WILLINGNESS TO USE BIOGAS INNOVATION AS AN ALTERNATIVE ENERGY AMONG RURAL WOMEN IN OYO STATE, NIGERIA.

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Abstract
Biogas is an alternative energy source that has the potential to provide eco-friendly energy without deteriorating the environment. The study assessed the willingness of rural women to use biogas as alternative energy in Oyo State Nigeria. An interview schedule was used to obtain data from the sampled women and the data obtained were subjected to descriptive statistics while the hypothesis was tested using Logistic regression. Fuel wood (72.4%) and charcoal (69.0) are the major existing local energy sources but encourage forest depletion. Most rural women perceived biogas as a clean cooking fuel that is environment friendly, and 65 per cent of them were willing to use biogas as an alternative domestic energy source. The hypothesis tested revealed that age (β=0.661, $p<0.05$); marital status (β=3.689, $p<0.05$) and livelihood activities (β= -3.874, $p<0.05$) significantly influence the willingness to use biogas. The perception, socio-economic and livelihood status are also important factors that can be considered if women will adjust their behavior to accept biogas innovation to provide energy and protect the environment.

Keywords: Willingness; biogas; domestic energy; rural women; agrarian communities.

Introduction

Energy, water and soil are necessities for sustainable development. These three elements interrelate to meet the need of man and the environment (McCollum *et al* 2018). Access to these resources and their sustainable management is the basis for sustainable development (Brandi *et al*, 2013). The domestic requirement of energy is to take of domestic chores. According to Phebe and Samuel (2016), the globe is rapidly becoming a global village as a result of the daily energy demands of all people around the world; even though the shape of the earth cannot be restructured but its energy requirements are becoming very vital for human health, social and economic welfare. All societies require energy to meet fundamental human requirements, and the importance of researching new energy sources that are both renewable and environmentally beneficial cannot be overstated (Edenhofer *et al*., 2011). Renewable energy resources offer the most potential energy conservation and development in the future. There is presently a large amount of biomass around the globe, which refers to all forms of organic matter. The presence of organic waste all over the surrounding pose hazards to the environment and health of the people (Omer, 2007)

The biogas digester can be used to create and deliver low-cost energy without requiring the harvesting of wood (Kurchania, 2012; Arthur *et al*., 2011). Biogas digestion (the technique of capturing biogas during waste breakdown and utilising it for energy) can help to reduce the consumption of fuel-wood energy (Abbasi, 2010; Harmse, 2010; Chand, 2012; Kumar *et al*., 2013). It reduces forest degradation in the area. This minimizes greenhouse gas (GHG) emissions into the atmosphere while also increasing carbon sequestration potential (Mshandete and Parawira, 2009). Biogas improved people's lives by lowering energy costs, reducing labour costs associated with wood harvesting, and providing organic fertilizers that improve soil fertility (Mulinda, *et al*., 2013; Mengistu, *et al*, 2015). The introduction of biogas energy sources have significantly benefited the livelihoods of rural communities, as the reliance on fossil and wood-based energy sources have decreased dramatically in recent years (Aggarangsi *et al*., 2013; Kabir *et al*., 2013; Cheng *et al*., 2013).

Biogas is a clean cooking fuel that is not harmful and toxic unlike the particles emitted from the burning of firewood. Biogas can generate power for lighting (Bajgain and Shakya, 2005). Individual families or small groups can benefit from biogas plants. They are generally inexpensive to construct since they make use of existing waste products like domestic garbage, human excrement, and cow dung. The biogas generates unpolluted cooking fuel and can be used for lighting. The consumption of firewood is also a significant factor in global forest degradation, and thus a significant factor in climate change (Bajgain and Shakya, 2005). Biogas is an alternative energy to the existing local energy sources that can effectively address energy usage issues among rural households in developing nations. Kerosene is commonly utilized for cooking and lighting in many underdeveloped countries. There is the possibility that as the use of biogas is increasing; the use of kerosene will significantly decline. Biogas is an

innovation that is emerging especially among rural households; the spreading of biogas depends largely on how the users perceived the innovation-considering the benefits, challenges and what it will take to use the biogas innovation. The user's consideration of the biogas innovation will help to determine their willingness to accept biogas innovation. Women are considered for this study because they are the custodian of meal preparation and food cooking for the households. They are required to cook among other domestic activities that will necessitate the use of available energy sources. To replace the existing local energy source with alternative, women must be convinced about the new energy source. The overall objective is to examine the willingness of rural women to accept biogas innovation as an alternative energy source. Specifically, the study describes socio-economic characteristics, determine the existing sources of domestic energy used by rural women, determine the awareness of the benefits of biogas as an alternative source of domestic energy among the respondents, determine the willingness to accept biogas and what are the reasons for rural women's willingness/unwillingness to accept biogas and determine the perception on biogas by the respondents. The hypothesis for this study stated that there is no significant relationship between the social-economic characteristics of the respondents, perception and their willingness to use biogas as alternative domestic energy.

Theoretical Background

Technology Acceptance Model (TAM)

This theory explains how users interact with technology to embrace and employ innovation. The theory was first proposed in 1986 (Davis, 1989). The model takes into account the users' perceptions of technology acceptance. The actual usage of technology, as well as the intention to utilize it, is influenced by the users' perceptions. The two major factors employed by this model to regulate and explain users' behaviours about certain technology or innovation are perceived usefulness and easiness of use. The views of the users on the benefits to be derived from an innovation influence their decision to use an innovation. The model helps to understand some factors that can persuade peoples' decisions on how and when an innovation can be remarkably accepted and used. The model affirmed that for an innovation or technology to be accepted and used, the intention to use by an individual cannot be ignored. Perceived usefulness of the innovation plays a vital role which affects the attitude of the users in the actual use of the innovation. People establish intents to undertake any action for which they have favourable feelings, according to the relationship between users' attitude and intention. Several models have been created that take into account both the indirect and direct impacts of attitudes on behaviour. For instance, consider the A-B-C model proposed by (Guagnano, Stern & Dietz 1995). This model will assist the researchers and experts to identify and describe the reasons for users' resistance to technology and, as a result, take apposite corrective action (Davis; Bagozzi; Warshaw, 1989; Davis 1989).

In this case, biogas innovation is an alternative energy source to the existing energy sources that most rural areas were exposed to and are using for domestic and industrial purposes. The existing energy sources had certain negative consequences on the environment and humans which the benefit of the biogas innovation can help to resolve. This can only be possible if the users can perceive the usefulness and consider the benefits of the innovation vis-à-vis the easiness of innovation use which will influence their behaviour to accept and use or even reject the use of the biogas based on a reason. TAM captures and explains different variables that can affect people's willingness to accept the use of the biogas innovation, this makes the theory to be relevant to this study because TAM is a model of user adoption of information system technology based on their rational behaviour and perceived utility.

Methodology

Study Area

The research was conducted in Nigeria's Oyo State's Ido Local Government Area with geographical coordinates of 7^{o} 30' 24" North, 3^{o} 42' 43" East. Ido Local Government Area was founded in 1989 and is bordered on the North and East by Iseyin, Afijio and Akinyele respectively, Ogun state on the South and Ibarapa on the West. The study area has a landmass of 1,010.954 square kilometers, with a population of 146,200, based on a 3.5 percent projection of annual population change and a population density of 193.2 people per square kilometer, up from the 2006 projected census. The majority of the population works in agriculture, trading, transportation, and the civil service. Yoruba are the predominant tribe and other tribes from all throughout Nigeria are also living in the study area The area's soil fertility boosts maize, cocoa, oil palm, kola nuts, cassava, and vegetable output.

Sampling procedure and data collection

The respondents for the survey were chosen using a multi-stage sampling process. The following is the technique for selecting respondents: The first stage was to choose one of four agricultural zones under the Oyo State Agricultural Development Programme at random (OYSADEP). Ido Zone was the chosen zone. The second stage consisted of a random selection of four blocks, followed by a simple random selection of three cells from each block to create twelve cells. One village was picked from the selected cells to make 12 villages, and the last stage involved simple random sampling of 10 rural women to yield 120 respondents. An interview schedule was

used to elicit information from rural women in the study area.

Measurement of variables

Existing sources of domestic energy used was measured at the nominal level as Yes and No while Yes = 2 No =1. Awareness of biogas as an alternative energy source was measured at the nominal level as Aware =2, Not aware =1. Willingness to use biogas as an alternative energy source was measured at the nominal level as Willingness to use =2 and Not willing to use =1) while perception about biogas was measured with 5-point Likert's scale of Strongly Agree =5, Agree = 4, Undecided =3, Disagree =2 and Strongly Disagree =1.

Data analysis

The responses were subjected to descriptive analysis using frequencies, percentages, and mean, while Logistic regression was used to test the hypothesis.

The Binary Logistic regression model

Prob (Y=1/X) = ln (Pi/1- Pi) = $\beta_o + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9$

Pi = Probability that rural women will use biogas

Y = 1= willing, 0=unwilling

β_o = constant

X_1=age (measured in years)

X_2=marital status (Single=1, otherwise=0)

X_3= religion (Christianity=1, otherwise=0)

X_4= Ethnicity (Yoruba=1, otherwise=0)

X_5= Educational status (No formal education=1, otherwise= 0)

X_6= Livelihood activities (farming=1, otherwise= 0)

X_7=estimated monthly income (measured at interval level as estimated monthly income of the respondents)

X_8= Years of residence (measured at interval level as the number years the person has been living in the community)

X_9= Perception of Biogas innovation (Favourable perception =1, Unfavorable perception=0)

Results and Discussion

Socio-economic characteristics of rural women

The result in Table 1 shows the distribution of the socio-economic characteristics of the respondents. The result reveals that the age of the respondents was an average of 40 years. It indicates that many of the women are young which suggest that they might probably be more open to receiving innovation and willing to try new ideas, unlike the older women. Also, the result revealed that 65.5% were married. Marriage is believed to confer responsibility on an individual. This implies that the majority of the respondents were mature and responsible to provide for their families. One of the needs of households is the provision of energy for domestic and commercial purposes. Only 16.4 percent of the respondents had no formal education, implying that the majority had some type of schooling. People who are educated have a greater knowledge of the innovation, which could affect their decision to adopt it. This means that rural women with a greater level of education are more likely to adopt innovation than women with a lower level of education. Understanding how social and cognitive variables influence farmers' views is critical to understanding environmental challenges. This can be accomplished by creating information and education programs that are sensitive to farmers' perceptions of science and technology's abilities to solve environmental problems (Gardezil & Arbuckle, 2020). In addition, the results revealed that more than half of the respondents (57.8%) earned less than ₦10,000. It means that the rural women in the research area have limited purchasing power. One of the variables of innovation adoption is income. This indicates that their income falls below the federal government's suggested minimum salary scale, which may limit their willingness to accept and use biogas as a residential energy source.

Table 1: Socio-economic characteristics of rural women

Variable	Frequency	Percentage	Mean
Age (years)			
Less than or equal to 30	16	13.8	
31 – 40	50	43.1	40 years
41 – 50	34	29.3	
51 and above	16	13.8	
Marital status			
Single	18	15.5	
Married	76	65.5	
Divorced	11	9.5	
Widow	11	9.5	
Religion			
Christianity	56	48.3	
Islam	50	43.1	
Traditional	10	8.6	
Ethnic group			
Yoruba	84	72.4	
Igbo	17	14.7	
Hausa	15	12.9	

Education			
No formal education	19	16.4	
Primary education	24	20.6	
Secondary education	30	25.9	
Vocational education	14	12.1	
Tertiary education	29	25.0	
Livelihood activities			
Farming	52	44.8	
Trading	38	32.8	
Public/Civil Servant	19	16.4	
Artisan	7	6.0	
Income (Naira)			
Less than or equal to 10, 000	67	57.8	
11, 000 – 20, 000	15	12.9	₦27,208.39
21, 000 – 30, 000	13	11.2	
31, 000 and above	21	18.1	
Years of residence			
Less 11 years	90	77.6	
11 – 20 years	18	15.5	9years
21 years and above	8	6.9	

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Existing sources of domestic energy used by rural women

Existing sources of domestic energy used by rural women is shown in Table 2. The result revealed that the most domestic energy used by the respondents were firewood (72.4%), followed by charcoal pot (69.0%) and kerosene stove (67.3%). This is an indication that the majority of rural women used wood, charcoal and kerosene as a source of energy. This may be due to the availability of the materials for the energy at their disposal. Findings as shown that the use of some of these materials for energy supply contributed directly or indirectly to climate change. Ahmad (2006) noted that the ever-increasing demand for fuel wood to meet up energy requirements has made most of the rural communities in Nigeria to be under the threat of deforestation which is one of the major factors of climate change.

Table 2: Existing sources of domestic energy used by rural women

Existing sources of domestic energy	**Used***	
	Frequency	Percent
Firewood	84	72.4
Charcoal pot	80	69.0
Kerosene stove	78	67.3
Electric stove	37	31.9
Gas cooker	32	27.6
Sawdust	22	19.0
Crop straw	19	16.4
Wood waste	20	17.2
Animal dung	22	18.9

* Multiple responses.

Awareness of rural women on biogas as an alternative energy source

Table 3 reveals the result of the awareness of the benefits of biogas as an alternative source of energy by the respondents. The result reveals that 44.8% of the respondents were aware that biogas has no smoke, unlike firewood. This implies that biogas is a saver and healthy to use, unlike firewood that produces smoke which can be detrimental to human health. Some (34.5%) were aware that biogas does not contribute to the depletion of the ozone layer. This implies that biogas is friendly to the environment and it is not likely to cause air pollution. 37.9% were aware that it is a renewable source of energy. Also, the result revealed that 25.0% were aware that an alternative source of income can from waste that is readily available in the rural areas. This means that biogas can serve as an alternative source of income to rural women. 36.2% were aware that it serves as an alternative source of income from waste that is readily available in rural area. There is a need to create more awareness on the use and benefit of biogas usage as an alternate source of energy among the rural populace. The level of awareness of

innovation could probably aid in forming behavioural intentions by the users. This concurs with the results of Qian *et al*. (2021), who found that those who are more certain about their beliefs rely more on their attitudes about the environment with greater strength to predict pro-environmental behavioral intentions such as willingness to pay (WTP).

Table 3: Awareness of rural women on biogas as an alternative energy source

Variables	Aware	
	Frequency	Percentages
Biogas has no smoke unlike firewood	52	44.8
It saves expenses on fuel used for cooking	46	39.6
It does not contribute to the depletion of the ozone layer	40	34.5
The use of biogas can lead to reduction in demand for wood/charcoal. Thereby reducing deforestation		
It is a renewable source of energy	44	37.9
It also helps in the treatment of waste which constitutes a major environmental hazard	34	29.3
It reduces the respiratory infection that smoke can cause as a result of using firewood	37	31.9
It helps to generate income from waste that is readily available in the rural area	29	25.0
Many local jobs could be created around the biogas project	42	36.2
The use of biogas could save time used in gathering firewood for cooking	47	40.5

Willingness of rural women to use biogas as alternative energy

The result in Figure 1 shows that most (65.5%) of the respondents are willing to use biogas as alternative energy due to its benefits while 34.5 percent of the respondents are unwilling to use biogas. The higher results of the rural women willing to accept the biogas innovation indicate that the acceptance and utilization of the innovation will be higher and that is a key factor in the adoption of innovation. However, more awareness needs to be done to sensitize about one-third of the respondents that are not willing to use biogas. Some of the constraints associated with the use of biogas, according to Parawira (2009) are incompetent professionals handling biogas plants installation, inadequate dependable information about the gains of biogas and poor technical knowledge on repairing and maintaining the biogas plants. This has an impact on people who are already inclined to protect the environment in terms of their knowledge, beliefs, concerns, and intentions.

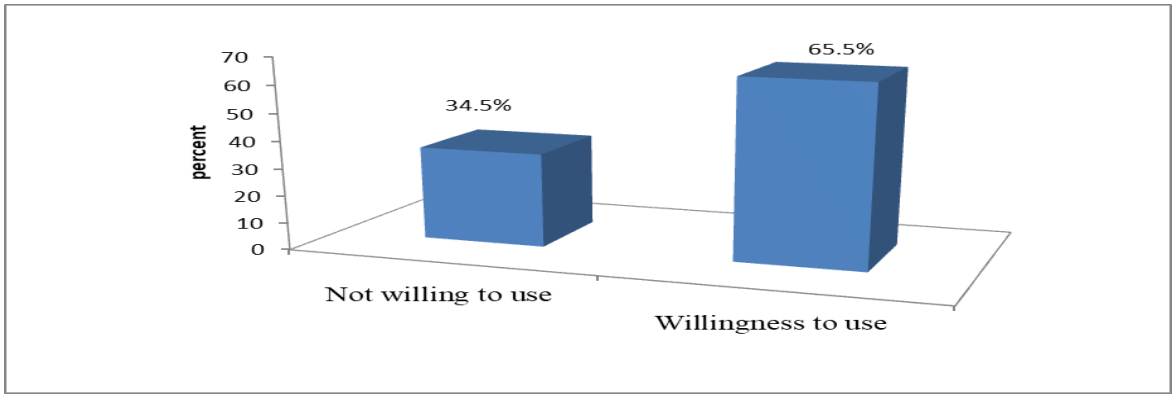

Figure 1: Willingness of the rural women to use biogas as alternative energy source

Perception of rural women about biogas as an alternative energy source

The result in Table 4 shows the respondents' perception of the use of biogas as an alternative source of energy. The mean score was used to describe the perception of the respondents on biogas as follows: biogas serve as alternative domestic energy (mean=4.21), harmless clean cooking fuel (mean=3.99), it aids in environmental preservation and health improvement (mean=3.96), using biogas can save the use of a lot of fuel wood (mean=3.72), and increased government spending to develop technical capacity for operating and maintaining biogas digesters will aid in solving the energy problem (mean=3.51). This indicates that the respondents thought biogas was a good idea. According to Taleghani and Kia (2005), universal understanding shows that biogas innovation is not sophisticated but simple to build and administer in the local context. Biogas is becoming increasingly

widely accepted in most African communities, where it is viewed as a simple and adaptable technology to the local environment. Fuel wood usage is frequently cited as a source of environmental degradation and as a source of energy instability in most African households. (Hiemstra-van *et al*., 2009).

Table 4: Perception of rural women about biogas as alternative energy source

Perception Statement	SA	A	U	D	SD	Mean
Biogas serves as alternative domestic energy	60(51.7)	44(37.9)	-	4(3.4)	8(6.9)	4.21
Biogas gel is readily available in the market	24(20.7)	31(26.7)	4(34)	33(28.4)	21(18.1)	3.04
It is cost effective	18(15.5)	43(37.1)	13(11.2)	23(19.8)	16(13.8)	3.21
The utilization and production of biogas is time consuming	31(26.7)	28(24.1)	17(14.7)	16(13.8)	18(15.5)	3.35
It can be used as clean cooking fuel	36(31.0)	50(43.1)	12(10.3)	5(4.3)	5(4.3)	3.99
Using biogas can save use of a lot of fuel wood.	33(28.4)	44(37.9)	12(10.3)	6(5.2)	13(11.2)	3.72
It helps in maintaining the environment and improving health condition	44(37.9)	48(41.4)	4(3.4)	3(2.6)	13(11.2)	3.96
Increase in government spending to develop technical capacity for running and maintaining biogas digesters will help to solve problem of energy	28(24.1)	38(32.8)	19(16.4)	10(8.6)	14(12.1)	3.51
Biogas pipe could break which leak gases that can cause fire outbreak	13(11.2)	28(24.1)	27(23.3)	23(19.8)	20(18.0)	2.92
Biogas is not produced when organic materials is digested in an anaerobic environment	14(12.1)	19(16.4)	29(25.0)	18(15.5)	25(21.6)	2.80
The operation of biogas plant is not complex	13(11.2)	22(19.0)	13(11.2)	27(23.3)	33(28.4)	2.58
Construction of biogas plant need not to be supervised by experienced technicians	18(15.5)	12(10.3)	9(7.8)	39(33.6)	31(26.7)	2.51
Biogas plant does not develop technical problem	14(12.1)	17(14.7)	9(7.8)	36(31.0)	31(26.7)	2.50
Biogas technology has not been so widely spread up to date	27(23.3)	19(16.4)	8(6.9)	28(24.1)	26(22.4)	2.94
There is no job creation around the biogas plant project	17(14.7)	11(9.5)	8 (6.9)	41(35.3)	35(30.2)	2.49
Experienced people are not needed in building of biogas plant	11(9.5)	13(11.2)	3(2.6)	35(30.2)	50(43.1)	2.11
Biogas production does not need public awareness	9(7.8)	12(10.3)	4(3.4)	29(25.0)	57(49.1)	1.98
The building and maintenance of biogas did not required competence	7(6.0)	6(5.2)	10(8.6)	30(25.9)	52(44.6)	1.91

Note: Strongly Agree =5, Agree = 4, Undecided =3, Disagree =2 and Strongly Disagree =1

Categorization of the respondents' perception of Biogas

The result in Figure 2 shows that 69.0% of the respondents had a favourable perception to use biogas while 31.0% had an unfavorable perception to use biogas as an alternate energy source. The perception of a subject is one of the key variables in adoption studies. Since the respondents had a favourable perception, this implies that the majority of rural women will be willing to use it. However, there is a need to create more awareness on the benefit of biogas so that those that have an unfavourable perception of it can see reasons why to adopt it as alternative energy source. Cheung, Chan and Wong (1999) pointed out that there is a strong relationship between actors' perceived capacity and various environmental behaviors such as protecting, conserving and recycling behaviours to mitigate degradation of the environment.

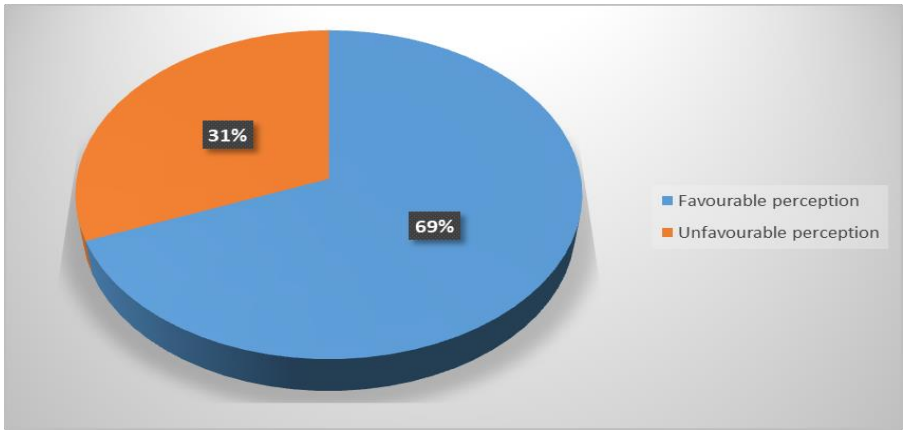

Figure 2: Categorization of the respondents' perception of Biogas as an alternative energy

Test of hypothesis

The entries in Table 5 show that there is a significant relationship between age (β=0.661, $p<0.05$); marital status (β=3.689, $p<0.05$); religion (β= 3.103, $p<0.05$); livelihood activities (β= -3.874, $p<0.05$) and willingness of the respondents to use biogas as an alternative source of energy. This implies that a unit increase of the variables with negative signs lead to a reduction in favour of the rural women willingness to use biogas while a unit increase of the variables with positive signs will lead to an increase in favour to adopt and use biogas as an alternative source of energy by the rural women. Age and marital status are found to significantly influence the willingness of the respondents to adopt and utilize biogas as an alternative source of energy while religion and livelihood activities of the respondents are found to negatively influence the willingness of the respondents to adopt and use biogas. The perception of rural women of the biogas benefits was found to significantly contribute to their willingness to accept biogas innovation as an alternative energy source. This further corroborates the Technology Acceptance Model and Theory of Reasoned Action that placed a vital role on the perception of the users on usefulness, easiness and conviction that an intended action and behaviour will lead to an outcome that will benefit them, thereby informing their decision to accept such innovation.

Table 5: Relationship between socio-economic characteristics of the respondents, perception and willingness to accept biogas as alternative source of energy

Variables	β	S.E	Wald	Df	Sig	Decision
Age	0.661	0.256	6.55	1	0.010	S
Marital status	3.689	1.462	6.371	1	0.012	S
Religion	-3.103	1.226	6.403	1	0.011	S
Length of residence	0.676	0.478	6.403	1	0.157	N.S
Ethnicity	-3.822	1.912	3.996	1	0.468	N.S
Educational status	-1.684	1.846	0.832	1	0.362	N.S
Livelihood activities	-3.874	1.638	5.592	1	0.018	S
Income	0.000	0.000	0.063	1	0.802	N.S
Perception	0.821	0.381	4.634	1	0.031	S
Constant	-2.867	4.179	0.467	1	.494	N.S

Conclusion and recommendations

The study concluded that the existing domestic energy used by the respondents were firewood, charcoal pot and kerosene stove and the process of using these energy releases certain substances that are not eco-friendly. Although rural women are aware of some of the benefits consigned to biogas, some factors still prevent absolute acceptance of biogas innovation even though a larger percentage are willing to accept the innovation. The perception of the rural women on biogas innovation was favourable and this factor could influence their decision, attitude and behaviours about the acceptance of biogas innovation among women. The result of the hypothesis revealed that age, marital status; religion, livelihood activities and perception must be given serious attention because they significantly influence the will of the people to accept new technology. It was therefore recommended that rural women should be enlightened about the benefits of biogas innovation, especially the younger ones who are more open to new ideas and technologies. Livelihood associations can also be mandated to campaign to their members about biogas innovation since they will require energy for commercial purposes. Policymakers should formulate policies that will encourage the use of biogas innovation so as to protect the environment, livelihoods and life of the people in agrarian communities.

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