

## Article

# Perspectives of Farmers on the Decline in *Pinus pinea* Nut Yield and the Sustainability of the Production: A Case Study in Kozak Basin in Western Turkey

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**Abstract:** In the Kozak Basin, which is the most important pine nut production and trade center in Turkey, there has been a significant decrease in production recently. In this study, the perspectives of the farmers in this area were investigated, specifically about reasons for the decrease in yields. For this purpose, a face-to-face survey was conducted with 378 pine nut farmers from the Kozak Basin. It was determined that the average age of the farmers is high, their educational achievement level is low, they generally also work in alternative sectors and almost all of them grow pine nuts in their own pine groves. The farmers' perception of cooperatives was found to be negative. In general, the local people continue to produce pine nuts in their own pine groves, but nearly half of the participants also worked in other sectors to maintain their standard of living. Farmers attribute the low yield in the Kozak Basin to both abiotic and biotic factors. Mining activities, which are increasing, are seen as a threat to the future of production in the area. Also, there is a growing perception of biotic harm, especially from Western Conifer Seed Bug, *Leptoglossus occidentalis*. Climate change and air pollution are other prominent factors.

**Keywords:** stone pine; cone yield; mining activities; environmental threats; *Leptoglossus occidentalis*



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## 1. Introduction

Several of the Sustainable Development Goals (SDGs) defined in the 2030 Agenda for Sustainable Development of the United Nations are relevant for Mediterranean pine and mixed forests. Because Mediterranean forests are an important source of natural capital, they can significantly contribute to the achievement of forest-related global goals, provided that their specific features are considered. One such specificity is due to the value of Mediterranean forests in non-timber forest products (NTFPs) and services rather than wood products. [1]. Mediterranean forests supply a diversity of NTFPs. The potential of NTFPs in the Mediterranean region as a source of livelihood and sustainable development has been widely recognized [2].

The stone pine (*Pinus pinea* L.) is one of the most characteristic tree species in the Mediterranean Basin due to its high economic value and the consumption of its seeds, a NTFP, by humans since the Paleolithic era. It covers more than 700,000 hectares in the Mediterranean Basin due to the restoration of forests and reforestation in agricultural areas [3–6]. The second most important product of pine forests after seeds is wood [7–9]. Besides the use of wood in industry and as fuel, another use is resin production [10]. The stone pine's heavy and resinous wood has been used in shipbuilding and construction

since the Roman period [11]. In addition, pinecones can be used to make medium-density fiberboard [12].

It is a characteristic species in the landscape of Mediterranean countries due to its widespread use in parks, streets and gardens, its ecological, aesthetic and economic value and its importance in reforestation programs [13,14]. Due to its generally well-developed root system and high tolerance to poor sandy soils, the species is widely cultivated and used for environmental protection functions such as consolidation of coastal dunes in the Mediterranean Basin, soil protection and erosion control in mountainous areas, and protection of coastal crops [15–17]. Stone pine forests are also used for animal grazing, animal shading, hunting, honey production, etc. and provide many products and services [18].

On the other hand, Mediterranean pine nuts have been accepted as a valuable food since ancient times. Stone pine cones and kernels have moved along the trade routes of ancient Mediterranean cultures since the Neolithic times. They have cultural, symbolic and spiritual attributes. Cultural history of Mediterranean stone pine continues to draw attention [3]. Therefore, stone pine forests contribute to sustainable development by providing economic, social, environmental and cultural benefits for present and future generations.

Stone pine fields, which are important for the production of both wood and NTFPs, have suffered from low cone-seed yield in recent years. There has been a decrease in productivity in the entire Mediterranean Basin, especially in Portugal, Spain, Turkey, Lebanon and Italy [19,20]. It is predicted that there may be a further decrease in cone-seed yield in Mediterranean Basin stone pines due to climate change [21,22]. In addition, it has been reported that Western Conifer Seed Bug, *Leptoglossus occidentalis* (Heidemann, 1910) (Heteroptera: Coreidae) causes low yield in stone pine pinecones and seeds [23–25]. Moreover, pollination of stone pine trees, which is important for fertilization rate, have been adversely affected by high precipitation and high relative humidity as well as extreme temperatures during the pollination period [26]. Although there are not yet enough data on the effects of poor air quality on cone and seed productivity, traffic-induced pollution causes narrow annual ring formation in stone pines [27].

In Turkey, the most widely distributed pine nut production areas are the Bergama District in the Kozak Basin and the Koçarlı Region of Aydın Province. The Kozak Basin has the largest stone pine fields in Turkey and it is known to be the most important pine nut production and trade center [28–31]. The farmers in the basin differ from the other local farmers in Turkey due to the large number of privately owned pine groves. The ecosystem created by stone pines in the Kozak Basin has its own unique features. Thus “Kozak type” pine nuts are described as being full-bodied, large, light cream-colored, soft-structured, and blunt. Because of these characteristics, Bergama Kozak pine nuts received Geographical Indication Protection (GIP) in 2011 [32]. In the Kozak Basin, the income from pine nuts is a significant share of the total household revenue [33,34].

Dramatic decreases in cone-seed yield, which have been experienced in the Mediterranean basin in recent years, are also occurred in the Kozak Basin [35,36]. Invasive species, increasingly violent mining activities, and global problems such as climate change are seen as ecological threats [37]. In the Kozak Basin, stone pine communities develop on granite bedrock [38], and the natural environment is damaged during granite stone and marble production, both of which are heavily quarried in the basin [39,40]. With the discovery of new gold reserves in the Kozak Basin there is an increase in cyanide gold mining, and this threatens the natural environment [41].

A critical first step towards sustainable management of natural resources is to ensure that resource managers have accurate and effective information about the status, availability, quality and change in the natural resources to be managed [42]. In many communities, this information is obtained by constantly monitoring the status of local resources [43]. At this stage, it is necessary for the societies living in rural areas to change from traditional production styles and start using scientific methods. However, for sustainable management of natural resources to work, it is important to include the views of local communities in the management process [44]. In particular, the COVID-19 pandemic has triggered concerns

about food availability throughout the food supply chain, highlighting the important role of farmers in society, and the need for them to keep both rural and urban environments alive [45]. Farmers' perception of the rural environment in which they produce can influence their interaction with the environment, their decision-making processes when choosing a particular type of production and adopting more (or less) sustainable practices on their land [46]. For this reason, it is important to understand the reality of production in rural areas, to discover the farmers' practices, and the differences and similarities between farmers regarding these practices.

The Kozak Basin farmers reported the difficulties they experienced with low stone pine cone yields to the local government and requested research to be conducted. An agreement was signed between the Foresters' Association of Turkey (FAT) and Izmir Metropolitan Municipality (IMM) to identify the cause of the reduction in pine nut production in the Izmir Bergama-Kozak Region and search for solutions to increase the yield, and research is ongoing [47,48]. In addition, the General Directorate of Forestry (GDF) has started a project to study only *L. occidentalis* damage in the decrease in cone yield, and to find a solution to this problem [49]. It is thought that *L. occidentalis* is the root cause of the yield problem. The incidences of this pest have increased recently in the basin, causing increased demand for spraying, and trials have been carried out [50].

The uncertainty regarding the role of *L. occidentalis*, an invasive North American seed beetle, in the observed decline in seed production of stone pine, is a limiting factor for resource management and emphasizes that this species has caused increasing alarm in Mediterranean Basin countries since it was first observed in Europe in 1999 [51]. The emergence of damage caused by invasive forest insects is known to have detrimental effects on various ecosystem functions and services, including wood feedstock from forest, NTFP, recreation, and aesthetic value [52]. The putative effect of *L. occidentalis* on the commercially valuable seed of stone pine, whose current retail prices may exceed 100 euro/kg, is increasing research interest in this invasive species [19,53].

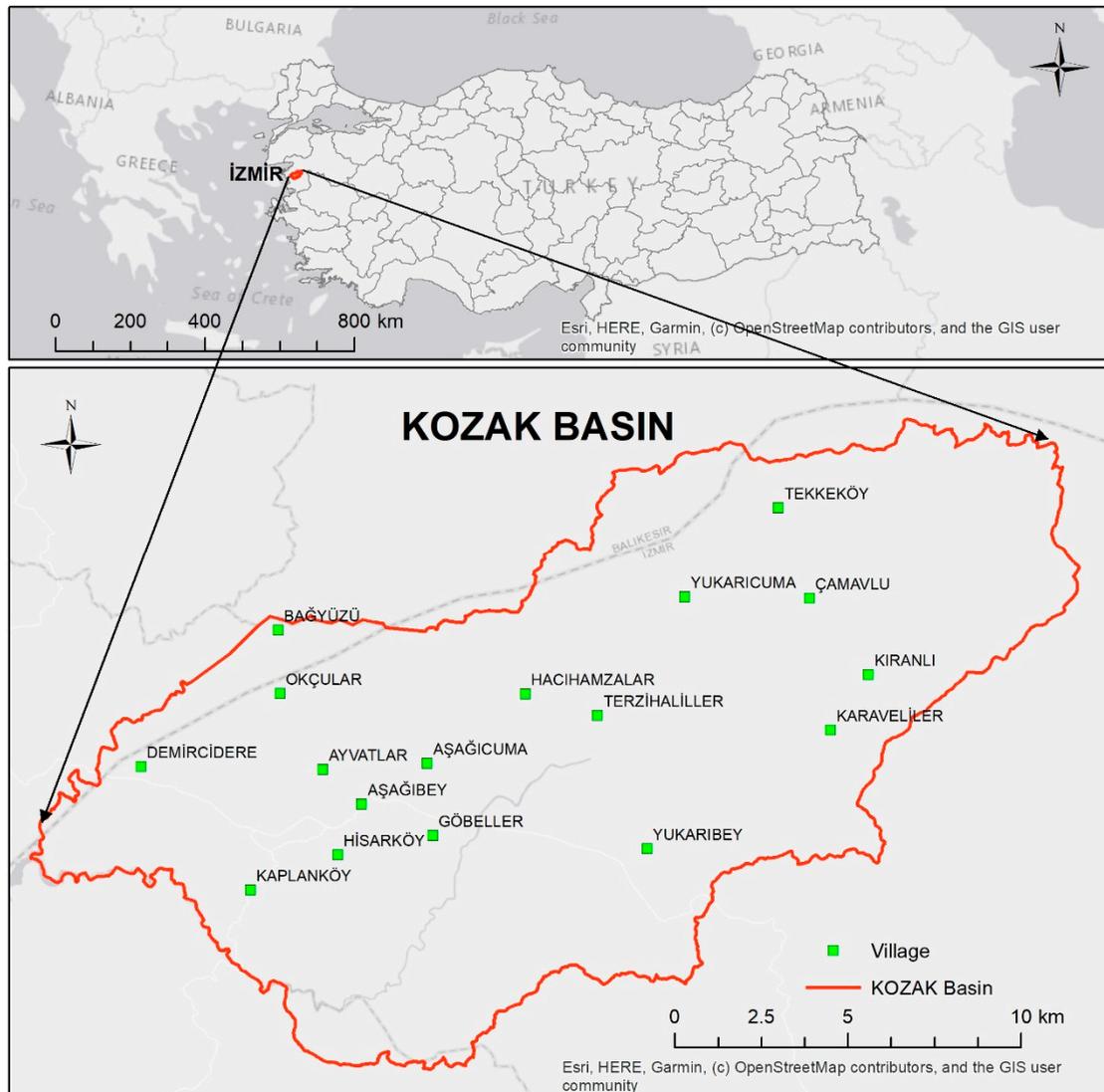
The dramatic decline in production in the Kozak Basin endangers the future of this traditional production method. The views of local people about the low yield in recent years are important to study for the future of the Kozak Basin, which has an important place in Turkey's forestry. In this study, the future of the traditional production system is considered in a multidisciplinary way, including the views of the farmers. Here, we aimed to characterize the current perspectives of pine nut farmers in the Kozak Basin of Bergama (Izmir) concerning the decline in yield and the sustainability of the current production model. Specifically, we aimed to: (1) define the profiles and socio-economic structures of farmers; (2) explore the field practices implemented by farmers (3) record the agro-silvopastoral systems followed by farmers; (4) explain the views of farmers regarding the decline in pine nut yields; (5) describe legal instruments protecting pine nut production, and (6) report farmers' expectations for the future and the main obstacles to pine nut production. Eventually, based on our results, we discuss the barriers and opportunities for sustaining the traditional production model in the study area.

## 2. Materials and Methods

### 2.1. Study Area

This study was carried out in the Kozak Basin located in western Turkey, between latitudes of 39°22'08" and 39°14'36" and longitudes of 27°13'01" and 26°53'05". Most people in this study are the residents of 17 villages in the Kozak Basin where pine nuts are produced. The Bergama district of İzmir province contains 16 of these 17 villages, while Bağyüzü village is part of the Ayvalık district of Balıkesir province (Figure 1). The total population of the 17 villages was determined to be 7047 people [54]. There are natural stone pine stands in Hacıhamzalar, Aşağıcuma, Ayvatlar, Okçular, Demircidere, Kaplan, Aşağıbey, Hisarköy, Göbeller, and Bağyüzü villages [28]. It is seen that the stone pine fields spreading in the south of the Kozak Basin in the last eighty years tend to the north.

Stone pine fields belonging to the villages of Yukarıcuma, Güneşli (Tekkeköy), Çamavlu, Karaveliler, Kıranlı and Terzihaliller were established by plantation [33,55].



**Figure 1.** Map of the study area, including the villages selected for the study.

## 2.2. Data Collection, Design and Data Analysis

To obtain an accurate and detailed picture of farmer's opinions, a large group of farmers was questioned by using Snowball Sampling Method. This method is one of the common types of non-probability sampling methods [56]. Researchers typically start with a small number of initial contacts, who meet the research criteria and are invited to join the study. The participants are then asked to refer other contacts who meet the research criteria. They may also be willing to refer participants, who in turn refer other potential respondents [57].

First, a preliminary field study was conducted based on focus group meetings and observations with farmers, cooperatives, forest management directorates, local authority (headmen) and municipal officials in the region. Survey questions were then prepared relating to the general information obtained from the preliminary field study and relevant literature. Second, a trial survey was conducted using the prepared survey questions. The final form of the questionnaire (presented in Supplementary Materials) was designed after the trial questionnaires had been tested and all necessary corrections had been applied. Surveys were conducted in the form of face-to-face semi-structured interviews during the

winter period (February 2020) when only the local population was present in the basin. The farmers' survey included a total of 378 pine nut farmers from the 17 villages in the Kozak Basin (Figure 2). The interview was designed and structured to address the six goals outlined in Table 1. The data obtained from the questionnaires were analyzed by using the appropriate statistical tests.



**Figure 2.** Descriptive photographs of Stone pines in the Kozak Basin. General view of Stone pine forests (a); Agroforestry implementing (b); Traditional harvesting (c,d); Manufacturing from cones (e) and kernels (f) to pine nuts (g), Livestock (h), Granite quarries (i).

**Table 1.** Interview structure, containing goals addressed and example questions in each section.

Questionnaire Section	Goals Addressed <sup>a</sup>	Examples of Questions by Goals
General characteristics of Respondents	1	Farmers' age, gender, education level, occupation and marital status
Socioeconomic characteristics of Respondents	1	Status of land ownership, total number of people farmers are to look after, membership in cooperative, alternative income sources
Field practices	2	field practices implementing by farmers such as irrigation, fertilization, pruning, months of harvest, reasons for early harvest
Agro-silvopastoral systems	3	Agrosilvopastoral systems followed by farmers such as livestock, beekeeping, grazing
Opinions of farmers on the decline in yield in pine nut production	4	Reasons for yield decline, opinions relating to <i>Leptoglossus occidentalis</i> , perception of disease and pests, methods offight against disease and pests, environmental pollution sources
Legal instruments protecting the product	5	Awareness of farmers for organic product certification and GIP
Expectations for future	6	Farmers' thoughts on the continuation of pine nut production and migration

<sup>a</sup> Specific goals: (1) define the profiles and socio-economic structure of farmers; (2) explore field practices implementing by farmers (3) remark the agrosilvopastoral systems followed by farmers; (4) explain the views of farmers toward declining in yield in pine nut production, (5) describe legal instruments protecting the product followed by farmers, and (6) report expectations of farmers for the future.

### 3. Results

#### 3.1. Characteristics of Respondents

##### 3.1.1. General Characteristics of Respondents

The distribution of farmers by gender, age, education, marital status and occupation are given in Table 2. The gender ratio of the farmers, male: female, was 82:18. The majority of the farmers (86%) are married. They are heads of households aged between 20 and 88, with an average age of 58. In terms of education, 79% of the farmers graduated from primary school, 8.5% from secondary school, 6.6% from high school and 1.6% are undergraduate, and 0.3% are graduates, while 4% of them are illiterate. Nearly half of the respondents (52%) are farmers. While 49% of them are only dealing with farmers, the remaining 3% work in other jobs besides farming. The second largest group after farmers is retirees with the rate of 23%.

**Table 2.** General respondent characteristics (n = 378).

Respondent Characteristics	Frequency	Percentage of Respondents
<b>Gender</b>		
Women	68	18
Men	310	82
<b>Age</b>		
Under 65	132	35
Over 65	246	65
<b>Marital status</b>		
Married	324	86
Single	54	14
<b>Education Level</b>		
None	15	4
Primary	299	79
Secondary	32	8.5

**Table 2.** *Cont.*

Respondent Characteristics	Frequency	Percentage of Respondents
High school	25	6.6
University	6	1.6
Graduate	1	0.3
<b>Occupation</b>		
Farmer	198	52
Retired	88	23
Worker	21	5.5
Tradesmen and trader	14	4
Civil servant	6	1.5
Others	51	14

### 3.1.2. Socioeconomic Characteristics of Respondents

Table 3 shows the farmers' number of dependents, their membership of the cooperative, the reasons if they chose not to be a member, their employment status other than pine nut production and their land ownership status. Regarding the number of dependents, 44% of farmers have two dependents, 20% have three, and 20% have four. Only 25% of the farmers are members of the cooperative. Of those that are not members, 84% stated that this is due to uncertainties and the powerlessness of cooperatives and 11% think the cooperative does not improve income levels. 5% think the cooperative provides insufficient communication. 54% of the farmers are engaged in livestock farming, 11% are engaged in mining, 11% are only engaged in their own profession and pine nut production. 87% of the farmers only produce pine nuts from their own lands. The remaining production comes from cooperative land, state-forest land and other lands.

**Table 3.** Socioeconomic characteristics of respondents.

Respondent Characteristics	Frequency	Percentage of Respondents
<b>Total number of dependents for farmers</b>		
1 person	9	2
2 people	166	44
3 people	76	20
4 people	76	20
5 people	21	6
6 people and more	6	2
Living alone	24	6
<b>Cooperative membership</b>		
Member	94	25
Non-member	284	75
<b>Reasons for not being member</b>		
Failure of farmers to improve their income level	31	11
Lack of corporate communication	13	5
Uncertainties and the powerlessness of cooperatives	240	84
<b>Have another production pattern</b>		
Livestock	231	54
Fruit and vegetable production	6	1
Beekeeping	6	1
Viticulture	38	9
Mining	45	11
Combination of some these	51	13
None	54	11
<b>Land ownership</b>		
Own	330	87
Cooperative	4	1
State	3	1
Others (rent, lease, borrow)	18	5
Combination of own/cooperative/state/	23	6

### 3.2. Field Practices Implemented by Farmers

The practices of pine nut farmers are shown at Table 4. Pruning was carried out by 90.21% of the farmers and 2.91% applied fertilizer as well as pruning. The percentage who does nothing to aid the cultivation of stone pine is 5.03%.

**Table 4.** Technical practices implemented by farmers.

Practices Type	Frequency	Percentage of Respondents
Fertilization	2	0.53
Pesticide	1	0.26
Irrigation	0	0.00
Pruning	341	90.21
None	19	5.03
Others	1	0.26
Combination of all	14	3.69

The cone harvest (Figure 2c–e) period, whether the harvest is early, and the reasons for this, are shown in Table 5. While 54.50% of farmers mentioned February and March as the harvesting period, 19.84% also included January in the harvesting period. Pine nut farmers in the region were asked whether they have an early harvest and 68.52% said they did not. The prior aim of the 44.54% of farmers who have early harvest is to prevent theft. Conversely, 41.18% of the farmers said their main reason for preferring an early harvest was to earn money for the pine nuts.

**Table 5.** Opinions of farmers concerning harvesting issues.

Harvesting Issues	Frequency	Percentage of Respondents
<b>Period</b>		
February-March	206	54.50
January-February-March	75	19.84
January-February-March-April	23	6.09
Other	74	19.57
<b>Early harvesting</b>		
Early harvesting is done	119	31.48
Early harvesting is not done	259	68.52
<b>Causes of Early Harvest</b>		
Prevention against theft	53	44.54
Reseller/Merchant pressure	1	0.84
To sell expensive	2	1.68
To get product revenue early	49	41.18
Combination of all	14	11.76

### 3.3. Agro-Silvopastoral Systems

Pine nut farmers were asked whether they were engaged in any agricultural activities under their trees (Figure 2b). Only 7.7% of the farmers stated that they carry out agricultural activities under stone pine trees (Table 6). Of the farmers who are engaged in these activities, 37.9% grow clover, 20.7% barley-wheat, 17.2% oat-vetch, 20.7% corn; additionally, 3.4% of them are engaged in viticulture. Theorem-type environments (including propositions, lemmas, corollaries etc.) can be formatted as follows:

A vast amount of the farmers (65.3%) stated that they keep grazing livestock, under their stone pine trees (Figure 2h). Agricultural production is conducted in limited areas in the stone pine fields. The agricultural products can be used as forage crops for livestock. Table 6 shows that silvopastoral farming is mainly conducted in the region. While 59.1% of the farmers stated that they graze cattle, 9.3% of them graze sheep. The percentage of farmers engaged in grazing both cattle and sheep is 31.6%. In addition, field studies have shown that animals benefit from shading under stone pine trees.

**Table 6.** Agro-silvopastoral systems practices under stone pine.

Agricultural Activity	Frequency	Percentage of Respondents
<b>Status of doing agricultural activities</b>		
Being done	29	7.7
Not done	349	92.3
<b>Type of agricultural activity</b>		
Clover	11	37.9
Oat-Vetch	5	17.2
Corn	6	20.7
Viticulture	1	3.4
Barley-Wheat	6	20.7
<b>Grazing Status</b>		
Grazing is done	247	65.3
No grazing	131	34.7
<b>Grazing Form</b>		
Cattle grazing	146	59.1
Ovine grazing	23	9.3
Bovine and ovine together	78	31.6

### 3.4. Opinions of Farmers

#### 3.4.1. Opinions of Farmers on the Decline in Pine Nut Yield

Table 7 shows the reasons for the decrease in *P. pinea* nut yield from the perspective of the farmers. Most of the farmers think there are multiple reasons for low yields. However, if they are asked to list the reasons in order of importance, 11.1% of farmers think the negative effects of mining are the main reason for low yield. 10.1% of farmers see the *L. occidentalis*, whose visibility increased in the winter of 2020, as the main reason for the low yield.

**Table 7.** Reasons for yield reduction from the farmers' perspective.

Reasons	Frequency	Percentage of Respondents
Stone quarries—gold mines	42	11.11
<i>L. occidentalis</i>	38	10.05
Climate change	23	6.08
Gold mines	19	5.03
Air pollution	18	4.76
<i>L. occidentalis</i> —Climate change	17	4.50
<i>L. occidentalis</i> —Stone quarries—Gold mines	16	4.23
Others	14	3.70
<i>L. occidentalis</i> —Gold mines	12	3.17
Stone quarries—Gold mines—Acid rains	10	2.65
<i>L. occidentalis</i> —Stone quarries—Gold mines—Acid rains	9	2.38
<i>L. occidentalis</i> —Air pollution	9	2.38
<i>L. occidentalis</i> —Stone quarries	8	2.12
Stone quarries—Gold mines—Air pollution—Acid rains	8	2.12
Stone quarries	7	1.85
Air pollution—Acid rains	7	1.85
<i>L. occidentalis</i> —Gold mines—Acid rains	6	1.59
Climate change—Other	6	1.59
<i>L. occidentalis</i> —Stone quarries—Gold mines—Air pollution—	5	1.32
Stone quarries—Gold mines—Climate change	5	1.32
Gold mines—Acid rains	5	1.32
Other combinations	94	24.87

Thirdly, climate change which has an increasing effect is thought to be responsible for low production of pine nut. Each possible cause of low yield investigated in our study was thought to be a cause by a certain percentage of farmers.

When the farmers were asked whether they had seen *L. occidentalis* (and when they had seen it), 50.2% stated that they had never seen the insect (Table 8). Of the farmers who had seen the *L. occidentalis*, 77% stated that they had seen it only during the last five years,

20% stated that they had seen it for 6–10 years, and 3% stated that they had seen it for 11–15 years.

**Table 8.** Farmers' views on *L. occidentalis* and the fight against diseases and pests.

Views	Frequency	Percentage of Respondents
<b><i>Leptoglossus occidentalis</i> incidence</b>		
Those who see the insect	188	49.8
Those who do not see the insect	190	50.2
<b><i>Leptoglossus occidentalis</i> incidence time</b>		
Those who have seen for 0–5 years	144	77
Those who have seen for 6–10 years	38	20
Those who have seen for 11–15 years	6	3
<b>Control practices against diseases and pests</b>		
Those who care and fight against diseases and pests	28	7.4
Those who do not take care and do not fight against diseases and pests	350	92.6

Farmers were asked whether they use control practices against diseases and pests (Table 8). 92.6% of the farmers stated that they did not conduct any control measures. Only 7.4% stated that they did performed maintenance.

The percentage of farmers who have cut down trees on their land is 54%. The most important reasons to cut down their trees were to earn additional income (for 60.98%) and the decrease in pine nut yield (for 29.3%); as few as 5% of the farmers cut down dead stone pines. The percentage of those who cut down trees to pay debt is 4.39% (Table 9).

**Table 9.** Reasons for farmers to cut down the trees on their private lands.

Cutting down the Trees on Farmers' Private Lands	Frequency	Percentage of Respondents
Farmers cutting down trees on their private lands	204	54
Farmers who don't cut down trees on their private lands	174	46
<b>Reasons</b>		
To combat diseases and pests	11	5.36
To earn additional income	125	60.98
In order to pay debts	9	4.39
Due to decreasing the pine nut yield	60	29.27

### 3.4.2. Farmers' Opinions on Geographical Indication Protection and Organic Product Certification

More than half of the farmers stated that they knew about GIP, and 30.4% knew about organic product certification (Table 10). Those who had knowledge of organic product certification were then asked what the benefits of it were. Their responses were: "maintaining product quality" with 32.2%, "providing competitive advantage" with 30.4%, and "earning additional income" with 18.3%.

**Table 10.** Farmers' opinions on GIP and organic product certification.

GIP and Organic Product Certificate	Frequency	Percentage of Respondents
<b>The status of having knowledge about Bergama-Kozak GIP</b>		
Yes	194	51.3
No	184	48.7
<b>The state of having knowledge about the organic product certification</b>		
Yes	115	30.4
No	263	69.6
<b>Farmer opinions on the benefits of organic product certification</b>		
Earning additional income	21	18.3
Providing competitive advantage	35	30.4
Maintaining product quality	37	32.2
All of them	22	19.1

### 3.4.3. Farmers' Expectations for the Future

Farmers were asked whether they would consider giving up production/cultivation due to the decrease in yield (Table 11) and 92.9% stated that they would not. The alternative professions for farmers who want to stop pine nut producing are listed in Table 11. This shows that: 51.9% of the farmers prioritized livestock breeding, 7.4% beekeeping, 7.4% gardening, 3.7% fruit growing and 3.7% olive farming. Another 25.9% said that they could turn to other business sectors such as shipping, weaving and tourism. Farmers were asked whether they had moved due to the decrease in yields (Table 11). The migration rate of families due to the decrease in pine nut production was found to be 4.76%. When pine nut farmers were asked whether their family planned to move in the near future, 6.3% answered yes.

**Table 11.** Thoughts on the future of pine nut production.

Thoughts	Frequency	Percentage of Respondents
<b>Tendency to abandon pine nut farming</b>		
Yes	27	7.1
No	351	92.9
<b>Alternative activities in case of giving up pine nut production</b>		
Livestock	14	51.9
Beekeeping	2	7.4
Horticulture	2	7.4
Fruit growing	1	3.7
Olive cultivation	1	3.7
Other	7	25.9
<b>Migration status of pine nut farmers</b>		
Yes	18	4.76
No	360	95.24
<b>Tendency of pine nut farmers to migrate</b>		
Yes	24	6.3
No	354	93.7

### 3.5. Chi-Squared Results

Table 12 shows the result of the chi-squared test to investigate the relationship between the number of dependents and the level of education of the farmers. A statistically significant relationship was found ( $p < 0.05$ ). As the level of education decreases, the number of dependents increases. Another chi-squared test was performed to determine whether practices in pine cultivation were dependent on the level of education, and this gave results that were not statistically significant ( $p > 0.05$ ). For example, the chi-squared test was used to investigate the relationship between thinking that the pinecones should be harvested early and educational level was not statistically significant ( $p > 0.05$ ).

Conversely, the chi-squared test was used to investigate the relationships between gender, education and occupation of the farmers, the villages they live or work in and the *L. occidentalis* sightings. This work showed a statistically significant ( $p < 0.05$ ) relationship between the villages where the farmers live, and the duration of seeing the *L. occidentalis*. Insects have been seen rarely and only in recent years in the villages of Aşağıbey and Çamavlu. Insect visibility has increased in the villages of Okçular, Bağyüzü, Yukarıbey and Göbeller compared to other villages, mostly in recent years. Conversely, the relationship between the gender of the farmer and the sighting of the *L. occidentalis*, was not statistically significant ( $p > 0.05$ ). The relationship between the education level of the farmer and the sighting of the *L. occidentalis*, was not statistically significant ( $p > 0.05$ ). The participants' occupation was not related to the sighting of *L. occidentalis*, as the dependence between these variables was not statistically significant ( $p > 0.05$ ).

**Table 12.** Chi-squared test results.

Relations	Chi-Squared	p-Value	Asymptotic Significance (2-Sided)
Number of dependents—educational status	97.515	$p < 0.05$	0.000
Applications in stone pine cultivation—education	60.102	$p > 0.05$	0.155
Those who think that the stone pine cones are harvested early—education	5.575	$p > 0.05$	0.350
<i>L. occidentalis</i> incidence time—villages	101.885	$p < 0.05$	0.000
Gender— <i>L. occidentalis</i> incidence time	4.770	$p > 0.05$	0.189
Education— <i>L. occidentalis</i> incidence time	10.498	$p > 0.05$	0.787
Occupation— <i>L. occidentalis</i> incidence time	42.014	$p > 0.05$	0.135
The situation of giving up on pine nut production—villages	19.940	$p > 0.05$	0.174
Migration status of pine nut farmers—villages	53.755	$p < 0.05$	0.000
Tendency of pine nut farmers to migrate—villages	15.233	$p > 0.05$	0.435
Knowing geographical indication protection—villages	28.126	$p < 0.05$	0.021
Knowing the organic product certificate—villages	31.949	$p < 0.05$	0.007
Knowledge and awareness of geographical indication protection—education	13.689	$p < 0.05$	0.018
Knowledge and awareness of organic product certification—education	5.617	$p > 0.05$	0.345

There was no statistically significant ( $p > 0.05$ ) relationship between the farmers' abandonment of pine nut production and the villages they live in. A statistically significant ( $p < 0.05$ ) relationship was found between the migration status of the farmers from their families and the villages they lived in. The relationship between farmers who were recently considering migration and the villages they live in was not found to be statistically significant ( $p > 0.05$ ). A statistically significant relationship was found between the villages they live in and whether they are aware of the Bergama-Kozak GIP ( $p < 0.05$ ). The low awareness (13.3%) in Çamavlu village is the reason for this. A statistically significant relationship was found between the farmers' knowledge of organic product certification and the villages they lived in ( $p < 0.05$ ). A statistically significant ( $p < 0.05$ ) relationship was found between knowledge and awareness of GIP and education, however the relationship between knowledge and awareness of organic product certification and education was not found to be statistically significant ( $p > 0.05$ ).

#### 4. Discussion

##### 4.1. Socioeconomic Structure of Farmers

According to TURKSTAT, while the rate of illiterate people among the active population in Turkey was 3.6% in 2018, there is a slight difference in the Kozak Basin with 4%. While the percentage of those who were only educated until university degree in this area is 94.1%, the percentage is around 77% across the country [58]. However, while the percentage who left education after primary school in the total population in Turkey is 35%, this rate is 79.1% in the basin. While the percentage of the population with university or higher education is 1.9% in the basin, it is 17.7% nationwide [58]. The İzmir province, which the basin is part of, is in an above average position in Turkey in terms of the education level of the working population. The percentage of illiterate population is 1.9%, 4.6% left after primary school, 76.4% left after high school or earlier, and the percentage with university degrees and higher qualifications is 21.4% [58]. While the İzmir province has an average level of education well above that of the country as a whole, the Kozak Basin has not emphasized the importance of education due to the production system that is in place and the income obtained from this production. Therefore, education levels have remained below the average of both İzmir and the country.

In the Kozak Basin, there is an average of one to two children per household, unlike the common cases in many rural households with a high number of children due to the need for labor. In addition, there's a common conscious birth control in the area in order to prevent lands from being unprofitable due to subdivisions by inheritance [55]. It is emphasized that these decisions of the people of Kozak are as a result of the pine nut economy. Since the local people are aware of their economic situation, the number of

children is not high as in other rural settlements, so the rate of migration from the region is almost non-existent [39,55,59].

There's a significant problem in the cooperative-farmers relationship is that the intermediaries are willing to buy the pinecones and seeds (Figure 2e,g) from the farmers at every stage of production, while the cooperatives only buy the product in one specific form (kernel, Figure 2f). This is due to lack of an effective structure of cooperatives in Turkey [60]. This is in line with the previous studies conducted in the Kozak Basin [31,33]. The cooperatives do not pay on time and the sales are invoiced. Additionally, farmers prefer to be able to sell the whole pinecone due to lack of capital, and do not appreciate the withholding of the tax collected from the farmers during purchase [61]. Previous studies in the Kozak Basin showed that purchasing cooperatives realize 15–20% of production profits [62], and the Kozak Cooperative is not effective in training and promotion activities for its work [63]. The lack of knowledge from the members about cooperatives limits their active participation in the cooperative's decision making and suggestions for effective management in future.

Only 25% of households in the basin include a member of the cooperative. Similar rates (23%) were found in the Gediz Basin, where pine nut production is intense [30]. The issue of cooperatives, which are part of contemporary agricultural production and welfare maximization, is an important problem that needs further study. While there is a decrease in both yield and income in the region, the opposite situation is seen in export figures. Instead of farmers, this situation benefits exporters. Cooperatives need to be rehabilitated and given strong financial and management structures to direct the surplus value created by the rise in prices to the farmers [64]. When this problem is solved, the added value that goes to the intermediaries will be returned to the farmers.

Different from the other pine nut production areas, the Kozak Basin is in a special location where farmers work on their own land. The local people of the Kozak Basin meticulously followed the land registry records applicable at that time [28]. Also, Çamavlu, Güneşli, Karaveliler, Kıranlı, Terzihaliller and Yukarıcuma villages have special reforestation areas [55]. This explains the density of owned lands in the Kozak Basin. Conversely, in the Gediz Basin, only 1% of the pine nuts harvested come from registered land, and 94% are from state land [30].

#### 4.2. Field Practices and Agrosilvopastoral Implementings of Farmers

The decrease in pine nut yield in the region causes an increase in the cutting of stone pine trees in private lands. According to the Kozak Forest Sub-District Directorate, the average amount of wood cut per farmer in the last ten years with this tree cutting practice is 63.3 m<sup>3</sup> [65]. Due to decreasing the pine nut yield, more than half of the farmers cut trees down on their land to earn additional income. This situation indicates that the farmer is in an economically difficult situation. If a solution cannot be found for the problem of low yield many of the trees may be lost in the medium term and a shift of farmers towards alternative professions may occur. This is especially likely since the wood pallet industry, which supports the increasing mining activities in the basin, and the company that produces root resin, have a growing demand for wood. Therefore, it is recommended to make plans to prevent this outcome.

When stone pine cones are harvested before they are fully ripe, the nutritional value decreases and the pine nuts lose flavor, aroma and whiteness. The collection of immature cones leads to product and quality losses [30,61]. In the Kozak Basin, farmers mostly wait for the product to mature and harvest at the appropriate time. A previous study stated that early harvest is not even considered in the Kozak Basin [28]. Considering the answers given by the farmers when asked about the month of harvest, about 75% of them do not harvest early. However, when we asked their opinions on early harvest in the basin, this rate drops to 68%. In the basin, the rate of early harvest was not high, because the farmers own their lands. In other regions where early harvest is common, it is seen that the harvest is restricted to early dates by the state, which owns the land. The two main reasons for early harvest in

the basin are prevention of theft which is common in areas close to main roads, and the desire to gain income early. However, this would be eliminated if there were strengthened cooperatives to support the producers outside the production period. A study conducted in the Gediz Basin, found that the pine nut harvest begins around August-September and ends before winter comes, due to the pressure of intermediaries/traders [30]. Conversely, the efforts of GDF to prevent early harvest are also noteworthy. According to FAO report GDF's efforts to prevent cone harvesting before 10th November are beneficial [55]. With the communiqué numbered 302 issued in 2016, the time for collecting pinecones was proposed to start in December-January and end in May [66].

Although there are fields suitable for stone pine silvopastoral production systems, most breeders do not engage in livestock farming in these fields. According to observations in the villages in the middle and lower parts of the Kozak Basin, animals are grazed in the stone pine forests where no agricultural activity is carried out. However, the wide pastures in the upper parts of the Kozak Basin can be defined as the areas where the local people farm livestock. The farmers who use the land under the trees, although only a small amount, generally produce products such as alfalfa, vetch, barley, wheat and corn to be used as animal feed. Even though 65% of the farmers' graze livestock under the trees, grazing is not a system that has the potential to add to the value of the land to the economy. The use of these fields for forage crops to support livestock should be supported.

#### 4.3. Reasons for Yield Decline and Future Perspective of Farmers

A dramatic decline in pine nut yields is linked a number of factors by farmers. However, when asked to list the reasons they consider important, the negative effect of the mining sector is given as the main reason for low productivity. The fact that the basin is historically suitable for granite stone mining [67] has led to an increase in the number of mining enterprise in the area (Figure 2i). Conversely, it is seen that farmers whose lands have granite stone potential tend to lose their income due to the decrease in yield and then sell their land since it is valued for the granite.

In addition, 10% of the farmers consider *L. occidentalis*, whose visibility increased in the winter of 2020 as the main reason for the low yield. The majority of those who have seen the insect have seen it in the last five years. *L. occidentalis* was first detected in Turkey in 2009 [68] and the negative assessments of the effects of the insect are expressed throughout the Mediterranean, and this perception becomes fixed due to the high commercial value of the product [19,53]. This is in line with a study conducted in Portugal, where branches covered with plastic covers for two years were found to be more productive than uncovered branches was interpreted as being caused by the insect [51].

While half of those asked claimed that they saw the insect during present field studies, this proportion has increased rapidly in the last year. The view that *L. occidentalis* causes a decrease in yield has become more common as more research is conducted in this area. Nevertheless, there are suspicions that spraying is being carried out in the Aegean Region, including Aydın Koçarlı, known by the villagers as one of the pine nut production centers [62,69]. The villagers believe that this spraying works, causing an increase in sympathy for spraying. However, uncontrolled spraying should be avoided until the root cause of reduced yields is shown to be insects, because this will cause different problems due to the destabilizing effect of pesticides on the ecosystem. Therefore, uncontrolled and unscientific interventions against the insect, which is seen as the prime suspect, may intensify in the coming period. Therefore, it is important to prevent such suspicions with activities that educate the farmers in the basin. Public support is essential in reducing the damage caused by invasive forest pests and taking effective measures against them [52].

Future expectations of the farmers (92.9%) don't consider giving up production, and they are still hopeful that yields will increase. The small number of farmers who are considering giving up pine nut production prioritized the alternatives as livestock farming, beekeeping, horticulture, fruit growing and olive growing, respectively. Some farmers would consider businesses such as transportation, weaving and tourism if they were to

give up on pine nut production. However, in the study conducted in the Gediz Basin, it was reported that pine nuts are not considered a sufficient livelihood for the young people living in the region [30]. When the results of both studies are compared, it demonstrates that the decrease in yield over time can change the views of the local people about the economic value of pine nut production.

The decrease in the farmers' production has only caused migration away from their families for 4.8% of the farmers asked. This result is an indication that the people of the basin are still hopeful for the future. Similar results were found in a study conducted in the Kozak Basin in 1993 [33]. The negative effects of mining activities on agricultural production were seen only in Okçular village, so it is predicted that the resulting decrease in agricultural production will cause a tendency to migrate from this village. Among the farmers' families, the percentage of those who intend to move away in the near future is 6.3%. In studies conducted in rural areas in other regions of our country, the tendency to move is high [70,71]. The low migration tendency in the Kozak Basin shows that the farmers have not abandoned pine nut production. This situation is positive for future studies that need to be undertaken.

#### *4.4. Protection of Pine Nut Product with Legal Mechanisms*

Geographical indications can create opportunities for rural development as well as contribute to the preservation of traditional knowledge and cultural values [32,70], community education studies should be carried out in this regard for the sustainability of the system. On the other hand, while the percentage of those who know about GIP in the region is 51.2% in Aşağıbey village, this percentage drops to 13.3% in Çamavlu village.

Although there is a great potential benefit from GIP in the Kozak Basin, it is seen that the added value that this mechanism will provide to the economy is not sufficiently used. The product value cannot be increased, and there is insufficient awareness of the society and its institutions. Peanuts that are shaped like pine nuts are still sold in some markets under the name of stuffed peanuts. Consumers buy these products at much lower prices without knowing the difference. Adequate and appropriate information on the type and origin of imported pine nuts is not provided on the label in international markets [2]. In order to meet the increasing demand for pine nuts, some pine nut species that do not taste as good are mixed with the main products and sold, revealing the importance of geographical indication protection [72]. Therefore, the place of production must be stated on the packaging of the peanuts produced in the Kozak Basin and precautions must be taken against counterfeiting. These measures will help the Kozak Basin's product to reach its real price, while protecting its origin and farmer, by distinguishing it from similar products. For the GIP of Bergama Kozak Pine Nuts to gain the importance at an international level, the European Union geographical indication registration studies should be started as soon as possible. The same lack of awareness is seen concerning organic product certification. Only 30.4% of the farmers said that they knew about organic product certification. Priority should be given to the villages of Güneşli (13.9%), Demircidere (16.7%), Göbeller (17.7%) and Kaplan (20%), where the awareness is 20% or below, but all villages require training on GIP and organic product certificates, how benefit farmers, and how production should be conducted to comply with the requirements for these certificates.

## **5. Conclusions**

Low production is an important problem for local people in the Kozak Basin, who regularly benefit from the stone pine stands and base their livelihoods on the cone yield of this species. The low cone and seed yield in stone pines directly affects human–nature relations. It can also affect how local farmers, who supply an ecological service of natural resources, decrease their income sources and earn their living as a group. Due to the low cone and seed yield in stone pines, changes can be made to land use in forest areas. The decrease in income sources for rural areas causes the search for alternative solutions and triggers the migration from rural to urban areas. At the same time, low yield can

cause uncertainty and instability in the planning and management of income from stone pine stands.

Historical population records and publications about the region show that rural migration, which is common in the rural areas of our country, has only recently begun in Kozak. However, the loss of income caused by the low efficiency of the dominant production system in this area is likely to cause an increase in the migration rate. Policy makers should start preparing a solution to this problem, and work to find alternative income sources urgently needs to start. Studies should be conducted to develop silvopastoral and agro-silvopastoral systems to obtain increased value in the basin. Cooperatives also need to be strengthened by gaining a stronger financial and management structure in the region.

*P. pinea* is one of the key components of the potential contribution of Mediterranean forests to achieving sustainable development goals. For this reason, measures should be taken to ensure the sustainability of these forests and to reduce the dependence of the local people on this pine nut production. The important measures to be taken for sustainable management can be listed as to encourage the local people to the cultural services of *P. pinea* forests, to focus on the production of alternative *P. pinea* products and to develop long-term projects to benefit from the landscape value of the region. Although the intensive researches in the region and the Mediterranean basin have not yet determined the root cause of the low yield, the rapid spread of invasive insect species due to climate change emerges as the most important factor. In order to solve the problem of low productivity that is not due to a single reason, a research center should be established in the Kozak Basin in cooperation with other international organizations. It will be possible to develop international policies with the participation of pine nut producers with different cultural values from different regions of the Mediterranean basin.

**Supplementary Materials:** The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/agriculture12071070/s1>, Farmer Questionnaire Form.

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