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Capacity Building Needs of Farmers in Biogas Production for Sustainable Environment in Benue State Nigeria.

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Abstract

Energy poverty continues to impede socioeconomic development in most parts of Nigeria. There has been continued and sustained over reliance on firewood for fuel. Most of inhabitant in Nigeria still rely on firewood for their cooking needs; thereby compounding the challenge of dwindling forest resources in the country. Biogas energy has been encouraged as a sustainable solution as it is a clean, instant and renewable energy source. The aim of the study is to assess Farmers capacity in biogas as an alternative and sustainable energy source in Benue State Nigeria. The study employed a descriptive survey design with purposive sampling technique adopted to select one university for the study. The selected university was Joseph Sarwuan Tarka, University, Makurdi. The population of the study was 1,001 respondents, comprising of 50 Lecturers of Agriculture from federal and state universities and 951 Farmers in Benue state, Nigeria. The instrument for data collection was a structured questionnaire, titled: Biogas Production Questionnaire (BPQ). The data collected from the respondents was analyzed using Improvement Needed Index and weighted mean to answer research questions while t-test was used to test null hypotheses at 0.05 level of significance. Findings indicated that Agricultural Lecturers and Farmers in Benue State utilized available feedstock's efficiently for biogas production. Findings also showed that Agricultural Lecturers and Farmers in Benue State needed capacity building in biogas construction and operation. Since Agricultural Lecturers and Farmers in Benue State already utilized available feed stocks efficiently for biogas production, it is recommended that this practice be sustained and enhanced through continuous awareness programs, demonstration farms, and farmer-to-farmer knowledge exchange platforms. It was also recommended that regular capacity building sessions be held on biogas plant operation, maintenance, safety protocols, troubleshooting, and efficiency optimization.

Key Words: Capacity building, Farmers, Biogas production, Sustainable Environment

1.0 Introduction

The issue of national development with its monumental benefit to the citizenry and the country has never been attained without harmonizing the various inherent technical skill of her people. It is also true that the development of nations whether in primordial times or in contemporary era has never been made possible without the identification, development and utilization of the various human capacities of the people for sustainability. Any development process visualized in its simplest or broadest context must meet the expectations of the people of the state for enhancing their standard of living and helping to contribute to national development. This must find root in effective techniques to bridge skill needs gaps for human

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capacity building (Basil, Victor and Chinonye 2017).

Capacity building means a new build-up of capabilities (Kogut & Zander in Gbeyongu 2023). Capacity building also increases the abilities and resourcefulness of persons, communities and organizations to manage change (Coutts, Roberts, Frost & Coutts in Gbeyongu, Onu and Akaa 2019). Capacity building refers to activities that improve an organization's ability to achieve its mission or a person's ability to define and realize his/her goals or to do his/her job more effectively (Hord, in Gbeyongu, 2023). Ikharehon, (2017) reported that capacity building focused on increasing an individual and organization's technical abilities to perform core functions, solve problems, and objectively deal with developmental needs. The author stressed capacity building as improving or upgrading the ability of a person, team and institutions to implement their functions and achieve goals over time. It is important at all levels, from individual farmers to national organizations.

From the foregoing, it becomes imperative that no nation of the world neglects the continuous improvement of the skills, knowledge base, education, competencies and the strategic alignment of its people, communities, businesses and other institutions to national development without concerted effort to effective human capacity building which is a sine qua non for an all-round sustainable development (Ikharehon, 2017). Humans and their capacity identification and development remains the center of creation of goods and services, advancement in science and technology, economics, agriculture, military; and above all value creation in all spheres of human endeavor (Isola 2012). Therefore capacity building as a human development strategy must aim at improving skills for carrying out key functions, solving problems, defining and achieving objectives and focusing on building the individual's knowledge base, skills, attitudes, competencies and abilities.

In the context of this study, capacity building of farmers in biogas production is the identification and acquisition of technical skills by farmers in feedstock identification and composition, plant construction, installation preservation and utilization. Farmers' capacity building in biogas production from simple organic raw materials such as animal dung, food waste, agricultural residue, municipal waste materials and human waste is the center stage for this research work, therefore, Understanding these practices and its comparative advantage in a given context is essential because each stage has different requirements. Knowledge of the key operation

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and maintenance issues and the benefits of organic fertilizer (bioslurry) is important. Bioslurry is a good alternative to chemical fertilizers and can help to rebuild soil health. Home sanitation can also improve as a result of better management of organic waste for better agricultural recycling. To determine the capacity building needs of these farmers, there must be need assessment.

Need assessment is explained by Anyakoha in Bala (2017) as a type of evaluation used by researchers in determining various areas of need or discrepancies in education. The author stated that need assessment is based on the notion that the relevance of education must be empirically determined and should identify the discrepancy between 'what is' and 'what it should be'. In the context of this study, need assessment is the process of determining the difference between the level of capability of farmers and their expected capability in biogas production. This process gives a gap called need gap.

Need gap analysis is describe by Chuta in Bala (2017) as a technique for determining the steps to be taken in moving from a current state to a desired future state. It begins with listing of characteristics factors such as competences, performance level of the present situation, cross listing of the factors required to achieve future objective and then highlighting the gaps that exist and needs to be filled. In this study, need gap analysis is the computation of the mean values of the expected performance of farmers in biogas production to ascertain their need and performance level.

A farmer is a person engaged in agriculture, raising living organisms for food or raw materials for industries. The term usually applies to people who do some combination of raising field crops, orchards, vineyard and livestock. A farmer might own the farm land or might work as a laborer on the farm land owned by others (Gbeyongu, et al, 2019). It is the science and art of cultivating the soil, including the allied pursuits of gathering in the crops and rearing livestock.

To summarize, farming is the characteristic activity that takes place on a farm, and typically it involves the management of a biological process, such as growing crops or raising livestock, for the purpose of harvesting products or reproducing a biological means of production.

This emphasis on the management of biological processes in crops and livestock makes it clear that farming is not defined on the basis of the purpose to which products are put: it is not necessary to produce food or animal feed. Biological processes are also managed to

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produce fiber (flax, cotton, and wool), flowers, fur, pharmaceutical products, and the by-product as feedstock's for biogas production.

Biogas is a colorless and odorless mixture of gases produced through anaerobic decomposition of organic materials by microorganisms. Depending on the nature of the organic materials and operating conditions, the gas composition includes methane, carbon dioxide, nitrogen, hydrogen sulphide, and ammonia with compositions of 40-75%, 25-40%, 0.1-1%, 0.1-0.5% and 0.1-0.5%, respectively (Weiland 2010). It's also defined as a gaseous mixture generated during anaerobic digestion processes using waste water, solid waste (example at landfills), organic waste, and other sources of biomass.

Krishna, Ravindra, and Nitesh (2016) also affirmed that biogas is an environmentally friendly energy source which is mostly comprised of methane (CH_4) (55-60%) and carbon dioxide CO_2) (35- 40%). Moreover, biogas contains a low quantity of other gasses such as ammonia (NH_3), hydrogen sulphide (H_2S), hydrogen (H_2), oxygen (O_2), nitrogen (N_2) and carbon monoxide (CO). Biogas can be used to augment conventional energy sources for various purposes including cooking, heating, vehicle fuel, and electricity generation, while the sludge from the anaerobic process can be used as organic fertilizer. It is a favorable dual purpose technology at present since used as bioenergy and fertilizer. The term "anaerobic" suggests that the process occurs in the absence of free oxygen and produces methane (CH_4) through decomposition of waste in nature and reduces environmental pollution. Leftover food fruit & vegetable wastes and cow dung can be subjected to anaerobic digestion for energy production through a complex process that takes place in four biological and chemical stages i.e. hydrolysis, acidogenesis, acetogenesis and methanogens. (Ilona, Meisam, Keikhosro, and Rajeev 2016).

The process of biogas production is seen as a promising pathway towards achieving sustainable development, ultimately reducing methane (CH4) and carbon dioxide (CO2) emission, while promoting ways to reduce energy costs, provide waste management solutions and produce organic fertilizer for own use or as an additional source of income (Biogas 2013). The researcher observed that many farmers in the study area lack the technical know-how in operating and maintaining biogas plants. Therefore, the present research work shall provide ideal technical skills outline for farmers in feedstock identification and composition, construction, operation, maintenance,

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preservation and utilization of biogas for efficient climate goals attainment.

It has been estimated that about 80% of Nigerian households living in the rural and urban areas use fosils and wood fuel and charcoal for cooking and heating. The use of fosil fuel, wood and charcoal for cooking and heating has dire consequences such as greenhouse gas emission GHG, global warming, environmental pollution, deforestation, desertification, erosion and flooding.

Considering the above trend, it is important to consider a cheap but reliable alternative source of energy such as biogas. It is worth noting that most of the wood fuel is used in rural communities as energy for cooking. Farmers in the rural communities also engage in charcoal production especially during the lean season which is transported to the cities for consumption. Integration of biogas technology into the farming system will reduce the use of firewood for cooking and reduce the involvement of farmers in charcoal production as they are likely to be busy on their farms.

Studies showed that biogas applications offer social, environmental, health and economic benefits. Economically it creates wealth, job and energy, environmentally it is friendly as it reduces volume of waste, does not produce but reduces carbon dioxide from the atmosphere; it reduces the need for fossil fuel, fuel wood and charcoal. Health wise, it is a clean energy and does not pollute the environment to cause diseases. Therefore, biogas production would reduce the use of fossil-fuel-derived energy and reduce environmental impact including global warming and pollution, improve sanitation, reduce demand for wood and charcoal for cooking and provide a high quality organic fertilizer. Biogas production can serve as a means to overcome energy poverty, which poses a constant barrier to economic development in Nigeria.

In Nigeria, there are abundant of wastes arising from the domestic and agricultural sources of which the potential has not been tapped. A look around in every rural/urban area in Nigeria shows enormous dumps every here and there of wastes lining up everywhere and polluting the environment. These could be re-cycled and used for biogas production. Hence, the growing global energy demand together with the limited availability of fossil fuels, unstable energy prices, and environmental problems necessitate the use of renewable energies such as biogas.

This study in a bit to bridge this gap and advocate biogas production from waste, intends to assess biogas potentials from organic waste in

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Benue State Nigeria. In order to encourage displacement of the use of charcoal and fuel wood for domestic cooking/heating, thereby reduce deforestation, greenhouse gas (GHG) emissions and enhance environmental sustainability.

The broad objectives for this study is to identify capacity building needs of farmers in biogas production and sustainable environment. Specifically, the study will determine capacity building needs of farmers in:

1. Feedstock utilization.

2. Plant construction

3. Plant operation

2.0: Area of the Study.

The area of the study is Benue State, Nigeria. It is rich in agricultural production and the people in the state are predominantly farmers; some of the crops grown in the area include rice, yam, cassava, soy-beans, cowpea, groundnut, maize, potatoes, and sesame among others. While animals reared in the region include cows, goats, sheeps, poultry, rabbit, pig, among others. This crops and animals by products are good substrate for biogas production. The choice of Benue State for the study is because plant and livestock production is practiced by a large population of the inhabitants and the feedstock are left un-utilized causing environmental pollution, erosion, and global warming. Also chosen was because of the temperature range of mesophilic (25-45oC) in the region which is suitable for biogas production.

The population of the study was 1,001 respondents, comprising of 50 Lecturers of Agriculture from federal and state universities and 951 Farmers in Benue state, Nigeria. The choice of Lecturers and farmers in the study was based on their knowledge in Agriculture and waste treatment.

3.0 Methodology

This chapter deals with the methodology adopted to carry out the study. It is presented under the following sub-headings: design of the study, area of the study, population of the study, sample and sampling techniques, instrument for data collection, validation of instrument(s), and reliability of the instrument, data collection and data analysis

The study adopted survey research design. Survey research design is one in which a group of people or items is studied by collecting and analyzing data from only a few people or items considered to be representative of the entire group. This type of design gathers data from a large number of subjects. Therefore, the purpose of the study is to gather information about

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variables of a large population. The design was adopted because questionnaire was used to determine the capacity building needs of the sampled farmers and lecturers of agriculture in biogas production.

The instrument for data collection was a structured questionnaire, titled: Biogas Production Questionnaire (BPQ). It was developed by the researcher from the literature based on the objectives/research questions. Section one (1) was concerned with Feedstock identification with (50) items, Section two (2) had Plant construction and it comprised of (19) items. Section three (3) covered Plant operation with (15) items.

In all the three (3) sections identified, the respondent were expected to rate section (1) on a continuum of whether the item were utilized or not. For the remaining sections (2-3), each item has (2) levels of responses (Needed level for lecturers of agriculture and performance level for the farmers). The needed category had four-point response options as follows; Highly Needed (HN) =4, Needed (N) =3, Slightly Needed (SN) =2, Not Needed (NN) =1. While the performance category had four-point responses as follows; High Performance (HP) =4, Average Performance (AP) =3, Low Performance (LP) =2 Very Low Performance (VLP) =1

The instrument was administered by the researcher and five research assistants who were familiar with the study area. This ensured that the respondents which the questionnaire is meant for were contacted. Out of the total of 153 copies of the questionnaire administered only 142 copies were retrieved and forwarded back to the researcher within one week for onward processing.

The data collected from the respondents was analyze using Improvement Needed Index and weighted mean to answer research questions while t-test was used to test null hypotheses at 0.05 level of significance.

To determine the performance gap (PG) and capacity improvement needs (CIN) of farmers, the following steps were taken by using weighted mean.

The weighted mean (*Xn*) of each item under the needed category was calculated.

The weighted mean (*Xp)* of each item under the performance category was calculated.

The difference between the two weighted means from each item of needed and performance *(Xn-Xp)* was calculated to obtain the need gap value (NG).

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(i) Where the difference is zero (0) there is no need for capacity building on that item because the level of need for that item is equal to the level at which the farmers will perform that particular task.

(ii) Where the difference is (-) for any item, there is no need for capacity building on that item because the level of need for that item is lower than the level at which the farmer could perform the task

(iii) Where the difference is (+) for any item, there is need for capacity building because the level at which that item is needed is higher than the level at which the farmers will perform the task.

The null hypotheses of no significance difference was rejected for any item whose t-test calculated (p-value) (P≥0.05) is greater than 0.05 levels of significance, while the null hypotheses of no significant difference was accepted for any item whose t-test calculated p-value is less than the value of P≤ 0.05 level of significance.

4.0 Result and Discussion

This section presented results of the data analysis and discusses the findings of the research. It was done under descriptive analysis, testing of hypotheses, findings and discursion of findings.

Results

The results of the descriptive analysis were presented as follows.

Research question 1

What are the feedstock Agricultural Lecturers and farmers utilized for biogas production?

Table 1; Respondent responses on the utilization of feedstock for biogas production in Benue State.

	Feedstock's Utilized for Biogas Production		
	Agricultural Crops Feedstock/Residue	U	NU
1	Cocoa husk/pod	✓	
2	Coconut shell/husk	✓	
3	Groundnut shell/hust	✓	
4	Maize cob/husk	✓	
5	Millet straw/stalks	✓	
6	Cassava peelings	✓	
7	Rice husk	✓	
8	Potatoes stem/leaves	✓	
9	Sorghum straw/stalk	✓	
10	Sugarcane baggage/straw	✓	
11	Soybean straw/pod	✓	
12	Tobacco stem/stalk	✓	
13	Cocoa yam residue	✓	
14	Tomato stem/leaves	✓	
15	Vegetable residue	✓	
16	Mango residue	✓	
17	Mellon residue	✓	
18	Ginger residue	✓	
19	Chill and Paper residue	✓	
20	Coffee husk	✓	
21	Citrus residue	✓	
22	Kolanut residue	✓	
23	Okora residue	✓	

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24	Pawpaw residue	✓	
25	Pineaple residue	✓	
26	Plantain residue	✓	
27	Wheat residue	✓	
28	Cotton stalk	✓	
29	Oil palm fruit/fibre/shell	✓	
Livestock Waste/Feedstock			
30	Dead livestock	✓	
31	Livestock Manure	✓	
32	Slaughter houses	✓	
33	Feather	✓	
34	Bones	✓	
35	Blood	✓	
36	Undigested food	✓	
37	Human waste/sewage	✓	
38	Used litter	✓	
39	Urine	✓	
40	Waste milk	✓	
41	Placenta	✓	
42	Birth tissues		
43	Aborted fetus	✓	
44	Horns		
Community Based Feedstock			
45	Water hyacinth	✓	
46	Algal	✓	
47	Grass clipping/garden waste	✓	
48	Food remains	✓	
49	Institutional waste	✓	
50	Municipal solid waste MSW	✓	

Key: Utilized (U), Not Utilized (NU)

Data in table 1 revealed that respondents in the study area accepted that items in the table above were utilized for biogas production. This indicated that farmers and agricultural lecturers have knowledge of effective feedstock for biogas production.

Research question 2

1. What are the capacity building needs of farmers in biogas plant construction?

Table 2; Need Gap Analysis of the mean ratings of Agricultural Lecturers and Farmers in Biogas Production in Benue State

S/no	Item statement	$\overline{Xn}$	$\overline{Xp}$	NG Xp-Xn	Remark
1	High excavation work is required for construction of a digester.	2.81	3.83	1.02	CBN
2	The minimum construction of the digester should be 5x3m3 and should be underground against physical damage	2.85	3.76	0.91	CBN
3	It should be constructed by a professional brick masonry	2.83	3.76	0.93	CBN
4	The inlet and outlet pipes should be connected according to specification	2.81	3.70	0.89	CBN
5	High quality branded cement should be used	2.84	3.69	0.85	CBN
6	Use fine aggregate sharp sand free from lumps size 7-30cm diameter is appropriate	2.78	3.69	0.91	CBN
7	Regular shaped kiln burnt bricks should be used	2.81	3.61	0.80	CBN
8	Mix cement and sharp/fine sand to the ratio of 1:3	2.89	3.63	0.74	CBN
9	Add water to the ratio of 1:1	2.90	3.56	0.66	CBN
10	Use hard, clean, strong stones for concrete works	2.89	3.21	0.32	CBN
11	6mm steel rods, 50m for 4m3 plant, 60m for 6m3 and so on should be used	2.55	3.58	1.03	CBN
12	Pipes of 60mm should be used	2.70	3.49	0.79	CBN
13	Construction a mixing tank meant for preparing a	2.78	3.49	0.71	CBN

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	homogenous mixture of raw materials				
14	. Fix a gas metre on top of the accumulator to monitor gas pressure	2.72	3.56	0.84	CBN
15	Connect a pipe on top of the accumulator to the gas storage bag/gas holder	2.74	3.44	0.70	CBN
16	The gas fittings should be gas tight during construction	2.71	3.51	0.80	CBN
17	The gas holder should be painted with a water proof material	2.93	3.59	0.66	CBN
18	Digester should be covered with earth up to the top of the gas filled space to counteract pressure	2.70	3.59	0.89	CBN
19	Use oil paint as a sustainable coating product	2.93	3.59	0.66	CBN

Data in table 2 revealed that the need Gap value of the 19 items ranged from 0.32-1.03 and were positive. This indicated that Agricultural Lecturers and Farmers needed capacity building in Biogas Plant Construction in Benue State

Research question 3

What are the Capacity Building Needs of Farmers in Biogas Plant Operation?

Table 3; Need Gap Analysis of the Mean Ratings of Agricultural Lecturers and Farmers in Biogas Plant Operation in Benue State

S/n	Item Statement	$\overline{Xn}$	$\overline{Xp}$	NG Xp-Xn	Remark
1	Fill the digester chamber with the organic material for fermentation process to commence	2.73	3.73	1.00	CBN
2	The biogas user should ensure that the gas storage bag is filled to capacity before he/she starts using the gas.	2.74	3.71	0.97	CBN
3	The very first gas produced should be vented unused from the water drain valve.	2.69	3.67	0.98	CBN
4	When the biogas plant is in use, feeding should be done on a daily basis.	2.92	3.67	0.75	CBN
5	Use adequate quantity of substrate daily.	2.90	3.65	0.75	CBN
6	The inlet to the digester must be blocked during substrate mixing	2.87	3.62	0.74	CBN
7	Ensure thorough mixing of the substrate with water and/or urine to the ratio of 1:1	2.83	3.57	0.76	CBN
8	Use impurity free substrate (dung/water mixture).	2.63	3.57	0.94	CBN
9	Pour the raw material into the base of the digester through the inlet pipe and close after use	2.78	3.67	0.89	CBN
10	Take out the slurry through the out let pipe as organic manure	2.91	3.64	0.75	CBN
11	If the digester accumulates volatile acids as a result of overloading, the situation can be remedied by reseeding, or by the addition of lime or other alkali.	2.71	3.65	0.94	CBN
12	Stirring of digester contents is recommended at regular intervals may be manually in order to avoid formation of scum.	2.77	3.63	0.86	CBN
13	Always monitor the Pressure gauge which indicates the amount of gas produced by the biogas system	2.69	3.61	0.91	CBN

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14	Gas valves should always be closed to ensure that the gas does not flow out through some leakages in the piping when the gas is not being used	2.58	3.55	0.97	CBN
15	The biogas stove should be carefully adjusted to ensure; a compact bluish flame,	2.68	3.53	0.83	CBN

Data in table 3 revealed that the Need Gap value of the 15 items ranged from 0.74-1.00 and were positive. This indicated that Agricultural lecturers and Farmers needed Capacity Building in Biogas Plant Operations in Benue State.

Hypothesis 1

There is no significant difference in the mean ratings of responses of Lecturers of Agriculture and Farmers on their capacity building needs in feedstock utilization.

Table 4: t-test Analysis of the Mean Ratings of Responses of Agricultural Lecturers and Farmers on their Capacity Building in Feedstock Utilization.

Status	N	Mean	SD	SD Error Mean	df	t-cal	Sig	Remark
Agricultural Lecturers.	20	2.76	.61	.21	96	.82	.59	S
Farmers	133	3.95	.74					

N= number of respondents, SD= Standard deviation, df= degree of freedom, t-cal= t- calculated, sig.= significant, Ns = not significant, S= significant

Table 4 showed a p-value of .82 which is greater than the alpha value of 0.05. This indicated that there was no significant difference in the mean ratings of Agricultural Lecturers and Farmers on their capacity building needs in feedstock utilization in Benue State. Therefore the hypotheses of no significant difference for the respondents on their capacity building needs in feedstock utilization was rejected.

Hypothesis 2

There is no significant difference in the mean ratings of responses of Lecturers of Agriculture and Farmers on their capacity building needs in biogas plant construction.

Table 5: t-test Analysis of the Mean Ratings of Responses of Agricultural Lecturers and Farmers on their Capacity Building in Biogas Plant Construction.

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Status	N	Mean	SD	SD Error Mean	df	t-cal	Sig	Remark
Agricultural Lecturers.	20	2.72	.58		94	.76	.53	NS
Farmers	133	3.89	.69	.19				

N= number of respondents, SD= Standard deviation, df= degree of freedom, t-cal= t- calculated, sig.= significant, Ns = not significant, S= significant

Table 5 showed a p-value of .53 which is greater than the alpha value of 0.05. This indicated that there was no significant difference in the mean ratings of Agricultural Lecturers and Farmers on their capacity building needs in biogas plant construction in Benue State. Therefore the hypotheses of no significant difference for the respondents on their capacity building needs in biogas plant construction was rejected.

Hypothesis 3

There is no significant difference in the mean ratings of responses of Lecturers of Agriculture and Farmers on their capacity building needs in biogas plant operation

Table 6: t-test Analysis of the Mean Ratings of Responses of Agricultural Lecturers and Farmers on their Capacity Building in biogas plant operation

Status	N	Mean	SD	SD Error Mean	df	t-cal	Sig	Remark
Agricultural Lecturers.	20	2.92	.69		97	.79	.63	NS
Farmers	133	3.90	.73	.23				

N= number of respondents, SD= Standard deviation, df= degree of freedom, t-cal= t- calculated, sig.= significant, Ns = not significant, S= significant

Table 6 showed a p-value of .63 which is greater than the alpha value of 0.05. This indicated that there was no significant difference in the mean ratings of Agricultural Lecturers and farmers on their capacity building needs in biogas plant operation in Benue State. Therefore the hypotheses of no significant difference for the respondents on their capacity building needs in biogas plant operation was rejected.

Findings of the Study

Based on the analysis of data collected for the study, the following findings were drawn.

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1. Agricultural Lecturers and Farmers in Benue State utilized available feedstock's efficiently for biogas production.
2. Agricultural Lecturers and Farmers in Benue State needed capacity building in constructing biogas plant.
3. Agricultural Lecturers and Farmers in Benue State needed capacity building in operating biogas plant.
4. It was found that, there was no significant difference in the mean ratings of the responses of Agricultural Lecturers and Farmers on their capacity building in biogas feedstocks utilization.
5. It was also found that, there was no significant difference in the mean ratings of the responses of Agricultural Lecturers and Farmers on their capacity building in biogas plant construction
6. It was also found that, there was no significant difference in the mean ratings of the responses of Agricultural Lecturers and Farmers on their capacity building in biogas plant operation

Discussion of Findings.

Discussion of findings of the study was presented as follows; the findings on research question one showed that Agricultural Lecturers and Farmers in the study area utilized all the substrate available as feedstock. This feedstocks included Cocoa husk/pod, Groundnut shell/husk, maize cob/husk, millet straw/husk, beans chaff, cattle dung, poultry manure, pig dung, blood meal, rotten fruits and vegetables amongst others. These findings were in agreement with Schnurer and Jarvis, (2010). The author asserted that all the feedstock utilized by the respondents where either from plants and animals waste. This includes agricultural resources, agricultural residues, forest resources, waste including animal waste, municipal solid waste MSW, industrial waste, and other wastes, as well as algae. These materials are referred to as feed stocks in bio-refining. The fuel form obtained after the processing or preparation of this feedstock is called biofuel, biogas or bio-solid and the energy output is called bioenergy. As an energy source, feedstock can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel.

The findings on research question two showed that Agricultural Lecturers and Farmers in the study area needed capacity building in all the items on biogas plant construction, these items were stated as follows; High excavation work is required for construction of a digester, The minimum construction of the digester should be 5x3m3 and should be underground against physical damage, The inlet and outlet pipes

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should be connected according to specification, High quality branded cement should be used, Use fine aggregate sharp sand free from lumps size 7-30cm diameter is appropriate amongst others. These were in agreement with Rajati, Adrjmand, and Rajati, (2014). The author maintained that; The life span of a plant very much depends on the quality of the material used for its construction. Therefore, quality materials should be used, preferably locally available to reduce the cost. A brief description and specifications is given below; Cement – High quality branded cement, sealed bags, protected from moisture and contamination. Sand - Fine aggregates or sand, clean and free from coagulated lumps, impurities especially mud. Coarse and granular sand can be used for concreting work but fine sand better for plastering. Gravel - Stone crushed, hard, strong and clean, it under 2cm in size. Water - Clean water, pH value not exceeding 7. Bricks - Regular shaped, kiln burnt bricks, soaked before use.

Stones - In case of stone masonry, clean, strong and good quality stones size 7-30cm in diameter. The findings on research question three showed that Agricultural Lecturers and Farmers in the study area needed capacity building in all the items on biogas plant operation. these were stated as follows; Fill the digester chamber with the organic material for fermentation process to commence, The biogas user should ensure that the gas storage bag is filled to capacity before he/she starts using the gas, The very first gas produced should be vented unused from the water drain valve, When the biogas plant is in use, feeding should be done on a daily basis, Use adequate quantity of substrate daily, The inlet to the digester must be blocked during substrate mixing, Ensure thorough mixing of the substrate with water and/or urine to the ratio of 1:1, Pour the raw material into the base of the digester through the inlet pipe and close after use amongst others. These statements supports the work of Ifhkhak and Shabir (2017). The author stated that the procedure required for the operation of biogas plant are; Feeding - Initially feed the digester at optimum level with mixture of water and raw material at a ratio of 1:1. After 1-2 weeks of operation, continuous daily feeding is recommended.

Seeding - Common practice involves seeding with an adequate population of both the acid-forming and methanogenic bacteria. Actively digesting sludge from a sewage plant constitutes ideal "seed" material. As a general guideline, the seed material should be twice the volume of the fresh manure slurry during the start-up phase, with a gradual decrease in amount added over a three-week period. If the digester accumulates

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volatile acids as a result of overloading, the situation can be remedied by reseeding, or by the addition of lime or other alkali **(**Ifhkhak and Shabir 2017).

Stirring/Agitation - Stirring of digester contents is recommended at regular intervals may be manually in order to avoid formation of scum.

Gas Collection - Gas can be collected from the drum through a non-return valve system. Preferably a water pipe is most suitable than gas pipe. Gas pipe should be regularly cleaned to remove moisture contents.

Similarly, in the discussion of hypotheses, it was retained that there was no significant difference in the mean ratings of all the responses of the respondents on capacity building needed in feedstock utilization, biogas plant construction and operation respectively. Hence null hypotheses were all rejected.

5.0 Summary

The study was on capacity building needs of farmers in biogas production and sustainable environment in Benue State. The specific objectives of the study were to determine capacity building in Feedstock utilization, Plant construction, and Plant operations, the hypotheses tested maintained that there was no significant difference in the mean ratings of respondents on the capacity building needs in the aforementioned items stated. Therefore null hypotheses were rejected. The study employed a questionnaire survey design. It was carried out in Benue State, Nigeria with a population of (1001) respondents. The sampling technique adopted was purposive sampling techniques which arrived at a sample size of (153). The instrument was validated by three experts, and the test of reliability of the items was done on 15 Agricultural Lecturers and farmers in Taraba State, Nigeria bearing in mind there similarities in terms of crop and livestock production which provides the waste for biogas production. Mean, improvement need index and t-test were the statistical tools used to analyzed data.

The study revealed that Agricultural Lecturers and Farmers in Benue State utilized available feedstocks for biogas production. They also needed capacity building in biogas plant construction and operations respectively. The study proof that there was no significant difference in the mean ratings of the responses of Agricultural Lecturers and Farmers on the capacity building needed in plant construction and operations with a table value greater than the p-value at 0.05 level of significance. Hence null hypotheses rejected.

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Conclusion

Based on the findings of the study, it was concluded that Agricultural lecturers and Farmers in the study area utilized all the feedstock for biogas production. It was also found that respondents needed capacity building in biogas plant construction and operations. The findings of the study provided an empirical frame work for future researchers which will serve as a reference material for further studies.

Recommendations

The researcher offered the following recommendations based on the findings of the study

1. Since Agricultural Lecturers and Farmers in Benue State already utilize available feedstocks efficiently for biogas production, it is recommended that this practice be sustained and enhanced through continuous awareness programs, demonstration farms, and farmer-to-farmer knowledge exchange platforms.
2. Relevant government agencies, NGOs, and tertiary institutions should collaborate to organize targeted training and workshops for both Agricultural Lecturers and Farmers on the design, construction, and installation of biogas plants, using locally available materials.
3. To ensure optimal and safe operation of biogas plants, it is recommended that regular capacity building sessions be held on biogas plant operation, maintenance, safety protocols, troubleshooting, and efficiency optimization.

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