irrigation at all. Soil cultivation frequency and disease/pest control methods also show diversity. The recommendations include adopting a balanced and informed approach to fertilizer usage, promoting high-efficiency irrigation methods like drip irrigation, reducing soil cultivation frequency, and supporting organic pest control methods. Proper implementation of these measures will strengthen the environmental sustainability of grape vineyard farms and contribute to the sector's long-term success.

The study findings reveal that the relatively high average age of farmers and the declining interest of the younger generation in agriculture could potentially hinder the continuity and social sustainability of grape vineyard farms. To address this, there is a need to implement encouraging policies and provide support to attract and retain young farmers in the sector. Moreover, fostering greater interaction between experienced, educated farmers and the community, while promoting knowledge sharing, is crucial. By taking these measures, grape vineyard farms can enhance their social sustainability and lay a strong foundation for the future of the agricultural sector.

Declarations

Data Availability

The data to support the results and conclusions of this study is presented within the article. Detailed data is available upon request.

Conflicts of interest

No potential conflict of interest was reported by the authors.

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References

Akaalp, H. (2007). Mardin İli Bağ Yetiştiriciliğinin Analizi, Yüksek Lisans Tezi, *Harran Üniversitesi Fen Bilimleri Enstitüsü,* Şanlıurfa.

Akdemir, U., & Candar, S. (2022). Regional economics of viticulture in Turkey in the period 1970. *Research-Review*, *2*(2), 55-71.

Anonymous. (2021). İllere ait mevsim normalleri (1991-2021), https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx?m=BATMAN_(Date of access: 20 August 2022).

Anonymous. (2022). https://batman.ktb.gov.tr/TR-56576/cografya.html (Date of access: 8 August 2022).

Aydın, Y. (2019). Batman ili toprak ve su kaynaklarının tarımsal açıdan değerlendirilmesi, *Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi*, 29(1), 178-186.

Bayramoğlu, Z., Gündoğmuş, E., & Çelik, Y. (2010). Ankara İli Kalecik ilçesinde yetiştirilen sofralık ve şaraplık üzüm üretiminin karlılık analizi üzerine bir araştırma. *Tarım Ekonomisi Dergisi*, *16*(1), 25-31.

Bingölbali, D. (2019). Van'da Sebze Yetiştiriciliğinde Yabancı Ot Sorunu, Yüksek Lisans Tezi, *Yüzüncü Yıl Üniversitesi Fen Bilimleri Enstitüsü,* Van.

Çakır, A., Karakaya, E., & Kuzu, K. (2014). Diyarbakır ili Eğil ilçesi bağcılığının mevcut durumu, sorunları ve çözüm önerileri, *Türk Tarım ve Doğa Bilimleri Dergisi,* 1(4), 490–500.

Çakır, A., Karakaya, E., & Uçar, H. K. (2015). Mardin İli Savur ilçesi bağ işletmelerinin mevcut durumu ve potansiyeli, *Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi,* 5(1):9-19.

Çakır, A., Odabaşıoğlu, M. İ., İşlek, F., & Alanko, M. (2017). Diyarbakır İli Dicle ilçesi bağcılığının mevcut durumu, başlıca sorunları ve çözüm önerileri, *Alatarım Dergisi,* 16(2): 37-46.

Çelik, H. (2014). Ülkemizde sertifikalı asma fidanı üretimi ile ilgili çalışmalar ve bu alanda sağlanan gelişmeler, TÜRKTOB, 3(11), 4-10.

Daane, K. M., Vincent, C., Isaacs, R., & Ioriatti, C. (2018). Entomological opportunities and challenges for sustainable viticulture in a global market. *Annual review of entomology*, 63(1), 193-214. https://doi.org/10.1146/annurev-ento-010715023547 .

Doğan, A., Erdinç, S., & Uyak, C. (2007). Erciş ilçesi bağcılığının geçmişi ve bugünü üzerine bir araştırma, *5. Ulusal Bahçe Bitkileri Kongresi,* Erzurum Atatürk Üniversitesi Ziraat Fakültesi 4-7 Eylül 2007, II. Cilt, 424-428.

Doğan Öz, B., & Saner, G. (2022). Determination of sustainability indicators of nut farms: The case of pistachio. *Turkish Journal of Agriculture-Food Science and Technology*, 10(12), 2609-2618. https://doi.org/10.24925/turjaf.v10i12.2609-2618.5447 .

Eşitken, A., Pırlak, L., Kara, Z., Bayramoğlu, Z., & Sabır, A. (2012). Konya İli meyvecilik ve bağcılık eylem planı, *Mevlana Kalkınma Ajansı Proje Raporu,* Konya.

Fallah-Alipour, S., Mehrabi Boshrabadi, H., Zare MehrJerdi, M. R., & Hayati, D. (2018). A Framework for Empirical Assessment of Agricultural Sustainability: The Case of Iran, MDPI, *Sustainability*, 10 (4823); 26p. https://doi.org/10.3390/su10124823.

FAO. (2022). Food and Agriculture Organization of the United Nations. http://www.fao.org/home/en/ (Date of access: 19 July 2022).

Freudenberg, M. (2003). Composite indicators of country performance: A critical assessment, OECD science, Technology and Industry Working Papers, 16, Paris. https://doi.org/10.1787/18151965.

Gazioğlu Şensoy, R. İ., Kısaca, G., Baş., E. Ö., & Yılmaz, Y. (2020). Siirt ili ve bazı ilçelerinde mevcut bağcılık işletmelerinin yapısal özellikleri ve tarımsal uygulamalara yaklaşımlarının belirlenmesi, *Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi,* Cilt: 30, Sayı: 2. https://10.29133/yyutbd.694930.

Ghazvini, M., Veisi, H., Mahdavi, D. A., Khoshbakht, K., & Nejatian, M. A. (2012). Study of sustainability status in vineyards of Takestan County by using framework for evaluation sustainable land management (FESLM), *Keshavarzi Bum Shenakhti Dergisi*,2(1), 104-115.

Göksu, A., Fuller, W. J., Altındişli, A., Boyacı, M., & Abak, K. (2015). KKTC Bağcılığı: mevcut durumu sorunları ve çözüm önerileri, *Selçuk Tarım ve Gıda Bilimleri Dergisi,* A.27 (Türkiye 8. Bağcılık ve Teknolojileri Sempozyumu Özel Sayısı): 660-669.

Gözener, B., Kaya, Y., & Sayılı, M. (2014). Erzincan ili üzümlü ilçesinde cimin üzümü üretimi ve pazarlama durumu, *Gaziosmanpaşa Bilimsel Araştırma Dergisi,* 9, 74-80.

Kızılaslan, N., & Somak, E. (2013). Tokat ili Erbaa ilçesinde bağcılık işletmelerinde tarımsal ilaç kullanımında üreticilerin bilinç düzeyi, *Gaziosmanpaşa Journal of Scientific Research,* 4, 79-93.

Kiracı, M. A. (2006). Tekirdağ İli Şarköy İlçesi Bağcılığının Mevcut Durumu, Üreticilerin Sorunlarının Çözümüne İlişkin Örgütlenme Olanaklarının Belirlenmesi, Yüksek Lisans Tezi, *Trakya Üniversitesi Fen Bilimleri Enstitüsü,* Tekirdağ.

Kiracı, M. A., Şenol, M. A., Kıran, T., & Candar, S. (2018). Çanakkale bağcılığının mevcut durumu, gelişimi ve üreticilerin eğitim ihtiyaç analizi, *Çanakkale Onsekiz Mart Üniversitesi Ziraat Fakültesi Dergisi,* 6(Özel Sayı), 77-84.

Korkutal, İ., Bahar, E., & Dündar, D. G. (2019). Edirne ili Uzun köprü ilçesi bağcılık yapısının incelenmesi, *Çanakkale Onsekiz Mart Üniversitesi Ziraat Fakültesi Dergisi,* 7(1), 127-136. https://doi:10.33202/comuagri.457451.

Korkutal, İ., Bahar, E., & Zinni, A. (2018b). Tekirdağ ili Şarköy ilçesi bağcılık yapısının incelenmesi, *Selçuk Tarım ve Gıda Bilimleri Dergisi*, 32 (3), 475-481. https://doi:10.15316/SJAFS.2018.89 .

Korkutal, İ., Bahar, E., Kök, D., Şahin, N., Uysal, T., Özalp, Z. O., Yaşasın, A. S., Candar, S., Alço, T., & Işın, M. A. (2018a). Collecting genetic materials and isolating DNAs of grapevine (*Vitis* spp.) as naturally grown in Ganos Mountains (in Turkish with English abstract). *Mediterranean Agricultural Science* 31(1), 5-15. https://doi:10.29136/mediterranean.377609.

Kök, D., Bahar, E., Korkutal, I., Bal, E., Alço, T., Candar, S., & Yaşasin, A. S. (2018). Determination of phytochemical properties in genetic materials collected from grapevines (*Vitis* spp.) found in natural flora of Ganos mountains. *Journal of Tekirdag Agricultural Faculty*, 15(3), 52-60.

Newbold, P., Carlson, W., & Thorne, B. (1995). Statistic For Business and Economics, by Prentice-Hall. *Inc., New Jersey, USA.*

OECD. (2008). Handbook on constructing composite indicators: Methodology and user guide, *Organization for Economic Co-operation and Development-JRC,* Joint Research Centre.; OECD: Paris, France, 162p.

OIV. (2008). Resolution CST 1/2008—OIV guidelines for sustainable vitiviniculture: production, processing and packaging of products. Available online: http://www.oiv.int/public/medias/2089/cst-1-2008-en.pdf (accessed on 17 March 2023).

Özatak, Ö. F., Doğan, A., Kazankaya, A., & Uyak, C. (2018). Hakkâri İli bağ yetiştiriciliğinin analizi, *Bahçe* 47 (Özel Sayı 1: Türkiye 9. Bağcılık ve Teknolojileri Sempozyumu): 443–450, ISSN 1300–8943.

Özdemir, B., Akbay, C., & Çalışkan, H. (2015). Mersin ili Tarsus İlçesi üzüm üretiminin mevcut durumu ve sorunları, *Türk Bilimsel Derlemeler Dergisi*, 8 (2), 71-73.

Öztunç, Y. (2015). Şanlıurfa İlinde Bağcılığın Yaygın Olarak Yapıldığı Bölgelerde Bağların Mevcut Durumu Üzerine Bir Araştırma, Yüksek Lisans Tezi, *Harran Üniversitesi Fen Bilimleri Enstitüsü,* Şanlıurfa.

Ren, C., Liu, S., Van Grinsven, H., Reis, S., Jin, S., Liu, H., & Gu, B. (2019). The impact of farm size on agricultural sustainability. *Journal of Cleaner Production*, *220*, 357-367. https://doi.org/10.1016/j.jclepro.2019.02.151.

Seçer, A., & Yener, G. (2017). Gaziantep İlinde üretici düzeyinde üzüm pazarlama yapısı, üretim ve pazarlamada karşılaşılan sorunlar ve çözüm önerileri. *Harran Tarım ve Gıda Bilimleri Dergisi*, *21*(4), 444-455. https://doi.org/10.29050/harranziraat.295804.

Söylemezoğlu, G., Dumanoğlu, H., Çelik, H., Kunter, B., Atıcı, A., & Tahmaz, H. (2010). Türkiye'de asma ve meyve fidanı üretimi ve kullanımı. Ziraat Mühendisliği VII. Teknik Kongresi. Bildiriler Kitabı–2, 891– 907, 11–15 Ocak 2010 Ankara. Ziraat Mühendisliği 7. Teknik Kongresi.

Şengül, Z. (2020). Ege Bölgesinde Arıcılık Yapan İşletmelerin Sürdürülebilirlik Yönünden Değerlendirilmesi, *EÜ. Fen Bilimleri Enstitüsü Tarım Ekonomisi Anabilim Dalı,* Doktora Tezi, İzmir.

Tamulienė, V., Raupelienė, A., & Kazlauskienė, E. (2017). Farmers' preferences selecting agricultural consulting services. *Montenegrin Journal of Economics*, 13 (4), 79-87. https://doi.org/10.14254/1800-5845/2017.13-4.6.

Tapkı, N., Davran, M. K., & Görgü, A. (2020). Üzüm üreten işletmelerin üretim ve pazarlama yapıları: Tarsus örneği. *Mustafa Kemal Üniversitesi Tarım Bilimleri Dergisi*, *25*(1), 75-83. https://doi.org/10.37908/mkutbd.679776.

Teker, T. (2021). Cumulative bioclimatic indices and climate data of recent years in some viticultural regions of Turkey. Çığ, A. (edt.) Agricultural Studies On Different Subjects, Iksad Publications. 468 p Ankara, Turkey., ISBN:978-625-8007-89-3. https://iksadyayinevi.com/home/agricultural-studies-on-different-subjects/

TURKSTAT. (2023). Turkish Statistical Institute, Bitkisel üretim istatistikleri. http://www.tuik.gov.tr/ (Date of access: 18 July 2023).

Uyak, C., & Gazioğlu Şensoy R. İ. (2009). Van ili bağcılığının mevcut durumu, sorunları ve çözüm önerileri, *Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi*, 19(2), 103-111.

Uyak, C., Doğan, A., & Kazankaya, A. (2011). Siirt ili bağcılığının mevcut durumu, sorunları ve çözüm önerileri, *Yüzüncü Yıl Üniversitesi Tarım Bilim Dergisi,* 21(3), 225-234.

Van Leeuwen, C., Destrac-Irvine, A., Dubernet, M., Duchêne, E., Gowdy, M., Marguerit, E., Pieri, P., Parker, A., de Rességuier, L., & Ollat, N. (2019). An update on the impact of climate change in viticulture and potential adaptations. *Agronomy*, 9(9), 514. https://doi.org/10.3390/agronomy9090514 .

Yener, H., & Cebeci, N. A. (2013). Manisa ili Sarıgöl ilçesi bağ işletmelerinin yapısal özellikleri ve bazı kültürel işlemlerin uygulanma durumları üzerine bir araştırma. *Ege Ünivesitesi Ziraat Fakültesi Dergisi,* 50(2), 223-230.

Yıldız, Ö. (2015). Ege Bölgesi'nde Sürdürülebilir Tarıma Tarımsal Yayımın Katkısı ve Üretici Eğilimleri, *E. Ü., Fen Bilimleri Enstitüsü*, Doktora Tezi, 169s.

Yılmaz, F., Shidfar, M., Hazrati, N., Kazan, K., Yüksel Özmen, C., Uysal, T., Özer, C., Yaşasın, A. S., Söylemezoğlu, G., Boz, Y., Çelik, H., & Ergül, A. (2020). Genetic analysis of central Anatolian grapevine (*Vitis vinifer*a L.) germplasm by simple sequence repeats. Tree Genetics and Genomes, 16(4). https://doi.org/10.1007/s11295-020-01429-z.