



## **The Effect of Activities Intended for Obtaining Geothermal Energy on Agricultural Production Systems**

*Jeotermal Enerji Elde Etmeye Yönelik Faaliyetlerin Tarımsal Üretim Sistemleri  
Üzerindeki Etkisi*

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## The Effect of Activities Intended for Obtaining Geothermal Energy on Agricultural Production Systems

### Abstract

It can be stated that geothermal energy provides an important input and raw material contribution to many sub-sectors, especially electricity generation and agricultural production systems. On the other hand, it is argued that in the production activities of this energy, possible damage to the environment causes undesirable effects such as agricultural production, human and animal health, and deterioration of the natural ecosystem. In this study, the possible effects of geothermal energy production activities on agricultural production systems in Aydın and Manisa provinces, where Türkiye's important geothermal production areas are located, are tried to be determined. For this purpose, the attitudes and thoughts of the farmers are taken as the basis. In the provinces of Aydın and Manisa, a survey is conducted with a sample of 200 farmers, 100 of whom were each. In choosing the farmers to be interviewed, it is considered that they continued their agricultural activities in lands relatively close to these facilities. Descriptive statistics such as arithmetic mean and percentage ratios are mainly used in determining and interpreting research results. In addition, since the data did not show normal distribution, Mann Whitney U test is used to determine the difference between Aydın and Manisa regions in some parameters. According to the results of the study, it is defined that there are significant yield and quality losses in agricultural products, especially in fig and vineyards, grown on lands close to geothermal energy production activities. For this reason, it is recommended that activities in geothermal energy production areas be carried out with more environment-nature-live-friendly approaches, and effective and purposeful auto-control systems are recommended.

Keywords: Ecosystem, Energy, Multifunctionality, Sustainability

### Jeotermal Enerji Elde Etmeye Yönelik Faaliyetlerin Tarımsal Üretim Sistemleri Üzerindeki Etkisi

### Öz

Jeotermal enerjinin, başta elektrik üretimi ve tarımsal üretim sistemleri olmak üzere, birçok alt sektöre, önemli bir girdi ve hammadde katkısı sağladığı ifade edilebilir. Diğer taraftan, bu enerjinin üretim faaliyetlerinde, çevreye verilen olası zararların tarımsal üretim, insan ve hayvan sağlığı, doğal ekosistemin bozulması gibi istenmeyen etkilere neden olduğu savunulmaktadır. Bu çalışmada, Türkiye'nin önemli jeotermal üretim alanlarının bulunduğu Aydın ve Manisa illerindeki jeotermal enerji üretim faaliyetlerinin, tarımsal üretim sistemlerine olan olası etkileri tespit edilmeye çalışılmıştır. Bu amaca yönelik olarak çiftçilerin tutum ve düşünceleri esas alınmıştır. Aydın ve Manisa illerinde, 100'er çiftçi olmak üzere toplam 200 çiftçiden oluşan örnek ile anket çalışması yapılmıştır. Görüşme yapılacak çiftçilerin belirlenmesinde, bu tesislere nispeten yakın arazilerde tarımsal faaliyetlerini sürdürmeleri dikkate alınmıştır. Araştırma sonuçlarının belirlenmesinde ve yorumlanmasında ağırlıklı olarak aritmetik ortalama ve yüzde oranları gibi betimsel istatistikler kullanılmaktadır. Ayrıca veriler normal dağılım göstermediği için bazı parametrelerde Aydın ve Manisa bölgeleri arasındaki farkı belirlemek için Mann Whitney U testi kullanılmıştır. Çalışma sonuçlarına göre, jeotermal enerji üretim faaliyetlerine yakın olan arazilerde yetiştirilen tarımsal ürünlerde, özellikle incir ve bağ bahçelerinde, önemli verim ve kalite kayıplarının olduğu belirlenmiştir. Bu sebeple, jeotermal enerji üretim alanlarındaki faaliyetlerin daha çevre-doğa-canlı dostu yaklaşımlar ile yapılması önerilmekte olup, etkin ve amacına uygun otokontrol sistemleri tavsiye edilmektedir.

Anahtar kelimeler: Ekosistem, Enerji, Çok fonksiyonluluk, Sürdürülebilirlik

## 1. INTRODUCTION

Geothermal energy (GE), as a renewable energy source, on the one hand, reduces the use of fossil fuels, which tends to decrease, on the other hand, it facilitates the reduction of pollutant emissions and allows the air quality in the ecosystem to remain at an optimum level. In addition, it is emphasized that GE, like other renewable energy sources, has potential undesirable environmental and social effects.

GE can be defined as a hydrothermal mass consisting of water and steam, which is in different layers of the earth's crust, and which creates the mechanism of action with the waters coming from the basins on the earth, accumulated heat, whose temperatures can vary regionally, and which contains mostly molten mineral salts and gases in its structure. The formations formed by some hard rocks such as granite underground can also be defined as a geothermal energy source, although they do not have water in their structures (Arslan et al., 2001). The main utilization areas of geothermal resources are as follows: Electric power generation, residential and greenhouse heating, tropical plant growing environments, city heating and hot water supply, soil and street heating, airport runways heating, swimming pool and physical therapy heating, various industrial uses, food processing, drying and sterilizing, canning, lumber and wood coating industry, paper, weaving and dyeing, drying and processing of leather, beer, etc. fermentation and distillation in industries, cooling facilities, drying of concrete blocks, use of drinking water by cooling, use in laundries for washing purposes, use of the spa (balneology) for health purposes (Dağdaş, 2004; Akkuş, 2009).

It was emphasized by Akar (2014) that the Büyük Menderes Basin is one of the important basins of Türkiye in terms of agricultural production potential. It is declared that there are geothermal resources with high potential along the tectonic fault lines in the Menderes Graben, which extends from Aydın-Germencik to Denizli-Kızıldereli and includes Pamukkale, in the north of this basin. It is of great importance to improve these resources and present them to the service of the local people

and the country for different purposes. On the other hand, it was notified that during the improvement process of the natural resources, potential negative environmental impacts that may occur should be eliminated appropriately in order not to adversely affect other important natural resources such as water and soil in the basin.

Hasdemir et al. (2015) performed a study to determine the factors affecting the decision-making processes of enterprises engaged in geothermal greenhouse cultivation in a total of 10 provinces in Türkiye where geothermal greenhouse cultivation is carried out. Within the scope of the research, the status of greenhouse enterprises that use GE as a heat source and other greenhouse enterprises that do not use GE were analyzed within the socio-economic framework. As a result of the logistic regression model; it was determined that those with high-income levels can grow agricultural products with geothermal greenhouse cultivation with a higher probability than those who do soilless agriculture compared to those with soil, those who apply Good Agricultural Practices (GAP) compared to those who do not, and those who do not receive support. In addition, adding 1 to the greenhouse area increases the probability of using geothermal resources by 1 time.

Dağ (2015) declared that, in the fig orchards located close to the geothermal power plant (600-650 m), it was determined that the nutrient and heavy metal contents of the leaf and dried fig fruit samples were higher than the samples taken from the fig orchards grown at longer distances. Especially in trees close to the geothermal power plant, it was determined that the heavy metal contents in the fruit samples were higher than the samples taken from more distant trees. In summary, it was concluded that the negative effect on the quality and yield of dried fig fruits decreases with distance from the geothermal plant.

Kepinska and Kasztelewicz (2015) tried to measure public perception of GE in selected European countries. It is discovered that public awareness and acceptance are among the indispensable factors that facilitate the development of GE use. Acceptance among key

social groups is very important to understand the current conditions and constraints affecting geothermal development and to undertake relevant educational and promotional activities to create positive attitudes among the public. The results of the socio-economic research aimed at a comparative analysis of public understanding and attitudes towards GE for proposed educational activities in seven European countries (Hungary, Italy, Macedonia, Poland, Romania, Serbia, and Slovakia) were discussed.

Çetiner et al. (2016) used a sequential explanatory questionnaire to explore public perception and acceptance. The results of the research have determined that the local people, in general, know that GE resources, especially in the Biga Peninsula in Türkiye, have significant potential for different uses, but they have insufficient knowledge about what geothermal energy is and its environmental effects.

Yılmaz and Kaptan (2017) analyzed the environmental effects of geothermal power plants (GPP) in Aydın province. The pollution of hot water resources with high boron concentration is one of the most important reasons for the high boron concentration in irrigation water resources such as wells and surface water, especially in the Büyük Menderes River. The concentration of boron level in soils is 0.43-2.34 mg kg<sup>-1</sup> and its toxicity is gradually gaining importance. While cotton growth is very common in the region, it is therefore believed that the severity and expansion of toxicity will increase further in the future. They interpreted that heavy metals are also dangerous for human life, like boron, because they also tend to bioaccumulate.

Protest movements against GE production in Aydın were investigated sociologically by Semerci (2019). A qualitative method based on the emergence and development process of the movement, based on the media news between the years 2016-2019 in Aydın province, and face-to-face in-depth interviews with twelve active participants in the movement was applied. In addition, the questionnaire, which is a quantitative technique for investigating the sociological basis of the movement, such as how the movement was

received by the local people, the level of participation in the movement among the residents, whether there are complaints or not, was applied to 724 people. The findings reveal that the basic values that ensure the development and continuity of the movement since its emergence are to protect life and nature.

Tolunay and Erden (2021) conducted a survey with a total of 401 people in Denizli, Aydın, Manisa, and Uşak and tried to determine the expectations of the participants for the GE use and ecosystem interaction. Accordingly, most of the participants (62.6%) believe that the extraction of GE has negative effects on the ecosystem and most of the participants (81.1%) in areas where GE resources are extracted, diseases, drying out, etc. in trees and plants. 79.9% of the participants think that the animals living in the environment where GE sources are extracted are negatively affected.

Fernández Fuentes et al. (2022) stated that one of the biggest challenges related to the energy transition is to create active support for renewable energy facilities at the local level. The CROWD THERMAL project is developed to positively influence local stakeholders to take different measures. Based on technical evidence and data from concrete case studies, the project explores ways in which community funding can increase the social acceptance of GPP. The solutions presented focus on alternative financial planning studies and risk reduction analysis in geothermal projects.

It can be stated that the use of GE, especially electricity generation, is very important in many sub-sectors such as greenhouse cultivation. Thus, the positive impact of this issue on micro and macroeconomic development in terms of added value and employment contribution is obvious. On the other hand, it is stated that environmental wastes and harmful substances, which are stated to occur in GE production, in production areas, may have negative effects in a certain ecological area, especially in agricultural production, as in many parts of the world and in Türkiye.

Zaim and Çavşı (2018) stated that Türkiye is the country with the 7th largest geothermal energy potential in the world. Geothermal applications in Türkiye have gained momentum since the beginning of the 2000s, and while the capacity used for heating and thermal use was 675 MWt in 2002, this value increased significantly to 2843 MWt in 2017. The amount of installed power used for electricity generation in 2002 has increased from 15 MWe (megawatt electricity) to 861 MWe today with the discovery of geothermal fields suitable for electricity generation and the investments in GPP. Tunçbilek and Yılmaz (2021) explored that of the 58 GPP in Türkiye, 28 are in Aydın and 15 in Manisa. With an installed capacity of 1570 MW, 49.5% of Türkiye's geothermal energy production is provided from Aydın and 24.5% from Manisa. In summary, approximately 74% of Türkiye's geothermal energy production is provided in Aydın and Manisa provinces.

In this study, GE production activities in Aydın and Manisa provinces, where agricultural production and GE production potential are quite high, are evaluated by the farmers' opinions.

## 2. MATERIAL AND METHOD

### 2.1. Material

In this research, the positive or negative effects of GE operations on agricultural production systems are evaluated by the farmer opinions. The main material of the research is the data obtained from the questionnaire forms made by face-to-face interviews with the producers in Aydın and Manisa provinces. Survey studies are carried out with the farmers in regions where GPPs are concentrated. These regions are in Aydın province; Germencik - Ömerbeyli, Sultanhisar - Salavatlı and Efeler - İmamköy fields. Kurudere town in Alaşehir and Göbekli and Caferbey towns located in Salihli district in Manisa province. A survey was conducted with a total of 200 farmers, 100 from each of Aydın and Manisa provinces (Map 1a and Map 1b). In the determination of the sample in question, the criterion sampling method, which is one of the non-probability sampling techniques, which is among the purposive sampling techniques, was used.

Map 1. The regions surveyed [a) Location of provinces within Türkiye, b) Provinces]



According to the literature review, while designing the survey questions, there are many studies (for example, Cataldi, 2001; Popovski, 2003; Kepinska and Kasztelewicz, 2015; İbrohim, Praseyto and Rekinagara, 2019) measuring the attitudes and behaviors of the public and the public towards GPPs. No other study has been found that puts measurable values for the determination of the effects of GPP on agricultural production

systems by farmer attitudes (Mariita, 2002). While benefiting from this research, Güneş et al. (2013) also designed and used a scale titled "Renewable Energy Resources Attitude Scale Towards Science Teacher Candidates: Validity and Reliability Study". For age, marital status and non-agricultural income status, answers were obtained by using binary data such as yes or no. While age and farming experience were taken as continuous

data, the education level of the farmer, the number of households, the number of individuals participating in agricultural production in the household and the number of students in the household were taken as discrete data (Table 1).

The locations of the operating lands of the farms according to the distance to the nearest GPP are given below (Table 2).

Table 1. The farmer characteristics

Abbreviations of variable names	Variables	Explanations
GEN	Gender	1= Male, 0=Female
AGE	Age	Year
EDU	Education	1=Literate, 2=Primary school, 3=Secondary school, 4=High school, 5=University
MAS	Marital status	1=Married, 0=Single
MEM	Household members	Number
INDI	Individuals participating in agricultural production	Number
STU	The students in the households	Number
EXP	Farming experience	Year
NAIS	Non-agricultural income status	1=Yes, 0=No

Table 2. The locations of the operating lands of the farms

Abbreviations of the variables	Variables	Explanations
GPP25	25% of the total operational lands are very close to the GPP (up to 1 km away).	1=Yes, 0=No
GPP50	50% of the total operational lands are very close to the GPP (up to 1 km away).	1=Yes, 0=No
GPP75	75% of the total operational lands are very close to the GPP (up to 1 km away).	1=Yes, 0=No
GPP100	All the total operational lands (100%) are very close to the GPP (up to 1 km away).	1=Yes, 0=No
GPPFAR	Almost all the agricultural lands living and owned in this region are in areas away from the GPPs (more than 1 km).	1=Yes, 0=No

## 2.2. Methods

First basic descriptive statistics (frequency, arithmetic mean, standard deviation, percentage rate, etc.) of the data set are defined. In the next step, it is determined whether the data set showed a normal distribution. According to Kolmogorov-

Smirnov and Shapiro-Wilk tests, it is clarified that not all the variables used are normally distributed ( $P<0.05$ ). Therefore, in order to explain and compare the statistical methods used below, equivalent parametric and non-parametric tests are explained together.

In the two groups whose averages will be compared, the t-test may not be performed for unrelated samples due to the low number of data, the abnormality in the distribution of the data even if the number of data is sufficient, the conditions of the test not being met, or the data not at least in the interval scale (i.e. the data are in the ranking scale). In this case, it is possible to test whether there is a difference between the means of the two groups with the Mann-Whitney U, which is a non-parametric comparison test, which can be considered as an alternative to the t-test, which is a parametric test. The Mann-Whitney U test processes data on a ranking scale (Karagöz, 2016; Can, 2017).

### 3. RESEARCH FINDINGS

Some characteristics of the farmers/households are determined. These are: (i) Distribution by gender, (ii) Average age, (iii) Education level (Table 3), (iv) Marital status, (v) Number of people in the farms, (vi) Farming experience of the

farmers (Table 4). The majority of the farmers are male producers in Aydın and Manisa provinces. The average age of the farmers is very close to each other in Aydın (51.82) and Manisa (52.93) provinces. In both provinces, it is explored that the education level of the farmers is concentrated at the primary school level, followed by secondary school, high school, and university graduates. On the other hand, the difference between the groups is not statistically significant ( $P>0.05$ ). Most of the farmers are married, while a smaller number of them live alone (single, divorced, widowed, etc.). The number of household members (3.51-3.79 people), the number of household members participating in the production (1.93-2.16 people), and the number of student members in the household (0.81-0.83 people) are defined. The farming experience of the farmers in Manisa (38.13 years) is higher than that of the farmers in Aydın (30.41 years), and this difference is defined to be statistically significant ( $P<0.01$ ). While 63 farmers in both provinces have non-agricultural income, 37 farmers do not have non-agricultural income.

Table 3. Farmers' education level by the farms

Regions	Primary school (n)	Secondary school (n)	High school (n)	University (n)	Mann Whitney U	P
Aydın	51	24	13	12	4867.500	0.722
Manisa	57	13	18	12		
Total	108	37	31	24		

Table 4. Farming experience of the farmers

Regions	Farming experience (year)	Mann Whitney U	P
Aydın	30.41	2678.000	0.009***
Manisa	38.13		

\*, \*\*, \*\*\* denotes statistically significance level at  $P<0.10$ ,  $P<0.05$ ,  $P<0.01$ , respectively.

At this stage of the study, the distribution of products grown on the farms is evaluated (Table 5). In general, it is defined that fig areas in Aydın and vineyards in Manisa provinces are more

intense in the farms. While the average size of the vineyard land in the farms is 31.21 decares, the size of the fig land is determined to be 20.48 decares.

Table 5. The distribution of products grown in the farms by the regions

Crop pattern in the farms	Unit	Aydın	Manisa
Number of farms with vineyard land	n	-	96
Vineyard land size	da	-	31.21
Number of farms with fig land	n	48	-
Fig land size	da	20.48	-
Number of farms with olive land	n	55	25
Olive land size	da	26.08	8.06
Number of farms with walnut land	n	1	2
Walnut land size	da	4	8.25
Number of farms with chestnut land	n	1	1
Chestnut land size	da	1.70	2.00
Number of farms with cherry land	n	-	3
Cherry land size	da	-	4.33
Number of farms with apple of paradise	n	-	1
Apple of paradise size	da	-	5.00
Number of farms with peach	n	1	-
Peach land size	da	10.00	-
Number of farms with citrus	n	2	-
Citrus land size	da	12.50	-
Number of farms with cotton	n	31	-
Cotton land size	da	88.94	-
Number of farms with trifolium	n	20	1
Trifolium land size	da	22.95	30.00
Number of farms with vetch	n	1	1
Vetch land size	da	40.00	18.00
Number of farms with barley	n	3	1
Barley land size	da	23.33	15.00
Number of farms with wheat	n	40	-
Wheat land size	da	35.06	-
Number of farms with corn	n	47	-
Corn land size	da	35.43	-
Number of farms with potatoes	n	1	-
Potatoes land size	da	150.00	-
Number of farms with sunflower	n	4	-
Sunflower land size	da	52.25	-
Number of farms with triticale	n	1	-
Triticale land size	da	15.00	-
Number of farms with ryegrass	n	3	-
Ryegrass land size	da	20.00	-
Number of farms with caramba	n	1	-
Caramba land size	da	18.00	-
Number of farms with vegetable	n	5	-
Vegetable land size	da	8.20	-



The fig is the ‘Sarılop’ dried fig variety, which is grown intensively in Aydın province. It is explored that olive groves in both provinces are grown relatively more intensively than other products. Interestingly, while cotton is not included in the product pattern in the farms in Manisa, cotton is grown in 31 farms in Aydın, and the average cotton parcel size was 88.94 decares.

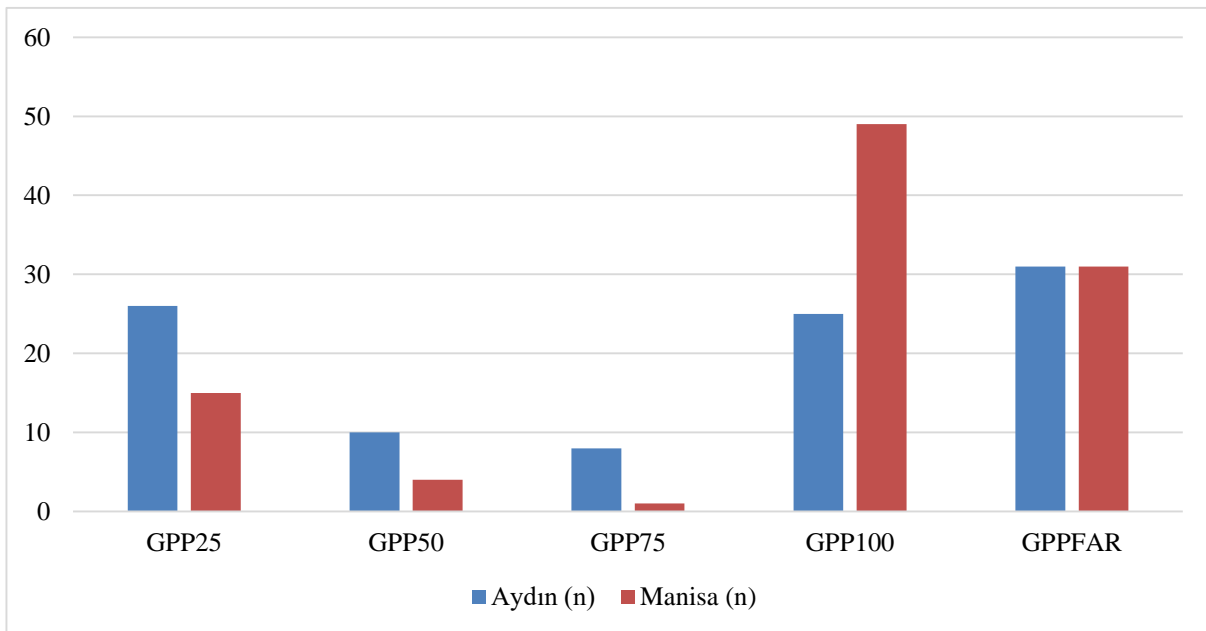
The farms produced ryegrass and caramba as fodder plants, on the other hand, are found to be included in the product patterns of farms where livestock is made to a certain extent, especially in Aydın province in recent years. It is determined that the production of these forage crops in Aydın and Manisa provinces has gained a significant development in recent years. Again, while there is a certain level of corn cultivation area in the farms in Aydın, interestingly, it is clarified that there is no corn cultivation in the farms in Manisa.

The distances of the operating lands to the nearest GPP have been determined (Graphic 1). Of the farms surveyed; 31 of 100 farms in Aydın province, nearly all their agricultural lands are in areas far from GPPs (more than 1 km). There are 31 farms in this position in Manisa. While it is

determined that all of the 49 farms in Manisa (100%) of the total operating lands are very close to the GPP (up to 1 km away), there are 25 farms in this location in Aydın. When evaluated in general, it is defined that 2/3 of the farms in Aydın and Manisa provinces, and most of their lands, are located very close to the nearest GPP. Thus, it is foreseen that the results to be obtained from this study can provide as accurate inferences as possible in the evaluations of the producers' GPP activities regarding agricultural production systems.

Most of the farmers stated that there are significant decreases in yield and quality in the above-mentioned agricultural products in the last 10 years. On the other hand, it is discovered that the decreases in the prices of these products are less than the decreases in yield and quality. Of course, it would not be correct to attribute the decreases, especially in yield and quality to GPP activities as they are. Climate change, the period and the nature of the agricultural operations carried out by the farmer can also cause significant effects on these parameters.

Graphic 1. The distances of the operating lands in the farms to the nearest GPP



The attitudes and thoughts of the farmers operating in the two regions on some issues related to GPP activities are evaluated in detail below (Table 6). In this part of the study, since there is no significant difference in the analyzed parameters according to the provinces and the proximity of the lands to the GPP, general evaluations are performed. In general, most of the farmers stated that "*GPP is an important renewable energy source*", and "*GE should be used for electricity generation*". This finding approved that the farmers believe GPPs have important roles, especially in electricity generation. These approaches are very important and that their evaluation together and separately has a unique importance in terms of economic, sociological, and sustainability. Although GPPs increase the employment level in the region at a certain level, this increase is not at the desired level. The majority of farmers agree with the following statements: "*It is thought that the GPP activities are effectively controlled*", "*It is foreseen that the GPPs have re-injection activities*", "*It is thought that the lands used by the GPP do not pose a negative impact on the use of the neighboring agricultural lands*", "*The lands on which it is located do not constitute a negative effect in terms of the use of occupied lands*". On the other hand, it is observed that the following expressions differed significantly. "*Geothermal energy can be used effectively in agricultural activities such as greenhouse cultivation*", "*Geothermal energy can be used in urban heating as well as electricity generation*", "*Common decisions can be taken by holding meetings with all stakeholders related to GPP*", "*GPP activities and a comprehensive data bank containing all the data related to agricultural production can be created*", "*This data bank to be obtained can be created under the coordination of the relevant units of Aydın Adnan Menderes University*". It is explored that the majority of them have a positive attitude towards their statements and they believe that the studies on this subject are beneficial.

#### **4. CONCLUSION**

As a result, it is defined that the majority of the farmers in Aydın and Manisa provinces believe

that GE has important contributions to electricity production and that its use in modern agricultural systems such as greenhouse cultivation and city heating will be very beneficial.

On the other hand, the farmers believe that there has been a significant decrease in the yield and quality of perennial plants such as figs, vineyards, and olives, as well as some annual plants such as cotton and corn, in the agricultural lands near GPP in the last ten years. In addition, it is stated that the inspections made in the GPP are not effective enough. To prevent agricultural production from being damaged by the GPP activities, the inspections of the GPPs should be adequately and effectively controlled. To ensure that the control mechanisms that control the GPPs carry out their controls in accordance with their place, it is necessary to carry out additional controls by the relevant units in the region. To put it briefly; GPP controls should be carried out not by a single institution, but by several related institutions, and these controls should be carried out in certain periods. The results obtained as a result of the controls should be archived by the relevant institutions and universities in the region. It should be shared with the local people at certain times and/or if deemed necessary. Data on productivity, quality and price parameters obtained from agricultural products grown in the region should be monitored and analyzed periodically. Again, data such as the amount of electrical energy production obtained from the GPP, the amount of toxic gas released into the air, the amount of water released to the soil should be obtained and evaluated. This created database, analysis and evaluations should be periodically shared with the people of the region and all stakeholders.

Periodic meetings should be held to inform the local people and listen to them problems, with the local administrative chiefs of the region, the members of the relevant ministries, the people in the relevant departments of the universities and the leading farmers. It is foreseen that a more sustainable environment will be created in terms of agricultural production if a system is created in which the producers are also taken into consideration while carrying out GPP activities.

Table 6. The attitudes and thoughts of the farmers operating in the two regions on some issues related to GPP activities

Statements	1		2		3		4		5		Total		Mean	Standard deviation
	n	%	n	%	n	%	n	%	n	%	n	%	$\bar{x}$	$\sigma$
GE is an important renewable energy source	71	35.50	16	8.00	12	6.00	71	45.50	30	15.00	200	100.00	2.86	1.56
GE should be used for electricity generation	60	30.00	21	10.50	2	1.00	71	35.50	46	23.00	200	100.00	3.11	1.61
GPPs do not have a negative impact on agricultural products	154	77.00	25	12.50	4	2.00	11	5.50	6	3.00	200	100.00	1.45	0.99
GPPs do not have a negative effect on animal production	98	49.00	21	10.50	43	21.50	35	17.50	3	1.50	200	100.00	2.12	1.24
GPPs do not have negative effects on human health	158	79.00	23	11.50	5	2.50	11	5.50	3	1.50	200	100.00	1.39	0.90
GPPs do not have a negative impact on environmental health	161	80.50	24	12.00	3	1.50	6	3.00	6	3.00	200	100.00	1.36	0.90
GPP has an employment-increasing effect	92	46.00	16	8.00	6	3.00	61	30.50	25	12.50	200	100.00	2.56	1.59
GPP has an economic activity and income-increasing effect in that region.	124	62.00	23	11.50	8	4.00	28	14.00	17	8.50	200	100.00	1.96	1.41
GPP activities are effectively controlled.	153	76.50	16	8.00	15	7.50	7	3.50	9	4.50	200	100.00	1.52	1.07
GPP carries out re-injection activities	106	53.00	19	9.50	16	8.00	36	18.00	23	11.50	200	100.00	2.26	1.52
The lands used by the GPP do not pose a negative impact on the use of neighboring agricultural lands	151	75.50	24	12.00	6	4.00	15	7.50	4	2.00	200	100.00	1.49	1.00
The lands used by the GPP do not pose a negative impact on the use of occupied lands.	142	71.00	22	11.00	8	4.00	22	11.00	6	3.00	200	100.00	1.64	1.16
GE can be used effectively in agricultural activities such as greenhouse cultivation	23	11.50	4	2.00	6	3.00	39	19.50	128	64.00	200	100.00	4.23	1.32
GE can be used for city heating as well as electricity generation	22	11.00	7	3.50	2	1.00	56	28.00	113	56.50	200	100.00	4.16	1.30
Various enlightening meetings can be held within a year with the participation of stakeholders such as GPP company managers, relevant public institution officials, manufacturer representatives, and local people	19	9.50	4	2.00	2	1.00	34	17.00	141	70.50	200	100.00	4.37	1.23
A database can be created where all agricultural data in the region and data to be obtained from GPPs are collected	15	7.50	5	2.50	4	2.00	16	8.00	160	80.00	200	100.00	4.51	1.16
The data bank to be obtained from GPPs can be created under the coordination of the relevant units of Aydın Adnan Menderes University	16	8.00	5	2.50	0	0.00	13	6.50	166	83.00	200	100.00	4.54	1.17

1: I totally disagree 2: I disagree 3: I have no idea 4: I agree 5: I totally agree

## Ethics Committee Approval

Ethics committee approval was obtained according to the decision no. 10 of Aydın Adnan Menderes University, Social and Human Sciences Research Ethics Committee on 21.10.2020

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