FACTORS INFLUENCING ADOPTION OF SMALL SCALE BIOGAS DIGESTERS IN KATAKWII DISTRICT, UGANDA

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ABSTRACT

This research was conducted to assess socio-economic factors influencing adoption of small scale biogas digesters in Katakwii District of Uganda. The socio-economic factors, the level of biogas, and the constraints faced by the farmers were assessed. A cross-sectional research design was utilized to collect data from 80 respondents (adopters and nonadopters of biogas). Purposive random sampling was applied to select seven key informants in the two sub-counties of Kapujan and Toroma, and four villages of Kokorio, omosingo, Ariet and orimai. Data were collected through personal observation, interviews, focus group discussions, and structured questionnaires. The Statistical Package for Social Sciences (SPSS) was used to generate descriptive and inferential statistics for quantitative data analysis. The binary probit model was used to determine the socio-economic factors influencing adoption of biogas. The findings indicate that there was a significant influence for gender ($p<0.01$), but a statistically significant influence for credit and extension services ($p<0.05$). Finally, the adoption rate of biogas is still low given the size of land dedicated to it by most farmers. Therefore, this study recommends that government and other institutions should strengthen the agricultural extension system, provide financial support and incentives, and sensitize farmers on conservation agriculture.

Keywords: Adoption, Biogas digester, Katakwii District, Socio-economic factors, Uganda

1. INTRODUCTION

Dependency on traditional fuels such as wood, charcoal, dung, and agricultural residues, as a source of energy is very high with around 3 billion people all over the world combusting solid fuels (Nigel, 2004). Use of traditional energy such as wood fuel in developing countries can be attributed to the fact that rural households in these nations are primarily based on traditional sources (Tata Energy Resource Institute, 2013). UNFCC, (2010) acknowledge that fuelwood accounts for about 5% of global deforestation with 55% of wood harvested from forests being used as fuel. Use of biogas technology has proven to be a remedy to problems of energy in rural areas of developing countries (Smith, 2005). It can suppress many adverse social, economic and environmental impacts linked with conventional energy sources such as traditional biomass. In Uganda, uptake rate of this technology in Uganda has been slow and unevenly extended since many households are still not aware of it despite its existence for over 50 years **(**Hivos, n.d.; Okello et al., 2013). This has been attributed to low penetration rate to inadequate information on biogas production and lack of awareness of its benefits by households. As much as biogas is viewed as a multifunctional renewable energy source, in Katakwii district, most households have persistently utilized wood fuel with the resultant negative effects. This research was hence meant to assess the factors influencing adoption of biogas at the household level in Katakwii district.

1.1. OBJECTIVES OF THE STUDY.

The main objectives of the study was to gain a better understanding of the factors influencing adoption of small scale biogas digesters in Katakwii district.

1.1.1. Specific objectives of the study

- Determine socio-economic factors which significantly influence adoption of biogas in Katakwii district
- Asses the contribution of biogas amongst the residents of katakwii district
- Determine the constraints/ challenges faced by biogas users in Katakwii district

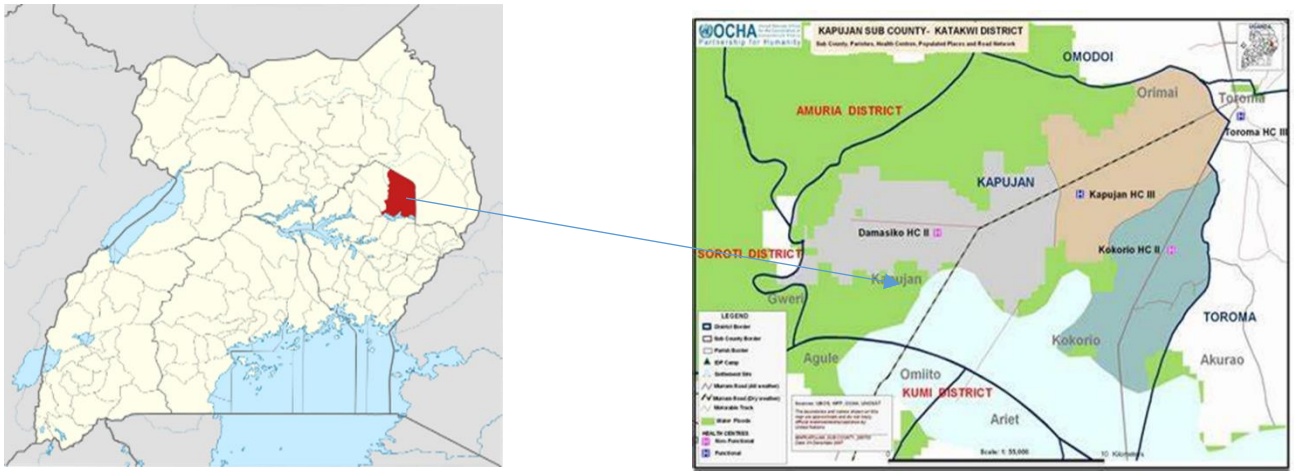
2. METHODOLOGY

2.1. Description of the study area

Katakwi District is located in Eastern Uganda. The district is bordered by Napak to the north, Nakapiririt to the east, Kumi to the south, Ngora and Soroti to the southwest and Amuria District to the west (Katakwii District Local Government, 2018).

The coordinates of the district are: 01 54N, 34 00E. Subsistence agriculture and pastoral animal husbandry are the two main economic activities in Katakwi District. The crops grown millet, cassava, Groundnuts, Sweet potatoes etc. The climatic zone has a rainfall average of 1250mm occurring in 140-170 days of the year. The population is estimated at 176,800 (UBOS, 2014).

FIGURE 1: MAP OF UGANDA SHOWING THE LOCATION OF KATAKWII DISTRICT



Source: District administrative boundaries (UBOS, 2010)

2.1.1. Sampling and sample size determination

A multi-stage sampling technique was used to select the target areas as well as the respondents. Sub-counties and villages in the district were stratified based on the estimated population of households using biogas. Hence, two sub-counties (Kapujan and Toroma) and four villages (Kokorio, Omosingo, Ariet and Orimai) were selected. For the selection of respondents to be included in the cross sectional survey, the choice-based sampling scheme was used which involves stratifying the population based on the dependent variable; in this case, biogas adoption (Donkers, Franses & Verhoef, 2003). Choice based sampling is particularly useful when the outcome to be explained is rare (Cram, Karan & Stuart, 2009). The households within

the selected sub-counties were grouped into two categories, namely those using biogas (adopters) and those not using biogas (non-adopters).

To determine the number of non-adopters to be interviewed within the second category, a probability formula was adopted from Saxena *et al* (2010). That is $n=z2\times p\times q/e2n=z2p\times q/e2$ where *n* is the required sample size, z is 1.96 at 95% level of confidence, *P* is 0.95 (which is approximately 95% and accommodates the margin of households not using biogas in Katakwii District) and $q = 1 – p$, i.e. 0.5, and $e = 0.05$ (which is the margin error at 5%). Therefore, a total of 80 households were sampled of which 40 were using biogas and 40 did not.

Primary data were collected through the use of questionnaires, interviews, physical observation, checklists, and focus group discussions. Secondary data were obtained from the district production office, sub-county agricultural office and from The Lutheran World Federation on the status of biogas in the four selected villages of study.

2.1.2. Data processing and analysis

All the collected data from the respondents were first entered into Microsoft Excel to enhance proper coding of the data and then exported to the software programme, Statistical Package for Social Sciences (SPSS) for analysis using descriptive statistics (frequency distribution, means and percentages) as well as inferential statistics.

The study analysed the socio-economic factors influencing adoption of biogas technology using a binary choice model, namely the probit regression model. This model was chosen since the dependent variable is binary in nature and takes a value of 0 or 1. Furthermore, the probit model is suitable for estimating parameters of interest when the dependent variable is not fully observed. The probit model constrains the probability to a 0, 1 interval and assumes that an event will occur is non-linear and that the random error terms follow a normal distribution.

The model is based on the probability of success of an event which in this case is the decision to adopt biogas technology. The probability that an individual will choose to adopt biogas

technology depends on an underlying response variable that the expected utility from adoption of biogas is greater than the utility of non-adoption. The random utility function (y^*) for a respondent in Katakwii District facing a decision to adopt biogas can be specified in equation 1.

Yi=1ifY_*=i ($xi\beta+\varepsilon$)>0, 0 if otherwise Yi=1ifY_* =i (xiβ+ε)>0, 0 if otherwise……(1)

Where Y is a dummy variable capturing households ownership of biogas (1 = if household has adopted biogas, 0 = otherwise), β = ($\beta 0$, $\beta 1$, $\beta 2$…… $\beta 6$) is a vector of unknown parameters, i is the choice of the practice, xi is a vector of covariates (explanatory variables), that is socioeconomic and demographic characteristics of the individual, and ε is the error term.
The empirical model that determines factors influencing the respondent's decision to adopt biogas is specified in equation 2. A household (i) makes a decision to adopt biogas (Yi) if the expected utility from biogas adoption is positive. Household adoption of biogas is associated with socioeconomic and institutional characteristics that can be described as follows:

Yi= ……. (2)

Where; γ = If the farmer had adopted CA or not

α = Constant

β = Coefficient of independent variable

χ_1 = Age (year)

χ_2 = Gender (1 if male or 0 if otherwise)

χ_3 = Education level (number of years spent in school)

χ_4 = Credit (1 if respondent has access to credit, 0 if otherwise)

χ_5 = Number of animals

χ_6 = Extension services (1 if yes, 0 if otherwise)

ε_i = Random error

3. RESULTS AND DISCUSSION

3.1. Demographic and socio-economic characteristics of the respondents

3.1.1 Age of the respondents

Respondents were divided into age groups, ranging from 16 to over 60 years of age. The largest proportion (30%) of adopters of biogas fell within the age group of 26 to 30 years. Furthermore, 15% of the adopters fell within the 21-25 age group as well as the 36-40 age group. There were no non-adopters falling in the age group of 41-50 years. Among those who were in the 61 and above age category, 10% had adopted biogas, while 5% had not (Figure 2). It is clear from the results that both young and older people had adopted biogas. The reason could be that young people have more ability to acquire information about new technologies while older people might have accumulated a lot of experience concerning the advantages of using biogas.

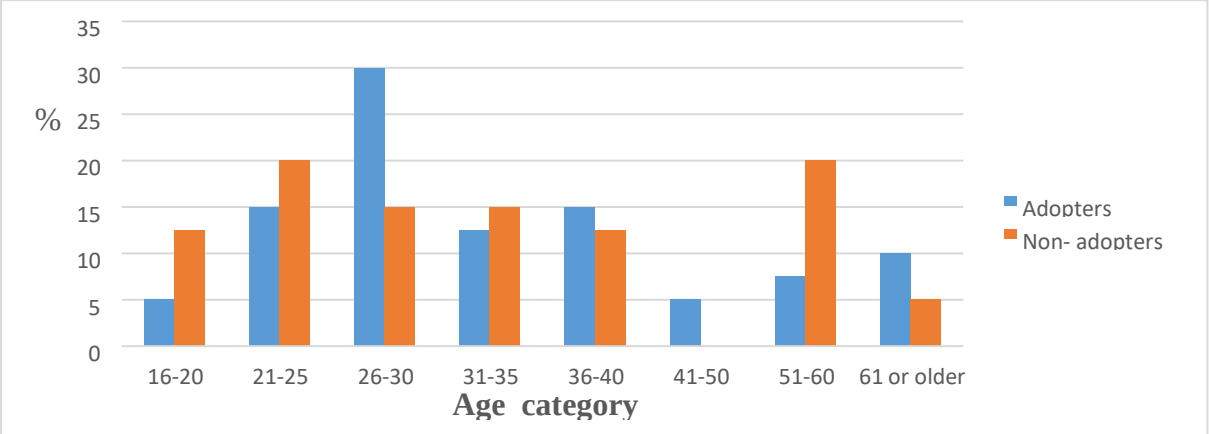


Figure 2: Age of the respondents

3.1.2 Educational level of the respondents

The findings show that the majority of adopters (65%) and non-adopters (77.5%) had attained primary level of education. Only a small proportion (12.5%) of adopters and non-adopters (15%) had not attained any formal education. The adopters who had acquired secondary education comprised of 22.5% of the sample (Table 1). It can be seen that moderately educated respondents had adopted biogas. Education helps in improving beliefs and habits which in turn creates favorable mental attitude for acceptance of new practices. These findings tally with the findings of Mwakaje (2008) that the likelihood of adoption of biogas energy increased with more years of formal education of the household head in Tanzania.

Table 1: Education level of the respondents

Variable	Biogas adopters (n=40)		Biogas non-adopters (n=40)	
	N	%	N	%
Never went to school	5	12.5	6	15
Primary education	26	65	31	77.5
Secondary education	9	22.5	3	7.5
TOTAL	40	100	40	100

3.1.3 Gender of the respondents

Table 2 shows that 55% of the biogas adopters were male and 62.5% of the non-adopters were also male. Females were less well represented with 45% of adopters and 37.5% of non-adopters. In general, the findings indicate that more males had adopted biogas technology as compared to their female counterparts. This could be attributed to women in Katakwii District having less access to resources and labor as compared to males, which would limit their adoption for biogas.

Table 2: Gender of respondents

Variable	Biogas adopters (n=40)		Biogas non-adopters (n=40)	
	N	%	N	%
Male	22	55	25	62.5
Female	18	45	15	37.5
TOTAL	40	100	40	100

3.1.3 Household size of the respondents

Table 3 reveals that the majority (55%) of biogas adopters had household members ranging from 58%, while 57.5% of non-adopters had household members in the same category. A further 35% of the adopters had 9 and above members, while 32.5% of non-adopters had household members in the same category. This finding implies that the number is large enough to influence households to adopt biogas digesters since they can provide enough labour. Similar

results were reported by Ayuya et al. (2011) who argued that households with more members have got the capacity to offset labour constraints during the introduction of new technologies.

Table 3: Household size of the respondents

Variable	Biogas adopters (n=40)		Biogas non-adopters (n=40)	
	N	%	N	%
1-4	4	10.0	4	10.0
5-8	22	55.0	23	57.5
9 and above	14	35.0	13	32.5
Total	40	100.0	40	100.0

3.1.4 Household source of labor

The current results show that 75% of adopters and 72.5% of non-adopters rely on family labour. Both adopters and non-adopters who relied on hired labor comprised of 22.5% of the sample. The adopters and non-adopters who were accessing labour from neighbours made up 2.5% and 5% of the sample respectively (figure 2). This implies that most respondents were relying on their families as a source of labor for biogas management. Labor is a major factor that is known to hinder adoption of technologies

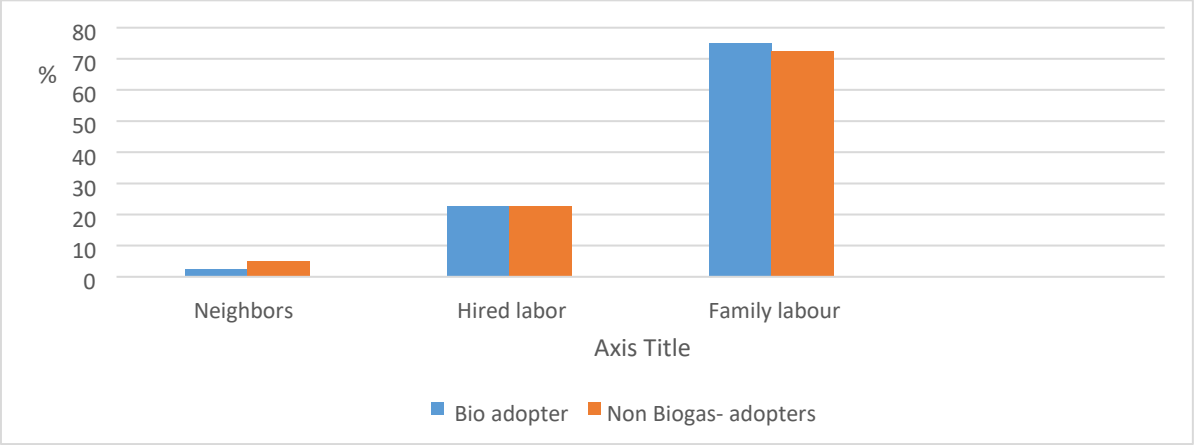


Fig 2: Household source of labor

3.1.5 Occupation of the respondents

The study results reveal that 40% of adopters and 42.5% of non-adopters were engaged in farming. The adopters who were involved in business comprised 27.5% of the sample, while 25% were non-adopters. The adopters and non-adopters who were involved in other activities like brewing, charcoal burning, and quarrying were both represented by 30% of the sample. (Table 4). These findings suggest that most respondents were dependent on farming to earn a living. The results are consistent with the Uganda bureau of statistics which reported that 66% of Uganda's population is engaged in agriculture (UBOS, 2009).

Table 4: Occupation of the respondents

Variable	**Biogas adopters (n=40)**		**Biogas non-adopters (n=40)**	
	N	**%**	**N**	**%**
Farming	16	40.0	17	42.5
Government employment	1	2.5	1	2.5
Business	11	27.5	10	25.5
Others	12	30.0	12	30.0
Total	40	100.0	40	100.0

3.1.6 Household income per annum of the respondents

The results represented in Table 5 show that 75% of adopters and 67.5% of non-adopters were earning below 100 000 shillings. Those farmers who were earning between 100 0001 and 200 0000 shillings made up 20% of the sample for adopters and 25% for non-adopters. Only 5% of adopters and 7.5% of non-adopters were earning 2000001-3000000 shillings. As the majority of participants were earning less than 100 000 shillings per annum, this implies that they are too poor to invest in the acquisition of information and knowledge accumulation that leads to the adoption of biogas digesters.

Table 5: Household income of the respondents

Variable	**Biogas adopters (n=40)**		**Biogas non-adopters (n=40)**	
	N	**%**	**N**	**%**
Below 1000000	30	75.0	27	67.5

1000001-2000000	8	20.0	10	25.0
2000001-3000000	2	5.0	3	7.5
Total	40	100.0	40	100.0

3.1.7 Household number of Animals

With reference to animals majority of households 64% adopters and 60% non-adopters had between 4-6 cows.

Table 6: Household number of Animals

Variable	Biogas adopters		Biogas non-adopters (n=40)	
	N	%	N	%
1-5	6	15	14	33
6-10	26	65	22	57
11 and above	8	20	4	10
Total	40	100	40	100

3.1.8 Awareness of the respondents about biogas

Table 7 indicates respondents' awareness of biogas. When respondents were asked about whether they have heard about biogas use, all of the adopters and three quarters of the non-adopters said that they were aware of biogas. Only 25% of the non-adopters had not heard about biogas. The high percentage of biogas awareness is due to the presence of government and NGO's in the district which provides biogas advisory services to the farmers.

Table 7: Respondents awareness of biogas

Variable	Biogas adopters (n=40)		Biogas non-adopters (n=40)	
	N	%	N	%
Yes	40	100	30	75
No	0	0	10	25

3.1.9 Perception of the respondents about biogas use

Even though some respondents had not adopted, the majority of participants (57.5%) were satisfied with biogas (Table 8). Participants' reasons for satisfaction was because biogas reduces use of fuel wood and provides bio slurry which is used as a Fertilizer.

Table 8: Satisfaction with Biogas use

Variable	Biogas adopters (n=40)		Biogas non-adopters (n=40)	
	N	%	N	%
Yes	23	57.5	16	40
No	17	42.5	24	60
TOTAL	40	100	40	100

3.2 Information source of the respondents

When respondents were asked about their source of information for biogas, 37.5% of adopters and 27.5% of non-adopters said they receive information from NGO's/ extension agents. This was followed by 35% of adopters and 25% of non-adopters who access information through their neighbors. Both adopters and non-adopters who access information through the Radio/ TV comprised of 20% of the sample. Only 7.5% of adopters and 27.5% of non-adopters use other means, such as newspapers, as their source of information (Table 9). It is thus clear that the main source of information that influenced adoption of biogas was NGO's/ extension agents. Access to information which occurs through extension meetings leads to adoption of new technologies.

Table 9: Respondents source of information

Variable	Biogas adopters (n=40)		Biogas non-adopters (n=40)	
	N	%	N	%
NGO's/ Extension agents	15	37.5	11	27.5
Farmers/ Neighbors	14	35.0	10	25.0
Radio/TV	8	20.0	8	20.0
Others	3	7.5	11	27.5
Total	40	100.0	40	100.0

3.2.1 Membership of the respondents

As can be seen from Figure 3, it was found that 62.5% of adopters and 55% of non-adopters were members of different associations which were available in the area. In contrast, 37.5% of adopters and 45% of non-adopters did not belong to any association. The results reveal that most adopters of biogas digesters are members of various associations. The reason could be that extension workers find it easier to provide information and back up technical support to support respondents who are in groups. This confirms the findings of a study conducted by Chi (2008) who reported that involvement of people in groups such as farmer associations and extension clubs leads to adoption of technologies.

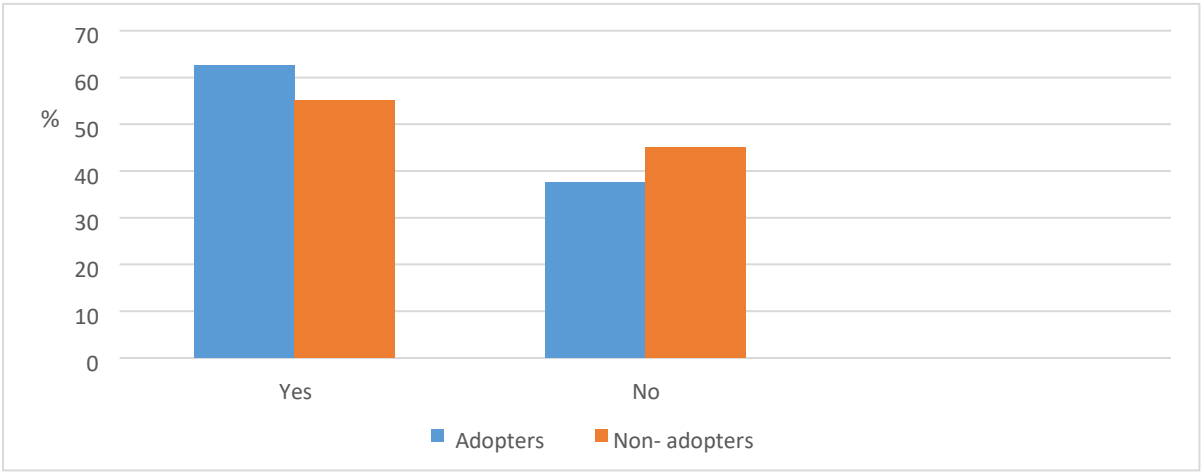


Fig 3. Membership of the respondents

3.3 Constraints to using biogas

The results in Table 10 indicate that limited information and knowledge was mentioned by biogas adopters (12.5%) as a challenge during implementation of biogas.

Insufficient water and manure was recorded as a major challenge facing biogas adopters (30%). This finding implies that most farmers are relying on subsistence farming hence little manure is obtained.

Out of the 40 adopters who were interviewed, 7.5% mentioned difficulty in retaining manure. The reason is simply because the major of economic activity in the Katakwii District rely on subsistence farming hence little or no manure for biogas use

Only 25% of biogas adopters mentioned a lack of sufficient labor as one of the challenges they face. Since biogas is a labor-intensive technology, this hinders the adoption of biogas.

Table 10: Constraints faced by adopters in using biogas

Variable	Adopters (n=40)	
	N	**%**
Inadequate information and knowledge	5	12.5
Insufficient water and manure	12	30
Difficult to retain manure and crop residues	3	7.5
Lack of labor	10	25
Other	10	25
TOTAL	40	100

3.4 Socio-economic and institutional factors affecting adoption of biogas

The probit regression model was used to analyse the socio-economic and institutional factors affecting adoption of biogas. The dependent variables were whether the famers had or had not adopted biogas, while the independent variables were age, gender, education level, access to credit, farming experience, and extension services.

Table 11: Estimated probit model results for socio-economic and institutional factors affecting adoption of biogas technology

Variable	Coefficient	S.E.	Wald	df	Sig.	Exp (B)
Age	0.002	0.186	0.000	1	0.990	1.002
Gender	3.857	1.117	11.930	1	0.001***	47.327
Education	0.055	0.604	0.008	1	0.927	1.057
Access to credit	2.039	1.057	3.718	1	0.054**	7.684
No. of Animals	-0.202	0.470	0.184	1	0.668	0.817
Extension services	3.436	0.896	14.710	1	0.000***	31.078
Constant	-2.896	1.472	3.78	1	0.052**	0.057

** = Significant ($p<0.05$); *** Significant ($p<0.01$)

The results revealed that factors which significantly affect adoption of biogas were gender of the respondent ($p<0.05$), access to credit ($p<0.01$), and extension services ($p<0.01$), while other factors were not significant.

3.4.1. Gender

As hypothesised, gender of the farmers had a positive impact on adoption of biogas and it is statistically significant at the 1% level. As previously mentioned, 55% and 62.5% of the adopters and non-adopters were male respectively. Biogas requires a significant input in labor for maintenance which results in the male-headed households having better access to capital and labor, making them more likely to adopt biogas.

3.4.2 Access to credit

Access to credit was found to be significant ($p<0.05$), implying that respondents who have access to credit are more likely to adopt biogas than those who do not. Credit is required for hiring of labour and the purchase of inputs.

3.4.3 Extension services

Extension services shows a positive correlation with adoption of adoption and was significant at the 5% level. This is due to the fact that famers get exposed to new information, which decreases information irregularities that is associated with the new technology, and hence the majority of the farmers are aware of the technology and are willing to take risks which are associated with it.

4. CONCLUSION

Current research findings revealed that access to extension services and credit, as well as the gender of respondents influences their decision to adopt or not to adopt biogas. Other socio-economic factors such as age and education did not significantly influence the adoption of biogas.

Finally, inadequate implements and inputs was highlighted by participating respondnets as the main challenge

5. RECOMMENDATIONS

The following recommendations are highlighted by the authors:

- Increased awareness of the social, economic, and environmental benefits which are derived from the use of biogas amongst the people.
- Provide training to the new and existing extension officers in relevant departments.
- Mainstreaming of biogas technology in relevant government ministries and other departments which are supported through the provision of human, material, and financial resources in order to ensure that famers receive timely and effective support from well-motivated and trained extension officers.
- The enhancement of adaptive research to modify biogas to the local conditions.
- Gender mainstreaming in knowledge extension whereby women are included in extension advisory services and have access to biogas technologies.

REFERENCES

Ayuya, I. O., Lagat, K. J. and Mironga, J. M. (2011). Factors influencing potential acceptance and adoption of clean development Mechanism project: Case of carbon trade tree project among small scale farmers in Njoro district, Kenya. Research Journal of Environment and Earth Science 2(3): 275 – 286.

Cram, D.P., Karan, V. & Stuart, I., 2009. Three threats to validity of choice-based and matched sample studies in accounting research. *Contemp. Account. Res.*, 26(2):477-516.

Donkers, B., Franses, P.H. & Verhoef, P.C., 2003. Selective sampling for binary choice models. *J. Mark. Res.*, 40(4):492-497.

Nigel, B., John M., Albarak R., Morten S., Smith R.K., Lopez, V., and West, C. (2004). Impacts of improved stoves, house construction and child location on levels of indoor air pollution exposure in young Guatemalan Children; Journal of exposure analysis and environmental epidemiology (2004), 14, 526-533.

Okello, C., Pindozzi, S., Faugna, S., & Boccia, L. (2013). Development of bioenergy technologies in Uganda: A review of progress. Renewable and Sustainable Energy Re views, 18, 55-63.

Uganda Bureau of Statistics (UBOS), 2014. National population and housing census. Kampala, Uganda.

Smith, J. (2005). "The potential of small scale biogas digester to alleviate poverty and improve long term sustainability of ecosystem services in sub-Saharan Africa".