



## Determination of Sustainability Indicators of Nut Farms: The Case of Pistachio

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### ABSTRACT

The aim of this study is to determine the indicators used to determine the sustainability levels of nut farms and to establish a set of indicators that can be used to measure the level of sustainability of pistachio farms, based on the literature review. As a result of the literature review, among the indicators commonly used to measure agricultural sustainability, a total of thirty sub-criteria were identified, including fifteen sub-criteria for the economic aspect (farm size, yield, etc.), six sub-criteria for the environmental aspect (pesticide, fertilizer, water, energy usage, etc.) and nine sub-criteria for the social aspect (farmer's age, education, etc.) which can be used in evaluating the sustainability of pistachio cultivation. According to this study's findings, although the theoretical principles, dimensions, and goals of agricultural sustainability are globally adaptable, the applicability of the indicators may vary between regions and countries due to geographic, climatic, and socio-cultural differences. Therefore, the sustainability assessment process requires special attention. Sufficient knowledge and expertise are required in setting goals, selecting indicators, and verifying indicators.

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## Introduction

Nuts are heavily consumed in the daily diets of individuals. Walnuts, almonds, hazelnuts, chestnuts, and pistachios are the most cultivated nuts species in the world, while hazelnuts, walnuts, pistachios, and almonds are the most cultivated nuts species in Türkiye (Ağaoğlu et al., 1997; Bars, 2016). 73.57% of the world's nuts production amount, which is approximately 12 million tons, is provided by the USA, China, Türkiye, and Iran (FAO, 2020). Türkiye has an important place in the world in terms of the production amount of these agricultural products, and according to the 2020 data of the FAO (United Nations Food and Agriculture Organization), it ranks first in hazelnuts, second in pistachios, fourth in walnuts and chestnuts, and fifth in almond production.

Although the total amount of nuts produced in Türkiye changes over the years, total production was 1384147 tons in 2021 and pistachio production is 8.62% of the nuts production in Türkiye (TUIK, 2021). Global pistachio production was 1125305 tons in 2020 with an increase of 27% compared to the previous year. In 2020, the USA met

42.12% of world pistachio production, 26.34% by Türkiye, 16.88% by Iran, 7.13% by China and 6.17% by Syria (FAO, 2020). Pistachio, which is produced in 41 provinces in Türkiye, is mainly grown in the Southeastern Anatolia Region. According to TUIK 2021 data, the highest pistachio production was 38576 tons in the the province of Şanlıurfa.

Pistachio exports also have an important share in international trade. According to FAO 2020 data, the largest share in pistachio exports was approximately 3.1 billion USD in the world, was the USA with approximately 1.5 billion dollars and 177598 tons. This country was followed by Iran with 132829 tons. Türkiye ranks fifth with 15614 tons. The actual export amount is far behind the potential export amount.

In parallel with the global demand for pistachio production, traditional agricultural methods are used in pistachio cultivation, and the increased unconscious use of fertilizers, energy, and pesticides, excessive tillage, and irrigation activities in recent years reveal the necessity of

sustainable pistachio cultivation (Aydın and Saltuk, 2018; Akboğa and Pakyürek, 2020; Dilmel et al., 2020). Sustainable agriculture, which explains the existence of a balanced relationship between agriculture and the environment, necessitates the management of natural resources in a way that will be beneficial in the future (Aydın Eryılmaz, 2017).

The measurement of agricultural sustainability is a challenging task as it involves the dynamic and simultaneous balance between environmental, economic, and social indicators (Hayati et al, 2010). More than 120 agricultural sustainability assessment methods are used in the world (Talukder and Blay, 2017). Some of these methods are MESMIS, RISE, SAFE, IDEA, SAFA, SAEMETH (Singh et al., 2012; Bartzas and Komnitsas, 2020; Keskinçelik, 2019; Şengül, 2020). Despite the of methods and frameworks for the assessment of sustainability, there has not been a general consensus on the widespread use of a methodology so far, and different frameworks and indicators are still used (Şengül, 2020).

The basic method in the evaluation of sustainability is the determination of “indicators” (Tanguay et al, 2010). There are many methods for the selection and analysis of indicators. Variable climatic and biophysical conditions in different countries, even in different regions within a country, limit the applicability of indicators to be used in a study. An indicator selected and successfully applied in the evaluation of agricultural sustainability in a region or country is not valid in another region or country (Tellarini and Caporali, 2000; Hatai and Sen, 2008; Sharma and Shardendu, 2011). Therefore, this study aims to reveal the indicators used in the sustainability of nuts and to develop an appropriate indicator package that can specifically address the three dimensions of sustainability of pistachio cultivation. This study will also as a guide for future studies by this aspect.

## Material and Method

The material of this study consists of a comprehensive review of the relevant literature and information provided by stakeholders involved in different stages of pistachio cultivation in Siirt province. Ten stakeholders that interviewed with them works at Siirt Provincial Directorate of Agriculture, Siirt Pistachio Producers Union, Kurtalan Chamber of Agriculture, Siirt Provincial Directorate of Commerce, Siirt Chamber of Tradesmen and Craftsmen.

A literature review was realized for the selection of indicators, and the resources related to the subject were categorized in this study. First of all, the studies on the sustainability of nuts were investigated and the indicators used in the studies were tabulated by including the place where the study was conducted, the year of the study, the authors of the study, and the sustainability dimensions evaluated in the study. Indicators that can be used in pistachio cultivation were determined and tabulated by using the data obtained as a result of the studies on the sustainability of other nuts species and the information provided by the stakeholders in the region. The sustainability indicators selected to be used in determining the sustainability of pistachio cultivation have been discussed by making use of the farm characteristics in the studies on pistachio cultivation.

## Findings and Discussion

### *Sustainability Indicators of Nuts and Pistachio*

The studies on the sustainability of nuts are investigated, and it can be seen that the studies evaluating the sustainability of farms in three dimensions using indicators related to the economic, social, and environmental dimensions of sustainability (Bartzas and Komnitsas, 2020; Darijani et al., 2019; Yıldırım et al., 2022; Demiryürek et al., 2018;), studies evaluating sustainability with its economic and environmental dimension (Baran et al., 2017; Banaeian and Zangeneh., 2011; Beigi et al., 2016), evaluating sustainability by only considering its environmental dimension and generally by making life cycle analysis studies were found (Bartzas and Komnitsas, 2017; Marino et al., 2018; Bartzas et al., 2017; Marvinney et al., 2015; Kendall et al., 2015; Sabzevari et al., 2015; Coppola et al., 2022; Rosa et al., 2017; Khanali et al., 2021). The dimensions of sustainability and some of the indicators used in different studies are given in Table 1.

In addition, studies on the measurement of sustainability in agriculture and the review of indicators were also examined (Hayati et al., 2010; Singh., 2012; Sabiha et al., 2016; Başer et al., 2017; Latruffe et al., 2017; Özkan ve Armağan, 2019). Finally, studies to determine the sustainability of some agricultural products at the farm level and to provide indicators were also reviewed (Gündüz et al., 2011; Waney et al., 2014; Ul Haq and Boz 2018; Doğruöz, 2021; Yılmaz, 2021).

Table 2 summarizes the set of indicators that can be taken into account to determine the sustainability of pistachio cultivation, by combining the information obtained as a result of the examination of studies on other nuts, other agricultural products, and pistachio, with the information obtained orally from the stakeholders that related to pistachio production.

### *Economic Sustainability Indicators of Pistachio*

Economic sustainability indicators are the most important factors that reflect the financial viability and profitability of farmer families and farms (Castoldi and Bechini, 2010). Ensuring food security and especially the provision for people to continue lives on their farms make economic sustainability the most important dimension (Başer et al, 2017). As a result of the studies examined, the size of the farm, yield, gross margin, product price determination (bargaining right), product diversity, risk strategy development, specialization, product storage possibilities, input supply, and access, total production cost, planning to expand the farms, related to the economic aspects of the sustainability of pistachio. Fifteen sub-criteria were selected, including the ratio of farms that have invested in the farm in the last five years, income satisfaction, satisfaction with product sales prices, and non-agricultural work. Of these, the most frequently used indicators of farm size, yield and gross margin in the literature are detailed.

#### *Farm Size*

The size of the farmland has a positive effect on agricultural production and is of great importance for economic development.

Table 1. Indicators used to determine sustainability in nuts

Country/author	Product	Sustainability Dimension	Indicators
Greece- Bartzas and Komnitsas, 2017	Pistachios	Environmental	Use of pesticides, water, fuel, fertilizer, electricity
Greece- Bartzas and Komnitsas, 2020	Pistachios	Economic Social Environmental	Gross margin, farm size, agricultural productivity Age, education level, agricultural employment, stakeholder support, membership in agricultural organizations Fertilizer, pesticide, water, energy use, agricultural waste, as well as global warming potential, acidification potential, eutrophication potential and cumulative energy demand
Italy- Marino et al., 2018	Pistachios	Environmental	Water use
Iran- Darijani et al., 2019	Pistachios	Economic Social Build human capital Variation Environmental	Insurance, credit utilization, production stability, agricultural productivity (output/input) Membership in agricultural organizations, degree of information exchange, degree of job satisfaction, level of access to government trust, level of access to agricultural advisory services Number of agricultural training, experience, innate abilities Number of produced varieties, product diversity grown, marketing diversity, number of water sources Organic fertilizer use, chemical fertilizer use, pesticide use, soil fertility index, water use efficiency
America- Marvinney et al., 2014	Pistachios, Almond, Walnut	Environmental	Fertilizer, pesticide, fuel, water, energy use, land clearing, tillage, crop yield, orchard life, planting interval, full fruiting time
America- Kendall et al, 2015	Almond	Environmental	Use of water, pollinator, energy, fertilizer, fuel, pesticides and fertilizers
Iran, Beigi et al., 2016	Almond	Environmental Economic	Use of labor, mechanization, fuel, fertilizer, pesticides, water, electricity Product price, gross production value, fixed costs, variable costs, total production costs, gross profit, net profit, the benefit-cost ratio
Türkiye, Yıldırım et al., 2022	Hazelnut	Economic Social Environmental	Gross margin, payback period, economic profitability, technical efficiency, labor productivity, labor productivity, income stability, continuity of farming from generation to generation, purchase of new land, willingness to sell land Age, education, old age, children's access to education services, access to clean drinking water, agricultural organization, non-agricultural income, migration, farmer's level of socialization, farmer's harmony with other farmers, trader harmony, relations with temporary workers, purchase of basic foodstuffs, children's meeting educational needs, social insurance Fertilizer use, eco-productivity, soil protection, erosion risk, erosion control
Türkiye- Demiryürek et al., 2018	Hazelnut	Economic Social Environmental	Benefit from support, agricultural income, non-agricultural income, degree of risk aversion, use of credit, record keeping, participation in training Education, participation in agricultural organizations, experience, organic farming experience, common land use, information resources on hazelnut cultivation, frequency of use of information resources Use of chemical and organic inputs
Iran- Sabzevari et al., 2015	Hazelnut	Environmental	Level of mechanization use, fuel consumption, fertilizer and pesticide use
Italy- Coppola et al., 2022	Hazelnut	Environmental	Level of mechanization use, tillage, fuel consumption, pesticide, fertilizer and water use
Portugal- Rosa et al., 2017	Chestnut	Environmental	Materials and energy data for farming, harvesting, transport, processing, distribution, retail and household consumption

Table 1. Indicators used to determine sustainability in nuts

Country/author	Product	Sustainability Dimension	Indicators
Iran- Khanali et al., 2021	Walnut	Environmental	Pesticides, agricultural machinery, fossil fuels, fertilizer, gasoline, electricity, water and labor inputs
Türkiye- Baran et al., 2017	Walnut	Economic	Yield, selling price, gross production value, variable production cost, fixed production cost, total production cost, total production cost, gross return, the net return, benefit-cost ratio
		Environmental	Use of labor, mechanization, fertilizers, chemicals, fuels, water
Iran- Banaeian and Zangeneh., 2011	Walnut	Economic	Product selling price, gross production value, variable costs, fixed costs, total production costs, gross profit, net profit, the benefit-cost ratio
		Environmental	Use of labor, mechanization, fuel, pesticides, fertilizers, electricity and water

Table 2. Indicators that can be used in the sustainability measurement of pistachio cultivation

	Sustainability Dimensions		
	Economic	Environmental	Social
Sustainability indicators	Farm size, yield, gross margin, product price determination (bargaining rights), product diversity, developing risk strategies, specialization, product storage possibilities, input supply and access, the total cost of production, the proportion of farms that plan to expand the farms, investing in the farm in the last five years ratio of farms, income satisfaction, satisfaction with product sales prices, non-agricultural work	Pesticide, fertilizer, water and energy usage, tillage, waste management, integrated control	Farmer’s age, education level, organizational status, agricultural employment, stakeholder support, social security, agricultural experience, social and cultural adequacy in the region, adequacy of education and health services in the region

Aygün and Gürsoy (2020), in their study, found that 12.73% of Siirt pistachio farms are smaller than 10 decares, 52.12% are between 10-50 decares, 19.39% are between 50-100 decares, 15.76% are over 100 decares. Özgüven et al. (2010) stated that the average farm size in Türkiye is 61 decares and that the fragmented and small structure of agricultural holdings restricts agricultural investments and accordingly the use of new technologies and prevents the efficient use of lands. Akçay and Baydaroğlu (2000) state that to apply modern techniques in agricultural production, plant production farms should be increased to at least 80 decares.

*Yield*

Agricultural productivity is one of the main factors affecting the economic performance of a farm. It is measured by the amount of product produced per decare or tree in a given year (Bartzas and Komnitsas, 2020). In the study of Açı (2021), the average yield per tree for Siirt pistachio was found as 2.46 kg. According to FAO 2020 data, when the average yield of Pistachio in the world is considered, it has been determined that it is 314.86 kg/da in America, 116.59 kg/da in Iran, and 77.62 kg/da in Türkiye. According to these data, it is seen that Türkiye lags behind the countries it competes with in terms of yield. Low yield and periodicity, which are among the most important problems of pistachio cultivation, have recently been attributed to water stress by some researchers (Kanber et al., 1993), and that irrigation has a positive effect on yield by reducing water stress, leads to improvements in product quality, and therefore has a reducing effect on periodicity. Therefore, they state that irrigation is a

prerequisite for optimum efficiency. Similarly, Arpacı et al. (1995) stated that Siirt pistachio yields better under irrigated conditions than dry conditions, and therefore, Siirt pistachio cultivation should be done under irrigated conditions. On the other hand, Açı (2021) found in his study that 8.3% of Siirt pistachio farmers are irrigating and 91.7% are growing without water. In addition to the negativities such as the lack of sufficient irrigation water and geographical conditions in the pistachio production areas of the Siirt region, the approaches of the farmers on this issue are also of great importance (Aydın and Saltuk, 2018).

Another important factor affecting yield and quality in pistachio cultivation is to pay attention to planting a sufficient number of pollinator varieties during the establishment of the garden. Since the flower structure of the pistachio plant is dioecious, it is necessary to have one male (pollinator) tree for 10-14 female trees in the garden to obtain high efficiency in production. If this cannot be done, at least one male variety should be planted per decare. Trees that set fruit in pistachio are female trees. Therefore, in general, farmers see the area covered by male trees planted in the garden as a loss of garden and try to plant as few pollinator varieties as possible in their garden (Akboğa and Pakyürek, 2020). Akboğa and Pakyürek (2020) determined that 36.7% of Siirt pistachio farmers have a pollinator variety in their orchards, 37.8% are not pollinators, and 29.6% are partially pollinators. In addition, the study, it was determined that 65% of Siirt pistachio growers had one in their garden, 30% had two and 5% had three, four, five or more pollinator varieties.

### *Gross Margin*

It is used to evaluate the profitability of production branches on one farm. It is calculated by subtracting variable costs from the gross income of the farm. The sum of variable costs includes fertilizer and fuel costs, as well as maintenance and labor costs (Bartzas and Komnitsas, 2020).

Külekçi (2014), in their study, the average pistachio gross profit per decare in pistachio farms is 11.60 USD/da in mountain villages and 19.87 USD/da in lowland villages, Eldoğan and Şahin (2015) find the average gross profit per decare in pistachio farms. They calculated it as 21.61 USD/da.

### *Environmental Sustainability Indicators of Pistachio*

Environmental sustainability is defined as the continuation of factors and practices that contribute to environmental quality in the long run (Pandian et al., 2013). As a result of the studies examined, seven sub-criteria were selected regarding the environmental aspects of the sustainability of pistachio, namely pesticide use, fertilizer use, water use, energy use, soil cultivation, waste management, and integrated control.

While the agricultural sector is greatly affected by environmental problems, it also plays a role in deteriorating the environment and causing environmental problems (Zengin, 2008). While the inputs used in the production process are transformed into goods and services that will meet human needs, wastes and emissions that can harm the environment arise. While the inputs used in the production of agricultural products increase the yield of the product per unit area and make it more resistant to diseases and pests, there may also be negative effects on the living things and ecosystem in its immediate vicinity (Parkalay et al., 2015).

### *Use of Pesticides*

*Pesticides* are mostly used to combat diseases, pests, and weeds in crop production. If pesticides are not used, it is known that there is a decrease in quality and yield in the products at rates reaching 60%. However, the use of pesticides negatively affects human health and the environment and brings many problems. When pesticides are used intensively and unconsciously; pesticide residues or transformation products may remain in food, soil, water and air. In order to ensure environmental sustainability in agricultural production, pesticides used in the fight against diseases and pests should be applied at the required doses, on time and with appropriate techniques (Tiryaki et al., 2010; Parkalay et al., 2015).

Dilmen et al. (2020) determined in their study that 66% of Siirt pistachio producers use pesticides regardless of the intensity of the pest, 71% do not prepare the pesticide dose according to the label, 83% do not know about biological control, and 88% do not know about integrated control.

In the research of Açıkan (2021), 92.7% of Siirt pistachio producers do spraying at regular intervals even if there is no disease or harmfulness, 1% of the producers do spraying once a year, 69.8% producers do spraying twice a year, producers do spraying 27.1% three times, and 9.4% producers do spraying of them four times a year. In the study conducted by Akboğa (2021), it was determined that 66.32% of Siirt pistachio farmers sprayed 3 or more times

a year, and it was concluded that the farmers were partially conscious of spraying.

### *Fertilizer Use*

Fertilizer is one of the most important inputs in agricultural production. When it is not used adequately, it causes significant losses in yield and quality, but when it is used excessively, it causes pollution of ground and surface waters, especially by washing the nitrogen and phosphorus fertilizers, and air pollution with nitrogen oxide emissions (Güler, 2004; Atılğan et al., 2007). The way to make fertilization on time and at a sufficient level is to make soil analyzes before fertilization. However, farmers do not give due importance to soil analysis. The use of fertilizer without soil analysis prevents the economic use of fertilizer, increases costs, reduces product quality and quantity, and harms the soil and the environment (Gök et al., 1998; Atılğan et al., 2007).

Akboğa (2021) determined in his study that 70.87% of the Siirt pistachio farms did not have soil analysis and 29.13% had soil analysis. In the study, it was determined that although the majority of Siirt pistachio farmers did not have soil analysis, 81.55% of them used fertilizers and 18.45% did not use fertilizers. In the study, it was determined that 24.14% of Siirt pistachio farms used compound fertilizers, 34.29% phosphorus and potassium fertilizers, 44.19% nitrogen-containing fertilizers, 43.48% barnyard manure, 14.93% base fertilizer.

### *Water Use*

Irrigation is very important in terms of the high yield and quality of products in arid and semi-arid regions. However, environmental problems that can reach serious dimensions arise as a result of unplanned and uncontrolled irrigation in agriculture and incorrect irrigation practices. Groundwater rise, salinity, deep penetration of fertilizer and chemical pesticide residues with irrigation water, mixing of water returning from irrigation with underground and surface waters by increasing salt concentrations, accumulation of trace elements in water resources, soil erosion and diseases on living things (plant, animal and human) benefiting from these waters and damages are the main environmental problems caused by incorrect irrigation practices (Aydın, 2002; Taşkaya, 2004; Alper, 2010 ).

Açıkan (2021) was determined that 8.3% of Siirt pistachio farmers were irrigating, while 91.7% were growing without water. In the study, it was determined that some of the farmers could not irrigate because they did not have irrigation facilities, the scarcity of water sources or the high costs of being far from the water source, and some of them did not prefer it because they thought that water dries the tree and causes diseases.

Considering that pistachio is grown on rough, stony-rocky marginal lands where other agricultural products cannot be grown economically, in a sense, farmers evaluate such unsuitable lands for pistachio cultivation. In the study conducted by Aydın and Saltuk (2018), it was determined that 39.5% of Siirt pistachio farmers stated that Siirt pistachio should be watered, 14.7% of them were unstable and 45.8% of them stated that they should not be watered. For many years from the past to the present, farmers have been worried that if pistachio is irrigated, they will be harmed and irrigation may cause some diseases. However, although this situation has decreased over the years, it still

maintains its effectiveness in terms of thought (Aydın and Saltuk, 2018).

One of the most important concerns of the farmers, who abstain from irrigation, is the increase in the number of dams built in the region. One of the main problems of pistachio cultivation is the formation of fruit (empty) fruit, possible increases in air humidity during flowering, heavier pollen and inability to reach the female flowers, which cause fertilization insufficiency in pistachio and lead to yield loss. It is thought that the construction of dams in the region and the increase in the lake surface areas will increase evaporation and air humidity and thus cause fertilization insufficiency (Aydın and Saltuk, 2018).

#### *Tillage*

Developments in agricultural technologies, especially agricultural mechanization, led to an increase in yield and production of many agricultural products between 1950 and 1984. In the 1990s, it was determined that this increase in productivity did not play the same role for soil and water resources and the environment, and the necessity of taking priority protection measures in the field of agriculture emerged. In addition to their effects on the soil, the variety and number of agricultural machineries, the use of which varies from country to country, primarily increased the emissions of carbonaceous and nitrogenous compounds to the atmosphere (Sönmez, 2012). Dry and sloping agricultural areas are located in agricultural areas belonging to the second and higher classes. These areas are in a structure that can be exposed to water erosion due to improper agricultural practices. These areas with low soil depth, slopes of more than 12%, and low organic matter content constitute risky areas in terms of carbon release during tillage. When the equipment of the farmers who make agricultural production based on precipitation in dry agricultural areas in Türkiye is examined, it is known that there are plows that make more tilting operations in the tillage tools. While there is a 40% decrease in the use of plows in the world, the plow continues to be widely used especially in dry agricultural areas in Türkiye (Akbolat, 2014). In these areas, it is very important to prefer the equipment that cuts the soil without overturning it as an alternative to the plow. In dry and sloping agricultural areas, it is necessary to present more conscious options to the farmers in order not to deteriorate the structure of the soil and to prevent soil loss by erosion by converting precipitation into yield.

Among the producers of the Southeastern Anatolia region, where pistachio cultivation is intense, there is a false statement that the more you till the soil, the more the yield increases. As a result, one of the most common mistakes applied in Pistachio fields is to do too much tillage. Excessive tillage in pistachio orchards both tires the soil and causes the moisture of the soil to be lost. In addition, the tools used in tillage close to the trunk of the tree can damage the superficial roots and cause fungal diseases. (Bilim, 2020).

#### *Waste Management*

Outside of the fruits collected from pistachio trees, there are two types of shells: a red colored soft outer shell and a very hard inner shell that protects the fruit. The soft outer skin constitutes 18% of the fruit, and the hard inner skin constitutes approximately 45% of the fruit (Demiral et al., 2008; Açıkalın et al., 2012). These waste shells are

destroyed by burning or storing them as garbage in traditional production methods, resulting in very low energy efficiency and negative environmental effects. However, when considered in terms of environmental sustainability, these wastes have a high production potential and can be used in the production of energy and various chemicals with new technology such as thermochemical methods. They can also be used in the production of biomaterials such as nature-friendly compost, biochar, and biogas, and in improving soil quality (Salan and Alma, 2014; Lazzano et al., 2014; Mohammadi et al., 2016; Çelik and Demirer, 2015). The reuse and recycling of agricultural waste not only reduces the environmental footprint of the product but also increases the income of the farmers as higher yields are obtained by improving the soil quality when using it as compost (Bartzas et al., 2015). No studies have been found to determine how Siirt pistachio farms evaluate pistachio shells.

#### *Social Sustainability Indicators of Pistachio*

Social sustainability in agriculture is based on providing a human-oriented development and thus increasing the welfare level of those living in rural areas (Aydın Eryılmaz, 2019). In this context, as a result of the studies examined, nine sub-criteria were taken into account related to the social aspect of the sustainability of pistachio. These are the age of the farmer, the education level of the farmer, the farmer organization, agricultural employment, stakeholder support, social security, agricultural experience, social and cultural field adequacy in the region, and the adequacy of education and health services in the region.

#### *Farmer's age*

Age is one of the important indicators used in calculating the social dimension in agricultural sustainability assessments, as it is a factor that affects the attitudes and behaviors of farmers in the conduct of agricultural activities.

Demiral (1989) determined that, the average age of the farmers in Siirt pistachio farms was 51.78, Ukav et al. (2011) found the average age of the farmers to be 48 in their study with pistachio farmers in Adıyaman, and Kantar Davran (2017) found the average age of the owners to be 49 in his study with the pistachio farms in Gaziantep. Aydın and Saltuk (2018) determined that approximately 77% of Siirt pistachio farmers are in the 30-50 age group, and in the study of Aygün and Gürsoy (2020), more than 80% of Siirt pistachio farmers are over 40 years old. On the other hand, Açıkalın (2021) determined that 44.8% of Siirt pistachio farmers were between the ages of 46-60 and 14.6% were aged 60 and over.

The age and educational status of farmers are important for the application of modern agricultural techniques in agriculture. Therefore, in order to successfully apply modern agricultural techniques in the region, it is necessary to increase the level of education and decrease the average age (Aygün and Gürsoy, 2020). In addition, agricultural activities are intense economic activities performed with physical strength. The increase in the average age affects agricultural activities negatively. In regions with a high rate of the elderly population, it is of great importance for the young population to stay in the region in order to ensure

agricultural sustainability. In order to reduce the migration of the young population, it is necessary to increase the support of young farmers, increase agricultural income and create alternative income sources, and the social infrastructure of the region should be brought to a level that will enable the youth to stay. In this way, both age and resident population indicators will rise together under the social dimension, and social sustainability will be approached (Beşen, 2017).

#### *Education Level*

The education level is directly related to the ability of farmers to adopt sustainable management practices promptly and successfully promote the use of modern technologies (Bartzas and Komnitsas 2020). However, management is one of the factors that affect the profitability and efficiency of the farms. While the effectiveness of the management increases the success of the farms, it also ensures the development of the farms. In this context, the educational status of the managers of the farms can be considered a factor affecting the efficiency of the farms (Beşen, 2017). Aygün and Gürsoy (2020) 21.82% of the Siirt pistachio farmers have never been educated, 46.67% of them are in primary school; It was determined that 20.61% of them were secondary school graduates and 8.48% of them were high school graduates.

Akboğa and Pakyürek (2020) found that 9.1% of the Siirt pistachio farmers were illiterate, 20.2% were literate, 17.2% were graduated from primary school, 14.1% were graduated from secondary school, 26.3% of them were high school graduates, 5.1% graduated from college, 3% graduated from faculty and 5.1% graduated from graduate school. It is seen that 60.6% of farmers have received education up to the secondary school level. Aydın and Saltuk (2018) determined in their study that 50.3% of the Siirt pistachio farmers have primary school graduates, 37.3% have only literate, 5.1% have secondary school graduates, and 3.3% have high school graduates and 4% of them have university graduates. Dilmen et al., (2020) in their study, determined that 5% of the Siirt pistachio farmers were illiterate, while 56% were secondary school graduates, 26% were high school graduates, and 13% were university graduates.

#### *Farmer Cooperation*

Farmers/Producer unions and cooperatives contribute to the development of society, increase employment, and increase the income of small farmers, and one of their important activities is to effectively market the products purchased from the partners. The role of cooperatives in branding and price formation shortens the marketing channel. With the shortened marketing channel, the income of the farmer's increases and the consumers buy products by paying less. Thus, it also contributes to the development of local economies (Everest et al., 2018). In the study of Açı (2021) determined that 7.3% of the owners of Siirt pistachio farming are members of the Chamber of Agriculture, 1% of the Agricultural Credit Cooperative, 3.2% of the Pistachio Farmers Union, 88.5% of them are not members of any organization.

#### *Agricultural Employment*

Türkiye's climate and natural conditions create significant differences in the production pattern between regions. Thus, regional products emerge as an important source of livelihood, and the lack of employment

opportunities outside of agriculture and the relatively low level of education necessitates continuing agricultural production (Keskin et al., 2017). Agricultural employment is an important indicator that represents the level of employment along with its social effects in the agricultural sector through the provision and distribution of income.

According to the 2021 data of the Siirt Provincial Directorate of Agriculture and Forestry, 3465 farms are operating Siirt pistachio cultivation registered in the Farmer Registration System (ÇKS) in Siirt. In this respect, it can be said that it has a significant contribution to agricultural employment and the country's economy. The rural population of the agricultural population is preserved by employing the population that makes a living from agriculture (Aydın Eryılmaz and Kılıç, 2018).

#### *Stakeholder Support*

Agricultural farms are in contact with the Provincial and District Directorate of Agriculture, Chambers of Agriculture, drug dealers and pharmaceutical company's representatives about their agricultural activities, and receive information from these institutions, especially on spraying, fertilization, various agricultural practices, and irrigation (Karadağ and Barış, 2009). In this context, the training and support provided by the institutions, especially on agricultural activities, is extremely important in terms of protecting and developing regional resources. This indicator can be measured as the total number of training programs/seminars participated by farmers.

Açı (2021) was determined that the owners of the farms received stakeholder support from the Agricultural Engineers when deciding which drug to throw against more diseases and pests, and from the pharmaceutical dealers when determining the dosage of drug use in Siirt pistachio farms. Akboğa (2021), Siirt pistachio farmers generally benefit from information sources on pistachio cultivation; 43.47% of agricultural engineers working in the Provincial/District Directorate of Agriculture, 12.5% universities, 11.96% fertilizer-pharmaceutical dealers, 11.96% other farmers, 16.30% their knowledge, 3.80% other (relative and family members). It has been determined that farmers generally benefit from the suggestions of agricultural engineers on irrigation, pruning, and fertilization, and the recommendations of fertilizer and pesticide dealers in fertilization, spraying, and fighting against diseases and pests. However, no study has been found in the literature that provides information about the participation of pistachio farmers in trainings organized by the stakeholders.

## **Conclusion and Recommendations**

The importance of the concept of sustainability has been increasing in the agricultural sector in recent years. For this reason, policy makers and authorities take measures and seek some solutions for farms to be sustainable. First of all, it is of great importance to measure sustainability accurately.

Nuts are in an important position in the world in terms of both production and trade among agricultural products. Pistachio is one of the nut species that has an important place in agricultural production and is one of the most economically important agricultural products grown in Southeastern Anatolia. Although traditional agricultural

methods are used in pistachio cultivation, the unconscious use of fertilizers, energy, pesticides, excessive tillage and irrigation activities in recent years have revealed the necessity of determining the sustainability level in pistachio farms. In this study, based on the literature review, indicators used to determine the sustainability of nuts were revealed and an indicator set was created to help measure the sustainability level of pistachio-growing farms.

As a result of the analysis of the studies in the literature on the subject, a total of thirty-one sub-criteria were determined, including fifteen sub-criteria for the economic aspect, seven sub-criteria for the environmental aspect, and nine sub-criteria for the social aspect, which can be used in the evaluation of the sustainability of the pistachio, which is one of the commonly used indicators.

It is thought that it will be useful to collect data by taking these indicators into account in studies to be carried out to measure the sustainability of the farms that grow pistachio. However, although the theoretical principles, dimensions and objectives of sustainability in agriculture are adaptable worldwide, the applicability of the indicators may vary due to geographical, climatic and socio-cultural differences between regions and countries. Therefore, the sustainability assessment process requires special attention, and there is a need for adequate knowledge and expertise in the stages of setting objectives, selecting indicators, and verifying indicators.

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