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Key Factors Influencing Adoption of Biogas Technology in Meru County, Kenya.

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Abstract: *Fuel wood is the predominant energy source for cooking in rural households of Abogeta division in Meru County. Previously most wood was sourced from Mt. Kenya forest reserve. However, since enactment of a legislation prohibiting cutting of trees in the national forest reserves in the year 2005 by Government of Kenya, there has been a serious shortage of wood fuel in Abogeta hence need for an alternative energy source. Biogas technology can greatly impact peoples' livelihoods particularly in rural areas through creation of local jobs, improving agricultural production, financial diversification and provision of cheap reliable energy and reduce pressure on forests. To determine factors influencing adoption of biogas technology in Abogeta division, 230 dairy farming households were sampled. Biogas adopters were purposively selected from 68 households that had already installed the systems while 163 non- adopters were randomly selected from study population based on administrative boundaries. Primary data was derived from field surveys using questionnaires, interviews and focus group discussions. Analysis of the data was done by use of Statistical Package for Social Sciences. Descriptive statistics as well as multiple linear regression were used to establish relationships between variables. The study revealed that household income ($B = 0.215$; $p = 0.012$) and education level ($B = 0.451$; $p = 0.000$) significantly influenced the uptake.*

Key terms: *Renewable Energy Technologies, Sustainable Livelihoods*

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I. 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 woodfuel 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, 2007). 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. According to Kenya National Domestic Biogas Programme, (2009) uptake rate of this technology in Kenya has been slow and unevenly extended since many households are still not aware of it despite its existence for over 50 years. Karanja (2001) attributes low penetration rate to inadequate information on biogas production and lack of awareness of its benefits by households. As much biogas is viewed as a multifunctional renewable energy source, most households have persistently utilized wood fuel with the resultant negative effects. It is therefore necessary to assess the factors influencing adoption of biogas at the household level in Abogeta division of Meru County

1.1 Biogas Technology worldwide

The history of biogas use suggests unbiased growth globally. Anecdotal evidence show that biogas technology has been in use in Assyria as early as 10th century BC and in Persia around 15th century. India started using biogas at around 1859 when the first biogas plant was built at lepers colony in Bombay.

Denmark has had the finest experience in large-scale biogas production and utilization where by 1996 18 centralized biogas plants were already installed and in operation (Danish Ministry of Energy and Environment, 1996). They committed themselves as a country to support and invest in technology and by the year 2000 biogas production had doubled and was anticipated to triple by the year 2005. They put in place key policy tools to encourage and speed up technology uptake. One among many tools deployed was "green pricing" which allowed producers of biogas-generated electricity to sell their products at a top rate. In Asia, biogas production is a key waste management strategy and an important source of energy. For instance, the biogas systems are popular projects as waste treatment systems in Thailand (Limmeechokchai & Chawana, 2005).

China, which is the biggest rural biogas user in the world, had already installed 5.7 million operational rural household biogas systems by the end of 1995 for cooking and lighting and in some cases for electricity generation (Ni & Nyns, 1996). In India, 35,647 biogas plants had been installed in the state of Himachal Pradesh alone by 1995 (Singh & Verma, 1996). By 1994, an estimated 265 million tonnes of net animal waste generated between 10,830 and 21,660 million m^3 of biogas per year in Pakistan (Ghaffar, 1994). In Nepal, over 37,000 biogas plants were established between 1992 and 1996, serving over 200,000 people (Biswas & Lucas, 1996)

1.2 Kenyan Context

In the mid-1950s, first attempts were made to use biogas technology to gain energy from coffee pulp in Kenya (Gitonga, 1997). Its success intrigued the owner to start a commercial venture, constructing 130 small-scale digesters and 30 larger plants throughout the country from 1960 to 1986. In the late 1980s the Ministry of Energy in collaboration with GTZ, a German organization built 400 floating dome digesters. KENDBIP (2012) reported that since 1957, 6,748 plants have been built by the year 2012 of which only a few in operation to date. The KENDBIP had a target of constructing 12,000 high quality, functioning digesters within a period of five years following its launching in 2009. To increase the uptake of the technology, Kenya National Federation of Agricultural Producers (KENFAP) under the Kenya National Domestic Biogas Programme (KENDBIP) offered Ksh 25000 subsidy to farmers a programme that was to end in the year 2014. As a result of the programme the technology has made makeable improvement in Kenya (KENBIP 2012). The department of renewable energy technologies under ministry of energy has set up demonstration farms where farmers are trained on biogas production. Biogas technicians whose work is to construct and maintain biogas plants as well as carrying out dissemination of information pertaining renewable energy technologies in the country have been trained. It is also within the ministry's mandate to avail new energy innovations and facilitate funding for awareness creation to promote them and enhance widespread dissemination. Adoption in Kenya has remained very low due to high installation cost coupled with inadequate maintenance and lack of facilitating conditions like availability of government and top management support. Water shortage has also been common in some areas yet it's a vital requirement (Mugo and Gatui, 2010).

1.3Technology adoption

Rogers, (1995) defines technology adoption as the level at which an innovation is chosen to be used by a person or an organization. Adopting a technology in keeping with (Abukhzam & Lee, 2010) depends on numerous elements which purpose a targeted user to adopt or reject. They include; perceived usefulness and ease of use, facilitating conditions e.g. availability of government support and managerial support, technology readiness and social influence. These factors can make a positive or negative contribution towards technology adoption. Customers may also reject some technologies due to the fact that technologies are not in line with their values, beliefs and past experiences. Davis *et al.,* (1989) argues that the successful implementation of any innovation is primarily determined by users attitude. However, factors such as technology characteristics (e.g. perceived usefulness and ease of use, compatibility, reliability, security), organisational and managerial characteristics have been found to be key instrumental factors affecting users attitude towards adoption or rejection of a particular technology.

1.4 Theory of Innovation Diffusion

Rogers (2003) described the innovation-diffusion process as "an uncertainty reduction process" and he proposes attributes of innovations that help to decrease uncertainty about the innovation. These attributes includes five characteristics of innovations: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability. "Individuals' insight of these characteristics predict the rate of adoption of innovations" The presence of these factors speed up the innovation-diffusion process. Theory further considers the categories of adopters as determinant of technology adoption.

Rogers defined the adopter categories as "the classifications of members of a social system on the basis of innovativeness" This classification includes innovators, early adopters, early majority, late majority and laggards. Innovators are the first individuals to adopt an innovation and they are very few (2.5%) followed by early adopters (13.5%). Early adopters consist of younger generation with high social status and finances to invest. Early majority and late majority (34%) follow later and finally the laggards up (16%) as the last group to adopt. In addition to the gatekeepers and opinion leaders who exist within a given community, change agents may come from outside the community. Change agents bring innovations to new communities– first through the gatekeepers, then through the opinion leaders, and so on through the community.

1.5 Factors Influencing Adoption of Renewable Energy Technologies

Innovation uptake relies upon different factors that vary from one place to another. To a greater extent, households' demographic traits, environmental elements, institutional support services, and technology usefulness as perceived by the consumers have been found to greatly influence adoption and dissemination of a new technology (Lionbergen & Gwin, 1991).

The relative advantage of a modern energy technology may be evaluated in financial phrases, social status, convenience, and satisfaction (Mengistu *et al.,* 2015). A technology that is deemed to be more advantageous than the existing one is most likely going to diffuse faster and be adopted by many. That which is in line with existing community norms and values has a greater chance of diffusing faster. A technology that is easy to use and understand has also a greater probability of being adopted swiftly as compared to those that are complex and difficult to understand. Still a technology that can be tested without problems for its suitability and has observable results to users then the uptake of such innovation will be more rapid than others.

There are several issues that consumers consider before rejecting or adopting an innovation and technology cost is one of the major consideration. Consumers particularly in regions where credit and/income access is low households go for technologies that have low initial cost than those that are likely to reduce operation costs which may extend for a long period of time (Mwirigi *et al.,* 2014). To echo this argument Gebreegziabher (2007) noted that the greatest impendent to significant biogas uptake in Ethiopia remained to be the high initial investment cost.

Subsidies have the potential to speed up technology uptake by resulting to adoption by consumers who would not have adopted without some external assistance (Rogers, 1983). Adoption of certain technologies that have socially desirable characteristics is not only beneficial to the user but to the entire society at large. Investment costs of such technologies may surpass private benefits but lower than the social advantages. Governments and NGOS should take an initiative to provide external assistance through subsidies to speed up the uptake of such technologies. Food and Agricultural Organization (FAO, 1996) acknowledged that making individual users pay for the entire cost of a technology whose benefits are shared by the non-users too would be unjustifiable. It is therefore justified to subsidise biogas technology since the technology extends the benefits to the entire society through forest conservation. The sizes of subsidies greatly have an impact on technology uptake. In China the adoption rate of biogas dropped as soon as the government downsized the subsidies (Rajendran *et al,.* 2012). Bajgain and Shakya (2005) also found out that Napalese farmers relied heavily on subsidy scheme to install the systems.

1.6 Socio- economic Factors Influencing Adoption

These are specific factors and/or attributes of an individual and his/her families that make him/her adopt or reject a certain technology. Socio-economic status is based on family income, household education level, occupation and social status (contact within the community, group association and community perception of the family) (Damarest *et al.,* 1993). In a review of socio-economic factors affecting adoption of biogas digesters in Sub-Saharan Africa (Smith, 2005) observed that most factors affecting adoption were related to costs and ability to pay; family income, size of farm, construction costs, costs of conventional fuels and availability of credit facilities. Other factors were associated with availability of feedstock; number of dairy cattle, average cost of a dairy cow, and land and water availability.

Insufficient water and manure are also among the key factors that may limit biogas uptake since both are requirements. In some instances, a household may possess adequate number of cows and water, but the nature of grazing systems such as nomadic, semi-nomadic, and free grazing systems make cow dung collection a laborious task (Winrock International, 2007). Other factors affecting technology uptake include; Education, awareness, age and sex of household head. These characteristics determine individual’s capacity to obtain information, know-how and perception towards the technology benefits which in flip have an impact on one’s decision to adopt or not.

Education helps in improving beliefs and habits which in turn creates favorable mental attitude for acceptance of new practices (Omer & Fadalla 2003). Education also increases information acquisition ability thereby providing awareness knowledge to new technologies and beneficial practices. Despite the fact that formal credit markets are becoming increasingly accessible to farmers, illiterates may find the complicated borrowing process and paperwork a major disincentive (Vien, 2011). Awareness about the technology also plays a major role in technology adoption. Arthur *et al.,* (2011) acknowledged that lack of knowledge about the technology in Ghana greatly led to low uptake. Success or failure stories of previous installations can positively or negatively affect uptake. According to Gitonga (1997) information from satisfied users on how well their systems are functioning is enough to convenience other potential users to install their own. Where the systems malfunction, uptake will be low since other individuals who may be willing to install will get discouraged and shun away from such technology.

Income is another prime factor influencing adoption since it is only with sufficient cash that an individual will be at position to meet technology costs (Mwirigi *et al.*, 2009). Incapacity of farmers to meet the full cost of biogas installation is a key impediment to biogas uptake (Arthur *et al.,* 2011).In support of this argument, Bensah and Brew-Hammond (2011) noted that inability to raise money to meet installation by farmers remained a major impediment to biogas technology uptake in Ghana. Evidence from many African countries indicates that the investment cost of even the smallest biogas unit is prohibitive for most poor African rural households (Karekezi, 2002). For instance in Kenya, for a standard size of a fixed dome biogas plant type with 6 cubic meters capacity that KENFAB has been subsidizing to farmers since 2009 costs approximately 80,000 (KENDBIP, 2009). Gender role in the household can either positively or negatively influence adoption of a technology. The gender roles can be in form of responsibilities and resource ownership amongst men and women. Women play a crucial role in the provision and use of household energy either for cooking or heating. Their energy concerns are in tune with the search for systems that would relieve them of tiresome repetitive responsibilities (Denton 2005).

II. Methodology

2.1 Study Area.

This study was carried out in Abogeta division which is an administrative division of Meru County. Abogeta lies within Coordinates 0˚03′N 37˚39′E/0.050˚N 37.650˚E of the equator. The County is endowed with climatic conditions that are favorable for agriculture both crop agriculture and livestock keeping.

2.2 Target Population and Sampling Procedure

Dairy farming household heads formed the target population. Respondent were sampled through stratified sampling process which involved classifying households into two groups, namely, the adopters and non-adopter households. Households that owned a biogas system were classified as 'adopters' while those that never owned one classified as 'non-adopters'. The sample size therefore comprised of 230 respondents, 67 biogas adopters who were purposively selected and 163 non-adopters who were randomly sampled from 575 dairy farmers from Abogeta division registered with Meru central dairy farmers corporation society. The list of all registered dairy farmers is available at zonal agricultural office at Kanyakine. During reconnaissance survey, the researcher with the help of biogas extension agents in the area; Ministry of energy at Mitunguu division and KENFAP officials in Meru were able to identify 67 dairy farmers with biogas systems. Therefore adopter households were selected from the entire population of those that owned biogas systems. The other 163 non-adopter respondents were selected using simple random selection of individuals from 10 sub-locations in Abogeta that formed the basis of cluster sampling.

To calculate Sample size (n) for non-adopter households, Yamane (1967) formula for sample size calculation was used.

$n = N/1+N(e)^2$

Where;

- n = desired sample size
- N = population of registered daily farmers
- e = margin of error 5%
-

2.3. Data Collection Procedures

Both primary and secondary data were relevant for the study. Primary data was collected through questionnaires and interviews with household heads while secondary data was synthesized from existing literature relevant to the study.To assess the factors influencing adoption of biogas technology, a research survey was carried out. Questionnaires, focus group discussions and interviews were used to collect field data.The researcher carried out 4 focus group discussions at 4 milk collection centres; Kirogine, Mwichiune, Kanyakine and Baranga. Each focus group discussion consisted of 6-8 members with both groups; adopters and non-adopters represented. The participants were guided by the researcher who was the moderator by introducing topics for discussion. Results were taken down in summary form that reflected participants opinions evenly and fairly.

2.4 Data analysis

After the data had been collected it was cross- examined to ascertain the accuracy, competences and identify those items wrongly responded to, spelling mistakes and blank spaces. It was then analyzed using statistical package for social science (SPSS) computer software for analysis at a significance level of $P< 0.05$. Descriptive statistics such as means, standard deviation, frequency tables, bar charts and percentages were employed to analyze the characteristics of the population.To determine the factors influencing adoption of biogas technology multiple linear regression was used.The regression model was of the form:

$Y= \beta o+ \beta_1X_1 + \beta_2X_2 + \beta_3X_3 +\beta_4X_4+ \beta_5X_5 + \varepsilon$

Where, Y= Adoption of biogas technology

B_0 = Constant

β_i = Independent variable coefficients

X_1 = Gender (binary, M/F)
X_2 = Age (Yrs)
X_3 = Education Level (yrs in school)
X_4 = Household size (No. people)
X_5 = Income (Ksh)
X_6 = Number of animals
ε = Error term

III. Results And Discussion

3.1 Social-economic and demographic characteristics of the respondents

Social-economic and demographic information of respondents was enquired. These characteristics included information on gender, age, education, income, number of animals per household and household size. These features were then analyzed to study whether they had significance influence on biogas technology adoption. In this study it had been hypothesized that social-economic factors at the household level significantly influenced rapid adoption of biogas technology.

Table 1: Summary of Social-economic and demographic characteristics of the respondent

Characteristic	**Adopters**		**Non-adopters**	
Gender	Frequency	%	Frequency	%
Female	17	26	30	25
Male	48	74	90	75
TOTAL	65	100	120	100
Household size				
1-2	3	4	7	5
3-4	15	23	53	44
5-6	42	65	57	48
7-8	5	8	3	3
TOTAL	65	100	120	100
No. Animals				
1-3	15	23	44	37
4-6	43	66	73	60
7-9	7	11	3	3
TOTAL	65	100	120	100
Age				
18-25	0	0	30	25
26-40	26	40	40	33
40 and above	39	60	50	42
TOTAL	65	100	120	100
Education level				
primary	0	0	20	17
Secondary	12	19	54	45
Post secondary	53	81	46	38

Table 1 summarises the social-demographic characteristics of the study population. The study established that the majority (74%) of adopters households and (75%) of non-adopters in the study area are male headed. Gender in this study had the implication on household decision making system and the influence between male and female gender in adoption decision. Most household heads 60% in adopter households were found to be in the age bracket >40 while 33% and 42% of non-adopter households were found to be in the age bracket 26-40 and >40 respectively. Majority of adopters and non-adopters households (65% and 48% respectively) had family sizes of between 5-6 members. This had an implication on household labour for running biogas system. Biogas requires regular feeding of dung and mixing it with water in the same ratio. Therefore, sufficient labour is needed to collect the dung from cowshed, feeding the plant and mixing. The study further found out that 66% and 61% of adopters and non-adopters households respectively had between 4-6 cows. This had significance on the availability of cow dung which in this study is the major substrate for biogas technology. The study further indicated that a majority of adopters household heads 82% had attained post secondary education while 45% and 38% of non-adopters had attained secondary and post secondary education respectively.

Households in the study area depended on a range of activities to earn their living but the major economic activity was agriculture, basically dairy and crop production. In addition to farming some were employed in either formal or informal sectors or engaged in business of some kind. The average income for the households per month was assessed and summarised in fig 3 below

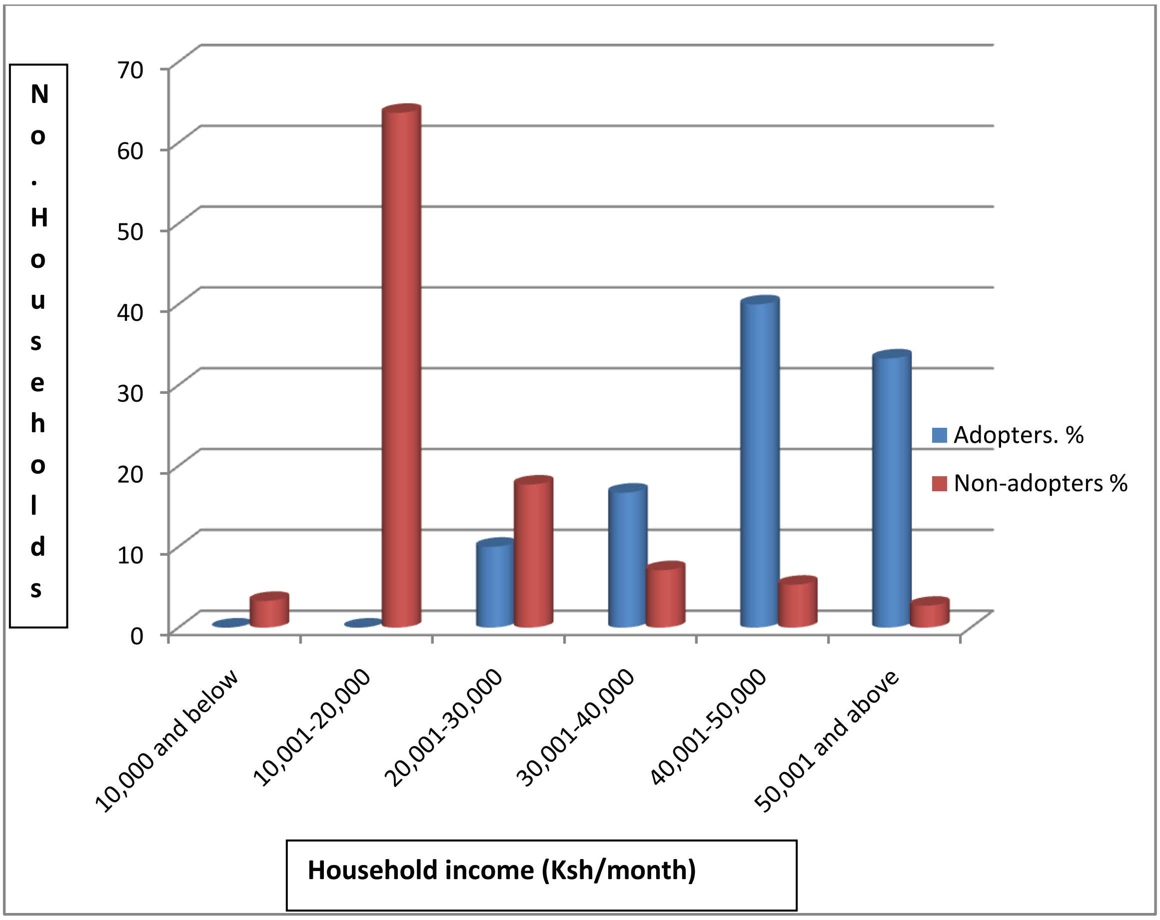

Figure 1: Income levels for adopters and non-adopter households

The income tends to differ significantly among households in the two groups where it is higher in adopters group as compared to non-adopters group. The results in the figure 3 above indicate that majority of adopters household (40%) were in between Ksh 40, 001-50, 000 income bracket while 33% earned above Ksh50, 000. Majority of non-adopters households; 44% and 40% were in Ksh 20, 001-30, 000 and 10, 001-20, 000 income brackets respectively.

3.2 Factors Influencing Adoption of Biogas Technology

The study had an objective of establishing the factors influencing adoption of biogas by households in Abogeta division. Multiple linear regression was performed with the following social-economic factors considered; number of animals, gender of household head, education level, age, household income and household size. The results are presented hereunder in Tables 2, 3 and 4. Results in Table 2 indicate that the r squared was 0.417 or 42% indicating that the factors included in the model (gender, education, age, household size, number of animals and income) can explain 42% of why residents used biogas. This indicates that there are other factors not included in the model that explain 58% of biogas adoption. From the literature review, adoption and diffusion of an innovation is influenced by many other factors apart from just household socio-economic and demographic characteristics. There other factors such as environmental factors, nature of technology in terms of triability and complexity and cultural factors all that were not included in the model.

Table 2: Summary of the model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.642	.417	.384	.35166

a. predictors:(constant) No of animals, gender, education level, age, income, household size

The findings presented in Table 3 below indicate that F statistic was 14.517 which was significant at 5% level (p = 0.000). This indicates that the model used to establish the factors affecting adoption of biogas was adequate and could provide predictive ability.

Table 3: Analysis of Variance

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	10.772	6	1.795	14.517	.000
Residual	15.335	124	.124		
Total	26.107	130			

Table 4: Factors influencing adoption of biogas

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.537	.206		2.609	.010
Gender	.087	.067	.097	1.302	.195
Age	.119	.076	.153	1.563	.121
Education Level	.314	.053	.451	5.946	.000
Household size	-.086	.046	-.194	-1.880	.062
Income	0.0000784	.000	.215	2.536	.012
No. Animals	.040	.026	.153	1.550	.124

a. Dependent Variable: Adoption

Findings in Table 4 above provide significance of the variables in the model. Factors that had a significant influence on biogas adoption were education level (B = 0.451; p = 0.000) and income (B = 0.215; p = 0.012). All other factors (gender, age, household size and number of animals) did not have a significant influence on adoption of biogas at 5% significance level.

These findings were used to test the hypothesis of the study which stated that household social economic factors significantly influence rapid adoption of biogas technology. The findings supported this hypothesis and established that social-economic factors such as education level of household heads and income of households significantly influenced adoption of biogas technology. Below is a discussion on how these factors influenced adoption.

3.3 Education and Biogas Adoption

The relationship between education and biogas adoption as indicated in Table 1 is that the majority of adopters household heads (82%) were those that had attained post secondary education. Increase in education level was positively associated with adoption of biogas. Only a few households 5% and 3% with secondary and primary education respectively had adopted the technology. Table 4 also shows that education level had significant influence on biogas adoption (B = 0.451; p = 0.000). This can be explained by the fact that education helps in improving beliefs and habits which in turn creates favorable mental attitude for acceptance of new practices. Higher education also enhances analytical capability of information and knowledge necessary to implement new technology. 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.

3.4 Income and Biogas adoption

The relationship between household income and biogas adoption as indicated in Figure 3 is that the majority of adopter household heads (73%) were high income earners earning above Ksh 40, 000. Fig. 3 also indicates that majority of non-adopter households 67.2% earn an income below Ksh 20, 000. Moreover, income positively influenced adoption of biogas with households having higher incomes being the ones mostly adopting biogas. Table 4 also indicates that household income had significant influence on biogas adoption (B = 0.215; p = 0.012). This can be attributed by the fact that biogas technology is a high cost investment which is affordable most likely by higher income earners.

The cost of a biogas plant varies with individual plant type and size since bigger sizes requires more construction materials hence higher cost. Expenditure involved in biogas construction included cost of cement, building stones, sand, ballast, pipings, valves and fittings, gas stove and labour (mason fee). A vast majority in the study area precisely over 90% have fixed dome plant type with between 6-8 cubic meters capacity. A fixed dome type measuring $6m^3$ ranged between Ksh 80, 000- 100, 000 while 8 m^3 plant ranged between Ksh 110, 000- 120, 000 (KENDBIP 2009). This amount is prohibitive for low income earners. Findings of this study agree with observation of (Arthur *et al.*, 2011) that the inability of farmers to meet installation costs remains the key barrier to biogas adoption by rural cattle farmers. Similarly Walekhwa *et al.*, (2009), empirical evidence suggested that probability of a household adopting biogas technology was directly proportional to a household income.

3.5 Gender, age, household size and number of animals

Majority of households in the sampled population were male headed with74% adopters and 75% non-adopters. The relationship between gender and biogas adoption in this study is viewed at the angle of influence and responsibility of male and female gender on household energy. Gender influence on biogas adoption was not statistically significant in this study. This is because the decision to adopt or not was made jointly by both husband and wife.

Table 1 indicates that majority of household heads 60% adopters and 42% non-adopters were found to be in the age bracket >40 years while about 40% of adopters households fell between 26-40 years. There were no adopters between 18-25 years. This is because majority were still schooling and did not own property while others had migrated to towns. The study found age having no significant influence on biogas adoption since households had adopted regardless of their ages.

With reference to household sizes majority of households 65% adopters and 48% non-adoper households had between 5-8 members. Household size had implication on labour provision since biogas requires regular feeding and collection of dung. Household size did not significantly influence adoption of biogas since households installed regardless of their family sizes. Moreover nowadays people in many parts of the world hire labour and no longer depend on their children to perform household tasks. With reference to animals majority of households 64% adopters and 60% non-adopters had between 4-6 cows. The study found that number of animals did not significantly influence biogas adoption. This is because even 2 or 3 cows are enough to provide enough dung for a household biogas (KENDBIP, 2009).

3.6 Biogas awareness and reasons for non-adoption.

The study also sought to establish awareness level of the respondents and the results are recorded in the Table 5 below.

Table 5 Awareness level

	Adopters		**Non-adopter**	
	frequency	%	frequency	%
Aware	65	100	110	92
Not aware	0	0	10	8
Total	65	100	120	100

Out of all the185 respondents both adopters and non-adopters combined only 4% of non-adopters households were not aware of the technology. All the others responded by saying that they were aware of this technology and when asked how they learnt about biogas most of the respondents indicated having learnt from friends, Government through ministry of energy and/or NGOs and the media. Others indicated that they had attended awareness creation seminar organised at by Ministry of energy-Mitunguu division at Kanyakine polytechnic. Therefore awareness alone did not have a significant influence on the adoption of technology in the study area since one would have expected high adoption levels in an area where 94% of the selected sample was aware. Moreover awareness alone is not sufficiently adequate to induce adoption decision. Rogers (1995), defines technology awareness as just the first stage of adoption process followed by accumulation of knowledge which in turn influences peoples' attitude on technology. Knowledge accumulation is a continuous process of acquiring information on how the introduced innovation functions and its financial aspect.

Non-adopters were then required to give the reasons as to why they had not adopted yet 92% was aware of the technology and findings are presented in Table 6. About 61% of the non-adopters indicated that high technology costs barred them from adopting biogas while 28% indicated that they lacked adequate funds to invest in biogas. Another 3% cited that they couldn't see the benefits of biogas plant since their household sizes were very small raging from 2-3 members where not all were present always hence didn't find household fuel as a major challenge while 8% were not aware of the technology.

Table 6: Reasons for non-adoption

Reasons for non-adoption	frequency	%
Don't see its benefits	3	3
Not aware of the technology	10	8
High Technology cost	74	61
Lack of adequate funds	33	28
Total	120	100

One respondent in a focus group discussion had this to say when responding as to why he did not install a biogas plant.

"I have learnt from my neighbours' experience who installed his biogas in the year 2013 that this is a very appropriate technology for every one of us. I have personally witnessed my neighbour reduce firewood usage and other fuel expenses as we used to go gathering firewood together. Nevertheless the main problem of installing one is the high financial investment involved during the initial stage as my neighbour told me that she spent over Ksh100,000. This amount is too huge to majority of us who depend on one income source to cater for all our household needs not forgetting that we have children in school in need of school fees. So as much as I understand that it is a good technology to me, i don't have the finances to pay for it."

Findings of this study agree with those of Bensah and Brew-Hammond (2011) that technology cost was a major impediment to rapid uptake in Ghana. Gebreegziabher (2007) also found that the incapacity of households to meet full investment cost hindered widespread dissemination in Ethiopia. A study conducted by (Mwakwaje, 2008) in Tanzania also had similar observations that rural farmers were willing to install the systems but they were barred from doing so by high initial costs.

3.7 Source of finance for biogas installation

Adopters were also required to indicate the sources of funds to finance the project. Findings in Fig. 4 indicate that 43% of the adopters financed biogas installation from their own savings, 34% installed through their own contribution and subsidy from KENFAP and another 23% through credits and loan. This shows that the Ksh 25000 subsidy given to dairy farmers by KENFAP since 2009 had greatly motivated farmers in this particular area to install biogas systems. Pertaining the subsidy, there was no particular criterion for selecting the beneficiaries. It was open to public and therefore any farmer could access with the condition that he/she would meet the remaining cost of construction. These findings are in line with those of Bajgain and Shakya (2005) which revealed that without subsidies, only a few of Nepalese farmers would adopt the biogas system due to financial constrains. A survey conducted in Uganda by (Walekhwa *et al.*, 2009) revealed that all the interviewed households had donor financial assistance in order to install their biogas systems. Similarly substantial subsidies under the National Programme on Biogas Development (NPBD)between 1985 and 1992 greatly facilitated a tremendous growth of biogas technology in India (Bhattacharya & Jana 2009).

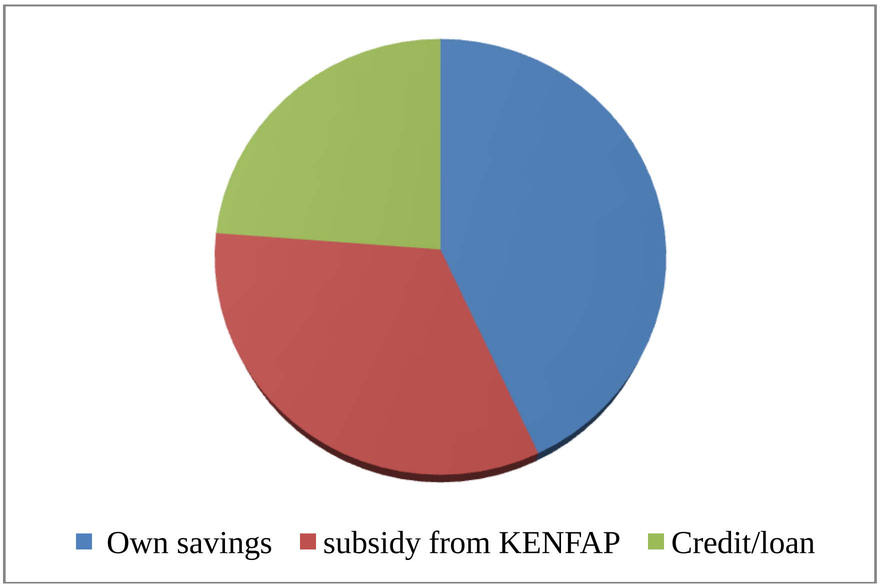

Figure 2: Source of biogas finance

IV. Conclusion And Recommendations

4.1 Summary and Conclusion

The rural dwellers of the study area primarily rely on firewood, charcoal and LPG for their household cooking energy. Biogas production and consumption can positively change the lives of rural population in Abogeta and conserve forest. It was though noted that adoption level was quite low where out of 12,100 households only 67 households had installed a biogas digester. On the quest to find the cause of this low adoption despite the area being a dairy farming area and connected to water supply, several factors were identified. Income played a major role in adoption where almost 85% of the adopters were high income households who could raise installation fee with little subsidy from biogas promoters. The initial investment cost for constructing a biogas plant remains the biggest challenge to people of Abogeta. It is estimated that the average cost of fixed dome biogas type which majority of households have installed rages between Ksh80000-110000. With Ksh 25000 subsidy offered by (KENFAP) from 2009 up to 2014, only a few Abogeta residents were capable of acquiring this technology. This is reflected in the number of biogas systems installed in the entire region. Education was also found to positively influencing the adoption. Close to 90% of the adopters had either secondary education or beyond secondary level.

4.2 Recommendations

1. Biogas disseminating companies and NGOs should review implementation strategies to design and construct low cost biogas plants that are affordable to all.
2. Biogas technology NGOs should increase and continue the subsidy scheme and give loans at low interest rates giving emphasis on low income groups who cannot afford the digester by themselves without external source of funding.
3. Sensitization of locals on economic social and environmental benefits of biogas is required from ministry of energy and private sector through awareness creation campaigns and seminars to enable them understand why biogas should be a choice for everyone.

4.3. Areas of future Research

Further research is needed on impacts of biogas technology use on peoples livelihoods.

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