Assessing the sustainability index of part-time and full-time hazelnut farms in Giresun and Ordu Province, Turkey

Çağatay Yıldırım1 · Hatice Türkten1 · İsmet Boz1

Received: 9 December 2021 / Accepted: 16 May 2022 / Published online: 16 June 2022
© The Author(s), under exclusive licence to Springer-Verlag GmbH Germany, part of Springer Nature 2022

Abstract
The study’s primary purposes were to assess the sustainability of hazelnut farms and explore the effects of part-time and full-time farming types on sustainability 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 by using face-to-face questionnaires. 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 values of farms were equal, and they were higher than the environmental index value. The values were 0.50 and 0.30, respectively. 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 regulating support policies, policy-makers should differentiate part-time and full-time farming. Training and extension programs must be planned to increase the level of knowledge of every willing farmer. To increase sustainability, specific policies are developed according to the farming type.

Keywords Hazelnut farmers · Sustainability index · Sustainability indicators · Part-time farming · Turkey

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 and 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 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 climatic 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, Füsun Tatlidil et al. (2009) studied farmers’ perception with farm sustainability and its determinants; Gündüz 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 have multidimensional impacts on farm management and on the use of farm resources; for example, in 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 main purpose of the study was 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 provinces of Turkey. 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.

Material and method

Material

Research area

Turkey is the largest hazelnut producer, having 62% share in the total world production. The whole hazelnut-growing area was 0.735 million hectares, and 0.665 million tons of hazelnut was produced in 2020 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 43% of the total hazelnut production area of the country.

© Springer
Moreover, these provinces contribute substantially (42%) 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.

Climatic conditions of the research area

Both selected provinces have a humid subtropical climate with hot and humid summer seasons 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 −80 and 360 °C throughout the year and rainfall more than 700 mm for bountiful yield. The mean minimum temperature went between 3.90 and 20.55 °C, and the mean maximum temperature remained between 10.35 and 27.45 °C from 1981 to 2010 in the study area. The precipitation varied between 63 and 129 mm throughout the year during the same period (Table 2). Hazelnut grows well in loamy vegetal and deep soils rich in nutrition as they allow 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.

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 Forestry. The first challenge in the sampling procedure was to determine a sample size to represent all the 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):

\[ n = \frac{N \sum N_h S_h^2}{N^2 D^2 + \sum N_h S_h^2} = \frac{e^2}{t^2} \]

Where:
- \( n \) = sample size.
- \( N \) = total hazelnut farmers in main layer.
- \( N_h \) = number of hazelnut farmers in each layer.
- \( S_h \) = standard deviation in each layer.
- \( D^2 \) = anticipated variance.
- \( e \) = accepted error from mean (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, hazelnut farmers in the study area of both provinces were divided into three strata according to their land size. The first

Table 1 Hazelnut area, yield, and production

| Provinces | Yield (kg/ha) | Area (ha) | % | Production (tons) | % |
|-----------|--------------|-----------|---|------------------|---|
| Ordu      | 867.9        | 227,225.8 | 30.9 | 197,230.0       | 29.7 |
| Giresun   | 715.5        | 117,639.0 | 11.6 | 84,167.0        | 12.7 |
| Turkey    | 905.3        | 734,538.0 | -   | 665,000.0       | 62.0 |
| World     | 1056.2       | 1,015,216.0 | - | 1,072,308.0   | - |

Table 2 Climate indicators of the study area

| Month    | Mean of maximum temperature (°C) | Mean of minimum temperature (°C) | Mean temperature (°C) | Mean precipitation (mm) |
|----------|----------------------------------|----------------------------------|-----------------------|-------------------------|
| January  | 10.8                             | 4.5                              | 7.2                   | 104.5                   |
| February | 10.4                             | 3.9                              | 6.8                   | 85.0                    |
| March    | 11.9                             | 5.2                              | 8.1                   | 79.0                    |
| April    | 15.1                             | 8.5                              | 11.4                  | 71.5                    |
| May      | 18.9                             | 12.6                             | 15.5                  | 58.0                    |
| June     | 23.8                             | 16.9                             | 20.3                  | 72.0                    |
| July     | 26.7                             | 20.0                             | 23.2                  | 63.0                    |
| August   | 27.5                             | 20.6                             | 23.6                  | 68.0                    |
| September| 24.2                             | 17.3                             | 20.3                  | 82.0                    |
| October  | 20.1                             | 13.6                             | 16.4                  | 129.0                   |
| November | 15.9                             | 9.1                              | 12.0                  | 122.0                   |
| December | 12.7                             | 6.4                              | 9.1                   | 121.0                   |

Turkish state metrological department (1981–2010)
stratum contained hazelnut farmers having a land less than 1 hectare. The second stratum consisted of hazelnut farmers having land between 1 and 1.99 hectares, and the rest of the hazelnut farmers were in the third stratum. Samples were made separately for each province. In this way, 152 (Ordu 75 and Giresun 77) hazelnut farmers were selected as the total size of this study (Table 3).

**Methodology**

**Identification and classification of sample farms**

In previous studies, classifications were made by income, farm size, labor force, farmers’ residence status, farming income, and capital elements (Greeley 1942; Lien et al. 2010; Mittenzwei and Mann 2017; Pfeiffer et al. 2009; Schmitt 1989). However, considering the socio-economic characteristics in the study area, we preferred to use the site-specific classification method. Due to the unique structure of agriculture, it would be more accurate to evaluate the working hours during a production period instead of weekly or monthly working periods such as the service and industry sectors. In addition, the need for labor in fruit production made from perennial plants such as hazelnuts is in certain periods. For these reasons, in this study, the phrase “working less than 2/3 of the normal working time” indicated in the Labor Law of the Republic of Turkey and the relevant Cabinet Decision has been taken into account. 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 and harvesting. 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.

**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, and (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 indicator-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 (Dillon et al. 2009; Gafsi and Favreau 2010; Rigby et al. 2001; Sajjad and Nasreen 2016; ul Haq and Boz 2018). 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 and age of the farm manager 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 viabilities, 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).

| Table 3 Accessible population and sample size in each stratum |
|---------------------------------------------------------------|
| Strata | Criteria (hectare) | Population (number) | Sample size (number) |
|--------|--------------------|---------------------|---------------------|
| Ordu   |                    |                     |                     |
| Stratum 1 | <1.00             | 15,675              | 30                  |
| Stratum 2 | 1.00 ≥ and ≤1.99     | 12,578              | 24                  |
| Stratum 3 | >1.99             | 10,702              | 21                  |
| Giresun |                    |                     |                     |
| Stratum 1 | <1.00             | 13,984              | 37                  |
| Stratum 2 | 1.00 ≥ and ≤1.99     | 8699               | 23                  |
| Stratum 3 | >1.99             | 6395               | 17                  |
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 (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. The research team included 1 professor and 1 research assistant who are experts in the field of agricultural policy, and 1 research assistant who is an expert in the field of agricultural management. In addition, opinions were taken from experts working in the region. 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 is 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 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.

![Table 4](#)

| 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 |
| 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 | 0 no, 1 yes |
|                             | Farmer wants to buy a 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 | Division of land among heirs                        | 0 no, 1 yes |
|                             | Farming continuity from generation to generation    |                                                      | 0 no, 1 yes |
|                             | The goal of selling hazelnut or farmland for the building is to gain profit |                                                      | 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    | Chemical fertilizer use has become a health problem | Ever farmer faced the health-related problem during the application of fertilizer                          | 1 no, 0 yes        |
| effects                                        | Land management practices that contribute to soil    | Erosion risk of soil                                                                                       | 0 no, 1 yes        |
| Good management                                |                                                    | Stable terracing                                                                                            | 0 no, 1 yes        |
|                                                 |                                                    | Tree planting at landside and erosion-prone land                                                           | 0 no, 1 yes        |

© Springer
due to their adaptability being confirmed after passing the indicators from the validation process.

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 and farmers’ responses were recorded in yes/no form or on a Likert scale (5-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 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 usable 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 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 data gathered from questionnaires 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 abovementioned 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.

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:

\[
\left( \frac{X - \text{minimum Value}}{\text{Maximum Value} - \text{Minimum Value}} \right) \quad \text{Here: } X = \text{Actual Value of indicator}
\]

Similarly, the following equation was used for that indicator, whose minimum value was cataloged as being more sustainable:
Step 2 The previous step resulted in the normalized value of each indicator between 0 and 1. As a result, the weights for each indicator 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.

\[
\omega_{Lj} = \frac{(\text{factor loading}_{Lj})^2}{\text{eigenvalue}_j}
\]

where \(\omega_{Lj}\) 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 factors consisting of many indicators. The intermediate composite indicators corresponding to each component \((I_{ik})\) were generated using the formula below for each dimension with multiple indicators.

\[
I_{ijk} = \sum_{L=1}^{L=n} \omega_{Lj} I_{Lk}
\]

Where \(I_{ijk}\) is the intermediate indicator for each dimension of sustainability; \(I\) is the economic, social, and environmental sustainability dimension for component \(j\) and farm \(k\); and \(\omega_{Lj}\) 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.

\[
CII_{ik} = \sum_{j=1}^{n} \alpha_j I_{ijk}
\]

The intermediate composite indicators were aggregated to calculate the composite index \((CII_k)\) of farm \(K\). The weight \(\alpha\) used in this equation was estimated by using the following equation.

\[
\alpha_j = \frac{\text{eigenvalue}_j}{\sum_{j=1}^{n} \text{eigenvalue}_j}
\]

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.

\[
CHFSI_k = \frac{1}{3} \sum_{j=1}^{n} CII_{ijk}
\]

CHFSI is the composite hazelnut farm sustainability index for \(K^{th}\) farm, and \(CII_{ik}\) is the intermediate composite index value for each sustainability dimension at farm \(k\).

Results and discussion

In the research area, full-time and part-time farmers’ ages were 54 years and 56 years; agricultural experience of full-time and part-time farmers was 30 years and 32 years, respectively. While schooling of part-time farmers was higher than that of full-time farmers \((p < 0.10)\), full-time farmers participated in more agricultural training than part-time farmers \((p < 0.01)\). Part-time farmers worked much more off-farm work \((p < 0.10)\) and earned much more non-agricultural income \((p < 0.05)\) than full-time farmers. Full-time farmers’ net income was mainly based on agriculture \((p < 0.10)\). Farmland size of part-time farmers was larger than that of full-time farmers \((p < 0.05)\). Regarding hazelnut production, full-time farmers produced more hazelnuts per hectare compared to part-time farmers \((p < 0.10)\).

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; Bollman 1982; Galiev and Ahrens 2018; Gasson 1988; Latruffe and Mann 2015; Canan and Ceyhan 2021) (Table 8).

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
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) ***                       | 224.6 ± 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 rentability *                        | 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 |
| 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 reflect that the difference between full-time and part-time farms is statistically significant

Table 8  Farms' group distribution of sustainability index by sustainability level

| Sustainability index | Full-time | Part-time | Full-time | Part-time |
|----------------------|-----------|-----------|-----------|-----------|
| Economic             |            |           |           |           |
| Low-sustainability farms | 39        | 38        | 41        | 34        |
| High-sustainability farms | 77        | 75        |           |           |
| %                    | 51%        | 49%        | 55%        | 45%        |
| Social               |            |           |           |           |
| Low-sustainability farms | 0.54 ± 0.01*** | 0.38 ± 0.01*** | 0.62 ± 0.01** | 0.42 ± 0.01** |
| High-sustainability farms | 0.46 ± 0.02 | 0.46 ± 0.02 | 0.56 ± 0.01 | 0.52 ± 0.02 |
| %                    | 51%        | 49%        | 55%        | 45%        |
| Environmental        |            |           |           |           |
| Low-sustainability farms | 0.10 ± 0.01*** | 0.20 ± 0.02*** | 0.40 ± 0.02*** | 0.54 ± 0.03*** |
| High-sustainability farms | 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
economically harmful (Barlett 1986; Haiguang et al. 2013; Jokisch 2002; McCarthy et al. 2009; 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; Massey et al. 1993). 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), and to increase production by making more investment in agriculture (Li and Tonts 2014), the negative approach’s 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).

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 farmer 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; 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); and to reduce adverse migration effects such as abandonment of land (Upton et al. 1982; Xu et al. 2019a 2019b). Barlett (1986) and 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.

One part of social sustainability indicators, 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). Most of the previous studies conducted by Barbier (2000), Caraveli (2000), Ceddia et al. (2009), Lorent et al. (2008), Swanson and Busch (1985), and 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).

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. 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 types (Fuller 1990; Paudel and Wang 2002) are generally more advantageous.

Table 8 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.

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 are presented in Table 9.

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 9).

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

| Farmers’ characteristics | Low-sustainability farms | High-sustainability farms |
|--------------------------|--------------------------|---------------------------|
|                          | 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 (%) | 1090.6 ± 149.6* | 853.3 ± 130.1* | 1177.4 ± 147.0* | 880.6 ± 131.2* |
| The yield of hazelnut (kg/ha) | 855.0 ± 95.3** | 686.0 ± 57.3** | 704.5 ± 64.1** | 593.3 ± 53.2** |
| Working time at farm (hour/ha) | 1089.8 ± 261.8 | 1113.4 ± 231.3 | 569.5 ± 156.5** | 1560.8 ± 465.3** |
| Chemical (/ha)            | 97.4 | 92.1 | 34.1* | 17.6* |
| Barnyard manure (yes) %  | - | 2.6 | 9.8 | 11.8 |
| Organic manure (yes) %   | 20.5 | 28.9 | 46.3 | 44.1 |
| Testing soil (yes) %     | 2.6 | - | 17.1** | 2.9** |
| Stable terracing (yes) % | 2.6 | 5.3 | 2.4 | 2.9 |
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 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). The effect of production efficiency of farms is identified in the study on sustainability of Ul Haq and Boz (2020); Ul Haq et al. (2021), Nielsen and Kristensen 2005; It is similar to the study of Van Passel et al. (2009) and differs from the study of Ul haq et al. (2017). Ul laq et al. found in their 2017 study that the economic efficiency of farms has no effect on sustainability. Gómez-Limón and Sanchez-Fernandez (2010) associated sustainability with technology and climate change.

Similarly, full-time farmers worked more time than part-time farmers (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 9). Using organic manure, testing soil, and stable terracing rate of farms with high sustainability levels is similar to many studies (Kleinhanß et al. 2007; Barnes and Thomson 2014). On the other hand, some studies show differences (Buckley et al. 2015; Westbury et al. 2011).

**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, and 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 an 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. These are the critical 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 such cases, agricultural policy tools can help to overcome trade-offs and appropriate incentives must be identified that allow for simultaneous improvement of welfare and sustainability.

In future work, improved practices should be developed to help farmers find win–win solutions to reduce sustainability opposition. In such cases, agricultural policy tools can help to overcome trade-offs and appropriate incentives must be identified that allow for simultaneous improvement of welfare and sustainability.

Acknowledgements We thank the Scientific and Technological Research Council of Turkey (TÜBİTAK) for supporting this study.

Author contribution CY and HT bulked and entered data. ÇY, HT, and IB analyzed and interpreted the sustainability indicator. HT and ÇY performed descriptive statistical analysis. All authors read and approved the final manuscript.

Funding This research was funded by TÜBİTAK, grant number 116K758.

Data availability Not applicable.

Declarations

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

Consent to participate Not applicable.

Consent to publish Not applicable.

Competing interests The authors declare no competing interests.

References

Alwang J, Siegel PB (1999) Labor shortages on small landholdings in Malawi: implications for policy reforms. World Development https://doi.org/10.1016/S0305-750X(99)00065-0

Amoud M, Owobabi J, Adeola S (2011) Resource use efficiency in part-time food crop production: the stochastic frontier approach. Niger J Basic Appl Sci 19:102–110. https://doi.org/10.4314/njbas.v19i1.69353

Andreoli M, Tellarini V (2000) Farm sustainability evaluation: methodology and practice, in: Agric Ecosyst Environ https://doi.org/10.1016/S0167-8809(99)00091-2

Barbier EB (2000) Links between economic liberalization and rural resource degradation in the developing regions. Agric Econ https://doi.org/10.1016/S0169-5150(00)00091-8

Barlett PF (1986) Part-time farming: saving the farm or saving the life-style? Rural Sociology.

Barnes AP, Thomson SG (2014) Measuring progress towards sustainable intensification: how far can secondary data go? Ecol Indic 36:213–220. https://doi.org/10.1016/j.ecolind.2013.07.001

Bell S, Morse S (2012) Sustainability indicators: measuring the immeasurable? Second edition, Sustainability Indicators: Measuring the Immeasurable? Second Edition https://doi.org/10.4324/9781849772723

Beyene AD (2008) Determinants of off-farm participation decision of farm households in Ethiopia. Agrekon https://doi.org/10.1080/03031853.2008.9523794

Bishop CE (1955) Part-time farming and the low-income farm problem. J Farm Econ https://doi.org/10.2307/1234052

Bockstaller C, Girardin P (2003) How to validate environmental indicators. Agricultural Systems 76 https://doi.org/10.1016/S0308-5121(02)00053-7

Bockstaller C, Girardin P, van der Werf HMG (1997) Use of ecological indicators for the evaluation of farming systems, in: developments in crop science. https://doi.org/10.1016/S0378-519X(97)80032-3

Bollman RD (1982) Part-time farming in Canada: Issues and non-issues. Geo J https://doi.org/10.1007/BF00240532

Bossel H (1999) Indicators for sustainable development: theory, method, applications. International Institute for Sustainable Development, Winnipeg.

Buckley C, Wall DP, Moran B, Murphy PNC (2015) Developing the EU farm accountancy data network to derive indicators around the sustainable use of nitrogen and phosphorus at farm level. Nutr Cycl Agroecosyst 102(3):319–333. https://doi.org/10.1007/s10705-015-9702-9

Brosig S, Glauben T, Herzfeld T, Wang X (2009) Persistence of full- and part-time farming in Southern China. China Econ Rev 20:360–371. https://doi.org/10.1016/j.chieco.2008.10.005

Caraveli H (2000) A comparative analysis on intensification and extensification in Mediterranean agriculture: Dilemmas for LFAs policy. J Rural Stud https://doi.org/10.1016/S0743-0167(99)00050-9

Cavazzani A (1977) Part-time farming and the common agricultural policy. The Place of Part-time Farming in Rural and Regional Development. 73–81.

Ceddia MG, Heikkilä J, Petrola J (2009) Managing invasive alien species with professional and hobby farmers: insights from ecological-economic modelling. Ecol Econ 68:1366–1374

Celio E., Flint CG, Schoch P, Grêt-Regamey A (2014) Farmers’ perception of their decision-making in relation to policy schemes: a comparison of case studies from Switzerland and the United States. Land Use Policy https://doi.org/10.1016/j.landusepol.2014.04.005

Canan S, Ceyhan V (2021) Exploring the farm level opportunity cost for protecting environment: evidence from Turkey. J Agric Sci Technol 23(2):253–263

Ceyhan V (2010) Assessing the agricultural sustainability of conventional farming systems in Samsun province of Turkey. Afr J Agric Res 5 https://doi.org/10.5897/AJAR09.434

Cloquell-Ballester, Vicente Agustín, Cloquell-Ballester, Víctor Andrés, Monterde-Díaz, R., Santamarina-Siurana, MC (2006) Indicators validation for the improvement of environmental and social impact quantitative assessment. Environ Impact Assess Rev 26 https://doi.org/10.1016/j.eiar.2005.06.002

Coutu AJ 1957. Planning of total resource use on low-income and part-time farms. J Farm Econ https://doi.org/10.2307/1234699

Demiryürek K, Abacía NL, Ceyhan V (2018) Sustainability of organic versus conventional hazelnut production in Turkey, in: Acta Horticult https://doi.org/10.17660/ActaHortic.2018.1226.66
Dillon EJ, Hennessy TC, Hynes S (2009) Towards measurement of farm sustainability-an Irish case study.

Eckert H, Breitschuh G, Sauerbeck DR (2000) Criteria and standards for sustainable agriculture. J Plant Nutr Soil Sci 163. https://doi.org/10.1002/jpln.19990163346-9

Edwards CA, Lal R, Madden P, Miller RH, House G (1990) Sustainable agricultural systems. Sustainable agricultural systems https://doi.org/10.2134/jeq1991.00472425002000030035x

Ellis NE, Heal OW, Dent JB, Firbank LG (1999) Pluriosity, farm household socio-economics and the botanical characteristics of grass fields in the Graanman region of Scotland. Agr Ecosyst Environ 76:121–134

FAO (2018) Hazelnut Statistics [WWW Document]. http://www.fao.org/faostat/en/#data (accessed 7.2.18).

Freudenberg M (2003) Composite indicators of country performance: a critical assessment.

Fuller AM (1990) From part-time farming to pluriactivity: a decade of change in Rural Europe. J Rural Stud https://doi.org/10.1016/0743-010X(90)90049-E

Fuller MA (1975) The problems of part-time farming conceptualised. Guelph Report II, in: Part-time farming: problem or resource in agricultural systems. Sustainable agricultural systems https://doi.org/10.1002/s00011-S

Gangelin W, Murillo C, Juan C, Sperlich S (2007) Efficiency subsidies and environmental adaptation of animal farming under CAP. Agric Econ 36(1):49–65. https://doi.org/10.1111/j.1574-0862.2007.00176.x

Kristensen SP (1999) Agricultural land use and landscape changes in Rostrup, Denmark: processes of intensification and extensification. Landsc Urban Plan 46:117–123

Lafatte L, Mann S (2015) Is part-time farming less subsidised? The example of direct payments in France and Switzerland. Cahiers Agricultures 24:20–27. https://doi.org/10.1684/agr.2015.0732

Li L., Tonts M (2014) The impacts of temporary labour migration on farming systems of the loess plateau, Gansu province, China. Population, Space and Place. https://doi.org/10.1002/pasp.1832

Lien G, Kumbhakar SC, Hardaker JB (2010) Determinants of off-farm work and its effects on farm performance: the case of Norwegian grain farmers. Agric Econ 41:577–586. https://doi.org/10.1111/j.1547-0862.2010.00473.x

López-Ridaura S, Masera O, Astier M (2002) Evaluating the sustainability of complex socio-environmental systems. The MESMIS framework, in: Ecol Indic https://doi.org/10.1016/S1470-160X(02)00043-2

Lorent H, Evangelou C, Stellmes M, Hill J, Papanastasis V, Tsiorulis G, Roeder A, Lambin EF (2008) Land degradation and economic conditions of agricultural households in a marginal region of northern Greece. Global and Planetary Change https://doi.org/10.1016/j.gloplacha.2008.05.005

Loyns RMA, Kraut M (1992) The family farm in the next decade: The positive role of part-time farming. Canadian Journal of Agricultural Economics/revue Canadienne D’agroeconomie 40:591–604

Lundell M, Lampiotti J, Fertev P, Pohlmeier L, Akder H, Ocek E, Jha S (2004) Turkey: a review of the impact of the reform of agricultural sector subsidization.

Massey DS, Arango J, Hugo G, Kouaouci A, Pellegrino A, Taylor JE (1993) Theories of international migration: a review and appraisal. Population & Development Review https://doi.org/10.2307/2938462

McCarthy N, Carletto C, Kilic T, Davis B (2009) Assessing the impact of massive out-migration on Albanian agriculture. Eur J Dev Res https://doi.org/10.1057/ejdr.2009.12

Meul M, Passel S van, Nevens F, Dessein J, Rogge E, Mulier A, Hauwemeren A, van (2008) MOTIFS: A monitoring tool for integrated farm sustainability. Agron Sustain Dev 28 https://doi.org/10.1051/agro:2008001

Meyers-Aurich A (2005). Economic and environmental analysis of sustainable farming practices - a Bavarian case study. Agric Syst 86 https://doi.org/10.1016/j.agsy.2004.09.007

Mitei Z (2011). Growing sustainable tea on Kenyan smallholder farms. Int J Agric Sustain 9 https://doi.org/10.3763/ijas.2010.0550

Mittenzwei K, Mann S (2017). The rationale of part-time farming: empirical evidence from Norway. International Journal of Social Economics.

Nambiar KKM, Gupta AP, Fu Q, Li S, (2001). Biophysical, chemical and socio-economic indicators for assessing agricultural sustainability in the Chinese coastal zone. Agriculture, Ecosystems and Environment 87 https://doi.org/10.1016/S0167-8809(01)00279-1

Nielsen AH, Kristensen IS (2005) Nitrogen and phosphorus surpluses on Danish dairy and pig farms in relation to farm characteristics. Livest Prod Sci 96(1):97–107. https://doi.org/10.1016/j.livprodsci.2005.05.012
Pannell DJ, Glenn NA (2000). A framework for the economic evaluation and selection of sustainability indicators in agriculture. Ecol Econ 33 https://doi.org/10.1016/S0921-8009(99)00134-2

Paudel K, Wang Y (2002). Part time farming, farm productivity, and farm income: evidence from the Southeast US. American Agricultural Economics Association annual meeting, Long Beach, California.

Payraudeau S, van der Werf HMG (2005). Environmental impact assessment for a farming region: a review of methods. Agriculture, Ecosystems and Environment 105 https://doi.org/10.1016/j.agee.2004.12.012

Pfeiffer L, López-Feldman A, Taylor JE (2009) Is off-farm income reforming the farm? Evidence from Mexico. Agric Econ 40:125–138

Phimister, Roberts D (2006) The effect of off-farm work on the intensity of agricultural production. Environ Resource Econ 34:493–515

Pirazzoli C, Castellini A (2000). Application of a model for evaluating the environmental sustainability of cultures in hill and mountain areas: the case of berries and fruit chestnuts in Northern Italy. Agricultural Economics Review 1.

QU H jiao, ZHU W bin, WANG H bin, CHENG X (2007). Analysis and Design of Agricultural Sustainability Indicators System. Agric Sci China 6 https://doi.org/10.1016/S1671-2927(07)60072-8

Reed MS, Fraser EDG, Dougill AJ (2006). An adaptive learning process for developing and applying sustainability indicators with local communities. Ecol Econ 59 https://doi.org/10.1016/j.ecolecon.2005.11.008

Rigby D, Woodhouse P, Young T, Burton M (2001). Constructing a farm level indicator of sustainable agricultural practice. Ecol Econ 39 https://doi.org/10.1016/S0921-8009(01)00245-2

Roy R, Chan NW (2012). An assessment of agricultural sustainability indicators in Bangladesh: review and synthesis. Environmentalist https://doi.org/10.1007/s10669-011-9364-3

Rudel TK (2006). After the labor migrants leave: The search for sustainable development in a sending region of the Ecuadorian Amazon. World Development https://doi.org/10.1016/j.worlddev.2005.11.001

Sajjad H, Nasreen I (2016). Assessing farm-level agricultural sustainability using site-specific indicators and sustainable livelihood security index: Evidence from Vaishali district, India. Community Development 47 https://doi.org/10.1080/15575330.2016.1221437

Salvati L, Zitti M (2009). The environmental “risky” region: identifying land degradation processes through integration of socio-economic and ecological indicators in a multivariate regionalization model. Environ Manag https://doi.org/10.1007/s00267-009-9378-5

Sands GR, Podmore TH (2000). A generalized environmental sustainability index for agricultural systems. Agric Ecosyst Environ 79 https://doi.org/10.1016/S0167-8809(99)00147-4

Sayssel AK, Barlas Y, Yenigün O (2002). Environmental sustainability in an agricultural development project: a system dynamics approach. J Environ Manag 64 https://doi.org/10.1006/jema.2001.0488

Schmitt G (1989) Farms, farm households, and productivity of resource use in agriculture. Eur Rev Agric Econ 16:257–284

Sharma D, Sharendu S (2011). Assessing farm-level agricultural sustainability over a 60-year period in rural eastern India. Environmentalist 31 https://doi.org/10.1007/s10669-011-9341-x

Singh BP (2013). Biofuel Crop Sustainability. Biofuel Crop Sustainability https://doi.org/10.9781118635797

Swanson LE, Busch L (1985) A part-time farming model reconsidered: a comment on a POET Model. Rural Sociol 50:427–436

Tellarini V, Caporali F (2000). An input/output methodology to evaluate farms as sustainable agroecosystems: An application of indicators to farms in central Italy, in: Agriculture, Ecosystems and Environment. https://doi.org/10.1016/S0167-8809(99)00097-3

Tereso R, Mohamed Z, Shamsudin MN, Latif IA (2015). Farmers sustainability index: the case of paddy farmers in state of Kelantan, Malaysia. Journal of the International Society for Southeast Asian Agricultural Sciences 21.

TURKSTAT (2018). Hazelnut Statistics.

ul Haq S, Boz I (2020). Measuring environmental, economic, and social sustainability index of tea farms in Rize Province, Turkey. Environ Develop Sustain. https://doi.org/10.1007/s10668-019-03310-x

ul Haq, S., Boz, I (2018) Developing a set of indicators to measure sustainability of tea cultivating farms in Rize Province, Turkey. Ecol Ind 95:219–232. https://doi.org/10.1016/j.ecolind.2018.07.041

ul Haq S, Boz I, Shahbaz P (2021) Sustainability assessment of different land tenure farming systems in tea farming: the effect of decisional and structural variables. Integr Environ Assess Manag 17(4):814–834. https://doi.org/10.1002/ieam.4379

Ul haq S, Shahbaz, P, Boz I, Yildirim C, Murtaza MR (2017) Exploring the determinants of technical inefficiency in mango enterprise: a case of Muzaffargarh, Pakistan. Custos e@ gronegócio online, 13, 2018–236

UN (2002). Report of the World Summit on Sustainable Development. Johannesburg, South Africa, 26 August–4 September 2002 (A/CONF.199/20), Rio +10.

Upton M, Bishop C, Pearce R (1982) Part-time farming: The Cyprus case. Geo Journal 6:343–350. https://doi.org/10.1007/BF00240537

van Calker KJ, Berentse PB, Romero C, Giesen GWJ, Huirne RMB (2006). Development and application of a multi-attribute sustainability function for Dutch dairy farming systems. Ecol Econ 57 https://doi.org/10.1016/j.ecolecon.2005.05.016

van Cauwenbergh N, Biala K, Bielders C, Brouckaert V, Franscois L, Garcia Cidad V, Hermy M, Mathijs E, Muys B, Reijnders J, Sauvenier X, Valckx J, Vancoooster M, van der Veken B, Wauters E, Peeters A (2007). SAFE-A hierarchical framework for assessing the sustainability of agricultural systems. Agriculture, Ecosystems and Environment 120 https://doi.org/10.1016/j.agee.2006.09.006

van der Werf HMG, Petit J (2002). Evaluation of the environmental impact of agriculture at the farm level: a comparison and analysis of 12 indicator-based methods. Agric Ecosyst Environ 93 https://doi.org/10.1016/S0167-8809(01)00354-1

van Passel, S, van Huyslenbroeck G, Lauwers L, Mathijs E (2009). Sustainable value assessment of farms using frontier efficiency benchmarks. J Environ Manag 90 https://doi.org/10.1016/j.jenvman.2009.04.009

Westbury JB, Park JR, Mauchline AL, Crane RT, Mortimer SR (2011) Assessing the environmental performance of English arable and livestock holdings using data from the Farm Accountancy Data Network (FADN). J Environ Manag 92(3):902–909. https://doi.org/10.1016/j.jenvman.2010.10.051

Xu D, Deng X, Guo S, Liu S (2019) Labor migration and farmland abandonment in rural China: empirical results and policy implications. J Environ Manag 232:738–750. https://doi.org/10.1016/j.jenvman.2018.11.136

Xu D, Deng X, Huang K, Liu Y, Yong Z, Liu S (2019b) Relationships between labor migration and cropland abandonment in rural China from the perspective of village types. Land Use Policy 88:104164. https://doi.org/10.1016/j.landusepol.2019.104164

Yamane T (2001). Temel Örneklemeler Yöntemleri, (1. Baskı). Cev. A. Esin, MA Bakır, C. Aydın ve E. Gürbüzsel, Literatür Yayınçuluk, Gıstanbul.
Yrjola T, Kola J, Yrjölä T (2002). Social benefits of multifunctional agriculture in Finland. Paper prepared for presentation at the Xth EAAE Congress 'Exploring Diversity in the European Agri-Food System Social benefits of multifunctional agriculture in Finland. Zaragoza (Spain) 28–31.

Zhang L, Zhang Y, Yan J, Wu Y (2008). Livelihood diversification and cropland use pattern in agro-pastoral mountainous region of eastern Tibetan Plateau. J Geograph Sci https://doi.org/10.1007/s11442-008-0499-1

Zhen L, Routray JK, Zoebisch MA, Chen G, Xie G, Cheng S (2005). Three dimensions of sustainability of farming practices in the North China Plain: a case study from Ningjin County of Shandong Province, PR China. Agric Eco Environ 105 https://doi.org/10.1016/j.agee.2004.07.012

Publisher’s note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.