Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 3 (2024)

Investigative the Extent of Greenhouse Gas Release Discount Caused by the Use of Biogas Plants and Evaluate the Degree of Acceptance of Biogas Technology in Jimma Zone, South West, Ethiopia

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Abstract :- Even though biogas technologies have been promoted for over a decade in many developing countries to reduce firewood consumption, their acceptance among smallholder farmers remains low, especially in countries with limited biomass resources, such as Ethiopia. This study aimed to investigate the factors influencing the low acceptance of biogas technology and to quantify the reduction in greenhouse gas emissions compared to fuel wood and wood coal. The research was conducted in four kebeles in Kersa, Southwest Ethiopia. A total of 130 households were interviewed using simple random sampling techniques. Descriptive statistics and a probit binary logistic regression model were used to analyze the acceptance of lower biogas technology and the extent of greenhouse gas emission reduction due to the usage of biogas plants. The results indicated that educational status significantly influenced the acceptance of biogas technology. Households with higher educational levels responded more positively to adopting biogas technology than illiterate households. The mean of non-biogas users was one hundred forty-three and biogas users were fourteen point one mainly used wood, whereas fourteen-point eight non-biogas users and seven-point one biogas users mostly depend on charcoal for baking. Greenhouse gas emissions reductions, measured in carbon dioxide equivalent (CO2e), were calculated using the Clean Development Mechanism methodology. The study found that emissions reductions from firewood and wood coal were approximately 228.5 tons of carbon dioxide equivalent/per year/per household and 24.5 tons of carbon dioxide equivalent/per year/per household, respectively. The result indicated a substantial change in renewable energy usage between biodigester plant owners and non-owners. To progress acceptance, renewable energy policies & strategies should be considered to increase public responsiveness about the advantages of up-to-date energy technologies.

Keywords: bargain, degree of acceptance, releasing of greenhouse gas.

1. Introduction

Biogas technology and extra-modern alternative energy potential have increased to be vital local renewable energy sources in several nations, as well as Ethiopia. The demand for biogas technology is considerable to maintain forests, employ renewable energy potential, and progress community livelihoods while reducing the use of fuel wood **[1].** The increasing demand for renewable energy and selectable renewable energy potential is currently attractive as a means of introducing the fuel circumstances. GHG extent, renewable energy quality, rigorousness, simple of use, and upkeep make this possible **[2].**

The main renewable energy potential is still using biomass energy, which includes wood and charcoal **[3].** Additionally, over 95% of households in our nation still rely on biomass fuel for cooking, with the percentage rising to over 99.4% in countryside areas **[4**]. Because of this, enclosed air contamination from traditional baking is a serious health problem in several East African countries **[5].** Explain to **[6],** that the need to find fresh, renewable fuelwood potential in evolving nations is imperative due to the widespread reduction of fuelwood reserves, the estimated rise in fuelwood demand in the future, and the ensuing social and environmental impacts.

Ethiopia's livestock resources rank among the top ten countries in the world and the best in Africa **[7].** In Ethiopia, the majority of people are promised some form of cow dung. The nation with the most potential for the development of biogas technology **[8]**. Among these variables, the size of the land of the farm, the cattle number, and the family size play a substantial part in forecasting whether the technology for biogas will be accepted positively or negatively **[9].** Family heads' financial condition affects how much technology they hug, and education level is a key issue in the introduction of new developments like biogas technology [10]. Education level, gender, household size, income, and fuelwood price are among the issues that affect a family's acceptance of clean and up-to-date energy sources and technology [11].

However, no study has been done on the energy consumption trends of late or the effects of rural people's awareness and use of anaerobic digesters in Kersa District. A large number of people continue to depend on biomass energy sources and lack of awareness in renewable energy technologies. Additionally, there are only forty-three biogas plant users in the study area, showing a small rate of success in the installation of biogas plants **[12**].

Moreover, because wood and charcoal are scarce at the study site, it is not uncommon to see women and children vying for dung fuel in communal grazing fields. Therefore, it is necessary to investigate the reasons behind the low acceptance of biodigester technology. This study's primary goal was to examine the reduced acceptance of biogas technology and the degree to which using biogas reduces greenhouse gas emissions **[13].** Mwirigi *et al.*,**[14]** went on to discuss the demographic barriers that sub-Saharan African nations face in accepting biodigesters.

More research on the financial viability of biogas digesters was conducted in Uganda by Walekhwa et al**.,[15**]. They calculated positive net present values for household digesters with volumes of 8 m3, 12 m3, and 16 m3, indicating that small-scale biogas systems are economically feasible. Tumwesige et al.,**[16]** also reviewed biogas appliances for various uses, such as biogas lamps, biogas-fueled engines, refrigerators, radiant heaters, and incubators. Tests on locally available biogas burners reveal that they are of low quality and very low efficiency. To keep on financially feasible, the biogas plants should be productive. Naik *et al.***,[17]** Using wood fuel or wood coal for household energy laces a daily economic burden on households. Deforestation means that the time spent gathering and the price of wood and coal are increasing. The impact deforestation of by replacing wood fuel or wood coal with biogas plants is discussed by Subedi *et al***., [18].**

2. Objectives

The majority of communities in Kersa District still rely on antiquated fuelwood energy, and they are still unaware of renewable energy technologies like biogas. The study aims to close these gaps by examining the acceptance of modern energy technology such as biogas plants, the scarcity of fuel wood and potential solutions, energy consumption, and the impacts of rural households on anaerobic digester awareness.

Due to a scarcity of fuel wood and other domestic energy sources at the research site, it is common to witness competition amongst members of the study area community for coal wood, dung cake, and fuel wood in communal grazing pastures. Therefore, it is necessary to investigate the reasons behind the low acceptance of biodigester technology.

3. Methodology

3.1 Population and Sample.

This research was conducted in Kersa district, Jimma zone. Jima is located 351 km from Finfinne. Geologically, located at 70° 40 N latitude and 360° 60 E longitude **[19].**

Kersa is one of the districts in the Jimma Zone of the Oromia Region. Geologically, the district is situated between 7°35′–8°00′N latitudes and 36°46′–37°14′E longitude, with an altitude that ranges from 1740 to 2660 m above sea level, and access to electricity is limited to urban areas in the Kersa district [20].

A multi-stage sampling technique was followed in this study to ensure its ability to provide equal opportunity to be included in the sample, hence the lower sampling error **[21].**

The total sample proportions were decided by using the approach from **[22]** and a confidence interval level of 10% (0.1) (m). The whole trial magnitude is determined as present:

Equation 1: $n = \frac{A}{1+A(m)2}$ 1

Where "n" is the sample size, "A" is the public size (entire family head size), and "m" is the level of precision. In the four kebeles (Kitimbile, Morowa, Toli & Girma), there were an entire 26362 non-owner families and 43 biogas owners' households.

Hence, = 100 (hundred) non-owners family) and = 30 (thirty) (biogas owners' household). So, the entire trial size for this research was 130 (one hundred thirty).

3.1.1. The component that touches on manipulating family biogas plants

In general, the amount of current written documents on the acceptance of household biogas technology relates to the organizational and economic factors that are important components of the acceptance process. The choice of respondents that could influence households' decision to accept biogas energy depended on the experience from field experiments and the written document that already existed. In this study, it was anticipated that the primary factors influencing the household's acceptance decision would be its demographic, economic, and organizational traits. Furthermore, the availability of firewood and water supplies to the household was thought to be a significant factor that could influence the decision of rural households to embrace biogas. This leads to a comprehensive list of chosen explanatory factors along with their descriptions and assumed effects on the acceptance of biogas technology.

Sex of households

Because domestic biogas technology is projected to reduce women's workload, especially in the area of firewood collecting, households may be more receptive to it than not. The impact of gender on the acceptance of biogas is thus thought to be indeterminate. Of the households surveyed, 84.13% (509) had a male head of household, while 15.87% (96) had a female head of household. The average age of the respondents was 48.30 years, and the average education level of the household heads was measured in terms of the number of years of schooling completed **[23].** In the nation, seven factors—age, gender, education, primary trading partners, awareness of AIV prices, community/group membership, and distance from the farm to the market—have a significant impact on power and decisions related to household access and ownership of resources as well as households' bargaining power **[24].** As a result, these factors may have a direct bearing on decisions regarding the acceptance of biogas technology. Thus, the gender of a household head was predicted to have a favorable or negative impact on the acceptance of biogas technology in this study.

Age of households

In comparison to younger people, older household heads are typically expected to have higher incomes, properties such as cattle, and total land ownership. In terms of how household heads feel about using firewood and biogas, 46.9% and 34.5% of respondents said that biogas is a clean energy source because it doesn't emit smoke and is simple to maintain and operate once installed **[25]**. Thus, able can react either favorably or unfavorably to the use of biogas technology. However, elderly households are more likely than younger ones to have access to new technologies **[26].** The head of the household's age was predicted to have a favorable or negative impact on the decision to use biogas technology in this particular study.

Family Size

A large parent is more likely to adopt biogas energy since they often have a large number of working members and more labor for biogas operation and maintenance tasks. According to research **[27],** a larger family may place a greater burden on the family's resources to the point where there is almost no money left over for investments in biogas acceptance decisions. As a result, it is anticipated that family size will both positively and negatively influence household decisions to use biogas technology in this study.

The education level of households

Evidence demonstrates effective communication between the home head's educational attainment and acceptance of **[28].** Higher-educated biogas consumers are more receptive to technology than less-educated heads of households. Therefore, it is anticipated that in this study, the acceptability of biogas technology will be favorably correlated with household heads' higher levels of education.

Number of cattle

Larger-scale cow owners' households are more likely to accept biogas technology than smaller-scale livestock owners' families **[29].** Because feedstock ownership is a requirement for guaranteeing the availability of livestock for the operation of biogas plants, this is a result of the nature of biogas technology. Thus, it is anticipated that in this study, the acceptance of biogas will positively correspond with the quantity of cattle.

Accessibility of technical services

The latest technology used by a few technicians may not be appropriately accepted in rural areas. According to a study by [32], many homes were able to embrace biogas, and its production was sustainable when people at the grassroots level had access to experts who provided maintenance services. Therefore, it was anticipated that in the current study, having access to technical services would have a favorable impact on the acceptance of biogas technology.

Obtainability of a water source

Since water is one substrate for the biogas production process where access to water, the acceptance of biogas technology is great **[30]** Water has a positive correlation with the acceptance of biogas technology decisions. So, in the research, it was recommended that the accessibility of water can positively impact biogas plants acceptance.

Accessibility of fuel wood

Numerous investigations have revealed a statistically significant negative correlation between the likelihood of fuel efficiency technology acceptance and the availability of fuel wood from neighboring forests. Put differently, a scarcity of firewood in a region could encourage people to use biogas technology **[31].** Thus, it was anticipated that household decisions about acceptance of biogas technology would be negatively correlated with fuelwood availability in this study.

Obtaining credit

Household decisions to embrace biogas technology are influenced, among other things, by finance availability for the installation of biodigesters and the purchase of spare parts. Many rural households in Ethiopia cannot afford the initial expenditure required to construct a biodigester [32]. Therefore, it was anticipated that home loan availability would favorably impact the uptake of biogas technology**,**

3.1.2. Decrease of GHG releases and wood kept due to the biogas digester

The Kitchen Routine Trial (KRT) was used to estimate the amount of wood kept owing to biogas plants. It is performed in an actual kitchen in the field **[33].**

The potential of renewable energy such as wood and charcoal for baking purposes and natural gas for lighting purposes were designated for this research. Then GHG emissions of biomass wood (fuelwood and wood coal)

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were calculated based on clean development mechanisms (general guidelines of CDM methodologies) according to **[34]** as follows:

Equation 2: AM_e (Annually minimizing emissions) =D, savings*nWRQ, *EDZ biomass* AB $_{\text{projected fossil fuel}}$ -----2

Where AB $_C$; Annually minimizes emissions in tone of carbon dioxide equivalent (tCO_2e), Q $_{y,\ savings}$ = quantity of biomass wood that is saved in tons or kilograms per device, and $_{WRQ\ y}$ = section of biomass wood saved by the fuel stove used in year y defined as non-renewable biomass. Since more than half of the fuel wood collected by households for cooking stems from forests, it is therefore justified to assume that 88% of the total consumed fuel wood stems from forests in the Ethiopian case **[35].**

Whereas, greenhouse gas emissions from natural gas were calculated based on the world standard emission estimation methodology (IPCC, 2013) as follows:

Equation 3: RFi (Releasing factor for GHGi) =DRF (Default Releasing factor) × RTV*:* (remaining temperature value) --3

Equation 4: Emission reduced from natural gas consumption (kg) =Average natural gas saved per HH (household) (L) ×RFi (Kg/L) --4

Where DES: Default emission Section (Kg/MJ) (IPCC, 2012), ESi: Emission Section for GHGi (kg GHG/unit fuel combustion)

RTV: remaining temperature value of (MJ/unit fuel ignition). The remaining temperature value (RTV) of fuel is 36 MJ/liter **[36].**

Typically, GHG reduced from natural gas contains CO2, CH_4, and other gases. Those gases should be presented in units of greenhouse gas components. Gases are converted to carbon dioxide by multiplying with their world hotness potential (WHP). To do so, multiply each emission by the corresponding GWP (listed in Table 7) as follows: Equation 5: $CO_2e = \sum_{i=1}^{n}(GHGi * WHPi)$---5

Where CO_2e = emissions in carbon dioxide equivalents (tons per year), GHGi = emissions of GHG saved "i"

WHPi = World hotness potential of GHG (Greenhouse emission); n = number of GHG emitted from the source.

3.2. Data sources

Key informant interviews, focus groups, field observations, and household surveys were among the major sources from which the primary data was gathered. A series of open-ended questionnaires were created and given to participants. The secondary data sources, which included both published and unpublished materials, were gathered from publicly accessible information sources.

3.3. Data Analysis

Data collected through interviews and field experiments were coded and entered into Microsoft Excel. Data cleaning was done by running frequencies of individual variables, and the clean data was exported to Python 3.8.2 and SPSSv25 software. The data were analyzed using descriptive statistics and presented in tables, pie charts, and graphs. A logit regression model was employed to determine respondents' demographic characteristics**.**

3.4. Definition of variables and probit model specification

3.4.1. Dependent variables (Factors affecting biogas acceptance)

The dependent dummy variable in this study was the acceptability of biogas, which was determined by factors such as "initial technology achievement and use for less than one year from the acquisition." Households that possessed a functional biogas technology were assigned a value of 1, while those that did not were assigned a rating of 0. Sample frames were families who had purchased biogas technology within the previous year and were biogas technology acceptor households. To get precise information regarding the problem, biogas technology acceptors with a minimum of one-year biogas connections were chosen. Households were also anticipated to be more knowledgeable about the pros and disadvantages of the technology. In the research region, this was done to estimate the elements that influence household decisions. This is because the probit binary logistic regression model requires a binary choice of the dependent variable **Puzzolo et al., (2016).**

3.4.2. Self-governing variable quantity

The determination of the independent variables was firmly grounded in the literature research, which examined the elements that impact farmers' favorable attitudes toward biogas technology acceptance as well as the facts surrounding renewable energy sources and consumption in the Kersa district. The dependent variable was anticipated to be explained by the following components: farm characteristics, education, livestock, household demographics, and technical factors. As a result, the following independent variables were thought to be explanatory factors influencing household decisions to adopt biogas technologies. Age, gender, family size, education level, number of heads of cattle, financial facilities available, availability of appropriate and secure water supplies, and technological know-how are all included. The variables that are predicted to determine a good attitude for acceptance behavior, together with a brief description of each component and its estimated value regarding the factors

3.4.3. Statistical tools and Probit model

The probit model was used to assess the dependent variables of biogas technology users and non-users to ascertain the likelihood. Furthermore, we used this model, which is more frequently associated with cross-sectional econometrics, in place of time series. There has also been an interpretation of the Probit model as a "latent variable" paradigm. This will impact our explanation of the dependent variable. We interpret it as meaning that we can or should do anything. We employed Excel, descriptive statistics, and SPSS Version 25 to further analyze the data.

4. Results

Table 1: Sex of respondents and their education level

Characteristics	Biogas users in %	Non-biogas users' in%	Overall, in %	χ^2
Sex				0.182***
Male	29	98	127	
Female	1	2	3	
Total	30	100	130	
Education				29.778***
Illiterate	3	30	33	
Grade 1-8	7	54	61	
Grade 9-12	11	8	19	
Higher education	9	8	17	
Total	30	100	130	

Source: field survey, 2023

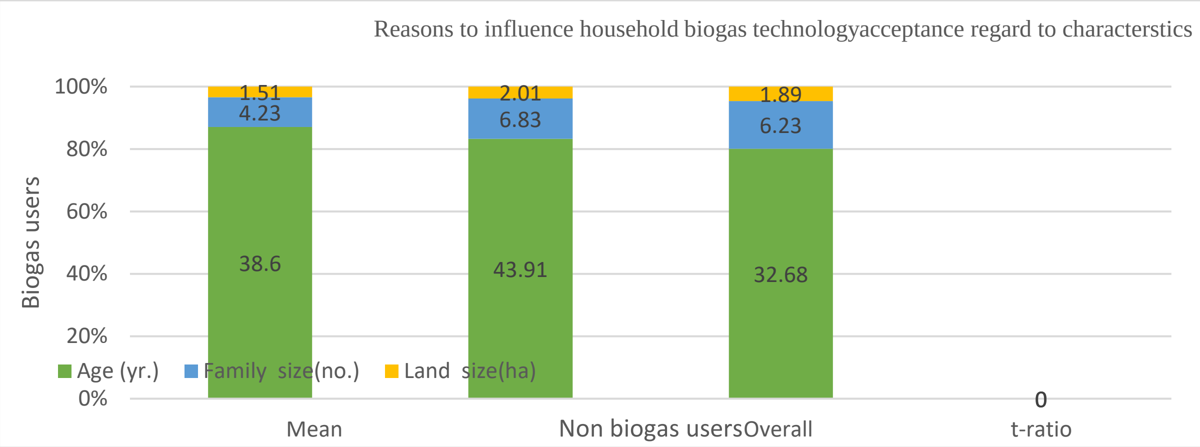

Figure 1: Demographic characteristics that influence biogas technology acceptance

Source: field survey, 2023

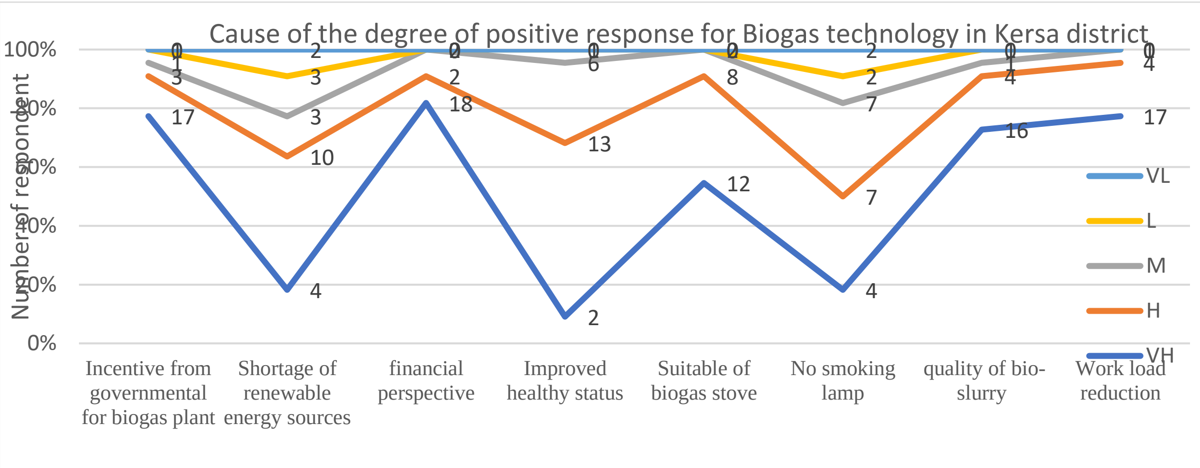

Figure 2 : The degree of positive response to biogas technology

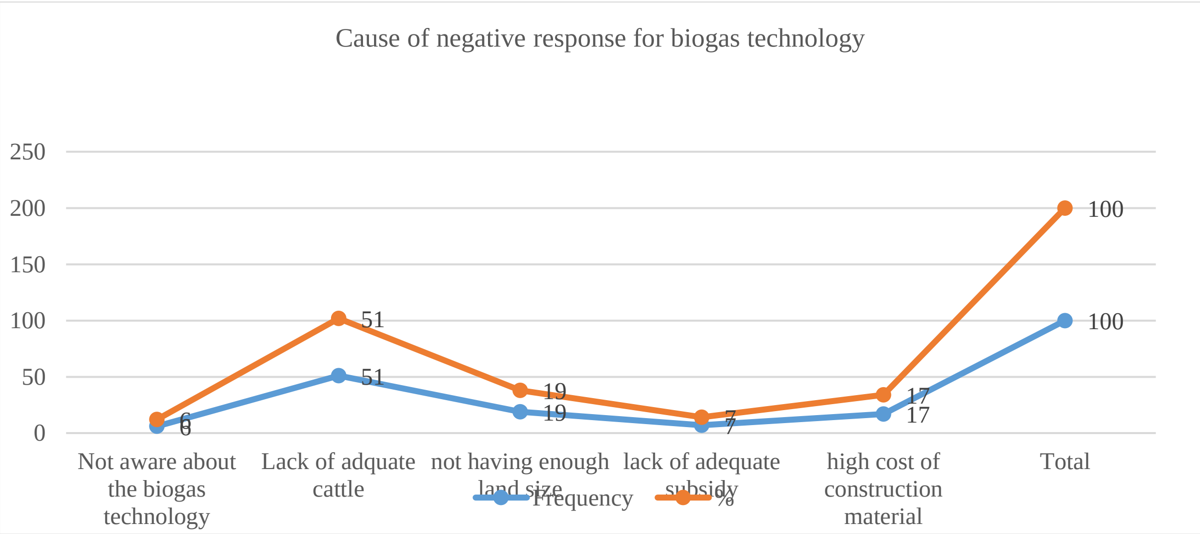

Figure 3 : Reasons for denial to positive response for biogas technology

Source: field survey, 2023

Table 2: Weekly fuel wood usage consumption in the study area

Types of fuelwood (in Kg per week)	Biogas users			Non biogas users			Total		
	N	Mean	St. D	N	Mean	St. D	N	Mean	St. D
Firewood	30	14.1	20.4	100	143	94	130	113.3	99.2
wood coal	30	7.5	7.1	100	10.1	14.8	130	9.5	13.4
Cow dung	30	6	4.3	100	15.7	26.9	130	6	24

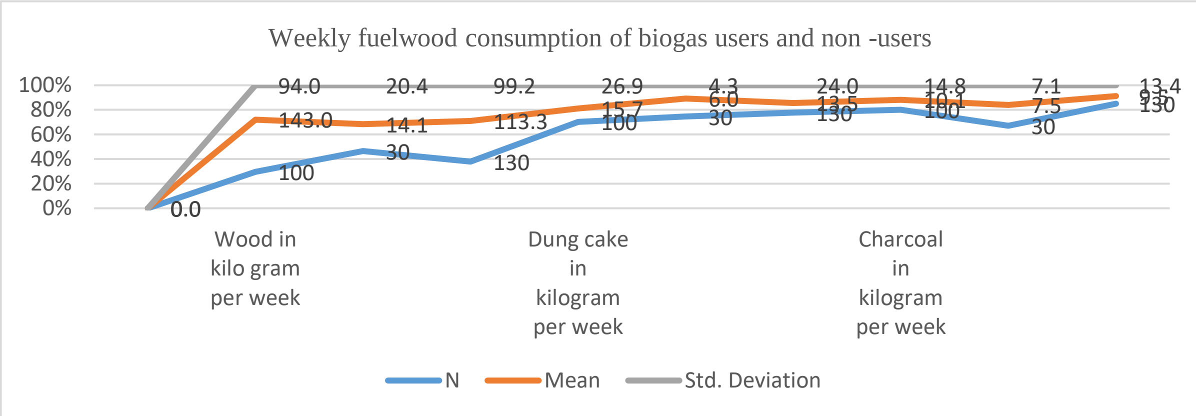

Figure 4: Weekly fuelwood consumption of biogas users and non-biogas users

Table 3: Yearly revenue and domestic energy usage

parameters	Types	R (Respondents)	Average	Standard deviation
Average yearly Revenue (income)	biogas users	12	3016.7	1201
	wood coal users	12	30533	7395.6
	biogas stove users	12	3016.67	1201
	Fuelwood users	12	29933.33	7526

Note: * shows that important at the 1% significant level.**

Source: field survey, 2023

Table 4: Types of energy consumed (kg) per week in different stoves in the study area from the field experiment

kinds of fuel	Kinds of device	N	Mean	St. D	t-test
Natural gas/week/hour	Household biogas (Lamp)	12	0	0	
	Kuraz	12	0.571	0.17	-13.103***
wood/week/hour	Clean biogas stove	12	0	0	
	TFS (three open stone stoves), firewood	12	44.70	7	-25.269***
biogas/week/hour	Clean biogas stove	12	0	0	
	Better cook stove (wood coal)	12	7.7	0.75	-39.559***

Note: * indicates significance at the 1% significant level.**

Source: field survey, 2023

5. Discussions

5.1. Demographic Factors Influencing and Causes of the Low Lower Biogas Acceptance Results (Table 1 & Figure 1)

The demographic variables of the sample households are listed in the above and following tables, and the result implies that the majority of the households can read and write as well as easily accept new information about biogas technology. Overall results showed that educated households accept biogas technology more than illiterate households. This result indicates that the gender and educational level of households influenced the acceptance of biogas technology.

The survey also shows that the mean of biogas users and non-users ages of respondents were both 39 and 44 years The average age was 32.7 years (Figure 2). This shows that there is an age gap among the respondents. However, the mean of respondents is in the productive age group; thus, the age of households was an incentive for enhancing biogas technology acceptance in the area of study. family size, the survey result showed that the mean family size of biogas users and respondents was both 2 and 6.8 (Figure 1).

All of the respondents have a land certificate, and they feel secure in their possession. The survey results indicated that the farmland means held by the households who have anaerobic digester plants and not owners of digester plants were both one point one and six point two hectares. The overall average farmland of respondents was less than 1 hectare (Figure 1).

5.1.1. Observed

The outcome of the descriptive statistics is concluded in Table 1 & Figure 1. To investigate the factors that affect the sample household's decision technology acceptance level, a total of six explanatory variables were selected and entered into the model.

5.1.2. Explanation of the probit model result

The likelihood that the technology will be implemented in a year and the likelihood of accepting biogas technology both grow with the age of the owners of biodigester plants (Table 2). This could be because elderly heads of households do not have any financial restraints and hence do have the resources (money, land, and cattle ownership) needed to build biogas plants. The results align with those reported in reference **[37]**. He stated that as household heads became older, there was a greater likelihood that they would accept biogas technology. Conversely, Table 1 and Figure 2 show that the chance of respondents positively accepting digester plants rises by 5.6% with an increase in intellectual capability. This suggests that the ability to learn about, comprehend, and then employ biogas technology grows along with the household's degree of education. The outcome indicated that the high acceptability of biogas technology can be attributed to lower levels of education **[38].** The study's findings showed that, at a 99% confidence interval, the constant on biodigester technical knowledge was very significant and correlated with biogas technology acceptability (Table 1). For individuals who knew the likelihood of accepting biogas technology, the probit model further suggested that maintaining the status quo was crucial. to participate in training, workshops, and seminars as a means of raising awareness and accepting technology such as biogas, compared to homes that have never done so. This consequence was reliable by research by **[39].** who stated that raising awareness was only the beginning of the acceptance process and that gathering knowledge is necessary to influence people's opinions about technology. The outcome suggests that more homes can adopt biogas technology if all other variables stay the same due to the accessibility of the technical support service in their neighborhood. This outcome is consistent with what was found in **[40]**. The findings showed that households with access to technical support services were more likely than households without such services to embrace biogas technology.

5.2. Assessment of the root reason for deciding optimistic response or adverse answer for biogas technology

5.2.1. Reasons to decide on the optimistic answer for biogas plants in the study area

Figure 2, the impacts of financial influence on the lower acceptance of biogas plants. Accordingly, 18 (81.82%) and 2 (9.1%) were very high, while the remaining 2 (9.1%) were medium. The mean score of the response was

4.40 (SD =7.67). The results indicated that the effects of economic benefit were at a moderate level. The bio-slurry from biogas digesters has been attested to be the best organic fertilizer and productivity by substituting chemical fertilizer [41]. From this, one understands that the financial benefit of household biogas motivated the lower acceptance of biogas technology.

According to Figure 2, respondents N17 (7.13%) and 3 (1%), respectively, had very high and high impacts on the lower acceptance of biogas technology as a result of administrative subsidies for biodigester plants; the remaining respondent, 1 (4.55%), had a medium impact. The response had a mean score of 4.4 (SD = 7.13). This suggested that the government subsidy had a moderate impact on the biogas plant's lower acceptance. In addition to this, through interviews with biogas users, there were government subsidizing systems to facilitate household biogas technology awareness creation. In support of this **[42],** It was postulated that subsidy was indicated to be important for biogas technology. This implied that administrative subsidies accelerated household biogas technology.

The impacts of lowering health risk as a stimulus of the lower biogas technology acceptance were very high, high, and medium, respectively, as seen in Figures 2, 2 (9.1%), 13 (59.1%), and 6 (27.3%). The average score suggested that a moderate variety of factors contributed to the lesser acceptance of biogas technology. Utilizing biogas technology has many health advantages, including a decrease in burning incidents and smoke-related illnesses such as headaches, eye burning, eye infection, and respiratory organ infection **[43]**. This implied that the reduced health risks associated with the biogas plant contributed to its improved health status. Figure 3 illustrates how a faster and more useful cooking biogas burner substituted for the increasing firewood and wood coal usage. In response to this request, twelve (54.55%), eight (36.4%), and two (9.1%) were classified as very high, high, and medium. The mean score of the responses was 4.40 (SD = 5.37). This suggested that there was a modest level of acceptance for a quicker and more practical cooking stove as a substitute for the lower acceptability of biogas technology. Interviews with acceptors awareness creation that one of the issues with embracing biogas technology was its speed and convenience as a cooking stove. This indicated that the research area's biodigester cooking stove's speed and convenience contributed to the decreased acceptance of biogas technology.

The optimistic light of biogas as a reason for the higher biogas acceptance was extremely high, high, medium, and low, respectively, in Figures 3, 18, 2.2%, 7 (31.82%), 2, (9.1%), and 2 (9.1%). However, the remaining 2 (9.1%) said that there was very little evidence of biogas lamp bright light as a reason for the higher acceptance of biogas. The responses had a mean score of 4.40 (SD = 2.51). This awareness created how the modest degree of biogas acceptability was driven by the stark contrast of the lower biogas acceptance. According to **[44],** lighting and cooking are the main applications of biogas technology in poor nations. **[45]** Further, biogas is used in Ethiopia for lighting and cooking. This suggested that consumers of biogas were being encouraged by the positive light of biogas.

Figure 2 illustrates this was a driving force behind the lower acceptance of biogas technology. Consequently, the percentages of very high, high, medium, and low were 16 (72.7%), 4 (18.2%), 1 (4.55%), and 1 (4.55%), respectively. 4.4 was the average score (SD = 0.6.67). This finding indicated that higher caliber recipients of. According to **[46]**, The ammonia level of fresh manure is lower than that of bio-slurry from biogas digesters, which is around 10% higher. Being the first biogas technology accepter, this facilitates a deeper understanding of the bio-slurry's quality as fertilizer. The participants were requested to optimize time savings and workload reduction by using biogas plants and promoting the technology to influence the acceptance of biogas technology. 17 (77.3%), 4 (18.2%), and 1 (4.55%) were deemed very high, high, and medium in response to this request. 4.40 was the average score (SD = 7.23). This result showed that accepting biogas frees up time for social activities about this **[47].** This suggested that those who used the technology were motivated by time savings and decreased workloads.

5.2.2. Reasons for denial of positive response for the biogas technology

Figure 3: Reasons for denial to accept the biogas technology in Kersa district responses of frequency N (6) and 6%. The study showed that the study site community is not aware properly about the technology. This implied lack of awareness was a discouraging factor for the lower biogas acceptance in the study area.

As can be seen in the table, a small number of cattle were used in the analysis of the cause of the low acceptance of biogas technology. Accordingly, responses of frequency N (51) and 51% indicated that the effects of responses of frequency N (51) and 51% were at a moderate level. Financial status is one of the most critical and frequently mentioned factors determining biogas technology's lower acceptance **[48].** This implied that a lack of adequate funds challenged the acceptance of biogas technology in the study area.

In Figure 4, N19 (19%), the effects of lack of land size on the low biogas technology acceptance were high in frequency and percent. The frequency score of the responses was N (19). This indicated that the effects of a lack of land size were at a discouraging level **[49].** This implies that the lack of land size in the study area highly discourages the analysis of a lower biogas acceptance **[50]**'

5.2.3. Overall Energy consumption pattern

The principal energy source for local use in the study area is biomass wood in the form of firewood and wood coal. The result in Figure 4 showed that, from the mean of all respondents, 143 non-biogas users head and 14.1 biogas users mainly use firewood; the mean of cow dung nonusers was 26.9 and 4.3 biogas users, followed by 14.8 of them non-biogas users and 7.1 biogas users mainly use wood coal as a source of energy for cooking. Finally, the finding showed that from the mean of all respondents, 7.5 and a standard deviation of 7.1 of biogas users were saved charcoal (table 3). This implies that the constant use of biomass wood as the main source of energy, which has led to deforestation, was high despite the existence of biogas development in the study area. This finding is supported by a study [51] that reported that, in Ethiopia, almost all rural households depend on fuel wood as a major source of energy (Figure 4).

5.3. Approximating greenhouse gas release reduction

5.3.1. Assessing GHG release reduction from biomass wood

From the field experiment, the emission factors of fuel woods (both firewood and wood coal) were 81.6% CO_2/TJ and 88%, respectively **[51].** The net calorific values for firewood and wood coal were different; They were 15.6 MJ/kg and 29.5 MJ/kg, respectively **[52].** The average quantity of firewood and wood coal saved per year per household was 254,259kg and 11,614.3 kg, respectively. The results of greenhouse gas emissions, CO_2e (carbon dioxide equivalent) reduced from biomass wood (firewood and wood coal), were calculated based on CDM methodology. GHG emissions reduced from firewood and wood coal were ≈ 228.5 tCO_2e/yr/hh and 24.6 tCO_2e/yr/hh, respectively.

The above results indicated that forty-three biogas plants saved about 228.5 tons of CO_2e and 24.6 tons of CO_2e in one year from firewood and wood coal, respectively. On the other hand, the average income of biogas users was 3016.7 birr and the standard deviation was 1201. Also, 12 biogas stove users saved 29933.33 firewood kg/week.

The result of the t-test also indicated that there was a significant difference between them. This implies that since the household size, the average frequency of end users per day, and the annual income of both biogas users and biogas non-users selected for this study are different (Table 4), the energy consumed for cooking and lighting for those households, whether from biogas or another energy source, is supposed to be different for this study **[53].**

The result in Table 4 shows that the average wood coal consumed/improved stove/week for non-biogas users was 7.68-kilo gram through a typical eccentricity of 0.8 kg, which was replaced by biogas in the households of biogas users. This indicates that the use of wood coal for cooking water and coffee has been substituted by biogas in the households of biogas users. So, one biogas user can save about 7.68 kg of wood coal per week or 1.07kg of wood coal per day in the study area. When it is translated to annual consumption, one biogas plant can save about 390.92kg of wood coal or improved stove. This result was higher than the national average wood coal consumption of 219 kg per year, which estimates that the wood coal consumption per household was 219 kg/annum (0.6 kg/day) **[54].** However, the result of this study is less than the result reported by **[55].** According to the study conducted in Addis Ababa city, which is 40–80 kg of wood coal per month. Since the total number of biogas plants in the study area was 43, if all are functioning, 16,809.3463 kg, or 17.07 tons of wood coal for only cooking wot and coffee, can be saved.

Moreover, the results in Table 4 indicated that the average firewood consumed per week or hour for cooking is 44.7kg with a standard deviation of 7 by using a three-stone fire stove, which was replaced by biogas. On the other hand, one biogas for cooking can replace 6.38 kg of firewood per three-stone fire stove daily. This is comparable to the result reported by **[56]** in Nepal, where a biogas user can be reduced to 6.13 kg of fuel wood per day. Consequently, when this result is converted to annual consumption, one biogas plant can save, on average, about 2328.4kg of firewood in one year. This indicated that if all have functioned, 43 of the digester plants in the study area can substitute 100,121.2 kg, or 100,1224 tons, of firewood for cooking **[57]**. Furthermore, the finding in Table 4 also shows that the average natural gas consumed per week for lighting was 0.57 liters with a standard deviation of 0.17, which biogas plants immediately substitute. This result only focused on households that use natural gas for lighting purposes, using Kuraz to estimate the amount of natural gas substituted by biogas. So, the yearly average natural gas/natural gas used for lighting by one household, which was saved due to biogas technology, was 29.72 liters. This showed that a total of 43 biogas plants in the study area can reduce 118.88 liters per year **[58]**.

6. Policy Issues

In the Kersa district, wood coal, animal manure, and fuel wood are the most popular fuel sources. In the research sites, biogas technology was uncommon, but the use of conventional biomass fuels was on the rise. Since inadequate subsidies are a prevalent issue in the region, policy-driven initiatives are crucial to delivering secure and adequate subsidies. Thus, these occurrences, in conjunction with the existing formal reorganization networks of the national biogas initiative, the Ministry of Water and Energy, and rural homes, may prove beneficial.

7. Conclusion

This research indicated that despite the positive response to technology acceptance, unfamiliarity with the technology, shortage of fuel wood, coal, and a small number of cattle were the primary barriers to the installation and acceptance of biogas. The binary logistic regression model indicated that the educational level, the number of cattle, age, gender, and family size had a significant effect on the lower acceptability of biogas technology. This study shows that the best approach to lessen dependency on energy sources derived from biomass was to accept biogas technology. Additionally, it leads to the reduction of deforestation, which lowers greenhouse gas emissions.

Acknowledgment

Special gratitude goes to Jimma University and the JiT Center of Excellence for their partial support, which is gratefully acknowledged.

Authors Contributors

TF, V.R.A, and AN were involved in manuscript writing, involved in analysis, and editing. All authors read and approved the final draft of the manuscript. TF will the responsible. Co-writers/authors gave their final approval for the version that would be published, agreed to the journal to which the article would be submitted, approved & responsible for all parts of this work.

Declaration

Author contribution statement. Data availability statements: The data has been used confidentially.

Declaration of Interest Statement

The authors declare no conflict of interest.

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