Assessing the Sustainability Index of Part-Time and Full-time Hazelnut Farms in Giresun and Ordu Province, Turkey

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Assessing the Sustainability Index of Part-Time and Full-time Hazelnut Farms in Giresun and Ordu Province, Turkey

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Abstract

The study's primary purposes were to assess the sustainability index of hazelnut farms and explore the effects of part-time and full-time farming types on sustainability index in hazelnut production in the Giresun and Ordu Province of Turkey. One hundred fifty-two hazelnut farms were selected using the stratified sampling method, and data were collected. Several steps were taken, including using factor analysis after standardizing the variables to determine their weights to calculate the composite hazelnut farms sustainability index. The research findings showed that overall hazelnut sustainability scores of farms varied from 0.28 to 0.59, and the average score was 0.44 at sampled farms. The composite hazelnut sustainability index was at an unsatisfactory level. The social and economic sustainability index value of farms was equal, and they were higher than the environmental index value. The values were 0.50 and 0.30, respectively. While the economic sustainability index score of full-time farms was higher than that of part-time farms, and part-time farms had higher environmental sustainability index scores than that of full-time farms. Social sustainability scores were not different in terms of farm type. It was recommended that when designing and regulation support policies, policy-makers should differentiate part-time and full-time hazelnut farming. Training and extension programs must be planned to increase the level of knowledge of every willing farmer. In addition, training and certification programs must be implemented to enhance the quality of the foreign labor force.

Keywords: Hazelnut farmers, sustainability index, sustainability indicators, part-time farming, Turkey

1. Introduction

Sustainable development is an essential component of every government and research institution's vision, mission, and strategies (Roy and Chan, 2012). Similarly, the sustainable agriculture concept is also commonly used, and it is strongly emphasized in the transition towards sustainable development (UN, 2002). Various problems limit the empirical application of the sustainable agricultural concept in the real world due to the temporal nature of sustainability. First, it has little practical value due to the limited feasibility of performing long-term experiments. Second, there is a need to identify the demand that is required to be satisfied by the farming system to achieve sustainability (Gómez-Limón and Riesgo, 2009).

Consequently, the concept of sustainability can be regarded as a social concept that can be reformed in response to society's requirements. Moreover, it can be stated that sustainability is the time and place-specific concept which describes sustainability as the social structure in geographical and temporary contexts (Gómez-Limón and Sanchez-Fernandez, 2010). Three sustainability dimensions (economic, social, and environmental) have gained importance to resolve these problems and deal with sustainability assessment. This approach of assessing agricultural sustainability in operational terms can be performed by developing indicators of fewer than three dimensions of the sustainability mentioned above (Bell and Morse, 2012).

Although there are many different interpretations of sustainable agriculture in the review of literature, the commonality among those definitions describes the farming should be economically sound, socially viable, and environmentally friendly (Edwards et al., 1990; Hansen, 1996; Singh, 2013). However, agricultural sustainability assessment based on the indicators still has some deficiencies. The difficulty of defining the entire set of indications is the fundamental issue with the indicator evaluation approach. Agricultural sustainability has been proposed to be measured by combining a multidimensional set of indicators into a single index (Gómez-Limón and Riesgo, 2009). This approach is commonly used (Andreoli and Tellarini, 2000; Pirazzoli and Castellini, 2000; QIU et al., 2007; Rigby et al., 2001; Sands and Podmore, 2000; ul Haq and Boz, 2020; van Calker et al., 2006). Though the theoretical principles, dimensions, and goals of sustainability in agriculture worldwide are adaptable, the applicability of the indicator is minimal due to the different social norms, geographical and climatic differences among the areas, regions, and countries. For this reason, the sustainability assessment requires particular attention, and it needs sufficient knowledge and expertise throughout the developing goals process, selection of indicators, validation of indicators, and evaluation of agricultural sustainability (ul Haq and Boz, 2020)

Commonly, there are three different spatial levels for assessing agricultural sustainability. Therefore, a minor spatial level is parcel/field level, followed by the farm level, and higher spatial level such as landscape, region, or state (van Cauwenbergh et al., 2007). Numerous researches have been carried out at various spatial levels all around the world, for example, farm-level(Eckert et al., 2000; López-Ridaura et al., 2002; Meyer-Aurich, 2005; van der Werf and Petit, 2002), field-level (Bockstaller et al., 1997; Mitei, 2011; Terano et al., 2015) and at the regional level (Payraudeau and van der Werf, 2005; Zhen et al., 2005). With the many sides that must be satisfied at each geographic level, these investigations differ in their indication adoption (field, farm, and regional). Although many studies have successfully adopted the indicators in the same region to assess agricultural sustainability, they have limited applicability in other areas due to the climatical and geographical differences among the countries and regions (Hatai and Sen, 2008; Sharma and Shardendu, 2011; Tellarini and Caporali, 2000). Consequently, the indicators became the essential tools for assessing agricultural sustainability in economic, social, and environmental dimensions over the years.

In Turkey, many studies focused on farm sustainability; for example, (Tatlidil et al., 2009) studied farmers perception with farm sustainability and its determinants; Gunduz et al., (2011)) assessed the apricot farm sustainability and analyzed its determinants model; Saysel et al., (2002) described the environmental sustainability in the project of agricultural development and Ceyhan, (2010) assessed the economic, social and environmental sustainability of traditional farming systems in Samsun province of Turkey. ul Haq and Boz, (2018) have proposed the selection of indicators for the tea crop, which is friendly in use for the other crops. Moreover, ul Haq and Boz, (2020) also applied the selected indicators to measure the tea farms' sustainability. Specifically, Demiryürek et al. (2018) focused on the sustainability of conventional and organic hazelnut farms. Although these studies explain farm sustainability from different aspects, literature related to the sustainability of hazelnut farms regarding full-time and part-time farming is not available.

The full-time and part-time farming has multidimensional impacts on-farm management and on the use of farm resources for example; the effect of full-time and part-time on resource use efficiency, part-time farmers use low labor inputs, and full-time farmers invest less in capital and materials (Amodu et al., 2011; Haiguang et al., 2013). Giourga and Loumou (2006) describe that part-time farming can lower the demand for natural resources and make farming in mountainous and semi-mountainous areas sustainable. Therefore, the prevalence of full-time and part-time farming in hazelnut production may be different in their farm practices, impacting sustainable hazelnut farming. Moreover, too close planting; bad soil conditions, soil erosion, the prevalence of old and underproductive shrubs, limited availability of necessary inputs and care were those problems which limited the yield of hazelnut in Turkey as compared to the other hazelnut producer of the world (Hütz-Adams, 2012; Lundell et al., 2004). The sustainability of the hazelnut is necessary to be evaluated regarding the full-time and part-time farming for a progressive rise in crop production.

The current study has the following study objectives. First of all, a set of indicators was explicitly developed relevant to the assessment of hazelnut farming in the study area of Turkey. Based on these indicators, the sustainability of full-time and part-time hazelnut farms was assessed.

2. Material and method

2.1 Material

2.1.1 Research Area

Turkey is the largest hazelnut producer, having 69% share in the total world production. The whole hazelnut grown area was 0.706 million hectares, and 0.675 million tons of hazelnut was produced in 2018 in the country (Table 1).

The eastern black sea region makes one-sixth of Turkey's geographical area and plays a vital role in the economy as this area is famous for tea and hazelnut production. Especially, Ordu and Giresun have significant contributions to the country's total hazelnut production. These provinces have 49% of the total hazelnut production area of the country. Moreover, these provinces contribute substantially (45%) to the country's total hazelnut production. They were selected as a research area by considering the importance of these provinces in Turkey's hazelnut production.

Table 1. Hazelnut area, yield, and production

Provinces	Yield (kg/ ha)	Area (ha)	%	Production (tons)	%
Ordu	940.5	227092.3	32.2	213572.0	31.6
Giresun	797.1	117102.0	16.7	93339.0	13.8
Turkey	**955.2**	**706667.0**	**-**	**675000.0**	**-**
World	**1031.0**	**948117.0**	**-**	**977500.0**	**-**

(FAO, 2018; TURKSTAT, 2018)

2.1.2 Climatic conditions of the research area

Both selected provinces have a humid subtropical climate with a hot and humid summer season and a cool winter season. They have a high and evenly distributed precipitation throughout the year. Hazelnut needs a mild climate with temperatures varying between -80C to 360C throughout the year and rainfall more than 700 mm for bountiful yield (Islam 2018). The mean minimum temperature went between 3.90 ^{o}C to 20.550 ^{o}C, and the mean maximum temperature remained between 10.350 ºC and 27.450 ºC from 1981 to 2010 in the study area. The precipitation varied between 63 mm to 129 mm throughout the year during the same period (Table 2). Hazelnut grows well in loamy vegetal and deep soils rich in nutrition as it allows hazelnut plants to intake a more significant amount of soil nutrients. Hazelnut crops cannot bear windy and stormy conditions with high summer temperatures and low dampness. Thus, the climate and soil of the selected provinces are well suited for hazelnut production.

Table 2. Climate indicators of the study area

Month	Mean of maximum Temperature (^{0}C)	Mean of minimum Temperature(^{0}C)	Mean temperature (^{0}C)	Mean precipitation (mm)
January	10.75	4.5	7.2	104.5
February	10.35	3.9	6.75	85
March	11.85	5.2	8.1	79
April	15.05	8.45	11.4	71.5
May	18.85	12.55	15.5	58
June	23.75	16.9	20.25	72
July	26.65	20	23.2	63
August	27.45	20.55	23.6	68
September	24.15	17.25	20.25	82
October	20.1	13.6	16.35	129
November	15.9	9.1	12	122
December	12.65	6.35	9.1	121

Source: Turkish state metrological department (1981-2010)

2.1.3 Sampling procedure

The target population of this study was hazelnut farmers residing in the Ordu and Giresun provinces of the black sea region. The list of farmers involved in hazelnut farming was obtained from both provinces' ministry of agriculture and forest. The first challenge in the sampling procedure was to determine a sample size to represent the all-hazelnut farmers residing in the study area. Therefore, the stratified sampling formula proposed by Yamane 2001 was used to estimate the sample size for each province separately. The formula used in the study is shown below (Yamane, 2001);

$$n = \frac{N\sum N_h S_h^2}{N^2D^2+\sum N_h S_h^2}, \quad D^2 = \frac{e^2}{t^2}$$

n = Sample Size.
N = Total hazelnut farmers in main layer
Nh = Number of hazelnut farmers in each layer
Sh= Standard deviation in each layer
D^2= Anticipated variance
e = Disturbance term (10%)
t = Confidence interval (95%)

The used sampling technique ensures that different groups in the mainframe are represented adequately in the study. Moreover, this method also reduces variance by separating homogeneous groups from the mainframe population. The accessible population was arranged in ascending order according to their land under hazelnut farming. After that, the study area's hazelnut farmers of both provinces were divided into three strata according to their land size. The first stratum contained hazelnut farmers having to land less than 10 decares. The second stratum consisted of hazelnut farmers having land between 10 to 19.99 decares, and the rest of the hazelnut farmers were in the third stratum. In this way, 152 (Ordu 75 and Giresun 77) hazelnut farmers were selected as the total size of this study (Table 3).

Table 3. Accessible population and sample size in each stratum

strata	Criteria (decare)	Population (number)	Sample size (number)
Ordu			
Stratum 1	<10	15675	30
Stratum 2	10≥ and ≤ 20	12578	24
Stratum 3	>20	10702	21
Giresun			

Stratum 1	<10	13984	37
Stratum 2	10≥ and ≤ 20	8699	23
Stratum 3	>20	6395	17

2.2 Methodology

2.2.1 Identification and classification of sample farms

The conceptual framework was used to classify full-time and part-time farming in the study area. In previous studies, classifications were made by income, farm size, labor force, farmers' residence status, farming income, and capital elements (Bishop, 1955; Bollman and Smith, 1988; Brosig et al., 2009; Fuller, 1990, 1975; Gasson, 1986; Greeley, 1942; Kada, 1982, 1980; Lien et al., 2010; Lund and Price, 2007; Mittenzwei and Mann, 2017; Paudel and Wang, 2002; Pfeiffer et al., 2009; SCHMITT, 1989; Shucksmith and Winter, 1990; Singh and Williamson, 1981). However, considering the socio-economic characteristics in the study area, we preferred to use the site-specific classification method. The study used the percentage of the payment for family members in total labor cost in hazelnut production as a classification criterion. When classifying the farmers, the labor cost coefficient was also used to reflect the risk and workload of each production activity, such as fertilizing, harvesting, etc. If the total labor cost percentage of family work payment were more extensive than 67%, the farms would be defined as full-time farms. Otherwise, farms were classified as part-time farms. The classification results showed that 53% of the total sample farms were full-time hazelnut farms, and the rest was part-time hazelnut farms. The percentages of part-time farms in Ordu and Giresun were 54% and 46%, respectively.

2.2.2 Indicator Selection

As possible confusing and varied aspects of an indicator limit its applicability to a precise location and time; selecting acceptable indicators to assess the sustainability of a farm for a region is a very complicated and thorough task. Because the indicator's applicability is limited due to varying climatic and geographic conditions, ul Haq and Boz (2018) have developed a comprehensive and user-friendly process for selecting indicators. They extensively focused on the site-specific characteristics of the region to develop the “basic factors.” The site-specific characteristics include a) climate and land requisites of the tea plant, b) farming community in locality c) socio-economic characteristics of the study area. Based on these site-specific characteristics and reviewing the literature, the basic factors were developed. The purpose of developing the basic factors was to obtain the basic information on the indicators representing the characteristics of the study area with concerned farming activity, for example, hazelnut farms in the study area. However, an indicator has limited applicability over the different areas, regions, and countries. The farm-level indicators-based sustainability studies can be consulted to determine the possible adaptable indicators in the study.

Similarly, the comprehensive list of indicators was prepared considering the different worldwide conducted farm-level sustainability assessment studies for example; (Binder et al., 2008; Dillon et al., 2009; Gafsi and Favreau, 2010; Gómez-Limón and Riesgo, 2009; Gómez-Limón and Sanchez-Fernandez, 2010; Häni et al., 2006; López-Ridaura et al., 2002; Pacini et al., 2003; Pretty et al., 2008; Rasul and Thapa, 2004; Rigby et al., 2001; Roy and Chan, 2012; Sajjad and Nasreen, 2016; ul Haq and Boz, 2018; Zahm et al., 2008). Subsequently, if the indicator is adoptable directly in the current study, then it is included in the final set of indicators after confirming the selection criteria are met. For example, education, age of the farm manager, etc., were the adoptable indicators in the current study.

The selection criteria were defined to select indicators to confirm their applicability in the study area. It included the ability of the indicator to clarify the complex phenomenon, measurability, user friendly, understandability, socially and economically viability, and fulfillment of defined objectives of the study (Bossel, 1999; Nambiar et al., 2001; Pannell and Glenn, 2000; Reed et al., 2006). The current study followed the selection criteria, which are explained below;

1. The indicator should be scientifically valid, having the ability to clarify the phenomenon clearly (scientific validity)
2. For calculating the true value of the indicators, the data should be available (data availability).
3. The method to measure the true values of the indicator should be available even though the data is available (measurability).
4. The indicator should be easily interpretable for any new researchers, and readers, etc. (easily interpretable)
5. The selected indicator should be easily understandable and easily usable by the end-user (Understandability)
6. The indicator should be sensitive to the three dimensions of sustainability status changes. It means the indicator should represent the true changes whenever used in the future (Sensitivity).

The indicator passed out the selection criteria and was adaptable, and then it passes through the validation process, which is necessary to confirm its creditability and correct performance (Cloquell-Ballester et al., 2006). While the development of the indicators for assessing farm sustainability has been happening for many years, very little has been described on the verification of the indicators (Rigby et al. 2001). It was defined that the indicator is valid when it is well-grounded, achieves the intended effects, and fulfills the desired objective (Bockstaller and Girardin, 2003). To confirm the validity of the indicators, the 3S methodology such as self, scientific and social authorization (Cloquell-Ballester et al., 2006) was used in this study.

The study's research team confirmed the self-validation considering the selection criteria defined herein. They tried to confirm the correct performance of the selected indicators to prevent theoretical contradictions and operational errors. They also ratified that the other researchers' indicators are easily understandable, interpretable, and usable. The experts' opinions were obtained to ensure the indicator's objectivity, accuracy, and fairness to check its scientific validity. The hazelnut stakeholders confirmed the social validity. This activity ensured the social soundness of the indicator.

If an indicator depicts its adaptability directly in the study, its validity was confirmed. If adaptability was poor, then the indicator was replaced with a new one, and a similar process was repeated for the newly added indicator to check its validity. Consequently, the final set of indicators was developed and illustrated in table 4, table 5, and table 6 and used for the data collection and scoring to assess the hazelnut farms' sustainability regarding full and part-time farming. This selection of indicators was performed according to the selection procedure extensively proposed by the ul Haq and Boz (2018), and the basic factors were considered the same as in the current study. Similar indicators were used in this study due to their adaptability confirmed after passing the indicators from the validation process.

Table 4. Economic sustainability indicators

Basic factors	Indicator	Definition	Unit
High value-added	Gross margin	Variable cost minus revenue	€/ha
	Financial return	The ratio of benefit to cost	Ratio
	Economic rantability	Profitability of using the total resources	Ratio
Productive use of inputs	Technical efficiency	The proportion of total productivity to maximum productivity possible.	Ratio (0-1)
	Labor productivity	Harvested quantity per unit of labor	Kg/person/day
	Productivity of the land	Quantity per unit of land	Kg/ha/year
Stable source of income	Income stability	Variation in farm profit	0-decrease, 1-fixed, 2-increase
		Hazelnut is enough source of income	0-no, 1-yes
Characteristics of farmers	Cultivation of crops and rearing animals	It measures how much farmer wants to be busy arming	1-crop, 2-crop, and livestock
	Hazelnut farmer wants to become a successful farmer	Farmers wish of becoming a successful farmers is a sign of satisfaction	
	Farmer wants to buy new land to grow hazelnut farming	Measuring farmer's wish to extend their hazelnut farming	0-no, 1-yes
	Desire to grow hazelnut farming by planting new trees		0-no, 1-yes
	Farming continuity from generation to generation	Division of land among heirs	0-no, 1-yes
	The goal of selling hazelnut or farmland for the building is to profit.	It determines the farmer's mindset to give up hazelnut farming in future	0-no, 1-yes

Table 5. Social sustainability indicators

Basic factors	Indicator	Definition	Unit
Higher and skilled human resources	Equity	Measuring the farm's ability to produce jobs	Number of persons
	Level of education	Farmer’s schooling years	Schooling years
	Farmer’s age	Age of farmers	Years
	Indicator of old age	Family labor age ratio at the farm	The ratio of family labor above 60 years old
Social inclusion	children's access to educational facilities	Children having easy access to school	0-no, 1-yes
	access to clean drinking water	Ensure the availability of clean and pure drinking water	0-no, 1-yes
	membership of the agricultural organization	A farmer having membership of any organization	0-no, 1-yes
	Migration status	Any family member migrated to another town or city	0-no, 1-yes
	Off-farm income	Having other sources of income	0-no, 1-yes
Social involvement	Relations with temporal workers	The good relationship with the labor working at their farm	1-Bad, 2-Normal, 3-Good
	Cohesion status with hazelnut merchant	Coordination between farmer and the different extension agents	1-Bad, 2-Normal, 3-Good
	cohesion status with other farmers	Farmers communication concerning hazelnut farming	1-Too bad, 2-Bad, 3-Normal, 4-Good , 5-So good
	Socialization level of farmers	Farmer’s level of communication with another farmer to share something new	1- Too bad ,2-Bad, 3-Normal, 4-Good , 5-So good
Social security	Buy necessary food	Ability to buy essential food items every time	0-no, 1-yes
	Meet educational needs of children	Ability to meet the educational needs of children	0-no, 1-yes
	House condition	Condition of house	0-bad, 1-good
	Family members' social security status	Any family member having a retirement, or welfare program	0-no, 1-yes
	Health insurance status of household	Household’s having health insurance	0-no, 1-yes
	Health status of household	Household’s health status	0-bad, 1-good

Table 6. Environmental indicators of sustainability

Basic factors	Indicator	Definition	Unit
Fertilizer use	Using chemical fertilizer	The actual quantity of fertilizer applied	Kg/ha
Produce with fewer resources	Eco-efficiency	The maximum value is achieved with the least amount of resources used and/or the minor environmental damage (Jollands et al., 2004).	Ratio (0-1)
Preservation of the soil	Sustainable soil management practices	Spreading barnyard manure	0-no, 1-yes
		Spreading organic manure	0-no, 1-yes
		Soil test	0-no, 1-yes
		Leaf test	0-no, 1-yes
Chemical fertilizers have a few adverse side effects.	Chemical fertilizer use has become a health problem	Ever farmer faced the health-related problem during the application of fertilizer	1-no, 0-yes
Good management	Land management practices that contribute to soil health	Erosion risk of soil	0-no, 1-yes
		Stable terracing	0-no, 1-yes
		Tree planting at landside and erosion-prone land	0-no, 1-yes

2.2.3 Data collection and scoring

Face-to-face interviews with hazelnut growers were performed to collect data using a well-defined and well-structured questionnaire. A diversified set of indicators requires different types of data (quantitative and qualitative) to calculate the final or true values of the indicator. For this, quantitative data was gathered related to the quantity and prices of inputs used in the crops cultivated at the farm, amount and fees of output produced at the farm, farmers' action, and their vision to make hazelnut farming economically viable, socially acceptable and environmentally friendly. Moreover, information about the farm structure, production technology, and characteristics of the farmers and farms was obtained. For example, the qualitative data, farmers' responses, was recorded in yes/no form or on a Likert scale (five-point). Calculating the true values of the indicators was not a difficult task. The only efficiency score of hazelnut farmers, including production, economic, and eco-efficiency, was estimated using the Data Envelopment Analysis (DEA) program.

The indicators given in above table 4, table 5, and table 6 were different; some were continuous, and some were in the response form. Furthermore, scoring was carried out to overcome the variety among these indicators to make them useable by converting them to a unit-free format. We used scientific information, a curve of production possibility, questionnaire responses, and expert judgment to score the indicators. For example, chemical fertilizer was scored based on scientific knowledge. It means the recommended quantity for the one unit of land or one hazelnut tree was used as a benchmark value. Moreover, chemical fertilizer is supposed to contribute to the adverse environmental effects, although their share in production is not negligible; in such a case, some farmers may apply fertilizer less than the recommended value. Therefore, the actual minimum amount of fertilizer applied was used as a benchmark.

The production possibility curve described the maximum attainable output of each hazelnut farm upon using similar level inputs (van Passel et al., 2009). Since the efficiency scores will be the ratio of the actual productivity achieved by the hazelnut farmer to the maximum achievable productivity of the farm (Meul et al., 2008). Consequently, every efficiency score was based on this concept. The maximum value of the efficiency score was used as the benchmark value in the current study. It describes that maximum efficiency contributes to farm sustainability positively.

The questionnaire results analyze subjectively various indicators in each dimension (Meul et al., 2008). Some indicators were generated using information from the questionnaire regarding the price and quantity of inputs and outputs used to grow the farm's crops. For example, the gross margin of the hazelnut farm was calculated based on the actual information of the market value of the output of crops produced at far less than the cost incurred to make them at the farm.

The experts' judgment helped score the response variable when none of those mentioned above scoring methods was suitable. In this approach, many indicators were responded to by the hazelnut farmers in yes and no forms. If a yes type of response positively helps sustainability, it was given a score of 1; otherwise, it was given a 0. Similarly, if no response contributes to higher sustainability, it was scored 1; otherwise, 0. For example, indicators such as buying the new land for extending the hazelnut orchard are responsive indicators. Their contribution toward the farm sustainability is based on the yes response of the farmer, 1 was given to yes response and 0 to no response.

2.2.4 Sustainability Index Calculation of the Hazelnut Farms

The selected indicators were put through a series of procedures to calculate the composite hazelnut farms' sustainability index (CHF), including normalization to estimate the weight for each indicator, calculation of intermediate indicators within each dimension, and aggregation of these intermediate indicators using their proportion of variance. As a result, all three elements of sustainability were calculated: economic, social, and environmental. All three criteria were equally weighted and aggregated to determine the composite hazelnut farms sustainability. Giving each component equal weight was because all aspects of sustainability were similarly significant.

Step-1

When all current indicators indicate various situations and have different units, they are not interchangeable. Therefore, the indicators need to be standardized to estimate each indicator's weights. This activity results in unit fewer indicators. The min-max normalization method was used (Freudenberg, 2003; Gunduz et al., 2011). The following formulas were used for normalizing an indicator whose maximum value was considered a higher contributor to sustainability. The following formula was used when the maximum value of an indicator was regarded as being more sustainable.

$$\left(\frac{X - minimum\ Value}{Maximum\ Value - Minimum\ Value}\right)$$ Here; X= Actual Value of indicator

Similarly, the following equation was used for that indicator, whose minimum value was cataloged as being more sustainable,

$$\left(\frac{X - maximum\ Value}{Minimum\ Value - Maximum\ Value}\right)$$ Here; X= Actual Value of indicator

Step-2

The previous step resulted in the normalized value of each indicator between 0 and 1. As a result, the weights for each indication were estimated using factor analysis. Because there are three dimensions to sustainability, each with its own set of indicators, the factor analysis was done individually. The weight for each indicator was calculated using the loading matrix and the proportion of variation. The weight for each indicator was calculated using the equation below.

$$w_{Lj} = \frac{\left(factor\ loading_{Lj}\right)^2}{eignvalue_j}$$

Where w_{Lj} illustrates the indicator weight L in j^{th} component.

Step 3

The next step was to calculate the intermediate indicators. The factor analysis resulted in the various factor consisting of many indicators. The intermediate composite indicators corresponding to each component (II_i) were generated using the formula below for each dimension with multiple indicators.

$$II_{ijk} = \sum_{L=1}^{L=n} w_{Lj} I_{Lk}$$

Where II_{ijk} is the intermediate indicator for each dimension of sustainability, I is the economic, social, and environmental sustainability dimension for component j and farm k. w_{Lj} is the weight assigned to each indicator in the preceding phase.

Step 4

The following formula was used to calculate the composite index for each component of sustainability, including economic, social, and environmental.

$$CII_{ik} = \sum_{j=1}^{n} \alpha_j II_{ijk}$$

The intermediate composite indicators were aggregated to calculate the composite index (CI_k) of farm K. The weight α_j Used in this equation was estimated by using the following equation.

$$\alpha_j = \frac{eignvalue_j}{\sum_{j=1}^{n} eignvalue_j}$$

Finally, the Composite index for each dimension of sustainability was equally weighted to aggregate them for measuring the composite hazelnut farm sustainability index (CHFSI); for this, the following simple average formula was applied.

$$CHFSI_k = \sum_{i=1}^{3} CII_{ik}/3$$

CHFSI is the composite hazelnut farm sustainability index for Kth farm, and CII_{ik} is the intermediate composite index value for each sustainability dimension at farm k.

3. Results and discussion

Overall, hazelnut sustainability scores of farms varied from 0.28 to 0.59, and the average score was 0.44 at sampled farms. Based on the overall hazelnut sustainability index, it was clear that the unsatisfactory level existed. The values are similar for both types of farms. There was no statistically significant difference between the two groups (p>0.05). Then economic and social sustainability index value of farms was equal, and they were higher than the environmental index value (p<0.05). The values were 0.50 and 0.30, respectively. At the same time, the economic sustainability index score of full-time farms was higher than that of part-time farms (p<0.05), part-time farms had higher environmental sustainability index scores than that of full-time farms (p<0.05) (Table 7). In previous studies, various evaluations have been made on economic, social, and environmental aspects of full-time and part-time farming, which are the three main indicators of sustainability, but these researchers reached conclusions without creating an index (Coutu, 1957; Fuller, 1990; Lien et al., 2010; Loyns and Kraut, 1992; Paudel and Wang, 2002). In these studies, using a limited number of indicators, a positive or negative perspective was given economically, socially, or environmentally (Barbier, 2000; Beyene, 2008; Bollman, 1982; Coutu, 1957; Galiev and Ahrens, 2018; Gasson, 1988; Jokisch, 2002; Latruffe and Mann, 2015; Phimister and Roberts, 2006; Salvati and Zitti, 2009; Swanson and Busch, 1985; Upton et al., 1982) (Table 8).

Table 7. Distribution of Sustainability Index by Farmers Type

Indicator	Full-time	Part-time	Overall
Economic sustainability index**	**0.58 ± 0.01**	**0.40 ± 0.01**	**0.50 ± 0.01**
Economic indicators			
Gross margin (€/ha) ***	2224.6 ± 248.7	474.1 ± 88.2	1267.6 ± 152.7
Financial return*	0.6 ± 0.1	0.3 ± 0.1	0.5 ± 0.1
Economic rantability *	1.7 ± 0.2	1.1 ± 0.3	1.4 ± 0.6
Technical efficiency**	0.86 ± 0.01	0.78 ± 0.02	0.82 ± 0.02
Labor productivity per person (kg/day)	52.7 ± 2.5	49.1 ± 3.0	50.9± 2.6
Land productivity (kg/ha) *	1129.4 ± 46.8	866.1 ± 43.9	985.5 ± 33.3
Income stability (response)**	1.5 ± 0.1	0.8 ± 0.9	1.2 ± 0.5
Characteristics of farmers (response)*	3.4 ± 0.1	2.8 ± 0.1	3.1 ± 0.1
Social sustainability index	**0.51 ± 0.01**	**0.49 ± 0.02**	**0.50 ± 0.01**
Social indicators			
Equity**	12.7 ± 1.8	30.2 ± 2.0	21.0 ± 1.5
Education level*	6.9 ± 0.4	9.1 ± 0.5	8.0 ± 0.3
Age of farmers	54.0 ± 1.4	56.2 ± 1.7	55.1 ± 1.1
Old age index	0.2 ± 0.0	0.3 ± 0.1	0.3 ± 0.0
Social inclusion	5.3 ± 0.1	5.1 ± 0.1	5.2 ± 0.1
Social involvement	26.8 ± 1.0	25.6 ± 1.0	26.2 ± 0.7

Social security	5.5 ± 0.1	5.3 ± 0.1	5.4 ± 0.1
Environmental sustainability index**	**0.25 ± 0.02**	**0.36 ± 0.02**	**0.30 ± 0.01**
Environmental Indicators			
Using chemical fertilizer (kg/ha) *	563.1 ± 37.8	544.4 ± 34.9	554.3 ± 25.8
Eco-efficiency*	0.43 ± 0.03	0.51 ± 0.03	0.47 ± 0.02
Sustainable soil management practices	1.1 ± 0.1	1.0 ± 0.1	1.1 ± 0.1
Chemical fertilizer application has become a health problem	0.3 ± 0.1	0.2 ± 0.1	0.3 ± 0.0
Land management practices	6.0 ± 0.0	6.0 ± 0.2	6.0 ± 0.0
Hazelnut Sustainability index	**0.45 ± 0.01**	**0.42 ± 0.01**	**0.44 ± 0.01**

€1=₺6.6

*p<0.10, **p<0.05 and ***p<0.01 reflects that the difference between full-time and part-time farms is statistically significant.

Economic sustainability score was higher in full-time farming than part-time farming (p<0.05) (Table 7). In literature, many studies reported that part-time farming is economically harmful (Barlett, 1986; Beyene, 2008; Brosig et al., 2009; Gray, 2009; Haiguang et al., 2013; Jokisch, 2002; McCarthy et al., 2009; Rudel, 2006; Zhang et al., 2008), while there are also studies that considered positively to part-time farming as economic aspect (Alwang and Siegel, 1999; Bishop, 1955; Cavazzani, 1977; Galiev and Ahrens, 2018; Li and Tonts, 2014; Massey et al., 1993) (Table 9). The common point of these studies was to make a sweeping statement by considering a few economic indicators. While researcher's reasons for the positive approach to part-time farming were to diversify income and to raise the standard of living (Cavazzani, 1977; Massey et al., 1993; Upton et al., 1982); to support the labor market (Alwang and Siegel, 1999; Bishop, 1955; Bollman, 1982; Galiev and Ahrens, 2018), to increase production by making more investment in agriculture (Li and Tonts, 2014), the negative approach' reasons were lower productivity and higher production cost (Haiguang et al., 2013; Jokisch, 2002; McCarthy et al., 2009) and inappropriate use of an agricultural resource (Barlett, 1986; Beyene, 2008; Brosig et al., 2009; Rudel, 2006; Zhang et al., 2008) (Table 8).

The average gross margin of farms was €1300 per hectares. Full-time farms had more gross margin than part-time farms (p<0.01). The farms' financial return and economic rentability were calculated as 0.5 and 1.7, respectively. The ratios of full-time farms were higher than part-time ones (p<0.10). Farm's average technical efficiency score was 0.82, and full-time farms were more efficient than part-time ones. Labor productivity for full-time and part-time farmers was 53 and 49 kg/day per person. The overall average labor productivity was 51 Kg/day in the study area. There was no statistically significant difference between part-time and full-time farmers groups (p>0.05). Land productivity at full-time farms was higher than part-time farms (p<0.10). The average land productivity of the research area was 986 kg ha-1. Similarly, full-time farmers had higher income stability and score of farmers' characteristics than part-time farmers. The average value of income stability and farmers' characteristics score were 1.2 and 3.1, respectively (Table 7).

Social sustainability scores were not different in terms of farm type contrary to the findings, in most of the previous studies, the part-time farming type was advantageous in terms of social aspects (Bollman, 1982; Brosig et al., 2009; Fuller, 1975; Giourga and Loumou, 2006; Haiguang et al., 2013; Upton et al., 1982; Xu et al., 2019b, 2019a; Yrjola et al., 2002). A couple of studies negatively evaluated part-time farming concerning the social aspect (Barlett, 1986; Swanson and Busch, 1985). As in the economic evaluation, the common points of the studies that make social evaluations were given general results by considering the few social indicators. The most important reasons for this positive approach are to increase access to education and other social requirements (Bollman, 1982; Brosig et al., 2009; Fuller, 1975; Yrjola et al., 2002); to decrease working time (Giourga and Loumou, 2006; Haiguang et al., 2013); to reduce adverse migration effects such as abandonment of land (Upton et al., 1982; Xu et al., 2019a, 2019b). (Barlett, 1986; Swanson and Busch, 1985) had a negative approach to part-time farming because of decreasing farmers' motivation and the working potential of laborers in agricultural sectors (Table 8).

Value of social sustainability indicators illustrated in table 8. Part-time farms generated more equity than full-time farms (p<0.05). The education level of full-time farmers was lower than that of part-time farmers (p<0.10). The average schooling year value was 8 years in the research area. Full-time and part-time farmers had the same value for other social indicators such as social security, social involvement, social inclusion, age, and old age index. While the average age was 55 years, the old age index was 0.3. Social security and social inclusion values were 5.2 and 5.4, respectively. The social involvement value of farmers was 26.2 (Table 7).

When environmental indicators were examined in the research area, part-time farmers produced more environmentally friendly than full-time farmers (Table 7). All previous studies conducted by(Barbier, 2000; Barlett, 1986; Caraveli, 2000; Ceddia et al., 2009; Ellis et al., 1999; Gasson, 1988; Giourga and Loumou, 2006; Kristensen, 1999; Latruffe and Mann, 2015; Lorent et al., 2008; Phimister and Roberts, 2006; Salvati and Zitti, 2009; Swanson and Busch, 1985; Yrjola et al., 2002) reported similar results except (Celio et al., 2014). He propounded that there was no difference between full-time and part-time farms in terms of environmental aspect score. These studies have suggested results considering only a few environmental indicators and other sustainability aspects. Some researchers suggested that part-time farmers preferred less chemical input for their farmland (Barlett, 1986; Ellis et al., 1999; Giourga and Loumou, 2006; Phimister and Roberts, 2006; Swanson and Busch, 1985) and land use behaviors of part-time farmers helped to protect the environment (Barbier, 2000; Caraveli, 2000; Ceddia et al., 2009; Gasson, 1988; Kristensen, 1999; Latruffe and Mann, 2015; Lorent et al., 2008; Salvati and Zitti, 2009; Yrjola et al., 2002) (Table 8).

Part-time farmers used less chemical fertilizer and were more efficient in eco-efficiency scores than full-time ones ($p<0.10$). Other environmental indicators' value of farms was similar in full-time and part-time farms (Table 7).

According to the composite sustainability index results, which is the average of the 3 main sustainability indicators, it is similar for full-time and part-time farming types; there is no significant difference (Table 8). While only one of the previous studies (Lien et al., 2010) reached a similar result, studies were suggesting that full-time (Coutu, 1957; Loyns and Kraut, 1992) and part-time farming type (Fuller, 1990; Paudel and Wang, 2002) are generally more advantageous (Table 8).

Table 8. The approach of Sustainability by Previous literature

Scope	**Study Area**	**Previous literature***		
		+	**=**	**-**
Economic	**-**	(Alwang and Siegel, 1999; Bishop, 1955; Bollman, 1982; Cavazzani, 1977; Galiev and Ahrens, 2018; Li and Tonts, 2014; Massey et al., 1993)	**-**	(Barlett, 1986; Beyene, 2008; Brosig et al., 2009; Gray, 2009; Haiguang et al., 2013; Jokisch, 2002; McCarthy et al., 2009; Rudel, 2006; Zhang et al., 2008)
Social	**=**	(Barlett, 1986; Bollman, 1982; Brosig et al., 2009; Ellis, 2017; Ellis et al., 1999; Fuller, 1975; Galiev and Ahrens, 2018; Giourga and Loumou, 2006; Haiguang et al., 2013; Latruffe and Mann, 2015; Upton et al., 1982; Xu et al., 2019a, 2019b; Yrjola et al., 2002)	**-**	(Barlett, 1986; Swanson and Busch, 1985)
Environmental	**+**	(Allanson, 2006; Barlett, 1986; Cavazzani, 1977; Ceddia et al., 2009; Ellis et al., 1999; Gasson, 1988; Giourga and Loumou, 2006; Kristensen, 1999; Latruffe and Mann, 2015; Phimister and Roberts, 2006; Swanson and Busch, 1985; Yrjola et al., 2002)	(Celio et al., 2014)	(Barbier, 2000; Caraveli, 2000; Lorent et al., 2008; Salvati and Zitti, 2009)
Mixed		(Fuller, 1990; Paudel and Wang, 2002)	(Lien et al., 2010)	(Coutu, 1957; Loyns and Kraut, 1992)

* The perspective of part-time farming type compared to full-time farming; (+) positive and more advantageous; (-) negative and not advantageous; (=) no difference.

Table 9 shows farms' group distribution of sustainability index by sustainability level. When focusing on the difference between the sustainability level of farm type, it was clear that the full-time and part-time farms had similar hazelnut sustainability index scores in low and high sustainability farms groups ($p>0.05$). But, the economic sustainability index of full-time farms and the environmental sustainability index of part-time farms are higher than that of another farm type in both the sustainability level group ($p<0.01$). The social sustainability index score was also nearly equal for full-time and part-time farms in low and high sustainability levels.

Table 9. Farms' Group Distribution of Sustainability Index by Sustainability Level

	Low-sustainability farms		High-sustainability farms	
n	77		75	
%	51%		49%	
Sustainability index	Full-time	Part-time	Full-time	Part-time
n	39	38	41	34
%	51%	49%	55%	45%
Economic	0.54 ± 0.01***	0.38 ± 0.01***	0.62 ± 0.01**	0.42 ± 0.01**

Social	0.46 ± 0.02	0.46 ± 0.02	0.56 ± 0.01	0.52 ± 0.02
Environmental	0.10 ± 0.01***	0.20 ± 0.02***	0.40 ± 0.02***	0.54 ± 0.03***
Hazelnut (overall)	0.37 ± 0.01	0.35 ± 0.01	0.53 ± 0.01	0.49 ± 0.01

*p<0,10, **p<0,05 and ***p<0,01 reflects that the difference between full-time and part-time farms is statistically significant.

Both farmers' characteristics (age, family size, agricultural experience, schooling year, etc.) and farms characteristics (farmland, the slope of orchards, production type, buying and selling land) associated with full-time and part-time farming by low and high sustainability farms were presented table 10.

Farmer characteristics such as age and agricultural experience of full-time and part-time farmers were similar for low and high sustainability farms. There was no statistically significant difference between farm-type groups in both sustainability levels in terms of age and agricultural experience ($p>0.05$). The family size of full-time farmers was more extensive than that of part-time farmers in low and high sustainability farms ($p<0.10$). Part-time farmers were more educated compared to full-time farmers in the low-sustainability ($p<0.10$) and high sustainability farms group ($p<0.05$). Although the family labor of full-time farmers was more elevated than part-time farmers ($p<0.10$), part-time farmers were hired more labor than full-time farmers ($p<0.01$). In comparison, the off-farm work ratio of part-time farmers was higher than part-time farmers in low sustainability farms ($p<0.05$), full-time and part-time farms were nearly the same off-farm rate in high sustainability farms (Table 10).

Regarding the farm characteristics, farms in low and high sustainability groups, part-time farms had higher farmland than that of part-time farms. In both groups, meters above the sea levels and slope were similar for full-time and part-time farms' orchards. Low-sustainability full-time farms sold their hazelnut at a higher price than part-time farms ($p<0.05$). The selling price of hazelnut of high-sustainability full-time and part-time farms was equal. In both sustainability groups, 48% of low-sustainability of part-time farms produced only crop, and 29% of the high-sustainability full-time farms had both crop and animal. Buying a new farmland ratio of low-sustainability full-time and part-time farms were 21% and 16%, respectively. There was no statistically significant difference between part-time and full-time low sustainability farms ($p>0.05$). In high sustainability farms, full-time farms bought more farmland than part-time ones ($p<0.05$). (Table 10).

Table 10. Some Characteristics of Farm and Farmers

	Low-sustainability farms		High-sustainability farms	
Farmers' characteristics	Full-time	Part-time	Full-time	Part-time
Age	56.4 ± 1.9	53.4 ± 0.2	51.8 ± 1.9	54.7 ± 2.7
Agricultural experience	32.5 ± 2.2	33.2 ± 2.2	29.2 ± 2.1	30.2 ± 2.6
Family size	4.0 ± 0.3*	3.0 ± 0.2*	4.0 ± 0.2*	3.0 ± 0.2*
Schooling year	6.2 ± 0.5*	8.3 ± 0.7*	7.6 ± 0.6**	10.0 ± 0.8**
Family labor (erkek iş gücü - person)	2.6 ± 0.2*	1.4 ± 0.2*	2.6 ± 0.2*	1.4 ± 0.2*
Hiring labor (erkek iş gücü - person)	5.6 ± 1.1***	20.0 ± 2.2***	8.3 ± 2.7***	19.4 ± 1.7***
Off-farm work (%)	5.5 ± 1.6**	14.5 ± 2.2**	12.8 ± 1.9	12.6 ± 2.6
Farm characteristics				
Farmland	13.5 ± 1.6**	17.4 ± 2.4**	11.8 ± 1.33**	16.5 ± 2.4**
Slope of orchards	38.7 ± 3.4	37.4 ± 3.2	32.5 ± 2.3	27.0 ± 3.6
Meters above sea level	417.7 ± 42.1	403.7 ± 31.5	304.5 ± 29.9	323.1 ± 44.6
Price of hazelnut(₺/kg)	11.9 ± 0.2**	10.9 ± 0.2**	11.7 ± 0.2	11.7 ± 0.2
Only crop farms (%)	51.3**	100.0**	70.7**	100.0**
Crop and animal farms (%)	48.7	-	29.3	-
Buying new land (%)	20.5	15.8	17.1**	2.9
Selling land (%)	2.6**	13.2**	2.4**	8.8**
Planting new land (%)	7.7*	15.8*	7.3	11.8
Variation in farm profit (%)				
The yield of	1090.6 ± 149.6*	853.3 ± 130.1*	1177.4 ± 147.0*	880.6 ± 131.2*

hazelnut (kg/ha)				
Working time at farm (hour/ha)	855.0 ± 95.3**	686.0 ± 57.3**	704.5 ± 64.1**	593.3 ± 53.2**
Chemical (₺/ha)	1089.8 ± 261.8	1113.4 ± 231.3	569.5 ± 156.5**	1560.8 ± 465.3**
Barnyard manure (yes) %	97.4	92.1	34.1*	17.6*
Organic manure (yes) %	-	2.6	9.8	11.8
Testing soil (yes) %	20.5	28.9	46.3	44.1
Testing leaf (yes) %***	2.6	-	17.1**	2.9**
Stable terracing (yes) %	2.6	5.3	2.4	2.9

When examining some management practices of farms, full-time farms produced more hazelnut per hectares than part-time farms in both groups ($p<0.01$). Similarly, full-time farmers worked more time than part-time farms ($p<0.05$). While full-time and part-time low sustainability farms used the same amount of chemicals, in high sustainability farms, part-time farms used more chemicals than full-time farms ($p<0.05$). High sustainability full-time farms used more barnyard manure than part-time farms ($p<0.05$). Full-time high sustainability farms tested more leaves of their hazelnut tree than that of part-time farms ($p<0.05$). Using organic manure, testing soil and stable terracing rate of farms were equal in all groups ($p>0.05$) (Table 10).

4. Conclusion and Recommendation

Hazelnut is of great importance in the food industry. Hazelnut farming is critical economically for Turkey, the largest hazelnut producer. The study examined the sustainability index of hazelnut farms with a set of indicators that were developed specifically relevant to the assessment of hazelnut farming in the study area and to explore the effects of part-time and full-time farming type on sustainability index hazelnut production in the Giresun and Ordu Province of Turkey.

Sustainable agriculture is defined as social equality, work, land use, protection of the environment, and biodiversity. The agricultural system is environmentally friendly, profitable, productive, and maintains the social networks of the rural population. Sustainable agriculture combines economic, social, and environmental components.

Based on the evidence from the research results, it was clear that the composite sustainability index value was unsatisfactory level. A similarly low-level index value existed in the classification by farming type. Although there was a difference between farming types regarding environmental and economic sustainability index values, the composite sustainability index is similar. To increase the overall index score and the general policies, specific policies are needed according to the farming type.

Economic sustainability is of lower value, especially in part-time farms that devote less time to their farm. The economic sustainability index value of part-times, which have a higher gross margin due to variable costs, and less profit due to their low-cost ratio and economic profitability, is lower than full-time ones. This profitability continues to decrease every year. Since they spend less time in their gardens, it is understood from the low technical efficiency score that they are technically inadequate. Particularly, part-time farmers' better monitoring of the market to reduce their average variable costs and their participation in training to increase their technical competencies would improve their economic sustainability. Full-time farmers with higher farming characteristics, which are essential indicators of adopting farming as a profession and connecting their income to farming, are advantageous in economic sustainability. In particular, the traditional structure in the region prevents complete separation from farming, negatively affects total production, and threatens the economic sustainability of part-time farms. It will be an important factor for economic sustainability for policy-makers to employ certified workers with high technical capacity in the region, with wage support, if necessary, without disturbing the traditional structure.

Farming groups have similar values in terms of social sustainability. Foreign labor employment status and education level are better among the social sustainability indicators in part-time farms. It is crucial to solving the aging problem in agriculture to increase social sustainability in hazelnut farmers in the region. In particular, both social and economic measures to be taken towards directing young people to agriculture will prevent aging in agriculture and increase education.

The value of the environmental sustainability index was the lowest among the sustainability index, exceptionally very low for full-time farms. The key reasons for the heavy use of chemical fertilizers and the low eco-efficiency score. Raising awareness of full-time farmers on the use of fertilizers would positively affect environmental sustainability. Increasing the farmers' rate for farming types, soil testing, and leaf analysis and strengthening farmers' motivation to use organic fertilizer could positively affect environmental sustainability.

The study suggested that policy-makers differentiate between part-time and full-time hazelnut farming when designing and regulating support policies. Training and extension programs must be planned to increase the level of knowledge of every willing farmer. In addition, training and certification programs must be implemented to enhance the quality of the foreign labor force.

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Ethical approval

Ethical approval for this study was obtained from *Clinical Research Ethics Committee of Ondokuz Mayıs University (2015/460)

Not applicable.

Consent to participate

Not applicable.

Consent to publish

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