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Research Article

Biogas Energy Awareness of Livestock Farmers: The Case of Çanakkale Province

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Abstract

The energy needed in the world is met from fossil sources or renewable energy sources. Renewable energy sources consist of sources that can feed themselves. Humans produce waste material during both production and consumption.

Most of the wastes are organic-based wastes with energy potential. It is possible to produce bioenergy from organic-based waste. In addition to being one of the renewable energy sources, biogas energy provides waste recycling. It is a lower cost energy and fertilizer source compatible with nature. As a result of biogas production, the factors that threaten the environment and human health disappear. In addition, organic wastes do not disappear after the process and turn into valuable organic fertilizer. This study was carried out in Örtülüce village of Biga district, where livestock enterprises are the most in Çanakkale. In the research, the awareness of livestock farmers about biogas energy was examined. According to the findings obtained from the study, 25.3% of the farmers believe that only electricity is produced from biogas, 17.8% know that biogas energy production facilities pollute the environment. On the other hand, 97.3% of the farmers have heard of the concept of biogas before. Also, 49.31% of farmers are willing to participate in biogas investments. Age, level of education, and internet use are found to be influential in farmers' decisions.
Keywords: Farmer, Biogas, Awareness, Logistic Regression, Çanakkale

Hayvancılık İşletmelerinin Biyogaz Enerjisi Farkındalığı: Çanakkale İli Örneği

Öz

Dünyada ihtiyaç duyulan enerji fosil kaynaklardan ya da yenilenebilir enerji kaynaklarından karşılanmaktadır. Yenilenebilir enerji kaynakları kendi kendilerini besleyebilen kaynaklardan oluşmaktadır. İnsanlar hem üretim hem de tüketim sırasında atık madde üretirler. Atıkların çoğu, enerji potansiyeli olan organik bazlı atıklardır. Organik bazlı atıklardan biyoenerji üretmek mümkündür. Biyogaz enerjisi yenilenebilir enerji kaynaklarından biri olmasının yanı sıra atıkların geri dönüşümünü de sağlamaktadır. Doğayla uyumlu daha az maliyetli bir enerji ve gübre kaynağıdır. Biyogaz üretimi sonucunda doğayı ve insan sağlığını tehdit eden faktörler ortadan kalkmaktadır. Ayrıca organik atıklar işlemden sonra kaybolmaz ve değerli bir organik gübreye dönüşür. Bu çalışma Çanakkale ilinde hayvancılık işletmelerinin en fazla olduğu Biga ilçesi Örtülüce köyünde gerçekleştirilmiştir. Araştırmada hayvancılık yapan çiftçilerin biyogaz enerjisi konusundaki farkındalıkları incelenmiştir. Araştırmadan elde edilen bulgulara göre, çiftçilerin %25,3'ü biyogazdan sadece elektrik üretildiğini, %17.8'i biyogaz enerji üretim tesislerinin çevreyi kirlettiğini bilirken, çiftçilerin %97.3'ü biyogaz kavramını daha önce duymuştur. Çiftçilerin %49.31'i biyogaz yatırımlarına katılma konusunda isteklidir. Çiftçilerin bu kararlarında yaş, eğitim düzeyi ve bilgiye ulaşmada internet kullanımı etkili bulunmuştur.
Anahtar Kelimeler:. Çiftçi, Biyogaz, Farkındalık, Lojistik Regresyon, Çanakkale

Introduction

As long as human civilization has existed, it has needed an energy source. With the agricultural revolution, people can access the energy they need to live more efficiently. Villages and towns were created with the energy they obtained through agricultural production, and their basic needs were procured. With the beginning of procurement, the basic needs and ideas emerged. Human civilization with access to energy has advanced in the fields of art and science.

Before the industrial revolution, the energy source used in the production with simple tools and the participation of a small number of people was muscle strength. After the industrial revolution, production started to be done with machines working with heat energy. In this period, the production was carried out with steam machines using the heat energy obtained from burning coal (Günay, 2002). The realization of the industrial revolution led human civilization to seek more energy than the agricultural revolution, and the detection and use of fossil fuels in the world increased. When the heat energy obtained from coal was not enough, other fossil energies such as oil and natural gas began to be used over time. Human civilization began to use these energies and the products produced from these energies intensively. In today's life, human society primarily supplies energy from fossil sources (IEA, 2012). The damage caused by fossil energy sources to the atmosphere and nature, and the greenhouse gases they cause, especially carbon, affect our atmosphere and, therefore our climate (Abdeshahian *et al*., 2010; Abdeshahian *et al*., 2016).

Fossil energy sources, which change the living spaces of living things as waste and climatically, are also the primary source of global warming. Climate changes after global warming have damaged the habitats of animals on a micro and macro scale. Due to global warming, which affects the coasts of many countries, especially polar regions, the melting of glaciers becomes unstoppable with the continued use of fossil energy sources. The amount of carbon dioxide resulting from the use of fossil energy sources is increasing in the atmosphere. CO_2, around 280 ppm in the atmosphere in 1750, reached 380 ppm in 2005 and 410 ppm in 2019 (Lindsey, 2020). Instead of fossil energy sources, renewable energies compatible with nature should be used.

The positive aspects of choosing renewable energy sources are: obtaining multiple alternative fuel types, decreased dependence on a single energy source, the decrease in the cost of the energy offered for consumption due to the increasing energy resources, and providing import substitution in countries that are poor in fossil energy resources. Being an energy source that does not cause health problems and does not produce waste compared to non-renewable energy sources, the renewable energy sources have positive effects on environmental pollution, water, and air pollution and provides new employment areas (Ploetz et al.,2016).

There is a strong link between climate change and renewable energy. As the share of use of renewable energy sources increases, the use of fossil-based non-renewable fuels will decrease, and it will provide an opportunity to prevent any damages, including harmful gas emissions. Fossil energies are formed due to some thermodynamic activities under the layers of organic-based wastes millions of years ago. The accumulation of organic matter continues today.

Plant and plant wastes, household wastes, garden wastes, forest, and paper industry wastes, food wastes, vegetable products, animal production, textile and leather, domestic and workplace organic wastes, treatment plant wastes, etc. inert and residual organic materials accumulate in significant amounts today. The way to combat these organic wastes and benefit from them is through biogas energy. Human civilization and other living things on earth are constantly producing organic waste. People, especially farms, make tons of organic waste daily. The amount of waste collected by municipal dumps in our country in 2020 is 32.3 million tons (Turkish Statistical Institute, 2022).

As a result of plant and animal production, tons of waste and waste materials are produced. Biogas plants can be used to recycle waste from organic matter, including nutrients (Kougias and Angelidaki, 2018). It is known that especially animal production wastes contain a significant amount of harmful gases to the atmosphere, especially methane gas. These organic-based animal wastes are processed using their natural structures thanks to the biogas plants. As a result of these processes, gas and heat energy from organic materials can be used in electricity generation, while the coarse material can be used as an organic burnt soil fertilizer. Biogas technology provides waste recovery. In addition to being environmentally friendly, it produces relatively affordable fertilizers and energy.

It ensures that the smell of animal manure is eliminated after the biogas production processes In addition, harmful organisms that threaten human health and the environment disappear. After the biogas energy production activity, the wastes do not disappear, and they turn into organic fertilizer, which is one of the most critical agricultural inputs. Its versatility makes biogas energy preferable to many countries. It is estimated that by 2050, more than 25% of the energy that will be actively used in the world will originate from biomass (Hosseini and Wahid, 2016).

The organic fertilizer obtained after biogas energy production processes and the recycling of inert and waste organic materials into agricultural production is a good example of a renewable and

nature-friendly agriculture target. This study was carried out in Örtülüce village of Biga district, where livestock enterprises are the most in Çanakkale. The survey study examined the livestock farmers' awareness about biogas energy.

Material and Method

Örtülüce village, located in Biga district, is the village with the highest number of livestock farmers in Çanakkale. There are 233 agricultural farmers engaged in animal husbandry in Örtülüce village (Çanakkale Provincial Directorate of Agriculture and Forestry, 2021). The livestock farmers in Örtülüce village, chosen purposefully, constituted the research population, and the sample size for the said population was determined according to the formula (equality 1) below (Newbold, 1995). With the 95% confidence interval and 0.05 margin of error, the sample size was found to be 146 (equality 2).

$$n = \frac{N*\mathrm{p}*\mathrm{q}}{(\mathrm{N}-1)*\sigma^2\mathrm{p}+\mathrm{p}*\mathrm{q}} \quad (1)$$

$$n = \frac{233(0.5)(0.5)}{(233-1)\cdot(0.02551)^2+(0.5)\cdot(0.5)} = \frac{58.25}{0.40} = 145.62 \sim 146 \quad (2)$$

n = number of farmers engaged in animal production in the sample
N = Population size
p = population ratio

In the research, basic descriptive statistics were used to reveal the socio-economic status, business characteristics and biogas awareness of the farmers. Farmers' willingness for biogas was tested with logistic regression analysis. Logistic regression: is a method used to determine the cause-effect relationship with explanatory variables in cases where the response variable is observed categorically in double, triple, and multiple categories (Özdamar, 2013).

Results and Discussion

Demographic Profiles of The Farmers and Agricultural Structures of The Farms

The average age of the farmers interviewed within the scope of the study is 44, and their education level is mostly primary school (49.3%). The average general agricultural experience is 24 years. 78.8% of the interviewed farmers attended a meeting about agriculture in the last three years. 84.2% of the farmers use the internet to access knowledge. 80.1% of the farmers have tractors. Annual agricultural incomes of 83.6% of the farmers are below 50000 TRY. 81.5% of the farmers have non-agricultural income (Table 1).

Table 1. Socio-Economic Characteristics

Criteria	n	%
Age (Year)		
≤44	70	47.9
>44	76	52.1
Min:18, Max:68, Mean:43.54, Std. Deviation:12.4		
Educational Status		
Literate but not graduated	3	2.1
Primary school	72	49.3
Middle School	22	15.1
High school	26	17.8
University	23	15.8
General Agricultural Experience (Years)		
≤23	72	49.3
>23	74	50.7
Min:2, Max:50, Mean:23.53, Std. Deviation:12.84		
Attendance at an Agricultural Meeting in the Last 3 Years		
Attending the meeting	115	78.8
Not attending the meeting	31	21.2
Internet Use in Accessing Knowledge		
Internet user	123	84.2
Not using internet	23	15.8
Non-Farm Income Status		
Yes	119	81.5
No	27	18.5
Annual Agricultural Income (TRY)		
0 to 10,000	30	20.5
10,001 to 20,000	23	15.8
20,001 to 30,000	26	17.8
30,001 to 40,000	24	16.4
40,001 to 50,000	19	13.0
50,001 to 100,000	12	8.2
100,001 to 150,000	10	6.8
150,001 to 200,000	2	1.4
Tractor asset		
Tractor owner	117	80.1
Doesn't own a tractor	29	19.9

It was determined that 86.3% of the farmers interviewed within the scope of the study were engaged in cattle farming and 13.7% in sheep and goats (Table 2).

Table 2. Types of farms

Farming type	n	%
Cattle Farming	116	79.45
Sheep and Goats	20	13.7
Cattle + Sheep and Goats	10	6.85
Total	146	100.00

The average number of animals in cattle breeding farmers was determined as 19 heads. The number of cattles in 59.5% of the holdings was below the average, and the number of animals in 40.5% was above the average (Table 3).

Table 3. Cattle assets

Cattle asset (Number)	n	%
≤19	75	59.5
>19	51	40.5
Min:3, Max:77, Mean:18.95, Std. Deviation:15.72, Total:126		

According to data, 30 farmers are engaged in farming of sheep and goats. While 23.3% of them raise more than 57 sheep and goats, 76.7% raise 57 heads or fewer sheep and goats (Table 4).

Table 4. Ovine animal existence

Sheep and Goats asset (Number)	n	%
≤57	23	76.7
>57	7	23.3
Min:1, Max:250, Mean:57.47, Std. Deviation: 64.22, Total :30		

Biogas Awareness of The Farmers

To determine the awareness level of the farmers engaged in animal production on the concept of biogas, the thoughts and general knowledge levels of the farmers about the concept of biogas were investigated.

The survey study revealed that almost all (99.3%) of the farmers know that energy was produced from animal wastes (Table 5).

Table 5. Farmers' knowledge of energy production from animal waste

Criteria	n	%
Farmers who know	145	99.3
Farmers who don't know	1	0.7
Total	146	100.0

According to Table 6, 2.7% of the farmers stated that they had not heard of the concept of biogas before. It was determined that 97.3% of the farmers had heard of the concept of biogas before.

According to a study conducted in Portugal, the type of energy that the society has the least knowledge of is biomass energy (Ribeiro et al. 2014). According to a study conducted with university students on renewable energy awareness, university students' awareness of renewable energy is at a low level (Assali et al. 2019). Similarly, according to the results of various studies, the knowledge level of the public, teachers, students, and farmers on renewable energy is generally low (Assali et al. 2019; Durmuş et al. 2021; İpekoğlu et al. 2014; Kardooni et al. 2018; Saraç and Bedir, 2014; Yıldırım and Everest, 2020).

Table 6. Farmers' knowledge of biogas

Criteria	n	%
Farmers who know	142	97.3
Farmers who don't know	4	2.7
Total	146	100.0

97.3% of the farmers know that energy can be produced from organic waste, and 2.7% of the farmers do not know this (Table 7).

Table 7. Farmer's knowledge on bioenergy production from organic waste

Criteria	n	%
Farmers who know	142	97.3
Farmers who don't know	4	2.7
Total	146	100.0

It has been found that 66.4% of the farmers engaged in animal production think that bioenergy production can reduce the amount of CO_2 in the atmosphere if applied under appropriate conditions, and 33.6% think that it cannot reduce it (Table 8).

Table 8. If bioenergy production is applied under suitable conditions, the amount of CO_2 in the atmosphere may decrease

Criteria	n	%
Yes	97	66.4
No	49	33.6
Total	146	100.0

It has been observed that only 17.8% of the farmers think that biogas energy production facilities pollute the environment, and 82.2% think that they do not pollute the environment (Table 9). According to Cebeci (2018), renewable energy production is an example of an environmentally friendly enterprise.

Table 9. Biogas plant pollutes the environment

Criteria	n	%
Yes	26	17.8
No	120	82.2
Total	146	100.0

While 25.3% of the farmers think that only electrical energy emerges after the processes in the biogas plants, 74.7% do not agree with this statement (Table 10).

Table 10. After the processes in the biogas plant, only electrical energy is generated

Criteria	n	%
Yes	37	25.3
No	109	74.7
Total	146	100.0

While 71.2% of the farmers stated that biogas technology is a cheap energy source, 28.8% consider biogas an expensive energy source (Table 11).

Table 11. Biogas technology is a cheap energy source

Criteria	n	%
Yes	104	71.2
No	42	28.8
Total	146	100.0

While 92.5% of the farmers think that the biogas plant will contribute positively in terms of employment to the region where it is established, 7.5% do not believe that it will contribute positively (Table 12).

Table 12. The biogas plant makes a positive contribution to the region where it is established as an employment opportunity

Criteria	n	%
Yes	135	92.5
No	11	7.5
Total	146	100.0

While 85.6% of the farmers think that a fertilizer low in carbon amount and rich in nitrogen and phosphorus will emerge as a result of the processes in the biogas plant, 14.4% of the farmers do not think so (Table 13).

Table 13. As a result of the processes in the biogas plant, a fertilizer that is low in carbon content and rich in nitrogen and phosphorus emerges

Criteria	n	%
Yes	125	85.6
No	21	14.4
Total	146	100.0

The farmers interviewed within the scope of the study were asked whether they would like to invest in biogas investments. Accordingly, 49.31% of the farmers support investing in biogas production. These farmers stated they could be partners in biogas investments (Table 14). According

to a study conducted with farmers in India, small-scale farmers have a positive approach to the issue of energy production with the wastes generated as a result of animal production (Winkler et al. 2018).

Table 14. Farmers' willingness to invest in biogas

Criteria	n	%
Yes	72	49.31
No	74	50.69
Total	146	100.0

In the study, the factors affecting the willingness of farmers to participate in biogas production investments were analyzed by logistic regression (Table 16). The model's dependent variable is the farmers' willingness to invest in biogas (Accepting:1, Disapproving:0). The explanatory variables that make up the model are as follows (Table 15).

Table 15. Explanatory variables of regression analysis

Variables	Explanation
Age	Year
Level of education	1: illiterate, 2: primary school, 3: secondary school, 4: high school, 5: university
Professional experience	year
Participation in agricultural meetings	0: no, 1: yes
Status of using the internet in accessing information	0: non-user, 1: beneficiary
Annual agricultural income	1: 0 to 10,000 TRY, 2:10,001 to 20,000 TRY, 3: 20,001 to 30,000 TRY, 4: 30,001 to 40,000 TRY, 5: 40,001 to 50,000 TRY, 6: 50,001 to 100,000 TRY, 7: 10,0001 to 150,000 TRY, 8: 150,001 to 200,000
Non-farm income asset	0: no, 1: yes
Total number of cattle's	Number

According to the analysis results, the model formed by the explanatory variables is significant. The model is statistically significant in general terms (Omnibus Test, $p<0.05$) (Doornik and Hansen, 2008).

In addition, the model's goodness of fit was determined (Hosmer-Lemeshow Test, $p<0.05$) (Lemeshow and Hosmer, 1982). The model makes a correct classification of 72.6%.

According to the results of the analysis, the farmers' age, education level, and internet use to access information are effective factors in the decision of the farmers to participate in biogas investments.

Accordingly, the increase in age by one year increases the farmers' odds ratio of investment decision by 9.2%. Improving the education level by one level increases the farmers' odds ratio of investment decisions by 175%.

Using the internet to access information reduces farmers' odds ratio of investment decisions by 83%. According to Zografakis et al. (2010), the level of income, the size of the house they live in, climate change awareness and electricity shortages have an impact on the willingness of the people to invest in renewable energy.

Table 16. Analysis of farmers' willingness to invest in biogas by logistic regression

Variables	B (Coefficient)	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Constant	20.090	22675.375	.000	1	.999	530839835.669		
Age	**.088**	**.041**	**4.642**	**1**	**.031**	**1.092**	**1.008**	**1.183**
Education level	**1.011**	**0.277**	**13.300**	**4**	**.001**	**2.748**	**1.596**	**4.732**
Professional experience	-.002	.031	.005	1	.943	.998	.939	1.060
Participation in agricultural meetings	.544	.525	1.073	1	.300	1.723	.615	4.823
Using internet	**-1.783**	**.688**	**6.719**	**1**	**.010**	**.168**	**.044**	**.647**
Annual agricultural income	0.001	0.112	5.686	7	.577	0.999	0.802	1.245
Having non-farm income	-.581	.555	1.097	1	.295	.559	.188	1.659
Total number of cattle	.019	.015	1.441	1	.230	1.019	.988	1.050

N=146, R^2 =0.155(Cox-Snell), R^2 =0.206 (Nagelkerke)
Model: Chi-square: 24.538, p=0.002 (Omnibus Test of Model Coefficients)
Model: Chi-square: 22.016, p=0.005 (Hosmer-Lemeshow Test)
Overall percentage: 72.6%

Conclusion and Recommendations

The following conclusions and suggestions were obtained from this study, in which the socio-economic characteristics and biogas awareness of the farmers engaged in animal production were determined. It seems that the middle age level of the farmers are involved in animal production in Çanakkale, they are usually primary school graduates with 24 years of general agricultural experience, cattle breeders raise an average of 19 heads, and sheep and goats breeders raise 65 heads or less. It was observed that the interviewed farmers knew that animal wastes were organic wastes and that vast majority of them knew that energy could be produced from organic waste. It has been observed that the number of farmers who think biogas energy is a clean energy source and does not pollute the environment is high, but the farmers are not fully informed about this issue. The fact that 25.3% of the farmers think that only electrical energy is produced in the biogas plants allows us to conclude that the farmers' knowledge about the biogas plants is incomplete.

It is essential to determine the level of knowledge that farmers have about biogas facilities and biogas and to increase their knowledge level. It will ensure that biogas, which is an essential alternative for the evaluation of organic wastes that will arise in agricultural production, is adopted by farmers as a selectable waste management method. In this context, to increase farmers' knowledge and awareness about biogas, cooperation with public institutions and organizations and universities can provide farmers with more inclusive training and presentations about biogas, which can make farmers more conscious about biogas.

Note: This study was produced from the master thesis.

Contribution Rate Statement Summary of Researchers

The authors declare that they have contributed equally to the manuscript.

Conflict of Interest

"The author(s) declare that they have no known competing financial or non-financial, professional, or personal conflicts that could have appeared to influence the work reported in this paper."

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