FACTORS INFLUENCING THE USAGE OF BIOGAS IN KENYA: A CASE OF NDARAGWA CONSTITUENCY, NYANDARUA COUNTY.

BY

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A RESEARCH PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF ARTS IN PROJECT PLANNING AND MANAGEMENT OF THE UNIVERSITY OF NAIROBI.

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DECLARATION

The research project report is my original work and has not been presented for any examination in any other university.

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This research project report has been submitted for examination with my approval as the university supervisor.

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DEDICATION

I dedicate this project to my parents and my husband for their great support psychologically and financially to my education and my friends and siblings for their patience and prayers to this end.

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ABBREVIATIONS/ACRONYMS

ABPP	African Biogas Partnership Programme
BSP	Biogas Sector Partnership
BT	Biogas Technician
CAMARTEC	Centre for Agricultural Mechanization and Rural Technology
CREP	Conservation Reserve Enhancement Program
FAO	Food and Agriculture Organization of the United Nations
GOK	Government of Kenya
GTZ	German Development Organization
HIVOS	Humanist Institute for Cooperation with Developing Countries
KENBIM	Kenya National Biogas Model
KENDBIP	Kenya National Domestic Biogas Programme
KENFAP	Kenya Federation of Agricultural Producers
LPG	Liquid Petroleum Gas
MDGs	Millennium Development Goals
NGO	Non-governmental Organization
SCODE	Sustainable Community Development services
SNV	Netherlands Development Organization
UNESCAP	United Nation Economic and Social Commission for the Asia and the Pacific
VEP	Visionary Empowerment Programme

ABSTRACT

Rising global challenges of energy generation, sustainability, cost, environmental concerns among others have triggered immense research on alternative energy sources and technologies in the recent past. Such previous works includes research into use of biogas as a substitute for traditional fuels-coal, charcoal, firewood and kerosene.

This research project report focuses on why despite a lot of promotion on biogas technology and the high potential it has in Kenya its uptake still remains low. One such place is Nyandarua which previous reports indicate has high potential like Kiambu, Nakuru, Muranga and Nyeri yet the uptake has been very low (Biogas for Africa Initiative and shell foundation 2009). The study sort to investigate to what extent the size of land, the cost of installation, the respondents knowledge of biogas and the alternative sources of energy influenced the decision to use biogas. Descriptive survey was conducted on the target population of 3500 dairy farmers in Nyandarua by the use of questionnaires that was administered to a sample population of 346 respondents then data was analyzed using SPSS. The results show that the majority of the population in Ndaragwa still relies heavily on traditional sources of energy because they cannot afford the cost of installation. It also showed that most of the respondents knew about biogas but they did not fully understand the many benefits of using biogas . There is therefore need for enhanced education on benefits of biogas and sensitization of financiers on the need for biogas credit or subsidies. Another finding was that due to land subdivision, some homes had small pieces of land and this acted as a hindrance to biogas usage. This calls for further research to remedy the situation. Further findings indicated that availability of other sources of fuel like firewood, charcoal and kerosene that do not need a lot of capital affects biogas usage. Though these fuels seem cheaper to the users, in the long run they are very expensive and pose a lot of danger to health and environment. If the lessons learnt from this study can be replicated in other counties with similar geographical characteristics, they will spread the benefits and improve the lives and livelihoods of many households.

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

Biogas production has been practiced for more than 100 years. However, widespread adoption has been hampered by inadequacy of information on its production, and potential benefits, and the prohibitively high costs of earlier designs. Initially, 2 types of biogas systems-the float-drum type (Indian digester) (Appendix II) and the fixed dome type (Chinese digester) (Appendix II) were promoted. There has been an improvement in the Chinese digester to improve on quality (Appendix II). The main features of the 2 systems were: An under-ground digester - may be made of masonry stones, concrete or a strong gauge metal sheet, an inlet pipe with a substrate receptacle, an outlet pipe for exhausted slurry, a floating fixed dome for gas collection and a gas outlet pipe. Although these systems have been successful in their countries of origin, adoption in Kenya has been minimal because of expensive installation costs estimated at more than KES 50,000 per unit (CAMARTEC, 1990, Silayo, 1992).

The idea that rotting vegetable matter gives off a flammable gas has been understood since the ancient Persians. In modern times, the first sewage plant was built in Bombay in 1859; an idea that was brought to the UK in 1895, when the gas produced was used to light street lamps. This system was developed in the UK and Germany in the early 1900s for the treatment of sewage. Centralized drainage systems were being installed in many towns in Europe and anaerobic digestion was seen as a means to reduce the volume of solid matter in the sewage. The gas produced was occasionally used as a source of energy, especially during the Second World War. Several sewage plants ran vehicles on biogas since then. The use of farm manure to generate methane was developed, again in Bombay, in the 1930s. It was only developed for use by Indian villagers in the early 1960s. This design, which used a floating steel gas drum, formed the basis of an ongoing Indian Government outreach programme to provide villagers with cooking fuel.

China started a similar programme in the 1960s and claimed that 5 million plants had been built by the early 1980s. The design was based on a septic tank. The Indian programme inspired a brief enthusiasm for on-farm energy generation via biogas in the UK in the early 1980s, when the oil price spikes caused people to look for alternatives. The drop in the price of oil, and therefore electricity, which followed made the farm-scale biogas plants look uneconomic, so few of the 200 or so plants that were built at that time survived. The projects set up in China, India and Nepal continued effectively in different ways. The three programmes were successful, because the respective governments offered subsidies. This allowed the government to have central control of quality. The biogas training institute claims over 12 million plants in China, based on thorough records. The numbers in India are less clear, but there must be more than 2 million plants. BSP (now Biogas Sector Partnership) in Nepal has thorough records for over 172,000 plants (with a claim of having more per head of population than anywhere else in the world).

Widespread dissemination of biogas digesters in developing countries stems from the 1970s and there are now around 70,000biogas plants in Africa (ABPP report). These are typically small systems in rural areas fed by animal manure. However, in many countries technology spread has foundered and/or up to 50% of plants are non-functional. This is linked to inadequate emphasis on maintenance and repair of existing facilities. Hence for biogas recovery technology to thrive in the future, operational support networks need to be established.(Tom, Michael 2011) Beyond this, there remains potential for domestic plants to utilize currently underexploited biogas substrates such as kitchen waste, weeds and crop residues. Thus there is a need for research into reactors and processes which enable efficient anaerobic biodegradation of these resources.

1.1.1 History of Biogas in Africa

In Africa Biogas programme is managed by Africa Biogas Partnership programme (ABPP). This is run is eight countries which include Kenya Ethiopia, Rwanda, Tanzania, Burkina Faso, Senegal, Benin and Cameroun. Kenya is ranked first out of nine African

countries in the implementation of the bio gas programme after farmers embraced the energy generating technology, according to the Kenya National Farmers Federation, about 300 farmers are taking up the technology every month and close to 6,000 have built bio gas units in their farms in the last three years. Out of the nine countries Kenya was leading in the year 2012 with a production of 2,557 units followed by Uganda with 1,511 units. (The Star magazine October 15, 2012). However this is still way below its potential being an agricultural country, since only a few homesteads have benefited from this project which is also under subsidy. Kenya had planned to construct 7000 by the year 2012 but achieved 6749; 251 plants below what had been planned. (ABPP report). According to ABBP the total number of plants constructed in the six countries the year 2012 was 10,998 out of a target of 13,694 plants. That means the biogas potential is not being met in Africa. However more units installed have stimulated interest among farmers as an appropriate technology for use in promoting women's well-being in the rural areas (Lekule, 1996).Africa is a continent with abundant, diverse and unexploited renewable energy sources that are yet to be well exploited for improving the livelihoods of the vast majority of the population (Mshandete& Pereira, 2010).

Table 1.1: Renewable energies in Africa which are most common

Renewable Energy	Challenges and constraints	Costs	Potential
Solar	Lot of land needed for construction. Not yet a big market.	Expensive, because the market is still small.	High; despite high costs, is solar one of the most easily accessed renewable energy form. Efficient form of energy.
Wind	Variable resource: you never know when there is wind and how much.	Costs are decreasing as the market is growing at a rapid rate.	Egypt, Morocco and Tunisia already started. Other countries are to follow. Easy accessible form of energy.
Biogas	Need for (zero-grazing) animals. Water is not always available.	Small digester cost as less as 45$. Bigger ones can be more expensive.	Making energy from waste. Bio slurry as a fertilizer. Clean.
Geothermal	High initial costs. Long project of finding the right places. Geological uncertainties are always present. Amount of heat can diminish	Initially high. Surveying of areas is costly. Operating costs are low. Per kWh 2-10 $ct.	Kenya and Ethiopia are using geothermal energy. Countries with rift valleys are very potential. Tanzania, Zambia, and Uganda are some of the Countries that are potential.
Hydro	The costs to set up the program are high. Financially not self-sustaining. Dependent on water flows.	Initially high; upkeep is relatively low. Per kWh: 800 Pounds	High. Supposedly, only 7% of Africa's hydropower is utilized.

Source: JRC Scientific and technical report, European commission 2011

1.1.2 History of Biogas in Kenya

Mr. Tim Hutchinson is the pioneer who introduced biogas in Kenya in 1948. He built the first biogas digester in Kenya in 1957. This provided all of the gas and fertilizer that his coffee farm needed. He found the effluent (or "sludge") an excellent fertilizer and that its application to his coffee trees greatly improved productivity. In 1958, he started constructing biogas digesters commercially, marketing the effluent as the main product with biogas as a useful by- product. Between 1960 and 1986, Hutchinson's company (called Tunnel Engineering Ltd.) sold more than 130 small biogas units and 30 larger units all over the country. Hutchinson biogas digesters (some still working after fifty years) can be found in various parts of Kenya, although mainly in the so-called high productive areas (Central and Western Kenya). Mr. Hutchinson is retired, though still manufactures solar water heaters, and a limited number of biogas units. The German development organization GTZ started promoting biogas in the middle to late 1980s in Kenya, in collaboration with the Ministry of Energy under the Special Energy Programme.

In Kenya, the Special Energy Programme opted for the floating drum type, possibly because there was local steel manufacturing capacity. Approximately 400 biogas units were built under the Special Energy Programme directly, though it is likely that the training and promotional activity spurred entrepreneur masons to build on an individual basis.

Over the last fifty years, biogas technology has been promoted by national and international organizations (both Government and NGO) and they, together with trained Kenyan technicians have built hundreds of biogas digesters in the country. However, earlier evaluations showed that, unfortunately, a high proportion of digesters appear to operate below capacity, are dormant or in disuse after construction because of management, technical, socio-cultural and economic problems. Biogas project in Kenya is spearheaded by the Kenya National Domestic Biogas Programme (KENDBIP) which aims at facilitating the provision of energy for cooking and lighting through

dissemination and construction of 8,000 bio digesters in Kenya by 2013. The Kenya Bio Digester Model (KENBIM) was chosen by stakeholders as the most appropriate and it is a hybrid version of the CAMARTEC and AKUT models. This was after the Renewable energy discussions during the World Summit on Sustainable Development in 2002 where the link between energy and poverty reduction was discussed with a new intensity on World Summit on Sustainable Development in Johannesburg in 2007.

In the action plan, the necessity to integrate energy improvements into the national policies for meeting Millennium Development Goals (MDGs) was pointed out. Although energy is not mentioned explicitly in any of the MDGs, it has been agreed that it is necessary for meeting almost all of them. The links between energy and poverty reduction through looking at the MDGs were elaborated for example by DFID (DFID 2002).In September 2000, the connection between clean sources of energy and rural energy access was explicitly made in the form of the United Nations General Assembly's commitment to a global partnership to achieve the Millennium Development Goals (MDGs) by the year 2015. Reducing rural poverty through rural development is viewed as a key requirement to achieving these goals, and underpinning this is the need for expanding access to modern renewable energy services (UN, 2010). The biogas produced has potential advantages which include: The replacement of an inefficient (but traditional) fuel with a more efficient and flexible one, the recoupment of the fertilizer value of the waste which is lost if the dung's are burned and the benefits to public health (especially in reducing eye diseases) if the cleaner, less Smokey, gas is used.

Biogas is a proven and widely-used source of energy in the world (World Bank, 2008). According to United Nation report, there has been a renewed interest in biogas owing to rising concerns over the greenhouse effect, high price of fossil fuels, and other environmental and health concerns in the past decade (UN, 2010).

Energy affects all aspects of development that is social, economic and environmental (Amigun et al., 2008), therefore provision of adequate, affordable, efficient and reliable energy services with minimum effect on the environment is crucial. The use of biogas has been greatly adopted in economies like Japan. Similarly, emerging economies such as Brazil, India and China have proven the importance of biogas technology (Bhattacharyya, 2006).

Through biogas technology, animal and crop wastes can be a good source of raw materials for the generation of renewable energy. This can lead to the attainment of the twin objective of sustainable waste management strategy and augmenting other energy sources to foster socio-economic development and environmental conservation of our country.

1.2 Statement of problem

Biogas is a valuable resource for improving the socio-economic status of millions of Kenyans but which remains completely untapped(Amigun et al., 2008). This research project report attempts to show that biogas has enormous potential because it can be generated cheaply from locally available materials; the skill required is simple; there is a large population of energetic unemployed but trainable youths for biogas digester construction; the market for biogas is inexhaustible, and the benefits to individual clients and the country are numerous

Although most of our biogas is generated from animal dung and related waste, it is known that biogas can also be generated from sewage systems and many other vegetable matter (UN, 2010). Therefore in most parts of Kenya, there is bound to be suitable raw materials for biogas generation. The market for biogas exists in urban and rural areas. The middle and low income population in urban areas currently relies on charcoal for cooking and electricity for lighting. Both these energy sources are extremely expensive and charcoal has negative effects on the environment and on health. Most of the rural population relies mainly on firewood for cooking and paraffin for lighting (Minae and Nyamai, 1988). Firewood dependence is a major cause of destruction of water towers and

the resultant negative effects on climate. According to KENDBIP report, 2012 at over Sh80 per litter, paraffin has become too costly for most of the rural poor. Firewood, paraffin and charcoal are also health hazards. The sizeable middle income population which currently relies on imported gas and charcoal for cooking is finding both too expensive. Electricity is tolerable for lighting but too expensive for cooking. Although solar lighting is cheap, the initial capital outlay is high because it uses imported materials. This analysis of the energy situation in the country leaves a huge gap of unmet need for both cooking and lighting for which only biogas seems to offer a viable solution.

It has been proved beyond doubt that biogas works. There already exist a number of models of biogas digesters that work. The skill for construction of digesters is simple and can easily be transferred to groups and individuals by one technician. Such groups or individuals can work to construct biogas digesters in many parts of the country, thus helping solve the serious youth unemployment problem (KENDBIP, 2012). Furthermore, biogas development is more than energy generation(World Bank, 2008). For a small scale farmer it is an important component in the farm. Slurry from the biogas is used to generate organic manure instead of buying fertilizer; and this is used to improve the quality of fodder and other crops for the family. And the cycle continues, making the farmer self-sustaining in food production and energy needs but also increasing cash incomes through improved yields. It is also possible for the farmer to sell excess biogas to neighbors and even the national energy grid. Lastly, experts assure us that biogas generation prevents release of harmful gases into the environment thus reducing chances of global warming and other chemical pollution effects (UN, 2010). Biogas digesters kill all the nasty smell around the zero grazing units and destroy the latrine and sewage smell, improving the standard of hygiene in the homes and community. Thus we can conclude that in terms of cost, suitability to the needs of the majority of Kenyans, and benefits, biogas stands out as the best and most viable energy option. One wonders why it is so grossly undertaken.

Despite all these benefits and the active promotion in Kenya since early 1980s, together with the apparent potential and the subsidy programme, technology uptake has been low and slow. Even the subsidy from Kenya National Domestic Biogas Program (KENDBIP), funded by the Netherlands' Ministry of Foreign Affairs, doesn't seem to be taken advantage of by most people. In Nyandarua the potential for biogas is among the highest in Kenya. According to a report by Biogas for Africa Initiative and shell foundation (2009), Nyandarua together with Kiambu, Nakuru, Murang'a and Nyeri were the most potential districts in the biogas sectors. The figure below illustrates the biogas potential against the number of livestock.

Table 1.2: Nyandarua Biogas Potential

District	Dairy Cattle Density No/km2	No. of Dairy cattle	Biogas potential (M3/day)	Average Small holder plot size[2] - (HA)	Proportion of Households with 2-10 cattle %
Nyandarua	80.6	266,181	255,534	3.05	58.4

Sources: 1KIHBS, 2Districts Development Plans 2002-2008, 3MOLD summary of livestock population 2008

1.3. Purpose of the study

The main purpose of this study was to investigate the factors influencing the usage of Biogas in Kenya.

1.4 Objective of the Study

The objectives of the study were:

1. To establish the extent to which cost of installation influences the usage of Biogas in Nyandarua County
2. To establish the extent to which knowledge of biogas influences the usage of biogas in Nyandarua County
3. To establish the extent to which size of land influences the usage of biogas in Nyandarua County.

4. To establish the extent to which alternative sources of energy influences the usage of Biogas in Nyandarua County

1.5 Research Questions

The study sought to find out:

1. To what extent does cost of installation influence the usage of biogas in Nyandarua County?
2. To what extent does knowledge of biogas influence the usage of biogas in Nyandarua County?
3. To what extent does size of land influence the usage of biogas in Nyandarua County?

To what extent do alternative sources of energy influence the usage of Biogas in Nyandarua County?

1.6 Significance of the study

Farmers represent 75% of the rural poor population of Kenya, who depend on agriculture, mainly mixed farming, through rearing livestock and cultivating land for their livelihoods. The majority of these farmers, forming the main component of the rural poor rely on biomass as their main source of energy for both cooking and lighting. Wood fuel accounts for about 68% of the total primary energy sources in Kenya, with the overall reliance on biomass being over 80%, with only 15% of Kenyans having access to the national electricity grid, resulting to heavy depletion of the country's forest reserves and thus serious environmental degradation. Farmers heavily depended on trees for many uses including fuel, fencing, building, food/fruits and aesthetics (ornamentals) (Minae and Nyamai, 1988). Kerosene (paraffin) is mainly used for lighting in the rural areas but is expensive for the resource-poor households. Its use is not sustainable because it is a non-renewable resource and since it is imported, it drains the meagre foreign exchange.

The above scenario justifies the exploitation of alternative energy sources, primarily solar, wind, water, geothermal and petroleum sources. In relative terms, biogas holds the greatest promise as a cheap household energy source because it is renewable, simple to

generate, convenient to use, and cheap. However, its potential is still under-exploited due to various reasons including limited awareness on the technology and limited disposable incomes from the farming activities. The biogas technology is an alternative energy source for cooking and lighting for the rural farmers. The biogas technology mainly utilizes the waste produced at the farm to produce clean renewable energy. The biogas digesters also produce slurry as one of the by-products which can be utilized to improve soil fertility. The overall goal of this study was to try and find out what influences the uptake of biogas or lack of it. The paper is of great benefit to the public, the government, policy makers and donors in identifying how best any challenges to the biogas uptake will be handled in order to improve the uptake in all regions. The paper will also help other researchers to understand ways of improving knowledge and skills of farmers for sustainable biogas projects. Further it will form a base for further research on the projects encompassing biogas uptake. The achievement of project objectives has consequently helped hasten the realization of the MDG's and hence vision 2030.

1.7 Delimitation of the study

The study was conducted in Ndaragwa district which is in Nyandarua county central Kenya. Nyandarua District has population of 479,902 and an area of 3,304 km² (Kenya population and housing census, Nyandarua 2009). The area was selected since as per the KENDBIP's reports it has had the lowest no of biogas plants than any other division known to be very potential in the same project. The table below shows a comparison in plant production in the year 2012 for the top five most potential counties in the country. Nyandarua County produces the highest amount of milk due to its higher population of dairy cows as compared to the other regions in Central Kenya (MoL&FD 2007). However, reports for Central Kenya indicates that dairy production potential for Nyandarua County is the least exploited (Romney 2004; Staal 2001; Schreiber 2000; Baltenweck 1998

It was also delimited to this area because of resources constraints. Survey was delimited to open and close ended questionnaire in data collection to allow respondents respond using their own words and also have adequate time to give well thought out answers.

1.8 Limitation of the study

Uncooperative informants were likely to be encountered due to suspicion of the real motives of the research. Working closely with the biogas supervisor and the KENDBIP officials helped explain the sole purpose of the study and hence warmed them up to the idea.

1.9 Assumptions of the study

The study assumed that the stated objectives would be achieved and that the respondents would be co-operative in answering the questions and their answers would be correct and truthful.

It assumed that the study would be completed within the scheduled time and budget without major external influences.

1.10 Definitions of the Significant Terms

Biogas	A gas produced by the breakdown of organic matter (animal manure) in the absence of oxygen
Knowledge	A familiarity with biogas, which can include facts, information, descriptions, or skills acquired through experience or education
Skill	The learned capacity or ability to carry out all necessary biogas Operations
Biogas Supervisor	An individual who is in charge of quality control in biogas Construction
Attitude	The way one thinks and feels about something (biogas), calling for commitment and ownership and willingness to take up and utilize.
Stakeholders	Stakeholders refers to all those people or institutions that have a stake on the biogas projects and for sustenance of the same.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter gives an overview of biogas uptake and usage and cause or lack of the same. It also summarizes what other researchers have done on the area of biogas locally and internationally.

The finding of this review helped the researcher identify the knowledge gaps and thus create an entry point for the study.

2.2. Overview of the biogas project

Economic Empowerment for the population is the cornerstone for sustainable development. This includes participation in such sectors as Agriculture, mining, manufacturing, transport, trade etc. (Institute Of Economic Affairs- Kenya, 2008)Majority of Kenyans reside in the rural areas where farming is the main source of livelihood. High population growth rate has led to reduction of the size of land useful for agriculture especially trees planting. With increased population there is also increase in energy needs. Deforestation hence has led to depletion of our forest resources leading to soil degradation and weather changes. To act on this KENFAP has increasingly promoted biogas construction to reduce on firewood and charcoal usage which heightens deforestation and therefore improve the rural livelihood. Biogas has also been stimulated by the need to reduce expenses on purchase of fuels and increase on saving. This has also been adopted by the peri-urban farmers who are now practicing backyard livestock farming to enable them have biogas energy.

In Kenya biogas project was introduced in 1948 by Mr. Tim Hutchinson and later was promoted by GIZ. Only recently was it taken up by KENFAP under its subsidiary branch KENDBIP and championed by its implementing partners; VEP, SCODE and CREP. Nyandarua County is Located in Central Kenya, it borders the following Counties: Laikipia to the North and North East, Nyeri and Murang'a to the East, Kiambu to the

South, and Nakuru to the South West and West. It has a population of 596,268 (Male - 49 %, Female - 51 %) with a Population Density of 184 people per Km2.69.9% of the farmers practice semi-zero grazing while 7.1% extensive grazing and 24% zero grazing.

2.3 Theoretical Framework

The purpose of this theoretical discussion was to serve as a basis for discussion to my empirical results. The theory I outlined provided insight into what I was look for while conducting my research. The study was based on needs theory.

Each of us is motivated by needs. Our most basic needs are inborn, having evolved over tens of thousands of years. Abraham Maslow's Hierarchy of Needs helps to explain how these needs motivate us all. Maslow's Hierarchy of Needs states that we must satisfy each need in turn, starting with the first, which deals with the most obvious needs for survival itself. Only when the lower order needs of physical and emotional well-being are satisfied are we concerned with the higher order needs of influence and personal development. Conversely, if the things that satisfy our lower order needs are swept away, we are no longer concerned about the maintenance of our higher order needs. The Hierarchy of Needs model comprised five needs.

1. **Biological and Physiological needs** - air, food, drink, shelter, warmth, sex, sleep, etc.
2. **Safety needs** - protection from elements, security, order, law, limits, stability, etc.
3. **Belongingness and Love needs** - work group, family, affection, relationships, etc.
4. **Esteem needs** - self-esteem, achievement, mastery, independence, status, dominance, prestige, managerial responsibility, etc.
5. **Self-Actualization needs** - Realizing personal potential, self-fulfillment, seeking personal growth and peak experiences.

David McClelland in his theory describes how a person's life experiences changes individual needs over time. Classified into three groups; achievement, affiliation or power. McClelland stated that we all have these three types of motivation regardless of

age, sex, race, or culture. These needs are shaped by own personal preference ,the experiences of the individual and the opinions of their culture. McClelland (1975).

Fuel is an essential need in each household and for every human being regardless of age, sex or gender. Fuels provide heat for cooking and warming as well as light. Fuel needs influence the decision regarding biogas uptake and usage. Most households have achieved the first need in Maslow's hierarchy of needs. With a piece of land and livestock they get some disposable income but most times this income goes to fuel expenditure on charcoal, kerosene, LPG gas, electricity and even fire wood. The need to save some money and improve their lives and livelihoods by having better fuels can influence decisions on biogas uptake for most households, for others it maybe the need to save the environment.

2.4 Empirical Framework

It'll sought and used data sources which already contained small link to validate data collected in the field.

2.4.1 Influence of Cost on Biogas Uptake

A survey on biogas utilization in Kenya carried out by the Ministry of Energy in 1997 and the Kenya Biogas Feasibility Study of 2007, funded by the Shell Foundation both confirmed an immense potential and demand for this technology in most agricultural high potential areas, and identified technical and financial constraints as the main challenges facing the promotion and uptake of biogas technology in Kenya. An obvious obstacle to the large-scale introduction of biogas technology is the fact that the poorer strata of rural populations often cannot afford the investment cost for a biogas plant. This is despite the fact that biogas systems have proven economically viable investments in many cases. Efforts have to be made to reduce construction cost but also to develop credit and other financing systems. A larger numbers of biogas operators ensures that, apart from the private user, the society as a whole can benefit from biogas. Financial support from the government can be seen as an investment to reduce future costs, incurred through the

importation of petrol products and inorganic fertilizers, through increasing costs for health and hygiene and through natural resource degradation.

While biogas technology appears to be competitive in economic terms, it is not generally financially viable to rural households who have limited capacity to be able to pay the high upfront cost of the biogas digester. For a wider dissemination of this technology in rural areas, efforts must be made not only to reduce construction costs, but also to develop credit and other financing mechanisms for biogas technology (UNESCAP, 2007).The lack of access to credit for the poor is attributable to practical difficulties arising from the discrepancy between the mode of operation followed by financial institutions and the economic characteristics and financing needs of low-income households (Vetrivel & Kumarmangalam, 2010). For example, commercial banks or lending institutions require that borrowers should have stable source of income out of which the principal and interest can be paid back. Unfortunately, regardless of its size, the income of many self-employed households is not stable which keep poor household out of the service domain of commercial banks and lending institutions. In order to minimize administration cost, commercial lenders prefer to deal with large loans in small numbers which is not the way to address the financial need of the poor who can be reached through small loans in large numbers; the collateral requirement of commercial banks also exclude low income households who don't have a clear title to their property.
In addition due to lack of prior information and awareness about biogas technology, MFIs may be resistant to extend loan for biogas users. Another reason could be, for biogas users MFIs may be required to adopt a collateral system other than group collateral, which may not suit the majority of MFIs who prefers group collateral.

2.4.2. Influence of Knowledge and Skills on Biogas Uptake

The existence of a well-educated population who is aware of energy issues is a key factor for the acceptance of biogas. According to Aldrich and Fiol (1994), cognitive legitimacy is related to knowledge as a prerequisite for the acceptance of a new technology. Without widespread knowledge on biogas, this industry may face difficulties to obtain the support

of people, policy makers, stakeholders and financial organizations. This is especially the case when the new technology is novel and unfamiliar to the people. In other words, important stakeholders are more likely to support issues that they perceive as understandable and feasible and for which they can promptly access reliable information. Many people are still reluctant to invest in renewable energy sub-sector. Culture, ignorance, lack of goodwill and initial cost of constructing a digester as reasons slowing the adoption of green energy in the country.

While developed countries have since established themselves as bastions of alternative energy, the Kenyan scenario is different, with only a handful of people understanding what biogas involves. Because of the inadequate, and sometimes inaccurate information about biogas and other forms of alternative energy, the Government should develop better education mechanisms to increase awareness on the viability of such projects. High education is an indication of ability to read, understand and process information about the harmful effects of fossil fuels and benefits of using biogas. The ministry should also develop ways defining how communities can benefit from the carbon fund resulting from the adoption of green energy. The biggest problem with renewable energy in Africa is the fact that there are not enough skilled people who can take care of the distribution, channeling and dissemination. Locating the energy is one thing, but you need people who can work the new energy as well. The same goes for MFI's. Without proper knowledge of the renewable energy sector they cannot build a support network around the sector. They lack the knowledge and funds to identify reliable energy suppliers and to educate loan officers (The Economist, 2010). Not always is information about renewable energies available. Belward sees a lack in the availability about energy in general and renewable energies in particular (Belward, B. Bisselink, K. Bódis, A. Brink, J.-F. Dallemand, A. de Roo, T. Huld, F. Kayitakire, P.Mayaux, M. Moner-Girona, H. Ossenbrink, I. Pinedo, H. Sint, J. Thielen, S. Szabó, U. Tromboni, L. Willemen 2011).

Wood fuel provides 70 per cent of the energy for all sectors in the country, except for the transport and commercial sector. About 80 per cent of households in rural areas use wood

fuel because it is relatively cheaper and widely available. The impact of these traditional fuels on rural households includes adverse effects, such as indoor air pollution, poor lighting and deteriorating environmental and economic wellbeing which not many people understand. Addressing basic energy needs for cooking, lighting and heating is a key element in reducing extreme poverty and hunger in developing countries. Kenya has abundant waste, from animals, garbage and sewerage, which could be used to generate alternative energy to supplement the hydro power electricity. Social acceptance is also identified as a very important constraining factor in achieving the target of increasing the share of renewable energy in many countries. It is not realistic to consider one general public and its realization as a relevant factor for the success of the various biogas technologies. There are different relevant publics from local to international around this issue (Rohracher, 2010).This dimension refers to the acceptance of local residents or stakeholders regards to sitting decisions. While several opinion surveys show a high level of public support for renewable energy systems, the actual development of many of these projects faces serious local opposition which has been defined as NIMBYism (Not In My Back Yard) (Devine-Wright, 2009). Proximity to a project like biogas projects has very strong influence on public attitudes to the project. But the level of this influence depends on the local context (Horst, 2007). It is demonstrated that time is also an influencing factor on local acceptance. Wolsink (2007) shows that local acceptance of a renewable project before, during, and after the implementation of a project has a typical pattern, and it is like a U- curve. It means that there is a high level of acceptance before and after implementation and a low acceptance during the implementation phase (Wolsink, 2007, sited in Wüsten-hagen et.al, 2007). Wüstenhagen et.al (2007) identifies three important factors influencing community acceptance of renewable energy projects. The first one is related to distributional justice or the way that cost and benefits of a project are shared. The second dimension refers to the fairness of the decision making process. It means all relevant stakeholders have an opportunity to participate in decision making process, which is named procedural justice. And the third dimension refers to the level of community trust in the outside investors and the information about the projects.

Perception of bioenergy differs from country to country. In some countries, biomass technology is seen as a modern source of energy, while in some other countries it is a dirty and traditional way to produce energy. There are also different reactions towards different types of biogas technologies. The reason is the diverse national structures and traditions. In all countries, more informed people and special groups e.g. green groups are more interested in renewable energy in general and not necessarily a bioenergy solution.
People's perceptions of a new technology have roots in social and cultural norms, and usually are not in line with expert opinions about advantages and disadvantages of a certain technology (Gold, 2010).The interaction between new technologies and local, historical, cultural, institutional, social, geographical, and economic contexts is one important component of social acceptance. Social acceptance is not just an issue of accepting or rejecting a new technology, but it is related to the way that this new technology is introduced in a specific context. Some common concerns related to biogas among people that make it more difficult to accept. The first one is the competition for agricultural land between food production and energy projects, growing population and increasing demand for food and housing.

The public perception is a determinant factor on their acceptance or resistance toward biogas technologies. So, it is normally assumed that people's perceptions and attitudes toward energy technologies need to change in order to better implement renewable energy technologies especially biogas, and it is important to know what the main factors shaping their perceptions and attitudes are (Devine-Wright, 2007).Clearly, one of the most important ways to improve understanding and acceptance of a new technology is providing adequate information and establishing a transparent communication with all people and stakeholders who are involved in, or affected by, biogas projects. Another element that should be considered in communication strategies is that such strategies should be based on a detailed market research and understanding of attitudes, perceptions, and incentives in different target groups, and the focus should be on successful solutions and services not on abstract technologies (Rohracheret.al., 2005). All positive aspects of the technology, like design or cost-effectiveness, should be

emphasized. It also would be helpful to use credible testimonials from people who have shifted from "traditional wood fuel" to innovative and modern biogas technology. The public's main concerns and needs should be considered in a sufficient communication process (e.g. the cost of biogas technology or provided incentives like subsidies).

2.4.3. Influence of Land on Biogas Uptake

Livestock is the largest user of land resources with grazing land and crop land dedicated to the production of feeds representing almost 80% of all agricultural land. Total land occupied by pasture is equivalent to 26% of the iced surface of the planet. (FAO, 2009)Three quarter of Kenya falls into arid and semi-arid zones with only 25% lying within medium and high potential agricultural area. Approximately 20% of the livestock in the country are found in the medium and high potential areas while 80% is in the arid and semi-arid areas. In the high potential areas, cash crops and other food crops occupy most of the land leaving only a small area for grazing. Furthermore, more land is increasingly being converted from agriculture to infrastructure and housing estates to cater for the needs of the growing population. With decreased lands, people are turning to zero grazing and tethering. Land is a scares resource especially in the high agricultural potential areas where crop production is more preferred than livestock production. Land is also used to secure loans from financial institutions; therefore livestock farming has to compete with the scarce resource. Biogas project is more viable in zero grazed livestock as manure collection is easier that for nomadic livestock. The biogas model KENBIM recommended takes up a very small space to construct hence being very attractive for people with smaller land. Households with large farm size have a higher probability of adopting biogas; this is because a large area can accommodate a bio-digester, the animal unit and fodder component in close proximity, helping feedstock collection to bio-digester and monitoring of routine operations.

2.4.4 Influence of Alternative Sources of Energy on Biogas Uptake

There are three main sources of energy in Kenya: Wood fuel, petroleum and electricity, accounting for 68 per cent, 21 per cent and nine per cent of energy in Kenya. In keeping

with the Millennium Development Goals, Kenya is committed to reducing by half the number of people who lack access to modern energy services by 2015 and reducing by half the number of people living in poverty. Access to affordable energy is an essential prerequisite to achieving economic growth and poverty reduction in Kenya. The majority of people who rely on biomass for thermal energy and who lack access to electricity are in rural areas and the specific ",,people" who cook with biomass or coal are almost universally women.

The lack of access to affordable energy services -- "energy poverty" -- disproportionately affects women and girls due to their traditional roles, household responsibilities, and low socio-political status. The current electricity demand is 1,191 MW while the effective installed capacity under normal hydrology is 1,429 MW. Generation capacities from Hydro, Geothermal, cogeneration and wind are 52.1%, 13.2%, 1.8% and 0.4% respectively while fossil based thermal contributes at 32.5%. It costs approximately KES 35,000 to connect to the grid. The costs are high because of the substantial investments needed to build new generation, transmission and distribution facilities, combined with the high operating cost of electricity supply. This high cost is a major obstacle to the expansion of electricity connection to low-income households. Weak transmission and distribution network, low countrywide electricity access and over-reliance on hydropower which is vulnerable to vagaries of weather, are some of the challenges facing the electricity sector sub-sector.

Biomass contribution to Kenya's final energy demand is 70 per cent and provides for more than 90 per cent of rural household energy needs. The main sources of biomass for Kenya include charcoal, wood-fuel, dung and agricultural waste for cooking and heating. Firewood remains the predominant fuel for cooking. Nationally 68.3 percent of all households use firewood as their main sources of cooking fuel. Over 80 percent of households in the rural areas rely on firewood for cooking compared to 10 percent of urban households. Charcoal is the second most popular type of cooking fuel used by 13.3 percent of households. Kerosene is ranked the third predominant cooking fuel, but is the

most common type of fuel for cooking among 44.6 percent of urban dwellers Kenya's forest cover currently stands at less than the world recommended 10%. This is largely due to land use activities and over-dependence on wood fuel as a source of energy particularly in the rural setting. Over 70% of the country's fuel needs are met from wood fuel resulting in depletion of the major forested areas which are also the water catchment zones for the country. The resultant effect has been unpredictable weather and drought patterns.

There are approximately 20,000 institutions including prisons, schools, clinics and hospitals in Kenya consuming about 270 tonnes each of wood fuel per year. In addition, a majority of Small and Medium Size Enterprises such as hotels, food vendors and small scale processing facilities use biomass resources as the primary source of energy.

Kerosene-based lamps are the leading source of lighting for Kenyan households. Over 79% of households use paraffin lamps. Electricity is the second most common source of lighting about 14% while paraffin is the most predominant in rural areas (87% of rural households).. In the urban areas, electricity was more common (42%), although the lantern/ paraffin lamp still remained the main source of lighting for 55% of households. There are disparities in energy use between female - headed and male - headed households. About 15% of male-headed households compared to 11% of the female-headed ones use electricity for lighting, but a larger proportion of female-headed households (81%) use Kerosene lamps or other unspecified sources as compared to male-headed (78%). Female headed households rely more on the fuel wood than the male headed households.

The table below shows the distribution of households by gender of household head and type of lighting.

Table 2.1: Distribution of households by gender and lighting

Gender	Electricity	lantern/ paraffin lamps	Others
Male	15.2	77.9	6.9
Female	10.8	81.2	8

Source: Kenya Population Census 1999

2.5 Conceptual Framework

The framework below graphically explains the relationship between the variables of the study. The dependent variable is uptake of biogas while the independent variables are Cost, Knowledge and skills, space available and alternative energy sources. The presumption is that the independent variables have a direct relationship with the dependent variables. The intervening variable identified is Government policies while moderating variable is availability of animals.

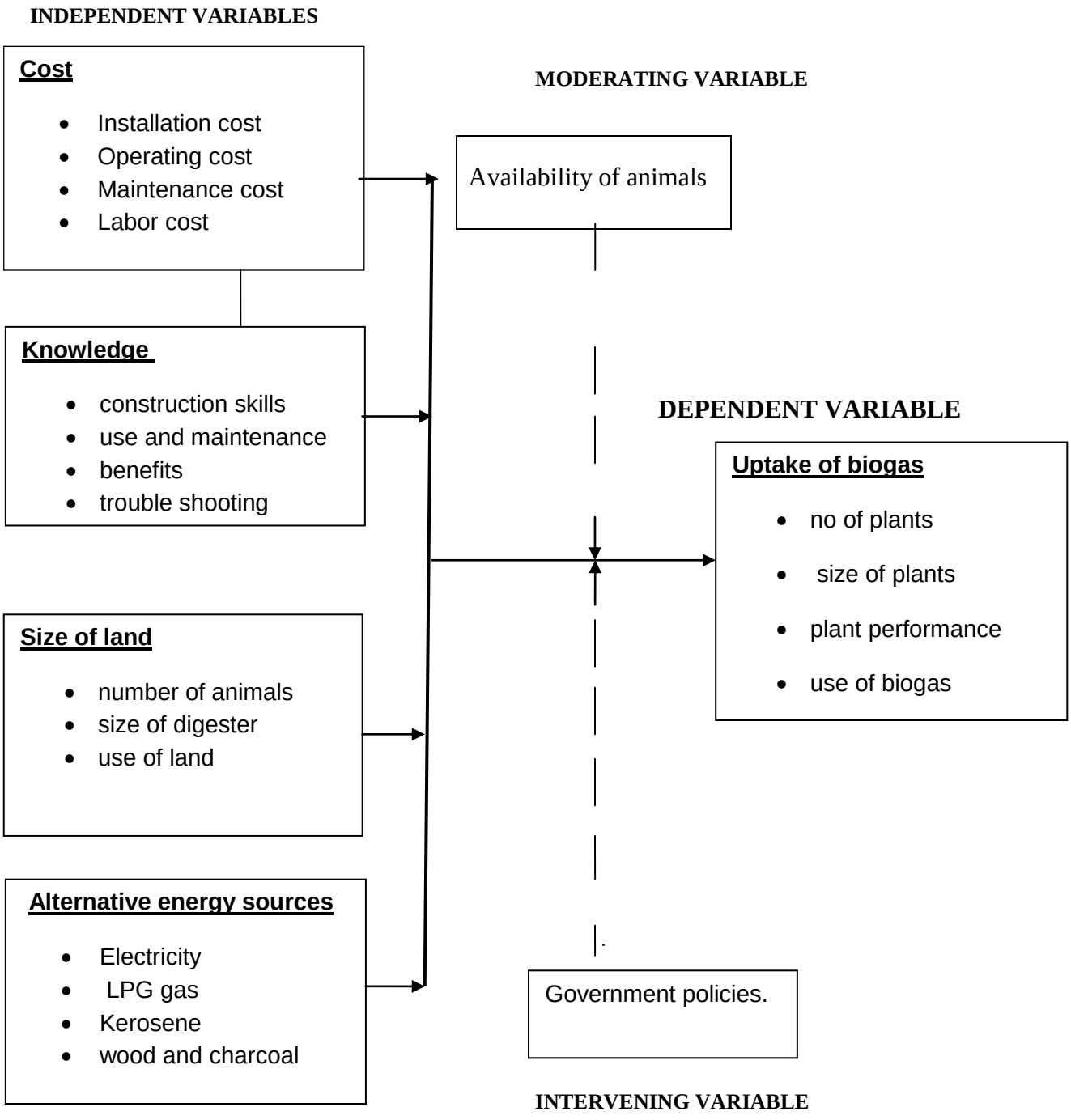

Figure 1: Conceptual Framework

2.6 Summary of Literature Review

In this chapter research work done by various researchers was reviewed and various information gaps revealed intended to be addressed. There seemed to be limited or no studies carried out in Nyandarua division on biogas and therefore the study intends to contribute to filling this information gap.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

In this chapter the research methodology used in the study is described. The geographical area where the study was conducted, the study design and the population and the sample are described. The instrument used to collect the data, including method implemented to maintain validity and reliability of the instrument are described.

3.2 Research Approach and Design

A research design is the arrangement of conditions for collection and analysis of data in a manner that aims at combining relevance to the research purpose with economy in procedure. It's the conceptual structure within which research is conducted; it constitutes the blue print for the collection, measurement and analysis of data. (Kothari, 2004)The study will employ a descriptive survey design, which involves the collection of data at a specific point in time from one or more populations. It's appropriate when a researcher wants to get information at a one point in time in order to describe the characteristics of a population. A survey is used to collect original data for describing a population too large to observe directly (Mouton 1996:232). A survey obtains information from a sample of people by means of self-report, that is, the people respond to a series of questions posed by the investigator (polit and hungler 1993:148). In this study the information was collected through self-administered questionnaires.

A descriptive survey was chosen because it provides an accurate portrayal of the characteristics e.g. knowledge, skills and attitudes of a particular individual, situation or group. This design was chosen to meet the objectives of the study i.e.to establish the social economic factors that influence the usage of biogas (Burns and Grove 1993:29). It was appropriate for this study as it aimed at describing the relationship between the independent variables and the dependent variable.

3.3 Target Population

According to (Burns and Grove 1993:779) a population has been described as an element that meets the sample criteria for inclusion in a study. The study population included members of Nyala Dairy cooperative, of households with and without biogas plants in Ndaragwa, Nyandarua County. The population comprised of 3,500 local dairy farmers. Mouton (1996) defines a sample as elements selected with an intention of finding out something about the total population from which the sample is taken. The sampling frame was developed from a village list compiled in consultation with the village local leaders and the KENBIP officials.

3.3.1 Sampling Technique

Kothari (2004) defines a sampling design as a definite plan for obtaining a sample from a given population. It refers to the procedure the researcher would adopt in selecting items for the sample. The sample was stratified into 2 groups, one made up of people with biogases and those without. According to Krejcie and Morgan (1970) (Apendix III), for a population size of 3, 500 people the optimum sample size is 346. The respondents were drawn randomly from those without biogas and purposively for those with biogas as they are few.

Subjects in the sample had the following criteria: Were mentally sound in order to consent to participation, were willing to participate, were of either sex or any ethnic group, Had a cow or pig, were 18 years and above and were from Ndaragwa constituency Nyandarua county.

3.4 Data Collection Instrument

Creswell (2003) indicates that the research instruments are the tools used in the collection of data in the phenomenon of study. This study used two types of questionnaires to gather responses from the respondents. A questionnaire was the most appropriate because:

It ensured a high response rate as questionnaires were distributed to the respondents to complete and collected by research agent, they required less time and energy to administer, they offered anonymity as respondents names were not included on the questionnaire, there was no Biasness as they were administered in a consistent manner, it made responses easier to compare.

The questionnaires consisted mostly of closed-ended questions and a few open-ended questions, as these provided more diverse details. Open-ended questions allowed subjects to respond in writing to questions in their own words and in details. Closed ended questions offered response options that made it easier to administer and analyze. They were also more efficient in the sense that a respondent was able to complete more closed-ended questions than open-ended ones at any one given time (Polit and Hungler 1993).

The questionnaires were in English and those who could not understand English translation was done for them. Those who were not able to read and write, questions were read and write the answers written for them. The questionnaire had have three sections A, B and C. Section A gathered demographic information like age, gender, and level of education. Section B sought to determine the details in regard to Knowledge and uptake while C was about other sources of energy.

3.5 Piloting the Instrument

The questionnaire once developed was tested on a small pilot sample of respondents with similar characteristics with the study respondents. Mugenda and Mugenda (2003) suggest that the piloting sample should be 1 to 10 % of the study sample depending on the study sample size. The test sample of 5% was selected on convenience and the piloting done on a neighboring division; Kinangop constituency in Nyandarua District. Piloting helped to reveal questions that were vague so that they could be reviewed until they conveyed the same meaning to all subjects. (Mugenda and Mugenda,2003)

3.6 Validity and Reliability of the instrument

According to Polit and Hungler (1993:448), validity is the degree to which an instrument measures what it's intended to measure. Validity is also defined as the appropriateness, correctness and meaningfulness of the specific inferences which are selected on research results (Frankel and Wallen, 2008). It's the degree to which results obtained from the data analysis actually represents the phenomenon under study. According to Kothari (2004) content validity is the extent to which measuring instruments provide adequate coverage of the topic under study. Polit and Hungler (1993) refer to reliability as the degree of consistence with which an instrument measures the attributes it's designed to measure. It's the consistency with which the measuring instrument performs such that apart from delivering accurate results, it also delivers similar results consistently after repeated trials. (Leedy,2000).

3.6.1 Validity of the instrument

To ensure content validity the researcher closely consulted research experts and also peers undertaking the same program. Further questions were based on literature review to ensure consistency with knowledge. Questions were kept clear and in simple language. Validity was also ensured by giving clear instructions to the subjects e.g. on answering the closed-ended questions. The researcher also had the questionnaires completed in her presence to prevent subjects giving the questionnaires to other people to fill for them. Piloting the questionnaire helped identify the gaps and weaknesses that needed to be edited before the final research questionnaire was administered.

3.6.2 Reliability of the instrument

To ensure reliability of the questionnaire the researcher administered the questionnaire personally to avoid biasness. Reliability was also ensured through use of split half method. The questionnaire questions were assigned arbitrary scores which then were keyed into the SPSS software and analyzed through spearman correlation coefficient to test for internal consistency. According to Mbwesa (2006), Nunnaly and Bernstein (1994), if a correlation coefficient of the instrument falls above 0.60 or higher (Miller)

the instrument is taken to be reliable. Also by ensuring physical and psychological environment is comfortable. This was done by assuring privacy, confidentiality and general physical comfort.

3.7 Data Analysis Technique

Completed questionnaires were edited for completeness and consistency. The data was then analyzed using descriptive statistics. The descriptive statistical tools (SPSS) helped the researcher describe the data and the findings were presented using tables. This generated quantitative reports through tabulation and percentages. Further Pearson's correlation analysis was used to assess the relationship between independent variables (cost of installation, knowledge of biogas, size of land and alternative energy sources) and the dependent variable (usage of biogas).

3.8. Ethical Considerations

The research was conducted with all honesty and integrity. The rights to confidentiality, privacy, anonymity and informed consent were well observed.

Open-ended questions were analyzed by the supervisor as well to ensure credibility. Closed-ended data was keyed in and analyzed through the SPSS system to avoid manipulation.

3.9. Operational definition of variables

Operationalisation of variables allowed variables to be expressed in measurable terms. Various key variables have already been outlined in the stipulated objectives of the study. The tabulation below shows the operational indicators that are used in the study.

Table 3.1: Operational definition of variables

Objective	Variable	Indicators	Measurement scale	Tool of Analysis	Type of analysis
To establish the extent to which cost of installation influences the usage of Biogas in Nyandarua County	**Independent:** Cost of installation	Installation cost Operating cost Maintenance cost Labor cost	Ratio Ratio Ratio Ratio	Percentage and frequencies	Descriptive statistics
To establish the extent to which knowledge of biogas influences the usage of biogas in Nyandarua County	Knowledge of biogas	Construction skills Use and maintenance Benefits Trouble shooting	Ordinal Ordinal Nominal Ordinal	Mean, Percentage and frequencies	Descriptive statistics
To establish the extent to which size of land influences the usage of biogas in Nyandarua County.	Size of land	Number of animals Size of digester Use of land	Nominal Ordinal Nominal	Mean, Percentage and frequencies	Descriptive statistics
To establish the extent to which alternative sources of energy influences the usage of Biogas in Nyandarua County	Alternative sources of energy	Electricity LPG gas Kerosene Wood and charcoal	Ratio Interval Inverval Nominal	Mean, Percentage and frequencies	Descriptive statistics
	Dependent: Usage of Biogas in Nyandarua County	Number of biogas installed	Nominal	Percentage and frequencies	Descriptive statistics

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter entails the analysis, presentation interpretation and discussion of the findings obtained from the field. There is a presentation of the background of the information from the respondents, together with the findings of the analysis based on the objectives of the study. In this study, descriptive statistics form a basis for the discussion of the findings. Presentation is done using tables which are then interpreted and discussed.

4.2 Response Rate

The study targeted a population of 3500 comprising of members of Nyala Dairy farmers. A sample size of 346 respondents were selected randomly and the responses are as presented in table 4.1.

Table 4.1: Response rate

Characteristics	**Description**	**Frequency**	**Percentage** %
Sample population n= 346	Those who responded	258	74
	Those who dint respond	88	26
Total		**346**	**100**
Sex of respondents n=258	Male	179	69
	Female	79	31
Total		**258**	**100**

Out of a sample of 346 respondents, 258 respondents filled in and returned the questionnaires making a response rate of 74 %. This response rate was satisfactory to make conclusions for the study. The response rate was representative. According to Mugenda and Mugenda (1999), a response rate of 74% is adequate for analysis and reporting; a rate of 60% is good and a response rate of 70% and over is excellent. Based on this assertion, the response rate in this study is considered to be excellent.

4.3. Socio-economic status of the respondents

Evaluating the socio-economic status of the respondents determined the acceptance level of biogas usage and the capability to undertake the biogas installation. This was measured by looking at the income levels, housing structures and ownership and Demographic information of the respondents. This was in response to objective one that sought to determine if cost influenced the use of biogas

4.3.1. Income structure of the respondents

To provide information on influence of cost of installation on biogas usage the respondents were requested to indicate sources of income. The responses are summarized in Table 4.2.

Table 4.2: Percentage distribution of respondents by occupation, source of income and external support

Characteristics	**Description**	**Frequency**	**Percentage** %
Occupation	Farming	141	50
n= 258	Livestock rearing	19	7.5
	Casual employment	5	2.0
	Artisan	4	1.6
	Salaried employment	69	25
	Trading	18	7.1
	Others	2	0.8
Total		**258**	**100**
Other source of income	Not receiving external help	65	75
N=88	Receiving external help	23	25
Total		**88**	**100**

From the study, it was established that 50% of the total respondents practice farming while 20% are in employment that is salaried. Over 25% of the respondents were

receiving financial help from external sources. Farming was identified as the main occupation of majority of the population in Ndaragwa, Nyandarua County. A majority of the respondents about 75% do not receive external funding and this implies that the potential of the respondents to adopt the technology of biogas is dependent on rural income circles. Measures of income and household expenditure are critical features of uptake of biogas. According to Karekezi and Kithyoma (2007) achieving a complete switch to consumption of biogas requires reaching a certain threshold of income or household expenditure. Households with higher incomes are likely to afford switching process and the requirements to use biogas.

4.3.2. House structure and ownership of the respondents

To add to the information on income levels the respondents were requested to indicate their type of house structure. The responses are summarized in table 4.3

Table 4.3: Percentage distribution of respondents by type of house

Characteristics	**Description**	**Frequency**	**Percentage** %
Type of house n= 258	With permanent houses	142	55
	With semi-permanent houses	83	32
	With Temporary	33	13
Total		**258**	**100**
With biogas N=112	With permanent house	67	60
	With semi-permanent house	45	40
Total		**112**	**100**

From the table above about 55% of the respondents live in permanent houses that have concrete foundations and floors as well as stone brick walls. About 32% of the respondents live in semi-permanent houses which have reinforced concrete foundations

but with wooden walls. About 12% of the respondents live in permanent houses with concrete foundations, brick walls and tiled roofs. The results from the survey also show that 50% of the respondents who have biogas technology live in permanent houses. On the other hand, about 60% of respondents with biogas technology or who are switching to biogas uptake live in semi-permanent houses.

Housing and housing type are good indicators of socio-economic status. The structure of the house and the number of rooms was reported to be associated with biogas uptake and switching to biogas uptake from other fuels. Most respondents in the region had permanent houses and so is most respondents with biogas. No respondent who had a temporary housing structure had a biogas. These findings are similar to those of Amigun et al (2008). According to Amigun et al (2008) the type of house one has is associated with biogas usage because of its association with wealth in that those who live in permanent houses are wealthier and can afford the biogas technology.

4.3.3. Demographic information of the respondents

To provide information on control of household income the respondents were requested to indicate their gender . The responses are summarized in Table 4.4.

Table 4.4: Percentage distribution of respondents by gender

Characteristics	**Description**	**Frequency**	**Percentage** %
Gender of participants n= 346	Male	301	87
	Female	45	13
Total		**346**	**100**

The study was not gender based and the respondents were randomly selected but this information was useful in determining if there was a difference in biogas usage depending on which gender headed the household and controlled the resources. Out of the 346 respondents who participated in the study, about 13% were households headed by females and about 87% were households headed by males. It was found out that the

higher the percentage of male headed households and the higher the level of education the higher the Biogas usage was in those households. In terms of size of households, uptake of Biogas was found to be greater in households with fewer members. This means there was more disposable income for biogas installation.

4.3.4. Funding sources for biogas adoption

To add to the information on influence of cost on biogas installation those with biogas were requested to indicate their source of financing. The responses are summarized in Table 4.5.

Table 4.5: Funding sources for biogas technology adoption

Characteristics	Description	Frequency	Ranking
Funding sources n= 112	Own savings	88	1
	Contributions from family and friends	10	5
	Bank loans	4	3
	Group loans	3	4
	Others (Subsidy)	63	2

The study shows that among the households who have adopted the biogas technology in Ndaragwa, 29% of the respondents have been assisted or received subsidies and about 70% have adopted the technology without assistance. Most respondents who had biogas incurred the cost of construction from their own savings. The number is followed by those who had some form of subsidy assistance. The respondents have cited high costs of installation as the main challenge for inability to adopt the biogas technology. This means that if financial assistance is not offered this technology will still remain low in adoption. This is in agreement with a report from (UNESCAP, 2007) which said that lack of financial assistance on the poor only increases the difficulties in biogas adoption and hence financial institutions should intervene.

4.4. Knowledge and skills level of the respondents

Awareness of a certain technology can influence its adoption or not. By measuring the knowledge and skills of the respondents in relation to biogas determined if they were likely to use the biogas technology or not. To do this we evaluated their level of formal education, level of biogas and biogas usage awareness and their willingness to adopt the technology.

4.4.1 Influence Knowledge on biogas usage

To provide information on level of knowledge the respondents were requested to indicate their level of education. The responses were as per the Table 4.6.

Table 4.6: Education characteristic of the respondents

Characteristics	Description	Frequency	Percentage%
Respondents	Formal Education	220	89
n=248	Other forms of education	28	11

The results from the survey indicate that more than half of the respondents have formal education. A larger percentage of the population has obtained education levels above the primary level. Even those with primary education could be assumed to have requisite capability to recognize the importance of Biogas as a technology and adopt its use accordingly. There has been a strong link between education and adoption of biogas technology. The study confirmed that formal education played an important role in the increase in adoption of Biogas technology but was not a limiting factor. The findings were similar to those of other scholars. Mary et al (2007) postulate that education enables people to have the ability to understand and embrace new innovations and have the exposure to development dynamics. In an analysis of nationally representative data from Kenya, a higher level of education was associated with adoption of biogas technology (Karuiki, 2009).

4.4.2. Level of awareness of biogas usage and benefits

To add to the information on knowledge, the respondents were requested to indicate their knowledge of benefits of biogas. The responses were summarized in Table 4.7.

Table 4.7: Household energy savings and benefits from adoption of biogas

Characteristics	**Description**	**Frequency**	**Percentage**%
Family expenditure energy reduced by use of biogas	YES	130	87
	NO	20	12
Characteristics	**Description**	**Percentage**	**Ranking**
The specific benefits of using biogas	Cheap source of energy	97	1
	Reduce smoke pollution	76	3
	Readily available	73	4
	Reduce deforestation	65	5
	Makes cooking convenient	90	2

The level of awareness of biogas technology among the respondents was very high at about 91%. Level of awareness varied with almost 95% respondents being aware that biogas energy can be used for cooking, 66% were aware that it can be used for lighting while 46% were aware that it can be used for running engines. From the survey data, it is evident that awareness towards applications of biogas technology is moderately high and this is an implication that some point it may be a contributing factor for impairing biogas adoption. It is therefore important to enhance the knowledge on the different uses of biogas that are beneficial to the users.

From the survey, households that adopted the use of biogas technology also confirmed to encountered lots of benefits. From the questionnaires, the respondents were to establish if they knew biogas use could reduce their monthly savings. For the households that were already using biogas, they were asked if biogas had helped save energy, time and money.

The study unveiled that many households about 87% have recorded reduction in family expenditure on energy as well as other benefits.

Respondents indicated that fuel saving through biogas had an impact on household expenditure and reduced amount of time spent by women to collect fuel. The study identified that there is a relationship between family expenditure and use of biogas technology. Fuel and time savings were considered to be an incentive for the use of Biogas by many respondents in Ndaragwa. Amigun et al (2008) explain that Biogas saves fuel and time and is therefore preferred by households who have adopted the technology and have other sources of energy as well. Biogas also reduced cooking time due to better heat transfer efficiency. The respondents reported to use up the reduced time for fuel collection and cooking for other household work.

4.4.3. Willingness and commitment to adopt biogas technology

To provide information on reasons for lack of biogas the respondents were requested to indicate if they were interested in installing a biogas and reason for lack of it. The responses were presented in table 4.8.

Table 4.8: Will and commitment to adoption of biogas technology

Characteristics	**Description**	**Frequency**	**Percentage**%
Interested in owning a biogas unit	Yes	300	97
	No	20	2.8
Reasons for lack of biogas	I don't have money	151	50
	I don't know a person who can construct for me	40	15
	I wouldn't know how to use it	125	47
	I am comfortable with my current source of fuel	22	8
	I don't have enough livestock	5	2

Results from the data show that many respondents about 97% are interested in owning a biogas unit but about 50% are drawn back due to lack of money, 47% lack of information and ownership of few animals among others. Since the first two reasons for not having a biogas unit are very major in biogas installation, the biogas project implementers need to invest in resolving those problems for the number of users to increase. The data from the study identified that many households rely on subsidies for funding their biogas projects, the subsidy component has to be articulated during advocacy and promotion campaigns of biogas technology. This information concurs with the findings of KENDBIP (2012)

4.5. Fuel and technology characteristics of the respondents

Availability of other energy sources can influence the use of biogas. To determine this we looked at the energy sources used by the respondents for cooking and lighting.

4.5.1.The influence of alternative energy sources on biogas usage

To provide information on alternative sources of energy the respondents were requested to indicate their sources of household energy. The responses were as per the Table 4.9.

Table 4.9 : Energy sources at household levels (Figures rounded to nearest whole number)

Characteristics	Description	Frequency	Ranking
Current household energy sources n=346	Firewood	200	1
	Charcoal	70	3
	Electricity	80	2
	Kerosene	40	4
	Biogas	37	5
	LPG	11	7
	Solar	21	6
	Generator (diesel and petrol)	3	8

Results from the interviews on respondents from Ndaragwa acknowledge the fact that most areas in Ndaragwa are energy stressed. Data from the survey shows that most biomass is depleted because of a reduction in forest cover or availability of wood. Most respondents are continually adopting Biogas technology because of the limited amount of wood available for fuel. The patterns of energy demands of the rural areas revolve around household energy end uses such as cooking and lighting. Results indicated that the main source of energy in Ndaragwa households was firewood followed by electricity and charcoal. Biogas was ranked 5th. The data from the survey confirmed that most households in Ndaragwa are energy stressed and many of them still use wood and charcoal fuel as the main source of energy. Karuiki (2009) states that government efforts have been aimed at connecting the households to the grid through rural electrification programs but not all segments of the rural population benefit from the programs. In Ndaragwa, most households rarely use electricity for cooking or lighting and therefore the biogas sector still has an important role to play in the area.

4.5.2. Main source of cooking energy for the respondents

To add to the information on alternative sources of energy the respondents were requested to indicate their sources of fuel for cooking. The responses were as per the Table 4.10.

Table 4.10: Fuel sources for cooking

Source	Before biogas	Percentage	After biogas	Percentage
Fire wood	93	70	49	40
Charcoal	22	16	11	9
Dung	8	6	5	5
Sawdust	4	1	4	1
Electricity	5	3	2	1.7
Kerosene	1	0.8	1	0.8
LPG gas	11	8	11	9

The study identified that the source of cooking energy among respondents was higher in households with biogas as compared to households without biogas. The main source of cooking energy was firewood with 70% in households without biogas and 40% in households with biogas. Firewood was followed by charcoal at 16% in households without biogas and then kerosene at 0.8% as shown in table 4.7. The second source of energy in households with biogas was biogas at 38%. The use of firewood in households with biogas reduced significantly from 70% to 40% indicating that the presence of biogas facilities reduces the demand for wood fuel as a source of cooking energy. Further analysis based on the data from respondents indicates that among the respondents with biogas facility, the reliance on firewood is lower. This shows that use of fuel can significantly reduce if biogas technology is adapted. Increased biogas uptake can therefore reduce the pressure on use of firewood and hence decrease deforestation. Wolsink (2007) shows that local acceptance of a renewable project before, during, and after the implementation of a project has a typical pattern, and it is like a U- curve. It means that there is a high level of acceptance before and after implementation and a low acceptance during the implementation phase.

4.5.3. Main source of lighting energy for the respondents

Adding to information on alternative sources of energy the respondents were requested to indicate their sources of fuel for lighting The responses are summarized in Table 4.11.

Table 4.11: Fuel sources for lighting

Source	Before biogas	Percentage	After biogas	Percentage
Kerosene	52	34	21	18
Candle	45	28	35	20
Electricity	67	50	80	69
Solar	12	9	11	9.5

The study identified that the most preferred source of lighting energy among Ndaragwa households was electricity. In households without biogas, electricity was the preferred source of lighting energy at 50% while in households with biogas, electricity was the

preferred choice at 69%. Electricity was followed by paraffin at 32% in households without biogas and 18% at households with biogas. It is evident from the survey that biogas is not widely used for lighting most households in Ndaragwa. This could mean they are not aware that biogas can be used for lighting or the cost of installing lights is high.

4.6. The influence of the availability and size of land on biogas usage

To provide information for this objective the respondents were requested to indicate the size of the land owned. The responses are summarized in Table 4.12.

Table 4.12: Size of land

Characteristics	**Description**	**Frequency**	**Percentage**%
Those with biogas n=112	With more than an acre of land	73	65
	With less than an acre of land	39	35
Total		**112**	**100**
Those without biogas n=146	With more than an acre of land	76	52
	With less than an acre of land	70	48
Total		**146**	**100**

The Survey showed that most of the respondents had relatively big pieces of land. 65% of those with biogas had above an acre of land and 35% of those with biogas had less than an acre of land. 52% of the respondents without biogas had more than an acre of land and 48% had less than an acre. According to (FAO, 2009) land is a scarce resource especially in highland areas, this means that land is an important aspect in influencing use of biogas. Biogas installation require space and hence when land is small it may limit the usage. The size of land also determines the number of livestock zero grazed, influencing the size of the biogas digester.

CHAPTER FIVE
SUMMARY OF THE FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1. Introduction

This chapter presents the summary of the findings, conclusions and recommendations contributing to the body of knowledge in regard to factors influencing the usage of biogas in Kenya and suggestions for further research.

5.2. Summary of the findings

This survey sought to determine the factors that influenced the usage of biogas with reference to Ndaragwa as a case study. It sought to find out to what extent cost, knowledge and skills, land and alternative energy sources influences biogas use. A descriptive survey through the use of Questionnaires was use to meet the objectives. The findings were constructive and instructive in different ways.

The survey results revealed that high costs of biogas installation made it difficult for a large number of households to adopt the use of the technology. Most people with biogas catered for installation costs from own savings and only a few got funding from loans or subsidy. The results show that the majority of the population in Ndaragwa still relies heavily on traditional sources of energy because they cannot afford the cost of installation. However even though installation costs are high, the results from the study show that there was a reduction in cost of household energy in households that were using biogas. It was unveiled that the usage of biogas resulted to more savings not only financially but also time savings for the females who take a lot of time fetching wood.

The study shows that there is awareness of the technology but the awareness is inadequately sustained. Even though awareness about biogas is high, the benefits derived from it were barely known by a large portion of the target population. However households which were aware of the benefits were willing to adopt the technology though limited by other factors. It was also confirmed that formal education played an important role in influencing the decision for biogas use. Most households with biogases had

decision makers who had gone through formal education. This was mostly in case of male led households.

The main source of cooking energy was firewood with 70% in households without biogas and 40% in households with biogas. Firewood was followed by charcoal at 16% in households without biogas and then kerosene at 0.8%. The use of firewood in households with biogas reduced significantly from 70% to 40% indicating that the presence of biogas facilities reduces the demand for wood fuel as a source of cooking energy. Biogas use therefore reduced the pressure on use of firewood and hence decrease deforestation and drudgery on women and girls. It was identified that the most preferred source of lighting energy was electricity, followed by kerosene. The government has made efforts aimed at connecting the households to the grid through rural electrification programs but not all segments of the rural population benefit from the programs because the cost is also high.

Therefore most households rely on kerosene as an alternative to cooking and lighting
Due to subdivision of land to family members for generations, some of the respondents pieces of land are relatively small and most livestock are zero-grazed. This is a conducive environment for biogas management. However where land was too small there was no space for biogas installation and this was a limitation. Those with bigger land were more receptive to the technology and were willing to install. The findings also showed that those with biogas had bigger pieces of land.

5.3. Conclusion of the study

The study conclusions are drawn from the analysis and the results. The study substantially met all the objectives and it can be concluded that it was a success. The conclusions drawn are as below.

The first conclusion drawn is that dependence on biomass fuel as the main source of energy is increasingly becoming unsustainable due to environment challenges such as depletion of forest resources. It is therefore important that sustainable sources of energy

are considered and support offered to ensure more uptake of the same. If biogas as a source of energy can be encouraged and its use promoted it can play an important role in energy and environment conservation as well as improve the health of women and children. Even though most conditions for exploration of this technology are favorable in Kenya, its exploration has been un optimized due to financial challenges and inadequate awareness of the crucial benefits. The success of biogas adoption by the target households can be made more successful if there is funding support through subsidies and if there is relevant information given to the households about the technology and its many benefits among other factors.

Another conclusion is that though most farmers were aware of the technology, the awareness was inadequately sustained and hence need for intense, repeat promotion of the technology in the target population. The findings of this study clearly show that the use of biogas has several benefits to the households. Biogas is considered as a clean, cheap, efficient and readily available source of energy because of the easy access to raw materials and the reduced carbon emissions to the air. It was observed that there was an improved conservation of the environment since the households whose biogas plants were functioning, reduced the use of other sources of energy that were polluting the environment. Cost of fertilizer also went down since the slurry was used to cultivate crops also ensuring a better way of disposing the waste.

The Kenyan government has been carrying out several programs across the country especially targeting rural areas such as Ndaragwa which seek to promote the use of biogas. If they can use lessons learnt from this study and replicate them in other counties with similar geographical characteristics, they will spread the benefits and improve the lives and livelihoods of many households.

5.4. Recommendations of the study

After analyzing and interpreting data from the study, there are several propositions to the stakeholders in the domestic biogas sector that can help increase the uptake of biogas.

1. There is need to develop and implement a campaign plan that is focused, strategic, sustainable and educative on the importance of alternative sources of energy. Special emphasis should be given to biogas technology during the campaign to promote the uptake and usage of biogas. The campaign should be majorly carried out in the rural areas where the knowledge and awareness of the biogas technology is limited.
2. There is need to develop an educational campaign targeted at women in enhancing their participation in the biogas adoption. Results from the study as indicated earlier show that households with female heads had lower percentage of biogas adoption. It is important to create awareness of biogas to women especially in rural areas because they stand to benefit more from the technology by saving time and energy of collecting firewood and coming under unhealthy conditions.
3. There is need to make improvements on the operations and maintenance of the biogas units through improved trainings and use of simple guidelines. In the findings, it was clear that some respondents in Ndaragwa did not have biogas units because they did not know how to use the systems or how to maintain them. Promotions should also be carried out in all vernacular languages to ensure that everyone gets information about biogas technology.
4. Findings also show that there are insufficient credit facilities for households in rural areas to facilitate installation of biogas units. There is therefore need to sensitize financial institutions to come up with innovative products at the grass roots level to trigger the increase of the uptake and use of the biogas technology. There is need for partnership with financial institutions in program implementation with the aim of making loans available and affordable for people in the rural areas an even in towns that can enable them adopt the biogas technology. There is also the need to lobby for subsidies and financial support

from the government that can help households to acquire biogas units cheaply and install them.

5. There is also need to establish a long lasting institutional framework to manage and implement biogas programs in the country. This framework will be important in promoting the use of biogas and advertizing its benefits to encourage households to increase or adopt the usage of biogas.

5.5. Suggestions for further research

1. Despite the findings obtained by the study, there are still some areas that need further research. It would be of great importance to find out if kitchen waste could produce the same quality of biogas as that from the livestock so that those households without livestock or with small pieces of land can also benefit from cleaner fuels.

2. Future studies should use different research instruments like observation and interviews to involve respondents more personally and generate more detailed information.

3. The research covered a county that has floating drum biogas digesters and dome-shaped biogas digesters installed. It is suggested that the study should be replicated in regions where plastic and fiber glass digesters had been installed to evaluate if the results are the same.

REFERENCE

Aldrich, H. E. & Fiol, C. M. (1994). *Fools Rush In? The Institutional Context Of Industry Creation*. Academy of Management Review, pp645-670

Amigun.B (2008) *Renewable and Sustainable Energy Reviews,* Journal of Cleaner Production12, pp. 690-711.

Amigun, B., Sigamoney, R., & von Blottnitz, H. (2008). *Commercialization of biofuel industry in Africa:* A review. Renewable and Sustainable Energy Reviews 12, 690-711.

Amugun B. and Von Blottnitz. H. (2007). *Investigation of scale economies for Africa biogas installation*. Energy conversion and management pp3090-3094

ASAE. 1997. Manure production and characteristics, ASAE D384.1 DEC93, In: ASAE Standards 1996, 44th Ed., ASAE the Society for Engineering in Agricultural, Food, and Biological Systems, St. Joseph, MI.

Baltenweck , I (1998) *Intensification of dairying in the greater Nairobi milk-shed: Spatial and household analysis.* Ministry of Agriculture (MoA), Kenya Agricultural Research Institute (KARI) and International Livestock Research Institute (ILRI) Collaborative Research Project Report. 26.

http://www.smallholderdairy.org/collaborative res reports.htm

Belward, A. Bisselink, B. Bódis, K. Brink, A. Dallemand, J.-F de Roo, A. Huld, T.

F. Kayitakire, P. Mayaux, M. Moner-Girona, H. Ossenbrink, I. Pinedo, H. Sint, J. Thielen,

S. Szabó, U. Tromboni, L. Willemen (2011. *Renewable energies in Africa* . Scientific and Technical Research series. Luxembourg: Publications Office of the European Union

Bhattacharya, P. 2006. *Kinetic studies of biogas generation using municipal waste as feed stock.*

Journal of Enzyme and Microbial Technology (38) 493-503.

Bond, T. and Michael.R (2011). *Templeton Energy for sustainable Development*, Vol 15 Issue 4 pp 347-354

Burns and Grove (1993), *The practice of nursing research: Conduct, critique & utilization*, Research Methodology. 2nd edition, Sanders (Philadelphia) P 29

CAMARTEC, (1990). Centre for Agricultural Mechanization and Rural Technology. Tanzania biogas extension service, GTZ.

Creswel, J.W (2003) *Research design: qualitative, quantitative and mixed methods approach*: (2nd edition). Sage publications, Thousand Oaks, California.

Devine-Wright, P. (2007).*Reconsidering public attitudes and public acceptance of renewable energy technologies*: a critical review. Research council energy program. Retrieved from http://geography.exeter.ac.uk/beyond_nimbyism/deliverables/bn_wp1

DFID 2002. *Energy for the poor*. Retrieved from, http://www.ecn.nl/fileadmin/ecn/units/bs/JEPP/energyforthepoor.pdf

FAO-Food and Agriculture Organization of the United Nations (2009).

Frankel, J.R and Wallen, E (2004).*How to design and evaluate research in education*. (7th edition).McGraw Hill International Edition.

Ghimire,Prakash C.(2009), *a report on Selection of Biogas Plant Design and Formulation of Quality Control Framework*, publication

Government of Kenya (GOK) (2007) *Kenya Vision 2030.Ministry of Planning and National Development. Government of Kenya*. A competitive and Prosperous Kenya. Nairobi, Kenya

Government of Kenya (2010). *2009 National Census Report*, GoK, Nairobi Kenya.

Hivos 2009. *Africa Biogas Partnership Initiative report*.Rerieved from

http://www.hivos.nl/eng/community/partner/10009895

Kamuzora, F. R. and Msanjila, S (2012*) Collaborative Networks as a Mechanism for Strengthening Competitiveness: Small and Medium Enterprises and Non-state Actors in Tanzania as Cases.* Journal of language, technology and entrepreneurship in Africa

Karanja, G.M. and Kiruiro, E.M. (2003)*Biogas Production,* KARI Technical Note No.10, Embu, Kenya.

Karekezi, S., W. and Kithyoma, S. (2007). *The potential for small and medium scale renewable in poverty reduction in Africa:* The role of renewable in poverty reduction Nairobi, African Energy Policy Research Network.

Karuiki L.N. (2009) *Indoor carbon Monoxide emission and particulates produced from Combustion of Carbon based Fuels and Their health Implications on rural Households of manyatta division, Embu Districts, Kenya.* Msc Thesis Department of environmental sciences Kenyatta University

Kothari, C.R (2004). *Research Methodology; Methods and Techniques*. New Age International limited, publishers, New Delhi India.

Leedy, P.N and Ormorod , J.E (2000*) Planning and Design,* practical research, 7th Edition

Lekule, F.P. (1996). *Technologies for improving the wellbeing of rural women in Tanzania.* Final report submitted to FAO /Sida Farming Systems Programme.

Mary .R, Prem .S. S and Guy. H. (2007); *Biogas for Better Life: An African Initiative A Cost- Benefit Analysis of National and Regional Integrated Biogas and Sanitation Programs in Sub-Saharan Africa*. Dutch Ministry of Foreign Affairs and Winrock International

Maskell P. and Malmberg A, (2007), *Myopia knowledge development and cluster evolution*. Journal of economic geography pg. 603-608

Maslow, A.H. (1943). *A theory of human motivation.* Psychological Review 50 (4) 370–96. Retrieved from http://psychclassics.yorku.ca/Maslow/motivation.htm

McClelland, D. C. (1978). *Managing motivation to expand human freedom*. *American Psychologist*, 33(3) 201–210.

Mshandete, A.M. (2010) , *Renewable. Energy*, Effect of particle size on biogas yield from sisal fiber waste.

Minae, S. and Nyamai, D. (1988). *Agroforestry research proposal for the coffee- based land-use system in the bimodal rainfall highlands of Central and Eastern provinces*, Kenya. AFRENA Report No. 16. ICRAF . Nairobi, Kenya.

Ministry of Livestock and Fisheries Development (MoL&FD) 2007 *Livestock Production Annual Report* 2006. Nairobi, Kenya.

Mouton, J.(1996) *Understanding Social Research.* Research design and methodology. Van Schaik Publishers, pg. 232

Paul Harris, 2013, *Beginners Guide to Biogas,* The University of Adelaide

Polit. D and Hungler.B.P. (1993. *Nursing Research. Essentials of nursing research: Methods, appraisal, and utilization*. 3rd edition, Lippincott Philadelphia P148

Rohracher, H. (2010). *Biofuels and their publics: the need for differentiated analyses and strategies*. Future science group.

Romney D L, (2004) *Understanding the role of dairy in smallholder systems and the effect of intensification.* Proceeding of the 9th Kenya Agricultural Research Institute (KARI) Biennial Scientific Conference, 8th-12th November, 2004, Nairobi, Kenya.

Schreiber C, (2000). *Sources of innovation in dairy production in Kenya*. International Services for National Agricultural Research (ISNAR) briefing paper No. 58. Ministry of Agriculture and Rural Development (MoARD), Kenya Agricultural

Research Institute (KARI) and International Livestock Research Institute (ILRI)/ISNAR. The Hague, the Netherlands

Silayo, V.C. (1992). *Small biogas plants*. Design, management and use. Agrotec

publications.

Staal S J, (2001) *Dairy systems characterization of the greater Nairobi milk shed*. Smallholder Dairy (Research & Development) Project. Kenya Agricultural Research Institute (KARI), Ministry of Agriculture (MoA) and International Livestock Research Institute (ILRI) Collaborative Dairy Research Program, Nairobi, Kenya..http://www.smallholderdairy.org/collaborative res reports.htm

Sweeten J.M., J.R. Clark, W.L. Harman, B.L. Harris, B.J. Johnson, W.R. Jordan, M.J. McFarland, C.B. Parnell, S.C. Ricke, and R.B. Schwart. 1994. *Animal Waste Management Task Force Report*, Agriculture Program, Texas A&M University System, College Station, September

The star News Paper (2012). *Kenya among top African states in Biogas use*. Monday, October 15, 2012. Retrieved from www.the-star.co.ke/news/kenya

UNESCAP- United Nation Economic and Social Commission for the Asia and the Pacific (2007) *Recent developments in biogas technology for poverty reduction and sustainable development*. Beijing 2007: UNESCAP

Vetrievel, S.C and Kumarmangalam, S.C (2010). *International journal of information technology and knowledge management*. Role of microfinance institutions in rural development. July-December 2010 pp 435-441

Wüstenhagen, R. Wolsink, M. Bürer, M.J. (2007). *Social acceptance of renewable energy innovation: An introduction to the concept.* Retrieved from: http://www.sciencedirect.com.ludwig.lub.lu.se/science?_

APPENDICES

Appendix I: Introductory Letter

University of Nairobi,

P.O. Box 3900,

Nairobi.

Dear Respondent,

I am a student from University of Nairobi pursuing a Masters Degree in Art (Project planning and Management). I am carrying out a research entitled:

"Factors influencing the uptake of Biogas: A case study of Ndaragwa constituency, Nyandarua county, Central Kenya".

Please assist me by filling in the questionnaires provided. The questionnaires are meant to help in fulfilling the research objectives. The researcher assures you confidentiality in the information given.

Yours Faithfully,

Purity Wanjira Ndereba

REG. No. **L50/72005/2011**

Appendix ii: Questionnaire for Biogas uptake Survey-Biogas Users

QUESTIONNAIRE

SECTION A: GENERAL INFORMATION

1. Gender (please tick one)
   i. Male ( )
   ii. Female ( )

2. Age of the respondent (please tick one)

   i. 15-20 years ( )
   ii. 21-30 years ( )
   iii. 31-40 years ( )
   iv. 41-50 years ( )
   v. Above 51 ( )

3. Education status of the biogas owner

a.	Illiterate	
b.	Primary level	
c.	Secondary level	
d.	College	
e.	University	

4. Family size (Number)

Male	**Female**	**Children**	**Total**

5. Location (village)……

6. What is the size of your land…….(acres)

7. How many livestock do you have?

i. Cattle 〔 〕

ii. Pigs 〔 〕

SECTION B: ABOUT BIOGAS

8. How did u learn about biogas project? (please tick at least one)

1	Through a friend	
2	Through a relative	
3	Through a neighbor who has a biogas	
4	Through promotional materials (brochures, fliers, posters	
5	Through media (T.V, Radio, Internet)	
6	Through a training forum	
7	Others(specify)…… ……	

9. Have you ever had any training on biogas? YES 〔 〕 NO 〔 〕

10. If yes, indicate which ones

	TRAININGS	
a.	Benefits of biogas	
b.	Construction of biogas	
c.	operation and Maintenance	
d.	Trouble shooting	

11. What is the size your biogas plant. (please tick one)

4m3	6m3	8m3	10m3	12m3	other

12. When was it constructed ……..(month)……(year)

13. What was the cost of construction…….……..(Ksh)

14. How was the construction financed? (please tick at least one)

a.	Own savings	
b.	contributions from family and friends	
c.	Bank loan	
d.	Group loan	
e.	Others (specify)……	

15. If you took a loan, what's your monthly loan expenditure……...(Ksh)

16. Was a subsidy provided? YES [ ] NO [ ]

17. If yes how much?.....(Ksh)

SECTION C: ENERGY SOURCES

20. Fuel sources for lighting

	SOURCE	**QUANTITY**	
		BEFORE BIOGAS	**AFTER BIOGAS**
a.	Kerosene (Liters per month)		
b.	Candle (No per month)		
c.	Electricity (Amt per month)		
d.	Solar		

21. Fuel sources for cooking

	SOURCE	QUANTITY	
		BEFORE BIOGAS	AFTER BIOGAS
a.	Fire wood		
b.	Charcoal		
c.	Dung		
d.	Sawdust		
e.	Electricity		
f.	Kerosene		
g.	LPG gas		

22. Change in consumption of conventional energy after biogas.

	SOURCE	INCREASED	DECREASED	SAME
a.	Fire wood			
b.	Charcoal			
c.	Dung			
d.	Sawdust			
e.	Electricity			
f.	Kerosene			
g.	Candle			
h.	LPG Gas			

23. Was the plant installation financially worthwhile? YES 〔 〕 NO 〔 〕

24. If No, Why……

……

……

25. Would you recommend someone without biogas to build one?

YES 〔 〕 NO 〔 〕

26. If No, Why…….....

……

……

Appendix iii: Questionnaire for Biogas Uptake Survey: Non-Biogas Users

QUESTIONNAIRE

SECTION A: GENERAL INFORMATION

1. Gender (please tick one)
   i. Male ( )
   ii. Female ( )
2. Age of the respondent (please tick one)

   i. 15-20 years ( )
   ii. 21-30 years ( )
   iii. 31-40 years ( )
   iv. 41-50 years ( )
   v. Above 51 ( )

3. Education status of the respondent

a.	Illiterate	
b.	Primary level	
c.	Secondary level	
d.	College	
e.	University	

4. Family size (Number)

Male	**Female**	**Children**	**Total**

5 Location (village)……..

6. What is the size of your land…….(Acre)

7. How many livestock do you have?

i. Cattle 〔 〕

ii. Pigs 〔 〕

SECTION B: ABOUT BIOGAS

8. Have you ever heard about biogas? YES 〔 〕 NO 〔 〕

9. Have you ever had any training on biogas? YES 〔 〕 NO 〔 〕

10. If yes, indicate which ones

	TRAININGS	
a.	Benefits of biogas	
b.	Construction of biogas	
c.	operation and Maintenance	
d.	Trouble shooting	

11. Have you ever felt interested in having a biogas? YES 〔 〕 NO 〔 〕

12. What would you say is the reason for not having a biogas at your home?

	REASON FOR LACK OF BIOGAS	
a.	I don't have money	
b.	I don't know a person who can construct for me	
c.	I wouldn't know how to use it	
d.	I don't want to use dung as a source of fuel	
e.	Am comfortable with my current source of fuel	
f.	I don't have enough livestock to sustain a biogas	
g.	My land is small	
h.	Other (specify)…… ……	

13. Would you construct a biogas if given a subsidy?

YES 〔 〕 NO 〔 〕

SECTION C: ENERGY SOURCES

14. Fuel sources for lighting

	SOURCE	**QUANTITY**
a.	Kerosene (Liters per month)	
b.	Candle (No per month)	
c.	Electricity (Amt per month)	
d.	Solar	

15. Fuel sources for cooking

	SOURCE	**QUANTITY PER MONTH**
a.	Fire wood	
b.	Charcoal	
c.	Dung	
d.	Sawdust	
e.	Electricity	
f.	Kerosene	
g.	LPG gas	

16. Do you think biogas can reduce your monthly energy expenses ?

YES [ ] NO [ ]

17. Please give reasons for your answer……

Appendix IV: Digester Models

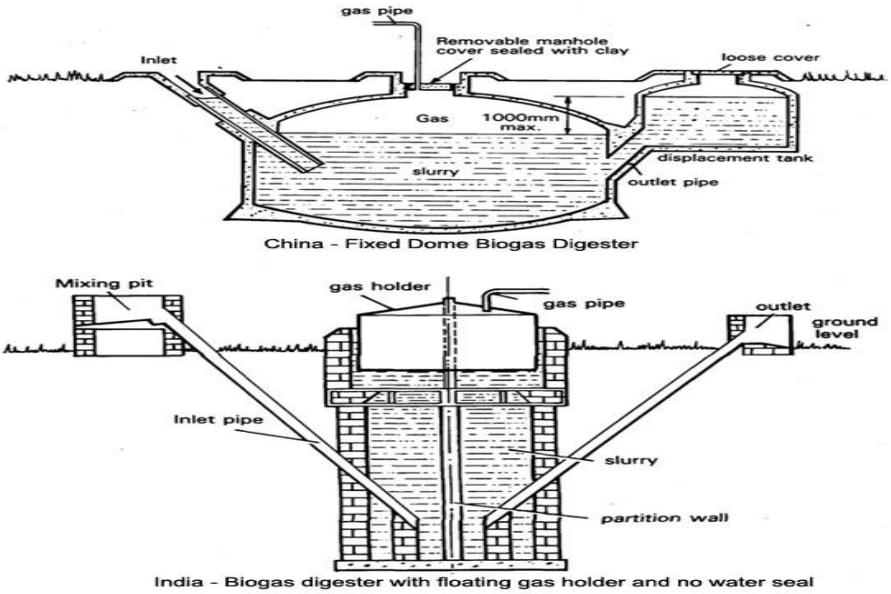

Figure 1. 1: Chinese Fixed dome and Indian Floating drum with cylindrical digester

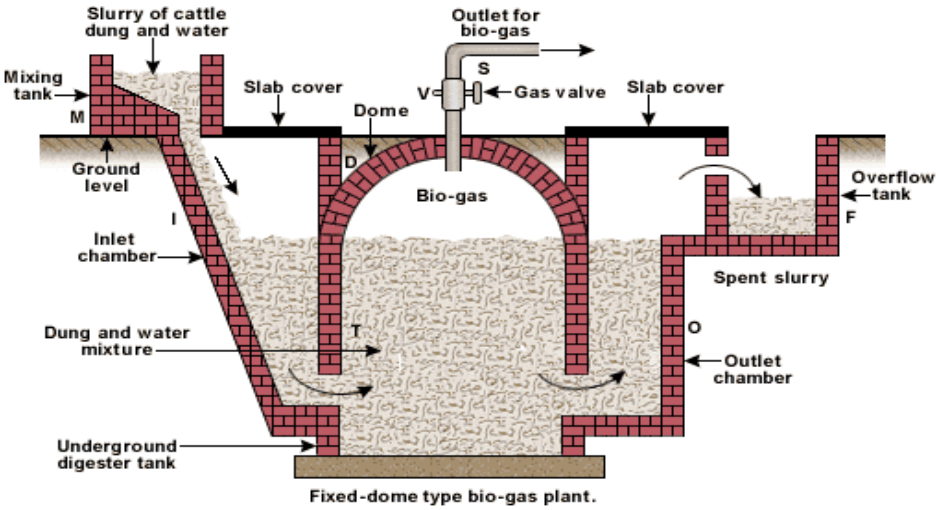

Figure 1. 2: An improved Chinese fixed dome bio-digester

Source: Green Energy; Special Section papers presented at the 2nd International Energy 2030 Conference, Volume 93, May 2012

Appendix V: Krejcie and Morgan

TABLE FOR DETERMINING SAMPLE SIZE FROM A GIVEN POPULATION

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	351
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	181	1200	291	6000	361
45	40	180	118	400	196	1300	297	7000	364
50	44	190	123	420	201	1400	302	8000	367
55	48	200	127	440	205	1500	306	9000	368
60	52	210	132	460	210	1600	310	10000	373
65	56	220	136	480	214	1700	313	15000	375
70	59	230	140	500	217	1800	317	20000	377
75	63	240	144	550	225	1900	320	30000	379
80	66	250	148	600	234	2000	322	40000	380

85	70	260	152	650	242	2200	327	50000	381
90	73	270	155	700	248	2400	331	75000	382
95	76	270	159	750	256	2600	335	100000	384

Note: "N" is population size

"S" is sample size.

Krejcie, R.V., Morgan, D.W., (1970).

Appendix VI: Permit

THIS IS TO CERTIFY THAT:
MS. PURITY WANJIRA NDEREBA
of THE UNIVERSITY OF NAIROBI,
1795-10 Nyeri,has been permitted to
conduct research in *Nyandarua County*

on the topic: *FACTORS INFLUENCING THE USAGE OF BIOGAS: A CASE STUDY OF NDARAGWA CONSTITUENCY, NYANDARUA COUNTY, CENTRAL KENYA*

for the period ending:
31st December,2014

Permit No : NACOSTI/P/14/6146/4185
Date Of Issue : 21st November,2014
Fee Recieved :Ksh. 1000

.....
Applicant's Signature

.....
Secretary
National Commission for Science, Technology & Innovation

Appendix VII: Authorization Letter

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471,
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When replying please quote

9th Floor, Utalii House
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P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.

Date:

21st November, 2014

NACOSTI/P/14/6146/4185

Purity Wanjira Ndereba
University of Nairobi
P.O. Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Factors influencing the usage of biogas: A case study of Ndaragwa Constituency, Nyandarua County, Central Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Nyandarua County** for a period ending **31st December, 2014.**

You are advised to report to **the County Commissioner and the County Director of Education, Nyandarua County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the rese.arch report/thesis to our office.

DR. S. K. LANGAT, OGW
FOR: SECRETARY/CEO

Copy to:

The County Commissioner
Nyandarua County.

The County Director of Education
Nyandarua County.