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Determinants and effect of adoption of small scale biogas technology by rural households: the case of Sodo Zuria district, Wolaita Zone, Southern Ethiopia

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Abstract

The aim of this study was to assess determinants and effect of adoption of small scale biogas technology by rural households in Sodo Zuria district, Wolaita zone, Southern Ethiopia. The population in selected three sample Kebeles were stratified into two categories (biogas user and non-user). A total of 153 respondents were randomly selected and interviewed by using interviewed schedule. Descriptive statistics, inferential statistics (chi-square and independent t-test) and binary logistic regression analysis were used to analyze the data. Logit model was used to analyze the adoption decision of biogas technology. The model result indicated that adopters and non-adopters differed in 6 out of 12 explanatory variables expected to influence the adoption of Biogas technology in the study area. Variables such as sex, education of respondents, livestock ownership, occupation, and attending training of respondents with biogas development had significant and positive influence on the use of biogas technology. On the other hand, distance to water had significant negative effect on the use of biogas technology. High installation cost (55%), negative attitude of community towards biogas energy (8%), inadequate skilled technicians (25%), lack of adequate fund, lack of interest, and poor infrastructure (10%) were the main challenges of using biogas technology. Biogas technology gives high contribution for the users especially in reduction of expenditure on cooking energy, saving time in preparation and cooking of food, provision of organic bio slurry, reduction of smoke in the kitchen, and making cooking more convenient 79%, 70%, 88%, and 95%respectively. The study suggests government and non-governmental organizations to strengthen farmers' capacity and make them to focus on construction of new biogas technology in order to expand its benefits in the study area.

Keywords: Biogas Technology, Adoption, Wolaita Zone

Introduction

Energy is the core factor that can affect other important developmental factors such as: education, health, environment, economic growth, food security and water. Approximately one-half of the world's population relies on biomass, wood, crop residues, dung and charcoal as the primary source of domestic energy, burning 2 billion kg of biomass every day in developing countries (Ezzati et al., 2000). In Ethiopia, 50% of the population has an income that is below the poverty line. The wide spread poverty is mentioned as a critical factor in continued dependency on persistent traditional and inefficient means of utilizing biomass energy (Abebe et al., 2012). Other studies indicate that about 1.2 billion people lack access to electricity and 2.8 billion still rely on unsustainable solid biomass. Among these, around 85% are without electricity and 78% depend on solid biomass live in rural areas (Memoire, 2016).

Biogas technology is best suited to convert the organic waste from agriculture, livestock, industries, municipalities and other human activities into energy and manure. Along with, biogas is in most contexts a sustainable energy source resulting in reduced consumption of firewood, kerosene and charcoal. This makes life easier for rural people, especially for women and children, who are more vulnerable from indoor air pollution and firewood collection (Lemlem, 2016).

Biogas is a renewable, high quality fuel, which can be produced from a lot of different organic raw materials and used for various energy services. Biogas technology has been developed and widely used over the world, because it has a lot of advantages, including reduction of the dependence on non-renewable resources, high energy-efficiency, environmental benefits, available and cheap resources to feedstock, relatively easy and cheap technology for production, extra values of digested as a fertilizer, etc. But the current status of biogas production and utilization largely varies among the different continents (Zhang and Chen, 2010). The biogas plants have the potential to reduce firewood use, time spent gathering fuel, and respiratory disease caused by household air pollution.

The per capita energy consumption of Ethiopia (0.3 tone) is among the lowest in the world (GTZ, 2014). However, the energy requirements of a large and fast growing population and the fact that the major proportion is supplied by traditional energy sources have serious implications on the natural resource base. Increasing energy demands on farm households in Ethiopia have escalated challenges related to land degradation, indoor air quality, and rural economic development. Soil deterioration followed by reduced carbon sequestration compounds the adverse effects of environmental degradation and climate change (Melaku et al., 2017). Ethiopian government has disseminated thousands of bio digesters across rural villages with the hope that introducing bio digesters to rural farm households would address all of these issues. However, there is scant information about how households make energy choices and consequently how the introduction of biogas energy will affect income and the environment in these rural agricultural communities (Melaku et al., 2017).

In Ethiopia deforestation essentially occurs to meet the two major demands, agricultural land and fire wood (Lemlem, 2016). Mainly minimize the problems in rural areas by adopting small scale technology such as: establishing the biogas technology. However, many households in have been suffering from shortage of fuel for many purposes. Wolaita zone energy regime is dominated by biomass energy and traditional fuels contributed of the rural energy consumption, with fuel wood being by far the most important source followed by dung and small amount of charcoal. As a consequence of the ever increasing consumption of woody biomasses to satisfy domestic energy needs, environmental degradation and climate change related challenges are imminent to occur and other serious challenges of populations in the area like deforestation, loss of soil nutrients and organic matter would become intensive.

Thus, this study aimed at filling this knowledge gap. Besides, interest on the problem was initiated due to personal experiences and observations as well as reading from literature. In the selected area where the researcher grew up, due to scarcity of wood-fuel, it is very common to observe children and women competing for dung fuel in communal grazing fields. Seeing the problem of household energy in the area, it was about nine years ago that the government built model biogas installations in the areas such as: Sodo Zuria, Damot Gale, Humbo and Offa. But for some reasons, the biogas installations did not survive for long and non-functional in many Districts. Thus, this research is intended to identify the factors affecting adoption of small scale biogas technology and the effects of its adoption among rural households in Woliata zone (Sodo Zuria district).

Materials and methods

Description of the study area

This study was conducted in Sodo Zuriya, one of the 16 districts in the Wolaita zone, Southern Ethiopia. It is bordered on the southwest by Offa, on the west by Damot Sore, on the east Damot Gale and on the southeast by Humbo district. It is located at 156 km south west of Hawasa town which is the capital of Southern Regional State and 330 km from Addis Ababa. Based on the 2007 Census conducted by CSA, the total population of Sodo zuriya district is 184,125 of which 90,794 are men and 93,331 women. The population density of the district is 502 per square km; which is much higher than the regional density141 person/km^2 (CSA, 2007).

Sample size and sampling procedure

In this study multi- stage sampling procedure was employed. In the first stage, the study areas were selected purposively as biogas technology users are available in the district. In the second stage, out of 16 biogas user Kebeles (small administrative unit in Ethiopia), three Kebeles which are high users of biogas technology were selected purposively. In the third stage sampling frame from the selected Kebeles were obtained. The sample Kebeles were stratified into the two categories (biogas technology user and non-user households). The sample size for the household survey was determined on the total number of technology user and non-user households in the selected rural villages (Wachiga Busha, Kuto Sorfela and Dalbo Wogene). In the fourth stage, a systematic sampling technique was applied to select the sample unit from each stratum at each Kebele via probability proportionate to size procedure. The target population comprised of the users and non-users of biogas technology. From the total 125 biogas user and 1350 non-user households that are found in three sample Kebeles, 60 user households and 93 non users were selected respectively. Hence, the total sample size of biogas technology users and non-user respondent households were 153. The sample size of this study was determined by Yamane formula (1957).

$$n=\frac{N}{1+N(e)2}$$

Where: n = Sample size;

N= Total number of households in the selected Kebeles;

e = precision level 10% (0.1);

Sources and methods of data collection

The study used both qualitative and quantitative methods of data collection so that both methods would complement each other. According to Bryman (2008), the strength of one method helps to overcome the weaknesses of another thereby achieving a cost benefit analysis balance. Qualitative and quantitative data were gathered from the primary and secondary sources. The instruments used were semi-structured questionnaire, focused group discussion and key informant interviews. The questionnaires were administered to all 153 subjects in the study area with the aim of gathering information on the potential of biogas technology on improving livelihoods. A focus group discussion (FGD) was also conduct to clarify and cross- check issues that was not adequately addressed by the respondents since the FGD (3 focus group discussion) members have in-depth knowledge of biogas technology in the study area. The key informants were interviewed on area and matters pertinent to biogas technology. Secondary data was also synthesized from reports, periodicals, journals, newsletters and electronic media. Additional investigation tools included observations, especially on the use of biogas technology at the study area.

Data analysis

After the data has been collected, it was cross- examined to ascertain their accuracy, competences and identify those items wrongly responded to, spelling mistakes and blank spaces. Quantitative data was subjected to the computer for analysis using SPSS Version 20 computer package. In order to determine the current relative importance of energy sources, data was collect from the sample population using researcher's questionnaires that was analyzed using SPSS computer package. The descriptive analyses was made using frequencies, percent and mean to analyze the socio-economic, institutional/organizational and physical characteristics, biogas user and non-user respondents' household. The statistical significance relationships of the dichotomous variables with the dependent variable (use of biogas technology) were tested through Chi-square with the help of Cross-tabulation and t-test (Independent t-test) was used to compare the mean of continuous variables between biogas user and non-user respondents' household.

To identify the determinants that influence the use of biogas technology, the binary logistic regression analysis was employed. It is selected because of the model relevance to deal with dependent variables that are dichotomous in nature. The Binary logit model was applied in this study to assists in estimating the probability of household's biogas technology adoption that can take one of the two values, adopter or non-adopter. According to Gujarati (1995), the functional form of the logit model is presented as follows:

$$P_i = \mathrm{E}\left(Yi/_{Xi}\right) = \frac{1}{1+e^{-(\beta_0+\beta_1 X_i)}} \quad (1)$$

$$P_i = \mathrm{E}\left(\frac{\mathrm{Yi}}{\mathrm{Xi}}\right) = \frac{1}{1+e^{-Z_i}}$$

Where Pi is a probability of a i^th household being adopted biogas technolgy and ranges from 0 to 1; Zi is a functional form of m explanatory variables(X) which is expressed as:

$$\mathrm{Z}_i = \beta_0 + \sum_{i=1}^{m} \beta_i \, \mathrm{X}_i \text{, i=1, 2, 3----------m} \quad (2)$$

Where; β_0 is the intercept and β_i are the slope parameters in the model. The slope tells how the log-odds in favor of a given household adopted biogas technology as independent variables change. If P_i is the probability of a household being use the technology, then 1-P_i indicates the probability of a given household is not using the biogas technology, which can be given as:

$$1\text{-}\mathrm{P}_i = \frac{1}{1+e^{Z_i}} \quad (3)$$

Dividing equation (2) by equation (3) and simplifying gives

$$e^{Z_i} = \frac{P_i}{1-P_i} = \frac{1+e^{Z_i}}{1+e^{-Z_i}} \quad (4)$$

Equation (1) indicates the odds ratio in favor/in terms of a given household adopting biogas technology. It is the ratio of the probability that a household will adopt the technology to the probability he will not use the technology. Lastly, the logit model is obtained by taking the natural logarsim of equation (1) as follows:

$$\mathrm{L}_i = \ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_i \quad (5)$$

Where; P_i =the probability that Y=1 (that a given household uses the technology);

1-P_i =the probability that Y=0 (that a given household does not use the technology);

L=the natural log of the odds ratio or logit;

β_i =the slope, measures the change in L (logit) for a unit change in explanatory variables (X);

β_0 =the intercept. It is the value of the log odd ratio, $\frac{P_i}{1+P_i}$, when X or explanatory variable is zero.

Thus, if the stochastic disturbance term (U_i) is taken into consideration the logit model becomes

$L_i = \beta_0 + \beta_1 X_i + U_i$

Hypothesized variables

Dependent variables: the variable adoption of biogas technology was used as a dichotomous dependent variable with expected mean value of 1 indicating the probability of adopted and 0 otherwise. The following independent variables were hypothesized to influence the adoption of the biogas technologies in the study area. Table (1) shows the description and measurement of independent variables and their expected relation with dependent variable.

Table 1. Description of explanatory variables used in binary logistic regression model

Variables	Description of variable	Expected sign
Age	Age of respondent household heads in year	+
Sex	Sex of respondent household heads (1=male,0=female)	+
Family size	Family size of respondent household in number	+
Farm size	Size of plots owned by the household in hectare	+
Education	Education level of the household head in illiteracy	+
Income	Annual income of respondent the household in Birr	+
Cattle ownership	Number of cattle owned by the household (heads/hh)	+
Water distance	Distance of water in km	-
Credit	Use of credit service (yes = 1; otherwise = 0)	+
Training	Well trained biogas experts (1 if a household trained, otherwise=0)	+
Extension	Number of extension agent visited/advised farmer (number)	+
Demonstration	Farmers demonstration on field days (yes=1, otherwise = 0)	+

Results and discussion

This part presents the findings and discussions of the descriptive and model output. First part contains analysis related with the description of variables in terms of descriptive and inferential statistics. Next part displays and deals with the findings from the logistic regression model with respect to the factors which affect the adoption of bio gas technology.

Descriptive statistic results

Descriptive statistical analysis of Dummy variables

The results presented in Table (2) below show that from the total biogas user respondents 83.3% were males and 16.7% were females. The proportion of males in the case of biogas user respondents was more than that of non- biogas user respondents. The Chi-square value below shows that, at 1% significant level, gender of respondents' had significant relationship with the use of biogas technology. In current study level the male population is greater than the female population in study area. In contrary, according to GTZ (2007) in gender, women producers are more effective than men.

The results in Table (2) shows that out of the total biogas user respondents 78.3% participate in farm activities and 91.4% of non-biogas user undertakes the same activities. In the findings farming provides manure for biogas generation and hence most of the households are potential owners of biogas plants. According to Walekhwa et al. (2009), an evidence suggest that probability of a household adopting biogas technology was directly proportional to a household income and trade, the number of cattle, farming and other. The chi square-value shows that occupation of respondents' had significant relationship with the use of biogas technology at 5% significant level.

Access to credit services is an important variable in rural energy choices. The survey results in Table 2 shows that in 2018/19, 20% of biogas user respondents used credit while only 11.8% of non-biogas users used credit. It is likely to increase households' decision on adoption of biogas technology by a factor of (proportion) 2:1, given factors. Access to credit enables the poor to be able to afford adoption of biogas technology. Provision of subsidy to biogas construction is a temporal solution but to scale up adoption and dissemination of biogas technology over a wider market, access to credit is quite essential (Ghimire, 2013). This credit used to construct a biogas structure at household level. The Chi-square value below shows that there was no significant relationship between the use of credit from institution and biogas of water use.

In below Table (2) shows that more than 75% of biogas users were attended on training that focused of biogas related practice. However, from the total 93 non-biogas user respondents' household, about 68.8% were not attended on training that is focused on biogas related practice. Chi-square tests further revealed that the respondent attended on the biogas training household had, the more the probability that they were likely to adopt biogas technology (χ^2=3.48, p=0.032). This observation could perhaps be explained by the recognition that many trainers taking experience to construct biogas plant, and therefore ensure sustainability of the technology. The Chi-square value below shows that at 10% significant level, there was significant relationship between attended on biogas related training and use of biogas.

The results in the Table (2) show that 86.6% the biogas user participated on demonstration of biogas. But 82.8% of non-biogas users were not participated on demonstration of biogas practice. Chi-square tests further revealed that the demonstration to farmers in using biogas, the respondent less participated, the probability that they were less likely to adopt biogas technology (χ^2=7.441, p=0.22). This result could perhaps be explained by the recognition that demonstration to respondent in the study area adoption of biogas is low; this ensures sustainability of the technology. The chi square-value below shows that not significant level at demonstration on biogas between user and non-user.

Mean value of continuous variables

The household heads' age determines to a probability for choosing biogas energy. The results in Table 3 below shows that from the total biogas user respondents more than half 45% were aged greater than 45 years old, and from the total non-bio gas user respondents. These belong 41.9% and 35.5% were aged between: 41-45 and greater than 45 years old. The maximum age observed was 68 whereas the minimum was 15 years. The finding shows that mean age of the adopter was 41.85 as compared to 37.5 years for the non-adopters household heads. According to Baiyegunhi and Hassan (2014) finding, increase in the age of household head correspondingly stimulates farmers to choose energy sources. The t-value in Table (3) shows that, the mean age of the two groups were not significantly different at 10% level.

The results also show that out of the total biogas user respondents 78.3% did attended formal education while 93.5% non-biogas user respondents did not attended formal education. Average mean of education level of respondents were 2.68 and 3.41 of adopters and non-adopters respectively. The t-test value shows that the education level of respondents' had significant relationship with the user of biogas technology at 5% significant level.

Table 2. Categorization of households on hypothesized dummy variables (2018/19)

Variables	Category	Biogas user.		Biogas non-user		Chi-square
		N	%	N	%	
Sex	Male	50	83.3	81	87.1	14.072***
	Female	10	16.7	12	12.9	
Occupation	Farming	47	78.3	85	91.4	10.864**
	Trade	6	10	1	1.1	
	others	7	11.7	7	7.5	
Credit use	Yes	12	20	11	11.82	0.158
	No	48	80	82	88.18	
Training	Yes	45	75	29	31.2	3.48**
	No	15	25	64	68.8	
Attending demonstration	Yes	52	86.6	16	17.2	7.441
	No	8	13.4	77	82.8	

Source: own survey, 2019. *, ** and *** represent significant at 10%, 5% and 1% level, respectively

In below Table (3) shown that the family size of the biogas user respondents 63.4% while non-biogas user respondents 66.7%. The result indicates that average family size of sampled households was about 6.75 persons. The family sizes of the households biogas user and non-user mean value was 7.5 and 6 persons respectively. This finding mean average is higher than the national level which is 4.7 persons (CSA, 2008). The mean difference between the family sizes of the biogas user and non-adopter user sample households was statistically significant at $p<0.01$.The t-test value shows that family size of the respondents is significant at 1% significant level.

The result in Table 3 reveals that 55% of biogas user respondents have land holding size ranging from 0.5-1.0 hectare and 50.54% of non-bio user respondents have land holding size ranging from 0.5-1.0 hectare. Mean holding of adopters was about 0.62 hectares with maximum and minimum of 1.5 and 0.12 hectares respectively. Non-adopter own about 0.25 hectare, the maximum and minimum holding of non-adopter was 1 and 0.12 hectares respectively. The mean land holding size of biogas user respondents' was 0.62 hectares and that of non-user respondents' was 0.49 hectares. But the finding of t-value below shows that there was no significant mean difference of the land holding size between biogas user and non-user respondents' household.

Livestock production is one of the main economic activities in the study area. Respondents rear various kinds of livestock in order to produce manure and dung to generate biogas. The survey results obtained from respondents' household in Table 3 shows that the majority 60% of biogas user respondents' household cattle number is 6-7 while 68.82% of non-biogas user respondents' household cattle number is 4-5. The total average mean of the cattle number is 3.12. The biogas user respondents' household mean cattle holding is 4.23 and that of non-biogas user respondents' household mean cattle holding is 3.43. The result is consistent with the findings of Walekhwa et al., (2009) in which cattle number was reported to have a significant positive association with that of adoption of biogas technology. The t-tests further revealed that the more the number of cows the household had, the more the probability that they were likely to adopt biogas technology (t=6.342, p=0.001). The t-value below shows that, there was significant mean difference of livestock holding between biogas user respondents' household.

The results in Table (3) below shows that out of the total biogas user respondents all of respondents' household farm distance from pipe and river is less than km while from the total 93 non-biogas user respondents 60.2% of respondents' household farm distance from pipe and river is above 1.5 km. The mean of biogas user respondents' household farm distance from pipe and river is 0.157 km and the mean of non-biogas user respondents' household farm distance from pipe and river is 1.38 km. The t-value below shows that, at 1% significant level there was significant difference between biogas user and non-user respondents' household in the mean farm distance from Rivers.

Table 3. Descriptive statistics for continuous explanatory variables

Variables	Biogas user		Biogas non-user		t-test
	Mean	STD	Mean	STD	
Age	41.85	3.02	37.5	4.7	-1.331
Education	2.68	0.75	3.41	0.86	0.446**
Family size	7.5	0.64	6	0.52	-0.19***
Land size	0.62	0.21	0.49	0.32	1.191
Livestock	4.73	2.58	3.81	1.25	6.342***
Water distance	1.07	0.58	1.28	0.42	0.492***

Source: Survey result, 2019. *, ** and *** represent significant at 10%, 5% and 1% level, respectively

Binary logit model result on determinants of adoption of biogas technology

After commanding the variables in binary logistic regression the model explained 81.28% of the total variation in the sample for the use of biogas technology. The correctly predicted biogas technology users were 83.7% while the correctly predicted non-technology users were 72.54%. Among the 11 explanatory variables included in the model, six variables significantly affected the use of biogas technology (Table 4).

Sex: The model results in table 4 shows that, gender of respondents; had significant negative effects on the use of biogas at 1% significant level. The odds ratio of gender of respondents' revealed that at 1% significant level, the odds ratio supports the use biogas by a factor of 33.45 when the respondents were being female headed. Therefore, female headed households have more chance to use biogas than male in households. The information gathered from FGD participants revealed that "in the study area, biogas yield a whole range of benefits to the rural community including production of heat and electricity, improvement of hygienic condition and environmental advantages through protection of soil, water and woods. Biogas can improve livelihoods of people in a sustainable way. As such, there is need to enhance the use of biogas energy to improving the lives of the rural area.

Cattle ownership: As illustrated in Table 4, the numbers of cattle were positive and significantly correlated to the probability of choosing biogas energy at 1%. The positive correlation indicates that there is a lower probability that biogas adopters will substitute traditional energy with biogas energy. The possible reason might be that biogas adopters possessing a high number of cattle are more likely to collect more dung. Similar studies conducted by Mengistu et al. *(*2015) in Ethiopia reported similar findings in that cattle holding significantly and positively affected household's choice to use biogas energy.

In addition also t-value further revealed that the more the number of cattle dung the household had, the more the probability that they were likely to adopt biogas technology (t=6.342, p=0.001) (Table 10). This observation could perhaps be explained by the recognition that many cattle would lead to production of huge quantities of dung. The number of cow owned was a useful indicator of the availability of feedstock for the digesters. This could be particularly true since other types of feedstock, such as crop residues, and other household waste.

In current study regarding occupation of work more of biogas user respondents 78.3% did dairy farming. The household adopting biogas technology was directly proportional to a household income, the number of cattle owned, a household size and the ever increasing cost of traditional fuels. Thus, from the above findings, dairy farming provides manure for biogas generation and hence most of the households are potential owners of biogas plants. Muriuki et al. (2001) observe that in developing country dairy farming is a very significant sources of income and food for an estimated many small holder producer households.

Education: The education level of respondents' had significant positive effects on the use of biogas at 5% significant level. The odds ratio for education level of respondents' shows that at 5% significant level, the odds ratio favoring the use of biogas increase by a factor of 1.77 when the respondents were being attended in formal education. Therefore, educated respondents have more chance to use biogas technology. The result obtained from key informant's interview revealed that in the study area the educated farmers easily understood the operation and adopt improve biogas technologies which increase their access to the use of biomass (tanker). In agreement with this finding, Riddell et al. (2012) have reported in their study that highly educated workers tend to adopt new technologies faster than those with less education workers.

Occupation: The findings also show that occupation in the study area and biogas energy has a positive and significant relationship. The odds ratio for occupation shows that at 1% significant level, the odds ratio favoring the use of biogas technology create chance by a factor of 4.52 for the respondents' who attended the get work activity. The positive result suggests that household energy utilization reflects a combination to get occupation from different work activity to develop biogas technology. The household adopting biogas technology was directly related to a household income, the number of cattle owned, and farming. The occupation concurs with results from this study that farming is the economic main stay of most of the respondent in the study area (Walekhwa et al., 2009).

Distance to water source: The distance of nearest water source had significant negative effect on the use of biogas technology at 5% significant level. The odds ratio for respondents' biomass (tank collector) distance from water shows that at 5% significant level, the odds ratio disfavoring the use of biogas technology by a factor of 0.28 for the respondents' biomass as distance increase from water increases at 0.5 km. Therefore, the respondents' household farm located far from the water and main biomass has less chance to use biogas technology. When the biogas distance far from main biomass which was constructed from the biogas plant, it needs high labor, financial and time costs to construct sub-plant towards individual household and minimize the chances to use biogas technology.

Training: Attended on biogas related training had significant and positive effect on the use of biogas technology at 5% significant level. The odds ratio for attended on training shows that at 10% significant level, the odds ratio favoring the use of biogas by a factor of 2.22 for the respondents' who attended biogas related training. Therefore, the respondent who attended biogas technology related training has better chance to use biogas. The result obtained from Key informant interview revealed that, attending on training improves household (farmers') skilled and knowledge to adopt biogas technologies and then increases their chance to use biomass. This finding agreed with finding of Tsion et al. (2010) that, the emphasis in extension education is helping people to help themselves. Hence extension service is an on-going process of getting useful information and disseminate to people and assisting them to acquire the necessary knowledge, skills and attitudes.

Table 4. Binary logistic regression results of independent variables

Independent variables	Coeff.	Odds Ratio	Wald	p-Value
Age of respondents’	0.178	0.92	0.596	0.484
Sex of respondents’	-0.103	33.45	1.223	0.001**
Number of cattle	0.243	2.12	0.626	0.001**
Family size of respondent household	0.092	1.96	0.032	0.001
Education level of respondents’	0.103	1.77	2.144	0.077*
Occupation of respondents’ household.	0.185	4.52	1.542	0.000***
Annual income of the respondents household	0.120	1.23	4.375	0.001
Access credit from institution last year	0.320	0.73	6.122	0.708
Distance to nearest permanent water point in km	-1.270	0.28	3.294	0.006***
Training biogas experts in number	0.800	2.22	0.456	0.032*
Farmers demonstration on field days	0.230	0.92	5.342	0.220
Constant	21.203	74.16	16.43	0.000

*, ** and *** represent significant at 10%, 5% and 1% level, respectively.

- Log likelihood= -65.434, LR chi2 (11) =122.38 and Probability > chi2 =0.000.
- Number of observation =153.
- The total variation in the sample for the use of biogas technology was 81.28%.
- The correctly predicted biogas users were 83.7%.
- The correctly predicted non-biogas users were 72.54%.

Practice and effect of biogas technology in the study area

Respondents’ experience in biogas practice in the study area

A Small-Scale biogas practice in Sodo zuria district has a recent history. However, there was no well-known written document about when the Small-Scale biogas practices begun in the study area.

The information gathered from FGD (three FGD) participants revealed that “in the area the small-scale biogas technology practices begun before some years ago in our country. During the previous period, small holder farmers had been using biogas technology to produce only by products such as manure, cow dung’s and other wastes. Now a day, the small-scale biogas technology practices in the area dramatically expanded and the farmers' collecting waste product practices also changed from only depending on production energy. The expansions of small-scale biogas technology practice also increase farmers' use of waste product frequencies; use of other farm inputs and also increased farm productivity to enhance energy"

The results in table 5 show that out of the biogas technology user respondents 6.66% have less than 2 years' experience in biogas practice, 33.34% have 4 years' experience in biogas practice, 51.67% have 5 years' experience in biogas practice and the remaining 8.3% have more than 5 years' experience in biogas practice. This result also revealed that the majority of biogas technology user respondents have 5 and more years' experience in biogas practice. Therefore, in the sample Kebele's most of biogas user respondents are well experienced in biogas practice.

Table 5. Biogas user's experience

Experience year in use of biogas practice	Frequency	Percent
< 2years	4	6.66
4 years	20	33.34
5years	31	51.67
> 5 and above years	5	8.33
Total	60	100.00

Source: Survey, 2019

Challenges of accessing energy among the respondents

The study showed that respondents faced various challenges when accessing their sources of cooking energy. The main challenges were high cost (67%), inaccessibility of cooking energy at (41%), transportation costs at (20%) and unreliable supply at (17%) (Figure 1). Respondents complained that, they incurred high costs in procuring cooking energy such as: wood fuel and charcoal. This may be attributed to increasing demand for these commodities. Further, the respondents who used kerosene gas felt that the commodity was more expensive in the study area given that it is a rural setting.

Declining of wood in areas and increased population density in the study area has forced people to cover their energy need by buying wood. The price of a foot of wood fuel varied between high costs depending on the size of the wood at the household level. The purchasing of wood fuel or other energy sources weakens a family economy to the extent that the money spent on energy is taken away from other basic supplies like food or school amount increasing their vulnerability and lessens their opportunities to plan their future or make other investments. According to FAO (2009), the demand of wood fuel in developing country is increasing, while at the same time the scarcity of firewood is a growing problem and degradation is making the fulfilling of the wood fuel need even more difficult.

The other major challenge is inaccessibility. In the past, wood fuel used to be a free or low cost energy source that was easily on hand in the study area. According to key informant interviews; "wood fuel is no longer as accessible since all the natural forests have been encroached on, so people no longer have anywhere to go fetching wood fuel or even burning charcoal, the few forests that exist are owned privately. The use of wood fuel increases household's vulnerability by raising the work load of women in particular and putting a hurt on a household fuel budgets".

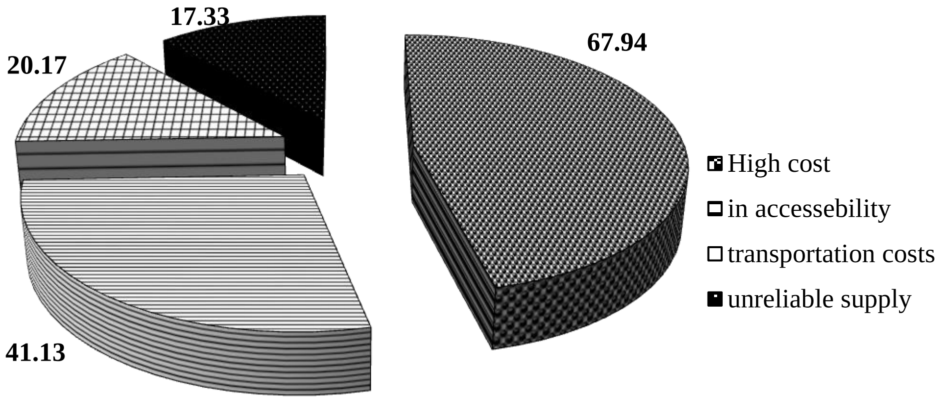

Figure 1. Challenges of accessing cooking energy at the household level

Challenge to biogas technology uptake in the study area

The study showed that several factors were responsible for the low adoption status of biogas technology in the area. The main factors were high installation costs (55%), negative attitude of community towards biogas energy (8%), inadequate skilled technicians (25%), lack of adequate fund, lack of interest, and poor infrastructure (10%) (Figure 2).

Majority of the farmers (70%) were in the view that the high upfront cost of installing biogas cost was one of the major barriers that have hindered adoption among biogas users in the study area. According to Quadir et al. (1995), high investment costs in installing biogas units have be blamed for the low adoption rates in many developing countries.

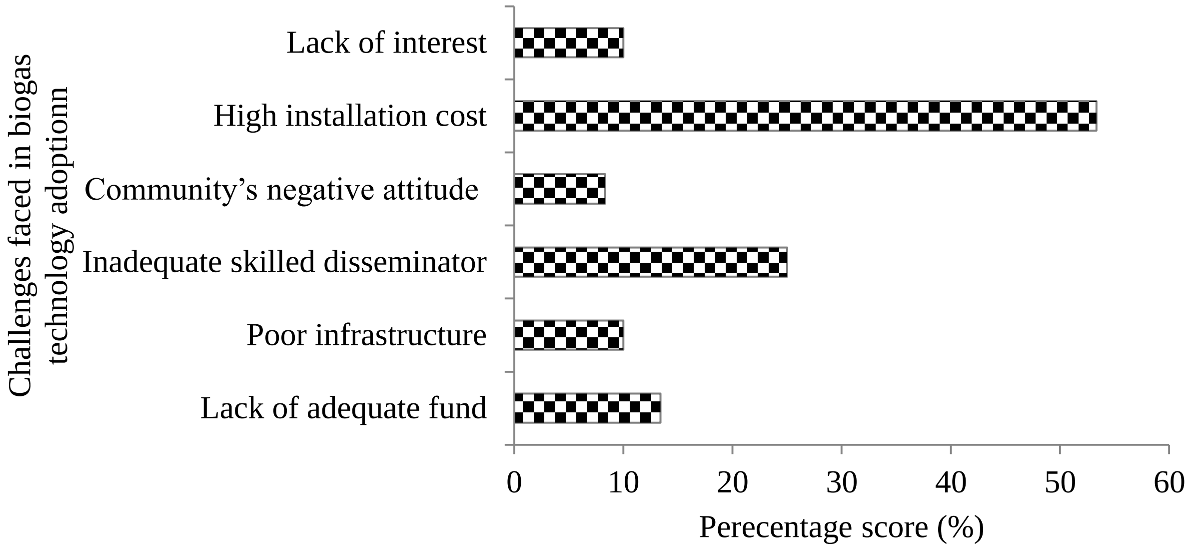

Figure 2. Challenges faced by the uptake of biogas technology in the study area.

The respondent that hindered the uptake of the technology was negative attitude of the community (8%) and the notion that biogas was dirty technology as it used animal waste to cook. According to the study of Mwakaje (2008), a number of people who have not accessed biogas technology had the perception that biogas is a dirty thing; however, on seeing physically the functioning of waste, many households were motivated to adopt the technology. The potential biogas users need biogas oriented training through demonstrations and dissemination of information on how biogas digesters work; the importance and viability of biogas energy in the area.

The other factors are availability of well trained and skilled biogas technicians; it was another barrier attributed to the low adoption status in the study area. According to Mugo et al. (2010), for increased adoption of biogas technology to occur, there is need to have sufficient number of trained crafts persons at the local level who can construct and provide quality services for any interested customers at a reasonable cost. This shows that if local people are trained in biogas installation, operation and maintenance skills, then the adoption rates would increase in the study area.

The other major factor is the lack of adequate fund facilities (15%). According to the respondents, the high initial cost and lack of credit financing arrangements have hampered the uptake of the technology among the potential customers. This clearly indicates that some of the potential biogas users may not have the cash to pay for biogas during not properly working time. According to Mwakaje (2008), 95 % of the dairy farmers reported that lack of credit facilities was one of the major factors for the low adoption status of biogas technology among users. These results agree with the findings of the current finding. A large number of the respondents were using biogas technology, local micro finance institutions provided low interest loans for biogas procurement, and many households in the study area could adopt the technology.

Effects of biogas technology in study area

According the respondents (79%), (70%), (88%), and (95%) of the biogas users said that it reduced expenditure on cooking energy, it saved time in preparation and cooking of food, it provided the much needed organic bio slurry, it reduced smoke in the kitchen, and it made cooking more convenient respectively (Figure 3).

Reduced expenditure on cooking energy was one of the main benefits of using biogas energy at the household level among the respondents. A study by Hamlin (2012) in rural area of Kenya showed that a woman whose main source of cooking energy was firewood reported that her supply of firewood would last about three to four months before installing a biogas unit could now be used for well over one year. This agrees with the results of this study that biogas use at the household level helps to reduce expenditure on energy. The reduced expenditure on energy helps to strengthen the family's economy; thus providing more money for essentials such as: food, school fees, clothing and income generating activities.

On time saving, most of the respondents mentioned that biogas energy helped to reduce the amount of time spent in cooking, fetching of wood fuel and cleaning of utensils as pots and other kitchen accessories do not get stained with soot so much, and time is therefore saved on their cleaning. The results of this study agrees with the research findings of Karanja and Kiruiro (2004), where 100% of the respondents in rural areas reported reduced work load after installing a biogas digester at the household level. The saved time can be used for acquiring additional incomes leading to livelihood diversification at the household level.

The provision of bio slurry, a by-product of biogas production was another benefit experienced by the respondents in the study area. The majority of farmers seemed to understand the importance of using bio slurry to improve agricultural productivity. The humus contained in bio-slurry improves soil nutrients and structure; the bio-slurry nutrients increase crop yields and save an inorganic fertilizer costs (Myles, 2004). The application of bio-slurry could result into higher crops yields; thus improve the food security of the dairy farmers.

From the study about (88%) of the respondents experienced reduced smoke in the kitchen as a result of installing a biogas digester at the household. The use of biogas energy positively affected the wellbeing of households by reducing indoor air pollution. According to Tereza (2011), one of the main health benefits of biogas are mainly related to a substantial reduction of smoke and indoor air pollution compared to a traditional wood fuel. This concurs with the results of this study. Reduced smoke in the kitchen has direct effects on wellbeing in that its disproportionate reduces health burden of smoke related diseases or health problems especially for women who are often responsible for obtaining energy source and cooking. Close to (95%) of biogas users, indicated that biogas provided a readily available fuel which made cooking more convenient. Some of the women respondents confirmed that they no longer woke up early to light wood fuel fire to assist their children to prepare for school and to warm water for milking cows. According to the women, the presence of biogas energy creates positive social impact on the lives, contributing to their empowerment.

According to the FGD collected information "the technologies people embrace and use play a fundamental role in shaping the efficiency, equity and environmental sustainability of natural resource management. These technologies are of little value unless they are judged to be appropriate by farmers and subsequently adopted. As such, the scaling up energy program should consider incorporating a biogas digester subsidy strategy especially among the low income dairy farmers to facilitate the acquisition and installation of biogas digesters".

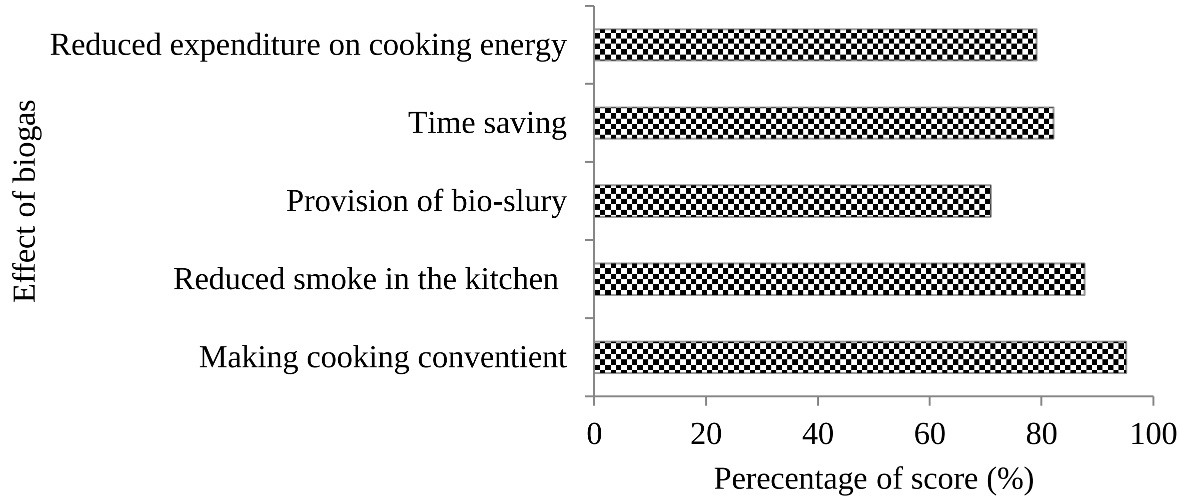

Figure 3. Effects of biogas technology among respondents

Conclusions

This study has identified key factors that influence adoption bio gas technology in the study area. This insight is also useful to rethink about the barriers of adoption of technologies such as biogas. Therefore, the result can be used by policy makers to promote technological change that is direly needed for the energy resource and economic development in study area. The study has revealed the key roles of livestock in biogas production. Farmers with large number of livestock are more likely to adopt and use the technologies. Therefore, biogas production requires concerted efforts to the livestock sector, improved veterinary service, credit for livestock purchase and water development as deemed necessary. The use of biogas technology has had significant impacts in the study area; it reduced energy expenditure, made cooking more convenient, reduced smoke in the kitchen, and also saved time in meal preparation and provision of bio-slurry. The results indicated that sex, occupation, educational level, training, livestock or cattle ownership and distance to water were statistically significant factors that affect household adoption of biogas energy. In contrast to the age, farmer's demonstration on field days, access credit from institution, size of plots owned by the respondents' household did not show a significant influence on biogas consumption energy. The study also shows that farmers faced a numerous of challenges in the uptake of biogas technology. Some of the challenges were high installation costs, lack of credit facilities from local financial institutions, and inadequate skilled technicians. Currently, public and private extension agents have played an active role in promoting biogas technology in the study area. However, their promotional activities are hindered by limited support from the government, such as high installation costs and absence of skilled biogas technicians.

Recommendations

The finding of the study came up with possible policy recommendations in the area of biogas technology adoption. In order to develop biogas Technology in study area, there is need for policy and institutional framework reforms by biogas promoters in the government to develop sustainable strategies to improve the use of biogas among potential users. The following issues need to be addressed:

Farmers with large number of livestock are more likely to adopt and use biogas technologies because many cattle would lead to production of huge quantities of dung to be effective for biogas technology which needs high amount of dung. Therefore, the biogas user farmers require a number of cattle to use sustainable biogas technology. And efforts to the livestock sector, through improved veterinary service and credit for livestock purchase is necessary for the biogas technology.

When the biogas technology have a distance far from main water sources, it needs high labor, financial and time costs to construct sub-plant towards individual household and minimize the chances to use biogas technology. Therefore encouraging farmers to have water sources near to the farmland is very crucial.

A loan for the construction of a biogas plant is difficult to an ordinary farmer; because farmer's income is seasonal and lack of potential flexible community friendly credit schemes to help poor farmers who have interest to construct biogas technology. Therefore the local government needs to facilitate the access of an external financial source to find the farmers through credit to construct biogas technology to change their life.

The biogas users should be encouraged attending on training to improve their skills and knowledge to adopt biogas technologies and then increases their chance of using biomass. And also the government needs to facilitate the biogas technicians in the cluster kebele's to maximize the functionality of the biogas technology.

Demonstration service is an on-going process of getting farmers useful information during farmer's field days, farmer's workshops, and meeting on the potential biogas technology to acquire farmers the necessary knowledge, skills and attitudes. This can be done through the combined efforts of the local government through private sector and civil society organizations.

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