Annals of Biology **40** (2) : 335-341, 2024

Impact Score : 0.32 (Scopus)

The Farmers' Economic Attitudes towards the Use of Renewable Energy in Agricultural Activities

JAWAD ATEF-AL-DALAEEN*

Department of Financial and Administrative Sciences, Karak University College, Al-Balqa Applied University, Karak, Jordan

**(e-mail: jawad.papers@gmail.com; jawad.dalaeen@bau.edu.jo; Mobile: 00962-79-620842)*

(Received: November 22, 2023; Accepted: January 3, 2024)

ABSTRACT

The use of renewable energy sources has been expanded in developing countries for feasible causes, environmental protection and maximizing agricultural production. The study was aimed at investigating the farms of different sizes, attitude for adopting renewable energy sources and their feasibility in the agricultural process. The questionnaire was used to collect the data through a simple random sample of farms that use renewable energy sources. The questionnaire included parts related to the characteristics of the farms, the attitudes for adopting renewable energy sources, the annual expenses on energy before and after the adoption and the effect on the farm production processes. The results showed that renewable energy systems changed the visions for the production process in agriculture by improving independence. The use of renewable energy sources increased the production process and increased the consumption of energy. The farmers expressed the feasibility of using renewable energy sources in production and recommended its use by other farmers. Renewable energy sources maximized the production process in agriculture and the returns of the production process and minimized the costs.

Key words: Renewable energy sources, feasibility use, agricultural production, agricultural activities

INTRODUCTION

Renewable energy plays a crucial role in the agricultural sector by improving productivity and environmental sustainability. It offers the potential to electrify regions disconnected from power grids, eradicate extreme poverty and hunger, and ensure environmental safety and energy independence (Babatunde *et al.*, 2019; Bolyssov *et al.*, 2019). The use of renewable energy sources such as solar, biomass, wind and hydro power can have a significant positive impact on the economy of agriculture, including job creation and economic growth (Campiotti *et al.*, 2019). In greenhouse agriculture, the escalating energy consumption can be reduced by utilizing renewable energy sources like solar PV, solid biomass and geothermal fluids, leading to cost-effective and sustainable energy solutions (Park and Kim, 2019). Renewable energy also helps in overcoming challenges such as increased input costs, greenhouse gas emissions and oil dependency in the agricultural sector. Hybrid renewable energy systems, comprising PV, wind turbines, diesel generators, batteries and converters, have been found to be feasible and effective in supplying electricity to agriculture-isolated areas, resulting in cost savings, reduced emissions, and fuel consumption.

Renewable energy sources that can be used in the agricultural sector include geothermal water, wind-solar clean energy grid, solar, biomass and hybrid renewable energy systems (HRES) comprising photovoltaic (PV) arrays and wind turbines (WT) (Bolyssov *et al.*, 2019; Dinakar and Deepika, 2019; Babu e*t al.*, 2021; Tomaszewska *et al.*, 2021). Geothermal water, with its high ionic content, can be used for irrigation after treatment, making it a cost-effective option for rural areas with geothermal fields (Bekir, 2018). Wind-solar clean energy grids can help reduce fuel usage and improve sustainability in greenhouse cultivation. Solar, biomass, wind and hydro generated power are also viable options for renewable energy in agriculture. HRES, combining PV, WT, diesel generator, battery and converter technologies, can provide safe, eco-friendly, and economic solutions for electrification in agriculture. These renewable energy sources offer long-term income opportunities for farmers and contribute to energy security and reduced environmental impact in the agricultural sector.

The feasibility of using renewable energy resources in the agricultural sector is widely recognized. Research has shown that renewable energy sources such as wind, solar, biomass and hydro power can be effectively utilized in agriculture to improve productivity and environmental sustainability (Babatunde *et al.*, 2019; Bolyssov *et al.*, 2019; Berishvili and Gejadze, 2020; Babu *et al.*, 2021). These energy sources offer a more environmentally sustainable alternative to fossil fuels, which are expensive and contribute to environmental problems. The use of renewable energy in agriculture can help alleviate energy shortages in both rural and urban areas, while also reducing the negative impact on the environment. Additionally, the integration of renewable energy technologies in the agricultural sector can contribute to the achievement of sustainable development goals, such as eradicating poverty and hunger, and ensuring environmental sustainability. Overall, the application of renewable energy resources in agriculture has the potential to provide long-term income for farmers, increase energy security and reduce environmental impact.

Jordan as a developing country extended much efforts in the past years to distribute the use of renewable energy sources in agricultural activities. The farmers were encouraged to adopt the renewable energy by government through assistance of the international donors. The experience of the economic consequences of these systems on the agricultural sector is still starting in general and the consequences on the farming economics also. The objective of this study was to investigate the level of adoption of renewable energy systems in agricultural activities as well as focusing on the economic effects on the farming feasibility.

The distribution of renewable energy systems in agriculture is influenced by several factors. These include the need for a secure, affordable and sustainable energy system to support economic growth in rural areas (Gangil and Mehta, 2022). The promotion of renewable resources such as solar, wind, biomass and geothermal power can help mitigate environmental damage caused by fossil fuels. The use of renewable energy technologies, such as solar photovoltaic water pumps and greenhouse technologies, can contribute to sustainable agriculture by minimizing the use of non-renewable resources and reducing greenhouse gas emissions (Majeed *et al.*, 2023). The invention of renewable energy collecting and generating systems, as well as the integration of renewable energy sources with facility buildings, can provide a reliable energy supply for agriculture (Campiotti *et al.*, 2019). The economic efficiency and application of renewable energy sources in agriculture depend on regional conditions, with solar energy, geothermal energy, biomass energy and wind energy being the main sources.

The distribution of renewable energy sources in farming is influenced by several factors. Diversification activities such as tourism and forestry, as well as the spatial, biophysical and geophysical attributes of farms, playing a role in the adoption of renewable energy technologies (Ge *et al.*, 2017). In India, the potential for agricultural involvement in renewable energy production is significant, and farmers can benefit from the long-term income provided by wind, solar, and biomass energy (Dinakar and Deepika, 2019). In Bavaria, factors such as technological regional transformation ability, agricultural structure and neighbourhood effects impact the adoption of on-farm renewable energy production (Schaffer and Düvelmeyer, 2016). The expansion of agricultural machinery and greenhouse horticulture has led to increased energy use in the agricultural sector, highlighting the need for renewable energy and energy-saving facilities in agriculture (Park and Kim, 2019). The application of organic mulches, organic manures and renewable energy sources can improve soil quality and increase crop yield in organic farming (Ibeawuchi *et al.*, 2015).

Farm size has been found to have an impact on the adoption of renewable energy sources. In the case of Californian farmers, the size of the installed system is influenced by factors such as the total value of production and acre value. In Scotland, farms that are more diversified are more likely to adopt renewable energy, including solar and biomass energy (Ge *et al.*, 2017). Additionally, the agricultural potential of farm land is an important factor in adoption of decisions (Efendiev *et al.*, 2016). In the context of ocean wave energy, simulations have shown that power fluctuations decrease with an increasing number of generators in a farm. In Russia, the creation of small combined

power plants based on renewable energy sources is recommended for independent consumers, particularly those located at a considerable distance from centralized energy systems (Gowreesunker and Tassou, 2016). Overall, these findings suggest that farm size plays a role in the adoption of renewable energy sources, with factors such as diversification, agricultural potential and distance from centralized energy systems influencing the decision.

Farm activities have been found to have a significant impact on the adoption of renewable energy sources (Ge *et al.*, 2017; Park and Kim, 2019). Diversified farms, especially those involved in tourism and forestry, are more likely to adopt renewable energy, particularly solar and biomass energy. Additionally, farms with high local energy demand and suitable conditions for renewable energy production are more inclined to adopt renewable energy (Huang *et al.*, 2022). Biophysical factors, such as the agricultural potential of farm land, also play a role in the adoption of decision. Non-farm work has been found to have a positive effect on clean energy adoption in rural households. Increasing household income and promoting health knowledge are the main channels through which non-farm work influences clean energy adoption. Overall, the integration of renewable energy policy with farm diversification policy and support schemes is crucial for promoting the adoption of renewable energy sources in the agricultural sector.

MATERIALS AND METHODS

The objective of this study was to investigate the distribution of the use of renewable energy sources (RES), the awareness of the economic attitudes towards RES, comparing RES to traditional energy sources in their farms, and its effect on farming activities and production. A simple random sample was selected from different agricultural areas in Jordan including 101 farms. The farms covered the northern, southern and eastern parts of Jordan. The questionnaire was used for data collection. The questionnaire included different parts to collect information about the characteristics of farms, the use of RES in farming activities and the economic aspects of RES and its effect on farming activities. The collected data were entered into the R software. The frequencies and percentages were used to measure the attitudes for the different aspects of the study.

RESULTS AND DISCUSSION

The objective of this study was to investigate the distribution and economic attitudes of the use of RES in agriculture. The use of RES is considered recent in Jordan as a developing country. The distribution of the RES relied on the available financial support as an aid for RES infrastructure and served it in the long run.

The sample of the farms used in this research covered the different parts of Jordan. The results showed that the farms in the northern parts of Jordan formed 7.9%, while the farms in the eastern parts of Jordan formed 20.8% of the sample. The per cent of farms in the southern parts of Jordan formed 21.0% of the total number of farms. The rest of the sample was taken from Jordan Valley areas which considered the food basket for Jordan. The farm area included areas that experienced high solar radiation in different parts of Jordan. Most of these areas were characterized as agricultural areas with different criteria and varied difficulties faced by the use of REW (Fig. 1).

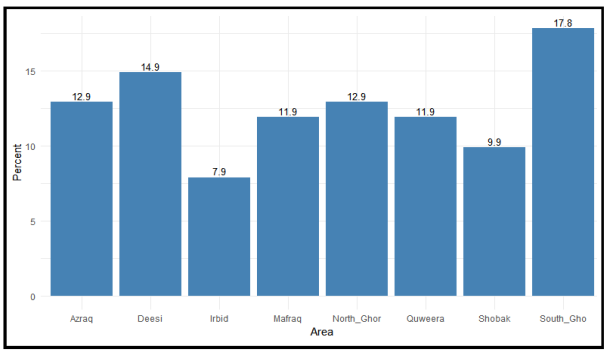

Fig. 1. Farms' geographical distribution.

Different farm sizes were included in the studied sample to investigate the adoption of RES in these farms. The highest percentage of farms had areas of more than 100 dunums (1 dunum equals 1,000 square meters or 0.10 ha). The results showed that one farm with a percentage of 0.99 had a size of less than 30 dunums. Seven farms with a percentage of 6.93 were found under the sizes 30 to less than 50 dunums and 50 to less than 100 dunums. The number of farms in the size 100 to less than 200 dunums was 16 with a percentage of

15.84 and the farm size 200 to less than 500 dunums contained 18 farms with a percentage of 17.82. The farm size 200 to less than 100 dunums contained 37 farms with a percentage of 36.63 forming the highest among the different farm sizes, while the largest farm size more than 1000 dunums formed 14.85% (Table 1).

Table 1. The characteristics of farms

Character	Frequency	Per cent
Farm area (dunum)		
less than 30	1	0.99
30 - 50	7	6.93
50 - 100	7	6.93
100 - 200	16	15.84
200 - 500	18	17.82
500 - 1000	37	36.63
More than 1000	15	14.85
Farm age		
1 - 3 years	3	2.97
3 - 5 years	1	0.99
5 - 7 years	12	11.88
7 - 10 years	33	32.67
10 - 15 years	5	4.95
15- 20 years	21	20.79
More than 20 years	26	25.74
Farming activity		
Plant production	101	81.5
Animal production	18	14.5
Other	5	4.0

Most of the farms were established more than seven years ago with a frequency of 33 farms and a percentage of 32.67. The farms established for more than 15 years formed 20.79% of the sample and the farms established for more than 20 years formed 25.74% of the sample. The results showed that most of the farms included in the sample had been established for more than five years which reflected experience in the area of the need and uses of energy. Most of the farms reflected their use of REW in plant production activities (81.5%), while 14.5% of the farms used REW in animal production. Only 4.0% of the sample used the RES for other purposes (Table 1).

The results showed that all the farms included in the study had RES. The renewable energy sources varied with the most dominant of the solar radiation system (47.8%), followed by the use of solar radiation and wind energy (38.0%). The methane biofuel was also used to produce energy in the farms. The majority of the farms showed that the use of RES was for less than six years, while only two farms showed that the use of RES started for more than six years (Table 2).

Table 2. The energy characteristics of the farm

Character	Frequency	Per cent
Possessing renewable energy source		
Yes	101	100
No		
Type of renewable energy		
Solar radiation	98	47.8
Wind radiation	9	4.4
Mix	78	38.0
Other (Methan biofuel)	20	9.8
Start using renewable energy		
Less than 2 years	4	3.96
2 - 4 years	57	56.44
4 - 6 years	38	37.62
6 - 8 years	2	1.98

The results showed that the farms used the solar energy, wind and methane biofuel produced by residues to save energy for their farms. Renewable energy systems were being increasingly used in agricultural activities. Biogas plants, which were utilized through agricultural waste such as manure and plant residues, were an important source of heat and electricity (Zapalowska and Bashutska, 2019). The use of biogas production from organic agricultural waste had economic, ecological and social benefits, particularly in rural regions (Acosta-Silva *et al.*, 2019). Additionally, agriculture played a dual role as both an energy user and supplier through the use of advanced technologies and alternative fuels to improve efficiency and minimize energy consumption (Chen *et al.*, 2018).

Renewable energy sources such as wind, solar and biomass were harvested indefinitely, providing farmers with a long-term source of income. Solar energy in particular was used in various applications in agriculture, including reducing electricity and heating bills, drying crops and providing hot water. The use of agricultural process residues for energy generation improved the energy supply and the sustainability of land-use practices.

Only two farms depended only on the RES (1.98%). The rest of the sample depended on both traditional sources and RES (98.02%). The farmers showed that they built their own RES by their financing (75.2%), while the rest of the sample showed that they received support from local organizations or external organizations that support these areas. The astonishing and interesting result was that more than 64.4% of the sample depended on RES by more than 80%, while 21.2% of the sample provided 60% of their electricity needs

from RES, and one farm was found to rely on RES to provide the farm completely with its needs. The rest of the sample showed reliability of 40% or less on the RES (Table 3).

Table 3. The economic characteristics of the renewable energy sources

Character	Frequency	Per cent
Using traditional and renewable energy sources		
Yes	99	98.02
No	2	1.98
The financial source of RES		
Governmental	0	0
Self-finance	91	75.2
Local organizations	6	5.00
Societies	5	19.8
Other external sources		
The ratio of using RES to traditional		
10	10	9.6
20	2	1.9
40	2	1.9
60	22	21.2
80	67	64.4
100	1	1.00
RES coverage of the farm needs		
Yes	34	33.66
No	67	66.33
The uses of RES		
Irrigation	101	15.2
Fertilization	100	15.0
Spraying	98	14.7
Water pumping	99	14.9
Artesian wells	81	12.2
Lighting	97	14.6
Heating and cooling systems	89	13.4

The majority of the sample (66.33) reported that the RES did not provide all their needs energy, while the rest of the sample showed that RES was enough to provide the farm needs. This justified the usage of two sources; RES and traditional sources, to provide the farm needs. The use of RES covered different activities of the farm. These activities included irrigation (15.2%), fertilization (15.0%), spraying (14.7%), water pumping (14.9%), pumping from artesian wells (12.2%), lighting (14.6%) and heating and cooling systems in the farm (13.4%; Table 3). Haupenthal *et al.* (2021) found that renewable energy sources were being increasingly used in various applications such as irrigation, cooling and heating and water pumping. The use of renewable energy in agriculture gained momentum as it offered a sustainable and environmentally-friendly alternative to fossil fuels. Solar power generators were commonly used as a power source for pumping water for irrigation, which helped in reducing dependence on fossil fuels and improved water consumption efficiency. Additionally, renewable energy-based systems, such as heat pumps and photovoltaics, were applied in buildings for heating, cooling, and electricity production. Zhang *et al.* (2022) reported that for high-efficiency achievement, thermal and electrical energy storage systems, such as phase change materials and battery energy storage systems, were utilized. Overall, RES provided a promising solution for various applications, offering abundant and sustainable energy sources (Lepadatescu, 2017).

The majority of the sample showed that the cost of using RES on their farm did not exceed 15% of the total expenses. Less than 16% of the sample showed that the cost may range from 20 to 30% of the total expenses. This led to the evaluation of the annual cost introduced by farmers for the use of RES which showed the cost was less than 2000 JD ($ 2850) per year in most farms (>80%). The highest per cent of the sample (33.66%) was within the category JD 1000 to 2000 expenses annually, while 46% of the sample showed expenses less than JD 1000 annually. On the other hand, the farmers showed that the cost of the traditional sources dropped to costs less than JD 1000. The results showed that the payment for RES sources formed 10% of the cost for the traditional sources of energy (Table 4).

Pestisha *et al.* (2023) reported that agricultural energy production became increasingly important with a focus on methods such as biogas and the circular economy. Furthermore, Dinakar and Deepika (2019) reported that a smart farm utilized eco-friendly energy sources like hydrogen, geothermal heat and sunlight to minimize contaminants and cultivate crops in a pollution-free manner. Finally, a renewable energy storage system was used in plant farms to grow plants 24 h a day and cultivate crops in seasons with limited sunlight. The results showed that the RES increased the production process and minimized the production costs. The results showed that the RES was considered feasible source used in farms.

The farmers showed that they paid the government to serve them using RES in their farms (87.13%). Moreover, the results showed that the consumption of energy increased after the use of RES. The results showed that the use of energy increased by 50% at least in all

Table 4. The cost and the feasibility of RES use in agricultural activities

Character	Frequency	Per cent
The expenses of RES to total expenses		
5	43	42.57
10	21	20.79
15	20	19.80
20	8	7.92
25	8	7.92
30	1	0.99
The annual cost of electricity used from traditional sources (JD)		
100 - 200	3	2.97
200 - 300	11	10.89
300 - 500	18	17.82
500 - 1000	20	19.80
1000 - 2000	34	33.66
More than 2000	15	14.85
The cost of traditional sources after using RES		
Less than 100 JD	29	28.71
100 - 200	23	22.77
200 - 300	22	21.78
300 - 500	15	14.85
500 - 1000	10	9.90
More than 2000	2	1.98
Paying for using REW for elect com		
Yes	88	87.13
No	13	12.87
The percentage of payment for REW compared to traditional methods		
10	62	61.39
20	9	8.91
30	2	1.98
40	7	6.93
50	21	20.79
The energy consumption increased		
Yes	101	100
The percentage of consumption increase		
10	0	0
20	5	4.95
30	6	5.94
40	34	33.66
50	56	55.45
Do you encourage the use of RES feasibility side?		
Yes	101	100.0
No	0	0.00

the farms (Table 4). The results showed that all farms included in the study used RES and they recommended its use in the agricultural activities in other farms. The general results showed that the use of RES reflected positively on the farm activities.

The impressions for RES were related to the technical problems faced by using RES and management problems (100%). Moreover, the use of RES increased productivity, and the consumption of energy, facilitated the use of farm facilities, decreased the labour force, the production expenses and improved farm independence in the production process (Table 5).

The use of RES minimized the farm expenses and increased the production outputs of the farm which maximized the feasibility of farm production. Berishvili and Gejadze (2020), Gangil and Mehta (2022) and Majeed *et al.* (2023) reported that RES had the potential to be feasible in agriculture. Also, RES feasibility depended on regional conditions. Successful implementation required addressing technical, economic and policy barriers, as well as fostering knowledge dissemination and capacity building among farmers and stakeholders. The RES was found to contribute to the energy needs of the farm in different processes and to save the annual expenses on the traditional sources of energy. The results showed that the feasibility of large-size farms increased compared to small ones.

Table 5. The advantages and disadvantages of using RES

Character	Frequency	Percentage
Technical problems	101	100
Management problems	101	100
Increase in energy use	101	100
Increase production	101	100
Easiness of executing agricultural processes	99	98.01
Minimize labour force	98	97.03
Increase agricultural activities	98	97.03
Decreasing expenses	101	100
Improve the farm life	101	100
Activities independence	101	100

CONCLUSION AND RECOMMENDATIONS

The objective of this study was to investigate the distribution of the use of RES and its impact on farm expenses and farm activities. Different farm sizes were selected of different farm ages. The results showed that the adoption of RES was new in agriculture in developing countries. The attitudes were positive for the use of RES in agricultural production due to its reflection on the independence of the farm and its feasibility in the production process. The farms figured out that the use of RES increased the farm production which increased the energy demand and so maximized the production process. The reasonable feasibility of the RES increased the farmers' attitudes towards financing these systems to improve farm production. Despite the technical and management difficulties faced by their use of RES, they recommended the use of RES in the agricultural processes. The study recommended that the government should increase the financial support for the adoption

of RES and provide technical assistance for farmers to use these systems.

REFERENCES

Acosta-Silva, Y. de J., Torres-Pacheco, I., Matsumoto, Y., Toledano-Ayala, M., Soto-Zarazúa, G. M., Zelaya-Ángel, O. and Méndez-López, A. (2019). Applications of solar and wind renewable energy in agriculture: A review. *Sci. Prog.* **102**: 127-140. *https://doi.org/10.1177/00368504198 32696.*

Babatunde, O. M., Denwigwe, I. H., Adedoja, O. S., Babatunde, D. E. and Gbadamosi, S. L. (2019). Harnessing renewable energy for sustainable agricultural applications. *Int. J. Energy Econ. Policy* **9**: 308-315. *https://doi.org/10.32479/ijeep.7775.*

Babu, R., Raj, S. and Prasad, B. R. V. (2021). A review at the utilization of renewable energy in an agricultural operation. *Biophys. Econ. Sustain.* **6**. *https://doi.org/10.1007/s41247-021-00092-9.*

Bekir, Y. (2018). Use of renewable energy resources in agriculture in the case of Turkey. *Afr. J. Agric. Res.* **13**: 2037-2054. *https://doi.org/10.5897/ajar2018.13415.*

Berishvili, V. and Gejadze, E. (2020). Renewable energy utilization feasibility for agricultural company–Georgia case. *ECOFORUM* **9**: 21.

Bolyssov, T., Yessengeldin, B., Akybayeva, G., Sultanova, Z. and Zhanseitov, A. (2019). Features of the use of renewable energy sources in agriculture. *Int. J. Energy Econ. Policy* **9**: 363-368. *https://doi.org/10.32479/ijeep.7443.*

Campiotti, C. A., Bibbiani, C. and Greco, C. (2019). Renewable energy for greenhouse agriculture. *Quality - Access to Success* **20**: 152-156.

Chen, G., Neugebauer, M., Solowiej, P. and Piechocki, J. (2018). Development in energy generation technologies and alternative fuels for agriculture. *Advances in Agricultural Machinery and Technology,* Chen, G. (ed.), CRC, United Kingdom. pp: 089-112.

Dinakar, J. and Deepika, T. (2019). Preface: Renewable energy sources and technologies. *AIP Conf. Proc.* **2161**. *https://doi.org/10.1063/1.5127590.*

Efendiev, A. M., Nikolaev, Y. E. and Evstaf'ev, D. P. (2016). Opportunities of energy supply of farm holdings on the basis of small-scale renewable energy sources. *Ther. Eng. (English Trans of Teploenergetika)* **63**: 114-121. *https://doi.org/10.1134/S004060151 6010043.*

Gangil, S. and Mehta, C. (2022). Application of renewable energy in Indian agriculture. *J. Rice Res.* **15** (Special Issue). *https://doi.org/10.58297/uvow8034.*

Ge, J., Sutherland, L. A., Polhill, J. G., Matthews, K., Miller, D. and Wardell-Johnson, D. (2017). Exploring factors affecting on-farm renewable energy adoption in Scotland using large-scale microdata. *Energy Policy* **107**: 548-560. *https://doi.org/10.1016/j.enpol.2017.05.025.*

Gowreesunker, B. L. and Tassou, S. A. (2016). The impact of renewable energy policies on the adoption of anaerobic digesters with farm-fed wastes in Great Britain. *Energies* **9**: 1038. *https://doi.org/10.3390/en9121038.*

Haupenthal, S. W., Vilas Boas, M. A., Cruz Siqueira, J. A. and Kazue Tokura, L. (2021). Evolution of photovoltaic energy system applied to water pumping for irrigation. *Latin Am. J. Energy Res.* **8**: 22-35. *https://doi.org/10.21712/lajer.2021.v8.n1.p22-35.*

Huang, L., Wu, H. and Zhou, M. (2022). Implications of non-farm work for clean energy adoption: Evidence from rural China. *Agriculture (Switzerland)* **12**. *https://doi.org/10.3390/agriculture12122120.*

Ibeawuchi, I. I., Iwuanyanwu, U. P., Nze, E. O., Olejeme, O. C. and Ihejirika, G. O. (2015). Mulches and organic manures as renewable energy sources for sustainable farming. *J. Nat. Sci. Res.* **5**: 139-148.

Lepadatescu, B. (2017). Renewable energy sources used in small installations to produce electricity and to provide water for domestic supply and irrigation. *Int. J. Renew. Energy Sour.* **2**: 55-68.

Majeed, Y., Khan, M. U., Waseem, M., Zahid, U., Mahmood, F., Majeed, F., Sultan, M. and Raza, A. (2023). Renewable energy as an alternative source for energy management in agriculture. *Energy Rep.* **10**: 344-359. *https://doi.org/10.1016/j.egyr.2023.06.032.*

Park, J. and Kim, Y. (2019). The effects of renewable energy in agricultural sector. *J. Korea Academia-Industrial Coop. Soc.* **20**: 224-235.

Pestisha, A., Gabnai, Z., Chalgynbayeva, A., Lengyel, P. and Bai, A. (2023). On-farm renewable energy systems: A systematic review. *Energies* **16**. *https://doi.org/10.3390/en16020862.*

Schaffer, A. and Düvelmeyer, C. (2016). Regional drivers of on-farm energy production in Bavaria. *Energy Policy* **95**: 361-369. *https://doi.org/10.1016/j.enpol.2016.04.047.*

Tomaszewska, B., Akkurt, G. G., Kaczmarczyk, M., Bujakowski, W., Keles, N., Jarma, Y. A., Baba, A., Bryjak, M. and Kabay, N. (2021). Utilization of renewable energy sources in desalination of geothermal water for agriculture. *Desalination* **513**. *https://doi.org/10.1016/j.desal.2021.115151.*

Zapalowska, A. and Bashutska, U. (2019). The use of agricultural waste for the renewable energy production. *Haykobi Ilpaui Jlicibhuyoi Akademii Hayk Ykpaihu* **18**: 138-144. *https://doi.org/10.15421/411914.*

Zhang, S., Oclon, P., Klemeš, J. J., Michorczyk, P., Pielichowska, K. and Pielichowski, K. (2022). Renewable energy systems for building heating, cooling and electricity production with thermal energy storage. *Renew. Sustain. Energy Rev.* **165**. *https://doi.org/10.1016/j.rser.2022.112560.*