DETERMINANTS OF BIOGAS TECHNOLOGY DEVELOPMENT AND USE AS AN ALTERNATIVE SOURCE OF ENERGY IN MOMBASA COUNTY, KENYA.

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DECLARATION

This research project report is my original work and it has not been submitted to any other examination body. No part of this research project should be reproduced without my consent or that of the University of Nairobi

SIGNATURE …… DATE …….

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L50/66365/2010

This research study has been submitted for examination with my approval as the University of Nairobi supervisor.

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LECTURER

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UNIVERSITY OF NAIROBI

DEDICATION

I dedicate this research project report to my parent, siblings and my wife for their tireless effort both financially, spiritually and psychologically throughout this programme.

ACKNOWLEDGEMENT

This research project work has been made possible through the guidance of my supervisor. That being the case, I acknowledge my supervisor Dr. Moses Otieno for he made the task accomplished. I also recognize my colleagues with whom we enriched each other, shared common experiences and they were great source of inspiration and strength. Thanks to the respondents for their willingness to respond to questionnaires and interviews giving true information for the research.

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ABBREVIATIONS AND ACRONYMS

SEP	Special Energy Program
GTZ	Gesellschaft, für technische zusammenarrbeit (German Technology organisation)
CH_4	Methane
CO_2	Carbon (IV) oxide
NH_3	Ammonia
H_2S	Hydrogen Sulphide
H_2O	Water
NGO_S	Non-Governmental Organisations
PVC	Poly Vinyl Chloride
TP	Tabular Plastic
AFDB	African Development Bank
KENDBP	Kenya National Domestic Programme
TTL	Tunnel Technology Limited
EUEFI	European Union Energy Facility One
KIST	Kigali Institute of Science and Technology
SACDEP	Sustainable Agricultural Development Programme
SNEP	Strategic National Energy Plant
NETFUND	National Environmental Trust Fund

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ABSTRACT

Biogas is a gas produced as a result of anaerobic respiration of organic matter under particular conditions. Biogas has been promoted in developed and developing countries and in some parts of Kenya more so the central and western regions. The research study focuses on some of the determinants of biogas technology development and use in Mombasa County. The objective of the research project study was to find out how determinants like availability of raw materials, awareness, maintenance and management practices and the availability of funds influence the development and use of biogas in Mombasa County. The research was carried out targeting schools, that is, boarding and lunch providing schools due to their fuel demand, farmers, restaurants, prisons and the municipal wastage disposal agents due to biodegradable materials availability in these sectors (inputs). Biogas development in Kenya, particularly in Mombasa County is moving at a snail's speed and therefore, the research intends to determine whether the availability of raw materials, awareness, maintenance practices and the availability of fund do influence the development of biogas technology. The researcher opted for a descriptive survey of research design. Questionnaires, interviews and content analysis were instruments used for data collection and the data collected was computed in frequency distribution tables. The measure of central tendency and relationship/association were used to show the relationship between the variables and the development of biogas technology. From the research analysis it shows that factors like availability of raw materials, maintenance and management practices and level of education attained do not influence biogas development, but the availability of funds, promoters and availability of trained personnel/skilled manpower were seen to have a major effect. Thus for biogas technology to take root in Mombasa County the government of Kenya together with the county government should encourage his citizens to venture and invest in biogas by either subsidizing them and even charging fee on landfills. Finally the government together with other stakeholder should promote biogas in schools/institutions and prisons which can then be used to sensitize others to promote it development.

CHAPTER ONE

INTRODUCTION

1.1 Background information.

Energy plays an important role in human development and welfare (Enaburekhan and Salisu, 2007). Therefore, the process of sewage, livestock dung, kitchen remains, and vegetative biodegradation leading to biogas production has to be promoted for higher yield and enhanced usage. Biogas holds the greatest promise as a cheap household energy source because it is renewable, simple to generate, convenient to use, and cheap (Karanja G.M and Karuiru, 2003). However, its potential is still under-/exploited due to a number of factors and this is quite the heart of this research.

Industrial revolution brought coal, a fossil fuel, to the forefront of the global energy scene. This was later overtaken by another fossil fuel, crude oil; and natural gas is trying fast to take over the dominant role in the world energy supply mix. The increasing world-wide awareness and concern about the environmental impacts of fossil fuels coupled with the oil price shocks of the early 1970s and late 1980s, and likely future price hikes, have lent enormous weight to a switch to renewable energy sources (Akinbmi et al, 2001

Biogas technology is a cost-effective investment if plants are properly constructed, effectively operated and well maintained. It was, however, noticed that there are many abandoned biogas plants in the country. It was estimated that only 25% of the installed units are operational, thus disrupting the technology. Continued use of plants is linked to the dissemination strategy adopted· by the promoting agency. High levels of use were observed in areas where the dissemination was followed with planned monitoring and support to the users. However, in areas where close follow-up activities were lacking, the level of use was low (Gitonga S, 1997). A study in China by Robert 2005, further explores the potential of benefits and suggests that biogas digester systems considerably enhance energy efficiency and agricultural productivity; as a result, a digester can increase a rural household's income and living standards. This is because biogas digester systems provide a reliable renewable energy resource (Hammond, 2007) and can be used for cooking, heating, lighting (SNV, 2009) and powering diesel engines, amenities such as reading lights, heat for schools and cheap fuel for machinery.

According to Omer A, 2011, biogas technology cannot only provide fuel, but is also important for comprehensive utilization of biomass forestry, animal husbandry, fishery, agricultural economy, protecting the environment, realizing agricultural recycling, as well as improving the sanitary conditions in rural areas.

Although a number of biogas digesters have been built, in the early 1980s, a low-cost tubular plastic (TP) bio-digester was developed in Colombia. The technology is widely used in Vietnam and Colombia and has been promoted in Kenya and Tanzania in the last 5 years by the FAO/Sida Farming Systems Programme. More than 40 units installed in Tanzania have stimulated interest among farmers as an appropriate technology for use in promoting women's well-being in the rural areas (Lekule, 1996).

While growth and development of biogas technology in some developing countries has been slow, its presence in others is quite strong. In 2005 it was estimated that there were 16 million small-scale household digesters around the world, with most of these plants in India and China. In India, 6 million tons of firewood was replaced by the use of biogas in 1996 (Bhat, 2001). Furthermore, 7 million digesters in China contribute to the energy demands of 4% of the country's population (Mwakaje, 2007). While biogas use in Kenya is still in its early stages of development, the technology has been present in the country for over 50 years. The first digester in Kenya was built in 1957 on a rural coffee farm. Its success prompted the owner to begin a commercial venture, resulting in the building of 130 small-scale digesters in addition to 30 larger plants throughout the country from 1960 to 1986. In the late 1980s the Ministry of Energy partnered with a German organization known as GTZ to build 400 floating dome digesters (“Promoting Biogas,” 2007). Today it is reported by the Kenya National Domestic Biogas Program (KENDBIP) that 6,748 plants have been built since 1957, however only about a quarter of these plants are believed to be operating by design (KENDBIP, 2012). The KENDBIP program, funded through the Ministry of Energy and the Dutch Ministry of Foreign Affairs, has a goal of building 12,000 high quality, functioning plants in the five years following its commencement in 2009.

In response, the Kenya Forest Service and the African Development Bank (AFDB) have initiated a project dubbed “Green Zone Development,” in which biogas technology is being introduced as an alternative energy source to learning facilities in the Rift Valley (Kemboi C., 2014).

1.2 Problem Statement

Biogas technology has received more support in most of the developing countries and even in the developed one, as a means of poverty alleviation and as a vehicle to environmental conservation. Promotion of biogas technology has been widely carried out in the humid and agriculturally rich areas of the country notably the central highlands, western Kenya and parts of Mombasa region (Gitonga S, 1997).

Gitonga S, (1997), further argued that a total of 43 households with biogas plants were visited between September and November 1995 showing the percentage use of biogas. The number of houses and areas visited ware as follows:

Table 1.1 biogas units visited

Area visited	No of household with biogas plants
Embu	19
Nandi	8
Kilifi/Kwale	8
Kisumu	4
Kakamega	4

From table 1.1 it's evident that Embu has the highest number of plants in place, followed by Nandi and Kwale while Kisumu and Kakamega have the least. These plants established are not enough to sustain the poor Kenyans and hence more are needed to be established. It's evident that factors like; lack of owner's interest, inadequate water, few cows reared by farmers and break down of some plants affected the growth and development of biogas technology in these counties.

The availability of microfinance organisations for example, the Golden Services Microfinance Organization in Mombasa that reaches out to communities along the coast, providing credit and training for individuals in these communities to start up biogas conversion centers is a motivating factor to the development of biogas technology. This shows that most of the biogas

plants have been built with the aid of the government and other non-governmental organisations country wide yet the coast region continues to suffer from a variety of problems. Emmett O'Brian (2010) noted that the Coast region in Kenya suffers from a variety of problems; youth unemployment greater than 50%, rising fuel costs, and unhealthy living conditions, which can be solved through a cheaper, reliable and safe source of energy.

1.3 Purpose of the study

The purpose of the study was to determine the determinants influencing the development of biogas technology and its use in Mombasa County.

1.4 Objectives of the study

The following were the objectives of this study.

1. To determine how the availability of raw materials influences the development and use of biogas technology in Mombasa County.
2. To determine how the awareness of biogas technology influences its development and use in Mombasa County.
3. To determine the extent to which the management and maintenance practices influence biogas technology development and use in Mombasa County.
4. To establish the extent to which the availability of funds to invest in biogas technology has influenced its development and use in Mombasa County and the agents involved to fund the technology.

1.5 Research question

The study intended to answer the following research questions.

1. To what extent does the availability of raw materials influence the development and use of biogas technology in Mombasa County?
2. How does the awareness of biogas technology influence its development and use as a source of energy in Mombasa County?
3. To what extent do the management and maintenance practices influence the establishment, development and use of biogas in Mombasa County?

4. To what extent does the availability of funds to invest in biogas technology influence its development and what agents are involved to fund the technology in Mombasa County?

1.6 Research Hypothesis

The research intended to test the following hypothesis:

H1: availability of raw materials influences the development and use of biogas technology.

H1: level of biogas technology awareness influences its development

H1: management and maintenance practices influences the development and use of biogas technology

H1: availability of funds, agents/stakeholders influences the development and use of biogas technology

1.7 Significance of the study

This research study will be of significance to the ministry of energy and special programs to evaluate the development of biogas in Mombasa County and hence strategically plan to alleviate the problems facing the resident of Mombasa County by providing them with a cheaper and reliable source of energy. The study will also be of beneficial to promoters of the program for it will enable them in realizing the problems facing the technology and make best alternative to achieve their goals.

In addition the study will bring into light more evidence and add to the existing knowledge of biogas technology to other researchers, academicians, donor agencies and willing investor in decision making and in utilization of the biogas technology as a cheaper source of energy to promote development. Finally it will be a source of reference and literature to future studies on biogas technology.

1.8 Assumptions of the study

The research project study was based on the following assumptions:

i. The respondents were willing to spare time and respond to questionnaires and interviews.
ii. The respondents gave honest information, a true reflection on the ground.
iii. The instruments used for data collection ware reliable and valid.

1.9 Delimitation of the study

The research study was delimitated to farmers, schools/institutions, hotels and waste disposal agents in Mombasa County. This targeted group is in a position to have enough input towards the production of biogas. Farmers have both inputs from animals and vegetative remains, schools/institutions and hotels have inputs from kitchen remains and human excreta, and finally the waste disposal agents have inputs from the municipal waste collection.

1.10 Limitations of the study

The research demanded the researcher to be aware of the established biogas plants which was impossible for individual constructed plants, hence factors like management and maintenance practices were not be fully exploited. Thus the researcher was forced to carry out a survey before selecting the portions for data collection. Finally the limited time that was available and the insufficient funds led to the research being restricted to a small population.

1.11 Organisation of the study

This research is subdivided into five chapters; chapter one consists of background information, problem statement, purpose of study, objectives, research questions, significance of study, delimitation, limitations and assumptions of study. Chapter two covers literature review, that is, biogas technology in Kenya biogas in schools and in municipal sewage. While chapter three cover the research methods, research design, target population, method of data collection, definition of variables, and data processing and analysis. Chapter four covers mainly the analysis of the data collected and its interpretation finally its chapter five which carries the summary, discussion of the findings, conclusion recommendation and the suggested areas o research.

1.12 Definition of Significant Terms

Raw materials: These are the essential inputs/feedstock in the process of biogas production.

Awareness: Is the ability of the consumer of the technology to know about its presence, functionality and the advantages and disadvantages of it.

Maintenance Practice: These are daily routines normally carried out at the plant site to facilitate its functionality and promote efficiency.

Funds: This is the owner's equity to invest in the production of biogas.

Stakeholders/agents: These are the individuals/agents/organisations/government being involved in the promotion of biogas technology development.

Biogas: This is a combination of two word; bio meaning living matters and gas the product as a result of the decomposition of the biodegradable materials. Hence biogas is the gas obtained as a result of the decaying waste materials.

Slurry: These are the remains in the digester after anaerobic process and can be used as manure in agriculture.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter covers the literature on the factors affecting the development of biogas technology in Mombasa County.

2.2 Development of biogas in Kenya

The level and intensity of use of commercial energy is a key indicator of economic growth and development. In Kenya, this is currently low and calls for intensified action for the development and use of energy services that are reliable, affordable, and readily available to the majority who are or want to be participants in the economy. Biogas being a reliable renewable source of energy, cheaper and readily available then it calls for an action for its development.

The first biogas digester in Kenya was built in 1957 by Mr. Tim Hutchinson. This provided all of the gas and fertiliser that his coffee farm needed. He found the effluent (or "sludge") an excellent fertiliser 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 (Gitonga S. 1997).

The German development organisation GTZ started promoting biogas in the middle to late 1980s in collaboration with the Ministry of Energy under the Special Energy Programme. 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 (Ashington N, et al, October 2007).

Over the last fifty years, biogas technology has been promoted by national and international organisations (both Government and non-governmental organisations) 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 (Hankins, M., 1987)

PSDA promoted biogas as from 2005 with demonstration plants co-financed at Moi and Egerton University. In 2007, PSDA sought for co-funding from the European Union Energy Facility one (EUEF I). A three year (2008 – 2010) co-financing project with EU was formulated. The objective of the biogas project is to provide small to medium level rural dairy farmers and other beneficiaries with improved living conditions and adequate supply of energy through use of biogas energy technology (PSDA Kenya Project Conference 2005).

According to Sessional Paper No. 4 of 2004 on Energy (page16) one of the main problems impeding high penetration of biogas technology is "high maintenance costs", however, from discussions with various stakeholders there seems to be a perception that financial maintenance costs for biogas are low, though labour costs may be high.

Ashington N, et al, October (2007) an African initiative program identified a number of challenges that affected the development of biogas technology and they include the following:

i). *High costs of installing the systems*: Installing any biogas technology in Kenya is expensive. The market for biogas technology is limited to those who can afford other sources of modern energy. Currently, there is a lack of capacity to install high volumes of biogas, creating a need to increase the number of technicians/artisans.

ii). Systems failures: As already indicated there has been a high failure rate of the technology in the past. Moreover, some functional units are operating below optimal capacity, which gives the technology a bad name.

iii). Inadequate or lack of post installation support: Because the technology is now largely commercially driven, there is limited post installation support, especially after the expiry of the guarantee period – usually 12 months.

iv). Poor management and maintenance: For optimal production, a certain level of management both for the zero-grazing units and the digesters is needed. But with so many competing uses for rural farm labour, management of the digesters can suffer. Households are content to get 'acceptable' and not 'optimal' levels of production from their investments.

v). Inadequate or lack of technology awareness: Many potential users of the technology are not aware of the technology, many have not even seen it, or those who have are ignorant about how it operates/works and its benefits and personal relevance to them. There is a need for a sustained awareness creation campaign to educate potential users on the uses and benefits of biogas.

vi). Scarce and fragmented promotional activity: Institutions promoting the technology are relatively few.

vii). Standards: A major issue currently facing the sector is a lack of quality control.

2.3 Biogas technology and the availability of raw materials

Although biogas technology has established itself as a technology with great potential which could exercise major influence in the energy scene in the rural areas, it has not made any real impact on the total energy scenario. One of its serious limitation as observed by Nagamani B. et al (1998) is the availability of feedstock followed by defects in construction, and microbiological failure.

Livestock and water availability are two major pre-requisites for the adoption of biogas technology in the rural areas. According to Gitonga S., (1997), a significant number of the plants visited in Meru were found to have been abandoned after the water supply the system originally depended on, broke down. The amount of water the farmers were able to collect from distant rivers or boreholes was only sufficient for domestic use. There is need for adequate supply of water if operation of biogas plants is to be successful. Water is needed for mixing the cow dung to form slurry and for cleaning the zero-grazing unit.

According to Krich K.et al (2005), livestock wastes for biogas generation include cow dung, poultry droppings, pig manure, kitchen waste, grass faecal matter and algae. Dairy wastes can be co-digested with other biomass, such as agricultural residues or food processing wastes, to augment methane production

In Kenya, more so the people from Mombasa County are pastoralists' in nature and therefore the availability of enough cow dung to use in biogas plants is a problem. According to Njoroge D.K. (2002), South Sudanese own large herds of cattle that are grazed in open fields and kept overnight at cattle camps. It is possible to collect several tonnes of cow dung from one cattle camp every morning. However during the dry season, cattle camps are moved far from the towns and villages in search of pasture and water. There could be a shortage of cow dung for biogas during such times. Currently, this problem is being addressed by introducing the use of oxcarts to transport dung from cattle camps to biogas plants.

A part from the feedstocks, the sewage disposal can also be used in biogas generation. As reported by Wakala M. (2014) Meru GK Prison is a government institution located in eastern

province in Meru County with over 1200 inmates and over 300 staff in the 15 hectare compound. The prison management realized the potential of the ecological sanitation through a sensitization from the EPP staff. The prison has a big problem of high firewood consumption for cooking the prisoners' meals. The prison had also high sewage treatment bills from the treatment plant. These issues combined made the prison management to look into possibilities of adopting new technology from ecosan Kenya network. Initially all the waste generated from the prison was treated by the municipal sewer. The new technology aimed at treating all the waste in the digester and baffle reactor and reusing the treated effluent in the prison farm as irrigation water and fertilizer. The product of anaerobic decomposition, biogas, also called methane was to be used in the kitchen as source of energy.

In Rwanda, Kigali Institute of Science Technology and Management (KIST) has designed and built a 150m^3 fixed dome digester in Cyangugu prison that is fed with human waste generated by 1,500 prisoners. This digester produces methane gas that caters for 50% of the cooking needs in the 6000 inmate prison. KIST has also solved the sewerage and hygiene problem at Lysee de Kigali School by providing a 25m^3-Fixed Dome digester connected to 6 bio-latrines. The methane gas produced is used to cook for 400 students and for operating Bunsen burners in the school science laboratories (Njoroge D. K, 2002).

According to Kimaro (2005), a 25 cubic meters digester has been built for the Lysee de Kigali school, solving its sanitation problem. The gas produced is used to cook for 400 students and for operating Bunsen burners in the school laboratories. In Nsinda prison, using biogas has reduced 85% of 1 billion Rwandan francs ($1.7 million) used to buy firewood each year (Rosemary, 2010). The system powers 12 biogas ovens in the same prison. Thus the Rwanda government has made use of the human excreta in the prisons and schools as a source of raw material to produce biogas.

Similarly, the use of municipal solid waste in the production of biogas is evidenced in Europe. According to J. Knight, (2006) Over 70 anaerobic digesters are in operation in Europe converting over 12% of the municipal solid waste to biogas. Europe has unique economic conditions which make anaerobic digestion very cost effective, such as high tipping fees for wastes and special premium prices paid for the purchase of renewable energy.

2.4 Biogas technology and awareness

Awareness is the ability of the users of a product being able to identify or being informed of the presence of a product, its use and then make an informed decision to use the product in order to enjoy its benefits. According to Njoroge D. K. (2002), in Rwanda, biogas technology is quickly catching up through the efforts of Kigali Institute of Science Technology and Management (KIST). The work being done by KIST with support from the Rwandese government is an excellent example of how government sensitize its citizens to move biogas technology forward and in the process, help to solve energy, budgetary and hygiene problems for poor countries in Africa.

To ensure a sustainable operating staff, technicians will trained to enable easy access of artisans in every 47 Counties of Kenya. The training will create a pool of trained biogas masons; through rigorous theory and practical technical training. Using human waste in making biogas is a challenging objective, as it requires overcoming long-standing cultural and social taboos associated with handling of this waste. To overcome this, designing an attached toilet system to eliminate and reduce any contact with this waste is crucial. An information and outreach program to educate and change the consumers' attitude (detainees and students) about the resulting biogas will be crucial. Hence, prior to the construction of biogas system, a set of relevant points will need to be discussed and agreed upon with the prison/schools authority and detainees/students (Kimaro A, 2005).

Omer A.M, (2011) noted that a poor rural peasant is very hesitant to enter a new venture. The negative attitude towards the use of biogas plant varies from place to place and awareness sensitizing should be provided to eliminate the negative attitude. Njoroge D.K. (200), carried a biogas technology community awareness workshop named "towards intensified use of Biogas in South Sudan", with the objective of gauging the level of acceptance of Biogas technology by the Sudanese community taking Rumbek County as a microcosm. Participants were shown the TPB installation Video and conducted on a tour of the Pilot Plant at Rumbek School where the working of the plant, including the fertilizer use, was explained. From the workshop it was noted that most participants heard no idea regarding biogas technology and its use even though they appreciated it.

With UKaid (2012) report on "The Potential of Small-Scale Biogas Digesters to Improve Livelihoods and Long Term Sustainability of Ecosystem Services in Sub-Saharan Africa"

Most respondents considered they had little or no knowledge about biogas digesters, with less than 5% believing they had good knowledge of the system and benefits. This is supported by the fact that there is little biogas production and usage in the village

According to Alison Hamlin (2012), While reductions in cost and growth in alternative financing methods is needed to grow the biogas industry in Kenya, ultimately if prospective consumers are uneducated in regards to the potential of biogas, they will not invest. Upon visiting feed stores in Kiambu Town and asking store workers whether or not they knew about biogas, it became clear that while many had heard of the technology, they had little specific knowledge in regards to its function and potential.

In Kenya the government in partner with the special energy programme took the mandate to train local craftsmen and formed the basis of the dissemination programme. In 1983, SEP undertook the training of plant builders at a three-week course in Meru. A number of demonstration plants were constructed by trainees under the guidance of a GTZ biogas specialist. The plants were located at educational institutions and it was assumed that they would generate awareness and interest amongst potential users (Gitonga S. 1997). This approach was not successful and most of the demonstration units broke down soon after. SEP changed the strategy and instead began to transfer know-how to local craftsmen in the target areas through on-the-job training provided by MOERD instructors.

According to Devkota (2011), a well constructed digester unit using bricks and concrete has a life time of is 20-30 years, and it requires less maintenance costs. He further argues that Kenyatta University seeks to introduce a unique strategy to ensure mass adoption of biogas plants countrywide. This will require a well developed promotion strategy to activate the sector and incentivize stakeholders. The University's awareness creation and consumer education programme will take into consideration and address concerns related to the challenges, barriers, risks, constraints and the lessons learned in the biogas sector in Kenya and elsewhere.

2.5 Biogas technology, management and maintenance practices

Or biogas technology to successfully succeed the owner of the biogas plants or sponsors of the technology should take the responsibility of executing the daily routines in order to keep the process alive. Biogas technology is a cost-effective investment if plants are properly constructed, effectively operated and well maintained. According to Karanja G.M. and Kiruiro

E.M. (2003), some of the management practices include inadequate feeding, use of wrong waste: water ratios, inadequate stirring and inadequate protection of the digester and gas reservoir against damage by children, pets and livestock. This management practice not only leads to failure in biogas plants but also creates a bad image on the technology hence affecting its development.

To successfully promote biogas systems, there is need to counter the existing poor image created by the failed technology. One way of achieving this is by promoting proven designs, and providing post installation support services (Gitonga S. 1997).

Bhat, Chanakya, and Ravindranath (2001) reviewed the use of biogas in the Sirsi region of India, and determined that the area experienced a high rate of success compared to other regions. This was as a result of large population of livestock, which prevented plant abandonment due to lack of dung. They also found that users living in this region had greater access to free or low cost digester maintenance through intermediate financing institutions, such as agricultural cooperatives. This infrastructure provided greater support to clients, impacting the overall success of biogas in the region.

In Africa, biogas technology dissemination has been relatively unsuccessful. This is attributed to failure of African governments to support biogas technology through a focused energy policy, poor design and construction of digesters, wrong operation and lack of maintenance by users. In addition, poor dissemination strategies, lack of project monitoring and follow ups by promoters, and poor ownership responsibility by users have also lead to the dissemination challenges (Richard Arthur 2010).

2.6 Biogas technology and availability of funds

In terms of finance, all costs and benefits are valued from the point of view of the user for whom this is being done. Since this analysis is undertaken before making a decision to install the plant, it is important to ensure that all costs and benefits are estimated as they are most likely to be realized by the user after the plant installation. Benefits and costs of a biogas plant will vary depending upon the use of inputs and outputs by the particular user. For example, if additional cost is incurred in the use of inputs, such as the need to buy cattle dung or use additional labour for feeding the plant, such cost should also be included in the financial analysis.

Ways and means of reducing the capital cost of biogas plants need to be explored, operating costs need to be reduced and the systems for operating and maintenance simplified. Opportunities for disseminating the technology in other sectors, such as the large dairy farms, may provide alternative market possibilities (Gitonga S. 1997).

While it is fairly easy to quantify the cost of installation and maintenance of a TP biogas system, quantification of both social and economic benefits would depend on factors such as the size of the unit, the location (environmental conditions), availability of alternative energy sources, and even dietary habits. Experiences at KARI-Embu have indicated that a biogas system fed by 2 dairy cows would produce enough gas to cook light dishes such as tea, rice, porridge

The major problem of rural cattle farmers face lies with the inability to afford the full cost of biogas plants. For example in 2009, the average investment cost of a 10 m3 biogas plant ranged from $2800.00 and $4200.00. These figures are far above the financial capability of the rural farmer (Richard Arthur 2010).

Other agents/organizations have participated in the promotion of the technology for example; SACDEP (Sustainable Agricultural Development Programme) has also helped individuals to put up the units, with at least ten people installing units in the last two years using skilled labour from the organisation. The cost of these installations was not immediately available. According to SACDEP, interest in the technology is rising while demand is growing. However, installation is slow because most of the poor farmers take long to organize themselves and raise money for the units. Units are installed in homes where the owners have raised some money for part of the costs. Also, the group members have to agree that installation be done in a given members' homestead. The subsidy given is not paid back as a revolving fund (Ashington Ngigi; feasibility study, 2007)

The main obstacle currently preventing substantial growth of the biogas industry is cost (Alison Hamlin, 2012).as discussed; this is also a hindrance in allowing biogas to have the greatest possible impact on its users as those who may benefit most from the technology may likely be those who are unable to afford the cost. Therefore, in order to promote biogas in Kenya, effort must be made in reducing plant costs while also improving financing options, as discussed. To keep costs down, inexpensive plastic digester bags were used in the Flexi Biogas system. Because these cost just US$40 each, the total price for the whole system was US$180.

However, experience showed that this plastic tore when the system was moved, and due to normal wear and tear it had to be replaced after two years. The systems now use a PVC tarpaulin bag that lasts at least 10 years. As a result of this and other improvements, the smallest system now costs US$410, including installation. Costs could be lowered further if the systems were produced in countries such as China or India, where the price of raw materials is less than half of what it is (Dominic Wanjihia et al, 2012).

Most biogas products are offered against the full price to end-users, though some grant support and/or financing facilitated by donor projects. Consumers themselves are able to provide finance through informal saving groups ("merry-go-round") or more formal saving groups (SACCOs). To ease the burden of purchasing biogas equipments on the users, KUSCCO the umbrella organization of the SACCOs, has made finance arrangements on behalf of its members between installers and SACCOs. Some micro finance and banks are becoming interested in offering credit facilities to consumers for pre-financing biogas installations (Ashington Ngigi; feasibility study, 2007)

2.7 Promotion of biogas technology

The government of Kenya should enact laws to promote the development of biogas as a source of energy in order to protect the environment and protect the economic development through the cheaper and reliable source of energy. For example, Biogas production in Germany has developed rapidly over the last 20 years. The main reason is the legally created frameworks. Government support of renewable energies started at the beginning of the 1990s with the Law on Electricity Feed (StrEG). This law guaranteed the producers of energy from renewable sources the feed into the public power grid, thus the power companies were forced to take all produced energy from independent private producers of green energy.

Similarly in Europe the production of biogas technology is promoted through charging a fee on these who dispose their wastes into the landfills. Knight J. (2006) currently much organic material in the municipal waste stream is going to landfill and thus paying the landfill fee. While in New Zealand it would be to collect organic materials separately, and to pay a lesser fee than for land filling. Certainly, landfill tax would provide that incentive here in Kenya if applied.

PSDA promoted biogas as from 2005 with demonstration plants co-financed at Moi and Egerton University. In 2007, PSDA sought for co-funding from the European Union Energy Facility one (EUEF I). A three year (2008 – 2010) co-financing project with EU was formulated. The objective of the biogas project is to provide small to medium level rural dairy farmers and other beneficiaries with improved living conditions and adequate supply of energy through use of biogas energy technology

According to Richard Arthur (2010) Ghana government will promote biogas-for-heating in institutional kitchens, laboratories, hospitals, boarding schools, barracks, etc. The Strategic National Energy Plant (SNEP) for Ghana- strategic target is to achieve 1% penetration of biogas for cooking in hotels, restaurants and institutional kitchens by 2015 and 2% by 2020.

Most of Kenya's educational institutions depend on firewood as their main source of energy for cooking, contributing to deforestation and placing a financial burden on schools and universities due to rising prices for their fuel.

In response, the Kenya Forest Service and the African Development Bank (AFDB) have initiated a project dubbed "Green Zone Development," in which biogas technology is being introduced as an alternative energy source to learning facilities in the Rift Valley (Kemboi C. 2014).

"Boarding schools and day schools use a lot of firewood for cooking, so this project will reduce the dependence on the forest, and hence ease pressure on the ecosystem," said Solomon Mibei, head of conservation for the Kenya Forest Service in the North Rift Valley area.

The award was created in 1999 by the National Environment Trust Fund (NETFUND), a nongovernmental organisation, to recognize innovation, groundbreaking research, ideas, and extraordinary grass-roots initiatives in Kenya. It aims to promote sustainable use and management of natural resources by rewarding the best examples. (Kemboi C. 2014).

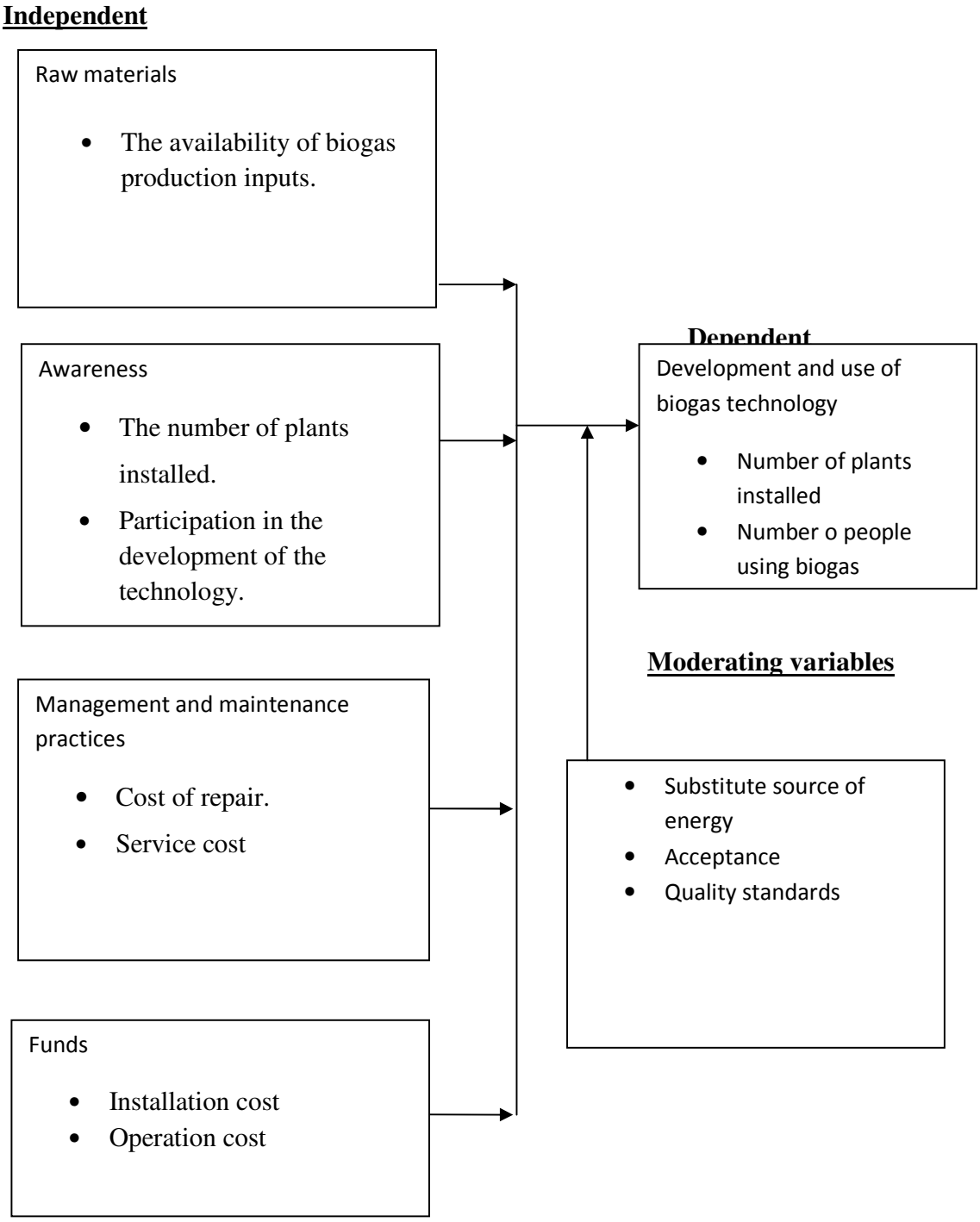
Introducing biogas technology in schools does appear to improve environmental protection in the local area. David Kipyego, chairman of the Eldoret Educational Resource Center, a school in Eldoret town, said that since the biogas project began there, use of firewood has been cut by half.

“We have reduced the use of firewood for cooking from 24 tons to 12 tons per term [of three months], which is an added advantage for the conservation of the environment, as well as being economical for the school,” Kipyego said.

The school biogas project is inspiring communities living nearby, and a number of them have adopted the same technology at household level.

2.8 Conceptual framework

Figure 2.1 conceptual framework



2.9 Summary of the literature review

In relation to the above discussion, it is true that most of the regions have not realized the use of biomass to generate a reliable source of energy, that is, biogas. In Africa, biogas technology dissemination has been relatively unsuccessful. This is attributed to failure of African governments to support biogas technology through a focused energy policy, poor design and construction of digesters, wrong operation and lack of maintenance by users (Richard Arthur 2010).This is evidenced from the data given on the number of units installed in developed countries like China, Denmark and India which is in terms of millions in relation to Africa were its in term of hundreds.

This trend is also observed in schools where most of them are coming up with lunch feeding programme and not making use of the remains to generate biogas. Although a few of them are showing direction with the aid of incentives from environmental conservation bodies like NETFUND. According to Alison Hamlin (2012), While reductions in cost and growth in alternative financing methods is needed to grow the biogas industry in Kenya, ultimately if prospective consumers are uneducated in regards to the potential of biogas, they will not invest. Thus it's the government responsibility to educate its citizens on the importance of biogas technology even enact a law to boost its development.

From the researches that have been done on biogas as a source of energy, it is found that biogas is a cheaper and reliable source of energy although it has experienced a number of obstacles in its development and use. The following factors stand out to have affected the development and use o biogas**;** High costs of installing the systems, Systems failures, Inadequate or lack of post installation support, Poor management and maintenance, Inadequate or lack of technology awareness, Scarce and fragmented promotional activity and Standards a major issue currently facing the sector.

Similarly, there are more potential areas which need to be promoted in enhancing biogas technology like in schools, colleges, prisons and restaurants. This is the responsibility of the governments in question to initiate the process through sensitization.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter covers the research methodologies used in the research project study and they include; research design, the research population, sampling procedure, variables definition, methods of data collection and methods of data analysis.

3.2 Research Design

A research design constitute decisions concerning what, where, when, how much and by what means an enquiry or a research study is done, Kothari C. (1986). This research study is a descriptive survey design. The research aims at finding or describing the state of affair as it exist at present. This study utilized both qualitative and quantitative approaches to collect data. Quantitative research produces quantifiable and numerical data while qualitative is limited to producing data in the form of statements or word rather than numbers (Mugenda and Mugenda, 2003).

3.3 Target population

The research study majorly focused on farmers, secondary schools, hotels and wastage treatment plants within Mombasa County due to the availability of biogas inputs in these sectors.

Table 3.1 Target population

Target group	**Target population**
Farmers	4,368
Secondary schools (Public/ Private)	51
Hotels/Restaurants	528
Waste disposal agents	17
Total	4, 964

3.4 Sample size

According to Kalton (1983), the principle object of any sampling is to secure a sample, which subject to limitation of size will produce the characteristics of the population. Purposive sampling was used to select 4 groups; farmers, hotels/restaurants, schools sand waste disposal agents for data collection.

In total, a sample size of 144 respondents was used. This was distributed between farmers, schools, restaurants, and other wastage disposal organizations/agents as 69, 24, 36 and 15 respectively.

3.5 Sampling Procedure

This is a definite plan determined before any data is actually collected for obtaining a sample from a given population. Kothari C. (1986). In this research the population under study was first divided into six strata namely; Mvita, Changamwe, Jomvu Kuu, Likoni, Kisauni and Nyali using stratified random sampling. In each stratum selected, then the respondents were stratified further into famers, schools/institutions, restaurants and wastage treatment plants. From the four groups, a slip was picked randomly from each stratum to provide a respondent for data collection for the research.

3.6 Data Collection Instruments

The data collection instruments used during the study employed both qualitative and quantitative techniques and they included questionnaires, interviews and content analysis.

3.6.1 Interviews

This involved presentation of oral-verbal stimuli followed by a reply in terms of oral-verbal responses. In this research the personal type of interview was more preferred and the researcher himself administered the structured interviews. The respondents were expected to respond based on the past records and level of knowledge and skilled they possessed.

3.6.2 Questionnaires

A questionnaire consisted of a number of questions printed in a definite order on a form or set of forms. The questionnaire constituted structured, unstructured and open ended questions. The questionnaires were taken round by the researcher assistant and the researcher himself and the respondents were expected to respond to the questionnaires at the moment. This method of data collection gave out a good return for the respondents were to respond to the questions and submit the questionnaire.

3.6.3 Content analysis

This method involved the analysis of the contents of research articles that have been published. This method of data collection involved the use of already printed information from the public/private individuals and organizations.

3.7 Validity

According to Kothari C. K. (1986) validity indicates the degree to which an instrument measures what it is intended to measure. It is the extent to which differences found with a measuring instrument reflect true difference among those being tested. The data collection instruments were tested for validity with the aid of the supervisor and colleagues for validation. A pilot study was then conducted in Kisii County using a total of 20 respondents in the four groups targeted for the research. This gave room to the correction and adjustment of the instruments before actual data collection.

3.8 Reliability

Reliability indicates the stability and consistency with which the data collection instrument measures the concept (Kothari C. K., 1986). A test-retest technique was employed to establish the reliability of the instruments. For the instruments to yield the expected results, they were re-administered to the same group of respondents.

3.9 Data processing

This technically refers to the editing, coding, classification and tabulation of collected data so that they are amenable for analysis.

Editing: the data collected from the field through the aid of questionnaires and interviews was examined to detect errors and omissions and corrected before data analysed.

Coding: for efficient analysis of data, the data collected was assigned numerals to answers so that the responses are group into a limited number of classes or categories. All responses with the same concept or response or characteristics were placed in one class or group.

Classification: Due to large volume of data collected, the data was arranged into groups or classes on the basis of common characteristics. In the research, the researcher opted to use attribute classification. Under this classification the researcher opted for manifold classification was two or more attributes were considered simultaneously.

3.10 Data Analysis techniques

This involved computation of indices or measures of dispersion along with searching for patterns of relationships that exist among the data groups. The various techniques and methods used in data analysis included the descriptive qualitative and quantitative techniques. Frequency distribution, measure of central tendency, measure of variability and measure of association or relationships were used to arrive at a general picture from which a conclusion was made.

3.11 Ethical considerations

Respondents under this study were ensured of confidentiality of the information that they gave and that it was to be used for the purpose of the study only.

3.12 Operational definition of variables

In this research, the development of biogas technology is a dependant variable and relies on the independent variable; financial standards of the individuals, the knowhow of the technology as a source of energy, the availability of raw materials (inputs) and the involvement of stakeholders to facilitate the development of the technology.

Table 3.2 Relationship between objectives, variables, indicators and scale of measurement

Objective	Variable	Indicator	Scale	Data analysis technique
To determine how the availability of raw materials influence the development of biogas and use in Mombasa county.	Raw materials	Inputs.	Nominal	Content analysis
To determine how the awareness of biogas technology affects its development and use in Mombasa county.	Plants installed	The number of plants installed. Participation in the development of the technology.	Nominal	Content analysis
Establish how management and maintenance practices affect biogas development and use	Plants functioning	The number of plants functioning and the collapsed one. The availability of trained personnel.	Ordinal	Content analysis
Establish how the availability of funds and agents involved to fund affect the development and use of biogas	Income and involvement in co-operatives	The size and type of plants build.	Ratio	Content analysis

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRENTATIOIN OF RESULTS

4.1 Introductions

This chapter covers the result of the research which are analysed after being presented in frequency distribution tables, percentages and other statistical distributions. It covers the response rate, demographic characteristic of the respondents, data analysis and interpretation for the determinants of biogas technology development and use in Mombasa County.

4.2 Response rate

From the research design, the population under study was segmented into six equal clusters in relation to the number of constituencies; Mvita, Changamwe, Jomvu kuu, Likoni, Kisauni and Nyali. From the 144 respondents; 120 were questionnaires, and 24 were interviews. All the questionnaires were returned for they required immediate responses except in Kisauni and Nyali where they were not fully returned.

Table 4.1 Response rate on questionnaires

constituencies	No of questionnaires issued	No of questionnaires returned	Percentage response
Mvita	20	20	100%
changamwe	20	20	100%
Jomvu kuu	20	20	100%
Likoni	20	20	100%
Kisauni	20	17	85%
Nyali	20	18	90%
Total	**120**	**115**	**95%**

The study realized an overall response rate of 95% which was quite adequate to produce a reliable result for the research.

4.3 Demographic characteristics of respondents

Out of 144 respondents who responded to the questionnaires and interviews, 95% were male while 5% were women. In the perspective of age; 30.71% of the respondents were of age 20-30, 40.98% of ages 30-40, 15.80% were of age40-50, 8.33% were of age 50-60 and 4.98% above the age of 60 years.

Table 4.2 Demographic profile of the respondents

Indicator	**Response classification**	**Number of respondents**	**Response percentage**
Age	20-30	36	30.71%
	30-40	49	40.98%
	40-50	19	15.80%
	50-60	10	8.33%
	60 and above	6	4.98%
Activity involved in/employment	Farming	47	39.5%
	Business	35	28.8%
	employed	38	31.7%
Education level	With primary education	51	42.5%
	With secondary education	45	38.3%
	With tertiary education	24	19.2%
Source of energy	Electricity	56	46.6%
	Firewood	42	35.0%
	Kerosene	38	31.6%
	Biogas	2	1.6%
	Solar	4	4.8%
	Wind	0	0.00%
	LPG	27	22.5%

Table 4.2 indicates that 39.5% of the respondents were farmers, 28.8% were engaged in business while 31.7% of the respondents were employed in various service provision industries. This trend shows that the Mombasa County residents are equally engaged in all activities.

Education seemed to be a very challenging issue in Mombasa County as the analysis reveals that 42.5% of the respondents had only primary education, 38.3% had secondary education and only 19.2% had attained education beyond the secondary education.

In response to the source of energy, the respondents appeared to prefer more than one source of energy and that is the reason to why the total number of respondents is more than 120 according to the target population.

From the table above, most of the respondents preferred electricity for its readily available requires only installation and thereafter only the bills are paid in relation to the demands. Due to technological development, most of the electronic equipments require electricity and hence the major reason to why most of the respondents prefer electricity. Other reasons to way most respondents preferred electricity include aesthetic value, low maintenance cost and long lasting.

The other sources of energy that appeared to be preferred more than biogas include; firewood, kerosene and LPG in order of preference. Solar and biogas lags from behind where biogas has a percentage preference of 1.6% that the two sources are least preferred.

In the following section, the researcher focuses on the factors that determines the development of biogas technology in Mombasa County and they include awareness, availability of raw materials, awareness, the availability of funds/promoters and maintenance and management practices.

4.4 Availability of raw materials

According to the data collected it's evidenced that a great proportion of the respondents were farmers, followed by schools/institutions, restaurants and finally the wastage disposal agents. This is illustrated as in the figure below.

Table 4.3 percentage proportions of the respondents

Target population	Number of respondents	Percentage proportion
Farmers	69	48%
School/institutions	24	17%
Restaurants	36	25%
Wastage disposal agents	15	10%

From table 4.3, the farmers represent the greatest portion of respondents in the research but due to the geographical position of the coast region in Kenya. The farmers do practice small scale farming yielding raw materials from livestock, vegetative materials and kitchen remains. For schools/institutions the raw materials for biogas production are available from the kitchen remains for boarding and lunch providing schools, human excreta and other vegetative wastes. This applies with the restaurants and hotels since there major activity is service provision in catering while the wastage disposal agents are found to be rich in solid wastes.

In connection to the activities done by the respondents, the following are some of the raw materials that were found to be available for biogas production; cow dung, poultry, kitchen remains, human excreta, vegetative materials, landfill and sewerage. Table 4.4 below shows the number of respondents against the nature of raw materials available for use in biogas production.

Table 4.4 availability of raw materials for biogas production

Raw materials	cow dung	poultry	Kitchen remains	Human excreta	Vegetative materials	Landfill	sewerage
Observed frequencies	78	6	40	24	30	14	8
percentage proportion	39%	3%	20%	12%	15%	7%	4%

Although all types of raw materials were available for biogas production from the table above, it is evident that none of them or very few of these raw materials are made use of in biogas production but most of the respondents showed the willingness to invest in biogas in the future. From the table above cow dung was found to be the most favourable and easily available material for use followed by kitchen remains, vegetative material, human excreta, landfill, sewage and finally poultry receiving least notice.

The chi-square method of hypothesis testing was used in measuring to measure the effect of availability of raw materials in relation to the development of biogas development.

Table 4.5 chi- square on availability of raw materials

group	Observed frequency (O_1)	Expected frequency (E_1)	O_1-E_1	$(O_1-E_1)^2/E_1$
Cow dung	78	28.57	49.43	85.52
Poultry	6	28.57	-22.57	17.83
Kitchen remains	40	28.57	11.43	4.57
Human excreta	24	28.57	-4.57	0.73
Vegetative materials	30	28.57	1.43	0.07
Landfill	14	28.57	-14.57	7.43
Sewerage	8	28.57	-20.57	14.81
Total	200			145.77

From table 4.5 the chi- square value was calculated as 145.77, but at 5% level of significance the table value for χ^2 =16.92. Thus the calculated value is greater than the χ^2 value at 5% level of significance hence we conclude that the availability of raw materials has no effect on the development of biogas technology, this leads to accepting the null hypothesis while rejecting the alternative.

4.5 Awareness of biogas technology

While conducting the research it was found that most of the people in Mombasa County are unaware of biogas technology as an alternative cheaper, reliable and readily available source of energy. Table 4.6 shows the relationship between age, the level of education and the awareness of biogas technology as from the research findings.

***Table 4.6 relationship between ages, level of education and biogas technology awareness*.**

Age	**Level of education**	**Aware**	**Not aware**
20-30 years	Primary	4	5
	Secondary	14	1
	Tertiary	13	0
30-40 years	Primary	6	9
	Secondary	17	7
	Tertiary	9	0
40-50 years	Primary	5	11
	Secondary	1	2
	Tertiary	0	0
50-60 years	Primary	0	7
	Secondary	1	1
	Tertiary	1	0
60 and above years	Primary	1	3
	Secondary	1	1
	Tertiary	0	0
Total		73	47

In relation to the above analysis it was found that the majority of the Mombasa county residents are unaware of the technology due to their level of education.60% of the respondents agreed that the level of education has no effect on the knowing of the technology, while 40% argued that the level of education do greatly affect the awareness of the technology. Table 4.6 above can be further studied using the chi-square in establishing the degree of significance as below.

Table 4.7 chi-square on level of education and biogas technology

Groups	Observed frequency O1	Expected frequency E1	O_1-E_1	$(O_1-E_1)^{2/}E_1$
AWARE				
Primary	16	24.33	-8.33	2.85
Secondary	34	24.33	9.67	3.84
Tertiary	23	24.33	-1.33	0.07
Total				6.76
NOT AWARE				
Primary	35	15.67	9.33	5.55
secondary	12	15.67	-3.67	0.86
Tertiary	0	15.67	-15.67	15.67
Total				22.08

The table value of $\chi 2$ for one degree of freedom at 5% level of significance is 16.92. The calculated values for the chi-square from table 4.7 for the aware and unaware are 6.76 and 22.08 respectively. The calculated value of aware is less than the table value, while the unaware is more implying that not being aware doesn't affect the development and use of biogas technology but the opposite is true. Hence the hypothesis hold good, implying that being aware and not being aware of biogas technology do affect its development and use.

Apart from age and the level of education, biogas technology awareness was found to be affected by the following factors as shown in the table below.

Table 4.8 factors affecting biogas technology awareness

Factors affecting biogas technology	Number of respondents	Percentage response
Education curriculum	39	34%
Government	72	63%
NGOs/agents	33	29%
County government	7	6%
none	15	13%

4.5.1 Curriculum and biogas technology awareness

Curriculum is a designed layout that is to be used as a guide line towards the achievement of the national goals. Therefore most of the respondents, that is 34 in number, argued that the idea of biogas technology is not spread since it's not incorporated in the education system of our country. This is also seen from the responses given in relation to the level of education attained by the respondents. For example, 68% of respondents with only primary education said that they had no knowledge about the technology and even on its functionality. While 16% with secondary education were unaware and there was none with tertiary education. This shows that the development of biogas technology in Mombasa County is directly related to the level of education attained by the residents.

4.5.2 Government/ ministry of energy

The government of Kenya plays a great role in the dissemination of the technology through the ministry of energy and other institutions which shows or has an interest in its promotion. From the result obtained in the research, it's observed that the government is the major organ to see the technology achieve a success. Most respondents, 52%, agreed that the government has failed to educate its citizens on the whereabouts of biogas technology, its production, management, trained personnel and provide funds to support such projects.

In this research, the researcher only came across one project of biogas production which is funded by the government of Kenya thorough BAOBAB Trust in Bamburi founded by Haller Foundation which is used in the promotion of the technology in and outside Mombasa County.

4.5.3 NGOs/ agents

These are non-governmental organisation and other stakeholders who have or shown interest in promoting the technology as a result of improving the welfare of the citizens. While doing literature review other non-governmental organisations (microfinance) were identified to provide finance assistance in the process of promoting biogas technology. But while on the ground doing the research, none of these organisations has been identified to provide the service.

Out of the 120 respondents, 29 of these respondents argued that the NGOs/agents have not come out to support the technology and also inform the citizens to invest in the technology as a result of their support.

4.5.4 County government

Kenya has 47 counties according to the new constitution and this is the first governance since the inauguration of the new constitution. Therefore, only 6 respondents claimed that the county governance has failed in promoting the technology. This can be observed in the disposal of waste by Mombasa municipal council where the agents involved in cleaning the city don't recycle the wastes but only dumps them in landfills.

Finally a group of 6 respondents were not able to identify among the above groups who has failed in promoting biogas technology particularly in Mombasa County.

4.6 Maintenance and management practices

Maintenance practices are these operation carried out on site of the plant, after and when the plant is on operation in order to improve on it productivity. While management practices are activities of controlling, staffing, financing, coordinating and organizing for the smooth execution of services and functioning of the plant.

From the data collected 75% of the respondents were unaware of the maintenance practices carried out in a biogas plant for they had no knowledge on how the biogas plant looks like and what it requires for its functionality. From the respondents only 25% who agreed that maintenance and management practices do greatly affect the development of biogas technology and 25% disagreed while 50% didn't have an idea. According to the data collected, only three respondents were in a position to give some of the practices since they had worked in a biogas plant and also they had evidenced it. Thus the following were some of the practices that the respondents managed to list and they include:

Table 4.9 maintenance and management responses

Maintenance practice	No of respondents	Percentage proportion
Repairing of leakages	34	23
Feeding the biogas digester	48	32
Removing the slurry	44	30
Cookers and lamps maintenance	22	15

The above maintenance practices were found to be carried out on daily and weekly basis, that is, the feeding of the digester is done on daily basis while the other on weekly basis in relation to the response of these who owned the biogas plants. The chi-square method was used to determine the effect of these factors on the development of biogas technology in Mombasa County as below.

Table 4.10 chi- square for maintenance and management

Maintenance practice	Observed frequency (O)	Expected frequency (E_1)	O-E_1	$(O-E_1)^2/_{E1}$
Repairing of leakages	34	37	-3	0.24
Feeding the biogas digester	48	37	11	3.27
Removing the slurry	44	37	17	7.81
Cookers and lamps maintenance	22	37	-15	6.08
				∑=17.40

From table 4.10 the chi- square value was calculated as 17.40, but at 5% level of significance the table value for χ^2 =16.92. Thus the calculated value is greater than the χ^2 value at 5% level of significance hence we conclude that the maintenance and management practices have no

effect on the development of biogas technology, this leads to accepting the null hypothesis while rejecting the alternative.

4.7 The availability of funds and promoters.

While conducting the research the respondents had the opportunity to state their activities and the amount of money available to invest in biogas projects in relation to their earnings. The following table shows the activities being done by the respondents and the average amount of money available for investment.

Table 4.11 number of the respondents against their occupation and earning

Occupation	**Farming**	**Teaching**	**Business**	**Security**	**Municipal**	**others**
No of respondents	42	22	29	14	5	8
Average earning	14,000	31,000	35,644	21,500	17,400	37,000

From the table the highest number of the respondents were farmers, followed by businessmen/women then teachers, security officers, municipal workers and finally the others group. The above five groups were arrived at as a result of the target population when designing the research while the others includes all occupations a part from the above mentioned five. From table 4.11 the average earning can be computed as below establish the average value source of earning.

$\bar{x} = \sum fx/\sum f$

$= 2,987,676/120$

$= 24,897$

When comparing the average earning of the groups, it clearly shows that farmers are more in number but there earning is too little to enable them venture into biogas production. The 42 farmers who responded to the questionnaire stated to have raw materials for biogas production but they had no idea on its production, functioning and use hence they couldn't invest in its production. And the other groups, that is, teachers, security officers, businessmen/women, municipal workers and the others agreed to have knowledge about biogas production but said

that they luck the skilled labour and expertise to assist them in installing the biogas plant and familiarize them on its operation.

In relation to the table 4.9, the respondents were asked to state their source of funding if they were to invest in biogas production and the majority stated their salary. The table below shows the sources of funding against the respondents using that source

Table 4.12 source of funding against respondents

Source of funding	Salary	Business	Grants/loans	Sponsors	SACCOs/co-operatives
Number of respondents	98	19	2	1	0

.

From the table, the number of respondents relying on their salaries for investing is more than 75% of the total number of respondents. But in regard to table 4.3 the average salaries or the respondents is not enough to cater for biogas installation and maintenance. In any growing economy its citizens must invest heavily by getting support from sponsors, grants/loans, being in SACCOs/co-operatives and finally from the government. But this was not true from the questionnaires since the majority of the respondents seemed not getting involved with sponsors, or grants/loans and SAACCOs/co-operatives.

4.7.1 Promoters of biogas technology

Biogas production is a highly demanding activity in terms of funds and knowhow, therefore from the data collected it was evident that only one body in Mombasa County is promoting its production and dissemination. BAOBAB TRUST is an organization in Bamburi under Haller Foundation and the government of Kenya has built some biogas plants in its firm were it people can learn on the functionality of biogas plants.

Although the organisation is trying its best in promoting the biogas technology, it was found to encounter some of the challenges and some of the challenges include:

i. The attitude of the farmers towards biogas production. Most of the farmers were reported to have a negative attitude towards the technology due to its requirements like feeding the digester on daily basis, removal of slurry when full and hence termed it as a dirty job.

ii. Resistance to change. Most of the respondents who respondent to the questionnaires and interviews agreed that biogas technology is a new thing and therefore it's difficult to invest in it without observing its functionality somewhere.

iii. The knowhow. 100% of the respondents from the collection instruments show that most of the Mombasa County residents have no or little knowhow on the production of biogas. This is also attributed by the level of illiteracy in the county and the culture of Mombasa county residents that Mombasa is a tourist attracting centre and therefore, there major concern is enjoyment, spending and tour guiding.

iv. Funds. The available funds are too little to invest and most o the respondents had no idea on sponsors, donors, stakeholders and government involvement in biogas promotion.

v. Passion to embrace the system.

In relation to the above factors , when the respondents were asked if they were willing to invest in biogas production in the future; 97 of the respondents said YES, 6 respondents said NO while the remaining 17 respondents were UNDECIDED on either to invest or not.

CHAPTER FIVE

SUMMARY OF THE FINDINGS, DISCUSSION, RECOMMENDATION AND CONCLUSION

5.1 Introduction

In this chapter, the major findings are summarized; discussed and conclusions made based on the findings and then recommendations are made for the concerned bodies.

5.2 Summary of the findings

It can be observed from the analysis above that the development of biogas technology in Mombasa County is greatly influenced by the availability of raw materials, the awareness off the technology, the maintenance and management practices and finally the availability of funds and organisations/agents promoting the technology.

With the availability of materials, it was found that the availability of materials do not affect the development of biogas technology. This is true since most of the Mombasa County residents particularly restaurants, farmers, schools and wastage disposal were found to have enough materials but never tried to utilize it in biogas production.

In relation to the second hypothesis which stated that, the level of biogas technology awareness influences its development is true since on comparing the levels of education and the awareness of biogas technology, it was found that 35 out of 51 respondents with primary education, 12 out of 46 respondents with secondary education and none with tertiary education were unaware of biogas technology. Apart from the level of education, the other factors that were found to affect biogas technology awareness included; the curriculum, the government/ministry of energy, agents/sponsors and the county government in that order.

The third hypothesis stated that the maintenance and management practices do influence the development of biogas technology. From the research finding, it was observed that most of the Mombasa County residents did not prefer carrying out the daily routine practices since they perceive the work as dirty and laborious.

Finally the concept of funds and organisations/agents involved in disseminating and funding the development of biogas technology was found to influence its development. From the data collected, the researcher came across only one biogas plant that has been promoted by the government under Haller Foundation (BAOBA TRUST). On further enquiry most of the respondents argued that the development of biogas has not taken roots here in Mombasa County since there are no organisations/agents/sponsors that can promoter the technology.

5.3 Discussion

The researcher herein outlines the discussions made following the analysis of the findings. According to the first objective, to determine how the availability of raw materials influences the development of biogas technology in Mombasa County. In relation to the findings, it was clear that there were enough materials available for biogas production. But from the indicator that is the activity being involved in and the size of plants installed, it was found that the availability of the materials do not greatly influence the development of biogas technology.

This can be supported from the value obtained in hypothesis testing using the chi-square method. The chi- square value was calculated as 53.33, this value is greater than the χ^2 value at 5% level of significance hence we conclude that the availability of raw materials has no effect on the development of biogas technology, this leads to accepting the null hypothesis while rejecting the alternative.

The only biogas plant that was functioning in Bamburi was found to operate using raw materials only from two cattle, while in most schools/institutions, restaurants and wastage treatment where there is enough raw material were found not involved in its production nor having an idea to use it in the future. Thus the availability of raw materials does not affect the development of biogas technology but only influences the size of the plant being constructed.

The second objective of the study was to determine how the awareness of biogas technology influences its development in Mombasa County. From the analysis of the findings it was proved that the awareness of the technology do greatly influence its development. This is attributed by the fact that most people either with primary, secondary or tertiary education confirmed that even if some of them knew the existence of the technology they had no skills on

its functionality, operation and use. This was supplemented by the unavailability of skilled personnel and labour to construct and repair the plants after failure or breakdown.

The third objective was to determine the extent to which the management and maintenance practices influence biogas technology in Mombasa County. This objective was somehow challenging to determine since most of the respondents had no idea on the functionality and operation of the biogas plant, but for these who had the idea and these with the plant highly participated showed that the maintenance practices do create a negative attitude for its laborious and sometimes regarded as a dirty work.

Finally the last objective was to establish the extent to which the availability of funds and organisations/agents to invest in biogas technology has influenced its development in Mombasa County. From the analysis of the findings it was clear that most of the respondents were not aware of any organisation nor agent funding biogas production and hence incase one was to invest in biogas production, the only source for funding is only their salary. On working out the average salary from the respondents, it was determined to be Ksh. 24,897. This amount of money is too little for one to invest and at the same time use it on his daily needs.

5.4 Conclusion

In regard to the study, it has been noted that biogas technology development here in Mombasa County is moving at a snail's speed and hence a retardant growth. When considering the development of Mombasa County in relation to other counties, it's observed to be lagging in both aspects of development. This has also contributed too to the lagging in biogas technology.

From the study it can be observed that biogas technology development is influenced by a number of factors apart from raw materials, awareness, maintenance practices and availability of funds. Some of these factors include; ignorance, lack of skilled labour/construction companies and water.

While analyzing the findings it was observed that the availability of raw materials doesn't influence the development of biogas technology but the knowhow to utilise the resource in promoting the technology. From the literature review, countries like Rwanda have decided to promote the technology by building biogas plants in institutions where its learners are educated

on the operation and use of biogas. Thus the Kenyan government should follow the same channel in promoting biogas technology through sensitization of its citizens and also train artisans and craftsmen to build and maintain the plants.

Finally, the most important section in any investment is finance, this was found to have discouraged most of the respondents from venturing into biogas production due to its demand during the initial stages of installation. This was even observed from the constructed plants where they were small as a result of the available funds.

5.5 Recommendations

For biogas technology to take root in Mombasa County, it requires both the citizens, sponsors and the government to put hands together and see the biogas technology forward. Therefore, from the study the government should restructure its curriculum more so in secondary and tertiary institutions to equip its learners with the knowledge and skills on the production and use of biogas.

The government through schools and other institutions like prisons, colleges and sport centers should promote biogas technology by harnessing the available raw materials and making use of them in learning there operations.

In regard to the availability funds, the government through banks and other recognized lending bodies should provide loans at a reduced rate in order to inspire more people to invest in the technology. Similarly the government of Kenya together with the county government should encourage companies to construct cheaper digester that are affordable to its citizens.

Finally the county government of Mombasa through the municipal council should encourage the construction of biogas plants which can be used in waste treatment. The municipal council should impose a fine for these who dump their wastes and collect the wastes at a reduced rate for these who take their wastes to the right place of disposal where it can be used for biogas production.

5.6 suggested areas for further research

After studying the factors influencing the development of biogas technology in Mombasa County, the researcher wishes that further research to be done to establish the impact of BAOBAB TRUST in the promotion of biogas technology in and out of Mombasa County. Second is to establish the impact of biogas technology on the social and economic development of Mombasa County.

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APPENDIX I

Questionnaire

This questionnaire has been designed to collect information for study purposes. Therefore, your response to the questions will be treated confidentially and there will be no jeopardize to whatever information given.

Don't write your name or other personal details in this questionnaire. Your participation is highly appreciated. Thanks in advance.

INSTRUTIONS

Mark inside the boxes where possible.

1. Gender: Male ☐ Female ☐
2. Age? 20 -30 ☐ 30-40 ☐ 40-50 ☐ 50-60 ☐ 60 and above ☐
3. State your source of income_____ and the approximate value _____
4. What is your source of energy? Electricity ☐ Firewood ☐ Kerosene ☐

   Biogas ☐ Solar ☐ or Wind ☐
5. If you use other source of energy apart from biogas, state three reasons why you prefer the source of energy in relation to biogas.

   a. _____

   b. _____

   c. _____
6. What kind of activity are you involved in? _____
7. In relation to your activity, is there enough wastage for biogas production?

   Yes ☐ No ☐

8. What are some of the raw materials that are available for biogas production in relation to the activity that you are engaged in?

   a). cow dung ☐ b).poultry ☐ c).kitchen remains ☐ d). human excreta ☐

   e).vegetative materials ☐ f).landfill ☐ h).sewage ☐

9. If yes, are you engaged in biogas production? Yes ☐ No ☐

10. If NO to question 7, do you have any feeling of being engaged in biogas production in the future? Yes ☐ No ☐

11. Do you own any plant for biogas production? Yes ☐ No ☐

12. Is the plant in operation? Yes ☐ No ☐

13. If yes, how effective is the plant? _____(%)_____

14. How do you compare it with other sources of energy?

    a). Excellent b).Good c) Average d). Below average e) Poor

15. State some of the challenges you encounter in running the plant.

    _____

    _____

    _____

16. State the reason to why you do not own or access a biogas plant in relation to question 17.

    _____

    _____

    _____

17. Are you aware of biogas as a source of energy? Yes ☐ No ☐

18. If yes, for how long have you known it? 1-5 yrs ☐ 6-10 yrs ☐ 11-15 yrs ☐

    16-20 yrs ☐ 20 and above yrs ☐

19. What is your level of education? Primary ☐ secondary ☐ tertiary ☐

20. Do you think your level of education do affect your knowing of biogas technology?

Yes ☐ No ☐

21. A part from the level of education, what other factors do you think that have affected the awareness of biogas technology?

Curriculum ☐ government/ministry of energy participation ☐ involved organisation/agents ☐ county government ☐

22. What are some of the maintenance practices that you do carry in your plant?

_____

_____

_____

23. How often do you carry them out? a). Daily ☐ b). Weakly ☐ c). Monthly ☐ d). Yearly ☐

24. Do you think the maintenance practices carried out in biogas plants discourage most of the people from investing in the activity? Yes ☐ No ☐

25. How?

_____

_____

26. What is your source of funding for your project?

_____

27. Are the funds enough to install and maintain the running of the plant? Yes ☐ No ☐

28. If No to number 28, what is your alternative source of funding?

_____

29. Around this area, how many farmers/individuals/groups are you aware of being involved in biogas production? _____

30. State the number of those who have successfully managed and those who have failed if any. Successful ☐ failed ☐

31. Are you aware of any agent promoting biogas technology? Yes ☐ No ☐

32. If yes state the agent. _____

33. Do you think the agent/organisation is effective in its promotion?

Yes ☐ No ☐

34. If NO state some of the factors that you think have affected its promotion.

_____

_____

_____

APPENDIX II

INTERVIEW

The following questions are intended for educational purpose, therefore, your contribution is highly appreciated and any information given should be treated confidentially.

1. How old are you?

2. What kind of activity do you engage yourself in for your daily bread?

3. From your activity, are there enough materials to be used in biogas production?

4. What are some of the raw materials that are available for biogas production in relation to the activity that you are engaged in?

5. Do you think the availability of materials do affect the development of biogas technology? How?

6. Are you aware of biogas as a source of energy, and do you own one?

7. If YES, how do you compare it with other sources of energy?

8. If you do not own one, how many are you aware of in your area of residence?

9. Are they functional?

10. What are some of the management and maintenance practice do you carry out in your plant?

11. Do this management and maintenance practice affect the development of biogas technology?

12. How do they affect?

13. What is the source of funding for your biogas plant?

14. Is the availability of funds the reasons to way most people don't own biogas plants?

15. Are you aware of any promoter funding biogas development, state them if any?

16. What are some of the challenges encountered in the promotion and development of biogas technology?

17. What is your future prospective with biogas technology?