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Social-Economic Factors Influencing Biogas Technology Adoption among Households in Kilifi County- Kenya

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Abstract
Biogas technology has been advanced around the world as a renewable source of energy by various organizations such as government agencies, International organizations and Non-governmental Organizations (NGOs) (Rai, 2009). The technology is being advanced because of its health and environmental benefits (Brown, 2006). In its effort to achieve vision 2030 the government of Kenya aspires to encourage wider adoption and use of biogas technology as one of the renewable energy sources. The purpose of this study was to analyze biogas technology adoption among households Kilifi County. The study examined the underlying factors of non adoption of biogas among households in Kilifi County. Descriptive survey research design was used. The sample size was made up of 150 respondents who were purposively sampled. Data was collected through structured questionnaire and focused group discussion and analyzed by use of SPSS version 20.0 soft ware. The data was analyzed using descriptive, cross tabulation statistics and presented using frequency tables. The findings from the study revealed that, various factors influenced adoption of biogas technology. These factors include; average household income, highest level of education of household head and unavailability of technical services whose root causes were: poverty, high school dropouts, and early marriages among women who are the main implementers of the technology. The study recommends that, the County government should employ strategies such as education and awareness, provision of loans and subsidies, provision of technical services and setting up of demonstration centers may go a long way in encouraging households to adopt biogas technology.
Keywords: Biogas technology, adoption, households, environment conservation

1.1. Introduction
Energy is central to sustainable development and poverty reduction efforts. Energy affects all aspects of development, social, economic and environmental, including livelihoods, access to water, agricultural productivity, health, population levels, education and gender-related issues (United Nations (UN), 2010). Access to clean and efficient energy for all people especially in developing countries is essential for the achievement of Millennium Development Goals (MDGs) (UN, 2010). According to UN (2010) energy is important in achieving universal primary education. It is required to attract teachers to rural areas; in addition it enables studies to continue after dusk in homes and schools. While the developed countries are concerned about rising global prices and the urgent need to curb climate change, the developing countries are faced with the challenge of lack of access to clean and efficient energy (Practical Action, 2009). An estimated two billion people worldwide continue to lack access to efficient clean energy services. To address this situation UNDP, called for all nations to put special emphasis on renewable sources of energy (UNDP, 1997).

Renewable energy sources such as biogas, hydropower, small wind power, solar photovoltaics, ethanol and biodiesel, and geothermal energy for heat and grid electricity are currently in wide use in some regions and being introduced in some areas in developing countries (Flavin & Aeck, 2005). According to Flavin and Aeck (2005) the use of renewable energy provides many benefits which include freeing women's time from survival activities, allowing opportunities for income generation, as well as reducing exposure to indoor air pollution thereby improving health and providing lighting for households. The need for clean, renewable energy is especially acute in the developing world, where little efficiency has been introduced. Biogas technology is therefore a very good solution to local energy needs, as it provides significant benefits to human and ecosystem health. Biogas technology has the potential to counteract many adverse health and environmental impacts associated with traditional biomass energy (Brown, 2006).

Biogas technology is considered as a sustainable renewable energy source that can be used for cooking, lighting, heating and power generation. It offers various benefits such as saving fuel wood and protecting forests as well as reduces expenditure on fuels. It further reduces household labor on time spend on cooking and housekeeping and improves hygienic conditions (Gregory, 2010). The gas is produced through anaerobic digestion process, a biological process that happens naturally when bacteria breaks down organic matter of plant origin in environments with little or no oxygen. On smallholder farms, biogas is derived from anaerobic decomposition of livestock wastes-dung, urine and waste feeds (Karanja & Kiruiro, 2013).

Biogas technology has been advanced around the world as a renewable energy by various organizations such as government agencies, International organizations and Non-governmental Organizations (NGOs). For instance, Biogas support program (BSP-Nepal) has been promoting the use of biogas in Nepal since 2003. By 2009 the program had achieved installation of 208,000 biogas plants benefitting 1.25 million people across the country (Rai, 2009). In Africa organizations such as African Biogas Partnership Program and SNV-Netherlands are actively involved in advancing the idea of biogas use in countries such as Uganda, Ethiopia Kenya and Rwanda.

Biogas technology in Kenya has continuously been promoted by national and international organizations (both Government and NGO) over the last 50 years. One such organization is Kenya National Federation of Agriculture Producers (KENFAP) which has set up the Kenya National Domestic Biogas Program (KENDBIP), with a goal of developing the biogas sector especially in high potential areas such as Central and Western Kenya. So far, under KENDBIP, almost 7,000 biogas digesters have been built with a target goal of 11,000 (2020 action). Special Energy Program (SEP) in conjunction with the Ministry of Energy and Regional Development (MOERD) undertook to promote biogas in Kilifi and Kwale in the late 1980's. The promotion has since been taken up by the energy centers under the Ministry of Energy (Gitonga, 2007). However, even with all the effort that has been put in by the various agencies to promote biogas, 80 % of people in Sub-Saharan Africa rely on traditional use of biomass for their cooking (Karekezi & Kithyoma, 2003), with over 90% of rural households in Kenya using fuel wood for cooking (Ndegwa, Breur and Hamhaber, 2011). In Kilifi County 67.2% of residents use fuel wood for cooking and only 0.8 % use biogas (Kenya National Bureau of Statistics (KNBS) & Society for International Development (SID), 2013).

1.2 Problem statement

The Kenyan government through the Ministry of energy has been promoting and disseminating biogas technology as one of the renewable energy sources. These efforts were meant to encourage households to adopt other sources of energy and move away from traditional forms of energy like firewood which have devastating effects on the environment and people's health (Ministry of Energy (M.o.E), 2013). Under the new constitution of 2010, the County governments have been given a mandate to regulate energy. County governments can therefore encourage use of renewable energy sources such as biogas which can be generated and used at local levels (Mumma, 2014). However despite numerous advantages of biogas technology, various efforts and studies that, have been carried out to establish the determinants of biogas technology adoption and results implemented in various parts of the world the adoption of biogas technology is as low as 0.8% in households in Kilifi County. It was against this background that the study sought to establish factors that contributed to the continued low adoption of the technology in Kilifi County

1.3 Conceptual Framework

The conceptual framework gives a diagrammatic representation of the variables in the study. Adoption of biogas technology in this study is the depended variable defined as production and use of biogas and is influenced by various independent variables which are interrelated.

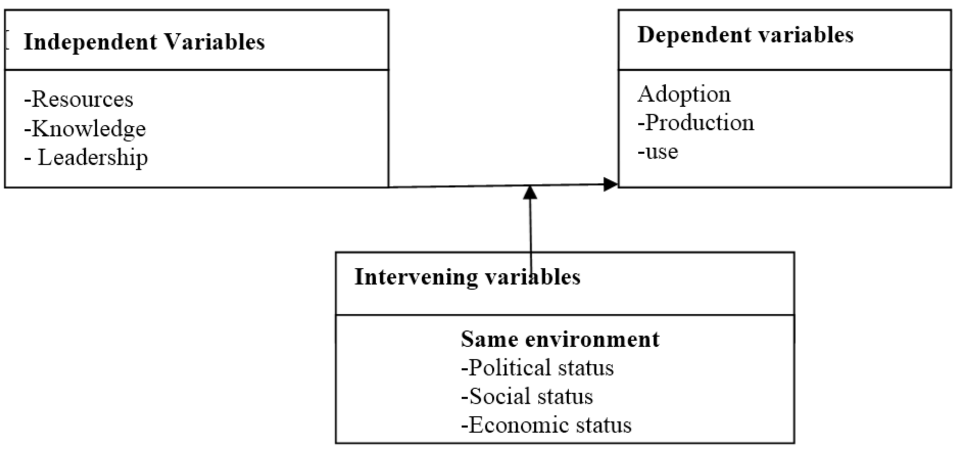

Figure 1: conceptual framework

The conceptual frame work indicates that resources in terms of household income, size of land, number of cattle and size of household could influence the decision to adopt biogas technology. Further, knowledge about the technology and maintenance of the biogas plants could affect adoption. Leadership role played by the gate keepers and innovators in the community is an important aspect in technology adoption as their decision to take up an innovation influences the other community members positively. The study was carried in a homogenous environment where the political leadership, economic status and social status are the same.

2.0 Research Methodology

2.1 Research Design

The study used descriptive research design. The design was appropriate as it seeks to obtain information concerning the current status of the phenomena and describe it as it exists with respect to variables in a situation (Mugenda & Mugenda 2003). It helped the researcher in getting information about perceptions and attitudes of respondents on biogas technology

2.2 Study Location

The research will be conducted in Kilifi County in the republic of Kenya. Kilifi County is the largest county in Coast region with a total population of 1,109,735 covering an area of 12,610 km^2 (Kenya National Bureau of Statistics (KNBS), 2010). The county is divided into six constituencies namely Kilifi North, Kilifi South, Ganze, Kaloleni, Rabai, Malindi and Magarini with a total of 35 wards.

Figure 2: Map showing Kilifi County

The settlement pattern is mainly linear in dimension and scattered all over the county because of the infrastructural network and the location of the agricultural potential zones. High population densities are found in

Bahari, Kikambala and Kaloleni divisions along the tarmac road of Mombasa-Malindi and Mombasa-Nairobi up to Mariakani urban town. This is due to fact that these areas provide employment in both the manufacturing and service industries. High population clusters are also found in Chonyi and some parts of Kaloleni where there are high potentials for agricultural production. Sparsely populated constituencies are Ganze and Magarini. These areas are rangelands and are less productive agriculturally. (Kilifi District Development Plan (KDDP), 2010).

The weather is generally warm throughout the year with average annual temperature of about 27^{0}C with two rainfall maxima seasons and an average annual rainfall of about 400mm-1,300mm. The long rains start around March to July and the short rains begin from around October to December. Areas with highest rainfall include Mtwapa and around the Arabuko Sokoke forest. Evaporation ranges from 1800mm along the coastal strip to 2200mm in the Nyika plateau. Highest evaporation rates are experienced during the months of January to March. The drainage pattern is formed by seasonal rivers which drain into the Indian Ocean through various creeks along the coastline (KDDP, 2010).

Agriculture is the mainstay of majority of the people. Livestock is a major economic activity which provides employment and income. In addition charcoal burning activities are also undertaken and deforestation is rampant especially with mangrove trees which are used for fuel wood and construction. This poses a great threat to marine life which depends on these areas for breeding. Households and institutions such as schools and hospitals are being encouraged to adopt renewable energies and make better use of energy saving jikos (KDDP, 2010). Biogas technology an environmental friendly energy source is being promoted to enhance sustainability in the larger ecosystem.

2.3 Population of the study

The population constituted all the households in Kilifi County which comprises of approximately 83, 742 households. The target population comprised of about 2000 heads of households who had been trained on biogas.

2.4 Sample size and Sampling techniques

2.4.1 Sample size

From the Ministry of energy a list of 2000 farmers who had been trained in biogas was obtained. With assistance from the office information on the number of trained farmers from each constituency was obtained.

Table 1:Sampling frame

Constituency	Kiliifi North	Kilifi South	Kaloleni	Malindi	Magarini	Ganze	Rabai	Total
Number of farmers	700	500	200	300	100	100	100	2000
Proportionate %	35	25	10	15	5	5	5	100
Number of respondents	52.5	37.5	15	22.5	7.5	7.5	7.5	150

The sample size composed of 150 respondents. According to Kathuri and Pals (1993), a sample size of one hundred (100) respondents is appropriate for a survey study. This is also asserted by Ballian (1988) who proposes a sample size of 100 to 300 to be adequate for survey research.

2.4.2 Sampling techniques

Multistage sampling procedure was used to obtain a sample size. This is a procedure where several methods of sampling are combined to select the sample (Mugenda & Mugenda, 2003). Purposive sampling was used to identify the ministry that is involved in promoting biogas technology among households. The County was divided into seven clusters based on the constituencies by applying cluster sampling technique. Proportional Purposive sampling was then used to select household heads from each constituency who were then interviewed.

2.5 Instrumentation

For successful collection of data in the field, a questionnaire, focus group discussion schedule and an observation guide were used to collect data.

2.5.1 Questionnaire

A set of closed ended and open ended questionnaires was developed and administered to respondents. The use of closed ended questions helped the researcher in collecting general information while the use of open ended questions enabled the respondents to give greater insight into their feelings or interest thus much information was acquired (Mugenda and Mugenda, 2003). The questionnaire was useful in collecting general information about opinions, attitudes and perceptions on biogas adoption among households. It also helped in obtaining suggestions on promoting biogas adoption.

2.5.2 Focus group Interview Schedule

A focus group discussion of eleven respondents was organized to help tackle issues which needed more clarification after administration of questionnaires. According to Gill, Stewart, Treasure and Chadwick, (2008) a focus group discussion composed of between six and fourteen members is adequate. The focus group discussions was composed of women, men and the youth and it offered general opinions on factors influencing biogas adoption, awareness, attitude and suggestions on the way forward.

2.5.3 Observation schedule

An observation schedule was developed to gather information in the field (Sekeran & Bougie, 2010).Observation provided an opportunity for the researcher to have a better understanding of what was happening on the ground. The technique ensures information gathered is free from respondents' bias. An observation guide helped in understanding the conditions of the biogas plants and the substrates used (Kawulich, 2005).

2.6 Validity

To achieve validity instruments were subjected to two (2) individual experts in the area of Community development from the department of Environmental Science who assessed the extent of internal and external validity in collecting relevant data. Their comments were incorporated in the instruments before being used in the field. Validation of instruments helped in ensuring face, content, and constructs validity, thus guaranteeing collection of accurate and meaningful information (Mugenda & Mugenda, 2003).

2.7 Reliability

Reliability of the instrument was established through using the test re-test technique. A set of questionnaires was administered twice to 15 household heads within a span of two weeks. These households had similar characteristics as the study sample but were not part of the sample population. This is important to avoid contamination of study subjects (Mugenda & Mugenda, (2003).

2.8 Piloting

Piloting was done by subjecting research instruments to a sample population which had similar characteristics to those of the actual study but not including the study group (Orodho, 2009). A sample size of 15 respondents representing 15% of the study group was chosen. This was based on Mugenda and Mugenda, (2003) who proposes that for a pilot study a sample size of between 1% and 10% of the actual sample size would be appropriate. Piloting helped in determining whether proposed methods or instruments were appropriate or too complicated (Teijlingen, 2000).The instruments were corrected and questions reframed to ensure they were well understood by the respondents and those that were irrelevant were deleted.

2.9 Data collection procedure

An introductory letter was acquired from the Graduate school which facilitated the acquisition of research permit from the Ethics Review Committee to allow for collection of data in field. A visit was made to the Ministries that are involved in promoting biogas technology. These were Energy Centre, Livestock development and Ministry of Agriculture. The officers in these departments helped in giving information on the area and farmer groups where training had been carried out. From the information given the groups of farmers were divided into clusters and then purposive sampling was applied to get the respondents. An initial visit was made to the groups where the interview date was scheduled. The individual respondents were interviewed in their homes or offices after initial appointment. The objectives of the study were explained to each respondent and consent sought for participation in the study by signing of consent participate he for those who could write. The interview was conducted in Kiswahili language since it the most understood by the locals.

2.10 Data analysis and presentation

Data collected was coded and organized by objectives into emerging thematic areas using descriptive and inferential statistics with the help of SPSS 20.0 soft ware. Data analysis refers to examining the collected data and making discussions, inferences and conclusions Kothari (2004). The data that was collected through questionnaires was coded and keyed into the Statistical Package for Social Scientist (SPSS 20.0). Data cleaning was done and later analyzed. Descriptive statistics are used to describe the basic features of the data in a study and they provide simple summaries about the sample and the measures (William, 2006). Descriptive statistics were appropriate for the three objectives since they simply describe what the data shows. The data is presented in frequency tables.

Ethical considerations

Application for Ethical clearance was made to the relevant Ethics Regulation committee and a permit to undertake the research was granted.

3.0 Characteristics of Respondents

Information on respondents' characteristics that was thought to have an influence on biogas adoption in the study area was collected using a questionnaire and is presented in Table 2

The results in Table 2 indicate that majority (55.3 %) of the households are headed by male. This has an implication on whether a household will adopt biogas or not. According to Simiyu (2012) household decision making is dominated by men. This is corroborated by Seebens (2008) who argues that men still play a dominant role in household decision making and even when absent due to labor migration, the woman may not be allowed to decide about important on-farm investments. This implies that the decision to take up the technology would be easier if men perceived it as useful. However this may not be the case as there is a mismatch between the beneficiary and the decision maker. While women reap most of the benefits of the installation; they often are not in the position to take the investment decision on their own (Ngw'andu, Shila & Hedge, 2009).

Table 2: Characteristics of Respondents

Variables		Percentage (%)	Frequency
Gender	Male	55.3	83
	Female	44.7	67
Age(years)	Young(21-35 years)	63.4	95
	Old (36-60)	36.6	55
Level of education	None	7.3	11
	Primary	46.7	70
	Secondary	25.3	38
	Tertiary	20.7	31
Size of household	Small (1-4)	42.7	64
	Large (above 5)	57.3	86
Average monthly income (Ksh)	below 5000	51.3	77
	5000-10000	26.7	40
	Above 10000	22.0	33
Number of cattle owned	None	45.4	68
	1-5	54.6	77
	Above 5	1.0	5
Land size	1-4 Acres	83.4	125
	Above 5Acres	16.6	25
Sources of energy	Firewood	68,0	102
	Charcoal	21.4	32
	Kerosene	5.3	8
	LPG	3.3	5
	Biogas	2.0	3
Main Occupation	Farmer	88.0	132
	Business	6.7	10
	Civil servant	5.3	8

Source: Field survey 2014 done by the author

The results further show that majority of the respondents (63.4%) are young. These age groups are the most energetic members of the community implying that, the labor required for biogas production activities such as feeding the biogas plant is available. Biogas plants need labor for operation and maintenance (Bond & Templeton, 2011).

The results in Table 2 indicate that majority (46.7%) of households heads in the study have primary level of education while a few are highly educated. With such low level of education many respondents may not be in a position to internalize and understand technical terms that may have been used in biogas technology training sessions. This greatly affects their ability in adopting the new technology and they may shun it completely. The results concur with those of Fabiyu and Hamidi (2011) who found out low levels of education act as a hindrance to technology adoption due to limited access to knowledge.

Majority (57.3%) of households have more than five members. This is an indication of sufficient labor to run biogas plant operations and it could be an inspiration for household to adopt biogas. Similar findings reported by Wang et al. (2011), found out that excess labor influenced positively households' willingness to adopt biogas.

From the Table 2 results indicate that 51.3% of respondents earn below Ksh 5000. The economic status of the respondents is very low and this is likely to affect their capacity to save and be able to construct biogas plant which requires relatively high initial cost for construction. The prohibitive high cost of construction hinders adoption of the technology (Mwakaje, 2012). Biogas plants have a high construction cost relative to household income (Bond and Templeton 2011) which can be prohibitive for many households. Further, the results (Table 2) indicate that 54.6 % own 1-5 cattle. This is an implication of sufficient cow dung to feed the biogas digester. The households in the study area may be influenced to adopt biogas technology due to availability of substrate. The results are supported by Iqbal et al. (2013) who posits that an increase in number of cattle increased the probability of a household adopting biogas technology.

Results in Table 2 on the size of land owned indicate that 83.1% own 1-5 acres. According to Gathu,

(2014) a quarter an acre is adequate for a biogas plant as such the land size is sufficient for biogas plant construction. This means that land size is not a limiting factor in biogas adoption. These results are similar to those of Wanjugu (2012) who reported that land was not a hindrance to biogas technology adoption.

4.0 Results and discussion

Table 3: Factors influencing Biogas Adoption among Households

Variables		Users	Non users
Gender of household head	Male	90 (9)	52.3 (74)
	Female	10 (1)	47.1(66)
Age(years)	Young(21-35 years)	0	67.9 (95)
	Old (36-60)	100 (10)	32 (45)
Highest level of education of household head	None	0	7.9 (11)
	Primary	0	50.7 (71)
	Secondary	60 (6)	30.0 (42)
	Tertiary	40 (4)	19.2 (27)
Size of household	Small (1-4)	20 (2)	44.3 (62)
	Large (above 5)	80 (8)	55.7 (78)
Average monthly income(Ksh)	below 5000	0	55 (77)
	5000-10000	0	28.5 (40)
	Above 10000	100 (10)	16.4 (23)
Number of cattle owned	None	0	39.3 (55)
	1-5	90 (9)	57.8 (81)
	Above 5	10 (1)	2.9 (4)
Size of land owned	1-4 Acres	20(2)	88 (123)
	Above 5Acres	80 (8)	12 (17)
Availability of technical services	Available	0	0
	Not available	100 (10)	100 (140)
Access to loans and credit	Available	0	0
	Not available	100 (10)	100 (140)

Figures in brackets represent frequencies and those outside represent percentages
Source: Field survey 2014 done by the author

The findings from the study indicated that there are various factors that influence a household's decision to adopt biogas technology. These factors include:

4.1 Unavailability of Technical services

Results from Table 3 reveal that unavailability of technical services was the most important factor in biogas adoption as 100 % of both users and non- users agreed that technical services were lacking. The study findings are similar to those reported by Rajendran, Solmaz and Mohammed (2012) who noted that lack of skilled labor and technical knowledge had hindered biogas dissemination and adoption. The problem of lack of technicians was also noted to have contributed significantly to failure of biogas plants in Ghana (Bensah & Hammond, 2010).

The lack of technical services in the study area was evidenced by either incomplete biogas plants (Figure 3) or broken down biogas plants which once worked but have lacked maintenance and repairs (Figure 4). Inadequate supply for spare parts can prevent the resolution of structural problems Alwis 2001 cited in Hazra et al. (2014). He further suggests that the lack of technical services may be an indication of poor training by biogas promoters or lack of interest from the respondents to learn more on the same. This is further expounded by Ngigi et al. (2007) who notes that without proper technical expert to help in the design, construction and maintenance of biogas digesters the technology may become difficult to embrace. Ngigi et al. (2007) further argues that neighbors are attracted by functional biogas digesters and attempt to build their own. However, it is imperative to note that biogas digesters are not as simple as they look. They must be properly designed and constructed by qualified personnel. An attempt by unqualified person only exposes the investor to losses and this discourages potential investors as confessed by one household head:

"I had used someone who is not trained to build biogas digesters and the digester has never worked and the technician ran away leaving the work halfway done. When I later contacted the trained technicians they advised me to demolish and start a fresh but I felt I had used so much money to start all over again''.

The narrative from the respondent is an indication of lack of technical support services. This may discourage others who may have had interest in the technology and thus impact on decision to adopt biogas. As one respondent put it: '*Sioni haja ya kusumbuka na hiyo biogas na ya jirani yangu haifanyi kazi na ametumia pesa nyingi kujenga'* (I don't see any need to stress myself with biogas technology yet my neighbor's is not working despite the huge investment in the technology).The implication is that without affordable and readily available competent and skilled service providers adoption of biogas will remain a great challenge. The failure of most biogas plants has led to biogas technology acquiring a less favorable reputation which affected the penetration rate of biogas technology (Ngigi, 2010). Bensah and Hammond, (2010) observed that users of biogas plants had little or no knowledge of the functions of the biogas plant and this contributed more than any factor to the breakdown of most biogas plants in Ghana. Those who showed interest in this technology also lacked the technical support on construction and maintenance matters or any information they would have liked to know. Personal communication from a key informant in the Ministry of Energy also confirmed that it is a challenge to his office since he has a few staff that are meant to serve the whole of Coast region.

Figure 3: An incomplete biogas plant due to lack of technical services.
Source: Field survey 2014 done by the author

Figure 4: Abandoned biogas plant due to lack of technical services (*Source: Field study done by author 2014*)

4.2 Average household monthly income

Findings in Table 3 indicate that 78% earn less than Ksh 10,000 a month. The low income level affects the ability of the respondents to take up biogas technology due to its initial cost of installation. The findings correlate with findings by Sufdar, Sifia, Waqar and Muhammad (2013) who posits that households with high income are more likely to adopt biogas technology as compared to households with low income. Household's income could be an indication of their ability to own a biogas plant. Those with high income are thought to have the ability to own a biogas plant unlike those with low income. Given the high initial cost of construction of a biogas plant which was estimated at US$1 000 US$410 for Fixed dome system and Flexi Biogas system respectively (IFAD, 2012), most respondents are unable to afford the biogas plant. Results from Table 3 indicate that 100% those households that had adopted the technology were earning more than Ksh 10,000 on average. This implies that the technology is affordable to relatively higher income earners.

Results from Table 2 indicate that 88% of the respondents were subsistence farmers and earned very little income. It was therefore difficult for them to have adequate funds to invest in such projects such as biogas plants given that their income is barely enough to meet various basic needs for the family members. Moreover the cost of traditional fuel such as firewood and charcoal was comparatively cheaper than biogas. Most households could access fuel at a minimal value of Ksh 20.

4.3 Household head's level of education

The results in Table 3 indicate 50.7% of non users of biogas have primary level of education at most with some having no education at all. The results are in agreement with those reported by Wang et al. (2011) who found out that low education level of household head influenced negatively the will to adopt biogas technology. Even though 50.7 % (Table 3) of the non users indicated to have attained primary level education, some may have dropped out of school due to poverty or ignorance. The low level of education could affect the ability of respondents to interpret and perceive information. The findings are similar to those of who Uaiene, Arndt and Masters (2009) advances that household heads with low education level have a low capacity of interpreting and responding to information on new innovations.

The findings were further corroborated by the focused group discussion who argued that education is paramount to ability to interpret and understand information. During focused group discussion, level of education of household head came out as critical factor in adoption of biogas technology. The members argued that a literate person is better placed to adopt the technology because he is able to understand and internalize issues much better and would benefit a lot from any trainings offered. Further literate people are able to understand technical language better than the less educated and they can express themselves better. Members strongly felt that having reading and writing skills put one in better position of adopting biogas technology. However this is contradicted by Walekhwa et al. (2010) who reveal that level of education was negatively correlated to adoption of biogas technology because people viewed it as the technology for the less educated.

4.4 Cattle ownership

The results in Table 3 above reveal that 100 % of the respondents who had adopted biogas owned cattle. The results are supported by Kabir et al. (2013), who posits that cattle ownership is an important step in owning biogas since it provides the substrate required for anaerobic digestion. However owning cattle may not in itself make one adopt biogas technology. As observed in the field during the study and results (Table 3) majority of non users (57.8%) own cattle but they do not own a biogas plant. The probable reason could be lack of enough cow dung to feed the digester as most households do not practice zero grazing which allows for accumulation of cow dung at a common point. Availability of cow dung as a factor that influenced biogas adoption was emphasized during focused group discussion where members indicated that the only source of cow dung was in the cow shed since most households practiced free range method of cattle rearing. The findings are in consensus with those of Walekhwa et al. (2010) who suggests that free range system of rearing cattle could greatly affect the quantity of cow dung available for biogas production and even the construction of the digester.

4.5 Lack of credit facilities

Findings in Table 3 indicate that both users and non- users did not have access to credit facilities. The results are in agreement with those of Van-Nes, (2005) who poses that, in the absence of credit and subsidies to low income farmers then the technology will only be affordable to the few who can afford it. Mureithi (2011) also argues that lack of access to credit facilities affects negatively adoption of biogas technology. Lack of loans could be due to the fact that biogas loans do not fit in services of credit facilities and financial organizations (Ng'wandu et al., 2009). Even if financial institutions were to give credit for biogas construction they would still require collateral which most respondents lack as was confirmed in focused group discussion. Members indicated that they lacked personal assets or title deeds which could be taken as security for them to be given loans.

During focus group discussion members indicated a willingness to adopt the technology if cost could be subsidized or if they could get soft loans. According to the respondents, it was difficult to service an interest bearing loan yet the project was not an income generating activity. There were concerns that given their reliance on subsistence rain fed farming and the weather changes sometimes they lose all their crops and might not be able to pay back the loans. Thus biogas is left to those who

This is asserted by Malla and Timilsina (2014) who posits that since biogas adoption is not perceived as an income generating venture people are afraid of taking commercial loans to construct a digester as they will have to service the loan from other sources. They were also of the opinion that given their reliance on subsistence rain fed farming and the weather changes that have been experienced sometimes they lose all their crops and might not be able to pay back the loans. Thus biogas is left to those who have stable income and capacity to repay loans.

Contrary, to the findings in this study, experiences elsewhere indicate that, where loans and subsidies have been availed even low income earners have been able to adopt the technology and enjoyed its benefits. In Nepal the subsidy support has helped biogas promotion by making the capital and interest payments on loans needed to finance the costs of the biogas systems affordable to poor farmers (Bajgain & Shakya, 2005).

4.6 Non-availability of household labor

The results in Table 3 show that 44.3% of non users had a small family size of 1-4 members an indication of lack of household labor for biogas adoption. The results are in agreement with those of a study in China which indicated that biogas adoption was facing challenges due lack of labor as a result of rapid urbanization (Zuzhang, 2014). Household members may not be able to provide the labor required as some, especially children could be going to school and the parents could be engaged in farm activities. The young men who are energetic and who could have provided the required labor migrated to town centers in search of employment leaving the parents who do not have the required energy. In addition the high cost of labor which many may not afford discourages adoption of biogas. Household labor is an important factor in adoption of biogas plants. The biogas plants require collection of cow dung, water, mixing the dung with water, feeding the plant, cleaning the cow shed and transporting the slurry to the farm (Wawa, 2012). Without enough people in the family to carry out all of the above activities it is difficult for biogas plants to run efficiently.

4.7 Gender of household head

The findings in Table 3 show that 90 % of the biogas users were male headed household. Similar results were reported by Wawa (2012), who found out that gender of household influenced decision to adopt biogas technology. Male headed households were more likely to adopt biogas than female headed households. The patriarchy system where men own resources and they are the decision makers (Njenga, 2013) gives them an advantage to make decision for or against adoption of biogas. This implies that if the man is not convinced about the advantages of biogas he will not invest in it. Even though women may desire to have biogas as an alternative energy to ease the responsibility of looking for energy in the homes, their hands are tied as they have to depend on the man who is not affected by energy problems to make a decision. Similar sentiments were shared by the members during focused group discussion where members explained that, the gender may affect the decision to adopt biogas technology as male made decisions in households and are difficult to convince sometimes especially when they don't see direct benefits. However in cases where female was heading a household and she was empowered financially she could make a decision.

4.8 Age of household head

Table 3 further showed that 100% of the users were older (36-60) years. Similar findings were reported by Iqbal, Akram and Irfan, (2013) that the probability of adopting biogas increased with increasing age. Older people have settled down and have enough savings and are willing to invest, unlike young people who are still not stable financially. This was confirmed by one contact farmer who is retired civil servant. He had invested in cattle and showed interest in constructing a biogas plant since his children had completed college and so he could afford to channel that money to a biogas plant. In addition he had the time as he was not engaged in office work. In the focused group discussion the younger generation felt the technology should be left to the old and preferred energy from solar or electricity. Further the young people indicated they were put off by the process of mixing dung with water which they felt is dirty and time consuming. The findings are similar with those of Wawa (2012) who revealed that the young people disliked holding cow-dung because they feel uncomfortable and fear that they might contract skin infection.

4.9 Land Size owned

The results in Table 3 indicate that biogas users owned relatively large sizes of land (> 5 acres) compared to non-users (< 5 acres). The results are similar to those of Gulbrandsen (2011) who posits that more households with larger sizes of land had adopted the technology as opposed to households with smaller sizes of land in Tanzania. The implication of these findings is that those with larger sizes of land have enough area for feedstock production and for rearing enough number of cattle to produce enough cow dung for the digester. On the other hand those who own small sizes of land may not adopt the technology as they feel it will take up space that could have been used for other activities such as planting food or cash crops.

Similar views were expressed by members during focused group discussion indicating that they would rather use their land to grow crops like maize which they can sell easily and get income for other family needs instead of biogas.

6.0 Conclusion

Descriptive analysis of the findings showed that a number of factors had an influence on biogas technology adoption. Adopters of biogas technology revealed that lack of technical services and high cost of maintenance were major factors that led to non adoption of biogas technology. Lack of technical services was evidenced in non completion or breakdown of biogas plants due to lack of maintenance services. This eventually led to abandonment of digesters and it also discouraged prospective adopters. Lack of technical services was as result of very few trained technicians. The few trained personnel shows that most local people did not have interest or the trainers were biased in their training for instance targeting the where they contact the elite of the community. Non adopters were of the opinion that the high cost of initial installation of the biogas plants. The cost seemed too high for most respondents because their average monthly income is low.

Low levels of education and average household monthly income are explained by: Poverty in the area occasioned by low agricultural productivity which is the region's main livelihood; low school enrollment rates and high school dropout rates; the socio-cultural norms and values that support the practice of early marriage especially for the girl child who has to drop out of school to get married. Early marriage of the girl child is in itself a major contributor to low adoption as it affects attainment of higher level of education and consequently low economic status and inability to afford the cost of biogas technology.

The work contributes to the knowledge area by providing knowledge on which factors need be addressed by biogas promoters and stakeholders in order to increase biogas technology adoption which will go a long way in addressing environmental and health problems associated with using non renewable energy sources and thereby enhance sustainable development by developing countries.

6.1 Policy Recommendations

The following recommendations are made to assist in promoting adoption of biogas technology in Kilifi.

1. The County government needs to establish a strong and sustainable institutional framework to coordinate and implement biogas programs in the County. This framework will be important in promoting the benefits and use of biogas as an alternative source of energy.
2. The financial institutions and small micro enterprises should come up with a tailor made loan scheme for those who would wish to adopt biogas technology to assist them do so.
3. The County government should consider partnering with development partners to give subsidies to low income earners to encourage them to adopt biogas technology.
4. Women are the main implementers and benefactors of biogas technology. Women should be empowered through creation of awareness and education and also financially to enable them adopt and enjoy the benefits of biogas.
5. Training of locals in the technical aspects of biogas technology to increase number of technicians available to offer technical services will ensure digesters are well constructed and fast and timely repairs are done.

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