ANALYSIS OF BIOGAS TECHNOLOGY ADOPTION AMONG HOUSEHOLDS IN KILIFI COUNTY

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A Thesis submitted in partial fulfillment of the requirement for the award of a Degree of Master of Science in Environmental Studies (Community Development) of Pwani University.

August, 2015
DECLARATION AND APPROVAL

Declaration

This thesis is my original work and has not been presented for a degree in any other University or any other award.

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Dedication

This work is dedicated to my dear husband Aggrey and my beloved daughters Shirleen, Nicole and Hope for their unwavering love and understanding.
Acknowledgement

I would like to thank my supervisors Dr. Ong’ayo Annie Hilda and Dr. Okeyo Benards for their untiring professional guidance, constructive criticism and encouragement throughout the study period. I am thankful to the chairman Dr. Maarifa Mwkumanya, staff and my fellow students in the department of Environmental Science for their valuable input and moral support. I acknowledge the support and cooperation of the respondents. My profound gratitude goes to my wonderful family for their emotional, financial and moral support throughout the study. While I am not able to mention each person individually, I am sincerely grateful to each person who in one way or another contributed to the success of this thesis. I thank God that this far His Grace has been sufficient for me.
Abstract

Biogas technology adoption has been advanced around the world as a renewable source of energy by various organizations such as government agencies and Non-governmental Organizations. The advancement of the technology is due to its health and environmental benefits. 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 identify the underlying causes of low adoption of biogas technology among households. The study was carried out in Kilifi County. Descriptive survey research design was used. The sample size comprised of 150 respondents who were purposively sampled. The sampling procedure constituted purposive and proportionate random sampling to select the study area and the respondents. One set of structured questionnaire and focused group discussion were used to collect data. Data was analyzed using descriptive and logistic regression analysis with the help of the SPSS version 20.0 software. The findings from the study revealed that, the significant determinants of biogas adoption among households were: household income, household head’s highest level of education and the unavailability of technical services. The underlying causes to the three areas of significant were: poverty at household level, low level of education and early marriages among women who are the main implementers of the technology. The study recommends that the County government of Kilifi should promote education, create awareness, create conducive environment for households to access loans from financial institutions, encourage organizations charged with the promotion of biogas technology to offer subsidies to households, ensure improved provision of technical services in the area of biogas construction, extension service provider should encourage households to pull resources together that will reduce the cost of construction of biogas digester. The government in liaison should develop national policy on green energy and set up demonstration centers that may encourage households to adopt biogas technology.
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<td>African Centre for Technology Studies</td>
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<td>ABPP</td>
<td>African Biogas Partnership Program</td>
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<td>BSP</td>
<td>Biogas Support Program</td>
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<td>EIA</td>
<td>Energy Information Administration</td>
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<td>EPDC</td>
<td>Education Policy and Data Centre.</td>
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<td>FiT</td>
<td>Feed in Tariffs</td>
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<td>GHG</td>
<td>Green House Gases</td>
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<td>GOK</td>
<td>Government of Kenya</td>
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<td>GwH</td>
<td>Gigawatt Hour</td>
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<td>IEA</td>
<td>International Energy Agency</td>
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<td>IIED</td>
<td>International Institute of Environment and Development.</td>
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<td>IISD</td>
<td>International Institute for Sustainable Development</td>
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<td>ISIS</td>
<td>Institute for Science and International Security</td>
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<td>IFAD</td>
<td>International Fund for Agricultural Development.</td>
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<td>KDDP</td>
<td>Kilifi District Development Plan</td>
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<td>KENDBIP</td>
<td>Kenya National Domestic Biogas Program</td>
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<td>KENFAP</td>
<td>Federation of Agriculture Producers</td>
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<td>MENR</td>
<td>Ministry of Environment and Natural Resources</td>
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<tr>
<td>KNBS</td>
<td>Kenya National Bureau of Statistics</td>
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<tr>
<td>M.o.E</td>
<td>Ministry of Energy</td>
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<td>MDGs</td>
<td>Millennium Development Goals</td>
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<tr>
<td>MOERD</td>
<td>Ministry of Energy and Regional Development</td>
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<tr>
<td>MW</td>
<td>Mega Watts</td>
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<td>NCEAPD</td>
<td>National Coordinating Agency for Population and Development.</td>
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<td>New Partnerships for African Development</td>
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<td>SEP</td>
<td>Special Energy Program</td>
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<td>Sub-Saharan Africa</td>
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<td>TWh</td>
<td>TeraWatt hours</td>
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<td>UN</td>
<td>United Nations</td>
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<td>UNDP</td>
<td>United Nations Development Program</td>
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<td>WEC</td>
<td>World Energy Council</td>
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<td>World Future Energy Summit.</td>
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CHAPTER ONE
INTRODUCTION

1.1 Background

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, 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 (African biogas Partnership Program [ABPP], 2011).

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 has endeavored to reduce dependence on biomass as a source of energy and enhance environmental conservation, human health and poverty reduction of rural households by promoting adoption of biogas technology as an alternative source of energy. This mandate has been emphasized in the new constitution whereby the national and county governments are mandated to plan and regulate the energy sector. The adoption of biogas technology has been promoted by both government and NGOs in all parts of the country Kilifi County included. Studies have been carried out to establish the factors that determine adoption of biogas technology and results implemented in various parts of the world. However despite the efforts by the Kenya Government and NGOs to promote biogas technology, in various parts of the country, adoption among households in Kilifi County has remained as low as 0.8%. Over 84% of the households use firewood and charcoal as the main source of energy resulting in adverse environmental impacts (Njogah, Machandi & Oyugi, 2014). It was against this background that the study sought to establish the underlying reasons for the continued low adoption of the technology in Kilifi County.

1.3 The Purpose of the Study

The purpose of this study was to analyze the adoption of biogas technology among households in Kilifi County and identify the underlying reasons to the determinants so as to come up with findings which could inform rational allocation of resources by the County government of Kilifi and shape the future of renewable energy sources.
1.4 **Objectives of the Study**

The study was guided by the following objectives:

(i) To establish the current status of biogas technology adoption in Kilifi County.

(ii) To identify factors that influence biogas technology adoption among households in Kilifi County.

(iii) To establish determinants of biogas technology adoption among households in Kilifi County.

(iv) To ascertain the underlying reasons to the determinants that influence biogas technology adoption in Kilifi County.

(v) To suggest strategies that can be put in place to improve adoption of biogas technology among households in Kilifi County.

1.5 **Research Questions**

The following research questions guided the study

i) What is the status of biogas technology adoption in Kilifi County?

ii) What are the factors that influence biogas technology adoption among households in Kilifi County?

iii) What are the determinants of biogas technology adoption among households in Kilifi County?

iv) What are the underlying reasons to the determinants of biogas technology adoption in Kilifi County?
v) What strategies can be put in place to improve adoption of biogas technology among households in Kilifi County?

1.6 Significance of the Study

The findings of the study may be useful to government and organizations who are interested in promoting biogas as an alternative source of renewable energy. The data collected will contribute to the pool of knowledge in the study area and it will help in shaping energy and environment policies as regards resource use and environmental conservation.

1.7 Scope of the Study

The study was aimed at establishing factors influencing biogas technology adoption in Kilifi County. The study focused on households to understand the underlying causes to the continued low rates of adoption despite the continued promotion of the technology. The respondents were head of households since they are the ones who make decisions regarding all matters in the family.

1.8 Theoretical and Conceptual Framework

1.8.1 Theoretical Framework for Technology Adoption

The study employed the Diffusion of Innovation Theory as advanced by Rogers, (1995). The theory states that, technology adoption is the process through which organizations or individuals decide to make full use of an innovation in their daily businesses (Rogers, 1995 as cited in Abukhzam & Lee, (2010). According to Abukhzam and Lee adopting a technology depends on many factors which cause a
prospective adopter to adopt or reject the technology. These factors include: absence of user involvement, lack of understanding, technical difficulties, lack of training, and insufficient support from top management and perceived complexity.

The theory explains that, Diffusion of Innovation theory is a valuable change model for guiding technological innovation where the innovation itself is modified and presented in ways that meet the needs across all levels of adopters. It also stresses the importance of communication and peer networking within the adoption process (Kaminski, 2011). According to Rogers 2003 cited in Sahin (2006), for technology diffusion to be successful these four elements must be met. The four elements include: innovation, communication channels, time and social systems. He further suggests that in addition to these elements an innovation has to go through a five step innovation-decision process for it to be accepted. These steps include knowledge, persuasion, decision, implantation and confirmation (Sahin, 2006).

According to Rogers 2003 cited in Sahin (2006), innovation characteristics such as: relative advantage which is the degree to which the innovation is perceived to be superior to current practice while compatibility is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters. Complexity is defined as the degree to which an innovation is perceived as relatively difficult to understand and use. Triability is the degree to which an innovation may be experimented with on a limited basis and observability the degree to which the results of an innovation are visible to others.
Rogers Theory further considers the adopter categories as influencing the rate of technology adoption. He classifies them as follows:

i) Innovators (2.5 percent): Are willing to experience new ideas. Thus, they are prepared to cope with unprofitable and unsuccessful innovations, and a certain level of uncertainty about the innovation. Innovators are the gatekeepers bringing the innovation in from outside of the system. They appreciate technology for its own sake and are motivated by the idea of being a change agent.

ii) Early Adopters (13.5%): Compared to innovators, early adopters are more limited with the boundaries of the social system. They are more likely to hold leadership roles in the social system, other members come to them to get advice or information about the innovation. As role models, early adopters’ attitudes toward innovations are more important. Their subjective evaluations about the innovation reach other members of the social system through the interpersonal networks. Their leadership in adopting the innovation decreases uncertainty about the innovation in the diffusion process as they put their stamp of approval on a new idea by adopting it.”

iii) Early Majority (34 %): Have a good interaction with other members of the social system; they do not have the leadership role that early adopters have. However, their interpersonal networks are still important in the innovation-diffusion process. They are deliberate in adopting an innovation and they are
neither the first nor the last to adopt it with their innovation decision usually taking more time than it takes innovators and early adopters.

iv) Late Majority (34 %): Includes one-third of all members of the social system who wait until most of their peers adopt the innovation. Although they are skeptical about the innovation and its outcomes, economic necessity and peer pressure may lead them to the adoption of the innovation. To reduce the uncertainty of the innovation, interpersonal networks of close peers should persuade the late majority to adopt it.

v) Laggards (16 %): The last group to adopt innovation, they are most localized group of the social system; their interpersonal networks mainly consist of other members of the social system from the same category. They do not have a leadership role they have limited resources coupled with the lack of awareness-knowledge of innovations, they first want to make sure that an innovation works before they adopt. This group tends to decide after looking at whether the innovation is successfully adopted by other members of the social system in the past.

The Diffusion Innovation Theory predicts that information flows through networks which could be media or interpersonal contacts. The nature of networks and roles of opinion leaders and gatekeepers in a society may also play an important role in diffusion of innovation.
Despite the strength of this theory in explaining the factors determining adoption of an innovation it has some weaknesses as identified by Ayodelle(2012) who argues that Diffusion of Innovation theory is linear and source dominated because it sees communication process from the point of view of elite who has decided to diffuse information or an innovation. He also feels that this theory underestimates the power of media which mainly create awareness of the new innovations by providing a basis for group discussions led by change agents.

1.8.2 Conceptual Framework

The conceptual framework Figure 1 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.

**Independent Variables**
- Biogas technology
  - Resources
  - Knowledge
  - Leadership

**Dependent variable**
- Adoption
  - Production
  - Use

**Intervening variable**
- Same environment
  - Political status
  - Social status
  - Economic status

*Figure 1: Conceptual framework depicting the adoption of biogas technology*
The conceptual framework 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.

1.9 Operationalization of Terms

In this study the following terms will be used as follows:

Biogas is the gaseous emissions from anaerobic degradation of organic matter (from plants or animals) by a consortium of bacteria (Wilkie, 2013) but in this study Biogas mean a gas produced by the biological process of anaerobic degradation of organic materials and specifically cow dung.

Adoption: In this study adoption means production and utilization of biogas energy borrowed from (Kabiret et al., 2013).

Household: According to Oxford dictionary the word household means a house and its occupants regarded as a unit. In this study a household means all the occupants of a house eating from one pot.
CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction
This chapter reviews the literature relating to the energy crisis, importance of renewable, current status of biogas utilization globally and in Kenya and the role of renewable energy specifically biogas. It further examines the determinants influencing biogas adoption, and strategies that have been put in place to promote biogas adoption.

2.2 Energy Crisis Around the World
Energy is at the forefront of the global agenda. It is central to the issues of development, global security, environmental protection and achieving the MDGs, (UN, 2010). Energy is important in enabling enterprise development, utilizing locally available resources and creating jobs (Flavin & Aeck, 2005). Furthermore, energy is essential in facilitating development, manufacture and distribution of drugs. Lastly energy boosts agricultural production by enabling irrigation and reducing post harvest loses through better preservation methods (Flavin & Aeck, 2005). Despite the importance that energy plays in development its demand has not been met as a result of continuing growth of the world’s population. The exerting demand on energy is becoming an ever more critical challenge for the world’s energy leaders (World Energy Council [WEC], 2012). Conservative estimates predict that the world’s energy needs will increase approximately three-fold by the end of this century (Donohue & Cogdell, 2006), with the world primary energy demand expected to continue growing. The International Energy Agency’s (IEA) assumes no major
change in policies as of mid-2010, projects a growth rate of 1.4% per year up to 2035 (EIA, 2013). World energy consumption is projected to grow by 56% between 2010 and 2040, from 524 quadrillion British thermal units (Btu) to 820 quadrillion Btu. Most of this growth will come from non-OECD (non-Organization for Economic Cooperation and Development) countries, where demand is driven by strong economic growth (EIA, 2013).

![Figure 2: World total energy consumption, 1990-2040](Retrieved from: www.iea.org.On5/4/14)

Asian countries, particularly emerging economies, are experiencing increasing demand for electricity as a result of rapid economic growth (WEC, 2012). Although China is the world’s fifth largest crude oil producer, since 1993 its production has not been able to keep up with escalating domestic demand. The vulnerability of energy security is not only reflected through energy demand, but also through rising energy price indices over the past decade. This indicates that supply is not the only problem that China faces: stabilizing energy prices is also an immensely challenging task for Chinese policy makers; severe pollution conditions and environmental
problems and severe shortages of electricity and water (Jian, 2011). According to EIA (2013), India was the fourth-largest energy consumer in the world after China, the United States, and Russia in 2011, and its need for energy supply continues to climb as a result of the country’s dynamic economic growth and modernization over the past several years. At the same time, India’s per capita energy consumption is one-third of the global average and is projected to grow at 2.8% by 2040.

The current state of the energy sector costs billions in public subsidies and leaves many developing countries exposed to high oil import prices. Shutz (2007) noted that oil accounts for 10% -15% of total imports for oil-importing African countries and absorbs over 30% of their export revenue on average. The skyrocketing oil prices means already struggling economies in Africa may well shut down under additional costburden(Shutz, 2007). For instance, Senegal is paying nearly twice what it used a few years ago to import the same amount of oil. This has had an impact on scarce budgetary resources desperately needed in the health and education sectors which are now being spent to cushion oil and electricity costs (Schutz, 2007). She further states that, even though East Africa may be less dependent on oil than other parts of the continent due to its considerable hydropower capacity, that buffer is fast eroding as the region experiences increasingly frequent and prolonged drought. Kenya has experienced an increase in energy demand which is linked to the rising population and expanding economy with Sixty percent of the electricity is hydro generated and supply has not been able to meet the increasing demand due to prolonged drought (Schutz, 2007). Over-reliance on primary biomass energy by over 68% of the population has led to widespread exploitation of forest resources with adverse
environmental impacts (Kirai, 2009). According to Njogah, Machandi & Oyugi (2014) 84% of the population in Kilifi County rely on traditional use of biomass for cooking. The demand for biomass energy has increased due to increasing population and this has put a lot of pressure on the few resources in the environment given it is a semi-arid region. This has prompted the County government to prioritize measures to shift the pattern of energy consumption towards modern forms of energy, in order to encourage environmentally sound resource exploitation and promote better health among the population (KDDP, [2008-2012]).

Society’s reliance on fossil fuels energy represents one of the major challenges to global environmental sustainability and economic stability. Fossil fuel combustion is also a major source of ‘greenhouse gas’ and chemicals that have been implicated in numerous health problems. Consequently, there are calls from governments, private sector and the scientific community to develop and adopt alternative energy sources that couple reductions in the use of fossil fuels with decreased greenhouse gas emissions (Donohue & Cogdell, 2006). Problems arising from non-sustainable use of fossil fuels and traditional biomass fuels have led to increased awareness and widespread research on the accessibility of new and renewable energy resources, such as biogas (Amigun et al., 2012) Renewable energy has the potential to play a major role in reducing Africa's acute power supply gap. Hence increasing energy supply from renewable sources not only reduces the risks from rising and volatile prices for fossil fuels, but also brings climate change mitigation benefits (UNEP, 2011). Biogas which is produced from renewable sources can play an important role
in meeting both energy and environmental problems (Kabir, Yegbemy & Bauer, 2013).

2.3 Renewable Energy

Renewable energy is derived from natural processes that are replenished constantly. It is derived directly or indirectly from the sun, or from heat generated deep within the earth, energy generated from solar, wind, biomass, geothermal, hydropower, ocean resources, bio-fuels and hydrogen derived from renewable resources (Energy Information Administration (EIA), 2008).

Renewable energy consists of the following forms:

i) **Solar Energy**: Energy from the sun which can be used directly for heating and lighting homes and other buildings, for generating electricity, and for hot water heating, solar cooling, and a variety of commercial and industrial uses. The advantages solar energy are numerous, first it is absolutely free, solar energy produces no pollution and extremely cost effective owing to the technological advancements in solar energy systems. Most systems do not require any maintenance during their lifespan which means you never have to put money into them and most systems have a life span of 30 to 40 years. The primary disadvantage to solar energy is the upfront cost.

ii) **Wind Energy**: Energy harnessed from wind. It is clean and renewable and relatively cheap. While these advantages are largely global in nature (e.g. reduced greenhouse gas emissions and fossil fuel depletion), the disadvantages are primarily local (e.g. land use, noise and visual pollution).
The main disadvantage being is that the wind does not blow consistently or steadily (Siegel, 2012).

iii) **Biofuels:** They can be solids (briquettes, pellets, wood and sewage), liquids (biodiesel and bio-ethanol) or Gaseous (methane, hydrogen and carbon dioxide). The advantages of bio-fuel include the fact that it saves fossil fuels and lower greenhouse emissions but its production needs biomass collection. Bio-fuels have been and are being developed in many countries because, together with other types, they offer the potential, in part, to address both oil challenges: lack of diversity of sources and resources, and reduction of GHG emissions from the transportation sector (Mandil & Eldin, 2010).

iv) **Geothermal Energy:** Geothermal energy is efficient and abundant, they produce no CO$_2$ emissions. Geothermal energy is generated with indigenous resources and is found in most countries and unlike solar and wind energy, geothermal energy is not disrupted by weather. However, geothermal energy requires large water sources in arid conditions and at steam plants; there is a higher seismic risk because the easiest places to access the hot rocks are near fault lines (Wang, 2008).

v) **Nuclear power:** Despite the disregard it was met with in the 1970s. It is now being touted as a more environmentally beneficial solution since it emits far fewer greenhouse gases during electricity generation than coal or other traditional power plants. It is widely accepted as a somewhat dangerous, potentially problematic, but manageable source of generating electricity.
A pivotal point in promoting the use of renewable energy sources occurred when the Kyoto protocol came into effect in 2005 that required signatory states to record levels of Green House Gases (GHGs) in their countries and report these figures to the United Nations Framework Convention on Climate Change (UNFCCC) (Brazier, 2011). Renewable energy demand is growing fast around the world and will edge out natural gas as the second biggest source of electricity, after coal, by 2016. Hydro-power is the fastest-growing power generation sector and it is expected to increase by 40% in the next five years. By 2018 it will make up a quarter of the world's energy mix. While non-hydroelectric sources such as wind, solar, geothermal and energy derived from plants are also expected to grow quickly, they contribute a far smaller amount of energy to the global mix (Fahey, 2013).

About 9% of all energy consumed in the United States in 2012 was from renewable sources and they accounted for about 12 percent of the nation’s total electricity production (IEA, 2010). Japan and Germany were two countries at the sharp end of the powerful trends in the solar market in 2012. Japan saw investment in renewable energy (excluding research and development) surge 73% to $16 billion, thanks largely to a boom in small-scale PV on the back of new feed-in tariff subsidies for solar installation (UNEP, 2013). Africa is endowed with substantial renewable energy resources. The region has 1.1 Gigawatt of hydropower capacity, 9000 Megawatts of geothermal potential and abundant biomass, solar and significant wind potential. As alluded by Karekezi and Kithyoma (2003), the renewable energy resource potential in Africa has not been fully exploited, mainly due to the limited
policy interest and investment levels. In addition, technical and financial barriers have contributed to the low levels of uptake of renewable energy technologies (RETs) in the region. There are, however, prospects for the wide scale development and dissemination of RETs in the region (Karekezi & Kithyoma, 2003). Figure shows the projections of renewable energy and fossil energy capacities between 2010 and 2030.

![Global power generation capacity additions](image)

*Figure 3: Global power generation capacity additions*

Retrieved from [www.theenergycollective.com](http://www.theenergycollective.com). Date 7/8/15

### 2.4 Biogas Technology as a form of Renewable Energy

Biogas is a clean energy which consists of methane (CH) 60%-70% and carbon dioxide (CO₂) 30%-40%, 1–5% hydrogen and traces of nitrogen, hydrogen sulphide, oxygen, water vapor, and slurry (Erdogdu, 2008). Biogas is produced by methanogenic bacteria acting on bio-digestible materials in absence of oxygen in the process known as anaerobic digestion. Anaerobic digestion occurs in digestive systems, rubbish dumps and septic tanks (Harris, 2005). Biogas producing materials
(substrates) range from animal dung to household, agricultural and industrial wastes. Materials to be fed into the digester should be right one of high quality to ensure production of enough gas. According to Aragaw, Andargiel and Amare (2013) mixing kitchen waste and cow dung produces more gas than using cow dung alone. Understanding the process, the outputs and even the right materials to be used in the digester is an important factor for adoption of biogas technology. Lack of knowledge in these areas may lead to poor performance of biogas plants and hence its non adoption.

The type of digester one chooses to adopt is paramount in this technology adoption as different types have different capacities and efficiency in gas production. The digester requires to be constructed using the right material such as the clean sand, average size gravel and straight and regular shaped bricks otherwise the digester will break down easily (KENDBIP,2009). There are many plant types but the biogas plants used in developing countries are mainly small-scale ones and are commonly referred to as family-size digesters (Singh and Sooch, 2004). According to Gitonga (2007) the following plant types are being promoted in Kenya.

i) **Floating Drum plants**: have a large inverted drum which acts as a gas storage tank. They were designed and developed in India but have been widely accepted in the developing world. They are easy to construct, operate and are reliable. The sizes range between 5m$^3$ to 15m$^3$. Refer to (Figure3)
ii) **Fixed Dome plants**: They were developed in China for processing of human waste. Its components are made using stones, bricks or concrete blocks with very few metal parts. They are consequently cheaper to construct than the floating Drum. Their sizes range between $5\text{m}^3$ to $200\text{m}^3$. The gas produced is stored in an underground space just above the digester called the dome. As gas accumulates in the dome, it displaces the sludge into a compensating tank. Gas pressure is not constant and when the volume is low in the dome, gas supply will not reach the appliances. Construction of dome-type plants has to be done very carefully otherwise slurry and gas leakages can lead to poor performance. Refer to (Figure 4)
iii) **Tubular polythene digester:** The Plastic Tubular bio-digesters are designed for households with two to three animals although bigger ones have been installed. Capacity of the former is about 8-9 m³, with a gas holding chamber of 1-3 m³. The smaller Plastic Tubular Bio-digesters can give gas for six hours using one burner. Refer to (Figure 5)

*Figure 5: Schematic representation of fixed dome biogas digester*


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*Figure 6: Schematic representation of a tubular biogas*

Retrieved from www.sswm.info on 6/8/15
2.4.1 Importance of biogas

i) **Environmental benefits:** Biogas has a very good eco-balance in comparison with many other alternative forms of energy and is also very versatile. It is used as fuel in combined heat and power plants for producing electricity and heat, but it can also be processed and transferred to the natural gas grid (Siemens, 2010). Biogas contributes to mitigation of greenhouse gas emissions, reduces air pollution and improves utilization of crop nutrients (Kabiret al., 2013). Since biogas technology provides significant benefits to human and ecosystem health in addition to providing local energy needs it is the best for developing world as the potential to counteract many adverse health and environmental impacts associated with traditional biomass energy (Brown, 2006).

Studies conducted by BSP-Nepal (2010) indicate that households with biogas plants save three hours per day on average, because collecting dung and feeding it to a biogas plant takes much less time than collecting fuel wood and preparing a cooking fire. Biogas is available whenever it is needed and cooks food quickly, so it is easier to prepare hot food before children go to school. Furthermore it reduces indoor air pollution because it burns with a clean flame. The implications are that women do not have to breathe wood smoke, which is a major cause of respiratory and eye disease responsible for an estimated 1.6 million deaths each year.

ii) **Economic benefits:** Adoption of biogas technology contributes directly to the economy through creating job opportunities for technicians during
construction and maintenance. The persons who undertake the routine operations also get income. There is also the direct saving for money initially used to buy kerosene, charcoal or firewood. The economy benefits directly from time used to collect firewood can be used in business opportunities. According to Warget (2009), attaching a latrine to biogas unit will improve hygiene, reduce diseases and lead to an economic value as people will be working instead of being sick or taking care of the sick.

Despite the many advantages of biogas technology, the bye products such as hydrogen sulfide have side effects. Health effects that have been observed in humans following exposure to hydrogen sulfide include death and respiratory, ocular, neurological, cardiovascular, metabolic, and reproductive effects (WHO, 2003). To reduce the effects of hydrogen sulfide a desulfurization unit is introduced where the aggressive trace gas hydrogen sulfide is extracted from the biogas by introducing air with certain bacteria culture which is able to establish colonies on chains and decomposes the hydrogen sulfide to harmless sulfur and water (Samer, 2012).

Considering all these benefits governments and Non-Governmental organizations have taken the initiative to promote and encourage households to take up this technology. For instance, SNV-Netherlands Development Organization’s support for national programs on domestic biogas spreads across three continents: Asia, Africa and Latin America. By the end of 2012, 500,000 households (2.9 million people) had been equipped with biogas plants across Asia. SNV’s biogas activities have been expanded to include Rwanda, Burkina Faso, Ethiopia, Tanzania, Uganda and Kenya (Kuyperstaat, 2009).
In Africa the interest in biogas technology has been further stimulated by the promotional efforts of various international organizations and foreign aid agencies through their publications, meetings and visits. Currently, a number of different organizations are establishing biogas initiatives in Africa, particularly in rural areas, in order to supply cleaner burning energy solutions. In 2010, it was reported that the Dutch government was to spend 200 million Kenyan Shilling to set up 8000 biogas digesters throughout the country. The initiative was targeting farmers practicing zero grazing. Similar projects are being implemented in Ethiopia, Uganda, Senegal, Burkina Faso, and Tanzania. There are also some other initiatives such as biogas for better life, which is at various stages of development in several countries. The Netherland Development Organization (SNV) has been supporting the development of National Biogas programs in East Africa (Amigun et al., 2012).

2.5 Biogas utilization

Bio-energy is already making a substantial contribution to supplying global energy demand, and can make an even larger overall contribution by facilitating greenhouse gas savings and other environmental benefits. Besides contributing to the energy security and improving trade balances, encouraging biogas provides opportunities for social and economic development in rural communities, and helps the management of waste, thus improving resource management (Athena Infonomics, 2012). Many European countries have established favorable conditions for electricity production from biogas. Germany has a leading role in Europe with almost 4000 biogas plants, most of them on farms for cogeneration. While the biogas sector grows impressively every year, it hasn’t received the same attention as for example liquid bio-fuels for
transportation. In Sweden 50% of the biogas produced is used for heat production, about 25% of the produced biogas is upgraded and used as vehicle fuel while the rest is used for other applications (European Biomass Association, 2009). In China IFAD-supported biogas project has assisted about 30,000 poor households by providing nearly 23,000 biogas tanks. These biogas tanks have improved the living conditions of the residents and the environment. Furthermore the family members have more time for agricultural production (IFAD, 2009). However, lack of financial capabilities to invest in biogas plants among poor farmers, flooding, blocked pipes and leakage of methane gas are some of the challenges the farmers face (Bajgain & Shakya, 2005). According to Jingming (2014) the potential market of Chinese biogas development is huge as it estimated that, the annual biogas production will get 200 – 250 billion m$^3$. As an important clean energy, China will continue to add the investment and support for biogas development.

In India biogas production has been quite dominant at household and community levels than on large scales. Thousands of small biogas plants in the villages use the cattle waste (especially cow dung) and provide biogas used for home heating and cooking. It is estimated that over 2 million biogas plants have been installed all over India (Nathan, 2010). Even though the use of biogas technology for electricity generation in India is more recent, the trend is accelerating. According to Nathan, sewage treatment centers and organic waste treatment plants (those treating organic municipal solid waste, for instance) already use anaerobic digesters to generate biogas and electricity in many cities across India. Indian households are faced with
various constraints that limit the adoption of this technology inter alia operational and structural problems; access to a sufficient quantity of dung and a high construction of cost relative to household (Hazra, Lewis & Singh, 2014). With the Indian government keen on promoting usage of renewable resources for energy production, it is likely that there will be a greater thrust and higher incentive for concepts such as biogas production from waste. An increasing awareness among the public regarding sustainable use of resources will only enhance the adoption of biogas technology (Athena Infonomics, 2012).

Biogas technology is viewed as one of the renewable technologies in Africa that can help reduce its energy and environmental problems. Domestic biogas provides the way to overcome the challenges of energy in the rural areas. This is because biogas production makes use of domestic resources such as agricultural crop wastes and animal wastes such as pigs, cattle, and poultry as well as human excreta. Biogas production using the existing domestic resources therefore, has a potential to provide a number of benefits to the rural communities in Africa. Biogas plants that are well functioning can provide a wide range of direct benefits to the users particularly in the rural areas. Many of these benefits are directly linked to the Millennium Development Goals of reducing income poverty, promoting gender quality, promoting health and environmental sustainability (Amigun et al., 2012).

To date, some digesters have been installed in several sub-Saharan countries, utilizing a variety of waste such as from slaughterhouses, municipal wastes, industrial waste, animal dung and human excreta. Small-scale biogas plants are located all over the continent but very few of them are operational. In most African
countries, for example, Burundi, Ivory Coast, and Tanzania, biogas is produced through anaerobic digestion of human and animal excreta using the Chinese fixed-dome digester and the Indian floating-cover biogas digester (Omer & Fadalla, 2003). Furthermore, Bio-digesters in five of Rwanda’s largest jails provide more than half of the prison kitchens’ energy, according to a 30 June 2005 BBC report (Brown, 2006). A study by Mwakaje (2012) in Tanzania revealed that households with biogas were saving 3-4 hours per day that was previously used in wood fuel collection. Biogas technology also helps in soil fertility improvement. Mwirigi et al. (2014), suggests that social-cultural factors have slowed down the promotion and dissemination of biogas technology in many areas of Sub-Saharan Africa, because biogas is considered to be a dirty technology and social stigma exists against its use. Amigun et al. (2010) observes that although the development of large-scale anaerobic digestion technology in Africa is still embryonic, but it has a lot of potential in the future.

Kenya was among the first countries in Africa to adopt biogas technology in the early 1950’s. However, uptake remained low until the Kenya National Domestic Biogas Program (KENDBIP) rolled out a biogas program in 2010. Under Kenya National Federation of Agricultural Producers (KENFAP) as the implementing agency, a total of 1884 plants had been constructed by June 2011. Production of biogas plants had been on a steady increase since inception and on target. About 2200 plants were earmarked for construction in 2011, with a flat subsidy of Ksh. 25,000 (approximately 200 Euro) (African Biogas Partnership Program (ABPP), 2011). Mwirigi et al. (2014) cited socio-economic factors including levels of
education, gender of household head, low levels of awareness of the potential uses of biogas, and the small size of land-holdings, which limits the number of different types of land use unless the uses are complimentary as some of the hindrances to biogas adoption in Kenya. The future for biogas energy in Kenya is bright especially in high density areas where zero grazing is practiced (Ngigi, 2010). The use of biogas in Kilifi is very low at 0.8% (Kenya National Bureau of Statistics (KNBS) & Society for International Development (SID), 2013).

2.6 Determinants of Biogas Technology Adoption

Various studies have been conducted to determine the social economic factors that influence biogas adoption. A study conducted in Bangladesh by Kabir et al., (2013) revealed that education is determinant in adoption of biogas as those who have more education want clean energy and they also recognize the importance of such energy to environmental conservation. He further asserts that government or organizational subsidies or loans make it easier for households to adopt biogas since the initial cost becomes or is made affordable and the people are given training and follow ups by the government. In Pakistan number of cattle, level of education, size of household and family income were some of the factors that influenced a household’s decision to adopt biogas (Iqbal et al. 2013). According to Wang et al. (2012) and Fei & Yu (2011) biogas use in China is affected by family size, age, gender, education level and knowledge and awareness. Support from government in terms of finances and policy also affected use of biogas in China (Tian, 2013).
A study conducted by Walekhwa, Mugisha and Drake, (2010), found out that younger headed households were more likely to adopt biogas than older headed household because older people are more risk averse than younger people and have a lower likely hood of adopting a new technology (Baidu-Forson, 1995.) cited in Walekhwa et al., (2010). Adoption also was more welcome if a house hold had experienced increased economic status since they could be able to afford the initial cost of a biogas plant(Walekhwa et al.,2010).They further suggests that the size of family members could influence adoption in case where a large family is viewed as additional help especially in providing labor for routine operation and maintenance. The study further concluded that with increased number of cattle households were likely to adopt biogas technology since they are the major source of substrate for biogas production. In addition the increasing cost of traditional fuel was also pushing households to adopt biogas technology as it was a high grade fuel that offered several advantages over traditional fuels.

Biogas technology requires space in terms of the area for constructing the biogas plant and providing pastures for the cattle needed to provide the feed stock, thus the area owned is a necessary determinant of biogas adoption as established by Walekhwa et al., (2010). Njenga (2013), observed that male headed households are more likely to adopt biogas than female headed households because men dominate and control access to resources. The level of economic status and the initial cost of setting up biogas plant were also cited by Wanjugu (2012) as impediments of adopting biogas technology. He observed that households in low economic status were discouraged from adopting biogas due to its high initial cost of plant.
construction. Finally neighbors who have adopted the technology can inspire others as they talk of the positive benefits of biogas.

2.7 Underlying Causes to the Determinants of Biogas Technology Adoption

Studies have found out the underlying causes to the determinants of Biogas technology adoption to be low level of education, level of household earnings and unavailability of technical resources. Literature on the root cause of low level of education indicated that it was as result of low enrollment rates. According to Rena (2007), parents never enrolled their children in school due to their low incomes. The low income made it difficult for parents to enroll and retain their children in school due to costs for uniforms, books and transportation to schools. High dropout rates were another factor identified as a cause for low level of education by Muhammad and Khuram (2011). Okereke, et al. (2013) revealed that early marriages undermine the achievement of universal primary education and subsequently the empowerment of women. A study carried out in Jordan by IFAD (2007) revealed that households continually earned very little due to a number of factors. These factors include: poor soil quality and topography of land, low rainfall, and limited access to alternative income sources. Unavailability of technical services could be due to biases in technology transfer such as spatial, project, professional, personal and diplomatic perpetuated by extension and professional officers (Chambers, 2013).

2.8 Strategies that Promote Biogas Technology Adoption

In an effort to promote biogas adoption various strategies have been put in place by stakeholders. These strategies include:
i) **Policies**

The international community has largely recognized the need to scale up sustainable and renewable energy to address energy security, poverty economic growth and environmental degradation. Since the UN Conference on Environment and Development (UNCED) in 1992, in Rio de Janeiro, Brazil, numerous related conferences have been convened such as World Future Energy Summit (WFES) which promotes innovation and investment surrounding renewable energy and environment (Catherine, Tallash, Jonathan, Mique, Delia & Ari, 2012).

Globally there is a strong focus on investment on renewable energy and achieving energy efficiency. Sustainable energy investment was $70.9 billion in 2006, an increase of 43% over that of 2005. The sectors with the highest levels of investment are wind, solar and bio-fuels, which reflects technology maturity, policy incentives and investor appetite. For instance, Nepal has made honest efforts to attract private to invest in renewable energy sector, and in Biogas sector about 40% cost is covered by the subsidy and the rest by beneficiary households (Junseng, 2004).

In its Sessional Paper No. 4, Kenya recognizes the role of renewable energy in its efforts to achieve vision 2030. The government aspires to encourage the wider adoption and use of renewable energy technologies and thereby enhancing their role in the country’s energy supply matrix because energy plays an important role in
economic development. On biogas technology, Kenya has realized there are many challenges and it endeavors to redress these constraints with a view to improving system management, and the level of awareness so as to enhance wider acceptance and adoption of the technology. Furthermore the Government will provide technical support in form of research, development and demonstration (G.o.K, 2004).

In January 2010, Kenya revised the Feed in Tariffs (FIT) policy, which resulted in the addition of three renewable energy sources: geothermal, biogas, and solar energy resource generated electricity (M.o.E, 2010). In the Energy Act of 2006 it is stated clearly that, the Minister shall promote the development and use of renewable energy technologies, including but not limited to biomass, biodiesel, bioethanol, charcoal, fuel wood, solar, wind, tidal waves, hydropower, biogas and municipal waste (G.o.K, 2006).

ii) Quality standards

Strict enforcement of carefully designed quality standards is crucial in the promotion of biogas technology (Jan Lam, 2010). He suggests that, these standards should not be limited to the design, construction materials or method and after sales service of biogas plants, but also include the quality of information provided to the potential users prior to their investment decision. Linking investment return with quality provides programs with the necessary leverage on service quality.

iii) Strengthening institutional capacities

Whereas the function of operation & maintenance can only be executed by the customers, other functions should as much as possible be undertaken by multiple rather than single stakeholders to avoid monopolies, dependencies and conflicts of
interest; for instance National and local Governments should not engage in construction or credit facilities, but could be involved in facilitation, promotion, regulation, financing and lobby for donor funding. Similarly, credit providers should not involve in construction (but can play an important role in promotion) (Jan Lam, 2010).

iv) Provision of credit facilities

Schemes should be established to provide financial support to small firms and individuals promoting the technology so as to enable them operate more efficiently and effectively (Gitonga, 2007). In addition, credit schemes should be established to provide loans to potential users who may be unable to raise the initial capital. Loans can be granted from government, banks and other financial institutions or from NGOs. This has been proven to work elsewhere. For instance the Nepal Biogas Support Program funded by Netherlands, has been very successful in disseminating biogas technology in Nepal (Gautam et al. 2009).
CHAPTER THREE
METHODOLOGY

3.1 Introduction

This chapter describes the research design, geographical position of the study area; population, sampling methods, data collection techniques and data analysis and presentation methods.

3.2 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.

3.3 Study Location

The research was conducted in the seven constituencies of Kilifi County namely Kilifi North, Kilifi South, Ganze, Kaloleni, Rabai, Malindi and Magarini. Kilifi County is in the republic of Kenya. The County has a total population of 1,109,735 covering an area of 12,610 km². It lies between latitude 2 ° 20" and 4° 0” South, and between longitude 39° 05” and 40° 14” East. It borders Kwale County to the south west, Taita Taveta County to the west, Tana River County to the north, Mombasa County to the south and Indian Ocean to the east. (Kenya National Bureau of Statistics (KNBS), 2010). The county is divided into seven constituencies namely
Kilifi North, Kilifi South, Ganze, Kaloleni, Rabai, Malindi and Magarini with a total of 35 wards. (Appendix I)

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°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.

3.4 Population of the Study

The population constituted all the households in Kilifi County which comprises of approximately 83,742 households (KDDP, 2008-2012). The accessible population comprised of about 2000 heads of households who had been trained on biogas.

3.5 Sample size and Sampling techniques

3.5.1 Sample size

A sample of 120 was obtained which was adjusted to make a sample size of 150 to cater for non respondents. According to Kathuri and Pals (1993) a sample size of 100 is appropriate for a survey study. Ballian (1988) proposes a sample size of 100 to 300 to be adequate and he further suggests percentage adjustment of between 10% and 30% on the initial sample to cater for non respondents or any other circumstances. The sample was adjusted to cater for those respondents who were not willing to respond
to the questionnaire. The addition of the sample made it large enough. With a large sample the researcher is confidence that if another sample of the same size was to be drawn the two samples would be similar to a high degree (Bordens and Abbot 2002). Therefore the sample size for the selected individuals was proportionately distributed as shown in Table 1

Table 1:

Proportionate purposive sampling

<table>
<thead>
<tr>
<th>Constituency</th>
<th>Kilifi North</th>
<th>Kilifi South</th>
<th>Kaloleni</th>
<th>Malindi</th>
<th>Magarini</th>
<th>Ganze</th>
<th>Rabai</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of farmers</td>
<td>700</td>
<td>500</td>
<td>200</td>
<td>300</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>2000</td>
</tr>
<tr>
<td>Proportionate %</td>
<td>35</td>
<td>25</td>
<td>10</td>
<td>15</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Number of respondents</td>
<td>52.5</td>
<td>37.5</td>
<td>15</td>
<td>22.5</td>
<td>7.5</td>
<td>7.5</td>
<td>7.5</td>
<td>150</td>
</tr>
</tbody>
</table>

3.5.2 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 (Shimizu, 2005). Purposive sampling was used to identify the organizations that promote biogas technology adoption and the households who had been trained in production and utilization of biogas technology. Proportionate random sampling was then used to select households’ heads that had been trained on biogas technology in the seven constituencies of Kilifi County.
3.6 Instrumentation

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

3.6.1 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 (Phellas, Bloch & Seale, 2011). 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 refer to (Appendix II).

3.6.2 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 refer to (Appendix IV)
3.6.3 Observation schedule

An observation schedule was developed to gather information in the field (Sekaran & 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) refer to (Appendix III).

3.7 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 (Drost, 2011).

3.8 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. Reliability was to determine the standardization of instruments and therefore reliable data. To ensure reliability, a piloting study 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 10% 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.

### 3.9 Data collection procedure

An introductory letter was acquired from the Graduate school (Appendix VII) which facilitated the acquisition of research permit from the Ethics Review Committee (Appendix VI) to allow for collection of data in field. A visit was made to the organizations that are involved in promoting biogas technology. These were Energy Centre, Livestock development and Ministry of Agriculture and Biogas International. The officers in these departments assisted in information on the area where training had been carried out. From the information given the households were divided into clusters based on constituencies and then proportionate 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 form for those who could write. The interview was conducted in Kiswahili language since it the most understood by the locals.
3.10 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 Statistical Package for Social Scientist software.

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.

Objectives one, two four, and five were analyzed using descriptive statistics. 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.

The logistic regression model was used to analyze objective three because the dependent variable was dichotomous. Logistic regression is used when the dependent variable is a dichotomy and the independent variables are of any type of variable. It applies maximum likelihood estimation after transforming the dependent into a logit variable and estimates the odds of a certain event occurring (Garson, 2008). The dependent variable is a logit, which is the natural log of the odds, that is:

\[ \ln \left( \frac{P}{1-P} \right) = a + bx \]

\[ P = e^{a + bx} \]
\[ l + e^a + bx \]

Where \( P \) is the probability of the event occurring, \( X \) are the independent variables, \( e \) is the base of the natural logarithm and \( a \) and \( b \) are the parameters to be estimated by the model.

The empirical form of the model

\[ P r Y = \frac{1}{1 + e^{- (a + bx)}} \]

Where \( Y \) is the logit of the dependent variable.

The logistic prediction equation

\[ Y = \ln \left( \frac{\text{odds (event)}}{\text{prob (nonevent)}} \right) \]

\[ = \ln \left( \frac{\text{prob (event)}}{1 - \text{prob (event)}} \right) 1 \]

\[ = b_a + b_1 x_1 + b_2 x_2 + \cdots + b_n x_n \]

Where \( b_a \) is constant term, \( X_1, X_2, \ldots, X_n \) are independent variables likely to affect the probability of adopting biogas technology and \( b_1, b_2, \ldots, b_n \) are the coefficients to be estimated.

The dependent variable \( Y = \) adoption of biogas technology

\[ = P(Y) = (1 \text{ if household choose to produce and use, and } 0 \text{ if not}) \]
Table 2:

**Definition of Explanatory Variables for Biogas Technology Adoption Model.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>Continuous</td>
<td>Age of household head in years</td>
</tr>
<tr>
<td>GENDER</td>
<td>Binary</td>
<td>Sex of household head (1=male, 2=female)</td>
</tr>
<tr>
<td>INCOME</td>
<td>Continuous</td>
<td>Average monthly income of household (Ksh)</td>
</tr>
<tr>
<td>HHSIZE</td>
<td>Continuous</td>
<td>Number of household members</td>
</tr>
<tr>
<td>No.CATTLE</td>
<td>Continuous</td>
<td>Number of cattle owned by household</td>
</tr>
<tr>
<td>TECHSERV</td>
<td>Binary</td>
<td>Availability or non-availability of technical services (1=available, 0=not available)</td>
</tr>
<tr>
<td>LANDSIZE</td>
<td>Continuous</td>
<td>Total area of land owned by household in acres</td>
</tr>
<tr>
<td>LVOEDUC</td>
<td>Continuous</td>
<td>Highest level of education of household head</td>
</tr>
<tr>
<td>CREDITFAC</td>
<td>Binary</td>
<td>Availability of credit facilities</td>
</tr>
</tbody>
</table>
Table 3:

Definition of Explanatory Variables with a priori sign for Biogas Adoption

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of household head in years</td>
<td>+/-</td>
</tr>
<tr>
<td>Sex of household head (1=male, 2=female)</td>
<td>+/-</td>
</tr>
<tr>
<td>Average monthly income of household (Ksh)</td>
<td>+</td>
</tr>
<tr>
<td>Number of household members</td>
<td>+/-</td>
</tr>
<tr>
<td>Number of cattle owned by household</td>
<td>+</td>
</tr>
<tr>
<td>Availability or non-availability of technical services (1=available, 0=not available)</td>
<td>+</td>
</tr>
<tr>
<td>Total area of land owned by household in acres</td>
<td>+</td>
</tr>
<tr>
<td>Highest level of education of household head</td>
<td>+</td>
</tr>
<tr>
<td>Availability of credit facilities</td>
<td>+</td>
</tr>
</tbody>
</table>

Findings from other researchers formed the basis of the selection of the variables to be included in the model.

Specific assumptions related to each variable in the model are as follows:

Age: Age of household head was expected to affect adoption of biogas either positively or negatively.

Gender: Sex of household head was assumed to affect adoption positively or negatively.

Household income: Higher income earners are expected to adopt the technology.

Number of cattle owned: It was expected that those households that owned a greater number of cows had a high probability of adopting the technology.
Land size: it was expected that households with larger acreage of land would adopt the technology.
Level of education: More educated household heads were expected to adopt the technology.
Size of household: It was expected to influence adoption of biogas positively.
Access to technical services: Access to technical services was expected to influence adoption positively.

3.11 Ethical considerations
Application for Ethical clearance was made to the relevant Ethics Regulation committee and a permit to undertake the research was granted (Appendix VIII)
CHAPTER FOUR
RESULTS, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter presents the results, interpretation and discussion of the study. The first section presents the characteristics of the respondents. The results and discussion are presented based on the objectives. The objectives include; factors influencing households on biogas adoption, determinants of biogas adoption, underlying factors of biogas adoption and strategies to promote biogas technology adoption.

4.2 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 (Appendix II) and is presented in Table 4.

The results in Table 4 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 4:

**Characteristics of Respondents**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>83</td>
<td>55.3</td>
</tr>
<tr>
<td>Female</td>
<td>67</td>
<td>44.7</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young (21-35 years)</td>
<td>95</td>
<td>63.4</td>
</tr>
<tr>
<td>Old (36-60)</td>
<td>55</td>
<td>36.6</td>
</tr>
<tr>
<td>Level of education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>11</td>
<td>7.3</td>
</tr>
<tr>
<td>Primary</td>
<td>70</td>
<td>46.7</td>
</tr>
<tr>
<td>Secondary</td>
<td>38</td>
<td>25.3</td>
</tr>
<tr>
<td>Tertiary</td>
<td>31</td>
<td>20.7</td>
</tr>
<tr>
<td>Size of household</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small (1-4)</td>
<td>64</td>
<td>42.7</td>
</tr>
<tr>
<td>Large (above 5)</td>
<td>86</td>
<td>57.3</td>
</tr>
<tr>
<td>Average monthly income (Ksh)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>below 5000</td>
<td>77</td>
<td>51.3</td>
</tr>
<tr>
<td>5000-10000</td>
<td>40</td>
<td>26.7</td>
</tr>
<tr>
<td>Above 10000</td>
<td>33</td>
<td>22.0</td>
</tr>
<tr>
<td>Number of cattle owned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>68</td>
<td>45.4</td>
</tr>
<tr>
<td>1-5</td>
<td>77</td>
<td>54.6</td>
</tr>
<tr>
<td>Above 5</td>
<td>5</td>
<td>1.0</td>
</tr>
<tr>
<td>Land size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4 Acres</td>
<td>125</td>
<td>83.4</td>
</tr>
<tr>
<td>Above 5 Acres</td>
<td>25</td>
<td>16.6</td>
</tr>
<tr>
<td>Sources of energy for cooking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firewood</td>
<td>102</td>
<td>68.0</td>
</tr>
<tr>
<td>Charcoal</td>
<td>32</td>
<td>21.4</td>
</tr>
<tr>
<td>Kerosene</td>
<td>8</td>
<td>5.3</td>
</tr>
<tr>
<td>LPG</td>
<td>5</td>
<td>3.3</td>
</tr>
<tr>
<td>Biogas</td>
<td>3</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*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 4 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 4 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 4) 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 Sufdaret al., (2013) who posits that an increase in number of cattle increased the probability of a household adopting biogas technology.

Results in Table 4 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.

4.3 The Current Status of Biogas Adoption among Households in Kilifi County

Households were asked questions concerning the current status of biogas adoption using a questionnaire (Appendix II). Table 5 presents the findings.
Table 5:

Current status of adoption of biogas in Kilifi

<table>
<thead>
<tr>
<th>Ownership biogas plant</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>10</td>
<td>6.7</td>
</tr>
<tr>
<td>No</td>
<td>140</td>
<td>93.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of biogas plant</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floating drum</td>
<td>3</td>
<td>30.0</td>
</tr>
<tr>
<td>Flexi biogas</td>
<td>5</td>
<td>50.0</td>
</tr>
<tr>
<td>Fixed dome</td>
<td>2</td>
<td>20.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size of the biogas plant</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4m³</td>
<td>4</td>
<td>40.0</td>
</tr>
<tr>
<td>6m³</td>
<td>6</td>
<td>60.0</td>
</tr>
<tr>
<td>9m³</td>
<td>1</td>
<td>10.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Production of biogas</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>3</td>
<td>30.0</td>
</tr>
<tr>
<td>No</td>
<td>7</td>
<td>70.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal waste</td>
<td>10</td>
<td>100.0</td>
</tr>
<tr>
<td>Crop residues</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Field survey 2014 done by the author

From the study findings in Table (5) only 6.7% of respondents owned a biogas plant. This indicates a slight improvement from previous literature which was 0.8% (KNBS & SID, 2013). However, observation in the field showed that most of these plants had broken down and had been abandoned while others were incomplete. Refer to (Plate 1).
Plate 1: A floating drum digester that has been abandoned due to lack of maintenance

Photo taken 15/6/2014

Source: Field survey done by author
According to Fern et al., (2011) abandonment of biogas plants could be a result of inability to maintain the units due to lack of time and lack of influence by women over household’s finances.

Results from the Table (5) indicate that only 30% of the plants were in working condition. This is an indication of very low adoption status. The low status of adoption could also be attributed to availability of other sources of energy such as charcoal and firewood which may seem relatively of low cost as compared to biogas. This is consistent with results from Table 4 which shows that 68% of respondents use firewood as their main source of energy for cooking an indication of its accessibility in terms of cost as compared to biogas. This is asserted by Negro, Alkemade and Hekkrt (2013) who argues that, a new technology may suffer from competing incumbent substitutes that have been able to undergo a process of increasing returns and this tends to associate the new product with a high price or poor performance and lack infrastructure. However, Abukhzam and Lee (2010) presents a different view indicating that biogas technology adoption could be hampered by; lack of an understanding, technical difficulties, lack of training, and insufficient support from top management and perceived complexity in its operation. Furthermore, the low level of adoption could be explained by the theory of Diffusion of Innovation advanced by Rogers. Rogers 2003 cited in Sahin, (2006), argues that the rate of adoption of a technology may be slowed by individuals with some individuals adopting the technology earlier and others taking time before deciding to adopt a new technology. The technology may be at its early stages where
only the innovators have adopted the technology and the rest are yet to adopt (Rogers, 2003).

Results from the Table (5) also indicate that 70% of those who had constructed a biogas plant at one time have abandoned them due to lack of spares such as gate valves, water taps and pipes, skills on maintenance and technical support services. Similar findings were reported by Bensah and Hammond (2010) who indicated that lack of skilled personnel in repair of biogas plants had led to most being abandoned.

Further, results from Table 5 shows that 50% of the biogas plants in the area were the floating drum and fixed dome. The high cost of constructing and maintaining such could have been a reason for low adoption. For instance the floating drum is made of a steel drum and requires regular painting to prevent it from rusting which most people may not afford. This is asserted by Ranjedran et al. (2012) who argues that although the amount of gas produced floating drum can be detected the drum needs regular painting and replacement and this makes it less attractive to most households. The results in the Table (5) also indicate that people are embracing the new flexi-biogas digester with 50 % having adopted it.

Results in Table 5 indicate that most plant owners had plant size of 6m$^3$. This is basically a family sized digester that can be run with one or two zero grazed dairy cows as they can produce enough substrate for the digester. According to KENDBIP (2009) with one or two cows that can produce 30kilograms of dung a day one can successfully operate a biogas digester of 6m$^3$. 
The Low level of biogas adoption could also be associated with malfunction in government policy and institutions involvement in biogas information dissemination Wawa (2012). During focused group discussion members indicated that they got information on biogas from an extension officer who had visited them only once. Some members were absent and got to hear from their counterparts in the group. Even those who were present during the meeting confessed to have forgotten much of the details.

According to Rogers2003 cited in Sahin (2006) information dissemination is a key process in bringing awareness to people about a new technology in their environment. After becoming aware people accumulate more knowledge through training, then test the new technology and when satisfied with the result, people take up the innovation. However, Wawa (2012)argues insufficient government extension services and minimal involvement of other government agencies may affect the information reaching the people and thus their understanding of the technology. As a result the information available to potential adopters is shallow, inaccurate and not adequate for one to make an informed decision and hence the low status of biogas adoption in the study area.

### 4.4 Factors influencing Biogas Adoption among Households

The study sought to find out the factors that influenced the decision of the respondents on biogas adoption. Data was collected using questionnaire(AppendixII)and summarized in Table 6.
Table 6:

Factors influencing Biogas Adoption among Households

<table>
<thead>
<tr>
<th>Variables</th>
<th>Users</th>
<th>Non users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender of household head</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>90 (9)</td>
<td>52.3 (74)</td>
</tr>
<tr>
<td>Female</td>
<td>10 (1)</td>
<td>47.1 (66)</td>
</tr>
<tr>
<td>Age(years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young(21-35 years)</td>
<td>0</td>
<td>67.9 (95)</td>
</tr>
<tr>
<td>Old (36-60)</td>
<td>100 (10)</td>
<td>32 (45)</td>
</tr>
<tr>
<td>Highest level of education of household head</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>7.9 (11)</td>
</tr>
<tr>
<td>Primary</td>
<td>0</td>
<td>48.6 (68)</td>
</tr>
<tr>
<td>Secondary</td>
<td>60 (6)</td>
<td>28.9 (32)</td>
</tr>
<tr>
<td>Tertiary</td>
<td>40 (4)</td>
<td>19.2 (27)</td>
</tr>
<tr>
<td>Size of household</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small (1-4)</td>
<td>20 (2)</td>
<td>44.3 (62)</td>
</tr>
<tr>
<td>Large (above 5)</td>
<td>80 (8)</td>
<td>55.7 (78)</td>
</tr>
<tr>
<td>Average monthly income(Ksh)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>below 5000</td>
<td>0</td>
<td>51.3 (77)</td>
</tr>
<tr>
<td>5000-10000</td>
<td>0</td>
<td>100 (40)</td>
</tr>
<tr>
<td>Above 10000</td>
<td>100 (10)</td>
<td>16.4 (23)</td>
</tr>
<tr>
<td>Number of cattle owned</td>
<td></td>
<td></td>
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<td>0</td>
<td>100 (68)</td>
</tr>
<tr>
<td>1-5</td>
<td>90 (9)</td>
<td>48.6 (68)</td>
</tr>
<tr>
<td>Above 5</td>
<td>10 (1)</td>
<td>2.9 (4)</td>
</tr>
<tr>
<td>Size of land owned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4 Acres</td>
<td>20(2)</td>
<td>88 (123)</td>
</tr>
<tr>
<td>Above 5 Acres</td>
<td>80 (8)</td>
<td>12 (17)</td>
</tr>
<tr>
<td>Availability of technical services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Available</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Not available</td>
<td>100 (10)</td>
<td>100 (140)</td>
</tr>
<tr>
<td>Access to loans and credit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Available</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Not available</td>
<td>100 (10)</td>
<td>100 (140)</td>
</tr>
</tbody>
</table>

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:
a) **Unavailability of Technical services**

Results from Table 6 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 refer to (Plate 2) or broken down biogas plants which once worked but have lacked maintenance and repairs refer to (Plate 3).

![Plate 2: An incomplete fixed dome digester](image)

*Photo taken on 22/6/14*
Plate 3: An abandoned digester.

*Photo taken 15/6/2014*

The abandoned and incomplete biogas plant was due little knowledge gain by the biogas plant owners on maintenance and repairs. The biogas plant owners agreed that they did not understand how to do simple repairs and they depended on technical experts who were not available. This is asserted by Alwis (2001 cited in Hazra *et al.*, 2014), 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.

b) **Average household monthly income**

Findings in Table 6 indicate that 51.3% earn less than Ksh 5,000 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 *et al.*, (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 or even maintain it refer to (Plate 3) Results from Table 6 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.

During focus group discussion it was established that most 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.

c) Household head’s level of education

The results in Table 6 indicate 48.6% 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 48.6% (Table 6) 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 whoUaiene, 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.

d) Cattle ownership

The results in Table 6 above reveal that 100% of the respondents who had adopted biogas owned cattle. The results are supported by Kabiret et al. (2013), who argues 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 6) majority of non users (51.5%) 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. In addition the site of the digester could also affect availability of cow dung. If the digester is near the cow shed the amount of dung that will be lost during transport to a far place will be reduced and thus adequate dung.
e) **Lack of credit facilities**

Findings in Table 6 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 from government or NGOs involved in biogas technology promotion. 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. This is asserted by Ngigi et al., (2007) and 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).

f) Non-availability of household labor

The results in Table 6 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 make up 64.3% of the population (Table 4) 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.

**g) Gender of household head**

The findings in Table 6 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 less 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.

h) Age of household head

Table 6 further showed that 100% of the users were older (36-60) years. Similar findings were reported by Sufdaret al.,(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. This indicates that the working population may find it difficult to adopt biogas technology as they may not have enough time to run the digester. 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.

i) Land Size owned

The results in Table 6 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.

j) **Water**

Access to water was noted to be a challenge to biogas technology adoption during focused group discussion. Members were clear that the quantity of water is a problem. Most members purchase borehole water for their daily chores and thus it may be costly for them to get water for mixing with cow dung to produce biogas. This is asserted by Wawa (2012) who suggests that water must be clean and accessible to support both livestock and plant operations. Those who get their water from boreholes may also find that the saline nature of borehole water in the area can affect the pH of the microorganism in the digester. The rains in the area are erratic and may not be a solution to the water problem.

### 4.5 Determinants of biogas adoption in Kilifi County

Binary logistic regression was used to establish the determinants of biogas adoption and the findings are summarized in Table 7.
Empirical results in Table 7 show that out of the nine variables included in the study eight were positively correlated with biogas adoption. These include gender, level of education of household head, age, household size, household income, credit facilities and availability of technical services. The number of cattle was negatively correlated to biogas adoption.

Average monthly income of households which is an indicator of household economic status was positively correlated with biogas adoption. At P<05 the significance is 0.005 indicating that income influences biogas adoption significantly. As hypothesized if a household experienced increased income they were more likely to adopt biogas as opposed to households where income was reduced. Increased income implies that a household could have the capacity to install a biogas plant.

Table 7:

**Binary logistic regression estimates of determinants of biogas**

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender(1)</td>
<td>.745</td>
<td>1.173</td>
<td>.403</td>
<td>1</td>
<td>.525</td>
<td>2.106</td>
</tr>
<tr>
<td>Age</td>
<td>.393</td>
<td>.526</td>
<td>.559</td>
<td>1</td>
<td>.455</td>
<td>1.481</td>
</tr>
<tr>
<td>Lvoeduc</td>
<td>1.266</td>
<td>.704</td>
<td>4.235</td>
<td>1</td>
<td>.001</td>
<td>3.546</td>
</tr>
<tr>
<td>Hhsize</td>
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<td>.907</td>
<td>.904</td>
<td>1</td>
<td>.342</td>
<td>2.370</td>
</tr>
<tr>
<td>Income</td>
<td>1.815</td>
<td>.652</td>
<td>7.747</td>
<td>1</td>
<td>.005</td>
<td>6.141</td>
</tr>
<tr>
<td>Nocattle</td>
<td>- .897</td>
<td>.777</td>
<td>1.332</td>
<td>1</td>
<td>.249</td>
<td>.408</td>
</tr>
<tr>
<td>Technserv</td>
<td>5.409</td>
<td>0.887</td>
<td>37.215</td>
<td>1</td>
<td>.000</td>
<td>223.51</td>
</tr>
<tr>
<td>Creditfac</td>
<td>.364</td>
<td>.341</td>
<td>1.138</td>
<td>1</td>
<td>.286</td>
<td>1.438</td>
</tr>
<tr>
<td>Land size</td>
<td>.264</td>
<td>.386</td>
<td>.467</td>
<td>1</td>
<td>.494</td>
<td>.768</td>
</tr>
<tr>
<td>Constant</td>
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<td>5.006</td>
<td>11.596</td>
<td>1</td>
<td>.001</td>
<td>.000</td>
</tr>
</tbody>
</table>

Variable(s) entered on step 1: Gender, Age, Lvoeduc, Hhsize, Income, Nocattle, Technoav, Creditfac, Landsize
As indicated in Table 7, if a households’ income was increased by one unit they were 6.141 times more likely to adopt biogas. Similar results were reported by Wanjugu (2012) who stressed that the level of economic status highly influenced a household’s decision to adopt biogas. If households in the study area are to be encouraged to adopt biogas their income must be increased substantially to such a level that they will be able to have enough money for basic needs and extra to construct and maintain biogas plants or design plants that equally efficient but relatively cheaper to construct and maintain.

The results further revealed that level of education of household head positively correlated with biogas adoption. Highest level of education of household head was significant at P<0.05 (0.001) as shown in Table 7. Similar findings by Ridell and Song (2012) showed that highly educated workers tend to adopt new technologies faster than those with less education. Low levels of literacy are associated with difficult in flow and comprehension of information which is likely to affect adoption of biogas (Uaiene et al., 2009). The results imply that for households to adopt biogas, individuals should be encouraged to attain higher level of education by stay in school longer than they currently do as majority (46.7%) of the respondents have primary level education (Table 4).
In this study availability of technical support services was found to have a positive correlation with biogas adoption and showed statistical significance of 0.000 at P<0.05 (Table 7). Households with access to technical support services were more likely to adopt biogas technology than those without. For instance Nasery (2011) found out that when people at the grassroots had access to trained technicians who provided construction and maintenance services for biogas plants, many households were able to adopt biogas and production of biogas was sustainable. The implication of these empirical results is that if technical services are accessible many households will adopt biogas technology.

Land owned was positively correlated with biogas adoption but was not statistically significant. The implication is that households with larger land size were more likely to adopt biogas than households who owned small size of land. According to Kiran (2013), biogas production requires enough space for the biogas digester and pasture for the cattle. The findings of the study are consistent with findings by Gulbrandsen (2011) who found out that more households with larger sizes of land had adopted the technology as opposed to households with smaller sizes of land in Tanzania. However Wanjugu (2012) reported that land size was not a limiting factor to adoption of biogas.

In the study (Table 6) gender was found to have a positive coefficient value of 0.745 which is an indication that male headed households were more likely to adopt biogas technology as compared to female headed households, though not statistically significant the probability of male headed households adopting biogas technology is
2.106 times more than female headed households. This could be an indication of men controlling resources and decision making in the family. These results are consistent with results by Njenga (2013) and Kabir et al., (2013) who both found out that male headed household adopted the technology since they own resources and they control decision making in the household. The same was also found true by Ng’wandu et al., (2009) who indicated that traditionally the male dominates decision making as well as resource ownership. Women are involved in many responsibilities in the home such as cleaning, cooking and child care. Lack of time and revenue constraints them from investing in new technologies resulting in low rates of adoption (Tanellari, Kostandi &Bonabana, 2012). The implication of these results in regard to biogas adoption is that, if women headed household are not empowered to make decisions and control resources it may be difficult for them to adopt biogas. The results however differ from results reported by Kileo (2014) that decisions to adopt biogas were made by the family and when it was left to the male or female, more female headed households (23%) made the decision to adopt the technology as compared to male headed household (16%).

In this study age of household head was found to have a positive correlation with biogas adoption (0.393) in (Table 6). The probability of a household adopting the technology increased with advancement in age. Younger household heads were less likely to adopt the technology than older household heads. This could be an indication of older people having the resources required to construct biogas plants since they may be having stable income or collateral to take a loan. The findings are in agreement with those of Sufdaret al.,(2013) who reported that the probability of
adopting biogas increased with increasing age because older people have resources for construction of biogas plants in terms of finances and land ownership. The results are contrary to those by Walekhwa et al., (2010) who reported that farmers’ age was negatively correlated with biogas adoption due to the fact that old people are risk averse and less willing to take up new technologies.

The results from Table 7 show that household size was statistically not significant but it was positively correlated with biogas adoption. The results are supported by Wang et al., (2011) who found out that excess labor in families were positively correlated with household’s willingness to adopt biogas. Findings in Table 4 indicate that almost half of the respondents’ (57.3 %) had between 5-8 household members but they had not adopted biogas. This is an indication that labor availability on its own cannot influence a farmer to adopt biogas.

The results of the logistic regression differ from the hypothesis that an increase in the number of cattle owned increased the probability of adopting biogas. The results are negatively correlated to biogas adoption meaning that a household with fewer or no cattle is likely to adopt biogas than a household with many cattle. This could imply that even without cattle one can adopt the technology so long as he can access cow dung from neighbors or use other materials. Results in Table 4 indicate that most households owned between 1-5 cattle (54.4 percent) and they did not own biogas. The results are supported by Wawa, (2012) who found out that number of cattle owned was insignificant in biogas adoption. The probable reason for this is that a large number of cattle may not necessarily generate the amount of cow dung required...
for daily feeds if the method of management is free range which makes it difficult to collect enough cow dung as much cow dung will be lost in the fields. What really matters is the amount of cow dung that the cattle can generate and not the numbers as asserted by Ngugi et al., (2007) that even two dairy cows which are zero grazed can produce enough substrate for the digester. Contrary to these findings Iqbal et al. (2013) reported that an increase in number of cattle increased the probability of a household adopting biogas technology since they would provide sufficient cow dung.

4.6 Underlying factors to the determinants of biogas adoption

Following the establishment of the determinants of biogas adoption, a focused group discussion was organized (Appendix IV section B) to give an insight into the root causes of the determinants of biogas adoption. The factors are as discussed:

a) Level of education of household head

Insights to the root cause of low level of education revealed by focus group discussion were:

i) Low rates of school enrollment: The focused group discussion indicated that many parents in the study area do not take their children to school due to poverty. Similar results were reported by Rena (2007), who posits that parents never enrolled their children in school due to their low incomes. Families with low income may find it difficult to enroll and retain their children in school due to costs for uniforms, books and transportation to schools. Members in the discussion group revealed that although primary education is free some parents are not able to buy uniforms for their children and this makes them remain at home. Some parents have a negative
attitude towards taking their girl children to school as they feel it is a waste of resources as she will eventually get married and they will not benefit directly from her education.

ii) *High school dropout rates:* With regard to dropouts members revealed that, even for those children who enroll in schools they don’t stay in school to finish their courses as most will drop out due to economic constraints. The results are in agreement with those of Muhammad and Khuram (2011) who argues that high dropout was due to high poverty levels. From discussions in focused group it showed that poor parents are forced to pull their children out of school so that they can help with caring for the young ones as the parents go to search for food or they are sent to engage in some income generating activity to get basic needs. Some children may go into hawking or to work in quarries or as house helps. According to Nybo(2006), the dropout rates in Kilifi increases during drought season. The drought season means that food and water are scarce and so some children are forced to drop out in search of the same. Parents may also feel they can not send their children to school on an empty stomach so they rather keep them at home and help with house chores. Members of focused group discussion also revealed that when a girl drops out of school due to teenage pregnancy it was not easy for her to be taken back to school as many parents felt she has to stay at home and fend for her child.

iii) *Cultural practices:* Further Mwiti (2006) argues that, cultural practices such as early marriages practiced in the County disadvantage the girl child from staying in school and later benefiting from education. Okereke *et al.* (2013) argues that early marriages undermine the achievement of universal primary education and
subsequently the empowerment of women. Members of the focused group discussion made it clear that some parents see their girl child as a source of wealth that will get them out of poverty and so they prefer marrying them off to get some income to meet family needs. However, they also indicated that a woman who has no education finds life difficult since if she cannot read and write, she may not be able to have access to information or comprehend much information on technological issues and in this case biogas adoption. This lack of information may be a barrier for in deciding whether to adopt biogas or not.

b) Average income of households

The very low average monthly income of households (Table 4) was attributed to poverty, unreliable rainfall, small scale farming and poor soils. These finding are supported by results by a study carried out in Jordan by IFAD (2007) which revealed that households continually earned very little due to a number of factors. These factors include: poor soil quality and topography of land, low rainfall, limited access to alternative income sources and lack of collateral needed to obtain loans for improvement of farm activities that could lead to higher incomes. Members of the focused group discussion asserted that, they earned very little income from their farms. The reason being the poor soils coupled with poor rainfall experienced in the area. This leads to a situation where they are not able to meet their basic needs properly or even have savings. Without savings it is difficult to undertake projects such as biogas which require high initial cost of installation. Further the members reemphasized that they did not have the capacity to buy farm inputs like quality seeds or fertilizer to improve yields which will in turn increase income. They
depended on government to provide seeds and fertilizer and when not available they planted without, which resulted in low poor yields. Within the adult population, 66.8% people (45% male and 55% female) cannot meet the minimum cost of food and non-food items essential for human life and hence are absolutely poor (NCAPD, 2005). Among the factors that contribute to the poverty incidence in Kilifi include climatic conditions (erratic rainfall, temperature, humidity sunshine and wind), low levels of education, geographical and land ownership (National Coordinating Agency for Policy and development (NCAPD), 2005). Focused discussion members also suggested that the young people have a negative attitude toward work and spend most of their time around the beaches watching the tourists. The youths are not productive and this increases poverty levels.

c) Unavailability of technical services

During focused group discussion to get an insight as to the reason why technical services are lacking in the area, members pointed out that the extension officers who should offer the technical services were few and the visits were irregular. Furthermore the approach that the extension officers had taken while transferring the technology to the residents may have been biased. Chambers (2006) identified biases that affect rural development or technology transfer in rural areas. These biases include:

i) Spatial bias: The extension or development officers make visits to urban centers or follow tarmac roads and avoid going deep in to the villages where the majority of the poor reside.
ii) Project bias: Projects that are already in place doing well near the urban centers will always be used for show casing development. The projects are shown to senior officers or foreign visitors but in the real sense they draw attention away from the real poor people.

iii) Personal bias: The person that the extension officer will contact will be the elite (progressive farmers, village leaders, headmen, traders, religious leaders, teachers, and paraprofessionals). They are the most fluent informants. They articulate ‘the villages’ interests and wishes; their concerns which emerge as ‘the village’s’ priorities for development. In contrast the poor do not speak, they are weak powerless and isolated.

Male bias: Most local-level government staff, researchers and other rural visitors are men. Most rural people with whom they establish contact are men. Female farmers are neglected by male agricultural extension workers and yet they often work for very long hours and are expected to implement new technologies.

User and adopter biases: Where visits are concerned with facilities or innovations, the users of services and the adopters of new practices are more likely to be seen than are non users and non-adopters.

iv) Dry season biases: Many urban professionals would prefer visiting rural areas during the dry season when they can travel more freely. This therefore implies that even if a biogas plant breaks down during the rainy season it might be difficult to get the technician to do the repairs.
v) Professional biases: Professional training sometimes focuses attention on the less poor. For instance agricultural extension staff trained to advise on alternative energy sources are drawn to the more ‘progressive’ farmers especially when in short of time. The reason being the adoption of any new practices can most readily be established with better-off, better-educated farmers.

vi) Diplomatic biases: politeness and timidity-The extension officers want to be polite and so they are afraid of making contact with the poor in the village as they may be seen to offend those who are influential.

Success story of biogas technology adoption in Mtwapa – Kilifi

Despite the low adoption status of biogas technology adoption in Kilifi County and the many challenges there are households who have embraced the technology and are reaping the benefits. One household has adopted the flexi biogas. At the time of the interview she had used it for more than six months. She said she took it up because she thought it would reduce the costs of fuel for cooking and due to the fact that she has five cows which are zero grazed and so the substrate was sufficient. Her farm is large enough to grow napiergrass for the cows feed and a borehole to supply water which is required for mixing with dung. The financing of the biogas plant was from her savings.

For the time she has been using biogas she had saved on the money she used to buy LPG and charcoal. She had started a vegetable garden near the plant so the slurry could be used there. Another benefit was that the cowshed looked tidier as the dung
was removed every day to be used in the digester. It had also helped create employment for the young man who is tasked with collecting and mixing the dung with water and general running of the biogas plant refer to (Plate 4a and b).

She however faced challenges of overproduction of the gas and had no storage system. If there was a storage facility this will go a long way in encouraging other households to adopt the technology.

Plate 4: (a) flexi biogas digester and (b) biogas cooker.

Photo taken on 17/3/2014

Source: Field survey done by author
4.7 Strategies to promote biogas adoption among households in Kilifi County

Data on strategies to promote biogas was collected by use of questionnaire (Appendix IV) and then ranked. The results are presented in Table 8.

Table 8:

Strategies to promote biogas adoption in Kilifi County

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Percent (%)</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education sensitization and awareness</td>
<td>34.0</td>
<td>51</td>
</tr>
<tr>
<td>Provision of technical services</td>
<td>27.3</td>
<td>41</td>
</tr>
<tr>
<td>Provision of loans and subsidies</td>
<td>20.0</td>
<td>30</td>
</tr>
<tr>
<td>Set up demonstration centers</td>
<td>14.7</td>
<td>22</td>
</tr>
<tr>
<td>Encourage farmers to adopt zero grazing</td>
<td>4.0</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>150</td>
</tr>
</tbody>
</table>

Source: Field survey 2014 done by the author

The respondents suggested a number of strategies to improve biogas adoption in Kilifi County namely:

a) Education and awareness

The respondents think efforts should be geared towards education and awareness (Table 8). In agreement with these findings is Sangwa (2013) who also recommended that local communities should be sensitized on benefits of biogas through education and awareness campaigns. They suggested that people should be taught about biogas technology in a simple language that they can comprehend. The teachings should cover all the areas of biogas technology how it works, construction and maintenance of the biogas units. The right person who is conversant with biogas technology
should do the trainings instead of may be a group leader being sent to a seminar and then trying to teach people what he learnt. Sometimes he may forget some parts or he may not be knowledgeable enough to fully answer members questions to a point of helping them to make the right decision on whether to adopt the technology or not.

The education should target both men and women so they can work together. They suggested that training and creation of awareness can be done through seminars, farmers’ groups or women and youth groups. However a challenge that came out is that people do not attend meetings a hundred percent since will be held up doing other activities and thus even when the training on biogas is being held some members are likely to miss out. In addition some confessed to have forgotten what they were taught in biogas technology sessions. They suggested trainings to be held regularly.

b) Provision of loans and subsidies

The respondents also suggested provision of loans and subsidies to help those households that were already aware of the technology, had interest but lacked the financial ability to adopt the technology. Mwirigi et al., (2014) concurs with this suggestion that soft loans and subsidies can go a long way in attracting households to adopt biogas technology. The loans will give them the financial ability they require to install biogas plants.

c) Provision of technical support services

Provision of technical support services would also go a long way in ensuring that those who desire the technology have ready and affordable technical support that
they require to adopt and maintain biogas digesters. Local persons should be trained and be adequately equipped with construction and maintenance knowledge and should be readily available at affordable cost.

\section*{d) Demonstration centers}

The rate of adoption of biogas has been very low and thus many people have not had any practical experience on how biogas works. Setting up of demonstration centers where people can see practically how biogas plant works may improve their understanding and help them in making a decision. The effect of demonstration is powerful influence in biogas adoption Iqbalet \textit{et al.}, 2013). During focused group discussion members claimed they were only shown biogas process in posters and handouts and have not seen it because there are no many digesters in the area. They felt demonstration centers may inspire many people to understand and embrace the technology.

\section*{e) Practicing zero grazing}

Many people keep cattle through outside grazing which implies insufficient cow dung for the bio digester since most of it is lost during grazing. Some respondents suggested if people were encouraged to practice zero grazing they will have enough substrate for the bio digesters. This is asserted by Mwirigi \textit{et al.}, (2014) who said that zero grazing farming systems are more conducive to biogas technology adoption due to the ease with which cow dung can be collected to feed the digester.

\section*{f) Formation of community based groups}
Members of the community can come together and form groups where they can save money and take loans to improve themselves in this case to construct biogas plants. During focus group discussion members said they had formed a group in where they were saving and take loans for small projects and they hoped they could also take a loan for construction of biogas plant in future. Furthermore, as a group they can organize for visits to areas where biogas has worked and gets to acquire more knowledge. Being in a group is important as it easier even to invite a resource person to come and give train on various issues in the community.
CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter highlights the summary, the key findings of the study, conclusion and recommendations to enhance adoption of biogas technology among households in Kilifi County.

5.2 Summary of Findings

The study was carried out to establish the underlying root causes of the determinants of biogas technology adoption among households in Kilifi County. The main objective was to determine the root causes that hinder adoption of biogas technology among households. The Kenya government in collaboration with various organizations has continued to promote biogas technology as an alternative source of energy and consequently conserve the environment. Despite the continued promotion and the known benefits, with reports from various studies showing a consistence on what determines its adoption among households, adoption of the technology in Kilifi county is reported to be low (0.8 %) and this coupled with charcoal burning and lumbering has resulted in reduced acreage under forest cover. The specific objectives that guided the study were:

i) To establish the current status of biogas technology adoption in Kilifi County.

ii) To identify factors that influence biogas technology adoption among households in Kilifi County.
iii) To establish determinants of biogas technology adoption among households in Kilifi County.

iv) To establish the underlying reasons for factors that influence biogas technology adoption in Kilifi County.

v) To suggest strategies that can be put in place to improve adoption of biogas technology among households in Kilifi County.

The study used descriptive research design. The design was appropriate as it allowed for gathering of information concerning the current status of the phenomena and describes it as it exists. Purposive sampling was used to get respondents who had training in biogas technology with an aim of capturing their experiences and attitudes toward biogas technology. Data was collected on the current status of biogas technology adoption, factors that influence biogas technology adoption, determinants of biogas technology adoption, the underlying reasons for factors that influence biogas technology adoption and strategies to enhance biogas technology adoption in Kilifi County. Frequency tables and percentages were used to analyze the data.

5.3 Key Findings Guided by Objectives

The following were the key findings.

1. The Status of biogas technology adoption among households was low. Only 6.7% of respondents owned a biogas plant. This was due to the presence of other sources of energy, malfunction of government policy on promotion of biogas technology which does not address biogas technology specifically but talks generally about encouraging people to
adopt renewable sources of energy. Lack of technology awareness in which case the information they have is not adequate enough for them to make an informed decision. Complexity in technology operation since the process of anaerobic digestion is not well understood some people see it as very complicated.

2. The factors influencing biogas technology adoption were: unavailability of technical services, gender of household head, age of household head, size of household, average monthly household income, level of education of household head, number of cattle owned, access to loans and credit facilities, size of land owned individual households owned.

3. Unavailability of technical services, highest level of education of household head and average monthly household income were found to be statistically significant. The factors that were positively correlated with biogas adoption were: unavailability of technical services, gender of household head, age of household head, size of household, average monthly household income, size of land owned, highest level of education of household head and access to loans and credit facilities.

4. The underlying causes to the determinants of biogas technology adoption were found to include: low rates of school enrollment, high school dropout rates, cultural practices, poverty, poor climatic conditions, insufficient technical staff and spatial and personal bias.
5. The suggested strategies to support promotion of biogas technology adoption included: education, sensitization and awareness creation, provision of technical services, setting up demonstration centers, formation of community based groups and promotion of zero grazing.

5.4 Conclusion

Although biogas technology has continued to be implemented among households by various organizations in addition to the Kenya government through its Ministry of Energy, its adoption among households has remained low in Kilifi County. This is a major concern given that the MDG number seven on environmental sustainability may not be attained if households are not facilitated to adopt this technology. The following are conclusions made from the study findings:

1. The low status of biogas technology adoption by households is explained by presence of other sources of energy such as firewood and charcoal. Despite the scarcity of firewood and inability of the households to purchase it, the incumbent sources of energy has an advantage over biogas technology. Households have experience in how to access and utilize it in contrast to the biogas technology which is a new, more costly and requires access to technical services to construct the plant.

2. Failure by the implementing agencies to apply appropriate strategies established by studies carried out in other parts of the world and in Kenya may have contributed to the low adoption of biogas technology by households. The implementation of recommendations from research works
carried out on determinants of biogas technology adoption may improve the rate of adoption considering that they are more less the same in most of the study area.

3. The holding of workshops and the short duration of the seminars offered for leaders to acquire knowledge and skills so as to train the rest of the community and may contribute to low adoption of the biogas technology. The leaders in the community are expected to train the rest of the community. But the level of education may hamper the dissemination of the knowledge and skills expected to have been attained from the workshop due to low education as revealed by the bio data of most members of the community. This results in fragmented information being passed on as some leaders may have forgotten the details. Also some members end up accessing information on the technology from neighbors who themselves lacked sufficient information on the technology consequently affecting adoption.

4. The promoters of biogas technology seem not to understand their clientele and they do not take into consideration previous findings on the technology adoption. For instance they should try to understand the economic differences of their clients, their age, level of education and family size. This is necessary so that they are sure their clients meet the basic requirements to adopt a biogas plant before going to an area to start doing the promotion. Having information on for instance the level of education of a client will help the promoter know how best to disseminate the information may be posters may
work better than just words. In this way information dissemination will be more effective.

5. Technology transfer biases may contribute to low biogas technology adoption. For instance the biogas promoters and extension officers visited urban centers and followed tarmac road and avoided going deep in to the villages where the majority are. This means only those who live along the tarmac road got the training. Furthermore the promoters of biogas technology may have had gender bias. Since most government staff and other rural visitors are men, they establish contact easily with men and they neglect the female farmers who work very hard and are expected to implement the technology. The female will not be in a position to adopt a technology they know nothing about hence the continued low status of technology adoption.

6. Inadequate research facilities and equipment has impeded biogas technology adoption. The lack of research into the right size and most cost effective biogas digesters that can be adopted by different levels of households has contributed to low adoption status. The promoters are promoting biogas technology without really understanding what the best is for Kilifi County households given their socio economic and geographical environment.

7. Poverty in the area occasioned by low agricultural productivity which is the region’s main livelihood due to poor climatic conditions is one of the main causes of low adoption of biogas technology. This is attributed to the erratic rainfall, 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.

8. 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 construction of biogas plantas alternative source of fuel. This is because, according to cultural norms and values, it is woman’s responsibility to source for fuel. Lack of education affects their economic empowerment. It is important to note that levels of education do play a major role in ensuring better economic status, improved household income and availability of technical services.

5.5 Policy Recommendations

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

1. Establishment of sustainable institutional framework.

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. The institutional framework should include:

i) Research

Inadequate research facilities and equipment and operating budget can impede the generation of technology that is adoptable by households at various levels of
income. The Ministry of energy in collaboration with research institutions in Kenya should facilitate researchers to engage in research that will enable them to identify, develop and disseminate most current biogas technologies that are more affordable by all households irrespective of their ability and one that is especially suitable to Kilifi County.

ii) Education and training of well trained technicians

Inadequate number and qualifications of staff in the field of biogas as source of alternative energy are limiting. The government Ministry of Energy should address this limitation by establishing staff and training plans. The staffing plan should have the record of the current human resources, identifiable staffing gaps and projects staffing needs over a specified period of time. The training plan should identify the specific type of training (in-service and formal) required to fill the skill gaps in the human resources and to cover staffing needs in the field in Kilifi County. The training for the staff for specific qualifications and needs should be in coordination with the educational organizations. To make training attractive the County government and educational organizations should work out and offer scholarships in the area of biogas technology.

iii) Supply of input

Households need inputs to adopt biogas technology, but access to these is often poor in rural areas in which Kilifi County is included. The County government needs to develop communication and coordination linkages with private and non-profit organizations so as to provide input and
advice to households on alternative source of energy that will contribute to the conservation of environment consequently healthy population.

iv) Credit facility

Access to credit is one way to improve adoption of biogas technology by households since the technology requires financial support. Household’s ability to purchase input such as cement, sand, gravel and water is important for the construction of the biogas plant. The Energy Centre under the Ministry of energy in collaboration with the Ministry of Agriculture at the County government should examine the existing credit situation so that factors affecting the adoption and use of the biogas technology can be identified and addressed to allow households to be empowered on availability and access of credit facilities that can enable them construct and utilize biogas plants.

2. Poverty

Poverty is a major factor that contributes to the root causes of the determinants of biogas adoption. The County government should come up with programs and projects to tackle poverty. For instance, introduction of irrigation projects to improve agricultural productivity and income and establishment of cottage industries to provide off-farm employment opportunities. These approaches that will support education levels and consequently result in improved livelihoods that enable farmers to afford the cost of biogas technology.

3. Socio-cultural
Addressing the negative social-cultural values and norms such as early marriage of girls and the patriarchy system in the society is an important factor in enhancing biogas adoption. The County government in conjunction with the Ministry of Gender and Social services need to create awareness on the importance of education for both boys and girls. Women and men are equal partners in development and thus both of them need to be empowered to participate in economic development by being given same opportunities in all spheres of life. This will enable them to contribute positively to environmental conservation through making wise decision on energy sources which are economically viable and do not degrade the environment.

4. Formation of community based groups

The residents should be encouraged to form and join community based organizations. The organizations can offer credit and saving services to members or as a group the members can secure a loan to assist each other in construction of biogas plants. The CBOs can also serve as points of training to members on biogas technology. In the community based organizations they can even organize for harambee and construct a community based biogas plant to serve a number of households in a locality.

5. Tax rebates and stimulation investment in biogas production and distribution

Local investments into biogas projects should be enhanced and encouraging local investors to invest in biogas projects to generate revenue and mitigate climate change.
5.6 Areas for further research

The following are suggestions for further research that should be undertaken on the feasibility of most viable types of digesters in the area.

1. Municipal waste has been used to generate biogas in other parts of the world. A study should be carried out to determine the possibility of this within the study area.

2. It is important that a study is done to establish the viability of biogas production from crop residues grown in the area. Since cow dung is the only known feedstock for biogas production and some people do not own cattle but they have crops.

3. Research should be undertaken to determine efficient digesters of different sizes to suit different economic needs and status of the households.
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APPENDICES

7.1 Appendix I: Map of Kilifi County

Figure 7: Map Showing Kilifi County

www.flickermaps.com Retrieved 10/6/13
7.2 Appendix II Questionnaire

Analysis of Biogas adoption in Kilifi County

I am a student at Pwani University and as part of my study program am required to undertake a study in my area of specialization and therefore, am undertaking a study to analyze biogas adoption among households in Kilifi County. To this end you are kindly requested to answer the following questions regarding adoption of biogas.

Your response will be highly appreciated and will be treated with confidentiality and it will only be used for academic purposes.

Please do not enter your name or contact address on the questionnaire. Thank you for sparing your time to assist.

Social-demographic characteristics

1) Sex of household head (1. Male ......... 2. Female)

2) Age of household head
   a) below 20
   b) 21-30
   c) 31-40
   d) 41-50
   e) above 50

3) Highest level of education of household head
   a) None
   b) Primary
   c) Secondary
   d) Tertiary (Certificate, Diploma, Degree)

4) Size of household
   a. 1-4
   b. 5-8
   c. Above 8

5) Occupation of household head
   a. Farmer
   b. civil servant
6) Average monthly income do you fall?
   a. Less than Ksh 5,000
   b. 5,000-10,000
   c. 10,000-20,000
   d. Above 20,000

7) Type of livestock do you keep and types of crops grown

<table>
<thead>
<tr>
<th>livestock kept</th>
<th>crops grown</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>i</td>
<td>i</td>
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<tr>
<td>ii</td>
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</tr>
<tr>
<td>iv</td>
<td>iv</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
</tr>
</tbody>
</table>

8) How many cattle do you keep?
   a. None          b) 1-5          c) 5-10          D) Above 10

9) Land size
   a) Less than 2 ha b) 2-5 ha c) 5-10 ha d) Above 10 ha

10) Main Sources of energy for cooking?
    a) Kerosene
    b) Charcoal
    c) Firewood
    d) Solar
    e) Electricity
    f) Biogas
    g) LPG (gas)
    h) Other-specify

11) Fuel expenditure per month
    a. Less than 1000 ksh b) 1000-3000ksh c) 3000-5000ksh d) Above 5000ksh

Part two: utilization and adoption of Biogas

Please respond to the following questions

12) Have you been engaged in biogas production?
a. Yes......... b) No.........

If NO to question 12 above go to question 13-15, 25-29
If YES to question 12 above go to question 14-28

13) What are the major reasons for not engaging in biogas production? use a tick

   a. Number of cattle owned............
   b. Lack of space (land size).............
   c. Initial cost of installation..........
   d. Education of household head.......  
   e. Unavailability of technical service... 
   f. Gender of household head.............
   g. Unavailability of household labor.....
   h. Lack of loans and subsidies.......    
   i. Age of household head
   j. Any other.............

14) Do you access to technical services
    Yes
    No

15) Do you have access to loans
    Yes
    No

16) What is your view of biogas as an alternative source of energy?

   a). Very expensive to install 
   b). Requires technical skills 
   c) Requires education 
   d) Requires large land size 
   e) Very complicated 
   f) Labor intensive 

For biogas users 

17) For how long have you been engaged in biogas production?

   a) 0-5 years
   b) 5-10 years
   c) Above 10 years

18) Are still engaged in biogas production?
19) If No give reasons if yes go to question 20
   a) Lack of technical services
   b) Feeding related problems
   c) Insufficient labor
   d) Cost of maintenance
   e) Lack of water

20) What type of biogas digester do own?
   a) Floating drum
   b) Fixed dome
   c) Flexi-biogas

21) What is the size of your digester?
    4m\(^3\) ... 6m\(^3\) ...... 9m\(^3\) ..... other..

22) Who initiated the idea of biogas to you?
   a) Biogas researcher
   b) Ngo
   c) Government extension officer
   d) Friend, relative or neighbor
   e) Politician
   f) Other

23) What was the major reason for starting a biogas plant?
   a) Own interest
   b) Problem fuel for domestic use
   c) Encouraged by extension officer
   d) Influenced by friend with biogas plant
   e) Awareness of environmental problems
   f) High cost of other energy sources

24) What was the source of initial capital for construction of the biogas plant?
   a) Own savings
   b) NGO support
   c) Government support
   d) Cost sharing with NGO or Government
25) What type of substrate do you use for generating biogas?
   a) Animal waste: cattle dung, Chicken droppings, Sheep droppings, goat droppings, pigs dung
   b) Crop residues: Maize stalk, Rice straw, Maize cobs, Grass trimmings,
   c) Forestry residues

26) What do you use it for
   a) Cooking  b) Lighting
   a) Ironing  d) other (specify)...........

27) What are the benefits(use a tick)
   a) Easy and fast in use
   b) Clean, no soot as compared to fuel wood
   c) Low running cost after installation costs
   d) Saving time used for firewood collection
   e) Others
      (specify).....................................................................................................

28) What do friends and neighbors think of your biogas system?
........................................................................................................................................
........................................................................................................................................

29) Are there any challenges you face in operating the biogas plant?
   a) Technical problems  b) Feeding related problems
   b) No enough labor  d) others
      (specify).........................

Promotion of biogas technology
30) Are there regular campaigns, seminars for promotion of biogas technology in your area?
   
   a) Yes
   b) No

31) In your view how can biogas production and utilization be promoted in Kilifi?

........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
7.3 Appendix III: Observation Schedule

1. Biogas plant
   - Present
   - Absent

2. Status of plant
   - Complete
   - Incomplete

3. Structural problems
   - Cracked digester
   - Chocking of outlet/inlet
   - Broken or leaking pipes
   - Shortage of cow dung
   - No gas

4. Presence of cattle

5. Cattle rearing method
   - Free range
   - Zero grazing


7.4 Appendix IV: Focus Group Guide

1. What are the major energy sources in your area?

2. Is there energy problem in your area? If yes to what extent

3. Do you see a need for alternative energy sources? If yes which alternatives do you think are appropriate to your area?

4. What is the acceptance status of biogas technology in your area, do you think the technology has been adopted to the expected level.

5. If you think adoption is low what are the reasons?

6. What do you think could have contributed to other people adopting the technology and others not?

7. Some people adopted the technology and stopped using it in the way. What could be the reasons?

8. Some people think biogas technology is not an appropriate technology and its advantages are less compared to its advantages. What is your opinion?

9. Are people really aware of environmental and health problems that come as a result of using firewood as a source of energy?

10. Do you have enough knowledge about biogas to the extent of being able to share the information with others? If not what areas do you think need more education/training?

11. In your opinion what kind of strategies can be put in place to enhance adoption of biogas in Kilifi County?

12. Is there sufficient water in this region for biogas production?

13. List in order of importance what factors affect biogas adoption

   Age of household head

   Size of household

   Economic status of household

   Number of cattle owned

   Size of land
Lack of technical services
Cost of traditional fuel
Education level of household head
Environmental problems
Gender of household head
Water problems

Section B: Focus group discussion on the underlying factors of the determinants of biogas adoption

1. What are the reasons for low school enrollment?
2. What are the reasons for high school dropout rates?
3. What are the reasons for low income in households?
3. What are the reasons for lack of technical services?
7.5 Appendix V (A)(English): Consent Form

RESEARCH ETHICS CONSENT FORM

Analysis of Biogas adoption among households in Kilifi County, Kenya

PART A: GENERAL INFORMATION ABOUT THE STUDY

You are kindly requested to participate in this research study Analysis of biogas adoption in Kilifi County. The study will be conducted by Momanyi Ruth Kwamboka who is a Masters’ student in the department of Environmental Science, Pwani University.

Participation in the study is voluntary and you will be required to fill out questionnaire soliciting for relevant information on the subject of the study and also answer oral questions.

Your involvement in this study may not benefit you directly but the information you will give will assist me to learn more about determinants of biogas adoption and probably come with recommendations on the way forward. If there is a question you do not wish to answer you can skip it.

I assure you that all the information you share with us throughout this study will be kept confidential. Study findings will be presented in summary and your name will not be used in any report.

For more information about the study please contact:

Ruth Momanyi, Mob 0722971762 E- Mail ruthmovi@gmail.com.

Kindly note that this study has been reviewed and approved by the Ethics review Committee (ERC) of Pwani University whose mandate is to make sure that participants are safe. For more information please contact the ERC Secretariat at Pwani University.

PART B: CERTIFICATION OF CONSENT

I have read and understood the information above I have been answered all questions to my satisfaction. I hereby give consent to participate in this study as a respondent.

Name..............................................................................................................

Signature........................................Date.............................................
7.6 Appendix V: (B) (Kiswahili: FOMU YA IDHINI

IDHINI YA KIMAADILI YA KUFANYA UTAFITI

Anwani: uchambuzi wa matumizi ya mvuke

SEHEMU YA A: UTANGULIZI

Madhumuni ya waraka huu ni kukuomba kuchangia katika utafiti kuhusu uchambuzi wa matumizi ya mvuke katika kaunti ya Kilifi. Utafiti huu utaendeshwa na Bi. Ruth Momanyi ambaye ni mwanafunzi wa uzamili katika idara ya Mazingira na sayansi Chuo Kikuu cha pwani.

Kuchangia katika utafiti huu ni kwa ihari na mshiriki anapokubali kuchangia atahitajika kuchaza fomu za hojaji na ashiriki kwa mahojiano yaana kwa hana na mtafiti. Mshiriki ana uhuru wa kutojibu maswali ambayo hana majibu yake.

Tunawahakikishia watakaoshiriki katika zoezi hili kwamba habari tutakazozikusanya kutoka kwao katika zoezi zima zitahifadhiwa vyema na zitatumika kwa madhumuni ya utafiti huu pekee.

Pendekezo la utafiti huu limakaguliwa na kuidhinishwa na Bodi ya Maadili na Ubora ya Chuo kikuu cha Pwani ambayo inahusika na maswala a utafiti. Pia inajihusisha na kuhakikisha haki za wanaoshirikishwa katika utafiti zimelindwa kwa njia zote.

Kwa maelezo na marejeleo zaidi wasiliana na: Ruth Momanyi: Nambari ya Simu: 0722971762 Barua pepe: ruthmoyi@gmail.com

SEHEMU YA B: KUBALI IDHINI

Nimesoma habari iliyopo hapo juu nimeuliza maswali na nimeridhirika na majibu niliyopewa. Ninatoa idhini ya kushirikishwa kwa ihari katika utafiti huu.

Jina.................................................................

Sahihi.................................................................

Tarehe.................................................................
7.7 Appendix VI: Research Permit
7.8 Appendix VII: Research Authorization Letter