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Use of Renewable Energy in Agriculture in Terms of Sustainability: Hatay/Turkey Example

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ABSTRACT

The aim of this study was to investigate the use of renewable energy in agriculture and environmental sustainability. Data was obtained with a face to face survey from 120 farmers whom selected randomly from the districts of Hatay province. The Kolmogorov-Smirnov test was used to analyze whether the numerical variables fit the normal distribution or not. Kruskal-Wallis test was used for nonparametric data. The variables found to be significant in the Kruskal- Wallis test were interpreted by using the Mann-Whitney U test. It is found out that age, education level, farm size, total energy cost and income of farmers had a significant relation between groups. Also, differences were identified between farmers' opinions about the use of renewable energy sources and their agricultural practices. Energy is one of the most expensive inputs in agricultural production (especially in irrigation) in the region. The annual total energy amount of the farmers was ₺48.991,60. The total cost of energy affects farmers' information resources. Big farms have a high level of technology use. As a result, the importance of agriculture, energy, environmental protection and sustainability has been evaluated and related recommendations were developed for the region.

Key words: Agriculture, environment, renewable energy, sustainability, Hatay.

Sürdürülebilirlik Bakımından Tarımda Yenilenebilir Enerji Kullanımı: Hatay/Türkiye Örneği

ÖZ

Bu çalışmanın amacı, yenilenebilir enerjinin tarımda kullanımı ve çevresel sürdürülebilirliğini araştırmaktır. Veriler Hatay ili ilçelerinden rastgele belirlenen 120 üretici ile yüz-yüze anket çalışması ile elde edilmiştir. Sayısal değişkenlerin normal dağılıma uygunluğunu analiz etmek için Kolmogorov-Smirnov testi kullanılmış olup, parametrik olmayan veriler için Kruskal-Wallis testi uygulanmıştır. Kruskal-Wallis testi sonucunda anlamlı bulunan değişkenler Mann-Whitney U testi yapılarak yorumlanmıştır. Elde edilen bulgulara göre; üreticilerin yaş, eğitim seviyesi, işletme arazi genişliği, toplam enerji maliyeti ve işletme gelir grupları arasında önemli bir ilişki olduğu belirlenmiştir. Ayrıca üreticilerin yenilenebilir enerji kaynağı kullanımına yönelik düşünceleri ve tarımsal uygulamaları hakkında farklılıklar tespit edilmiştir. Bölgede enerji, tarımsal üretimin (özellikle sulamada) en yüksek maliyetli girdilerindendir. Üreticilerin yıllık toplam enerji tutarı ortalama ₺48.991,60'dir. Üreticilerin toplam enerji maliyetinin bilgi kaynaklarını etkilediği; büyük ölçekli çalışan işletmelerin teknoloji kullanım düzeyinin daha yüksek olduğu görülmüştür. Sonuç olarak; tarım, enerji, çevre koruma ve sürdürülebilirliğin önemi değerlendirilmiş olup, bölgenin ihtiyaçları doğrultusunda öneriler geliştirilmiştir.

Anahtar kelimeler: Yenilenebilir enerji, tarım, sürdürülebilirlik, çevre, Hatay.

INTRODUCTION

Agriculture is the first economic activity in the whole world. It has the feature of meeting many needs in terms of usage areas. With the increasing energy demand in the world, agricultural products and agricultural wastes used in energy production are of great importance today. In terms of the sustainability of agricultural activities, it is necessary to consider agriculture and the environment as a whole (Kaya and Bostan Budak, 2022).

Sustainability is the ability to operate continuously. It involves depleting the essential resources of the ecosystem and protecting the environment (Peterson et al., 2000). It is the abandonment of practices that will negatively affect future generations. The economic and social needs of the society must be met in environmental integrity. It also requires the protection of resources.

Industry creates economic, sociological and environmental problems. People, countries and even all living things in the world pay the price.

Today; agriculture is holistic and multi-dimensional with biological, economic, environmental, social and political aspects. Sustainable agricultural practices offer new approaches that reduce or eliminate the negative effects of the sector and modern methods. It evaluates the problems as a whole (Mollavelioğlu, 2009; Panwar et al., 2011). Sustainable agriculture is based on the protection of soil, water, energy and the environment (Açıksöz and Memlük, 2004). There is a minimization of input usage and optimum efficiency (Kaya et al., 2011). Foods with high nutritional value are important for a sustainable society. For this reason, agricultural activities concern societies that produce and consume in terms of sustainable environment (Ridgeway, 2007; Demir et al., 2015).

One of the strategic components of countries is to reduce excessive energy use in agricultural activities (electricity, oil, etc.). Sustainability is required with local renewable energy sources. Renewable technologies are known to be clean energy sources. With the optimal use of these resources, the waste and environmental impact is minimal (Panwar et al., 2011). With economic growth, the need for energy also increases in Turkey. Most of these energies are primary energies that have harmful emissions to the environment. This situation creates a disadvantage in the vision of a sustainable economy (Durgun and Durgun, 2018). Energy resources are examined in two groups according to their use and convertibility (Koç et al., 2013; Yağlı et al., 2016). Exhaustible energy are resources that have a certain reserve and are predicted to disappear in the future (Ataman, 2007). Inexhaustible energy, on the other hand, is an energy source with a bright future and open to continuous use (Khalil, 2012). Renewable energy production supports efficient and sustainable use. The use of renewable energy facilitates daily activities. It improves the livelihoods of small farms. It ensures effective use of local natural resources. New policies are required to increase the use of renewable energy (Winkler, 2018).

This study raises awareness for efficient resource use. According to the recommendations, the available output amounts are obtained by using less input. It is foreseen that there will be an increase in individuals who are more sensitive to the environment and social interests. The needs of the increasing population are met with efficient use of resources. Also the level of input used is high in agriculture. Thus, increasing input costs are challenging farmers in respect of sustainability. In this context, the energy used is a serious cost component. It causes disruption and decrease in agricultural activities. In addition, chemical inputs used in agriculture have negative effects on the environment. All these effects necessitate the sustainability of agriculture and environment.

Energy, which is a high-cost input to the agricultural sector, is an important problem in production. Reducing production costs for sustainable agriculture is a common problem of the whole world. Environment, supply security and cost factors are among the main objectives of energy policies.

The aim of this study was to investigate the use of renewable energy in agriculture and sustainability.

MATERIALS and METHODS

The Mediterranean Region is of strategic importance for Turkey. It has important contributions to the national economy. The main material of the research has been determined purposefully from the province of Hatay located in the Eastern Mediterranean Region. Primary data (survey and researcher observations) collected from farms were used. In addition, secondary data were also used on the subject.

Individuals are determined according to the farmer lists in the Hatay Directorate of Provincial Agriculture and Forestry. In 2019, a total of 19 887 (the number of farmers 21 000 in 2022) farmers are registered in the Farmer Registration System. These farmers have a total growing area of 1 228 930,49 decares. Agricultural activities are carried out intensively in Hatay. Altınözü, Kırıkhan and Antakya districts stand out in respect of the number of farmers (46.94% of total farmers). Kırıkhan, Reyhanlı, Antakya and Altınözü districts (68.57% of total area) are districts with wide growing areas.

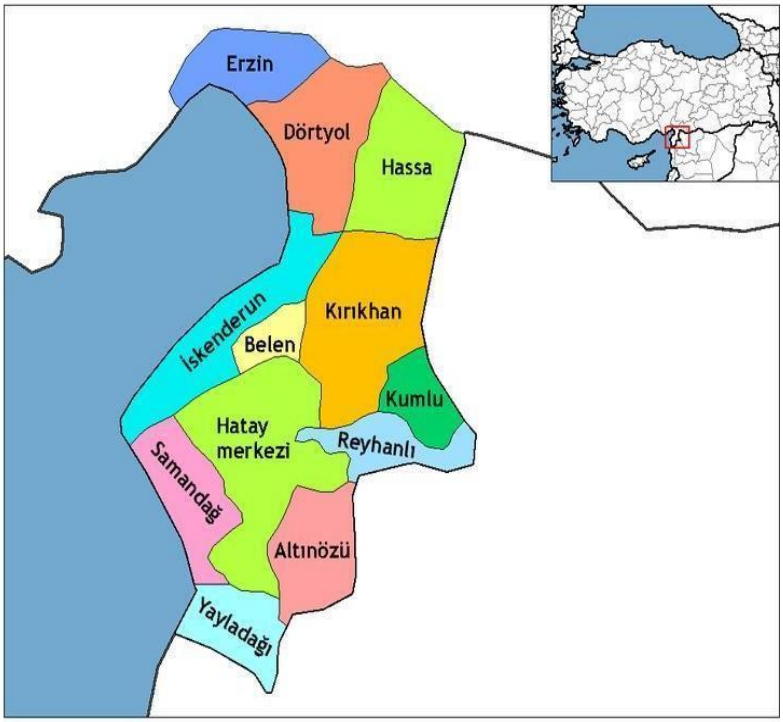

Figure 1. Location of study (Anonymous, 2021)

The study area is suitable for agriculture in respect of climate and soil. It allows more than one crop to be grown in a year. Since it is at the border, it is possible to market the products to neighboring countries. The survey forms prepared were subjected to pre-test. Field observations and group interviews were used to develop the data set. In the study, the views of the farmers on the use of renewable energy resources in agriculture were examined.

In the study, farmers were determined by sampling. A survey was applied randomly with 120 farmers. The determined research area has an important place in the agriculture sector in Turkey. There has been an increase in the adoption of innovations in recent years. The following formula was used to determine the sample volume (Çiçek and Erkan, 1996).

$$n = N(p*q)/(N-1)D^2+(p*q)$$

In the equation;

n= sample volume, N= number of units, p= probability, q= 1-p, D= (d/t), D= deviation from the mean, t= confidence interval definitions.

The methods were chosen for the purposes of the study. Analyzes were made using the SPSS package program. Different statistical analyzes were applied according to the aims of the study. The Kolmogorov-Smirnov test was used to analyze whether the numerical variables fit the normal distribution or not. Kruskal-Wallis test was used for nonparametric data. The variables found to be significant in the Kruskal-Wallis test were interpreted by using the Mann-Whitney U test. The Kruskal-Wallis test is the nonparametric equivalent of one-way analysis of variance (One-Way ANOVA) between groups. Compares three or more groups with continuous variables (Kalaycı, 2016).

RESULTS and DISCUSSION

The individuals participating in the study are generally farmers within the active population. Young people are less engaged in agriculture. This situation shows that the confidence in the agricultural sector has decreased in the region. Due to the high input costs, the new generation has turned to different work areas. With the increasing level of education in the region, they are encouraging their children to university.

In the study, it has been determined that approximately 55% of the farmers have a high school or higher education level, and 80% of them keep farm records. The increase in the education level of farmers has also affected the use of computers and the internet. While nearly half of the farmers could use computers, nearly 70% of them have internet access (Table 1). They were determined to use mass media mostly for weather and information purposes.

Table 1. Farmers' general informations

Variables	Definition	Frequency	%
Gender	Female	8	6.7
	Male	112	93.3
Education	Primary school	53	44.1
	High school	47	39.3
	Graduate	20	16.6
Farm record	Yes	95	79.2
	No	25	20.8
Use of computer	Yes	62	51.7
	No	58	48.3
Internet access	Yes	83	69.2
	No	37	30.8

Field activities are common in the Amik Plain. Farmers' land in this area is wider than the mountain region. The income distribution of the farmers also varies from place to place. The average income of the farmers is determined as ₺309 004,24. The farmers have a high income. However, increasing input costs create difficulties in terms of agricultural activities. Increasing energy costs necessitate the use of renewable energy. It is preferred by the farmers due to its low cost and environmental friendliness. In addition, the energy costs used in agricultural activities are high. This situation has revealed the necessity of utilizing waste on farms. The total cost of energy also affects the knowledge resources of the farmers. The technology usage level of big farms is also high. These farms are more relevant. Knowledge about the farmers and the average values are given in Table 2.

Table 2. Values by farmer groups (age, income, land, cost etc.)

Variables	Definition	Frequency	%	Max	Min	x̄	SD
Age	20-35	11	9.2	78	21	51.86	11.511
	36-50	45	37.5				
	51-65	53	44.1				
	65+	11	9.2				
Out of agriculture income (₺)	10.000-50.000	35	77.7	200 000	10 000	49 200	45 427,57
	50.001-100.000	7	15.6				
	150.000+	3	6.7				
Farm income (₺)	0-100.000	28	23.9	2 410 000	9 000	309 004,24	388 835,31
	100.001-500.000	73	62.4				
	500.001-1.000.000	14	12.0				
	1.000.000+	2	1.7				
Farm size (da)	1-100	48	40.3	1 550	3	211,16	231,84
	101-300	46	38.7				
	300+	25	21.0				
Electricity cost (₺/year)	0-50.000	53	74.6	300 000	1 000	37 895,83	52 723,70
	50.001-100.000	15	21.1				
	100.000+	3	4.2				
Oil cost (₺/year)	0-10.000	65	56.5	200 000	200	20 141,74	31 561,71
	10.001-50.000	43	37.4				
	50.000+	7	6.1				
Energy total cost (₺/year)	0-50.000	77	64.7	500 000	1 000	48 991,60	65 539,81
	50.001-100.000	31	26.1				
	100.000+	11	9.2				

Farmers' perception of renewable energy differs in Hatay. When it comes to renewable energy, about 70% of the farmers stated that solar and solar panels come to mind first. They also argued for the high investment costs. Farmers have stated that there is no information on renewable energy and its use. It is considered to be a great loss not to use renewable energy in the region.

All of the farmers participating in the study use fossil fuels. Farmers do not use renewable energy on the farm. Energy use is intensive in agricultural activities. Especially in irrigation (electricity and oil), it is quite costly. For this reason, electricity and oil costs used in agriculture are also high. Different amounts of energy are used in agricultural activities. The highest energy use was realized in irrigation (x̄=8.02) and soil preparation (x̄=7.14). Used of energy varies according to the soil structure and water condition of the region (Table 3). The

energy cost of the farmers is on average ₺48 991,60 (Table 2). According to the information obtained from the farmers, energy cost constitutes approximately 1/3 of the total cost. Not using renewable energy in agriculture causes an increase in input costs. Boran and Pınar (2013) it was determined that renewable energy supports the efficient use of water resources and agricultural lands. Taşkın and Vardar (2016); Shah et al. (2020) stated that fossil fuels are used as energy in the production, transportation, processing and storage of agricultural products. Also, it reported that fossil fuels cause cost increases and environmental pollution.

Table 3. Use of energy in agriculture

Activities	N	x̄* (mean)	SD	Source of energy (electricity, oil, biofuel etc.)
Soil preparation	92	7.14	1.953	oil
Planting	85	4.72	2.328	oil
Irrigation	81	8.02	2.574	electricity, oil
Care (spraying of pesticide, fertilizer)	84	3.19	2.015	oil
Harvest	76	3.58	2.379	oil
Product processing and evaluation	10	3.50	3.064	electricity, oil
Storage	15	2.07	1.387	electricity, oil
Heating/cooling	5	5.80	3.493	wood, animal turd, oil
In livestock activities	19	4.21	3.066	electricity, oil
Transportation of agricultural products and wastes	80	2.85	1.988	oil

* Each activity is rated with a score of 1-10.

There are sources of knowledge to increase and improve the use of renewable energy. Internet (x̄=3.41), radio and TV (x̄=3.36), experienced users (x̄=2.58) and their own knowledge (x̄=2.78) are the most important for farmers. A Cronbach's Alpha coefficient of 0.78 indicates the reliability of the scale (Table 4). Lale (2016) stated the necessity of ensuring the active participation of individuals. Extension services should be increased through activities such as seminars and promotional brochures. In addition, it emphasized the necessity of sustainable environmental understanding by including non-governmental organizations, professional associations and unions, universities and other public institutions.

Table 4. Knowledge sources on renewable energy

Sources of knowledge	N	x̄	SD	Cronbach's Alpha
Internet	98	3.41	1.698	
Radio, TV	98	3.36	1.575	
My own knowledge	98	2.78	1.489	
Experienced users	98	2.58	1.637	
Printed materials (newspaper, magazine etc.)	98	2.53	1.587	0.78
University/institutes	98	2.28	1.491	
System established firms	98	2.19	1.511	
Provincial and district directorates of agriculture	98	1.83	1.244	
Organizations, agencies etc.	98	1.61	1.109	
Chamber of Agriculture/Unions	98	1.32	0.698	

Scale: 1= not important 2=less important 3=middle 4=important 5= very important

According to study findings, farmers complain that there is no information on the use of renewable energy. Farmers have reported that its use in agriculture is low. However, they are also aware that it will contribute to the ecological balance and the world economy. A Cronbach's Alpha coefficient of 0.76 shows the reliability of the scale (Farmers' views regarding renewable energy). Kurt and Nacar Koçer (2010); Chel and Kaus Selamk (2011) stated that rural areas will experience an increase in welfare along with economic recovery. Khodeir (2016) stated in her study that the use of renewable energy sources has macro contributions in many areas such as economic diversity, employment and sustainable development. Khobai et al. (2020) reported that in addition to macroeconomic contributions, renewable energy consumption has an impact on environmental protection.

Electricity produced with renewable energy could be used in all areas (such as natural lighting, heating, hot water, irrigation, drying). For this reason, it has been found attractive for farmers. It has different usage advantages such as greenhouse heating and irrigation. However, farmers complain about the high cost. More farmers consider it very difficult and costly to install renewable energy systems. There are reasons why farmers

cannot use renewable energy in agriculture. Some of these reasons are lack of infrastructure and raw materials, insufficient financial power, lack of knowledge and land. 60% of the farmers think to produce and use energy in their own farm and to sell the surplus. Some of the farmers also reported the existence of legal obstacles. Taşkın and Vardar (2016) explained that renewable energy sources in agriculture are irrigation with solar energy, spraying, pesticide, greenhouse ventilation, fence system; it was suggested that geothermal energy will be used as greenhouse heating, water extraction with wind energy and dryers with renewable energy.

In addition, approximately 2/3 of them think that there is a limited number of companies and technical staff operating in this issue. More than half of the farmers reported that they do not have sufficient knowledge on the issue. Almost all of the farmers say the knowledge and information is insufficient. In addition, approximately 55% of them stated that their support policies are very insufficient. Also, Kızılaslan and Unal (2015) stated the necessity of legal procedures for incentives and supports in order to increase renewable energy production and consumption. Agyekum (2020) stated that bureaucratic barriers hinder the use of renewable energy.

Single-sample Kolmogorov-Smirnov test was used to decide on statistical analysis. It was observed that the age (K-S(z)=0.066; p>0.05) variable showed a normal distribution. Other variables do not show normal distribution.

Kruskal-Wallis test was used for nonparametric data. This test reveals the difference between groups. The Mann Whitney U test was used to determine which group favored the difference. The views were significant at the 0.05 significance level according to age groups. In other words, the views of the farmers about the use of renewable energy differ according to the age groups (Table 5). Kendirli and Çakmak (2010); Erdal (2011) reported that the use of renewable energy sources will reduce environmental damage.

Table 5. Analysis of age groups

Views	Age groups	N	Rank average	x^2 (Kruskal Wallis)	p	Difference
Clean energy	20-35	11	72.50	8.042	0.045	1-4
	65+	11	45.09			
Decreases rural to urban migration	36-50	45	68.14	10.760	0.013	2-4
	65+	11	33.00			
Maintains the ecological balance	36-50	45	67.21	10.404	0.015	2-4
	65+	11	35.50			
New employment	20-35	11	75.77	14.776	0.002	1-4
	65+	11	44.14			
Regional development	20-35	11	72.05	9.234	0.026	1-4
	65+	11	42.41			
Wind is used in region	20-35	11	72.55	13.883	0.003	1-4
	65+	11	40.36			

Paired comparative Mann Whitney U test results showed that farmers in the 20-35 age group are more knowledgeable than farmers over 65. A significant difference was found between the mean rank of the views on renewable energy. Young farmers know more about innovations. In addition, they are more aware of the advantages of using renewable energy. Young farmers think that renewable energy contributes in its advantages such to issues such as clean energy (U(z)=-2.472; p<0.05), creating new employment areas (U(z)=-2.442; p<0.05) and regional development (U(z)=-2.283; p<0.05). Önal (2020) stated that a sustainable and clean environment is one of the most important elements of its development. Kaya and Bostan Budak (2022) it was determined that most of the farmers support the use of renewable energy in agriculture. However, the number of farmers who think that agricultural products should be used for nutritional purposes is at a considerable level.

CONCLUSION and RECOMMENDATIONS

Energy contributes significantly to the development of countries. There are serious differences between developing countries and developed countries in this regard. Countries with insufficient energy resources are dependent on foreign and import them. Supply security, environment and creating employment with different cost factors are among the main objectives of energy policies. It is also a serious cost component in agricultural

activities. It is the most costly input of the agricultural sector. For sustainable agriculture, production costs must be reduced in Turkey. Actually, this issue is the common problem of the whole world.

There is an important relationship between the adoption and use of innovations by the farmers and their research opportunities. The use of radio, TV, internet, printed materials (newspapers, magazines, etc.) is higher by young farmers. In addition, young farmers have a higher rate of technology usage and adoption of innovations. This situation has affected the views of the farmers on the use of renewable energy. Young farmers are more knowledgeable about renewable energy. Young farmers know a little about the advantages and disadvantages of agriculture. They are also more sensitive in terms of the negative consequences of fossil fuel consumption. Environmental awareness is also higher in young farmers.

Farm size groups have an effect on the knowledge sources used by the farmers. In addition, energy costs such as electricity and oil used by farmers have increased according to the farm size groups. Big farms have more information about renewable energy. They also adopt innovations more quickly. Technology use is also high in big farms. The problem is the insufficient land availability in respect of renewable energy use for small farms (between 1-100 decares). Depending on the production area, energy costs also increase. Therefore, the use of renewable energy is a necessary need for farms. It also reduces the use of fossil fuels, which is threatened with extinction. Due to its low cost and environmental friendliness, farmers prefer policies for their use in agriculture.

- ✓ Education programs for renewable energy sources should be organized and extension activities should be accelerated.
- ✓ Project studies should be carried out through voluntary farmers.
- ✓ Legal procedures should be facilitated regarding renewable energy.
- ✓ Effective policies in energy supply should be developed in agriculture.
- ✓ The limited number of officials should be increased by providing firm and investor support. Farmers' concerns about the company and risk factor should be eliminated.
- ✓ Production of domestic equipment and increased productivity should be ensured. Also, efficient use of resources should be supported.

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