International Journal of Emerging Engineering Research and Technology
Volume 9, Issue 1, 2021, PP 26-39
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)
DOI: https://doi.org/10.22259/ijeert.090103

Assessment of Farmers Attitudes towards Small-Scale Floating Drum Biogas Units for Rural Communities: Palestine as a Case Study

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ABSTRACT

This paper focused on determining farmers' attitude towards Small-scale Biogas Floating Drum Biogas Units. The study was conducted in the West Bank part of Palestine. Two hundred respondents were selected in following random sampling technique during the period from June 2011to January 013. Five attitude domains were tested in addition to sample characteristics. Findings indicated that majority of the respondents were middle aged (with an average age of 36.7 years), lived in separate houses (85%), had a garden (72%), had high level of education (30.2% with university degree), and had large family size (7 members). Farmers had low extension contacts and/or services related to biogas technology use. It was also found that majority of the farmers (70%) had low technical knowledge of biogas unit operation and maintenances or its financial aspects. They showed high attitude towards willingness to accept and use the biogas unit in their farms (84%), towards proper on-farm waste management (82%), and towards the use of produced biogas and fertilizer (85%). The results of the study showed that the small-scale floating drum biogas units were needed and beneficial to Palestinian farmers and to on-farm waste disposal and accordingly good effort is needed by the Palestinian Authority as well as the private sector in promoting and institutionalizing of this technology in rural Palestinian areas.

Keywords: *Farmer' Attitude, Small-Scale Biogas Units, on-farm Waste Management, Rural Palestine.*

INTRODUCTION

With globally increasing population, urbanization, and industrialization, the use of fossil fuels (more than 85% of the total energy consumed currently) [1]has dramatically increased resulting in depletion of those non-renewable resources, harming the environment, affecting materials and people's health and social belongings. Consequently, the interest in the search for alternate cleaner source of energy was growing worldwide. In the other hand, Environmentalists are always concerned in finding an energy source that is environmentally sustainable, economically feasible and socially acceptable.

One of the innovative methods for producing green energy is to use a biogas plant that an aerobically digests organic solid waste and animal manure to produce biogas and soil fertilizers. The biogas plant does not only represent a source of energy but it also represents an efficient method for organic solid waste disposal[2] In addition, it was found that there is a direct relationship between renewable energy and sustainable development via its effect on human development and sustainable economic growth[3]

The produced methane of the biogas is used for heating, electricity generation or as a transport fuel. Biogas technology is increasingly used worldwide and plays an important role in producing energy for several uses like cooking, electricity production and heating [4,5and 6]

Biogas units are in general designed and built to provide the microorganisms with the suitable environmental conditions to digest organic material and produce biogas. Due to continuous improvements and developments in biogas technology, the applicability and the benefits of biogas units have grown in importance,

especially in developing and third world countries [7,8].

Biogas is characterized based on its chemical composition and the physical characteristics which result from it. It is primarily a mixture of methane (CH_4, 55-70%) and inert carbonic gas (CO_2, 30-42%) and may have small amounts of water vapor (H_2O) and hydrogen sulfide (H_2S), moisture and siloxanes [9]. However, the name "biogas" gathers a large variety of gases resulting from specific treatment processes, starting from various organic waste - industries, animal or domestic origin waste etc. [10].

There will be some emissions from anaerobic digestion (AD). Air emissions from anaerobic digesters are generally lower than other forms of waste disposal. The health risks from the solid and liquid residue from the AD plant should be low as long as source-separated waste is being used - i.e., no chemical contaminants are entering the system from other wastes-[11].

There are a lot of studies about the economics of small-scale biogas units around the world. Several studies especially in India indicated that biogas technology is only economically feasible under certain conditions; such as the presence of government subsidies [12-15].

The success of biogas plants depends on availability of organic materials, cost of construction, founded energy sources and its costs, experience, knowledge, ambient climate conditions especially temperature, and acceptability for people constructing and using these plants [16]. In most of the studies the success or failure were based on the economic benefits arising from operating biogas units.

Discussion of the economics of the digestion of municipal solid waste (MSW) or wastewater sludge (MWS) is case specific and complex due the wide range of parameters that affect the costs and the number of "external" benefits that are accrued. Even within a single country these costs vary considerably [17-19].

A small-scale unit has different conditions than MSW or MWS units. In the case of small-scale unit, the project developer is forced to have a very close view to the different aspects of the unit and its implementation [20].

It was found that investments in small-scale biogas agricultural units in Hungary and Germany are no longer economically attractive for farms smaller than 5 ha due to the high fixed investment costs and rising prices of biogas feedstock [21].

Much research was found in the literature on evaluating public attitudes of farmers on various aspects and issues, while inadequate publications were found on the attitudes of farmers on small-scale floating drum biogas units [22-39].

Biogas production in Palestine has not been given enough care and few studies have been done and biogas units were limited to a few small-scale units that were constructed mainly for educational and demonstrational purposes.

The Palestinian public was not involved and/or did not participate in any small-scale biogas unit implementation and it is good to know their positions adopted, or expressions of views or thoughts that have an effect on behavior, ideas, or emotions.

The impact of introducing and implementing small-scale biogas units on the poor in the rural communities in Palestine is expected to be one of the positive impacts introduced. Other impacts include improving farm economy, waste management, improving farm environment, energy access and security, and farmers' social, health and overall quality of life.

Most of the Palestinian energy needs of natural gas are met by importing oil products from Israeli companies. The prices are high and usually not affected by international market prices especially when the international prices drop. It was stated that the theoretical amount of biogas that could be produced in northern Palestine is 8,640 tons/year based on the 115,200 ton of solid waste that Zahret Al-Finjan landfill receives annually [40].

The main objectives of this study were to discuss, assess, and evaluate Palestinian farmers' attitudes towards the use of small-scale floating drum biogas units. A parallel objective was the persuasion and promotion of the biogas units to farmers in the rural Palestinian communities.

METHODS

Study Area

The West Bank is part of the Palestinian Territory. The land area of the West Bank is estimated at 5572 km^2 extending for about 155 km in length and about 60 km in width (see Figure 1). The West Bank may geographically be divided into four regions: the semi coastal plains, the central upland, the eastern slopes, and the Jordan valley. Rainfall in the West Bank ranges from 30 mm/year in the southern part to

700-1100 mm/year in the northern part. Average annual rainfall in the West Bank is 409 mm/year[41,42].

Palestinian population projections reveal that mid-year population in 2013 totaled 4,327,751 persons, of whom 2,643,435 in the West Bank and 1,684,316 in the Gaza Strip. According to the Palestinian Central Bureau of Statistics [43].

According to the official list of local authorities adopted by the Palestinian Central Bureau of Statistics and the ministry of local governments, there are 686 localities in Palestine. The localities include 54 urban, 603 rural, and 29 refugee camps administered as 107 municipalities, 11 local councils, 374 village council or project committee, and 29 director of refugee camp. An additional 76 rural localities either are not inhibited or joined to larger nearby locality [44].

Population of Palestine reached 4.781 million people in 2017, 77% of them lived in urban areas while 15% in rural areas and 8% in refugee camps. Population density was estimated at 794 capita/km2 in Palestine in 2017.In 2010, About 21.5% of the total area of the West Bank used for various forms of agriculture of which 2.64% is irrigated, 6.21% of the total area was used for built-up areas and public infrastructure, 59.1% for pastures and grazing, 2.05.1% for forests the remaining land of the West Bank represent mountainous and unusable land [45].

Fig1. *General Location Map of Palestine including the Study Area [46]*

Farmer's Persuasion and Training

Because Palestinian farmers were not acquainted with small-scale floating drum biogas units, a persuasion process through conducting onsite workshops with farmers including lectures and designing, preparing and printing, and distributing educational/training materials including an illustrated biogas manual took place at each site or village visited.

During onsite workshops description and physical demonstration of small-scale floating drum biogas units was conducted including their installation, operation, and maintenance. An open question-and-answer session between organizers and farmers on all aspects of small-scale floating drum biogas units including economic and financial feasibility took place (See Figure 2).

In addition, a research assistant-trained engineer, followed up with farmers who received biogas units for one year on unit technical aspects including its operation and maintenance of the units as well as data collection on the type and quantity of organic matter used and biogas generated and how it was used. The research assistant was helping in farmer's persuasion and training.

Fig2. *Example of Small-Scale Floating Drum Biogas Units Demonstration*

Attitude Survey

A field survey in the form of a detailed questionnaire was conducted. The questionnaire design, including questionnaire structure, target group, and implementation procedure, and sample size and distribution, are described below.

Questionnaire Design, Structure, and Size

A questionnaire was developed and distributed among various farmers over the West Bank covering 12 rural villages (See Table 1). The villages were identified and selected to cover as comprehensive as possible of the area of the West Bank and to stay within project budget. The field application of the study started in June 2011, and ended in January 2013. The West Bank also was divided into three main geographic centers: southern districts, central locations, and northern districts (See Table 1, See Figure 3).

To conduct a check on content validity of the questionnaire, a panel of experts working in the field at An-Najah National University were selected for this purpose. Their comments were valuable and taken in consideration in the final draft of the questionnaire which was approved by them.

The questionnaire structure consists of six parts in fifty-two questions. The first part asks for biographic and socioeconomic and general data about the respondents (20 questions). The second part poses 8 questions seeking/assessing farmers' knowledge about on-farms generation and use of biogas. The third part sought to test farmers' acceptance and willing to use biogas technology (9 questions).The fourth part was directed towards farmers' attitude towards the use of produced biogas and the resulting organic fertilizer (4 questions). The fifth part was on farmers' perception towards biogas unit management aspects (six questions). The sixth part was on farmers' perception towards financial and economic aspects (five questions).

The response to questions was scaled according to a Likert scale of responses [47]. A questionnaire was developed and distributed among various farmers all over the West Bank covering rural villages.

The field application of the study started in June 2011, and ended in January 2013. 200 copies of the questionnaire (in Arabic language) were distributed on 200 families (farmers) who live at different Palestinian rural areas in the West Bank. The number of questionnaires for each location was dependent on the number of farmers who could attend the workshop called upon by village council/municipality (See Table 1). The questionnaire was distributed, completed, and collected in onsite workshops in each location.

Onsite Workshops

Onsite workshops were organized through village council or municipality and aimed at introducing and promoting the concept of biogas technology among Palestinian farmers people (the workshops were led by the authors of the paper).

In preparing for the onsite workshops, the researcher should be equipped with all the material needed: overhead projector, laptop, copies of questionnaire, and copies of biogas manual.

It should be noted that the contact persons at villages or municipalities were very helpful and valuable in the success of the onsite workshops.

Onsite Demonstration and Handling of Small-Scale Floating Drum Biogas Units

During the onsite workshops, a presentation of the technology and all its aspects was presented. A physical demonstration of a sample small-

scale floating drum biogas unit was made, and farmers were enabled to ask questions about its installation, operation and maintenance. A specially prepared and illustrated manual of the biogas unit was distributed and explained to all attending farmers and some additional copies were left with the village council. Depending on the size of the village one or two biogas units were handled to farmers for use in in their farms.16 biogas units were distributed and handled to farmers free of charge in villages all over the West Bank. Farmersin accepting the biogas units they agreed to supply the organizers with all the data and information on its operation, maintenance, and efficiency.

Fig3. *Both Authors at Aqqaba Workshop where Farmers Completing the Field Survey*

Table1. *Distribution of Field Survey Questionnaires by Locations*

Ref.	Location Name	Governorate	Population	Number of Questionnaires Completed
1	Biet Lid	Tulkarm	5969	25
2	Saida	Tulkarm	4022	21
3	Aqqaba	Tubas	8914	22
4	Tammoun and Tal al Himma	Tubas	14191	21
5	BietLehem and BietFajjar	BietLehem	30880 14909	14
6	Al-Jeftlik	Jericho	3306	14
7	At-Tabaqa	Hebron	2081	21
8	Hebron	Hebron	221136	24
9	Jenin	Jenin	53721	14
10	Arbouna	Jenin	1103	16
Total No. of Questionnaires Completed				192
Total No. of Questionnaires Distributed				200

The questionnaire domains and questions were explained to the workshop participants for removing any misunderstanding. The participants answered the questionnaire before the beginning of the workshops to ensure the impartiality and neutrality of the answers. Then, the filled questionnaires were collected and the obtained data were organized and statistically analyzed.

Planning Site Visits and Survey Piloting

Planning the site visits was made through direct contacts with village councils or municipality. A contact person was assigned for each location for coordination, organization of on-site visits and for follow-up purposes. In villages, the head of the village council was the contact person while in municipalities a responsible person was assigned by majors.

A pilot survey was conducted during the first two weeks of the study by the authors to check the questionnaire-survey procedure, to refine the questionnaire before actual distribution among the target groups, to determine the time needed for a respondent to complete the questionnaire and to allow the master students to be acquainted with the survey procedures. The survey piloting stage includes a great deal of writing and re-writing of questions that will elicit answers aligning with the objective of the study, identifying placement of questions to allow for an easy flow when taking the survey, and making sure that the survey length is adequate.

We started with seventy-two questions and our final selection for the pilot comprised fifty-two questions. This decrease in the amount of question was because we aimed at minimizing

the completion time and simplifying the questions for farmers.

Survey Procedure and Response

The designed questionnaires were distributed to target groups directly by the second author. The second author along with 2-4 master students from the same program were oriented and trained prior to start of questionnaire distribution on how to explain the purpose, structure, and completion of the questionnaire and how to deal with various farmers.

Because of the onsite distribution and completion of questionnaires, all of the distributed questionnaires were returned completed. However, minor percentage (4%) of the completed questionnaires were incomplete and discarded. Approved, properly completed, questionnaires were sorted in tables and entered the computer in Excel files.

Data Management

- The data management step consisted of the following processes or actions:
- Editing and coding all farmer's responses before data entry
- Data were entered into the computer as Excel files.
- Use Microsoft Office Excel software
- Statistical Package for the Social Sciences software (SPSS) [48].
- Statistical Analysis System (SAS) software [49].
- The critical percent for evaluating the positivity or negativity of the questionnaire responses is considered 60%.
- The average reply equals to the sum of number of replies multiplied by their scores divided by the total number of replies. Percent of reply equal to average reply divided by the maximum score.

Results and Discussion

Sample Characteristics

General characteristics of the sample surveyed including the biographic and socioeconomic data of the respondents as well as sanitation and waste management are summarized and presented in Tables 2, 3,4 and 5. These results are discussed briefly in the following paragraphs.

The respondents were mostly mid-age (21 to 60 years) males with an average age of 36.7 years (see Table 2). The respondents were highly educated: one third were having a first or higher college degree while the other half were mostly with school degrees (See Table 2). The number of family members was large and mostly over ten members. (See Table 3).

This is a characteristic of rural communities in Palestine. Most respondents (73%) have health insurance (mostly governmental) which gives good health coverage and services. Generally, the social level of Palestinian farmers is considered high.

The distribution of the total monthly income of respondents was much diversified. However, over 79.2% of all the respondents were with monthly income less than 3500 NIS or about one thousand US$, and about one quarter of them with income of less than 1000 NIS or about 300 US$ (see Table 3). These records are consistent with previously published figures by the Palestinian Bureau of Statistics and the Applied Research Institute of Jerusalem [50-52].

Respondents live mostly in separated houses (85%) while the rest 15% live in apartments. For villagers living in apartments, this percentage is considered high. However, it is preferred in terms of biogas technology for a family to live separately, because living in apartments may not give enough space for placing and operating biogas units, unless operating the biogas unit is meant to be a joint process between the building residents.

The respondents were working in private sector related to agriculture (41%) or directly in farming (29%). This was a good indication that respondent understand farming limitations and benefits and easily absorb related information.

Most respondents live in houses that mostly have gardens (72%). The grow in house gardens fruits (60%), vegetables (20%), and flowers (26%). The vegetable growing percentage at home is relatively low due to the fact that respondents were mostly working in the field and have free access and availability to vegetables.

Also, most respondents were raising animals (57%) either in their farms or houses including: 59% sheep, 39% poultry and rabbits, and to a lesser extent cows and birds. Sheep in an economic animal for farmers since they get milk from it and from milk, they make cheese and fat and at older age they sell it for meat.

Table2. *Sample Classification by Income and Education*

Description	Classification	Response		
		By Number	By Percent	Cum. Percent
Income level In NIS	Less than 1000	47	24.5	24.5
	1000 to 2000	67	34.9	59.4
	2000 to 3500	38	19.8	79.2
	More than 3500	21	10.9	90.1
	No response	18	9.4	99.5
Educational level	Uneducated	12	6.3	6.3
	Elementary	17	8.9	15.2
	Primary	44	22.9	38.1
	Secondary	53	27.6	65.7
	University graduate	58	30.2	95.9
	No response	8	4.0	99.9

Table3. *Sample Characteristics by location, Family Number, Sex, and Age*

Description	Location												
	Grand total	Aqaba	Arbouna	BietLehem and BietFajjar	Biet Lid	At-Tabaqa	Hebron city	Jeftli	Jenin city	Talal Himma	Saida	Tamoun	Incomplete
Sample Number	200	22	16	14	25	21	24	14	14	18	21	3	8
Sex, by %													-
Male	70.0	95.5	100.0	50.0	36.0	28.6	70.8	85.7	35.6	94.4	95.2	100.0	
Female	30.0	4.5	0.0	50.0	64.0	71.4	29.2	14.3	64.3	5.6	4.8	0.0	
Number of Family members													
≤ 2	22	1	1	3	4	4	1	0	3	0	5	0	
3-5	28	3	8	3	1	1	2	3	5	1	1	0	
>5	118	14	6	6	19	14	14	9	5	13	15	3	
Not provided	32	4	1	2	1	2	7	2	1	4	0	0	8
Age, by %													-
≤ 20	18.2	0.0	0	71.4	60.0	19.0	12.5	7.1	7.1	0.0	4.8	0.0	
21-30	15.1	4.5	12.5	14.3	0.0	23.8	29.2	14.3	21.4	27.8	9.5	0.0	
31-40	14.1	18.2	25	0.0	12.0	4.8	16.7	14.3	21.4	22.2	9.5	0.0	
41-50	22.9	36.4	12.5	0.0	12.0	9.5	29.2	35.7	28.6	16.7	42.9	33.3	
≥ 51	16.1	31.8	37.5	7.1	8.0	19.0	4.2	0.0	7.1	16.7	19.0	66.7	
Not provided	13.5	9.1	12.5	7.1	8.0	23.8	8.3	28.6	14.3	16.7	14.3	0.0	

The majority of respondents indicated that they collect/clean animal waste within a week (69%, See Table 5) and they use animal waste generated in their farms as fertilizers (59.3%) while 12.1% disposing it in village solid waste containers or leaving it in place where it was produced. The last two options, producing biogas and leaving waste in place, were understood as small amounts generated at house (See Table 5).

This waste management practicesis expected to be suitable and positive element for the use of small-scale floating drum biogas unit because waste is available all the week which is the raw material needed as input for the unit operation.

The use of animal waste as fertilizer to plants/crops is an eco-friendly solution and provide nutrients for the plants, but if it was stabilized before use. Using raw manure without treatment as a fertilizer to plants has negative health effects, and is even prohibited by some legislation around the world and in Palestine [53-55]. So, the presence and use of small-scale floating drum biogas unit will be of great importance and help to farmers to treat animal waste before using it to fertilize the land and generate biogas for in-farm applications.

For household waste, most respondents (53.1%) reported that they dump it in village solid waste containers, while small fraction of them burned it (13.3%) or feeding the organic proportion to animals (12.8%) or using it as in land application as fertilizer (7.2%).

As shown in Table 5, most respondents (54.7%) rely on septic tanks or dry pits for domestic wastewater disposal while 38.5% of them use

village wastewater collection network. The rest of respondents dispose generated wastewater in open channels outside their houses (6.3%) or use it in irrigating their gardens (14.5%).

Table4. *Respondents by Work, Health Insurance, Residence, and Gardening*

Description	Classification	Response		
		By Number	By Percent	Cum. Percent
Work Type	Owner/Private Sector	78	41	41
	Agricultural	56	29	70
	Trade Sector	46	24	94
	Employee/Governmental	12	6	100
Health Insurance	Available	141	73	73
	Un-Available	51	27	100
Residence Type	House	164	85	85
	Apartment	28	15	100
Garden Availability	Available	139	72	72
	Un-Available	53	28	100
Garden Type	Flowers	36	23	23
	Vegetables	25	14	37
	Fruits	75	48	85
	Other trees	23	14	99
Raising Animals	Yes	109	57	57
	No	83	43	100
Animal Type	Poultry & Rabbits	43	30	30
	Birds	23	16	46
	Sheep	64	44	90
	Cows	6	4	94
	Other Animals	9	6	100

Table5. *Respondents by Waste Management*

Statement	Description	Average *	Percentage	Rank
Methods of dealing with animal waste	Selling it to fertilizers factories	0.32	10.7	4
	Using it as a fertilizer to my plants	1.78	59.3	1
	Producing biogas from it	0.17	5.7	5
	Disposing it in waste containers	0.36	12.1	3
	Leaving it in place	0.37	12.2	2
Animal Waste Cleaning Frequency	Once Daily	0.72	24	2
	Once every 2-4 Days	0.72	24	3
	Once every 5-7 Days	0.63	21	4
	Over one Week	0.93	31	1
Methods of dealing with household waste	Burning the waste	0.40	13.3	3
	Disposal in public containers	1.59	53.1	1
	Feeding organic waste to the animals	0.38	12.8	4
	Fermenting household organic waste to obtain biogas and / or organic fertilizer	0.22	7.2	5
	Disposal in a nearby land	0.41	13.6	2
Wastewater Collection and Disposal	Village Network System	1.16	38.5	2
	Septic Tank/Dry Pit	1.64	54.7	1
	Using Open Channel	0.19	6.3	4
	Using wastewater in Irrigation	0.44	14.5	3

Attitudes towards Farmer's Biogas knowledge Aspects

It was noticeable based on survey results that previous farmer's knowledge about biogas technology which was 80% (See Table 6). This response is considered high and also considered as a positive element in biogas units' promotion in rural Palestinian communities. This high knowledge level was expected from farmers with high education (See Sample Characteristics Section).

About one half of farmers, 43% heard about biogas technology from school or universities, while the second half , 57%, new about the technology from various media sources, the internet and meetings and conferences (See Table 6). This result reflects the importance of education at schools and universities as well as

media sources in building people's culture and knowledge.

The smallest percentage was given to the internet, although the internet is considered one of the most important tools nowadays in spreading any information, its use in rural Palestinian communities seems inadequate.

In answering the question about the origin of biogas, most farmers, 78%, indicated the organic waste digestion. Again, this response reflects the high knowledge that Palestinian farmers have. Other responses did not gain any noticeable weight.

Table6. *Farmers Knowledge of Biogas Technology*

Statement	Description	Average *	Percentage	Rank
Have you ever heard about biogas?	Yes	154	80	1
	No	38	20	2
If you know about biogas, where did you hear about it?	school or university	43	10.7	4
	Media	28	59.3	1
	Internet	5	5.7	5
	Workshops/conferences	24	12.1	3
	Other	0	12.2	2
Origin of Biogas	Organic waste digestion	78	24	2
	Burning of organic waste	5	24	3
	Petroleum	8	21	4
	Have No Opinion	9	31	1

Palestinian farmer's knowledge and perceptions of on-farm waste management its use in biogas production was highly positive (See Table 7). Also, high attitude (85% of respondents) was found towards the understanding of the positive impact of biogas unit introduction on the environment. Palestinian farmers considered the cost of biogas units installation in their farms was high (70% of respondents). Comparing the benefits of biogas unit introduction, farmers' response indicates and reflect their incomplete knowledge of the financial aspects and feasibility of the units.

Table7. *Farmers Knowledge and Perceptions of on-farm Waste Management*

Statement	Responses	
	Average*	Percentage
Using biogas technology reduces the final waste volume.	4.30	86.1%
The primary cost of installing a biogas unit is high	3.50	70.1%
The digestion of organic waste through biogas technology produces solid and liquid output.	3.75	75.0%
The digestion of organic waste produces a fertilizer for plants.	4.14	82.8%
Using biogas technology had positive impacts on the environment.	4.25	84.9%

** Score is sum of all responses out of 5.*

Attitudes towards Farmers' Acceptance and Willingness to Use Biogas Technology

Farmers were clear (over 83% of respondents) about their willingness to accept the presented biogas technology and about using it in their farms (See Table 8). This result is in agreement and aligned with the level of knowledge and awareness that farmers have about the technology and its benefits. However, farmers were binding their agreement to be associated with the financial gains that this use will bring to their families (See Table 8, second question). Similarly, farmers expressed their willingness (82% of respondents) to separate on-farm or in-house generated the organic waste from other waste in order to use it in the biogas unit (See Table 8, fourth question).

In responding to the question about the existence of other alternatives better than biogas technology to treat organic waste, farmers were poorly agreeing (only 58.2% of respondents are in agreement) reflecting their uncertainty and trust about such existence (See Table 8, third question). This response is a positive and encouraging element in the way of promoting the technology to farmers. Similarly, farmers responded to the fifth question related to the effort needed to operate the biogas unit in the house or on-farm (will require a lot time and effort (only 56.5 of respondents are in agreement),), and to the seventh question related to the quality of the fertilizer resulting from biogas unit (only 61.5% of respondents are in agreement), and to the eighth (52.8%) and nineth (51.8%) question regarding their ability

to fix or find an expert to fix an operating or maintenance problems faced respectively. Overall, farmers in such level of responses, from one side they prove their high education and knowledge and from the other side they express their skepticism about their technical capacity, knowledge, and handling ability of it. Accordingly, this matter is needed and need to be addressed properly through training and extension programs.

Table8. *Farmers by Willingness to Use Biogas Technology*

Ref.	Statement	Average*	Percentage
1	like to buy and use biogas unit for the house or farm.	4.18	83.6%
2	will use biogas technology if it will have financial profit on the family.	4.29	85.8%
3	there are other alternatives better than biogas technology to treat organic waste	2.91	58.2%
4	Do not mind the separation of organic waste (kitchen and garden waste) from other household waste.	4.11	82.2%
5	operating a biogas unit in the house or farm will require a lot time and effort.	2.83	56.5%
6	have fears regarding the quality of the fertilizer quality resulting from biogas unit.	3.08	61.5%
7	have fears regarding my ability to fix it by my own in case any damage occurs.	3.64	52.8%
8	have fears regarding the unavailability of appropriate expertise capable of following up the unit and its maintenance.	2.59	51.8%

** Maximum range and score are 5*

Attitudes towards farmer's Willingness to Use Produced Biogas and Organic Fertilizer

Over 84% of farmers were in agreement of all questions of this group, i., e., their willingness to use the produced gas and the fertilizer (See Table 9). However, most farmers prefer to use the produced biogas in cooking (68%) which is considered one of the easiest and simplest ways to use biogas. Small fraction of farmers (13%) expressed their willingness to use the produced biogas in heating or in producing electrical energy.

Table9. *Farmers by Willingness to Use Produced Biogas and Organic Fertilizer*

Ref.	Statement	Average*	Percentage
1	Would like to use the fertilizer resulting from biogas technology at the farm or garden.	4.21	84.2%
2	Using biogas is preferred on the house level.	4.21	84.3%
3	Using biogas is environmentally and economically feasible.	4.32	86.4%
Average		4.25	85.0%

Attitudes towards farmer's Perceptions on Biogas Unit Management Aspects

Poor and skeptic percentage of farmer were agreeing to use and manage all aspects of the small-scale floating drum biogas unit at home (only 46.3% are in agreement, See Table 10). This agreement was worse (40.5%) when the management was proposed to be joint in a neighborhood committee or else. Likewise, farmers poorly agreed (51.4%) to grant the biogas unit management aspects to a private company or to let this task to the government (50.0%), or to shareholding company (See Table 10). This result of close percentages and poor agreement are in accord and harmony with farmers' poor knowledge of the technical specifications and details of the biogas unit and its operational and maintenance needs.

Attitudes towards farmer's Perceptions on Financial and Economic Aspects

The farmer's answers to questions related to the income earned by farmers from using the biogas unit was uncertain and reflect that they don't know specifically (70% of participants),about the family income from using biogas technology. All respondent's answers to questions related to financial and economic aspects were poor and ranging from 38% to 44% (See Table11). Similar to the management

aspects attitudes, it is important to accompany any biogas promotion project with proper training and extension as well as follow-up and extension institutions to optimize the process and ensure positive results and continuation.

Table10. *Attitudes towards farmer's Perceptions on Biogas Unit Management Aspects*

Ref.	Statement	Average*	Percentage	Rank
1	Would like to use biogas unit in my house and by house management only.	2.31	46.3%	2
2	If biogas unit management is joint, I would like to participate in a management committee regarding it.	2.03	40.5%	1
3	Recommend the biogas technology to be managed by private company.	2.57	51.4%	4
4	recommend the biogas technology to be managed by the government or its local representatives.	2.50	50%	3
5	recommend the biogas technology to be managed by joint shareholder company.	2.60	52%	5

Table11. *Farmers by Perceptions on Financial and Economic Aspects*

Ref.	Statement	Average*	Percentage	Rank
1	recommend the income of biogas technology to be distributed on the village inhabitance.	2.21	44.2%	3
2	recommend the income of biogas technology to be distributed on the village inhabitance according to their participation level.	2.08	41.5%	2
3	recommend that the government participate in biogas technology establishment cost.	1.93	38.6%	1

CONCLUDING REMARKS

Based on the results of the conducted survey, the following main concluding remarks were observed:

- Palestinian farmers were found highly educated and knowledgeable of biogas technology.
- Palestinian farmers were found to have limited knowledge of the technical and financial aspects of biogas units.
- Positive attitudes were observed among Palestinian farmers towards the use of biogas technology in their farms binding to financial gains.
- Palestinian farmers prefer among other purposes to use biogas as fuel for cooking.
- Biogas technology was found good and needed to Palestinian rural communities and should be encouraged and promoted.
- Identifying and considering farmer's attitudes towards various aspects of small-scale floating drum biogas units by planners and decision makers represent an important developmental element relating not only to the spread of those units in rural Palestinian communities but also to the production of biogas and fertilizer and proper disposal of on-farm solid waste.
- Biogas units use in rural Palestinian communities need to be institutionalized by the Palestinian authority in the form of extension and support services.

ACKNOWLEDGEMENTS

The authors would like to acknowledge and thank the Public Affairs Office, USA Consulate General in Jerusalem for their support and cooperation in conducting this study during the period 2010-2014 under contract No. SIS400=10-GR-0091 with An-Najah National University, Nablus, Palestine. The authors would like personally to thank the Consul for Public Affairs Frank Finver and his co-workers who stimulated this study - their support have been invaluable.

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Citation: *Marwan. Haddad, Dania Maraka . "Assessment of Farmers Attitudes towards Small-Scale Floating Drum Biogas Units for Rural Communities: Palestine as a Case Study", International Journal of Emerging Engineering Research and Technology, 9(1), 2021, pp. 26-39. DOI: https://doi.org/10.22259/ijeert.090103*