# ADOPTION OF BIOGAS TECHNOLOGY PROJECTS AMONG RURAL HOUSEHOLDS OF LANET LOCATION, NAKURU COUNTY-KENYA.

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## ABSTRACT

*Biogas technology is one of the renewable energy with various benefits and the ability to provide an alternative to the more expensive hydro-electric power. Effort by the government of Kenya to promote the adoption of the Biogas technology is well spelled out in the National Energy Sessional Paper of 2004 and in the Energy Act No. 12 of 2006. There is evidence that adoption of Biogas technology is very low and little is known about factors that could be causing this poor adoption rate particularly among the rural population. This study sought to investigate how selected household characteristics, household attitudes, and household income influenced adoption of biogas technology projects. Descriptive research design targeting 6,956 households in Lanet Location, Dundori Division of Nakuru North District was employed. A sample size of 364 households was selected proportionally and systematically from two sub-locations forming Lanet location (Mereroni and Muruyu). Descriptive statistics were used to analyze the data. The study established that only 24.1% of households had adopted biogas technology. The adoption levels between Male-headed and female-headed households were found to be 41(12.7%) and 37(11.4%) respectively. Among the households heads with positive attitude towards biogas technology projects, only 18.8% had actually adopted the technology. Of those who had not adopted the projects, 37% had neutral attitude towards the technology. Income was the main factor behind the adoption of biogas technology. The study concluded there was low adoption which could have been caused by factors such as education level of the respondents.*

**Key Words:** *Biogas technology; sustainable energy; Technology adoption; community projects*

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## 1. Introduction

Africa has substantial new and renewable energy resources, most of which are under-exploited. Based on the limited initiatives that have been undertaken to date, renewable energy technologies (RETs) have been cited to contribute significantly to the development of the energy sector in eastern and southern African countries. Renewable energy technologies are well suited for meeting decentralized rural energy demand, they utilize locally available resources and expertise, and would, therefore, provide employment opportunities for the locals (Karekezi and Kithyoma, 2003). Placing low income households at the center of energy, sanitation, and hygiene interventions offers opportunities to address multiple development priorities effectively and simultaneously using integrated approaches. In Sub-Saharan Africa, the majority of poor households lack basic cooking facilities such as rudimentary latrines and engage in poor hygiene practices. An estimated 80- 90% of African households rely on traditional biomass fuel (such as firewood, charcoal, dung, and agricultural residues) to meet their daily cooking needs (WHO, 2000).

Wood fuel in Kenya constitutes 90% of energy consumption in the rural areas with the demand growing at 3.6% per annum. The use of such fuel has significantly contributed to deforestation through felling of trees leading to a low forest cover in Kenya of less than 4% of the total land area compared to the world requirement of 20%.The rate at which wood fuel is obtained from forests has caused alarm since the 1970's due to lack of sufficient information that would lead to sustainable management of forest resources (GOK, 2010). Biogas technology has been in Kenya since 1950's but is restricted to the highly productive areas of Kiambu, Nakuru and Kisii (Mulwa et al, 2010).

The Government of Kenya has recognised the fact that there are significant economic and environmental benefits the country could derive from undertaking increased investment in clean energy through a combination of efficient energy use and increased use of indigenous forms of renewable energy mainly leading to a reduction in global emissions of Green House gases. The projects that have received funding are those that exploit Kenya's renewable energy which exists in abundance: these include geothermal, wind, solar, biomass, solid waste and other recycled power generation facilities (Ochieng and Makoloo, 2007). The national energy policy as outlined in Sessional Paper No.4 of 2004 and operationalized by the Energy Act No. 12 of 2006 encourages implementation of these indigenous renewable energy sources to enhance the country's electricity supply capacity.

## 1.1 Statement of the Problem

Continued overdependence on unsustainable wood fuel and other forms of biomass as the primary source of energy has contributed to uncontrolled harvesting of trees and shrubs with negative impact on the environment (NEMA , 2005). Yet in Kenya since 1951, there exists Biogas technology which is appropriate and economically feasible since it combines solid waste and wastewater treatment, which can simultaneously protect the surrounding water resources and enhance access to affordable energy. With all its values, benefits and other sources of energy, it is interesting that most rural households have not embraced this technology despite government support. It is in relation to the foregoing background that this study aimed at establishing the determinants of adoption of biogas technology projects among rural households of Lanet Location, Dundori Division in Nakuru County Kenya.

## 1.2 Objectives of the study

The study was guided by the following objectives:

i. To examine how selected demographic characteristics of households influence their adoption of biogas technology projects in rural households in Lanet location

ii. To establish the extent to which the attitudes of rural households towards biogas technology projects influence adoption in Lanet Location.

iii. To determine the extent to which household income level influences adoption of biogas technology projects in rural households in Lanet Location.

### 1.3 Research Questions

The study was guided by the following research questions: -

i. How does selected demographic characteristics of households influence their adoption of biogas technology projects in rural households in Lanet location

ii. To what extent do rural households attitudes towards biogas technology projects influence its adoption by rural households in Lanet Location?

iii. To what extent does household income levels influence adoption of biogas technology projects in rural households in Lanet Location?

## 2. Literature Review

Continued over-dependence on unsustainable wood fuel and other forms of biomass as the primary sources of energy to meet household energy needs has contributed to uncontrolled harvesting of trees and shrubs with negative impacts on the environment (deforestation). Environmental degradation is further exacerbated by climate variability and unpredictability of rainfall patterns. In addition, continued consumption of traditional biomass fuels contributes to poor health among users due to excessive products of incomplete combustion and smoke emissions in the poorly ventilated houses common in rural areas. Biogas is an energy technology that has the potential to counteract many adverse health and environmental impacts (NEMA, 2005). The study by Shell Foundation in 2007 noted a low level of education among the targeted population owing to the scarce and fragmented promotional activities by agencies promoting the energy. Institutions promoting the technology were found to be relatively few. Poor dissemination strategy by promoters was also rife. Biogas demonstrations are carried out with little or no digester research and development to understand quality and end-use issues (Shell Foundation, 2007;Hankins, 1987).

There is growing consensus among policy makers that efforts to disseminate Renewable Energy Technologies (RETs) in Africa have fallen short of expectations. While it is recognized that RETs cannot solve all of Africa's energy problems, they are still seen as having a significant unexploited potential to meet the growing energy requirements on the continent. Renewable energy is already the dominant source of energy for the household sub-sector (biomass energy). If properly harnessed, it could meet a significant proportion of energy demand from the industrial, agricultural, transport and commercial sub-sectors. Despite recognition that they are important sources of energy for sub-Saharan Africa, RETs have attracted neither the requisite level of investment nor tangible policy commitment. Although national and international resources allocated to developing, adapting and disseminating RETs in the last two decades may appear substantial, the total amount is still insignificant compared to that allocated to the conventional energy sector. The success of RETs in the region has been limited by a combination of factors which include: poor institutional framework and infrastructure; inadequate RET planning policies; lack of co-ordination and linkage in RETs programmes; pricing distortions which have placed renewable energy at a disadvantage; high initial capital costs; weak dissemination strategies; lack of skilled manpower; poor baseline information; and weak maintenance service and infrastructure (Ochieng and Makoloo, 2007).

A study by the Shell Foundation in 2007 cited several challenges facing the adoption of biogas technology that included poor management and maintenance emanating from lack of proper knowledge. For optimal production, a certain level of management both for the zero-grazing units and the digesters was needed but with so many competing uses for rural farm labour, management of the digesters was bound to suffer. The findings indicated that households were content to get 'acceptable' and not 'optimal' levels of production from their investments in the biogas technology. Poor maintenance was cited as a key challenge with digesters being built without proper explanation to users on how to care for them. In other cases, people simply stop maintaining them, especially the repair of the gasholder. The study further noted that many potential users of the technology were unaware of the technology with many having not seen it. There were some who were ignorant about how it operates/works, its benefits and personal relevance.

Karekezi and Kithyoma (2003) point out that experience in Africa shows that the introduction and success of any renewable technology is to a large extent, dependent on the existing government policy. Government policies are an important factor in terms of their ability to create an enabling environment for RETs dissemination and mobilizing resources, as well as encouraging private sector investment (Sampa and Sichone, 1995). Most of the early policy initiatives on renewable energies in the region were driven by the oil crises of the early and late 1970s. In response, governments established either an autonomous Ministry of Energy or a department dedicated to the promotion of sound energy policies, including the development of RETs. For example, Zambia responded by outlining policy proposals in its Third National Development Plan (1979-83) to develop alternative forms of energy as partial substitutes for conventional energy resources (Karekezi, 1988).

One of the variables measured in this research is the attitude of the rural population towards biogas technology. It is instructive to note that attitudes are evaluative statement either favourable or unfavourable concerning objects, people or events. Attitude reflect how one feels about something. A person acquire attitude in the course of his or her experience and maintains them when they are reinforced. Thus, attitude are learned and not inherited and can be acquired in one or more ways, including direct experience with a particular object, which generates an attitude based on whether or not such experience was rewarding or punishing. This experience, in case of biogas technology, could include the positive or negative attitude developed by an individual's direct experience or learning about the performance ability of the technology after use. Performance expectations have been found to be powerful predictors of adoption of technology or innovations (Vankatesh, et.al, 2003). Attitudes may also form by associating an object with another about which attitudes had been previously formed; or through learning from others. According to the social theory, an individual tends to comply with other referees' opinion (Bagozzi and Lee, 2002), thus, developing a positive attitude towards adoption of technology. Generally, attitudes which are acquired through personal experience tend to be more resistant to change than those learned from association or from others.

Financing plays a major role in the formulation of RET policies. Studies have shown that one of the main obstacles to implementing renewable energy projects is often not the technical feasibility of these projects but the absence of low-cost, long-term financing (News at Seven, 1994). This problem is complicated by competition for limited funds by the diverse projects and becomes critical if the country is operating under unfavourable macro-economic conditions.

Governments and private enterprises must, therefore, seek creative ways of financing RETs projects. Economically, the evaluation of biogas technology can be approached as a macroeconomic problem incorporating the investment in the wider context of the economy's overall fuel and rural development policies. It can also be treated as a microeconomic problem in which the returns to a safe investment are examined at a specific location and within specific economic conditions (Barnet *et al.*, 1978). In deciding whether to develop or adopt a new technology, individual entrepreneurs engage in calculations of expected benefits and expected costs to themselves and if the former is likely to exceed the latter then they adopt the technology (Teich, 1990). This is referred to as cost / benefit analysis. Another economic consideration is that of alternatives where the evaluation of the impact of an investment is in principle the comparison of the investment with the next least expensive investment alternative. Land tenure and time horizon also affect the adoption of technologies. An example is that of technologies that are inherently long term and which require security such as land tenure for effective adoption. Many farmers are resource poor and may lack the land security and may, therefore, be unable to invest in such technologies (Drechsel *et al.*, 2005)

### 2.1 Theoretical Framework

The study is guided by Technology Acceptance Model (TAM). The main assumption of the TAM model is that when an individual forms an intention to act, they will be free to act without limitation (Davis, 1989). However, it is known that in real life situations there are constraints such as limited ability (cognitive, psychomotor or materials), time, environmental or even organizational issues, and unconscious habits that will limit the freedom to act.

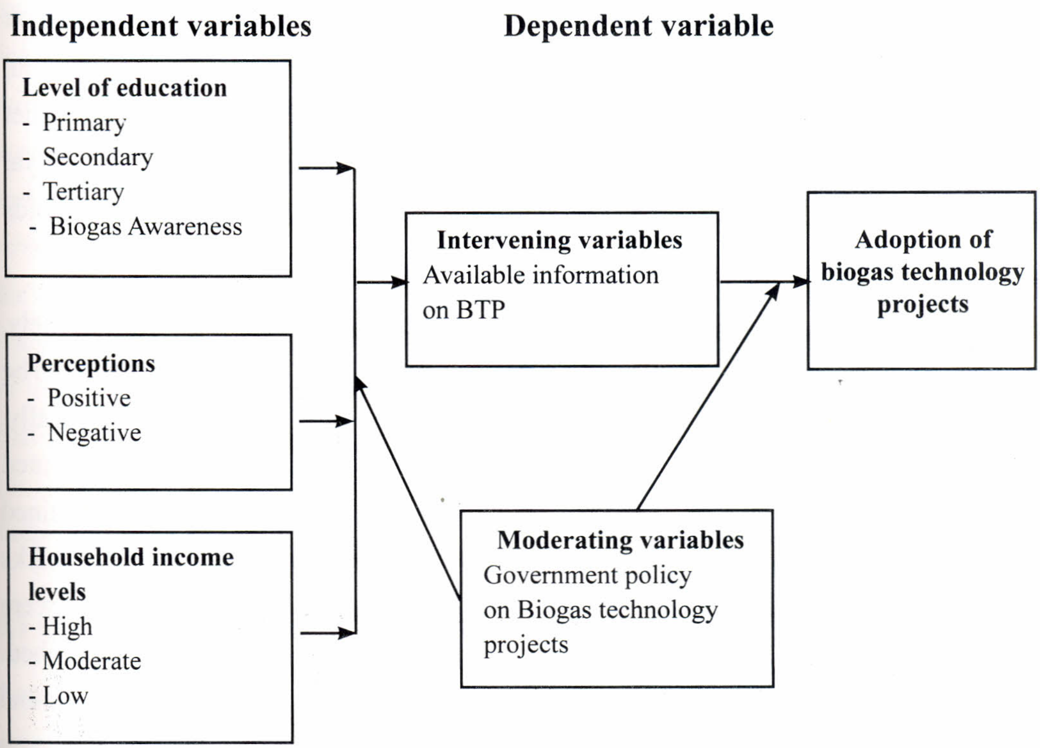
The model suggests that when users are presented with a new technology, a number of factors influence their decision about how and when they will use the same. TAM helps to understand the role of perceptions such as usefulness and ease of use in determining technology adoption and holds forth that external variables influence behavioural intention to use, and actual usage of technologies, indirectly through their influence on perceived usefulness and perceived ease of use. Perceived risk is taken as a direct determinant of attitude towards adoption of technology; in relation to this, the perceived usefulness and perceived ease of use are taken as direct determinants of attitude (Davis, 1989). This model is relevant as it helps in understanding the attitude of the household as shaped by the environment they live in and how this on the other hand influences their attitude towards adopting biogas technology.

Perceived usefulness (PU) was defined by Davis (1989) as "the degree to which a person believes that using a particular system would enhance his or her job performance". The technology acceptance model has identified the role of the perceived usefulness and perceived ease-of-use constructs in the adoption process of new technology. Whereas past research has been valuable in explaining how such beliefs lead to system use, it has not explored how and why these beliefs develop. TAM represents an important theoretical contribution towards understanding usage and acceptance behaviour.

Davis (1989) defined Perceived Ease-Of-Use (PEOU) as "the degree to which a person believes that using a particular system would be free from effort. Perceived ease of use has been identified as one of the key factors that motivates individuals to accept and use specific technologies. Studies have found PEOU to be influenced by characteristics of the technology on the one hand, and individual differences among the prospective users, on the other hand (Hong et al., 2002). Individual differences such as personality traits determine how individuals think and behave in different situations. Therefore, personality traits are commonly used in psychological research to explain beliefs and behaviour. Introduction of new technologies often involves some form of change for users. As such, the recent identification of the Resistance To Change (RTC) personality trait, and the development of a scale to measure it, provides an opportunity to assess the impact of RTC on the PEOU of users.

Concern Based Adoption Model (CBAM) by George, Hall and Stiegelbauer (2006) postulates that individuals have certain concerns that they always feel need to be addressed as they prepare to adopt new technology. The model mainly concerned itself with change implementation at system level and not the individual. It is a model that can help change agents (supervisors, change leaders) to understand the dynamic process of change particularly how individuals respond to change and how the right corrective actions are taken to facilitate the success of the change initiative. The main tenets of the model are as follows: that it is important to understand how people typically respond to, or think about change; and that change initiatives are more successful if they are implemented in a community of interested individuals (learning community), which creates a sub-culture of practitioners from whom other individuals can learn from. CBAM was selected to fill in the gaps left by TAM in that CBAM looks at the system as the main influencer for adoption while TAM looks at the individual. In this study CBAM was used to show how government policy can influence adoptions. According to this study the it is assumed that the combined interaction of the two models have implications on the adoption of technology in general and the adoption of biogas technology in particular.

Based on the above theoretical framework, the study was guided by the following conceptual framework.




This study was guided by the conceptual framework which has the following independent variables: level of education, perceptions of households, household income levels and size of household land. Other intervening variables included government policy on energy and investments in biogas technology. Level of education of the respondents is bound to affect their adoption of biogas technology since those with formal education have access to information and are, therefore, more likely to invest in biogas unlike those without formal education. How people react when presented with biogas technology depends on their attitudes or perceptions regarding its use and cost, among other factors. Perceptions may either be positive leading to their investing in the technology or negative which may mean their declining to invest. House hold incomes play an important role in determining the decision to either invest or not based on the amount of disposable income available as well as priorities that require allocation of scarce resources within the household.

## 3. Study Methodology

The descriptive research design was adopted for this study. The design enabled the researcher to provide description factors enabling the adoption and none adoption of biogas technology projects among households (Mugenda and Mugenda, 1999). The target population comprised 6,956 households drawn from Lanet location, according to 2009 population and housing census (Republic of Kenya, 2009). From the aforementioned population, a sample size of 364 households was derived basing on Krejcie and Morgan (1970) table.

Lanet location is in Nakuru North District and has two sub-locations, namely, Mereroni with a total of 1,888 households and Muruyu with 5,068 households. The sample size of households in each sub-location was determined proportionally. The implication was that out of 363 households, Muruyu sub-location contributed a proportion of 265, while Mereroni's proportion was 99 households. Trained research assistants were used to identify geographical features/landmarks within each sub-location. In Muruyu sub-location, five features/landmarks were identified and around each one of them, a total of 50 households were reached. In Mereroni sub-location, three features/landmarks were identified and around each one of them, 33 households were reached. At every landmark, the assistant researcher sampled households in four directions: North, South, East and West. For instance, in Muruyu sub-location, at every landmark identified, 13 households were sampled towards the North, while 12 households were sampled to the South, East, and Western directions respectively. In Mereroni sub-location, around the three landmarks identified, 9 households were sampled to the North and 8 towards the South, East and West respectively. Sampling of individual households in each direction selected was done systematically. For every household interviewed, the researchers skipped four households toward the determined direction. At every household, the researcher interviewed the head of the household

The Main instruments for collection of primary data was a structured questionnaire targeting households and an interview guide for household heads of ten selected households selected randomly (five from adopters and 5 from none adopters). This variation was to help me to triangulate information given in the household questionnaire. The questionnaire comprised five sections: personal characteristics of the household respondents, level of education and technological knowhow, respondents' attitude towards biogas technology projects, and level of income of respondent. The instrument had 20 items seeking the respondents' attitude towards biogas technology projects. These items were based on a 5 point *likert* scale with scores ranging from Strongly Disagree with a score of 1; Disagree, with a score of 2; Neutral with a score of 3; Agree with a score of 4 and Strongly Agree that was rated with a score of 5. The research instruments were pilot-tested on five households in Dundori Location, Nakuru North District that had similar characteristics as Lanet location. To ensure validity of the instruments, the researchers sought the opinion of two research experts and adjusted the instrument accordingly. Split half technique was used to determine the reliability of the instrument. A correlation coefficient index of 0.734 was realized implying that the instrument could be considered reliable enough to draw conclusions on the subject matter. Data analysis was done using descriptive statistics using SPSS version 17.

### 3.1 Construction of Attitudinal scale

Analysis of attitudinal items was done manually. The 20 items seeking households' attitude towards the projects were analysed by computing the average score per household. The households were then tallied against the attitude rage and attitude classification on the attitude scale. The range included 61 – 100 positive attitude;

60 Neutral and 59 and below negative attitude. For a household to be considered to have a strong positive attitude, it was assumed that the highest score on each perception items was 5, thus if one were to score 5 on 20 items, it will give a score of 100, which was considered as strongly positive. For a household to be considered as having a neutral attitude with regard to the adoption of biogas technology, , the household head would be expected to score 3, and the average for 20 items would be 60. Anything below a score of 60 meant negative attitude, while any score above 60 was an indication of positive attitude. After construction of the attitude range, each household was tallied as per the average score on the 20 items before the frequency and percentages were determined.

## 4. Findings and Discussions

This section presents analysis, interpretation and discussion of findings on influence of demographic characteristics, education, perceptions and income status of household on their adoptions of biogas technology projects.

### 4.1 Forms of energy consumed by Lanet household

The study established that charcoal was the most preferred form of energy as cited by 64.2% of the households, electricity came second as cited by 56.2% households, Liquefied Petroleum Gas (LPG) was third as cited by 46% households, firewood came fourth as cited by and 45.4% of the households. Biogas technology and paraffin were preferred by 24.1% and 16.4% households respectively. From these findings, it is clear that charcoal, and firewood are the most popular sources of energy for the households around Lanet area of Nakuru District. These findings conform to similar findings in a government study which reported that wood fuel in Kenya constitutes 90% of energy consumption in the rural and peri–urban areas. Due to this preference/prevalence, deforestation, felling of trees and a low forest cover have become a growing and serious challenge to the country (GOK, 2010). The above statistics reveal low adoption of Biogas Technology within Lanet areas, which can be one of the reasons why forest products such as charcoal and firewood are on the increase in terms of utilization.

### 4.2 Selected demographic characteristics and biogas adoption

In this section, the researcher sought to analyse how/the extent to which household characteristics such as gender and age of the respondents, influenced the adoption of biogas technology projects.

#### 4.2.1 Age of the respondents and adoption of biogas technology projects

The sampled respondents were asked to indicate their ages in order to help the researcher to understand how different age segments of the population perceived investing in biogas technology and the responses were summarised in Table 1.

Table 1 shows age group of respondents cross tabulated with investing in biogas technology..

**Table 1: Age of respondents and adoption of Biogas Technology**

| Age in years | | | |
|---|---|---|---|
| | Yes | No | Total |
| Below 25 years | 2<br>0.6% | 1<br>0.3% | 3<br>0.9% |
| 25 to 30 years | 2<br>0.6% | 19<br>5.9% | 21<br>6.5% |
| 31 to 40 years | 16<br>4.9% | 63<br>19.4% | 79<br>24.4% |
| 41 to 50 years | 29<br>9.0% | 97<br>29.9% | 126<br>138.9% |
| above 50 years | 29<br>9.0% | 66<br>20.4% | 95<br>29.4% |
| Total | 78<br>24.1% | 246<br>75.9% | 324<br>100% |

In Table 1, the age groups with the highest ratings in terms of adopting biogas accounted for 29 (9%) of the sampled respondents, coming from 41 to 50 years and above. These findings contrast sharply with the fairly low ratings of 16 (4.9%) and 2 (0.6%) in the age groups of 40 years and below. The age groups below 30 years reported significantly low proportions of respondents having adopted biogas technology. This suggested that the technology was more acceptable to relatively older populations that seemed to have invested more in the technology as opposed to the younger generations. These findings are different from that of Rubas (2004) who found that older people are generally less likely to adopt technology than younger people. The adoption of biogas technology projects by older households in Lanet area seems to be propelled by experience of elderly people about usage of various sources of energy. This seems to be captured in the following statement by one elderly household head: *'I have tried several sources of energy in this household and I think this one (biogas) is more sustainable'*.

### 4.2.2 Gender of the respondents and adoption of biogas technology projects

The respondent's gender was essential in order for the researcher to understand how different people adopt biogas technology based on their gender. This was analysed and the findings presented in Table 2.

**Table 2:Gender of the respondents and adoption of Biogas technology projects**

| | **Adoption of Biogas Technology** | | |
|---|---|---|---|
| **Gender** | **Yes** | **No** | **Total** |
| Male | 41<br>12.7% | 77<br>23.8% | 118<br>36.5% |
| Female | 37<br>11.4% | 169<br>52.2% | 206<br>63.6% |
| **Total** | **78**<br>**24.1%** | **246**<br>**75.9%** | **324**<br>**100.0%** |

The study sought to determine the distribution of the sampled respondents based on their gender. Findings from the study sample indicated that 206(63.6 %) were female while the male accounted for 118(36.4 %). This indicated a relatively skewed distribution in favour of the females while their male counterparts formed a minority of the study sample. The findings further indicated an almost fair distribution of males and females in the households who had adopted biogas accounting for 41(12.7%) and 37(11.4%) respectively. It is, therefore, evident that no status of gender featured highly as a factor in determining whether to adopt biogas or not as the responses from both sexes were fairly distributed. Based on simple comparisons and observations, evidence consistently suggest that male-headed households adopt new agricultural production technologies faster than female-headed households across regions (Doss, 2001; Bourdillon *et al.*, 2002; Jagger and Pender, 2006; Ragasa, 2012). There is a high relationship between Biogas technology projects and agriculture since the biogas depends on the by-products of agriculture. From the findings, it is clear that more men adopted the biogas technology than female households justifying the findings from other studies.

### 4.2.3. Education and adoption of biogas technology project

An analysis of extent to which the level of education influences adoption of biogas technology was done. This was established through cross tabulating the responses given by the sampled households in Lanet location. The respondents were asked to indicate their highest level of education and whether or not they possessed biogas technology projects in their homesteads.

**Table 3: Highest level of Education and adoption of biogas technology project**

| | **Highest level of Education** | | | | |
|---|---|---|---|---|---|
| **Response** | **Non formal** | **Primary** | **Secondary** | **Tertiary** | **Total** |
| Yes | 5 | 4 | 40 | 29 | 78 |
| | 1.5% | 1.2% | 12.3% | 9% | 24.1% |
| No | 19 | 11 | 105 | 111 | 246 |
| | 5.9% | 3.4% | 32.4% | 34.3% | 75.9% |
| **Total** | **24**<br>**7.4%** | **15**<br>**4.6%** | **145**<br>**44.8%** | **140**<br>**43.2%** | **324**<br>**100.0%** |

The majority of the respondents 246 (75.9%) acknowledged that they do not use biogas, while only 78 (24.1%) used biogas. A larger segment of those who use biogas in their homes had secondary education 40 (12.3%), followed by those educated up to tertiary level 29 (9%), followed by those educated in non-formal institutions at 5(1.5%) and lastly those with primary education at 4 (1.2%). We can conclude that majority of those who use biogas in their homes have secondary and tertiary education, hence education influences investment and adoption of biogas technology.

The study further sought to establish distribution of respondents based on access to knowledge on Biogas technology. Davis (1989) argues that the perceived ease of use has been identified as one of the key factors that motivates individuals to accept and use specific technologies. Individual differences such as personality traits, which include their level of education, determines how individuals think and behave in different situations, and in this case, how they make their decision to invest in biogas technology.

The respondents' access to knowledge on biogas technology project was also analysed to establish the level at which it influenced households' adoption. The respondents were asked to indicate how they got to know about biogas technology. Analysis of the responses revealed six sources of information cited by the households in the following order: friends and neighbors 67.9%; agricultural shows and exhibitions 55.9%; media 46.3%; promotional groups and agencies 28.7%; local meetings and barazas 6.5% and other sources such as schools 2.8%. Access to information about technologies has also been consistently mentioned as a key factor explaining observed gender difference in technology adoption. The limited available studies on new and more controversial technologies, such as genetically-modified organisms (GMOs), highlights the need for greater understanding of these new technologies and stresses the key role of extension agents or rural advisors in bringing this information to both men and women farmers to facilitate their adoption (Ragasa, 2012).

### 4.3 Households' attitude and adoption of biogas technology projects

The research sought to examine the extent to which households' attitude towards biogas technology projects influenced their uptake of biogas technology projects.

The respondents were, therefore, asked to respond to a set of general statements that were geared to measure their attitude towards adoption of biogas technology projects. The responses were based on a five point likert scale that was rated as follows: strongly disagree with a score of 1, disagree with a score of 2, neutral with a score of 3, agree with a score of 4 and strongly agree with a score of 5. The items were presented to both adopters and none-adopters whose responses were analysed and compared as recorded in table 4.

**Table 4: Attitude scale for adopters and none adopters**

| Category | Attitude Range | ADOPTER | | NONE ADOPTER | | TOTAL | |
|---|---|---|---|---|---|---|---|
| | | Freq. | % | Freq. | % | Freq. | % |
| Positive | 61 - 100 | 61 | 18.8 | 50 | 14.5 | 111 | 34.3 |
| Neutral | 60 | 9 | 2.8 | 120 | 37.0 | 129 | 39.8 |
| Negative | 0 – 59 | 8 | 2.5 | 76 | 23.5 | 84 | 25.9 |
| **Total** | | **78** | **24.1** | **246** | **75.9** | **324** | **100** |

The analysis of data showed that 129 (39.8%) of both the adopters and none adopters scored neutral on the attitude scale while 111 (34.3%) scored positive. Those recording negative attitude constituted 84 (25.9%). The scale also revealed that out of those respondents with positive attitude towards biogas technology projects, 61 (18.8%) had adopted the projects, while only 50 (14.5%) had not. This implies that those who had adopted the technology were sure about it. Another interesting revelation from the scale is that the majority of those were recorded neutral on the scale 120 (37.0%) had not adopted the biogas technology projects. It is important to note that the same number of those who had not adopted the technology indicated lack of information about the projects. It is obvious that one can have either positive or negative attitude towards something based on the knowledge and experience he/she has about that object. Thus, the neutral attitude and lack of adoption of the biogas technology can be attributed to lack of information. Further analysis indicates that out of those who recorded negative attitude, a big number 76 (23.5%) had not adopted the technology, while only 8 (2.5%) had. One of the main reason given for the negative attitude towards the projects by the households was the cost of setting up biogas units which was cited by 77.3% of none adopters. The Sessional Paper No. 4 of 2004 on Energy points out that despite the potential benefits of biogas, the penetration rate of biogas technology is still very low and attributes this to poor management, high initial capital costs, high maintenance costs, limited water supply and weak technical support necessitating the need for a legal and regulatory framework for promotion of renewable energy, which includes biogas (Government of Kenya, 2003).

### 4.4 Household income levels and investment in biogas technology

The study sought to determine whether household income levels influence investment in biogas technology. The respondents were requested to indicate the sources of their income as well as the range on their monthly income. They were further required to state whether their level of income influenced their decision to invest in biogas technology projects.

The study established that 200 (61.7%) households cited salary as the main source of income, 55 (17%) indicated business sources, 46 (14.2%) pointed at farming, 20 (6.2%) derived income from casual employment, and 3 (0.9%) depended on donations as their main source of income. The cross-tabulation of sources of income and adoption of biogas technology projects was computed as reflected in Table 5.

The study established that slightly more than a half 170(52.4%) of household that had not adopted biogas technology projects depended on salary as their main source of income. Further analysis indicated that 38 (11.7%) of those who had adopted biogas technology projects depended on farming as the main source of income. These findings imply that there is a relationship between farming as a source of income and adoption of biogas technology projects probably because the biogas is produced from the animal refuse among other agricultural by-products.

**Table 5. Cross-tabulation of source of income and adoption of biogas technology projects**

| Source of income | Adoption of Biogas technology | | Total |
|---|---|---|---|
| | Yes | No | |
| Salary | 30 (9.3%) | 170 (52.4%) | 200 (61.7%) |
| Business | 19 (5.9%) | 36 (11.1%) | 55 (17.0%) |
| Farming | 38 (11.7%) | 08 (2.5%) | 46 (14.2%) |
| Casual Employment | 0 (0.0%) | 20 (6.2%) | 20 (6.2%) |
| Donation | 0 (0.0%) | 3 (0.9%) | 3 (0.9%) |
| **Total** | **78 (24.1%)** | **246 (75.9%)** | **324 (100.0%)** |

Farming, therefore, provides key resources and inputs required to complete the biogas technology projects, leading to the conclusion that availability of biogas technology projects inputs enhances adoption of the technology. The same seemed to be suggested by Ragasa (2012) who pointed out that availability of inputs is affected by distribution systems and physical infrastructure, as well as the geographical location and remoteness of the rural people and by the presence of social networks or organizations that can help facilitate their access to these technologies.

Households were asked to state whether the level of income influenced the adoption of biogas technology projects and the responses were cross-tabulated against adopters and non-adopters as presented in Table 6.

Table 6 shows that an overwhelming proportion 262 (80.9%) of the total respondents affirmed that the level of income influenced the adoption of Biogas technology projects. Out of this number, 62 (19.2%) had adopted the projects while a big number 200 (61.7%) had not. A small number 62 (19.1%) of the households felt that income had no influence on adoption of biogas technology projects and that could explain why 46 (14.2%) had not embraced the technology while only 16 (4.9%) had adopted the projects.

**Table 6: influence of income on adoption of biogas technology projects**

| Influence of income | | Biogas technology | | Total |
|---|---|---|---|---|
| | | Adopters | None Adopters | |
| | YES | 62 (19.2%) | 200 (61.7%) | 262 (80.9%) |
| | NO | 16 (4.9%) | 46 (14.2%) | 62 (19.1 %) |
| **Total** | | **78 (24.1 %)** | **246 (75.9 %)** | **324 (100%)** |

Given that the majority 200 (61.7%) household heads agreed that income influenced adoption of biogas technology, but they had not actually adopted it, we can conclude that although income was one of the predicting factors for adoption of the technology, a combination of other factors such as access to information, inputs and perception of the households are key in influencing adoption of the technology (Ragasa, 2012).

## 5. Recommendations on policy

The following recommendations were made based on the study:

i. There is need for concerted efforts in conveying and organization of seminars and workshops on Biogas targeting rural households in an attempt to raise more awareness on the technology and its benefits and applicability

ii. There is need for better sensitization and support in the area to increase the uptake of the technology. Innovative strategies such as biogas loans as has been done by Kenya power (*stima* loan), may be considered as a mechanism of helping rural households scale up its use in the long term.

iii. The government, NGO's and other agencies promoting the use of biogas technology need to address challenges that appear to hinder the adoption of technology, namely, costs and access to information. They should consider subsiding the cost.

iv. Enactment of strong legislation to deter use of firewood and charcoal, alongside incentives to the private sector, through tax waivers on materials, to encourage more private sector participation in provision of renewable energy solutions to the rural and urban households

v. The need for more research on the usage of alternative biomass materials in the generation of biogas such as human waste and kitchen refuse so as to encourage more households to consider investment in the technology

vi. Provide incentives to large scale establishments to adopt biogas technology, while also supporting more research to generate new cost effective innovations.

vii. The Government and other partners to consider setting up demonstrations on biogas units on small plots to encourage uptake of the same in rural areas.

## 6. Conclusion

The study concluded that among other sources of energy, charcoal was most preferred among the households in Lanet location, while biogas technology was the least. Male-headed households adopted biogas technology faster than female-headed households. Higher education and access to information about the biogas technology had an influence on the adoption of the technology. Perception of the households on the biogas technology projects and their income level were key factors that influenced the level of adoption of the technology in Lanet location of Nakuru District. The overall conclusion of study, therefore, was that the adoption of biogas technology projects among the rural household was very low.

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