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Research Paper

Factors Affecting Biomass Energy Utilization by Small Holder Farmers in Iran

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Abstract

The main purpose of this survey was to assess biomass production and use as a source of energy by smallholders in Tafresh County located in Markazi Province, Iran. A descriptive survey method was used for data collection. The statistical population consisted of 2,470 smallholders. A sample size of 300 was selected by using the stratified random sampling technique. A questionnaire was used to collect the data. A panel of experts confirmed the validity of the questionnaire. A pilot study was conducted to establish the reliability of the instrument. The Cronbach alpha's coefficient was higher than 0.75 for the main scales of the questionnaire. The results showed that the residues of plants and animals are recognized as a potential source of renewable energy, but there exists no specific policy or technical instruction for their optimal use, particularly in organizations such as Agriculture Jihad. Therefore, many farmers burn a considerable amount of firewood without being aware of its potential use. Findings revealed that "diversification of productive activities" had the greatest influence on the use of biomass energy, and the variables "annual cost of gas at home" and "animal farming experience" were ranked the 2nd and 3rd most important factors influencing the dependent variable, respectively.

Keywords:
Biomass; crop residue; renewable energy resources; small-holder farmers

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INTRODUCTION

Energy has an influential role in the development of key sectors of economic importance such as industry, transport, and agriculture. This has motivated many researchers to focus their research on energy management. In fact, energy has been a key input of agriculture since the age of subsistence farming. It is an established fact worldwide that agricultural production is positively correlated with energy input (Singh, 1999).

Nowadays, to meet the food demand of the growing population, the agricultural sector has relied upon energy sources like electricity and fossil fuels, just like the other sectors (Hatirli et al., 2005). In response to the population growth, the limitation of arable lands and the improved living standards, the consumption of energy in the agricultural sector has increased (Hiremath et al., 2007). These factors have increased input energy in all societies to maximize crop production, minimize labor need of operations and/or both of them (Esengun et al., 2007). The consumption of energy in agricultural productions has increased versus the other economic sectors of the world mostly due to the high rate of mechanization and the use of reinforcements like commercial fertilizers (Karkacier & Goktolgu, 2005). The rate of energy consumption to employ the population in this sector depends on the rate of cultivated lands and mechanization level (Ozkan et al., 2004). Different agricultural sectors have different energy situations (Karkacier & Goktolgu, 2005) and can be either consumers or producers of energy in the form of bioenergy (Alam et al., 2005).

Agriculture is one of the most important economic sectors of Iran. Its contribution is approximately 27 percent to GDP, 23 percent to employment (employed 3.5 million people) and 24 percent to non-oil exports. In recent years, the agricultural sector has shown a significant potential for development. It can meet 85 percent of Iran's food need and 90 percent of the raw material demand of its food processing industries. Therefore, the agricultural sector has the most important place in the macroeconomy in Iran (Shabanali Fami et al., 2009).

The 2004 public agricultural census revealed that from the total number of 3,473,383 of farming plots owned by farmers, 3,011,461 (approximately 86.7 %) of them held less than 10 hectares out of which 34.62 percent had less than 1 hectare; 15.04 percent 1 to 2 hectare(s); 22.91 percent 2-5 hectares and finally 14.12 percent 5-10 hectares (Ashrafi et al., 2007; Shabanali Fami et al., 2009).

The management of energy consumption in agriculture is a worldwide concern because of the adverse effects of CO_2 emissions from fossil fuels, which are generally used as an energy source for various applications in agriculture such as water heating and irrigation. Renewable energy technologies are promoted in many parts of the world for various agricultural applications to mitigate CO_2 emissions associated with fossil fuels. The renewable energy system plays an important role in the agricultural sector in reducing fossil fuel consumption by various applications (Chel & Kaushik, 2011). Sustainable agriculture is an alternative to tackle fundamental and practical issues related to food production in an ecological way (Lal, 2008). Nowadays, the development of a sustainable indicators framework towards sustainable energy policy-making should be characterized by clarity and transparency. Although energy policy-making has been subject to many research works, studies proposing an appropriate framework of sustainable indicators are absent in the international literature. The purpose of some related research has been to present an integrated review of the methodologies and the related activities of the energy indicators and to recommend an operational framework of appropriate indicators, thus supporting the policymakers/analysts/citizens towards a sustainable energy policy-making (Patlitzianas et al., 2008). The sustainable energy approach promotes renewable energy in the agricultural sector, especially in remote or rural areas all over the world where solar energy is available in abundance. The various sources of energy, e.g. solar, wind, hydraulic, biomass, organic wastes, biofuels, and combined heat and power, provide a simple, sustainable and effective solution for the conservation of valuable non-renewable fossil resources without resulting in environmental pollution (Barnard,2019, Chel & Kaushik, 2011).

Renewable energy creates multiple public benefits such as environmental improvement (reduction of power plant greenhouse emissions and thermal and noise pollution), increased fuel diversity, reduction of energy price, volatility effects on the economy, and national economic security as fossil energy is vulnerable to political instabilities, trade disputes, embargoes and other disruptions (Gielen at al., 2019; Menegaki, 2008).

Farmers can make a significant contribution to energy supply and climate change mitigation regionally and nationally (Scurlock, 2008). In fact, renewable energy and farming are a winning combination. Wind, solar, and biomass energy can be harvested forever, providing farmers with a long-term source of income (UCS, 2009). Agriculture can play an important role in the production and consumption of different renewable energies (Fischer et al., 2006). In the United States, one policy response has been to provide financial incentives for supplying 25 percent of energy use from renewable resources by 2025 (Peskett et al., 2007).

Biomass is an important resources of energy in farming communities that is present in a variety of different materials such as wood, sawdust, straw, seed waste, manure, paper waste and household waste (Perea-Moreno et al., 2019). Biomass energy is a type of renewable energy that can potentially be produced from plants and organic wastes – everything from crops, trees, and crop residues to manure. Crops grown for energy purposes can be produced in large quantities, just as food crops are. Crops and biomass wastes can be converted to energy on the farm or sold to energy companies that produce vehicular fuel or heat and power for homes and businesses. According to the U.S. Department of Energy, tripling U.S. use of biomass energy could provide as much as $20 billion in new income for farmers and rural communities and reduce global warming emissions by the same amount as taking 70 million cars off the road. New incentives are available from the federal government and a number of states to help capture these benefits (UCS, 2009). Agricultural activities generate large amounts of biomass residues. While most crop residues are left in the field to reduce erosion and recycle nutrients back into the soil, some could be used to produce energy without harming the soil. Other wastes such as whey from cheese production and manure from livestock operations can also be profitably used to produce energy while reducing disposal costs and pollution (Shabanali Fami et al., 2010). If agricultural wastes are not controlled, the result may be land, air and water contamination (Hansen and Cheong, 2019).

Bhatia (1990) found that despite the economic feasibility of biogas production from the farmer’s perspective, they are reluctant to engage in this project at a large scale due to the lack of an appropriate pricing policy. In a cooperative study on biofuel production in Vienna, Austria, Bender (1999) concluded that government support of farmers would encourage them to grow rapeseed for biofuel production in the margins of their fields and wasteland.

Sheehan et al. (2003) found that corn farmers in Iowa cornfields left considerable amounts of corn straw at farms while it could be converted into the biofuel ethanol. This fuel can be blended with 15 percent gasoline and used in light vehicles. This fuel is called E85 since it contains 85 percent ethanol. This study showed the possibility of farmers’ cooperation in producing 8 billion liters of ethanol from corn stubble in the states. With the fuel E85, 95 percent of light vehicles would reduce gasoline consumption. As such, the total energy use of fossil fuels (coal, oil, and gas) and emissions (CH_4 and N_2O, CO_2) would decrease by 102 percent and 113 percent, respectively.

Geller (2012) argued that poor infrastructure, lack of education and knowledge, lack of resources to define procedures for purchasing and supply constraints and pricing tax, regulatory and policy constraints were the major obstacles to the deployment of renewable energy.

Naghiu and Burnete (2005) found that agriculture in Romania, like other European countries, needed a network to be able to increase production and use biofuel crops. Rapeseed production in this country is of great potential for use in biofuel production. They believed that the use of renewable energy should be developed incrementally to be competitive against fossil fuels.

Meijer et al. (2007) concluded that the diffusion of renewable energy technologies is not possible without the involvement and participation of entrepreneurs in the agricultural sector because entrepreneurs have a high tolerance of ambiguity and risk. This study that was conducted in the Netherlands showed that uncertainty in technology, policy, and resources influences entrepreneurs' decisions on adopting renewable energy technologies.

Ramachandra and Shruthi (2007) state in their study that to evaluate the potential of bio-energy, it is necessary to consider bio-resources as separate villages and be determined using GIS software. The biological resources, including agricultural waste, horticulture and forestry waste, manure and biodiesel plants, are producers. Draw a map of the area with the capacity and potential of bioenergy can be a detailed plan for the development of this type of energy. In this study, it was found that the main sources of bio-energy in the state of Karnataka in India were Gardening waste (43.6%), forests (39%), agriculture (13.3%), livestock (3.01%) and crop production (15%). The availability of biological resources depends on the climatic characteristics of the region.

This study was conducted in the Tafresh area to assess biomass production and use as an energy source by smallholders. Tafresh County (Lat. 34°41' N., Long. 50° E., Alt. 1878 m.) is located in Markazi Province, Iran, 222 km off the southwest of Tehran, on the slopes of the mountain and completely surrounded them. The county with an area of 3,735 km^2 has a temperate climate with cold winters and mild snowy mountain summers. The county has four municipalities under the central part *Bazrjan, Rudbar, Kharazan,* and *Kooh Panah.* Tafresh County has 60 villages and about 3000 operational units, 85 percent of which are peasant units. These farmer-operating units are mostly small-scale and their fragmentation is evident. Most units perform their agricultural, horticultural and animal farming activities under a single management. The main sources of water supply for the agricultural units are the Qanats, seasonal and permanent rivers, deep and semi-deep wells, and spring rivers. A considerable amount of the residues of annual crops and livestock farms in the county are mainly used in cooking and providing heat. Despite the capacity of the biomass power sector, it has been overlooked because of the lack of modernization and development of IT systems in the area, so new studies are needed.

METHODOLOGY

A descriptive survey was conducted to achieve the objectives of the study. The statistical population of the study consisted of 2,470 smallholders working in the smallholder farming system of Tafresh County in four rural districts including *Bazarjan, Rodbar, Kharazan,* and *Kohpanah*. According to Krejcie and Morgan (1970)'s table, a sample of 330 farmers was selected using the proportional stratified random sampling method (Table 1). Data were collected using a questionnaire. Out of 330 completed questionnaires, 300 were used in the analysis.

Table 1
Distribution of Farmers and Samples in Different Districts

Name of rural district	Total number of farmers	Number of samples
Bazarjan	1248	155
Rodbar	592	72
Kharazan	321	36
Kohpanah	309	37
Total	2470	300

A panel of experts in agricultural development and extension approved the face and content validities of the questionnaire. The reliability of the main scales of the questionnaire was examined by Cronbach's Alpha coefficients, which ranged from 0.7 to 0.95, indicating the reliability of the research instrument. The data were analyzed by SPSS for Windows (19). Appropriate descriptive statistical procedures such as frequency, percentage, and cumulative percent were used to describe and summarize the data. In addition, correlation and regression analysis were used in the inferential analysis section.

RESULTS

Personal and professional characteristics

The findings indicated that about 93% of the respondents were male and 7% were female. On average, respondents had 59 years of age. Meanwhile, about 88% of them belonged to the category of more than 40 years of age. With regard to the level of education, 90% of the respondents belonged to either illiterate or less than high school diploma categories. The average size of a household was equal to 6.6. The average farming experience was about 35 years. About 44% of the respondents had less than 30 years of experience in agriculture. The average experience in livestock husbandry was about 29 years, and only less than 10% of the respondents had no experience in livestock husbandry (Table 2).

Economic Characteristics

According to the results, households have applied a wide range of energy sources for different purposes as follows:

- Heating the house

Frequency distribution in terms of sources of energy used in the past to heat houses is as follows: firewood (74.6%), fuel oil (43.3%), natural gas (0.7%), livestock manure (0.7%), and electricity (0.3%). Currently, this trend has changed so that natural gas (64.7%) stands first, followed by fuel oil (36%), firewood (17.7%), and electricity (0.7%).

Table 2
Personal and Professional Characteristics of the Respondents

Variable	Min.	Max.	Mean	SD
Age (year)	22	95	59.42	13.69
Size of the household (people)	2	17	6.58	2.36
Experience in agriculture (years)	1	80	35.26	17.85
Experience in livestock husbandry (years)	0	70	28.77	18.4

- Cooking at home

In the past, respondents used firewood (57.1%), fuel oil (40.3%), and natural gas (16.3%) as the main sources of energy for cooking indoors. But now, nearly all respondents prefer natural gas (98.5%) for this purpose. However, some still use other sources of energy such as fuel oil (5%), firewood (0.7%), and electricity (0.03%).

- Heating the garden shed

Frequency distribution in terms of energy sources used in the past to heat the garden shed revealed that firewood (57%), fuel oil (40.3%), natural gas (16%), and manure (0.7%) were mostly applied by the respondents. At the present time, they still use firewood (51%), fuel oil (15.3%), natural gas (9%), and electricity (1.7%) as the main sources of energy for heating the garden shed.

- Heating barns

The respondents mostly used firewood (57%), fuel oil (40.3%), natural gas (16%), and manure (0.7%) as the main energy sources to heat barns. At the present time, the ranking of their preferences for energy sources is nearly the same: firewood (51%), fuel oil (15.3%), natural gas (9%), and electricity (1.7%). But what is worth to note is that the respondents have reduced fossil fuel consumption for this specific purpose.

- Cooking at the farm

Formerly, the respondents used firewood (88.5%) as the main source of energy for cooking at the farm. Also, some of them rarely used natural gas (3.3%) and fuel oil (3.3%), while 9.7% of them had never cooked at the farm. Presently, they still use firewood (69.4%) as the main source of energy for this purpose. The results also reveal a gradual tendency toward fossil fuel such as natural gas (20.7%) and fuel oil (5.7%). The number of respondents who do not cook at the farm has also increased (13.7%).

- Boiling milk

According to the respondents, energy sources such as firewood (88.5%), fuel oil (3.3%), and natural gas (3.3%) were already used for milk boiling. Now, the respondents prefer natural gas (88.4%) as the main source of energy for milk boiling. Additionally, in some cases, the respondents still use firewood (9.4%) and fuel oil (6.8%).

As shown in Table 3, the main sources of income for the respondents are farming followed by livestock husbandry and off-farm activities whereas their sources of energy included natural gas followed by electricity, oil, and firewood as indicated by the amount of cost in each area. Accordingly, despite the predominance of the agroforestry system in the study area and the availability of firewood, the farmers do not prefer using this energy source.

Table 3

Economic Characteristics of the Respondents

Variable	Min.	Max.	Mean	SD
On-farm income (crop farming)	0	1379111.4	67669.65	95414.65
On-farm income (livestock farming)	0	1000675	42628.98	105622.09
Off-farm income (IR rial???)	0	120000	22935.2	27777.84
Annual electricity cost (for home use)	180	10020	1300.35	1044.8
Annual electricity cost (for barn)	0	3960	375.43	548.21
Annual natural gas cost (for home use)	300	30000	3961.13	4195.6
Annual cost of firewood	0	600	19.13	67.36
Annual cost of oil	0	4840	476.2	778.46

Farm characteristics

Descriptive data regarding farm characteristics of the respondents are summarized in Table 4.

Social and psychological characteristics

As shown in Table 5, women are mostly involved in cooking activities. They also participate in such activities as drying leafy vegetables and carrying fresh fruits and leafy vegetables to the house. However, they rarely participate in activities such as firewood gathering, livestock manure gathering and transferring, firewood transferring, and forage selling. Women's participation in energy-related activities is calculated by adding up variables in Table 5. Accordingly, the average of women's participation score is about 27.34.

Table 4

Farm Characteristics of the Respondents

Variable	**Min.**	**Max.**	**Mean**	**SD**
Farm size (m^2)	280	160000	24172.32	19597.84
Area under cultivation of clover and alfalfa (m^2)	0	80000	9104.42	10818.08
No. of farms/gardens	1	13	2.07	1.41
No. of plots	1	100	9.53	8.96
No. of cultivated horticultural plants	0	20	3.86	2.91
No. of cultivated crops	0	7	3.2	1.91
No. of cultivated vegetables	0	20	4.34	2.76
Time spent at the farm (hours per year)	0	3906	1619.5	807.76
Diversity of production activities (number)	1	13	7.67	2.66
Production of animal waste/manure (t)	0	225	13.68	20.7
Production of plant residues (kg)	0	56497.98	4185.51	6360.73
Use of animal manure per year (t)	3	52	16.77	11.17

Table 5

Social and Psychological Characteristics of the Respondents

Variable	**Mean**	**SD**	**Priority**
Cooking	4.29	0.84	1
Heating the house	4.12	3.12	2
Drying leaf vegetables	3.35	1.4	3
Transferring fresh fruit and leafy vegetables to the house	3.05	1.45	4
Drying fruit	2.55	1.71	5
Heating garden shed	1.84	1.69	6
Gathering vegetable residues	1.54	1.6	7
Drying forage for hay	1.34	1.54	8
Selling dried leaf vegetables	1.51	1.6	9
Gathering leaves	0.93	1.3	10
Selling dried fruit	1.10	1.58	11
Gathering firewood	0.67	1.18	12
Gathering and transferring animal manure	0.47	1.14	13
Transferring firewood	0.55	1.03	14
Selling forage	0.38	0.94	15

Information resources

Results of the prioritization of accessible information sources regarding renewable energy sources are provided in Table 6. So far, no energy-related training course has been organized in Tafresh. The respondents acknowledged radio and TV as the main sources of information about energy-related issues.

Using residues of plants and animals to produce fuel (in the past and at the present time)

Prioritization of different types of residues used for cooking and for fuel revealed that the respondents mostly use firewood for these purposes (Table 7).

Willingness to equip the farm with renewable energy technologies

As shown in Table 8, the willingness to equip farms with renewable energy technologies is, on average, 39.53% (SD=32.64). About 10.7% of the respondents were unwilling to equip their farms with such technologies, while more than 40% expressed their moderate willingness.

To analyze the relationship between two variables of "willingness to equip farms with renewable energy technologies" and "the use of biomass energy", the Chi-square test was applied. As summarized in Table 9, the relationship between these two variables is positively significant. This implies that those who apply biomass commonly are more willing to take advantage of renewable energy technologies.

Table 6

Descriptive Statistics of Farmers with Regard to the Application of Information Resources

Variable	Mean	SD	Priority
TV	0.99	1.25	1
Radio	0.32	0.78	2
Newspaper and magazine	0.29	0.81	3
Neighbors	0.28	0.78	4
Books	0.23	0.72	5
Experts	0.2	0.69	6
Classes and courses (Agriculture Jihad)	0.15	0.57	7
Computer	0.09	0.46	8
Internet	0.08	0.47	9

Likert scale: (0=never, 1=very low, 2=low, 3=moderate, 4=high, 5=very high)

Table 7

Prioritizing Residues with Regard to the Purpose of Use from the Respondents' Point of View

Used for fuel			Residue	Used for cooking		
Priority	Mean	SD		SD	Mean	Priority
1	3.28	1.39	Firewood	1.56	1.35	1
2	2.55	1.65	Forage, Leaf	1.28	0.81	2
3	1.69	1.66	Animal Manure, Cow waste	0.91	0.43	3

Likert scale: (0=never, 1=very low, 2=low, 3=moderate, 4=high, 5=very high)

Table 8
Frequency Distribution of the Respondents with Respect to Willingness to Equip Farms with Renewable Energy Technologies

Willingness (%)	**Frequency**	**Percent**	**Cumulative %**
Never	32	10.7	10.7
Very low	98	32.7	43.4
Low	51	17	60.4
Moderate	42	14	74.4
High	40	13.3	87.7
Very high	37	12.3	100
Total	300	100	

Table 9
The Relationship between Willingness to Equip the Farm with Renewable Energy Technologies and Use of Biomass Energy

Willingness to equip the farm with renewable energy technologies							
		Never	**Low**	**Moderate**	**High**	**Total**	
Use of biomass energy	**Low**	3.3	3.7	4.7	10	21.7	X¯ =14.84 *p*-value=0.023
	Moderate	5	2	7.7	15.6	30.3	
	High	2.3	8.3	13.3	24	48	
	Total	10.7	14	25.7	49.6	100	

In order to examine the relationship between the uses of biomass energy with random variables, the correlation analysis was used. The results of the correlation coefficient in Table 10 showed a significant and positive relationship between the random variable of “the use of biomass energy” and the random variables of ‘annual cost of buying firewood’, ‘annual cost of buying oil’, ‘the use of agricultural machinery’, ‘the use of electricity’, ‘cultivated area of clover and alfalfa’, ‘number of farm and garden’, ‘number of land pieces’, ‘number of horticultural crops’, ‘number of agricultural crops’, ‘number of vegetable crops’, ‘living conditions on the farm’, ‘annual consumption of animal manure on the farm’, ‘producing plant debris’, ‘diversification of productive activities’, ‘women’s participation in activities related to energy’, and ‘willing to install solar and biogas equipment in case of governmental support’. Also, the two variables of ‘non-agricultural- animal keeping income’ and ‘the annual cost of gas at home’ were negatively and significantly related to the use of biomass energy.

The multivariate regression with the stepwise method was used to predict the impacts of independent variables on the dependent variable of the use of biomass energy. The results are shown in Table 11.

Taking the above results and those in Table 3 into account, linear equation resulted from regression analysis is as follows:

$$Y= 232.22 + 43.04X1 + 1.01X2 - 1.005X3+ 12.86\ X4+ 6.57X5$$

where

Y= The use of biomass energy,
X1= Diversification of productive activities,
X2 = Experience in animal husbandry,
X3= Annual cost of gas at home,
X4= Number of farms and gardens,
X5= Number of vegetable crops.

According to the results shown in Table 11, the variable of "diversification of productive activities" (β=0.618) had the greatest influence on the use of biomass energy, the variable of "annual cost of gas at home" (β =0.102) and "experience in animal husbandry" (β =0.100) were ranked the 2nd and 3rd most important factors influencing the dependent variable, respectively.

Table 10
Correlation Coefficients between the Use of Biomass Energy with Random Variables

Selected variables		Correlation coefficients	*p*-value
Individual and professional characteristics	Family size	0.183**	0.002
	Agricultural work experience	0.190**	0.001
	Experience in animal husbandry	0.291**	0.000
Technical and economic characteristics	Non-agricultural- animal husbandry income	- 0.189**	0.001
	Annual cost of electricity	0.117*	0.043
	Annual cost of gas at home	- 0.179**	0.002
	Annual cost of buying firewood	0.150**	0.009
	Annual cost of buying oil	0.156**	0.007
	The use of agricultural machinery	0.198**	0.001
	The use of electricity	0.219**	0.000
Agronomic characteristics	Cultivated area of clover and alfalfa	0.347**	0.000
	Number of farms and gardens	0.256**	0.000
	Number of land pieces	0.180**	0.002
	Number of horticultural crops	0.140*	0.013
	Number of agricultural crops	0.419**	0.000
	Number of vegetable crops	0.191**	0.001
	Living conditions on the farm	0.255**	0.000
	Annual consumption of animal manure on the farm	0.253**	0.000
	Producing plant debris	0.172**	0.003
	Diversification of productive activities	0.647**	0.000
Psychological and social characteristics	Women's participation in activities related to energy	0.209**	0.000
	Willing to install solar and biogas equipment in case of governmental support	0.132*	0.022

**p<0.01, *p<0.05

Table 11
Results of Regression Analysis Related To the Use of Biomass Energy

Independent variable	R	R^2	R^2 Ad.	B	Beta	*p*-value
Constant	-	-	-	232.22	-	0.000
Diversification of productive activities	0.649	0.421	0.419	43.04	0.618	0.000
Animal keeping work experience	0.658	0.433	0.429	1.01	0.100	0.032
Annual cost of gas at home	0.665	0.443	0.437	-1.005	- 0.102	0.021
Number of farm and garden	0.671	0.450	0.442	12.86	0.094	0.037
Number of vegetable crops	0.677	0.458	0.449	6.57	0.098	0.042

CONCLUSION

Based on the results, the average size of the household was 7. This can be, certainly, considered an opportunity for peasant farmers who primarily rely on family labor. Accordingly, larger families are able to engage in a wide range of on-farm activities including horticulture, growing of cereal crops, cultivating vegetables, raising low/high weight livestock, etc. Although this would positively affect the traditional use of biomass energy, it has negative impacts on incentives to apply renewable energy sources.

Given that the respondents were highly experienced in agricultural activities and in raising livestock, the adoption rate of innovations among these farmers is low. Thus, rather than modern practices, they frequently apply traditional farming methods.

Analysis of the energy-related expenses revealed that with regard to fossil fuels, respondents used more energy at home. Meanwhile, electricity costs and natural gas costs were low for garden sheds and barns. This implies that in spite of the fact that garden sheds are common in about half of the farms and that electricity is widely used as the main energy source for barns and milking, the costs of application of these energies are low. Although those farmers who pay more for electricity to be used in barns or pay less for natural gas consumption at home are traditionally more eager to use biomass energy, they are not motivated to invest in renewable energy technologies.

Since agroforestry is the dominant pattern of farming in the study area, the production of firewood is a prevalent activity in these farming systems. The produced firewood is possibly applied at home or at the farm level. Consequently, trade in firewood does not take place in this area and thereby, 90% of the respondents do not pay for firewood. Farmers, who are more engaged in farming and livestock husbandry activities and thus have a lower capacity to produce firewood, are traditionally more interested in using renewable energy.

The application of plant and animal residues provides an opportunity for respondents to take advantage of renewable sources of energy. However, these residues can be applied for multiple purposes such as feed for livestock or manure for soil which, in turn, limits the application of these residues for energy production purposes. Given that the amount of residues produced at the farm level is not significant and that the rate of self-consumption is high among farmers, so it is not reasonable for them to invest in technologies such as biogas unless they manage to apply such technologies all together through farmers' organizations or alliances.

Given the fact that there exists no training program regarding the use of energy in the agriculture sector, farmers are not sufficiently aware of renewable sources of energy such as biomass.

Biomass was previously used to heat houses, garden sheds, and barns and also to make food either at home or at the farm. In a similar manner, this source of energy is currently applied for cooking at the farm and for heating garden sheds or barns. Meanwhile, with regard to the type and number of livestock, other sources of energy are also used to heat barns. Since the cost of supplying firewood is high particularly for those who produce no firewood and have no access to natural gas, fossil fuels can play a key role in energy supply. Also, since their application is easier and cleaner, respondents prefer to keep using fossil fuels. Hence, farmers are less motivated to use biomass energy.

Awareness about policies regarding renewable energy will effectively influence the development of solar or biogas energies. Hence, farmers who are more aware of these policies are more likely to equip their farms with biogas technologies.

In recent years, due to drought occurrence and the increased use of groundwater resources for urban consumption, many farms have faced a scarcity of water resources. This has resulted in a shift from the production of plants with high water requirements to those with low water requirements. If farmers cultivate plants with the potential of being used as a source of energy, the willingness to equip farms with renewable energy technologies will increase. This implies that water can play a crucial role in directing the use of technologies.

Since renewable energy resources can be used for a wide range of activities from production to transportation, need assessments must be done to further recognize the potentials for technology development.

Residues of plants and animals are recognized as a potential source of renewable energy, but there is no specific policy or technical instruction for their optimal use, particularly in organizations such as Agriculture Jihad. Therefore, many farmers burn a considerable amount of firewood without being aware of its potential use. So, programs must be designed and implemented to optimally take advantage of plant and animal residues.

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