AN ASSESSMENT OF FACTORS INFLUENCING THE CHOICE AND ADOPTION OF BIOGAS TECHNOLOGY AMONG THE PERI-URBAN RESIDENTS OF KISII COUNTY

BY

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AUGUST 2014
DECLARATION

I declare that the work incorporated in this research project is my own original work and it has not been submitted and will not be presented to any other university or any other institution of higher learning for a similar degree award.

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DEDICATION

This report is dedicated to the Almighty God, to who all the glory and honor is by His mercy and grace; I have been able to accomplish this work. Secondly, I dedicate this report to all Governmental and non-governmental institutions involved in promoting biogas technology in Kisii County. Also to the hardworking and optimistic farmers of Kisii County who have seen the importance of investing, adopting and embracing biogas technology for environmental sustainability of Kenya and the World at large.
ACKNOWLEDGEMENT

The completion of this work would have not been possible was it not for the contributions of various personalities, organizations and institutions. It is not easy to mention everybody here by name, but allow me to sincerely wish to express my gratitude to them all.

I am indebted to my supervisors, Mr. Wilson Nyaoro of Kenyatta University for whose professional guidance, encouragement, constructive criticisms and comments has resulted to the success of this work. I also thank Mr. Allan Kirui who partly supervised me and Prof. Simon Onywere all from Kenyatta University who gave me an insight on research methods.

My fieldwork would not have been successful without support and cooperation of local administrators and officials in institutions and organizations in Kisii County head offices. I sincerely appreciate the contributions of Mr. Dominic Simbe from the Ministry of Agriculture, Livestock and Fisheries who was very instrumental in linking me to the resource persons such as NALEP and biogas farmers. Mr. Samuel Maina from the Ministry of Energy, Department of Renewable energy and Petroleum who tirelessly helped the researcher to identify the various institutions dealing with biogas technology as well as availing relevant information for literature and research and managers of agencies and organizations such as NEMA,HIVOS,GTZ. St. Barbara CBO group and farmers who gave their time to answer research questions with honesty and sincerity, community members who volunteered to guide the researcher to resource persons who had the experience of biogas technology.

Last, but not least, I am indebted to my family, my father, Gilbert Bundi and my mother, Sarah Moraa, and dear aunt, Susan Nyabuto through their prayers, financial and moral supports contributed to the psychological calmness during the course of my study.

MAY THE ALMIGHTY GOD BLESS YOU ABUNDANTLY
ABSTRACT

Biogas technology in Kenya dates back to the 1957. Efforts to promote the technology in most potential areas had not been effective in the country until May 2007 when the plan for implementation of national biogas energy programme started with the formation of the Kenya Biogas Task Force. Despite the potential and demand the adoption level has been low and on a decreasing rate. The study sought to assess the level of people’s awareness and attitude towards biogas technology, to explore the root causes of low technology adoption in relation to the efforts so far executed in biogas promotion, to assess the efficacy of biogas technology in comparison to other sources of household energy and sought to explain the roles and challenges stakeholders face in their effort to promote biogas technology in Kisii county.

Multi-Stage sampling procedure involving purposive selection of resource persons who have been reached by biogas programmes with the purpose of capturing the experiences of biogas users and potential adopters. The study was conducted in the peri-urban of five town centers in Kisii County namely: Kisii, Sunek, Mosocho, Marani and Kiogoro. The study adopted both qualitative and quantitative approaches in data collection and analysis. A conceptual framework based on the adoption theories guided the analysis of factors influencing biogas adoption. Study findings show that 85.71% of the population was aware of the technology and only 114 units of it in 2007 and 167 units as by 2013 December. Biogas technology adoption has continued to decrease. The decrease has been associated with reduction and subsequent withdrawal of subsidies for biogas plant constructions.

Based on the results of factors influencing biogas technology adoption in the area, starting from the most influential to the least are: high installation costs of plants, multiple use of household fuels, level of income and education, promotion of the technology, and from the experience of biogas users, biogas was very efficient when well maintained and very clean, no health implications were reported though they complained of inadequate combustion efficiency to provide more energy for cooking and inadequate or rather lack of facilities and appliances such as stoves and lamps. There was minimal coordination between stakeholders and lack of a central coordinating body. The study further identified that the government institutions have not fully engaged in promoting biogas technology in the area and instead the responsibility has been left to NGOs without effectual intervention on other factors including information dissemination, access to credits motivation and coordination.

Based on the study, the researcher recommends that first the ministry of energy should harmonize the policy on energy and environment so as to uphold biogas technology as an alternative clean green
energy, secondly there is need for a central biogas coordinating body at the national and regional level to coordinate and monitor stakeholder roles as well as financial management and also introduce technologies that are cheap such as the plastic tubular design through enhanced research.
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CHAPTER 1

1.0 INTRODUCTION

1.1 Background to the Problem

The year 2012 was declared the year of sustainable energy for all by the United Nations in recognition of the importance of energy for sustainable development (UNEP, 2012). This recognition presents an opportunity to raise awareness about the importance of increasing sustainable access to energy, energy efficiency, and renewable energy at the local, regional and international levels.

Energy is central to everything that we do, from powering our economies to empowering women, from creating job opportunities to improving security (Ban Kimun-UN Secretary General, 2012). Provision of adequate, affordable, reliable and efficient energy lies at the heart of every country's core interests. For instance, in Kenya, Vision 2030 highlights ways that Kenya can be sufficient in energy supply (NESC, 2006).

Now more than ever, the world needs to ensure benefits of sustainable modern energy is available to all. Energy poverty is a threat to the realization of the Millennium Development goals (MDGs). The World Summit for Sustainable Development (WSSD) in the Johannesburg Plan of implementation made a call for the International community to take joint action and improve efforts to work together at all levels to improve access to energy services for sustainable development sufficient to facilitate the achievements of MDGs (ESMAP, 2002a). Promotion of modern energies should be an integral part of all government policies. Wider access to energy services is not only essential in achieving Vision 2030 in Kenya, but also in achieving all the MDGs (Modi, 2006).

Worldwide, more than two billion of the population lack access to clean and safe fuel thus rely on traditional biomass burning such as fuel wood, crop residues and cow dung (UNDP, 2000). Such fuels are used mostly in rural areas, though wood is also used as fuel by the urban poor (World Bank, 1996). Statistics show that nearly 2.4 billion people rely primarily on traditional biomass fuels for cooking and nearly 1.6 billion have no access to electricity network Worldwide. The World is hungry to global challenges and recognition of modern energies that are CFC-free provides multiple opportunities to enhance equity, revitalization of the global economy and helps to protect the
ecosystems that sustain the World.

Unsustainable use of fuel wood has detrimental effects on the environment, productivity and human health (Mwakubo et al., 2007). The use of inefficient and unsustainable energy sources leads to environmental degradation through deforestation of forests and woodlands, reduced agricultural productivity due to erosion and imbalanced rainfall regimes, and respiratory disorders due to smoke inhalation (World Bank, 2006). Indoor air contaminated with particulates, carbon monoxide and formaldehyde has been ranked the forth course for premature deaths in the developing countries (Bruce, 2000). About 1.6 million women and children die each year from exposure to indoor pollution (IEA, 2006), as they spend much of their time indoors in houses with limited ventilation.

Developing countries have used fuel wood as the major source of energy over history and still the primary source of fuel for nearly half of the world population (Enger, 2006). Wood fuel is becoming scarce. People in the developing countries are in daily struggle to find enough fuel to warm their homes and cook their food (Cunningham et al. 2007). Shortage of fuel wood encompassing firewood and charcoal, imposes heavy costs on urban and rural consumers alike (Wawa, 2012). Women in particular, are the major victims of the domestic energy crisis.

Kenya's energy is dominated by traditional biomass of firewood, charcoal and agricultural waste, a bulk of which is used in rural households and small businesses. The country is also dependent on hydro-power whose potential has dramatically reduced in the past 20 years due to the destruction of water catchment areas, yet the country's demand has grown as high as supply leaving a reserve margin of about 7% (MoE, 2011). Day (2010), postulated of having an energy gap of 23% in the 2015. Though the approximation seems higher, it is not very far from reality. There’s therefore an urgent need to look for alternative sources of energy which are sustainable and affordable to the majority who are mostly in rural and urban areas.

With the impacts of climate change, the situation is likely to worsen. This is because the country experiences prolonged drought and flooding that fluctuates the water levels and therefore the hydro power production potential. In order to address such challenges, the response strategy has given a lot of emphasis on Green Energy options, which are sources of energy with zero or low levels of greenhouse emissions. Such energy sources include hydroelectric power generation, geothermal, wind, solar and renewable biomass sources.

It is believed that the biogas technology would benefit the societies by providing alternative clean fuel
in form renewable biomass, biodegradable municipal and industrial wastes and help end energy poverty in rural and urban setting (Parawira, 2009). Nes and Nhete, (2007) advocate that biogas technology is an excellent tool for improving life, livelihoods and health in the developing world and that it is a service that is broader than just energy supply. It uplifts the dignity of women and improves their health and the hygienic conditions of families.

Biogas will be viable when the prospective acceptor is driven to the necessity of encountering physical limit to the amount of fuel available from the traditional sources. The benefits of biogas technology mean that it can contribute to integrated development. However, if the technology is to play a more extensive role in Sustainable development then solutions to the dissemination problems have to be found (Hulscher et al. 1994).

The Sessional Paper No. 4 on energy connotes that despite the massive potential of Kenya to harness and exploit biogas technology its uptake is still very low. For instance, majority of households in Kisii region still rely on fuel wood as their main source of household energy and this accounts for 80% of the total energy requirements (RoK, 2002). Awareness has been created in the rural and urban areas of the region on the need to switch to greener and effective alternative energies, whereby biogas forms the best alternative but in spite of this efforts and the apparent potential in the County, technology uptake in some areas has been generally slow, (KNDB, 2011). The study therefore aims to examine the root causes for the low level of biogas technology uptake in the Peri-urban settlements of Kisii County in comparison to promotion efforts so far executed.

1.2 Statement of the Problem

Wood fuel scarcities, dramatic increase in fuel prices in both at the local and an international market coupled with high population pressure on land are the challenges facing the rural and urban people of Kisii County. 80% of households in Kisii region still rely on fuel wood as their main source of household energy (RoK, 2002). Apart from over dependence of biofuels, the problem has been amplified further by increased land fragmentation that minimizes vegetation recovery through afforestation and reforestation programmes in the area.

The current forest cover in Kenya is estimated to be less than 2% so far away below the international threshold of 10% (NEMA, 2010). Kisii County has no gazetted forest, and the existing non-gazetted forests are facing excision due to high wood fuel and forest product demand (KCIDP, 2013). Poverty among the people has been identified as a major constraint of energy switching among the Kisii people.
Majority of the households in the area cannot afford modern and efficient sources of energy such as LPG and Solar due to their high costs of installation hence the need for an alternative source of household energy in the area.

The increased deforestation in Kisii County as a result of fuel wood extraction to meet the energy demand for the rural and urban residents has strained the resource hence the available wood is not enough to satisfy the area's fuel-wood demand. Consumption of wood fuel is itself not an issue but once the resources are reaped unsustainably and energy conversion technologies are inefficient, there are severe adverse effects on health, the environment and economic development.

A potential option towards reducing both urban and rural demand for wood fuel is through having a shift switch to use renewable energies. Despite the efforts made in introducing bio-energy programmes or interventions and their apparent advantages, such efforts have met with finite success. Biogas technology in particular is yet to be exploited fully as an alternative source of energy in Kisii County despite its rank as high potential area for adoption of biogas technology (PID, 2009).

Previous studies in the region have identified barriers which affect large scale biogas technology dissemination in the region such as inadequacy in information on its production and operations, potential benefits and prohibitively high costs of installation (Nyaoro et al., 2010). Seemingly, the factors identified by these studies are a manifestation of promotional factors which have not been deeply studied. The study therefore aims to examine the root causes for the low level of biogas technology uptake by the residents of the Peri-urban areas of Kisii County in comparison to promotional efforts so far executed.

1.3 Research Questions

The following questions were postulated to guide this study:-

1. What is the level of awareness and attitude towards adopting biogas technology?

2. What are the factors influencing the choice and adoption of biogas technology?

3. How does biogas compete in efficiency with other sources of household energy in the region?

4. Are there institutions creating awareness and sensitization on the shift to adopt modern, cleaner and efficient fuels in Kisii County? And if so, what challenges do they face as they endeavor to execute their roles and responsibilities?
1.4 Objectives of the Study

The main objective of this study was to explore the root causes for low adoption of biogas technology as an alternative source of household energy among the Peri-Urban residents of Kisii County.

1.4.1 Specific Objectives

The specific objectives of this study include:-

1. To assess the level of people’s awareness and attitude towards biogas technology.

2. To explain the main factors influencing the adoption of biogas technology among the residents in the study area.

3. To assess the efficiency of biogas technology as compared to other sources of household energies within the area of study.

4. To explain the roles and challenges stakeholders face in their effort to promote biogas technology in Kisii county.

5. To prepare an action plan for sensitization and awareness creation about biogas technology among the Kisii County residents.

1.5 Research Premise

The research was carried out based on the following premise:-

1. Access to information on biogas technology is limited to a few individuals hence residents in the area are not aware of its potential benefits.

2. Multiple use of fuel is just among the many factors influencing switching to cleaner and efficient fuel technologies among the Kisii Peri-urban residents.

3. Biogas technology has higher efficiency compared to other sources of household fuels in Kisii County.

4. Lack of stakeholder coordination, support and capacity on biogas technology has been a barrier to its widespread adoption in the county.
1.6 Justification of the Study

Kisii has been ranked one of the highest potential areas for biogas development in Kenya by the Kenya Domestic Biogas Programme (KDBP-PID, 2009). Statistics show that 51 per cent of the people in Kisii county live below the poverty level, hence most of them find it difficult to afford conventional and advanced fuels such as LPG, kerosene and solar energy due to their dynamic and high costs (KIDP, 2013). The population therefore gets it a big challenge to shift from traditional fuels to modern fuels. Fuel wood and charcoal are dominantly used in the area to provide fuel as in any part of the Peri-urban area of Kenyan towns. Multiple use of fuels is exhibited also despite the fact that such fuels are not efficient for use in less ventilated housing due to their excessive smoke from incomplete combustion.

Continued over-dependence on bio-fuels, increasing population and tea industries that use fuel wood in their furnace stoves, land fragmentation and inadequate public awareness to switch to convenient fuels in Kisii Peri-urban settlements has resulted to unsustainable fuel wood consumption in the area hence massive deforestation of catchment areas to supply firewood and charcoal to the urban residents, increasing incidences of respiration disorders among the users, limited potential for afforestation and reforestation programmes due to land fragmentation and minimum acreage. Due to this challenges there’s urgent need for an alternative source of energy technologies that are efficient, reliable readily available at an affordable cost where biogas forms the best option.

The study took place in the Kisii Peri-Urban areas owing to the fact that this is a potential transition zone that captures the urban and rural population as well as the study population. The area is the most affected by the power outages resulting to frequent blackouts. The area practices both dairy and urban agriculture to supply to the town's population. Furthermore, the population has access to Municipal biodegradable wastes which would provide the source of material for development of modern energy for lighting, cooking and refrigeration.

Sessional Paper No. 4 on Renewable energy recognizes the contribution of renewable energies to the country's energy supply matrix in which biogas provides cleaner, affordable and environmentally friendly alternative. Regrettably, the benefits of adopting and promoting the technology have not been comprehensively documented. As a result, few research studies have been done on the causes of low adoption, efficiency of biogas in comparison to other household fuel, benefits and challenges of adopting the technology especially in the Peri-urban settlements.
There’s pressing need for a transition from traditional conventional energy systems to modern cleaner technologies based on renewable resources to meet the ever increasing demand and to tackle the problem of energy efficiency, energy dependence, energy security and cost, as well as utilization of organic municipal waste to produce viable energy that can boost economic growth envisaged in Vision 2030. Therefore this is an opportunity which would not be foregone.

1.7 Significance of the study

The findings of this study would contribute to better understanding of the root causes of low adoption rate of biogas technology in potential areas. From this, the relevant stakeholders involved in promoting the technology would set strategies to increase its adoption hence as pointed out earlier, biogas dissemination and adoption would reduce deforestation and this will be a major stride to achieve 10% forest cover in Kenya, save time wasted in firewood collection and in turn increase women participation in other productive work. Further, the technology would improve in health by reducing the respiratory disorders from smoke and ensure continued and increased agriculture productivity from the organic fertilizer yielded as the end by-product of the technology hence enriches the lives of users.

The study needs to establish the underlying factors, drivers and household motivations in household energy use would assist policy makers in designing policies that will enhance household welfare while sustaining the environment as stipulated in the Millennium Development Goals and Vision 2030 (NESC, 2006). Consequently, following the enactment of the National Energy Policy of Kenya 2012, the findings of this study could expose some areas which need improvement as far as energy choice and adoption is concerned since the previous policies in Kenya have poor and inadequate empirical literature foundation due to few studies done on the subject. As such the study will contribute to future County and National energy policies.

In addition, the findings would provide additional knowledge to the present literature on bio-energy technologies about the potential of agro-based residues to be used as raw materials for renewable energy source and also expose the opportunity in biodegradable municipal waste as a solution to energy shortages in the County.

The findings would further come up with the sensitization and awareness action plan for the County on biogas technology which would be duplicated at the local and national levels to facilitate energy switch to achieve sustainable development. It is also anticipated that the study would also stimulate interest on more researches in the field of renewable energy sources as well as facilitate new technological
improvements in biogas production, efficiency, quality, management of surplus gas.

1.8 Scope of the Study

The study was carried out among the Peri-Urban residents of five urban centers lying within the jurisdiction of Kisii County which covers an area of 1318 Km$^2$ capturing the rural-urban transition zone of five Urban centers namely; Kisii, Marani, Suneka, Mosocho and Kiogoro. The study involved a sample of 45 households that consisted of adopters and those who had not adopted the technology. The study assessed the level of people’s awareness and attitude towards biogas technology, explored the factors influencing the choice and adoption of biogas, the efficacy of biogas technology in comparison to other sources of household energy and sought to explain the roles of stakeholders and the challenges they face in promoting biogas technology.

1.9 Limitation of the Study

The study encountered a number of problems which were not beyond the researchers copinging capacity. Some respondents hesitated to fill questionnaires or rather partially fill them. This was overcome through explaining to them the purpose of the study question and giving them time to peruse through the questions before they answered and further assuring them anonymity and confidentiality of their answers. Alternatively, where we could not strike an understanding, I would opt to move to the next household since I was using stratified random sampling.

Institutional interview schedules were not done within the set time-frame because most of the officers were in leave and being a festive season, some of the cooperating officers who would help to give relevant information pertaining biogas technology had left for the festive season. I had to book appointments for later consultation and data collection which happened to work out.

There was strain of resources such as time and finance. Time was limited for collection of data and the problem was exacerbated by short rains that interrupted the schedules. Travel and printing costs were a challenge since the project was not sponsored. This was overcome by restricting the questionnaire administering to morning hours before it rained in the afternoons. I had to make questionnaire mark sheets to cut the expenses of printing many questionnaires. The mark sheets worked effectively and eased data analysis.
Definition of terms

Energy services-Refers to the benefits produced by using energy supplies, generated from a variety of primary energy sources-oil, gas, coal and other renewable.

Biogas- A gas produced when biodegradable materials are acted upon by methanoic bacteria in the absence of oxygen by the process known as anaerobic digestion. Biogas consists mainly of 50-70% Methane, 30-40% carbon dioxide and low amounts of other gases.

Green energy-energy sources with zero or low levels of greenhouse emissions.

Technology-the way people use knowledge, tools and systems to make their lives better and easier.

Fuel switching-the choice to completely shift and use a new fuel.

Combustion efficiency-refers to the fraction of airborne carbon emissions that are releases as carbon (iv) oxide.
CHAPTER 2.0

2.0 LITERATURE REVIEW

This chapter explores empirical literature studies related to awareness of energy situation and biogas technology, factors influencing the choice and adoption of household fuels, the comparative efficiency of household fuels as well as the roles and challenges facing stakeholders in promoting the adoption of biogas technology. There is also an analysis of the various theories surrounding the choice and adoption of technology and fuels in terms of household behavior.

2.1 Level of Energy Shortage awareness and use of biogas technology

The World nations are aware of the creeping energy and environmental crisis. The mark of the year 2012 as the year of sustainable energy for all by the United Nations and the recognition of the importance of energy in sustainable development shows recognition of the World nations awareness of the creeping energy crisis and the implications of using inefficient energy technologies if measures are not put in place to counteract the predicted situation (UNEP, 2012). The states further recognized the environmental, social and health implications of using traditional fuels and further echoed the need for governments to raise an awareness about the importance of increasing sustainable access to energy, energy efficiency, and renewable energy at the local, national and international levels (EASWN, 2012 and ESMAP, 2002a).

Sufficient energy is supply is needed to improve the living conditions to allow more time for education, improved health services and production and eventually allow establishment of small businesses. Sustainable and efficient supply of energy is essential in the realization of all Millennium Development Goals (Modi, 2006). This awareness has influenced the governments take initiatives to provide renewable energies that are cheap and invest more on the energy sector.

East Africa is facing growing energy demands alongside rising levels of fossil fuel consumption coupled by acerbated cost. Together with the growing urban populations and deforestation, greenhouse gas emissions are increasing, hats why there is need for renewable energies (UN Secretary-General Ban Ki-moon, 2012). For many years there have been predictions that energy supplies particularly fossil fuels would run out and cause recessions from which the world would not recover. Production of oil, gas and coal would not be available to keep indefinitely the growing global demand, (Day, 2010). According to Day, at some stage there must be a supply gap. Recent reports as quoted by Day,
estimated that there will be a gap of 15% of energy supply by 2010 rising to 23% in 2015 and 32% in 2020.

He further comments that as the World fields decline, the prices will rise as it was evident in the year 2008 where prices rose from 100 US dollars to 139 US dollars per barrel against a long term trend of fewer than 50 dollars. What this data indicates is that there is an increasing energy supply gap caused by diminishing supply of non-renewable energy sources hence demand for alternative renewable energies to fill the gap.

In developed countries, energy for cooking, heating and lighting is readily available at a relatively low cost. This is due to the fact that being aware of the energy predicted energy shortages, they have invested in both the centralized sources and extensive distribution systems to make the energy available to the citizens and business (Wawa, 2012). On the other hand, developing countries, processing and cooking food is accomplished mainly by biomass energy where women spend significant part of their time during the day gathering fuel wood and are exposed to harmful smoke and other by-products of burning organic material (English Articles, 2010).

Kenya’s being aware of the energy implications to the realization of the Millennium Development Goals has laid strategies in her development blue print objectives that are aimed to meet each of the goals 1-7 (Gok, 2003). There is an awareness as the plan recognizes the need to provide adequate, sustainable and cost-effective energy, which is an economic driver to achieve these objectives. However such recognition, the energy policy of Kenya has not spelt the benefits of renewable energies such as biogas and strategies to promote the technology which may be attributed to the low technology uptake.

Presently, Kenya has not provided enough energy that is readily available, reliable and affordable to its population both in the urban and rural areas. Our towns are experiencing power rationing and frequent blackouts which take hours to days. Further the country still relies on imported energy such as crude oil and electricity which strains the foreign earnings that would develop the country. Currently, the country uses 40% of foreign exchange earnings on crude oil importation (EASWN, 2012).
2.2 Biogas technology awareness in Kenya

A technology is people using knowledge, tools, and systems to make their lives easier and better. Biogas technology is therefore, a complete system in itself; it includes cost effective production of energy and fertilizer for soil (Wawa, 2012). Awareness of a technology entails mastery of operation, use, maintenance, use and its implications. Biogas technology awareness dates 1957 when it was built by Mr Tim Hutchson who introduced the floating dome technology. Gunnerson and Stuckey (1989) identify about seven types of biogas plants or digesters, but the Kenyan market is aware of three technologies; the floating dome, the fixed dome and the plastic tubular technologies.

2.2.1 Fixed-dome (Chinese design)

Fixed dome design, according to Gunnerson and Stuckey (1989) is the most common digester type in developing countries. It was introduced to Kenya through Tanzania. The digester type consists of a gas tight tank constructed of bricks (Fig 1.0 a) stone or poured concrete. Both the top and the bottom of the reactor are hemispherical and joined together by straight sides. The inner surface is sealed by thin layers of mortar to make it gas tight. At the top of the digester there is a manhole plug to facilitate entrance during cleaning, and the gas outlet pipe exits from the manhole cover. Biogas plants can be of various sizes ranging from 2m³ for a single family of 5 people, to 140m³ for a community. The plant is normally divided into three parts: digester, inlet and outlet slurry pits, and gas holder.

2.2.2 Floating Dome Technology (Indian design or KVIC model)

The technology is extensively used in the world. A typical design consists of a reactor wall and bottom. Usually constructed of bricks reinforced with concrete, a concrete pit partly sunk into the ground, and an inverted dome (Fig.1.0b)made mainly of steel floated in the liquid in the digester. This acts as a container within which the gas can collect. The gas produced in the digester is trapped under a floating metal dome which is the key feature of this technology. As the gas accumulates the dome rises up indicating a rise in the amount of gas. When the gas is used up the dome sinks. This provides a useful visual indicator of the available gas volume for use in the households.

In Kenya, several models of this technology have been made of which most of them were designed and fabricated by Tim Hutchison Tunnel Technologies Ltd. And later the GTZ and the Special energy programme. Floating drum digesters need cleaning, painting fixation of leaks as maintenance. In addition, household appliances may need regular maintenance due to corrosion. Depending on the
construction materials, management and maintenance, the lifespan of such digesters vary from 30-Over 40 years providing services in lighting, fertilizer and cooking gas.

**Figure 1.0 a and b: the Fixed and Floating Dome biogas Designs**

![Fixed and Floating Dome biogas Designs](image)

**Source:** SNV, 2006

### 2.2.3 Tubular plastic design technology

In the early 1980s tubular plastic design plant was developed in Columbia and later disseminated to Vietnam (Fig 1.1). In mid 1990s the design was introduced to Tanzania by a group of scientists from Sokoine University of Agriculture who visited Vietnam and on their return they collaborated with farmers and improved the design to fit the Tanzanian condition (Gunnerson and Stuckey, 1989).

According to Gunnerson and Stuckey (1989), tubular plastic digester consist of a long cylinder made of PVC, a Neoprene coated nylon fabric. The digester is placed in a trench and filled with water to expel air before dung is introduced. Depending on the temperature, it may take two weeks before gas is produced. Materials for a biogas plant are locally available and when all materials are delivered to the site it takes between 3 to 4 hours to set up the plant.

In Kenya, a Plastic manufacturing company ventured in plastic tubular digester manufacture in 2006. The major drawback of the tubular plastic bio-digester is its limited durability due to its delicacy. However, the company, Pioneer Technologies has improved on it to make it UV treated, pressure resistant with larger accommodating volumes between 9m³ and 18m³.
To achieve clean, convenient and affordable household use of fuel, and reap the full range of socio-economic benefits of biogas technology, there is need for multi-pronged approach from all actors (SNV, 2009). Biogas technology awareness is promoted by the government, the non-government organizations and agencies.

Figure 1.1: The Plastic Tubular Biogas Design

Source: Biovision, 2004

2.3 Determinants of household fuel choice and adoption

It has been found that as household's income increases, households not only increase their consumption of their fuel choice, but they also use multiple fuels. Most empirical studies have found contradicting results for this. In Ethiopia for instance, the income effect dominates so that households consume more of all energy sources as budgets grow (Kabede et al., 2002).

Barnes and Quian (1992), using the actual survey of Urban household energy consumption in developing countries, found that as income increases wood fuel does not disappear completely as households continue to increase its use thus reflecting the utility of these fuels in urban households. Increasing levels of income tends to result in decrease in the share of biomass in total energy consumption (Wayuan et al., 2008).

The World Bank explains using the Guatemala household survey to explain the relationship between household size and fuel use. Using the logit and multinomial logit regressions, the results found a positive relationship (World Bank 2003). Meconnen and Kohlin found similar results in Ethiopia where households with more members were more likely to use charcoal and firewood and less likely to use kerosene.
Pundo and Freser (2003) analyzed the data from Kisumu, Kenya using multi-nominal logit model and they found that the level of education improves knowledge of fuel attributes, tastes and preferences for better fuels. Opportunity cost of time becomes an aspect of concern with regard to household participation on various activities. According to them, a highly educated woman is likely to lack time to collect firewood and may opt for firewood alternatives. Wayuan et al. (2003) explains that when resident's education level is higher, they use less biomass or more commercial fuels because the opportunity cost of biomass collection is increasing.

Several studies attest to the fact that household age is a key in making decisions on household energy choices. Pundo and Freser (2003) note that a woman's age influences fuel choice through loyalty to firewood so that the older the woman (when all factors are held constant), the more likely the household will continue using firewood. This has been found to be true by Mekonnen and Kohlin (2008) in Ethiopia. They demonstrated that older household heads prefer the use of solid fuels while non-solid fuels are more likely to be adopted by the younger household heads.

Preference of a given type of fuel is another factor. This preference can be associated with a stronger attachment to indigenous culture and traditional cooking. Attitude of people influences the choice of household fuel in that some people believe that some fuels are faster than the others which is true of course, some fuels such as the food cooked using charcoal has a tasty flavor (Israel, 2002) and that some fuels are dirty to use and have low efficiency.

The type of dwelling unit and the house ownership has been identified by Pandu and Fraser (2003) to be another important factor affecting household fuel switch. They argue that if a household owns the main dwelling unit, it is more likely to use occupancy rules. If a dwelling unit is a permanent house, the household is likely to use firewood alternatives that do not stain the walls and the roofs of the unit.

In most empirical studies accessibility to electricity as one of the factors has been omitted. The World Bank (2003) found out that for the households that were connected to electricity grid tended to use less wood fuel. These studies also explain that electricity access triggers fuel use to LPG and adoption of cleaner energies such as solar and biogas. They further argue that access to electricity is associated with a higher probability of using LPG and a lesser likelihood of firewood usage.

Results from Albebaw (2007) show that housing expenditure is higher for those who are non-home owners and this limits households from switching to cleaner fuels as hypothesized by the energy ladder model. Housing expenditure is one of the components of consumer expenditure.
2.4 Comparative efficiency of Household Fuels

2.4.1 Efficiency of heating stoves

Cooking stoves operate with a variety of fuels, such as solids, liquid, gaseous and other fuels. Animal dung, agricultural residues, wood, charcoal, sawdust, biomass briquette are considered as solid fuels (Lai and Sup, 1998). Kerosene, alcohol and other hydrocarbons are termed as liquid fuels. LPG (Liquefied Petroleum Gas), natural gas, biogas etc could be considered as gaseous fuel (ibid). Efficiency of a stove could be categorized as burning efficiency and overall efficiency. Burning efficiency of a stove accounts for the capacity of that stove in terms of combustion of fuel. In other words ability of the stove to change the energy from fuel to heat energy is related with burning efficiency, (Mukunda, 1998) The ability of the stove to change the energy from fuel into the energy gained by the specimen such as water, rice, milk etc is termed as overall efficiency of the stove (ibid.)

Generally the efficiency of a stove is indicated by the overall efficiency. Household energy provision through the use of various fuels has both health, environmental and socio-economic implications. Studies on combustion efficiency show that biogas has the highest nominal overall efficiency (Table 1.0) an indicator of less indoor pollutants compared to other fuels (Kirk et al., 1998)

Table 1.0: Efficiency of Small-Scale Combustion Devices based on greenhouse emissions in developing countries

<table>
<thead>
<tr>
<th>Type of stove</th>
<th>Nominal combustion efficiency %</th>
<th>Overall efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogas</td>
<td>99.4</td>
<td>57.4</td>
</tr>
<tr>
<td>LPG</td>
<td>97.7</td>
<td>53.6</td>
</tr>
<tr>
<td>Kerosene</td>
<td>96.5</td>
<td>49.5</td>
</tr>
<tr>
<td>Wood</td>
<td>90.1</td>
<td>22.8</td>
</tr>
</tbody>
</table>


The results are consistent with the findings of Red et al (1998) who also found the efficiency of the kerosene stove as 35-50%, that of wood stove 10-25%, electric stove 75-85% and that of a charcoal stove 20-35%. Combustion efficiency of a stove and the calorific value of a given fuel give the amount of pollutants emitted by fuel and the impacts it may have on the users’ health.

Prof. H. S. Mukunda (1998) and the Regional Energy Development Programme (RWEDP) mention the
calorific values of different fuels in their publications "Understanding Combustion" and "Energy and Environment Basics respectively as in table 1.1 below:

**Table 1.1: Calorific value of household fuels**

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Density (kg/m³)</th>
<th>Calorific value (RWEDP) (MJ/kg)</th>
<th>Calorific value (Mukunda) (MJ/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG</td>
<td>560</td>
<td>45.5</td>
<td>44</td>
</tr>
<tr>
<td>Kerosene</td>
<td>806</td>
<td>43.1</td>
<td>42</td>
</tr>
<tr>
<td>Biogas</td>
<td>varies</td>
<td>24.28</td>
<td>32-36</td>
</tr>
<tr>
<td>Coal</td>
<td>N.A</td>
<td>29.3</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Mukunda, 1998 and RWEDP 1992/93*

These results indicate that the calorific values of fuels have direct effect on the efficiency value because the amount of carbon atoms burnt is directly proportional to the amount of energy calories released by the fuel. According to the Energy Synopsis Report-Nepal (2006), biogas was highlighted as the most efficient clean green energy with lesser pollutants to the environment and minimal implications on human health (SNV, 2006). This claims are further re-emphasized by Collins (2009) who asserts that despite the fact that methane combustion results to the emission of CO₂ which is another green house gas, 1 ton of methane (equivalent to 23 tons of CO₂ if allowed to vent) yields only 2.75 tons of CO₂ which is a significantly lower emission as illustrated below:

\[
\text{CH}_4(g) + 2\text{CO}_2(g) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O}(l) \quad \Delta^0 = +891\text{Kj/mol}
\]

Whereby, bracketed ‘g’ and ‘l’ show the gaseous and liquid states.

**2.4.2 Cost-effectiveness**

11.9% of the Kenyan urban population and 0.71% of the rural households use LPG as their main source of fuel (GoK, 2005/06). Upfront cost of the durable goods needed for LPG use was Ksh 7,150 and Ksh 6,530 for 12kgs and 23kgs gas cylinder respectively from various retail stations in 2009 (KIPPRA, 2009). The fixed costs required for kerosene is quite minimal since the cooking requires one small burner with a simple fuel container. Kerosene stoves ranged from Ksh 350 to Ksh 2000.
2.5 Role of Stakeholder Participation in Biogas Promotion

The World economies common goal is the strife to achieve green economy. This requires decision makers, civil society, the private sector and development organizations to reconsider the approaches for introducing environmental sound technologies (EST) Worldwide. The introduction of EST has traditionally occurred through government or donor financed technology transfers (UN,2005). However, technology transfers have been misunderstood as one-time transactions between active donor and passive receiver who has the perceptive that neglects the pivotal importance of the recipient country’s obligation to adopt, absorb and improve new technologies to the local context (Mathews,1995,IPCC,2000).

Studies have shown that the private sector represents 90% of all technology transfer while the role of the government is pronounced when technologies are not commercially viable from the outset (UN,2005). Rodrik (2004) argues that for national industry policies to address the actual demand for products and services the information is often at the national governments’ reach unless they exploit local knowledge of private companies and civil society, hence the ability of achieving sustainable results from a technology transfer on a sectoral level depends on the embeddedness of multiple cooperating agencies.

According to Flyvbjerg (2006), the SNV case is a paradigmatic case, as it confirms the common support in development cooperation to local ownership, sector-wide and program-based approaches, capacity development, multi-stakeholder participation for sustainable outcomes and importance of competitive private sector.

2.5.1 Stakeholders Promoting Biogas technology in Kisii County

2.5.1.1 Banking and Microfinance Institutions

There are more than seven banking institutions in the region and several MFIs which provide loan facilities to the farmers at an interest. MFIs advice farmers to take loans for biogas projects. For instance Equity bank has a lending program by the name ‘Jamii Safi Loan’ for promoting projects that increase sanitation, among which biogas technology is included.
2.5.1.2 Ministry of Agriculture, Livestock and Fisheries

The ministry provides for technical extension services to the farmers who own biogas technologies. In their visits to farms they encourage them to adopt technologies that are profitable and encourage rearing of livestock in Zero-grazing units, thus promoting biogas technology. The ministry is also involved in organizing for agricultural shows where biogas technology trainings and demonstrations are done to embrace the technology. Through special programmes and association with agencies such as NALEP have promoted the technology in the area.

2.5.1.3 GTZ/GIZ

This is a Germany organ involved in promoting biogas. The organization has been at the fore line in helping farmers practicing dairy farming to construct biogas plants in the area and providing relevant extension advice. The organization has been known to provide training to local artisans on the construction of fixed dome technology design and financing biogas projects through subsidy.

2.5.1.4 SNV

These are managers with HIVOs in KENDBIP programme that ended in December 2013 where KENFAP is the implementing agency. The body gives advisory services to KENFAP, and other partners promoting biogas at all levels, supports the development of biogas office, and offers special training and experience sharing.

2.5.1.5 European Union

This is one of the donors in the promotion of renewable energies through the European Union Energy Facility. Funds the biogas programme undertaken by GIZ.

2.5.1.6 HIVOs

This is a Dutch NGO not-for-profit organization inspired by humanist values. It started its access to the energy sector in 2005. The organ makes funds available for annual operational plans and budgets. The organization mobilizes resources to ensure additional funding for the programme and facilitates the design and development of systems and processes for accessing carbon financing. Further it is involved in management of funds in KENNDBIP Kisii.
2.5.1.7 Ministry of Energy

The ministry has the department of renewable energies. It has established demonstration farms for training farmers. In addition it has trained technicians who construct and maintain biogas plants as well as carrying out sensitization of clean technologies in the County. The ministry is responsible to avail technologies that are viable with the appliances and also financing civic education to promote these technologies.

2.5.1.8 Farmers and neighbors

Farmers are the core stakeholders who implement the biogas projects. Farmers need to be fully convinced so as to adopt the technology. From these farmers’ experience on biogas technology, neighbors take the initiative to adopt the technology

2.5.1.9 Private Sector

The private sector provides construction materials, finances biogas projects, offers training of technicians among other roles.

Other institutions include CBOs such as St.Barbara Mosocho and the Mosocho Farmers CBO which play a role of sensitizing people to adopt biogas technology

2.6 Challenges in the Institutional Sector

The institutions have weak capacity to carry out their devolved functions due to inadequate information for planning and policy formulation and they are limited of both financial and human resource. Secondly, there are weak linkages between the institutions involved in development and promotion of biogas technology thus making it difficult in decision making.

2.7 Theoretical Frameworks for Technology Adoption

Technology adoption is a complex area of study that has been studied over time using several theories. Abkhzam and Lee ( 2010 ) mention several popular models used to investigate adoption behavior of an individual. Technology adoption frameworks are information systems that provide a theoretical foundation for examining the factors influencing technology adoption.

Since it is not easy to discuss them all, this study will focus on three theories: Energy Ladder model, the theory of Planned Behavior and the Diffusion of innovation as they seem to suitably fit the study.
2.7.1 Theory of Planned Behavior

The Theory of Planned Behavior was proposed by Icek Ajzen in 1985 and later improved on in 2006. The content remains in spite of the additives (Ajzen, 2006). The theory consists of three conceptual determinants of the adoption of a new technology, these include the attitude towards the technology, social factor termed as subjective norm, (which refers to the perceived social pressure on either to use or not to use the technology) and facilitating conditions such as availability of government support and technology support (Fig. 1.2). It is the assumption of this study that lack of institutional support on biogas technology has been a barrier to its widespread.

Figure 1.2: The Planned Behavior Model, Ajzen 2006

Source: Ajzen, 2006

2.7.2 Energy Ladder Model and Energy Stack Model

Researchers have attempted to understand the dynamics in the household energy usage in relation to their income earn. The studies have always involved the Energy ladder model to examine the determinants of household decisions to substitute or to switch between available fuels (Barnes and Floor, 1996).

The theory postulates of a three-stair fuel switching process. The first stage is manifested by universal reliance on traditional biomass fuels such as firewood, animal waste and agricultural residues. The second stage, households move to "transition" fuels such as kerosene, coal and charcoal in response to higher incomes and other factors such as deforestation and urbanization. In third phase, households switch to the use of LPG, natural gas or electricity.
It is hypothesized that the major driver affecting the movement up the ladder is income and relative fuel prices (Barnes et al., 2005). The theological statement is an echo by Smith (1994) in his interpretation of the 'traditional energy ladder' that as families gain socio-economic status, they abandon technologies that are inefficient, less costly and more polluting, that is those in the lower energy ladder. Such as dung, fuel wood and charcoal.

An increase in available income allows them to leave these fuels behind and purchase technologies that are "higher" in the ladder. These advanced technologies are usually non-efficient and costly, but require fewer inputs of labor and fuel, and produce fewer pollutants per unit fuel. Implicit in this theory is that it assumes that once incomes increase, the households discard the consumption of the traditional fuels and adopt modern clean fuels that they can afford thereby going contrary to the Energy Stack Model which states that. Households do not switch completely to a new fuel as income increases, but will continue using more than one fuel.

2.7.3 Diffusion of Innovation Theory

This theory was developed by Rodgers in 1995 and is the most widely recognized technological framework. The theory postulates three determinants of technological adoption to be the characteristics of an innovation, individual categories and communication channels (Fig.1.3).

The characteristics that may influence adoption include the ease to use, cost-effectiveness, efficiency and convenience. The theory considers the categories of adopters as a determinant to technology adoption. Rogers (1995) categories the members of a social system into five adopter categories. These are innovators, early adapters, early majority, late majority and laggards. These categories follow a standard deviation curve. He explains that very few innovators adopt the innovation in the beginning, 2.5 per cent, early adopters making up to 13.5 per cent a short time later, the early majority 34 per cent, the late majority 34 percent and after sometime the laggards make up for 16 per cent.

Innovators are ventures in a social system with ability to cope with high degree of uncertainty and play an important role in importing new ideas because they have financial resources and the ability to understand and apply complete technical knowledgeably adopters are more integrated to the social system than innovators and are said to speed up the diffusion process. Potential adopters seek advice from them since they find it necessary to make decisions innovation decisions (Lionbergin and Gwin,1991). Through interpersonal networks, the category reduces uncertainty of the new innovation by adopting it and then conveying a subjective evaluation of it (Rogers,1995).
The early majority comprises of the members who adopt the technology after a good number has adopters interact frequently with peers but they seldom take lead positions like the early adopters. The category links the early adopters with the late adopters by the diffusion process. Innovation decision period seems to be relatively longer for the innovators and early adopters. (Feder et al., 1985). The late majority adopt the technology relatively late after a majority of the people in the society have adopted the technology. This adoption has been described to rely on economic necessity and peer group pressure (Rogers, 1995).

Laggards are the last group in a social system to adopt innovations, according to Rogers (1995). These people possess no opinion leadership and are the most localized in their outlook. The individuals often make decisions in terms of what has been done in previous generations and interact primarily with others who also have certain traditional values. It can therefore be argued that laggards tend to be suspicious of innovations and change agents (Msuya, 1998).
The Diffusion of Innovation Theory further predicts that media as well as interpersonal contacts provide information and influence opinion and judgment. The information flows through networks. The nature of networks and the roles opinion leaders play in them determine the likelihood that the innovation will be adopted. Opinion leaders exert influence on audience behavior via their personal contact, but additional intermediaries called change agents and gate keepers are also included in the process of diffusion.

2.8 Critiques and Research Gaps

The Energy Ladder model has been criticized on its main focus on the household income factor while overlooking other factors with potential to influence fuel choice (Osiolo, 2009). In addition its implicit assumption that more expensive technologies are locally and internationally perceived to signify higher status, and that households desire to move up the energy ladder not just to achieve greater fuel efficiency or less direct pollution exposure, but to demonstrate an increase in socio-economic status which may not be always true. Scholars such as Masera et al. (2000) argue that the energy transition is a bi-directional process, as users can go up or down the ladder, and continue using traditional fuels.

Abukhzam and Lee (2010) in their analysis of adoption frameworks came up with a conclusion that despite widespread interest in understanding factors affecting users attitude towards technology adoption, limited attention has been paid to describing factors that affect workforce attitude towards the adoption of a new technology. The Diffusion of Innovation Theory has been criticized in terms of its deficiencies in explaining the effect of adopters’ demography on innovation adoption (Abukhzam and Lee, 2010). Rogers (1995) ignores the impact of demographic differences among adopters such as age, income, gender and education which; according to Abukhzam and (Lee 2010), these factors have found to have a significant influence on users’ attitude towards the adoption of technological innovation. Abukhzam and Lee further argue that Rogers’ theory is a simplified representation of a complex reality.

Technologies are not static; there is continual innovation to attract new adopters. By Diffusion of Innovation Theory, the communication process involved is one way flow of information. The sender of the message has a goal to persuade the receiver, that the person implementing the project controls the direction and outcome. Though in some cases this approach can be appropriate, in most cases a participatory approach is encouraged for the success of many projects.

On the other hand the Theory of Planned Behavior is incorporated as it considers the facilitating
conditions such as government and technology support as factors influencing individuals’ attitude towards technology adoption. The Diffusion of Innovation theory on the other hand is incorporated due to its consideration of demographic characteristics and communication channels as significant determinants of technology adoption.

The overall assumption of this study is that inadequate support from stakeholders particularly the government institutions has got an influence on adoption and non-adoption of biogas technology. Government institutions and other stakeholders’ support involves among others; effective information dissemination and promotion strategies through communication channels such as media which assumed to influence awareness and peoples’ attitude towards the technology adoption.

2.99 Conceptual Framework of the Study

In all fuel choice and fuel technology adoption theories, awareness forms the first phase of adoption. Before any technology is ingested, people would want to have information about this technology and associated benefits. Governments and non-governmental organizations play an important role in information dissemination. The information households have about various fuels influences their fuel choice.

Government institutions in particular can influence the adoption of biogas technology through policies, offering extension services, awareness creation campaigns, and through financial support. Special programmes on biogas technology, media channels and biogas beneficiaries form other crucial channels for its adoption both in the rural and urban setting.

These channels are expected to promote the technology through implementation of policies, projects, advertisements, demonstrations, motivation, and provision of technical support services. Being aware of the technology and its benefits, people develop a positive attitude towards the technology. For biogas technology, the benefits include cheap and efficient energy, saving time for firewood collection and engaging it in productive works, lighting the houses for student assignments.

In a wider context there would be reduced deforestation emanating from deforestation, waste handling mechanisms for all biodegradable wastes and improved crop productivity from the bio slurry which is an excellent fertilizer obtained as a byproduct of the aerobic process.

After the awareness phase, potential adopters face a challenge in decision making on whether to adopt the technology or not (Simon,2006 ).This can be directly or indirectly be influenced by the channel
information follows. For biogas, information dissemination is affected by socio-economic, technological and environmental factors.

Socio-economic factors such as education level, age, household size, gender, type of dwelling, main economic activity of the household, location of residence, distance from the fuel source determine an individual's ability to access information, perception and knowledge which in turn influence one's decision to adopt the fuel or not adopt (Osiolo, 2009). Consequently, these factors determine the ability of a household to install and operate the technology.

Potential adopters also look at environmental factors, that is, the problems that biogas technology intends to solve. This perception undermines the development efforts of the technology. Others factors related to the environment include accessibility to water and availability of feed-stocks. This facilitate efficacy of routine biogas maintenance activities. The study makes an assumption that the willingness of individual household to adopt biogas technology in addition influenced by these factors.

For technology to be adopted it is ought to be simple, reliable and compatible with the surrounding environment. In addition, its benefits should be apparently visible. Biogas installation potential is determined by household income. Outstanding workability performance could attract other potential adopters of biogas technology.

The synergy of the attitudes towards a technology, technological, institutional and environmental factors influence the individual household’s willingness to invest in the technology resulting into adoption of biogas technology. It should be clear here that there’s no factor that is independent, they are intertwined and the outcome is the influence on the technology adoption (Fig1.4).
Figure 1.4. Conceptual Model of the Study

Source: Adapted from Rodgers (1995) and Ajzen (2006) with modification
CHAPTER 3

3.0 AREA OF STUDY

3.1 Geographical Location and extent

Kisii County is one of the forty seven Counties of Kenya. It shares common borders with Nyamira County to the North East, Narok County to the South and Homa Bay and Migori Counties to the west (Fig. 1.5). The County lies between latitude 0° 30' and 10° south and longitude 34° 38' and 35° East. It is the second smallest County in Nyanza region after Nyamira County and has an area of 1302.1 km².

Kisii County is found in Eastern Africa, in the Nyanza Region of Western Kenya. The county headquarters are in Kisii town.

Figure: 1.5: Kisii County Headquarters at the Regional Context

The study was conducted in the Peri-urban areas of four selected urban centers within the former Municipal boundary jurisdiction namely Suneka, Mosocho, Kisii and Marani within Kisii County which has an area of 1318 Km$^2$ (Fig.1.6)

**Figure 1.6: Map of the Study Area**

![Map of the Study Area](image)

*Source: Survey, 2013*

### 3.2 Physiographic and Natural Conditions

#### 3.2.1 Topography

Kisii County is characterized by a hilly topography with several ridges and valleys. It can be divided into three main topographical zones. The first zone covers areas lying below 1,500m above sea level located on the western boundary and include parts of Suneka, Marani and Nyamarambe. The second zone covers areas lying between 1500-1800m above sea level located in the Western parts of Keumbu and Sameta divisions, Eastern Marani and Gucha River basin. The third zone covers areas lying above 1800m above sea level in parts of eastern and southern Keumbu, Masaba and Mosocho.

The general slope of the land is from east to west. The County is traversed by permanent rivers which flow westwards into Lake Victoria. Among the notable ones are Kuja, Mogusii, and Riana and Iyabe rivers which have potential waterfalls to have hydro sub-stations but they remain unexploited despite
the high demand for energy by tea processing industries and other activities in the area. The hilly landscape and valleys hinder development and accessibility to electricity connections especially around the interior and the Manga Escarpment and notable hilly landscapes such as Nyangweta and Sameta which surround major urban centers.

### 3.2.2 Ecological Conditions

75% of the County has red volcanic soils (nitosols) which are deep in organic matter. The rest of the County has clay soils which have poor drainage (phaezems), red loams and sandy soils. In the valley bottoms, there exist black cotton soils (verisols) and organic peat soils (phanosols). The growth of cash crops such as tea, coffee, pyrethrum and subsistence crops such as maize, beans and potatoes are supported by the red volcanic soils (kidp, 2013).

The County can be divided into three ecological zones comprising the upper midland (UM) 75 percent, Lower Highland (LH) 20 percent, and Lower Midland (LM) 5 percent. Approximately 78 percent of the County is arable of which 57 percent is under crop.

### 3.2.3 Climatic conditions

Kisii County exhibits a highland equatorial climate resulting into a bimodal rainfall pattern with average annual rainfall of 1,500mm. The long rains are between March and June while the short rains are received from September to November. The months of July and January are relatively dry. The biomodal rainfall distribution impacts those who use firewood as the main source of fuel as they have to succumb with smoke from wet firewood. This calls for emergency response to have an alternative source of household energy that is available, sustainable and efficient for use whereby, biogas forms the best option.

The maximum temperatures in the County range between 21°C – 30°C while the minimum temperatures range between 15°C and 20°C. These temperatures are ambient for maximum micro-bio activity for biogas production (Table 1.2). The high and reliable rainfall coupled with moderate temperatures are suitable for growing crops like tea, coffee, pyre thrum, maize, beans and bananas as well dairy farming.
Table 1.2: Average Monthly Temperature and Precipitation Data, Kisii

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>July</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
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</thead>
<tbody>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high °C</td>
<td>31</td>
<td>32</td>
<td>32</td>
<td>31</td>
<td>30</td>
<td>30</td>
<td>29</td>
<td>30</td>
<td>30</td>
<td>31</td>
<td>30</td>
<td>30</td>
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<tr>
<td>Average</td>
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<td></td>
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<tr>
<td>low °C</td>
<td>10</td>
<td>11</td>
<td>11</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Av. rainfall</td>
<td>95</td>
<td>130</td>
<td>194</td>
<td>268</td>
<td>235</td>
<td>156</td>
<td>116</td>
<td>167</td>
<td>156</td>
<td>143</td>
<td>185</td>
<td>132</td>
</tr>
</tbody>
</table>

Source: Suneka Meteorological Sub-station and KARI, 2012

3.3 Availability of Main Resources

3.3.1 Water

The County has several permanent rivers and streams which drain to the L Victoria Basin. River Kuja is the main and has adequate water for development of a mini-hydro-electric station. Streams such as Mogusii, Riana, Charachani and Iyabe augmented by springs and boreholes, roof catchment water harvesting forms the other sources of domestic and industrial water that is quite essential in biogas substrate preparation for biogas digesters (Rok, 2002).

3.3.2 Forests

The County does not have a gazetted forest; however, there are non-gazetted forests like Nyangweta, Ritumbe and Ndonyo forests in Gucha South sub-County, and Keboye Hills in Kisii South, Sameta Hills in Sameta Sub-County. The total forest cover is approximated at 228.4 ha. Afforestation has been taking place in swamps and hill tops. The survival rate of trees is high due to frequent rains. Deforestation is the major problem leading to excision of forests by tea industries and fuel wood for households. Strategies to increase forest cover from the present 228.4 ha through agro-forestry and preservation of individual woodlots that provide bulk of forest products for domestic use is encouraged but land fragmentation compromises the efforts due to less acreage (RoK, 2002).
3.4 Demographic Characteristics

County population was 1,152,282 comprising 550,464 males and 601,818 females in 2009. With a growth rate of 2.0 percent (KBS, 2009). The total population of the major town centers was 82,587 in 2009 and projected and is projected to increase to 95,371 by 2015 and 99,262 in 2017. Kisii has the largest population given that it is home for major businesses, institutions of higher learning and banks are located in the town.

Such population statistics are an indicator of upcoming shortages in resource use especially energy, competition and stress of available resources such as land, energy, water, employment just to mention but a few. This calls for proper timing and adoption of technologies to have enough energy since it is the key driver of the county’s economy. Statistics indicate that the County’s population density in 2012 was 932 persons per square kilometer.

The average farm sizes in the County range from 0.2 ha to 2.1 ha of land with 85% of the population relying on agriculture (RoK, 2002). The small size of land holdings is as result of the high population which has led to sub-divisions of land into small units that are not economical. This has serious implications to the County in terms of food security and measures such as land policies on land use ought to be put in place and intensifying modern methods of farming like Zero grazing which require small sizes of land and help reduce household energy gap through biogas technology development.

The main Livestock bred in the County are goats, sheep, poultry, rabbits, pigs. The dairy animals bred dairy cattle and zebu grade cattle. The land has an average capacity of 1-4 animals/ha (RoK, 2002).

3.5 Human Development Indicators

3.5.1 Economy

Kisii County Human Development Index (HDI) is measured through the welfare of the community (HDI) through life expectancy, poverty levels and adult literacy. The poverty level in the County is placed at 49.6 percent (KBS, 2010). This of course is slightly less than the national poverty index which is at 49.9 percent. Efforts to bring this level further down are needed in targeting the improvement and strengthening of the economic and social sectors in the County through placing strategies to provide adequate reliable and efficient energy alternatives for industry and households.
Life expectancy in the County is estimated at 50 years compared to the National indicator of 54 percent. The adult literacy level in the County is estimated at 71.5 percent as compared to that of the national level at 79.2 percent (KBS, 2010). Measures aimed at improving human development indicators such as empowering women through provision of clean and sufficient energies for small scale businesses and coming up with technologies to store and sale biogas and bio slurry for crop production would improve the county's economy.

3.5.2 Industry

The County has 5 manufacturing industries, 4 bakeries and 10 Jua Kali associations with 1543 jua kali artisans (KNBS,2012). The county has tea and coffee processing, soda bottling as the major manufacturing industries. The county also has a high potential for such industries as Soapstone, brick making, tea factories and sugar factory to cater for the cash crops in the County. Tea factories have reduced forest cover in the area due to their high demand for firewood as a substitute to furnace fuel that is costly and highly polluting (MoALD,2010). These factories need to generate their own power by using the river potentials to develop mini-hydro-electric stations.

3.5.3 Health

Health facilities are inadequate in the County, unevenly distributed and lack essential medicine and facilities and staff to attend to for emergency. Estimates show that the average distance from households to health centers is 4 km and the bedding occupancy rate is at 160.3% (Worldlilngo).

The five most common diseases in the County in order of preference are Malaria, AIDS diarrhea, urinary tract infections, skin diseases, pneumonia and respiratory diseases. Most of the diseases are preventable hence preventive and promote interventions such as promoting green technologies, would have impact in the health status of the people. There is need to upscale interventions such as sensitizing people to switch to efficient fuel technologies to reduce respiration disorders, maintaining hygiene in our homes as well as using efficient agricultural production methods such as organic farming.

3.5.5 Financial Institutions

The County is served by ten major banks. There are also five major micro-finance institutions and SACCOs. It is however worth noting that all the institutions are concentrated in Kisii town hence there is need to open branches in other regions in the County to bring services closer to the people. These
financial institutions have helped many small scale business persons to upscale their businesses as well as farmers through access to credit facilities. They have also partitioned with other organizations, finance projects and programmes such as those of improved Jikos, biogas household installation, greenhouse projects, just to mention but a few to promote efficient and sustainable energy technologies in the County.

3.5.6 Education

The County has 467 primary schools and 334 secondary schools. There is no national polytechnic in the County. The County has 7 colleges, one training institute, 1 public university and 8 university campuses. Due to increasing number of students joining all levels of education there’s high demand for accommodation and energy in the town that is derived mostly from the surrounding environment.

Students need clean energy to do their assignments and homework. The increasing number of educational institutions raises demand for fuel wood for student meals, electricity and laboratory gas. There’s need for institutions to cut the cost on energy by installing institutional biogas plants that can supply energy for school kitchens as well as laboratories since they rear more than 30 dairy zero-grazed cattle and pigs.

3.5.7 Energy

The main sources of energy in the County are firewood, paraffin, electricity, charcoal and biogas. The electricity coverage in the County is estimated at about 45 percent. More than 90% of rural energy needs are met by the use of fuel wood. The county is in the process of exploring renewable resources such as sunlight and biogas technology (Worldlilngo, 2010). In the Urban and Peri-Urban centers, other energy sources that are used include kerosene, LPG, charcoal and electricity.

There’s fair distribution and connectivity of electricity in the county with interior parts having limited coverage. The rural electrification programme is committed to serve this population though a few still can excess. The low levels of electricity coverage are attributed to high cost of connection including the installation of transformers and the hilly landscapes (GoK, 2012). There are decentralized petrol and kerosene filling stations in the county and the County wants to invest in promotion and adoption of renewable energies through installation of biogas and solar systems. There is need to lower the cost in order to enhance rural electrification and at the same time encourage use of renewable energy such as biogas and solar energy which are cheap and environment friendly.
3.5.6 Housing Types

The main housing types in the County are mud houses, stone houses occupied by 2,456 households, brick/block houses occupied by 51,676 households, mud/wood houses occupied by 189,596 households, mud/cement houses occupied by 21,297 households, timber and other houses occupied by 5,637 households.

Consequently, the type of housing units has been closely linked to the type of fuels used in these households. For instance, those in mud housing units and semi-permanent houses tend to use firewood than those in permanent units who use charcoal for cooking and are accessible to electricity.

3.5.1 Road Network

The County has a network of 1,133 km of classified roads and 435km of rural access roads. About 171.Kms of the roads are tarmacked. The tarmacked roads pass through major town centers like Kisii, Ogembo, Nyamache, Gesusu, and Suneka. The total length graveled road is 293km. while 669 km are earth roads. These roads serve high agricultural potential areas. Though the roads are well distributed, poor maintenance and hilly terrain of the County make them inaccessible during the rainy season (RoK, 2009).
CHAPTER 4

4.0 RESEARCH METHODOLOGY

A research is a systematic and organized undertaking with an aim of investigating a specific problem that needs a solution. The activity involves careful thought and application of procedures to identify the root causes contributing to the escalation of the problem, so as to make an informed decision from the findings on how to approach the issue to minimize its negative impacts or improve efficiency.

Research is done to identify opportunities through giving novel ideas. It helps also in diagnosing the unknown problems and opportunities. Research also helps to establish a standard of taking action on any chosen area of the knowledge domain. Research has also been used to fill knowledge gaps and approve theories applicability. This chapter describes the research design and methodology that was used to accomplish and meet the objectives of the study.

4.2 Research Design

The research design employed both a research survey and a case study. This is because biogas technology is a broad area of research and therefore it was narrowed down into a focal research topic on the factors influencing its choice and adoption of biogas technology. In-depth study was carried out using various research tools in the peri-urban areas of sampled towns in Kisii County.

Like any other case studies, the study gives not a comprehensive answer to the topic under question but will give indicators that will allow further elaboration and test the applicability of the theories and models that have been used to explain the root causes of household fuel choice and technology adoption.

Both qualitative and quantitative approaches were employed due to the nature of the study. The study involved assessing attitudes and behaviors of individual households which assumed to have influenced adoption of biogas technology. The qualitative approach enabled the researcher to make an in-depth investigation of the variables related to adoption and non-adoption of biogas technology.

The household questionnaire was designed to have both closed and open-ended questions. Four major themes were designed to address the objectives: the first part was designed to collect information on
household characteristics and availability of important energy resources in the study area; part two was aimed to collect information on biogas awareness in the study area and experiences from biogas adopters and gender involvement in biogas related activities; part three was designed to capture information relating to policy particularly government involvement in promotion of biogas technology; and part four was concerned with peoples’ attitude towards biogas technology and promotion strategies.

4.3 Nature of Data

Data that was collected was objective-based. This included household energy statistical reports, energy sector strategies to meet energy demand, initiatives, operations and performance of the institutions involved in creating awareness and promotion of biogas technology

Both primary and secondary data were collected and used to achieve the objectives of the study.

4.3.1 Primary Data

Primary data were collected using oral interviews from the target population and the opinions of various stakeholders in the Ministry of Renewable Energy and Petroleum and KENDBIP. This was further facilitated by institutional interviews with resource persons including; government officers from the MoREP, Department of Agriculture and Livestock, Agriculture extension officers, NEMA, St. Barbara Mosocho CBO, GTZ officer and farmers in the region.

4.3.2 Secondary Data

Secondary data was collected from existing published and unpublished information sources such as government official reports, books, maps in libraries, institutions and websites. The information was used to complement information obtained from respondents.

Secondary data collected provided background information on energy situation in the country, on biogas technology, policy issues related to adoption of biogas technology, factors affecting adoption and non-adoption; and promotion of biogas technology which also formed the basis of the research literature.
Table:1.3: Objective, Nature of Data, Source and Method of Collection

<table>
<thead>
<tr>
<th>Objective</th>
<th>Nature of Data</th>
<th>Source of Data</th>
<th>Method of Data collection</th>
</tr>
</thead>
</table>
| 1. To assess the level people’s awareness and attitude towards biogas technology. | • Level of plant maintenance and functionality  
• Technical expertise in operating and detecting faults within the system  
• Reasons for adoption and non-adoption of biogas technology.  
• Challenges in biogas usage, benefits and recommendation of the technology | Household questionnaires,  
Department of Agriculture and Livestock, GTZ, NALEP  
Ministry of energy, St. Barbara CBO | Observation and responses, administering questionnaires, photography |
<table>
<thead>
<tr>
<th>2. To explain the main factors influencing the adoption of biogas technology among the residents in the study area.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. To assess the efficiency of biogas technology as compared to other sources of household energies within the area of study.</td>
</tr>
</tbody>
</table>

| • Types of household fuels used in the area of study |
| • Economic and non-economic factors influencing household energy switching. |
| • Strategies to cope with fuel shortages |
| • Health problems from both biogas and substitute fuel usage |
| • Combustion efficiency of fuels, |
| • Availability and efficiency of equipments and facilities for use |
| • Comparative cost-effective analysis of other fuel substitutes used |

| Household responses, |
| Institutional questionnaires |
| Empirical literature |
| Household questionnaires, MoALF, MoE |
| GTZ, KENDBIP, Filling stations. |

| Conducting household surveys and interviews |
| Conducting institutional interviews |
| Reading reports from databases |
| Conducting household and institutional interviews, |
| Observation, Checking on price lists |

| Conducting institutional interviews, administering |
4. To evaluate the role and challenges of stakeholders in promoting biogas technology in Kisii County

| Names of institutions and agencies actively promoting biogas technology in Kisii County |
| Government and non-governmental assistance in BT promotion |
| BT promotion strategies and their shortcoming |

Governmental and non-governmental institutions: NEMA, MoA, MoE, GIZ, HIVOS

Household questionnaires,
4.4 Sources of Data

4.4.1 Oral Interviews

A combination of methods was used to collect both qualitative and quantitative data. These included structured and semi-structured interviews, checklists for focus group discussion and field observations. The use of a combination of methods in data collection was due to diversity of information that was required to achieve the objective of the study.

The interview was adopted as a method for data collection partly due to its cost effectiveness and its strength of capturing empirical data in both informal and formal settings (Kothari, 1990).

The interview guide consisted of both open and closed-ended questions. Open ended questions were designed to solicit information relating to actual and expected returns on respondents and study area characteristics and their relations to adoption of biogas technology. Closed ended questions on the other hand were intended to capture information relating to respondents’ attitude towards the adoption of biogas technology. The questions that were asked to all respondents were identical in order to solicit homogeneous information.

The interview method was very useful since it allowed face-to-face interaction with respondents and allowed the researcher to restructure the question or give clarification to questions when necessary. The choice of interview method for this study was dictated by the experience gained from previous academic experiences whereby the majority of respondents preferred oral discussions with the researcher filling in the questionnaires. This may be attributed to the nature of sample population (peri-Urban residence) where illiteracy is high.

4.4.5 Focused Group Discussion

This method involved interviewing a small group of respondents drawn from similar background, who were believed to present general public opinion towards biogas technology. The advantage of this method according to May (1993) is that it allows the interaction with a range of key informants and allows the researcher to focus on group norms and dynamics around the issue being investigated. Moreover focus group discussions are useful in verifying and clarifying information and in filling in gaps of information caused by inadequate information gathered from the interviews and observations. Focus group discussions were conducted in Kitutu Chache South Sub-county.
This involved one focused group discussion with the St. Barbara Women Group. The Participants’ responses were recorded in a field notebook during the discussions or immediately or thereafter. Time was limited and would not allow such groups in various parts of the study area.

4.4.6 Field Observation and Photography

Observation makes it possible to study behavior as it occurs, the researcher simply watches people as they do and say things. This enables the generation of first hand data that are uncontaminated by factors standing between the investigator and the object of the research (Nachimias, 1976). According to Nachimias (oppcit), the observation method might also be used when respondents are unwilling to express themselves verbally. Furthermore verbal reports can also be validated and compared with actual behavior through observation.

In this study apart from interviews and discussions, direct observations were used to evaluate existence of biogas plants, designs and types of plant feeds also to confirm functioning of biogas plants. Furthermore observation helped to study some facial expressions, gestures and other behaviors during interviews which portrayed the hidden or doubtful responses during interactions between the observer and respondent particularly on sensitive issue like income, beliefs and attitudes towards biogas acceptance.

Moreover, the camera was used to capture some events and structures of interest to this study. The information gathered using observation was used to counter-check information provided by household respondents and focus group participants.

4.4.7 Questionnaires

Both household and institutional questionnaires were used to collect relevant data for the study. They had both open and closed ended questions to suit collection of qualitative and quantitative data that is easier to analyze.

4.4.8 Checklists

This was lists designed with questions for the discussion group. These lists had open-ended questions to facilitate discussions on the study topic. They were effective and opened a good forum to understand information which would not be obtained from literature and household questionnaires. Consequently,
the use of checklists and guides facilitated formal institutional interviews and eased retrieval of required data by the departmental officers and thus saving time.

4.5 Target Population and Sample size

The study involved an assessment of factors influencing the choice and adoption of biogas technology among the Kisii Peri-Urban residents. The target population for the study was therefore focused on the residents who practiced dairy agriculture in the Peri-urban settlements of Kisii town and the surrounding major urban centers.

4.5.1 Sample Size

45 farmers from the study area formed the sample size of the study out of which 7 had adopted the technology while 38 had not adopted. This is because the research sought to find out the reason for the low uptake considering the promotion efforts so far done.

4.5.2 Sampling Procedure

4.5.2.1 Multi-stage sampling

The study used the Multi-stage sampling of towns in the Dairy Commercialization areas (DCAs) in the county. These were the clusters that were used by the SNV programme in implementing the Kenya National Domestic Biogas Programme.

4.5.2.3 Cluster sampling

The county has 3 DCAs within the municipality and in each area respondents within the Peri-Urban who had adopted and those who had not adopted the technology were interviewed. The table below shows the clusters and distribution of samples (Table1.3).
Table: 1.3: Clusters of the Project and Biogas adoption

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Sampled Centers</th>
<th>Urban</th>
<th>Number of adopters</th>
<th>Number of non-adopters</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCA 1</td>
<td>Kisii Town</td>
<td>3</td>
<td>9</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kiogoro Township</td>
<td>2</td>
<td>6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>DCA 2</td>
<td>Suneka Town</td>
<td>1</td>
<td>8</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>DCA 3</td>
<td>Mosocho Township</td>
<td>2</td>
<td>8</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marani Town</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>8</td>
<td>37</td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

Source: Survey, 2013

4.5.2.4 Systematic sampling

Since the Peri-urban was somehow planned, systematic sampling was the best in administering the household questionnaires. In this procedure, counting of plots and the use of approximate distances was found effective.

4.5.2.5 Purposive sampling

Purposive sampling was used to identify those who had adopted biogas technology and the specific resource persons and the relevant institutions that would data on biogas choice and adoption.

4.6 Data analysis and Presentation

Concept analysis is the process of analyzing verbal or written communications in a systematic way to measure variables. After data collection, they were organized and analyzed based of study objectives. Qualitative and quantitative methods were incorporated to analyze information gathered from the respondents through calculation of means, percentages and mode. Desktop analysis and SPSS and Spreadsheet software were used to analyze the data that was collected from the field.
Analysis targeted respondents’ expressions, perceptions, events, questionnaires, behavioral observation, photographs, and records. In addition, data were represented using descriptive statistics representing frequency tables, pie bar and bar graphs.

4.7 Logistical and Ethical considerations

To facilitate easier collection of data in the field an introduction letter was obtained from the University for Identification which was used hand in hand with the University Identity card. Prior permission was sought from all the relevant resource persons in institutions before the actual visit. The respondents were informed about the purpose of the study, the procedures, and assured of no potential risks or costs involved.

To render the study ethical, the rights to self-determination, anonymity, confidentiality and informed consent were keenly observed. In order to eliminate or reduce probability of ethical dilemmas that might limit acquisition of information, confidentiality remained a priority in research. This statement of declaration remained on the first page of all questionnaires. Scientific honesty was maintained by clearly recording answers from the respondents’ honestly and without any manipulation.

4.8 Reliability and validity

Reliability is the degree of consistency with which an instrument measures the attribute it is designed to measure. The study measured reliability of data based on the set guidelines and ability to meet objectives. Content validity is the extent to which an instrument represents the factors under study. To achieve content validity, the study relied on current data from relevant stakeholders.
CHAPTER 5

5.0 RESULTS AND DISCUSSION

The following section gives objective explanations of the research findings. Statistics are based on the sample size and responses to each question that was asked. According to the researcher, the results are reliable to draw general conclusions and recommendations.

5.1 Level of Awareness and Attitude towards Biogas Technology

The data collection tool was designed to ask if the respondents have heard about biogas technology and the media that channeled the information about the technology for the first time. A sample population of 45 was taken and only 42 respondents responded to the question. The findings from the sample towns that were visited Mosocho had the highest number of people aware of the technology, 21.4% followed by Kisii town, 10.7%, Kiogoro at 14.3%, Sunela and Marani at 11.9% and 9.5% respectively (Fig 1.7). These results show that awareness of Biogas technology declines as you go further from Kisii town. This shows that the level of awareness is influenced by the town. Mosocho township respondents were very aware of the technology supposedly because of the organized CBOs that sensitize people about the technology and also that they are found in the DCAs which form active areas for KENBIP and GTZ to embrace the technology.

Figure 1.7: Awareness of Biogas Technology in Kisii Towns

Source: Field data, 2013
Generally, 85.71% have heard of the technology, 14.29% have never heard of the technology (fig1.8). From this statistics it implies that efforts by the various stakeholders to sensitize people about this technology through various channels has been done satisfactorily but the question remains, why the low technology uptake?

**Figure 1.8: Awareness of Biogas technology among Kisii County Peri-Urban residents**

Source: Field data, 2013

The respondents that were not aware of the technology attributed the lack of awareness and lack of campaigns especially from extension officers who visit them to popularize the technology.

Further, to a certain the level of the respondents' awareness, benefits and role of stakeholders in promoting of the technology, seven statements were used to gauge based on the degree of agreement or disagreement. The statements are:-

- **Biogas will solve the problem for fuel wood for cooking.** Findings showed that 81.4% strongly agreed to the statement, 11.6% agreed generally and 7.0% would not respond to the question.

- **Biogas technology will help to improve soil fertility.** 86.04% of the respondents agreed to the statement, 4.70% were undecided and 9.30% would not respond to the question.

- **Biogas technology helps to improve hygiene due to the use of wastes.** The statement has
88.10% respondents strongly agreeing to it 4.76% agreeing generally to it and 7.14% having no response to it.

- **Biogas will reduce the rate of deforestation.** 92.86% of the respondents to these statements strongly agreed while 7.14% would not respond to it.

- **Biogas will relieve women workload and save time used for fuel wood collections.** According to the World Bank (2003) report, valuable time and effort is devoted to fuel collection instead of education or income generating activities and this reduces productivity. 93.02% of the respondents strongly agreed to the statement while 6.98% would not rate the statement.

- **Generally, the benefits of biogas technology over weigh limitation.** The statement received 88.37% respondents strongly agreeing to it, 9.30% agreeing and 6.98% not rating it.

- **The government and other stakeholders HAVE NOT sufficiently promoted biogas technology.** The statement received 84.62% respondents strongly agreeing to it, 2.56% of the total respondents agreeing it and 10.26% of the respondents strongly disagreeing with it. From these statistics, it can be deduced that despite the respondents having some information on the technology, the government and other stakeholders have not been actively involved in promoting biogas technology among the Kisii Peri-urban residents.

### 5.1.1 Source of information

The study identified various channels of information that sensitize the public about the appropriateness, efficiency and advantages of adopting Biogas technology. These included biogas researchers, extension officers, personal research, neighbor, relative or friend who had adopted biogas technology, biogas project staff as well as radio and education curriculum.

The research findings indicate that 52.38% of the sample population received the information from neighbors, relatives and friends who had already adopted biogas technology, 35.71% were sensitized by radio media and personal research in school curriculum, Biogas researchers and biogas project staff had 4.76% contribution in the awareness creation of this technology in the Peri-urban centers of the county.
5.1.2 Awareness of Fuel wood Scarcity Problem

There was a question on ranking of the fuel wood problem in the area whereby 54% admitted that the problem of wood scarcity was serious, 37% ranked it as moderate while 9% said it was small (Fig. 1.9). This is enough evidence that there’s struggle to meet household energy demand in both the urban and the rural areas as Cunningham et al. (2007) found in his research in the Developing countries of the Sub-Saharan Africa.

**Figure 1.9: Rank of Fuel wood Problem in Kisii Peri-Urban Centers**

![Pie chart showing the ranking of fuel wood problem.]

**Source: Field data, 2013**

The respondents had to give the best strategy to solve the problem of fuel wood scarcity in the area and the responses indicated that there was an awareness of scarcity of fuel and land acreage and planting trees would not be a viable solution. A number of strategies were recommended as summarized in the figure 2.0, below:
Figure 2.0: Strategies to solve the problem of Fuel wood in Kisii County

Source: Field data, 2013

The attitude towards the technology was assessed by asking the adopters and the people who had not adopted the technology if they were finding the technology being appropriate or not. Out of the 42 respondents who answered the question, 88% of the respondents said the technology was appropriate, 2.4% found it inappropriate and 9% did not answer the question.

There was a question on whether one recommends the use of Biogas technology or not based on the awareness and usage. Out of the 41 respondents who responded to the question 83% strongly recommended the technology, 10% moderately recommended it and 7% happened not to recommend since they had little or no information about the technology(Fig 2.1 a and b). Those who strongly recommended were well informed of the benefits of the technology and adopted it or seen where it is used, those who recommended it moderately had some doubt and their recommendation was based on what they heard and left it for the user preference. Those who did not recommend had never heard of the technology before or seen where it works.
The survey findings show a wide contrast on the attitude versus the recommendation, an indication that people are aware of the technology and they can recommend it for those who are willing to adopt. The question remains; if 85.71% is aware of the technology, 83% find it an appropriate technology and 83% recommend it as the best alternative source of energy, what causes the low technology uptake? This implies that there are other factors which influence biogas technology adoption.

5.2 Factors Influencing the Adoption of BT among the Kisii Peri-Urban Residents

Biogas technology uptake in the Kisii Peri-Urban is being influenced by a number of factors ranging from socio-economic to non-economic factors. These factors influence fuel choice and substitution. The implications of fuel choice are on the user’s health and reduced poverty, increased productivity as well as general sustainability. The study identified the following factors to have a strong influence on the choice and adoption of biogas as an alternative fuel among the Kisii Peri-Urbans.

5.2.1 Level of Education

Out of the 85.711% of the respondents who had heard about biogas technology a good number were those who had attained secondary and tertiary level of education( Table 1.4 ). This is an indication that the level of education has a greater role to play in creating awareness of the technology.
Table 1.4: Level of education influence in technology adoption

<table>
<thead>
<tr>
<th>Level of Education</th>
<th>No of Adopters</th>
<th>No of Adopters (%)</th>
<th>Approx cost of plant (KSh ,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tertiary</td>
<td>1</td>
<td>12.5</td>
<td>80-100</td>
</tr>
<tr>
<td>Secondary</td>
<td>5</td>
<td>78.1</td>
<td>40-90</td>
</tr>
<tr>
<td>Primary</td>
<td>2</td>
<td>25.0</td>
<td>40- 70</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>0.00</td>
<td>None</td>
</tr>
</tbody>
</table>

Source: Field Data, 2013

The findings show that the higher the level of education the respondents had also influenced the size and cost of the biogas plant installed as shown on table above. This explicitly may also be attributed to the basic salary earnings of the respondents that can be linked to the level of education also.

5.2.2 Level of income

The level of education influences the level of income directly or indirectly. From the study the findings showed that most people in Kisii Peri-Urban installed plants ranging from 75,000 to 120,000. Most of those who had adopted the technology said that they used cash from own savings, loan and subsidy from the promoting agencies to install the plants.

5.2.3 Type of Housing and Livestock Management system

The study found out that 100% of the households that had installed biogas plants had permanent buildings. These findings agree with Pandu and Fraser (2003) who found out that if a house owns the main dwelling unit, it is more likely to use occupancy rules. They state one advantage of firewood as producing smoke that can stain walls and roofs. They further add that if a dwelling unit is a modern house the household is likely to use firewood alternatives because these fuels are cleaner.

The type, number of livestock and the type of management system used determines the availability of the substrate and availability of gas. 35.12% of the population used open grazing, 54.05 % used zero grazing and 10.81% used semi-grazing management system. 100% of those who had installed the plants had zero grazing units with an average number of 1.7 cattle. From the statistics, the Peri-Urban
area has a potential of more than 54.05% to switch to biogas when all other factors are held constant.

### 5.2.4 Multiple use of Fuels

Most Peri-urban residents used multiple household fuels to complement the main fuel. Biogas adopters sometimes used firewood and charcoal when they cooked heavy meals for many people. Multiple use of fuels has been mentioned to be the reason why most residents in the Sub-Saharan Africa are reluctant to switch to more efficient household energy alternatives, (Osiolo, 2009). Table 1.5 shows the major three fuel combinations adopted for use as main fuels by the Kisii Peri-urban residents in percentages:

<table>
<thead>
<tr>
<th>Type of Fuel/Rank</th>
<th>Main Fuel 1</th>
<th>Main Fuel 2</th>
<th>Main Fuel 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire wood</td>
<td>85.2%</td>
<td>25.0%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Biogas</td>
<td>9.3%</td>
<td>0.0%</td>
<td>0.00%</td>
</tr>
<tr>
<td>LPG</td>
<td>4.7%</td>
<td>12.5%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Charcoal</td>
<td>0.0%</td>
<td>37.5%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Electricity</td>
<td>2.3%</td>
<td>12.5%</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Source: Field data, 2013*

85.2% of the Kisii Peri-urban residents use firewood as the main fuel. Biogas adoption and use is ranked the second of the main fuels and has not been ranked in the second or third main fuel to complement other fuels. This suggests that when one owns a biogas plant it solves the problem of household fuel problems; a statement that was strongly agreed by 81.4% of the respondents as discussed earlier.

### 5.2.5 Accessibility to Electricity

The study found out that most of the households in the Kisii Peri-urban settlements were connected to electricity. Households that were connected to electricity used less firewood bundles than those that were not connected. Findings show that those households that were connected to electricity used an
average number of 7.5 bundles per month while those that had no connection used an average of 13.5 bundles per month. The study also found out that the households that were connected to electricity used LPG, solar and they were the ones that had adopted biogas technology.

5.2.6 Gender roles

The study findings showed that the responsibility of household was for women. 75.61% of the household responses had the women ensuring household fuel availability, 14.63% the husband, 4.9% children, 1.71% the wife and children and 2.4% the husband and children.

For biogas installed households, the husband played the role of installing the plant but the wife and children had the responsibility of maintaining it (plate 1.0 a and b). The study findings showed that 71.4% of the plants were maintained by women, 14.28% by the husband and 14.28% of the households visited, all the family members were involved.

Plate 1.0 a and b: One respondent explaining how a Biogas plant is maintained.

Source: Field Survey, 2013

5.2.7 Promotion, Training and Seminars

Promotion of biogas through various channels influenced the choice to switch and adopt the technology. Responses identified agricultural shows, radio, extension officers, subsidization of installing costs as well as demonstration farms as major sources of information as discussed earlier. The use of training by the use of seminars also was identified by 71.1% of the respondents to take place once a year of which they rarely attended. Trainings are organized by various promotion groups in the
DCAs but attendance is always low as affirmed by one of the extension officers in Mosocho. Promotion strategies included giving subsidy, organizing shows and campaigns and developing of demonstration farms.

5.2.8 Costs of Fuels

A quantitative and qualitative survey of the influence of fuel prices found out that prices had negative effects on fuel choice and adoption. Higher kerosene prices made households to choose either solid fuels only or a combination of non-solid fuels.

58.14% of the respondents who had not adopted biogas technology said it was because of high technology costs, a statement that was affirmed by the Ministry of Renewable energy and Petroleum (MoE) to be true as the cost was high for the people to reach. Mr. Bosire, a technician for the ministry admitted that the promotion strategies by the use of subsidy encouraged many residents in the area to adopt the technology but since it were withdrawn, adoption drastically dropped.

The study found that people tended to go for cheaper fuels that had low efficiency. Biogas faced some competition by LPG but adoption of LPG was constrained by the high costs of purchasing and refilling cylinders. High costs of household cooking fuels and high costs of stoves resulting from improved technologies acted as a market barrier to switch to cleaner fuels such as biogas. The results agree with Schlag and Zuzarte (2008) who found the same results using qualitative analysis in the Sub-Saharan Africa. The findings from the survey study of three filling stations and one supermarket and other essential fuels sold locally had the following quantitative data for costs as at December,2013(Table 1.6).
Table 1.6: Average Prices of Commonly used Household fuels in Kisii Peri-Urban Area

<table>
<thead>
<tr>
<th></th>
<th>Cost @ 3kg gas</th>
<th>Cost @ 6kg gas</th>
<th>Cost @ 13kg gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG gas</td>
<td></td>
<td>Sh.1470</td>
<td>Sh.3195</td>
</tr>
<tr>
<td>K- Gas</td>
<td>-</td>
<td>Sh.1455</td>
<td>Sh.3135</td>
</tr>
<tr>
<td>Hashi gas</td>
<td>-</td>
<td>Sh.1320</td>
<td>Sh.2850</td>
</tr>
<tr>
<td>DFL gas</td>
<td>-</td>
<td>Sh.750</td>
<td>Sh.1470</td>
</tr>
<tr>
<td>TOTAL gas</td>
<td></td>
<td>Sh.1470</td>
<td>Sh.3190</td>
</tr>
</tbody>
</table>

Average cost of cylinder: Sh.1480, Sh.2600, Sh.4400

1 unit of Power Watt: Sh.120.00

1 Bag Charcoal: Sh. 1600.00 per Bag

Kerosene: Sh. 84.80 per Litre

Source: Field Survey, 2013

5.2.8.1 Source of cash for installation and Biogas Plant maintenance

The findings from the study found out that 57.14% of the Biogas adopters used their own contributions and subsidy from the biogas promoters to install biogas plants for their households, showing that subsidies play are crucial strategies to promote the technology.

Consequently, the study findings show that the government has played minimal role or no role to facilitate adoption of biogas by subsidy. The research also found that 28.57% used their own cash to install the plants; mostly they happened to be retired civil servants such as teachers. Though some lending financial institutions gave loans, their interests were as higher as 18% p.a such as Jamii Safi Loan from Equity bank hence most of the people were reluctant to go for them(Fig.2.1)
The implication here is that the low adoption rates experienced by biogas promoters is probably due to withdrawal of the subsidy and reluctance of the government to give financial support in form of subsidy. Further the low adoption can be attributed to high interests on loans in the finance institutions.

5.2.9 Availability of important materials

Availability of essential resources ensures availability of substrate material for the biogas plant as well as maintenance. The assessment that was done showed that essential resources such as water, grazing land were readily available for most respondents while fire wood was in short supply research findings tally to the fact that Kisii County has been listed as one of the high potential areas for biogas production by the KDBP(Figure1.7). The research showed that despite the availability of hay most of the population still engaged in semi-zero grazing and others practice.
Table 1.7: Availability of Essential Resources For the need and production of Biogas

<table>
<thead>
<tr>
<th>Resource/Availability</th>
<th>Water</th>
<th>Fire wood</th>
<th>Grazing Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Readily Available</td>
<td>84.09%</td>
<td>39.53%</td>
<td>48.72%</td>
</tr>
<tr>
<td>In Short Supply</td>
<td>15.91%</td>
<td>60.46%</td>
<td>38.46%</td>
</tr>
<tr>
<td>Not available</td>
<td>0.00%</td>
<td>0.00%</td>
<td>12.82%</td>
</tr>
</tbody>
</table>

Source, Author 2013

5.3 Efficiency of Biogas in Comparison to other Household Fuels
Qualitative and quantitative approaches were used to assess the efficiency of biogas in relation to other fuels. Six household fuels commonly used among the Peri-Urban residents of Kisii town were studied. Efficiency of each fuel was assessed in terms of cost, the ease to use and reliability.

5.3.1 Biogas
All respondents that had adopted biogas agreed that the technology was easy and fast to use, it is clean in comparison to kerosene stoves and firewood that are sooty. Biogas doesn't scent food like kerosene stoves, firewood and charcoal use. They agreed that the cost of installation is high but however, the running and maintenance costs are low and it saves time to fetch firewood.

The cost of a complete biogas plant installation ranged from sh.40,000 to sh. 120,000 which was relatively high for most of them. 40% attested that biogas was very reliable while the remaining 60% said it was simply reliable. These responses indicated that biogas was readily available continuously after installation of the plant and gas production and efficiency of the burning gas was rarely affected by weather conditions as long as the plant is routinely well maintained contrary to the firewood and charcoal which reduced efficiency when rained and paraffin when its in scarce supply.

The respondents mentioned some limitations of the technology which 88.37% of the respondents strongly agreed that they outweighed the benefits of biogas. They mentioned of insufficient energy for cooking foods that require more time and energy to be prepared because of the pressure of the gas and the efficiency of burning stoves. They said that modern biogas stove went for sh. 5500 to sh. 10,000 which was expensive and therefore they opted to use those that are cheaply made by Jua kali artisans.
Plate 1.1: Modern Biogas stove

Source: Survey, 2013

Other benefits the technology were the production of well rotten organic fertilizer free from crop pests and disease hence increasing agricultural production. Maize crops and Napier grass performed well with this fertilizer. All that has used the fertilizer claimed increase in crop consequentially their homes were clean as sorting of waste was done regularly.

Plate 1.2 a and b: Use of Bio-Slurry in Crop production

Source: Field Data, 2013
5.3.2 Firewood
85.19% of the Kisii Peri-urban use firewood and charcoal combination to provide household energy for cooking. Contrary to literature, 5.26% of the respondents said it was very efficient, 57.89% said it was efficient and 10.5% said it was not efficient.
Firewood was not cost-effective as one bundle of four pieces went for sh.100. For most households visited such a bundle would hardly be used for two days hence in most families women and children struggled to obtain firewood from the surrounding as their were no permanent sources of fuel wood in the area.
13.6% of the firewood users said it was very cheap, 44.74% was less affordable and 42% it was very expensive; not affordable especially during rains the problem was further amplified. I quote, "Ekeroyaturechinkochikobaobokong'unaendechimpese,.....eriokirikoreriaabanaamaiso,goikatorimieomo rerobamanyegoanzagosoma.Nonyenintweetokoremereriaekiagerantobwatienchera." Which translates: "When it has rained there is a problem of firewood and they are wet....smoke from the wood irritates the eyes of children doing their assignments, sometimes it forces us to extinguish fire after cooking so that children can start settle to read. Even us we are forced to use it because we have no alternative."
A statement with heavy weight and requires urgency in response. Biogas adoption is the solution to all this as it can be used for lighting, cooking and operating electronics. From observation, utensils were covered by soot especially cooking pots. The respondents admitted of sometimes using crop remains that scented and stained food with soot.

5.3.3 Electricity
93.9% of the sample population was connected to electricity. As by the time of visit the respondents said that the connection was not reliable as they experienced frequent blackouts which lasted even 2-3 days. The respondents said that power failure during this time made them to switch to candles and kerosene, a problem which can be completely solved by biogas technology as it can be used for lighting, cooking, operating electronics and is available throughout.
84.62% of the respondents said that electricity was very efficient for use in the household. The research found out that electricity was not used for cooking but for lighting homes, operating electronics and ironing. In regard to this, most of the households that were connected used Biogas, charcoal and LPG or a combination.
23% found electricity billing being very cheap, 38.46% found it less costly and another 38% found it being very expensive. Installation costs were sh.35, 000 by then and at present sh.75,000; cost that would be used to install a biogas plant and solve all household energy issues.
5.3.4 Kerosene
Like firewood, kerosene was ranked second for the most fuels used among the Kisii Peri-urban residents. Kerosene was sold at an average price of sh. 84.70 per litre in most filling stations. Most residents purchased in low packages of measurements which went as low as sh.5.00. This price seemed to be very expensive for the respondents. For those who used kerosene stoves and kerosene lanterns for lighting they would use to almost 55 shillings per day as they purchased for every cooking hour and every evening for those who used it for lighting also.

In terms of efficiency, 64.71% of the respondents said kerosene was not sufficient, 17.64% it was efficient and 11.6% said it was very efficient. Whichever the degree of efficiency, all the respondents had complaints of smoke irritating the eyes, choking dour smoke after use, scenting of clothes and beddings as well as the food cooked.

Kerosene was found to be reliable during blackouts and a complement fuel with other fuels such as charcoal though it was expensive to most of the respondents.

5.3.5 LPG
Liquefied petroleum gas was one of the fuels used by 4.65 of the sample population. The filling station attendants regrettably said that though it was a good alternative, most of the residents in Kisii County generally have not switched to its use.

62.5% of the user respondents said that LPG was very efficient and 37.5% said it was efficient. The frame that it produced was very hot compared to that of biogas and the pressure of the gas was high. It was very fast to use in cooking though one had to take extra caution in its handling because of its high flammability. Regrettably some of the adopters had dropped using it because of the risk exposure to children.

A survey that was done in major supermarkets and filling stations showed that a 3kg cylinder gas was filled with an average price of sh. 750 and a 13kg cylinder with sh. 3,092.5. Further the user had to pay a deposit of sh.1480 for a 3kg cylinder, sh.2600 for a 6kg cylinder and sh.4400 for a 13kg cylinder. 71.43% of the user respondents said that though they used it, it was very expensive and 28.57% said it was affordable. This tallies with a research survey that was conducted in Kenya where it was found that the attempt to motivate households to use LPG has been gloomy in Kenya because of a number of factors. This forms a fertile area of research too.
5.4 The Role of stakeholders in Promoting Biogas Technology

5.4.1 Ministry of Energy
The ministry has a department of renewable energy and petroleum. The department has a mission to facilitate provision of clean, sustainable, affordable and secure energy for National Development while protecting the environment. Among the technologies being promoted include biogas, solar Photovoltaic, improved stoves and energy saving ceramic Jikos.

The Ministry has technicians who offer trainings and technical services to the farmers within the demonstration farms. They also facilitate tree planting projects through sale of various species of tree seedlings. The ministry promotes the fixed and floating dome technologies. However, according to Mr. Odhiambo, a chief technician in the center said farmers prefer the fixed dome to the floating dome; the reason why there are very few floating technologies. By the time of research 114 plants had been installed where 3 were working floating dome.

Discussions in the demonstration farm had the following concepts of literature coming clear:-

- All digesters are round to ease the movement of micro bacteria, since they cannot move past sharp corners,
- The floating drum needs to be painted black so that it absorbs heat to maintain ambient temperatures for microbe activities
- The water and cow dung substrate ratio at the inlet chamber should be 1:1.
- The expansion chamber is also the recycling chamber; can recycle the substrate for 90 days
- The problem of humidification can be reduced by introduction of a water through and leakages along the piping system be avoided by the use of PVC pipes which are cheap and continuous hence minimal joint work.

5.4.2 Ministry of Agriculture, Livestock and Fisheries
The Ministry provides agricultural extension services under the National Agriculture and Livestock Extension Programme (NALEP) The MoA is involved in the provision of livestock extension and product services as such providing extension advice in the maintenance of biogas plants and zero grazing units. According the County agricultural Officer, Mr. Dominic Sambe, Kisii County had a great potential for biogas production. The technology is experiencing low uptake due to its high installation costs and withdrawal of subsidies by promoting and funding agencies. The Ministry had a plan to introduce plastic tubular technology which is cheaper compared to the other two common technologies. Through her extension officers and Agricultural shows it promotes the technology
5.5.3 Kenya National Biogas Committee (KENBIC)
The committee was established in 2007 as the Kenya National Biogas Task Force. It comprises of a multi-stakeholder group to see the maturity of biogas programmes in Kenya. The membership of the committee is: MoE, KENFAP, HIVOS, SNV, Association of Biogas Contractors in Kenya, Project developers, Association of Microfinance Institutions, Kenya Bankers Association, JKUAT, MoALF.

The roles of the Committee involve:-

i. Provides overall policy guidance;

ii. Provides advice and facilitate actions that abide to generally accepted standards; for project management and administration;

iii. Assists the programme to establish beneficial linkages, mobilization of funds, and creation of a favorable environment for project development;

iv. Endorses the programmes strategy, reviews activities and the outcomes and approve annual plans and budget.

5.5.4 NEMA
NEMA encourages the adoption of clean technologies according to EMCA, 1999. Mr. Oloo; the Assistant County Director of Environment regretted that NEMA has never been involved directly to promote biogas technology in the County.

5.5.6 Kenya Forest Service
The institution has been involved in promoting the technology by recommending it as one way to achieve 10% forest coverage in Kenya. It also provides free seedlings for agro forestry planting.

5.5.7 Kenya National Federation of Agriculture Producers (KENFAP)
This is the organization involved in the implementation of the Kenya National Domestic Biogas Programme which is a component of Africa Biogas Partnership Programme. The programme is funded by the Government of Netherlands and is managed jointly by SNV and HIVOS.

The Kenyan government gives support for these initiatives through the following ways:-

I. Providing a secure national funding for executing the programme,

II. Engaging into local agreements with partners to provide finance, training and extension services

III. Administration of subsidies and sourcing funds

IV. Provision of an enabling environment for KENDBIP through establishment of linkages and networks countrywide and undertaking specific supporting activities at all levels
5.5.8 GTZ Biogas
Major promoter of biogas technology in Kisii County. Sensitizes and creates awareness among the dairy farmers to adopt biogas technology and also provision of training and extension services. Promotes fixed dome design technologies in the area.

5.5.9 European Union
EU is one of the donors to promote renewable energy technologies in the County. The EU energy facility has been funding the biogas programme by the GTZ.

5.6 Challenges to the Biogas technology Promotion and Adoption
Harmonized reports from the institutions identify the following factors to hinder promotion and adoption of biogas technology in Kisii County

1. Cost installations are very high for both biogas technology designs and most farmers cannot afford it even if they are given subsidy.
2. Most technicians are not well trained in the installation of digesters; at many times they ignore dimensions and procedures on its construction hence resulting to faults such as leakages, humidification and low pressure of the gas are frequently reported problems.
3. The ministry provides extension services three times a year. The extension services and civic education/training are tedious as the programmes require finances which are not easily availed by the government. In addition, the population is large compared to the number of extension personnel available.
4. Information flow channels are biased. People are not ready to share information they have heard about the technology or the channels used do not reach all the people.
5. Many people use multiple household fuels hence they find it difficult to switch.
6. Inadequate and inefficient appliances to use biogas technology such as lighting mantles and efficient stoves.
7. Limited links and coordination of both the policies and the institutions. Most of biogas institutions and agencies tend to work independently.

5.7 Achievements and Research
i. Research is ongoing on the available materials that can be used as a substitute of cow dung as a substrate to produce methane gas.
ii. The ministry has managed to conduct civic education once a year.
iii. Organizing for demonstration and training sessions in the Kisii Agriculture Training Center (KATC).

iv. The Ministry of Agriculture and that of Energy have on way plans to avail efficient technologies to maximize the beneficial use of biogas energy and also introduce a cheaper Plastic design that can be afforded by many farmers.

5.8 Weakness of Biogas Promotion Institutions
Weak linkages of institutions and stakeholders developing and promoting biogas technology in the area have undermined promotion strategies in the area. There is no coordinating body to harmonize ideas for promotion of biogas technology hence the institutions act independently.

The existing institutions, though acting independently, do not have enough capacity to play their roles. Key institutions have inadequate human personnel and limited access to finances to carry out their devolved functions. In addition, the legislations do not uphold the technology. Therefore, there is need to come up with a national Biogas institution to Coordinate overall devolved activities of the biogas sector.
CHAPTER 6

6.0 SUMMARY OF THE FINDINGS, RECOMMENDATIONS AND SUMMARY

6.1 Summary of the Findings

- Biogas technology uptake has been generally low. Presently there are 114 biogas units in Kisii County.
- Low uptake of the technology has been attributed to the withdrawal of subsidy by promoting agencies in 2011. The average plant installation cost is sh. 75,000.
- Biogas technology is viable for those farmers who own zero-grazing units who are accessible to adequate water and livestock feeds.
- There is limited number of trained technicians and those available have low capacity for the construction of plants the reason why most adopters experience post-installation problems with their plants.
- The government support in promoting biogas technology has been below par. Only promotion agencies provide incentives but the government has not been actively involved.
- There’s limited coordination between stakeholders and institutions promoting biogas technology hence the limited coordination in its promotion.
- The existing energy policies and school curriculums have not upheld biogas technology as the best alternative green energy in
- Biogas adopters in Kisii County lack efficient appliances such as stoves, lighting and storage of gas hence the benefits of the technology have been restricted to cooking.
- Biogas technology has been given little attention as a source of alternative energy in the Peri-Urban areas in comparison to electricity which has been given emphasis by the Rural Electrification Authority.
- Multiple uses of fuels among the Kisii Peri-Urban residents is the major hindrance to fuel-switching.

6.2 Conclusion

Energy is central to all economic, social and industrial development. Access to efficient and reliable energy powers economies and empowers women and the youth. Since the 1970 energy crisis, predictions show that production of oil, gas and coal would not be available to keep indefinitely the growing global demand of energy as depicted by the ever increasing energy gap. Worldwide there have
been efforts to develop alternative energy supplies from renewable sources such as solar tidal waves, geothermal, wind and biogas. Biogas forms a viable source of alternative energy for the Kisii residents as 64.86% of the Peri-Urban population practice zero grazing.

The County lies among the high agricultural potential areas with high population densities and a result, there’s reduced land acreage to plant trees for fuel wood production. Crop residues and degradable municipal waste in Kisii towns have the potential that can be used as feeds for livestock and or alternatively used directly as a substrate for community biogas plants. Promoting agencies such as KENFAP, NALEP, GIZ-SDCP, SNV and KENDHIP have played an important role in sensitizing the people to adopt biogas technology. From the 114 plants that have been installed so far, the multiplier effect has been evident through increased agriculture productivity from the disease and pest free organic fertilizer, commercialization of gas in the rentals, proliferation of hatchery and poultry projects as well as reduced excision of plant cover in the area.

The Ministry of Energy through the Energy Centre in Kisii provides training on farmers on the construction of biogas digesters and sensitization of the use of other renewable sources of energy and energy saving facilities. Despite such efforts, appliances that would ensure maximization of biogas technology benefits have not been availed due to financial constraints.

6.3 Recommendations
1. Introduce and promote less costly and with low capacity technologies such as the Plastic tubular design to encourage farmers who cannot afford and who have less livestock install biogas.
2. Provide subsidized rates of interest on loans those who are willing to install such beneficial technologies in financial institutions.
3. Establish efficient information flow and coordination channels to link actors promoting Biogas technology and the community.
4. Local based technical and institution training centers need to be supported to provide capacitated personnel to provide efficient energy technology solutions in terms of services, appliances and practices.
5. Apart from awareness creation and provision of technical extension services, the Central government should provide incentives through special programmes under line Ministries.
6. Harmonize energy policies to uphold biogas technology as the best alternative green energy for the rural and urban residents.
6.4 Areas of Further Research

1. There is need to research on other locally available organic materials that can be used as a substrate substitute for cow dung to produce Methane gas as well as those which can catalyze the gas production as well as increase its purity.

2. Further research needs to be done on the technologies that can be used in the packaging and storage for both household and commercial purposes.

3. Further comprehensive research needs to be done on the implications of fuel Choice on the environment and health.

4. These is need for further research on the influence of multiple-use of fuels (stacking) on fuel switching to cleaner and green energies.
APPENDIX I

REFERENCES
5.
12. EASWN (Jan – June 2012).”The East African sustainability Watch Network”.Vol 1 Issue 1 Magazine


43. WHO.(2005).Sustainable Development and Health Environments
44. World Bank (2003).Household Energy use in Developing countries
53. EASWN (Jan – June 2012)."The East African sustainability Watch Network”.Vol 1 Issue 1 Magazine.
## APPENDIX II

### THE PLANNING MATRIX

<table>
<thead>
<tr>
<th>ISSUE</th>
<th>CURRENT INTERVENTION</th>
<th>PROPOSED INTERVENTION</th>
<th>RESPONSIBILITY</th>
<th>TIMEFRAME</th>
<th>MONITORING AND EVALUATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To assess the level of people’s awareness and attitude towards biogas technology</td>
<td>High level of awareness but low adoption</td>
<td>Subsidy of Ksh. 18 000-25 000, Sensitization on the multiplier effect of adopting BT, Establishment of demonstration farms</td>
<td>Introduce technologies that are cheaper in cost and maintenance, Increase subsidy to an average of Ksh 75 000, Increase and decentralize demonstration farms, Create awareness on the multiplier effect opportunities of BT</td>
<td>GoK, NGOs, Ministry of Energy, Ministry of finance, Donor institutions</td>
<td>Short term Medium term</td>
</tr>
<tr>
<td>Fuel preferences and multiple fuel usage</td>
<td>Develop a comprehensive energy policy to uphold clean and environmental friendly energies-biogas, Subsidize costs for all green</td>
<td>GoK, Private sector, NEMA Ministry of Youth,</td>
<td>Continuous Short term</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited and centralized campaigns/seminars</td>
<td>Establishing Demonstration farms in DCAs, Use of Agricultural shows to create awareness, Regional campaigns are done a year</td>
<td>Encourage creation of CBOs to promote biogas as an appropriate technology, Decentralize demonstration farms to satellite towns and villages, Use public forums such as barazas to create awareness</td>
<td>CBOs, County Government, NGOs, Media, Ministry of Higher education Science and Technology, Ministry of Agriculture, Livestock and Fisheries.</td>
<td>Short term</td>
<td>CBOs, MoALF, MoE, County Government</td>
</tr>
<tr>
<td>Limited technical skills and information at consumer-end-user level</td>
<td>Technical extension services available at varying fee</td>
<td>Introduce appropriate technology, Disseminate operational and maintenance manuals to biogas adopters, Training and certification of local artisans in technical institutions eg Gusii Institute of MoE, MoALF, Ministry of Higher education Science and Technology, NGOs, Local CBOs, Mo L</td>
<td>MoE, MoALF, NGOs, Local CBOs, Mo L</td>
<td>Medium term</td>
<td>MoE, MoALF, NGOs, Local CBOs, Mo L</td>
</tr>
<tr>
<td>Cultural household fuel preferences (BT is dirty)</td>
<td>Provide protective gear and equipment for handling and routine maintenance of biogas plant, Educate people on the efficiency of biogas as an excellent fuel and waste handling technique</td>
<td>MoE, MoALF, CBOs, MoE Private sector</td>
<td>Short term</td>
<td>MoE, MoALF, CBOs, MoE Private sector</td>
<td></td>
</tr>
</tbody>
</table>

2. To explain the main factors influencing the choice and adoption of Biogas Technology

<p>| High biogas plant installation costs | Giving subsidy Ksh. 18 000-25 000, Full sponsorship through SDCS program, Financial institutions giving loans at an interest | Increase subsidy to Ksh. 75 000 Build The capacity of local MFIs in lending for biogas, Mobilize seed capital to catalyze biogas lending program in MFIs, Subsidize interests on loans and make collateral requirements for loan flexible, Increase research and development especially on | Local MFIs, Cooperator societies, Donor agencies, GoK, KENDBIP, Banking institutions, Ministry of Higher Education and Research | Short term | NGOs, MoE’ GoK MoE | Medium term |</p>
<table>
<thead>
<tr>
<th>Inadequate substrate for digesters</th>
<th>Borrowing from neighbors</th>
<th>Advocate for communal/corporate plants, Use alternative substrates such as vegetables, poultry droppings, organic municipal waste Research on cow dung substrate substitute, Encourage more zero-grazing practices</th>
<th>CBOs, NGOs, Community leaders, Media</th>
<th>Medium term</th>
<th>CBOs, NGOs, Community leaders,</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple use of household Fuels</td>
<td>Sensitize people on the cumulative cost and health implications of energy stacking, Encourage innovation and sensitization through science congress exhibitions in schools</td>
<td>Media, MoH, CBOs, MoE</td>
<td>Continuous</td>
<td>MoH, CBOs, MoE</td>
<td></td>
</tr>
</tbody>
</table>
3. To assess the efficiency of biogas technology compared to other household fuels

<table>
<thead>
<tr>
<th>Inadequate energy for cooking</th>
<th>Use of multiple fuels</th>
<th>Use appropriate stoves designed for biogas, Enhance training on the ratios of substrate preparation, Issue free training manuals on biogas digester maintenance</th>
<th>KENDBIP, CBOs, MoALF, MoE</th>
<th>Short term</th>
<th>CBOs, MoALF, MoE, Private sector NGOs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor quality and quantity of gas produced</td>
<td>Training on appropriate feeding of the digester with correct ratio substrates Use disulphide to enhance quality of gas, Avoid discharge of acaroids into the digester, Research on substances that can catalyze production of methane</td>
<td>GoK, NGOs, CBOs, Farmers MoE</td>
<td>GoK, NGOs, CBOs, Farmers MoE</td>
<td>Short term</td>
<td>GoK, NGOs, CBOs, Farmers MoE</td>
</tr>
<tr>
<td>Inadequate appliances and facilities to handle BT</td>
<td>Burning excess gas, KENDBIP sales appropriate appliances, Use of modified LPG stoves from Jua Kali</td>
<td>Encourage farmers to purchase modern biogas stoves to increase combustion efficiency, Import technologies from other countries, Provide gas balloons for storage and sale of gas, Research and development.</td>
<td>Local CBOs, MoE, Private sector, Donor agencies, GoK, County Government</td>
<td>Short term</td>
<td>County government, MoE, Private sector, CBOs</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>---------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>----------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Inadequate policy to uphold Kenya Biogas as clean development mechanism</td>
<td>Energy Policy, 2012</td>
<td>Include biogas as a clean development mechanism, Development of a legislative regulatory framework for biogas</td>
<td>GoK, County government, Private sector, Communities, MoALF, MoE, NGOs and Donor agencies</td>
<td>Medium term</td>
<td>GoK, NGOs, CBOs</td>
</tr>
<tr>
<td>Lack of an overall central biogas coordinating body</td>
<td>Establish an overall coordinating body in the energy sector to monitor the operations of stakeholders, Link government and NGOs objectives on biogas technology</td>
<td>GoK, County government, Private sector, MoALF, MoE, NGOs and Donor agencies</td>
<td>GoK, NGOs, CBOs</td>
<td>Short term</td>
<td>GoK, NGOs, CBOs</td>
</tr>
</tbody>
</table>

4. To explain the role and challenges of stakeholders in promoting biogas technology
| Inadequate communication channels capacity to reach farmers | Use of local media and extension officers | Provide transport vehicular to extension officers to reach more farmers, Maximixe the use of local media stations, Use neighbors and CBOs to sensitize People. | CBOs, MoALF, Media GoK County Government | Medium term Continuous | CBOs, MoALF, Media GoK County Government |
| High interest rates on loans | Subsidize interests on loan facilities by the lending institutions on green technologies, Mobilize seed capital to catalyze biogas lending programs | MFIs, Banking institutions, Cooperative saccos, Donar agencies GoK | Short term | GoK CBO, Private sector |
APPENDIX III

INSTITUTIONAL INTERVIEW GUIDE

Applicable to all Government Ministry offices/Departments/Institutions Dealing with Biogas Technology

Greetings. I am a Kenyatta University Undergraduate student taking a course in Environmental Planning and Management. I am undertaking a research entitled "An assessment of factors influencing the choice adoption of Biogas Technology among the Peri-urban residents of Kisii County." I kindly request you to help me in the endeavor by answering a few questions.

Any information you will give will be handled with confidentiality and will be used for no any other purpose other than for academic purposes. Thank you in advance.

1. Policy statements and Strategies on alternative energy sources versus the implementation stat
2. Please if you can provide data on the following:-
   - Situation in Kisii County,
   - Renewable energy technologies so far Implemented in Kisii County,
   - Government and Non-governmental organizations dealing with biogas technology,
   - Number of biogas plant units so far installed.
3. Who monitors the operations of NGOs dealing with energy issues and what are the reporting mechanisms or channels used by both project owners and the public (beneficiaries of the technology)?
4. What are the promotion strategies and support services by the offered by the Ministry/Government organizations to biogas projects and the community to facilitate promotion of biogas technology?
5. What are the challenges facing the Ministry/Department/organization on promotion of renewable energy technologies particularly Biogas Technology?
Greetings. I am a Kenyatta University Undergraduate student taking a course in Environmental Planning and Management. I am undertaking a research entitled "An assessment of factors influencing the choice adoption of Biogas Technology among the Peri-urban residents of Kisii County." I kindly request you to help me in the endeavor by answering a few questions.

Any information you will give will be handled with confidentiality and will be used for no any other purpose other than for academic purposes. Thank you in advance.

PART 1
A: Preliminary information

Village .................................................................

Ward ....................................................................

Sub-County ..........................................................

PART A: Baseline Household Information

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>Education Level</th>
<th>Occupation</th>
<th>P.a Income (Ksh)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PART B: LIVESTOCK

Indicate number, and management system of the various livestock types in your farm.

<table>
<thead>
<tr>
<th>Type</th>
<th>Number Kept</th>
<th>Management</th>
<th>Key to management System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cattle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goats</td>
<td></td>
<td></td>
<td>1 = Zero grazing</td>
</tr>
<tr>
<td>Sheep</td>
<td></td>
<td></td>
<td>2 = Semi grazing</td>
</tr>
<tr>
<td>Pigs</td>
<td></td>
<td></td>
<td>3 = Open grazing</td>
</tr>
<tr>
<td>Donkeys</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicken/ducks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others (specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PART C: Availability of important resources

i. Are the following resources available in your area?

Key on availability of resources

(i) Readily available ( ii) Is in short supply (iii) Not available

<table>
<thead>
<tr>
<th>Resource</th>
<th>Availability (use key)</th>
<th>Distance to the resource (Kms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water for domestic use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel wood for cooking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grazing land for livestock</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ii. Do you sort your household waste?

( i) Yes ( ) (ii) No ( )

iii. What is the major source of fuel for your domestic uses?..................................................
iv. If you are using Firewood or Charcoal, What is the average number of fuel wood bundles and or bags of charcoal used per month .................................................................

PART D: Gender Roles and Awareness of Fuel Shortages

i. Who is responsible for energy availability in your household;
   (i) Wife (   )
   (ii) Husband (   )
   (iii) Children (   )
   (iv) Wife and children (   )
   (v) Husband and children (   )

ii. How do you rank the problem of fuel wood shortage in your area?
   (i) Serious (   ) (ii) Moderate (   ) (iii) Small (   )

iii. What do you think is the best strategy toward solving the problem of fuel wood?
   (i) Migrate to an area closer to the source of fuel wood (   )
   (ii) Plant trees (   )
   (iii) Stop free range cattle, goats an (   )
   (iv) Stop charcoal making (   )
   (v) Prevent bush fires (   )
   (vi) Looking for alternative sources of energy (   )
   (vii) Others (specify). .................................................................

iv. Do you know any alternative energy other than fire wood and charcoal?
   (i) Yes (   ) (ii) No (   )

   (b). If Yes, mention them;
   ( i ) ...........................................................................................................
   ( ii ) ...........................................................................................................

   (c). For the alternative energy sources you mentioned above, which ones do you use?
   (i) ...........................................................................................................
   (ii) ...........................................................................................................

PART E: Awareness, Attitude, Choice and promotion of Biogas Technology
1. Have you ever heard about the biogas technology?
   (i) Yes ( )  (ii) No ( )

2. Have you adopted biogas technology?
   i. Yes ( )  (ii) No ( )

3. Who gave you information about biogas technology for the 1st time?
   a. Biogas researcher ( )
   b. Extension officers ( )
   c. Politician ( )
   d. Neighbor, Relative, friend who adopted BT ( )
   e. Biogas Project staff ( )
   f. Others (Specify) .................................................................

4. If your answer in 2 (b), above is NO, why have you not adopted biogas technology?
   a. Do not see the benefit of biogas technology ( )
   b. Shortage of household labor ( )
   c. Plenty of fuel wood in the area am living ( )
   d. High Technology costs ( )
   e. Not aware of the technology ( )
   f. I find it not appropriate ( )
   g. Others (specify) ........................................................................

5. What is your comment concerning biogas technology as alternative energy source;
   a. Is Appropriate technology ( )
   b. Is Not appropriate technology ( )

What is your recommendation on biogas technology promotion?
   i. Strongly recommended ( )
   ii. Moderately recommended ( )
   iii. Not recommended ( )

Give reason if 3* .................................................................
6. Use the following Key to complete the table below:

**KEY**

<table>
<thead>
<tr>
<th>Availability</th>
<th>1-Available</th>
<th>2-Readily Available</th>
<th>3-Not available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>1 Very Efficient</td>
<td>2-Efficient</td>
<td>3-Not efficient</td>
</tr>
<tr>
<td>Cost</td>
<td>1 Very cheap</td>
<td>2-Less Costly</td>
<td>3 Very Expensive</td>
</tr>
<tr>
<td>Affordability</td>
<td>1 Affordable</td>
<td>2-Less Affordable</td>
<td>3 Not Affordable</td>
</tr>
<tr>
<td>Reliability</td>
<td>1 Very Reliable</td>
<td>2 Reliable</td>
<td>3 Unreliable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household Fuel Type</th>
<th>Availability</th>
<th>Cost</th>
<th>Affordability</th>
<th>Efficiency</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firewood/Charcoal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kerosene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biogas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Circle one number based on whether you strongly agree (SA), agree (A), undecided (UD),
Disagree (DA) or strongly disagree (SD) statement.

<table>
<thead>
<tr>
<th>STATEMENT</th>
<th>SA</th>
<th>A</th>
<th>UD</th>
<th>DA</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Biogas will solve the problem of fuel wood for cooking.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>• Biogas technology will help to improve soil fertility.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>• Biogas technology help to improve hygiene due to the use of wastes</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>• Biogas technology will reduce the rate of deforestation.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>• Biogas will relieve women workload and save time used for fuel wood collections.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>• Generally benefits of Biogas technology over weighs limitation/weakness.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>• Government and other stakeholders have not sufficiently promoted biogas technology</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

PART C: Experience on biogas technology. FOR BIOGAS USERS ONLY

1. Which year did you start using biogas technology as source of energy? ………
2. Who/ which company built you a biogas plant..................................................
3. Where did you get cash for biogas Installation and maintenance?
   (i) Own savings ( )
   (i) Credit /Loan ( )
   (ii) Fully Sponsored by Biogas project ( )
   (iii) Own contribution and subsidy from Biogas project ( )
   (iv) Own contribution and subsidy from the Government ( )
   (v) Other sources (Specify) .................................................................

4. What influenced you to adopt Biogas technology?
(i) Out of my own interest
(ii) Encouraged by extension officer
(iii) Influenced by friends/neighbors who have already adopted
(iv) Biogas technology
(v) Given/promised some incentives (Specify)
(vi) Awareness of environmental problems
(vii) By-laws against tree cutting
(viii) High costs of other energy sources
(ix) Sensitized by the media
(x) Others (specify) ...............................................................

5 (a). Is your biogas plant functioning?
   (i) Yes (      ) (ii) No (      )

(b). If yes what are the benefits of using the technology:
   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) ...............................................................

(c). If your biogas plant is not functioning, for how long? .......... (months)

(d). What are the reasons for none functioning of your biogas plant?
   i. Technical problems (      )
   ii. Feeding related problems (      )
   iii. I don’t know (      )
   iv. Others (specify) ................................................................

(e). How frequent are the Biogas project staff visit you to see the progress of the plant?
   (i) Often (      )

87
(ii) Not often
(iii) Never came back since installation of the plant

(f). Are technical services available when needed?
(i) Easily available
(ii) Available but not frequent
(iii) Not available

(g). What are weaknesses/limitations of biogas technology?
(i) Difficult to operate
(ii) Unavailability of feed stocks
(iii) High maintenance costs
(iv) Difficult in getting maintenance services
(v) Not producing enough energy for cooking
(vi) High costs of installation
(vii) Others (Specify) .................................................................

(h) How do you manage surplus gas from your biogas plant?
........................................................................................................

PART E: Biogas technology Promotion

1. (a) Are there any campaigns, seminars for promotion of biogas technology in your area?
   (i) Yes ( ) (ii) No ( )

   (b). If Yes how many time were the campaigns/seminars this year (2013)...........

   (c). Have you ever attended any of the following?
   (i) Training workshop on biogas technology ( )
   (ii) Biogas village campaign ( )
   (iii) Public/Political biogas campaign ( )
   (iv) Visited Biogas project for consultation ( )
2. (a) Which promotion ways/strategies are being used Biogas disseminators?
   (i) ........................................................................................................
   (ii) ........................................................................................................
   (iii) ........................................................................................................

(b) Which weaknesses do the strategies mentioned above has?
   (i) ........................................................................................................
   (ii) ........................................................................................................
   (iii) ........................................................................................................

(c). In your opinion, is the Kenyan Government fully involved in promoting biogas technology?
   (i) Yes (  )  (ii) No (  )

THANK YOU FOR YOUR TIME AND ANSWERS
GOD BLESS YOU