Assessing the uptake of biogas as a source of clean energy for cooking by low income households in Kibera slum, Kenya

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BY

JUMA IGNATIUS MAIYAH

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DECLARATION

This thesis is my original work and has not been submitted in any other university for a degree or any other institution of higher learning for examination

Candidate: **Juma Ignatius Maiyah**

Reg number: Z50/7730/2017

Signed: *Juma Ignatius* **Date: 3rd September 2020**

This thesis has been submitted with our approval as University Supervisors.

Supervisor: Prof Stephen Anyango, PhD

Signed: **Date: 7th September 2020**

Centre for Advance Studies in Environmental Law and Policy (CASELAP), University of Nairobi

Supervisor: Prof Richard Mulwa,PhD

Signed: **Date: 4th November, 2020**

Centre for Advance Studies in Environmental Law and Policy (CASELAP), University of Nairobi

DEDICATION

This thesis is dedicated to all the young people of Kibera slum. Those who have been told that they cannot achieve what they set their eyes on and cannot go beyond their rusty roofs. Your dreams are in your hands.

While all may seem lost due to the existing conditions in your families, the challenge to change the narrative and be just what you want to be is in your hands. The road may be long, the climb steep but the oasis of hope and a new dawn will always be in front of you. Keep moving further and further. In the end the universe will converge to help you soar like an eagle.

ABSTRACT

Kibera households use various energy mixes for their cooking and lighting needs. Their energy mix is characterised by environmentally unstable energy sources that include charcoal, wood fuel and kerosene. Biomass sources for cooking, in the form of biogas, were introduced in the area by a non-governmental organisation, Umande Trust, with the aim of providing a cheaper and environment sustainable energy source to the residents. The project similarly aimed at enhancing the sanitation and hygiene of the study area. This study aimed at assessing the uptake of biogas as a source of clean energy by low income households for cooking in Kibera. The objectives of the study were: i. to establish the socio-economic factors that determine the energy used by the residents of Kibera, ii. to establish the levels of awareness and perception on the use biogas by the residents of Kibera and iii. to find out the Kenyan Government policy on production, distribution and use of biogas in the urban and peri-urban environments of the country. For data collection, focus group discussions, key informant interviews, direct observation and household survey were used. To determine factors influencing adoption of biogas technology, 572 households were sampled and interviewed using the prepared household questionnaires. Six key informant interviews were conducted with representatives of the Ministry of Energy, Ministry of Environment, The National Environment Management Authority and representative of Umande Trust. Similarly, the study conducted four focus group discussions. From the study, it was revealed that the uptake of biogas in Kibera was very low. Many of the bio-centres were falling to disuse. The study revealed that household income, education level, cultural affiliations, household size, and distance from biogas centre significantly influenced the uptake of biogas. In conclusion, this study observed that biogas was not an energy source of choice for the people of Kibera mainly because of the fact that it came from human excrete. Secondly, the study noted that while the people of Kibera were aware of the source of the biogas, their perception towards the gas was skewed. Additionally, while the government has made attempts to enhance biogas uptake in the country, there is been no emphasis on the use of human excreta to produce biogas in urban and peri-urban set ups. Most of the attention has been on the use of animal waste and agricultural waste. To enhance the uptake of the biogas, there is need for continuous sensitization, awareness creation and education of the masses on the link between the source of the biogas (human excrete) as well and the end product (the gas). Also, since the distance from the bio centre and communal kitchens affected the uptake of the biogas, for future projects, piping of the gas to individual houses would be recommendable i.e the enhancement of the operational and maintenance of the facilities. Similarly, on the policy, the government should incorporate biogas plans in its wider development programmes in the country innovative slum upgrading strategies. Other recommendations include, improved public participation, provision of tax breaks, trainings of artisans and proper marketing strategies of the biogas.

Key words: Biogas, Energy, production, households, Kibera

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CHAPTER ONE: INTRODUCTION

1.1 Background to the study

Energy is an important factor of human life and can be used as an indicator for the socio-economic development of a given group of people (K C, Surendra et al. 2014.). Despite the progress that has been made technologically in terms of the energy being adopted globally, many households continue to encounter the challenge of an insufficient energy supply (Abeeku, B. and Edem, C. 2008). More than 2.4 billion people rely on burning wood for cooking, according to 2017 data from the UN's Food and Agriculture Organization (FAO). Up to 7% of global greenhouse gas emissions caused by humans come from the production and use of fuel-wood and charcoal. A big part of the problem is unsustainable forest management, which contributes to forest degradation and deforestation.

Globally, around 17% of all the wood used as fuel is converted to charcoal. Greenhouse gas emissions from inefficient and unsustainable uses of charcoal can be as high as 9kg carbon dioxide equivalent per 1kg charcoal produced. The World Bank estimates that close to three billion people in developing countries are still tied to using traditional sources of energy such as burning of biomass for cooking using traditional cook stoves. (World Bank Report, 2016.) A big part of this population is found in sub Saharan Africa.

Traditional cooking stoves (TCSs) are generally heat sourced by wood or biomass in the form of charcoal via wasting and not complete (unclean) burning processes. This translates to extra fuel needs and in users using excessively huge amounts of time to collect fuel or money to purchase it

(World Bank Report,2018). The continued use of the traditional energy sources has been found to have far reaching implications to the environment, the economy and the general health of the users. Similarly the easy access to traditional cooking energy sources such as wood, agricultural remains, dried dung and charcoal is declining. At the same time, commercial fuel is often too expensive and comes with negative impacts to the environment. To this effect therefore, the need for alternative energy sources like biogas that are less detrimental to the environment and the users becomes unquestionable (Surendra et al 2015).

In terms of production globally, a lot of biogas generation is done in the United States and Europe, although other regions are similarly increasingly deploying the technology as well. World biogas generation skyrocketed from 0.28 EJ in 2000 to 1.28 EJ in 2014, with a total global volume of fifty-nine billion metre cubed biogas (35 billion m^3 methane equivalent). In the countries that comprise the European Union, basic energy production from biogas production has gone up in the past ten years from just 167 PJ in 2005 to 654 PJ in 2015, with their biogas volume rising from 2.5 billion metre cubed in 2000, to 18 billion metre cubed methane equal in 2015, representing half of the of the entire world biogas production (World Bio-Energy Statistics 2016).

In terms of use, the countries forming the European Union are the world leaders in the usage of biogas as electricity, with more than 10 Gigawatts installed. In this region, biogas provided 127 TJ of heat and 61 TWh of electricity in 2015; about 50% of all the gas consumption in Europe was destined to heat generation. The region leads in the world in terms of producing bio methane which is used as vehicle fuel or for incorporation into the natural gas grid, with four hundred and fifty-

nine plants in 2015 producing 1.2 billion m^3 and three hundred and forty plants connecting into the gas grid, with a capacity of 1.5 million m^3. It is estimated that approximately six hundred and ninety-seven biomethane filling points ensured the use of one hundred and sixty million m^3 of bio-methane as fuel used for transportation purposes as of 2015 in Europe and America (World Bio-Energy Statistics 2016). For the African continent, it is estimated that close to seventy per cent of the continent's population does not have reliable electricity supply (World Bank, 2015). The World Bank posits that manufacturers in Sub-Saharan Africa face an average of fifty-six days shutdown per year due to power shortages. For a long time, the continent has heavily relied on fuel-based power generation technologies. These are the most expensive sources of power and contribute to emissions that lead in environmental pollution globally (World Bank, 2015).

For many East African countries, low-income households face a high energy burden, which is defined as the percentage of the overall amount of income a household spends on financing their energy needs[1]. As a result of this, the households settle on applying traditional energy means to satisfy their energy needs. Consequently, the households face a myriad of negative long-term side-effects on their health and general wellness. Such families are likely to get respiratory diseases and increased stress; they have to deal with increased economic hardship and difficulties in emancipating themselves from poverty[2]. It is out of concerns such as the ones stated above, a growing concern for carbon emissions, the need for sustainable development and climate change that has led to the development of opportunities in the renewable energy arena in the east Africa region and beyond (The Forum of Energy Ministers of Africa, 2012). Globally, research has

[1] (https://aceee.org/press/2016/04/report-energy-burden-low-income, n.d.)
[2] (Aerial Drehobl, https://aceee.org/press/2016/04/report-energy-burden-low-income, n.d.)

demonstrated that renewable energy technologies, if well harnessed and implemented, do not just lower the cost of energy for low income (Biswas W. K.,Lucas D. J. N., 2016) households but have similarly been proved to better indoor air quality, safety and comfort, and thus enhancing human health as well as ensuring that the environment is protected (Arthur, R., Baidoo, M.F., Antwi, E. 2011.).

1.1.2 Biogas in Kenya

Just like in many parts of Africa and the east African region, there is over reliance on biomass energy for cooking and heating in both the rural and urban areas of Kenya. There have been several promotional efforts by the government, development partners and private stakeholders since the 1980s to promote the uptake of biogas, but the spread of this technology has remained to be extremely low (FAO, 2018).

From a historical perspective, it is noted that the first biogas digester was built by Mr. Tim Hutchinson who used the energy produced in his coffee farm in 1957. 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 (FAO, 2018).

About 22,000 biogas plants have been installed in the country of which 20,000 rely on livestock manure and the rest from other wastes, including human waste. The initiatives have mostly been supported by the GIZ. Out of these, 90% of them are domestic; others are institutional while the rest are in flower farms. The biogas digesters in learning institutions are majorly for training on biogas technology. The government through the prison services has constructed 14 biogas plants

in various correctional institutions across the country. This has reduced wood fuel consumption by 30%.

Kenya Biogas Programme (funded by Dutch Government) is supporting expansion with Phase II targeting 26,500 biogas plants. 3 universities (Moi, Egerton and Nairobi) have signed an agreement with Italian Government and the government of Kenya to develop model dairy farms through which the excrete from the animals will be used to make biogas. Moi University will develop a centre of excellence for biogas production from dairy offshoots.

Recent studies show that a high proportion of the biogas digesters operate below capacity, are dormant or incomplete disuse after construction. Additionally there is still a very low reliance on biogas production from human waste.

1.2 Statement of the Research Problem

Innovative environment smart technology is bringing relatively affordable energy to the residents of Kibera slum in the form of biogas (Shimanyula James 2014). The technology converts human waste, obtained from communal toilets, into energy in the form of biogas. Consequently, practicing waste recovery and enhancing public health and sanitation of the residents.

The methane gas generated is either directly pumped into communal kitchens or packaged in 3 kg cylinders and sold to local residents as fuel at a cheaper cost compared to other sources of energy like charcoal (UN Habitat 2014). Calculation done by the implementers' estimates that a family of

six may spend Ksh.400 a month on the biogas. While the same family could spend Ksh. 3000 on Charcoal for the same period.[3]

Despite the fact that the bio centres are evenly distributed in many parts of the slum, the rate of uptake of the energy availed, though cheap, has been very low ((KENDBIP)., 2009). Many households are still inclined to the use of kerosene, charcoal and electricity for cooking and lighting. There is limited information to ascertain the reasons leading to this turn of events. Currently, a number of non-governmental organizations have put up biogas production programmes and projects which they aimed at providing, clean and affordable energy to the residents of the different villages of the larger Kibera slum.

Of importance to this study was establishing the concrete reasons as to why there is low uptake in biogas for cooking by the people of Kibera despite the fact that this source of energy is clean and relatively cheap compared to the other sources of energy available.

1.3 Research Questions

The main research question of this study was; what is the status of the uptake of biogas as a source of clean energy for cooking in Kibera?

1.3.1 Specific Questions

1. What are the socio-economic factors that determine the uptake of biogas as a source of clean energy for cooking by the residents of Kibera?

2. What is the level of awareness and perception of the residents of Kibera on the use of biogas as a source of clean cooking energy?

3. How are the National policies and legal frameworks promoting the production and use of biogas in the urban and peri-urban environments of the country?

1.3.2 Research objectives

The main objective of this study was to assess the uptake of biogas as a source of clean energy by low income households for cooking; with a focus on Kibera slum in Nairobi, Kenya.

1.3.3 Specific Objectives

i) To establish the socio-economic factors that determine the uptake of biogas by the residents of Kibera

ii) To establish the levels of awareness and perception on the use biogas by the residents of Kibera.

iii) To assess the National policies and legal frameworks on production, distribution and use of biogas in the urban and peri-urban environments of the country.

1.4 Justification of the study

The worldwide challenge of environmental protection calls for a modified, environment-focused energy system that will ensure that future generations' survival and needs for energy shall not be compromised. One of the best and surest ways of achieving this must be increased efforts to increase the production of energy from renewable energy sources such as biogas.

Getting of the “green energy” from biogas avails an environmentally friendly way of obtaining energy by reducing carbon iv oxide amounts produced to the environment. These clean energy sources help in combating environmental degradation and contribute to energy security, economic growth and jobs creation. While it is true that renewable energy sources too contribute to negative impacts on the environment, their effects are much less damaging compared to the impact of the oil and nuclear energy.

This study is therefore relevant to the Government, the academia and the general Public. To the governments (policy makers), it helps provide insights on what lacks in their biogas policy formulation process and provide actionable alternative sets of actions. To the academia they shall be informed of the gaps on what are the factors that influence the uptake of biogas as a source of clean energy as well as provide a focus for future studies on the same subject. Lastly the general public is better informed about the merits of adopting biogas as a source of clean energy and how best to market it out in the case that some would wish to take it up as a business venture.

Kibera was chosen as a case study, since for a long time, there have been efforts by non-governmental organisations to try and put up biogas centres for the locals to adapt the new energy source. Despite the heavy investments put in, the uptake of the gas produced from methane still remained to be very negligible and the biogas centres are shutting down.

CHAPTER TWO
LITREATURE REVIEW

2.0 Chapter Overview

This section provides an extensive analysis of literature that has been produced before in relation to the subject under study. The section gives a detailed explanation of the science involved in biogas production, provides an explanation as to why biogas is an important source of energy that will enhance sustainable development, looks into the national policies and legislative frameworks associated with biogas production in Kenya, provides an analysis of the theory used to advance this study as well providing the conceptual framework that explains the social, economic and environmental factors that contribute to the uptake or non-up-take of biogas in Kibera.

2.1 Biogas Production

Biogas is a mixture of various gases obtained by the breaking down of decomposing living matter in the absence of oxygen. The gas can be gotten from substrates such as, green wastes, agricultural refuse, municipal waste, manure, plant material and agricultural refuse (Obrecht, Matevz; Denac, Matjaz,, 2011). (Ho and Kangmin, 2006)assert that the first biogas digestion plant to generate the gas from wastes was realized in Bombay, India in the year 1859.

The production is done through an anaerobic (an oxygen absent) process. An anaerobic treatment process is a high three-step technology process that produces methane gas plus other products from the digestion of the green waste (R.Braun, 2007). The initial step is the chemical breakdown of lipids, cellulose, and protein. Extracellular enzymes produced by the inhabiting bacteria breakdown these macromolecules into smaller and more digestible forms. Secondly, these

molecules are decomposed into fatty acids such as propionic, acetic, and butyric acid (Juanga J. P, 2005). This decomposition is performed by several facultative and anaerobic bacteria such as clostridium, bifidobacterium, desulphovibrio, actinomyces, and staphylococcus. Finally, bacteria such as methanobacterium, methanobacillus, methanococcus, and methanosarcina digest these fatty acids, resulting in the formation of methane gas (Metcalf, 1991). The bacteria are referred to as methanogenic bacteria.

Generally, in the anaerobic digestion process, the stage where methane gas is produced is very slow and very sensitive. This is because it calls for specific environmental settings for the growth of the essential bacteria that digests the fatty acids which produce the methane gas (Balat M, 2009).The methanogenic bacteria (the essential bacteria) operate best under a limited temperature range, many a times it is in the moderate temperatures (32–40 degrees Celsius) - neither too hot nor too cold. Often this calls for an initial heating of the waste before being fed into the bio-digester (Zenebe Gebreegziabher et al., 2017).

2.2 Biogas as a source of sustainable energy

Achieving Sustainable Development Goal 7 (SDG7) is technically and economically feasible but requires strong and concerted policy action. Despite revolutionary advances in technology, more needs to be done. Challenges remain to increase the share of renewable energy in the global energy mix. Unsustainable patterns of energy production and consumption threaten not only human health and quality of life, but also deeply affect ecosystems and contribute to climate change. Sustainable energy, however, not only tackles these challenges head on, but is also an engine for poverty

reduction, social progress, equity, enhanced resilience, economic growth, and environmental sustainability.

Biogas cooking stoves are attractive in places with wood scarcity. They displace the use of wood or charcoal entirely, and they are particularly viable in agricultural locations due to the readily available feedstock. Cook stoves based on biogas and other sustainably produced renewable fuels can greatly improve health and welfare. Roughly 50 million biogas cook stoves have been installed worldwide, and the number is growing at about 10% annually (IRENA, 2014a). China leads the world in biogas digester installations for cooking, accounting for over half of all installations globally. African countries, specifically sub-Saharan countries, also would stand to benefit from their uptake.

For a very long time, the idea of biogas production has been focused on rural settings where mostly there has been overreliance on cow dung and agricultural wastes which are readily available for the biogas production. This trend however is now changing and currently, the technology of biogas production is being implemented using human excreta in urban and peri-urban set ups where there is a high population density. In these places, safe and hygienic disposal of human waste is increasingly becoming a problem. This has led to the provision of public toilets where one pays for use. For the case of Kibera, owing to its high population and absence of basic services like conventional sewerage systems, such toilets have been introduced and are helping solve the hygiene and sanitation problem that the area is widely known for ((Surendra, , 2014).

Similar initiatives have been introduced in other regions of the world such as Sulabh in India where over 6000 such toilet complexes have been constructed in market places and slums. Similar ventures have been introduced in Indonesia and Cameroon. All these places have one thing in common; they are in a densely populated area and there is the absence of conventional sewerage systems, (Kostof, 2009). The toilets are linked to bio digesters that convert the human wastes into methane gas which is sold to the locals for cooking.

Biogas cook stoves have positive environmental performance (Smith et. al, 2016), matched only by that of solar cook stoves (Kammila et al., 2014) and a comparable combustion efficiency and particulate emissions profile to liquefied petroleum gas (LPG) or ethanol (Berkeley Air Monitoring Group, 2012). Emissions otherwise resulting from biogas decay are foregone, thereby reducing the release of pollutants including black carbon, carbon monoxide and methane ((Grieshop et al., 2011). Biogas stoves avoid the use wood or charcoal, which often is unsustainably sourced.

Additionally, the production of biogas from human waste has helped enhance the sanitation of the targeted areas as well as enhanced resource recovery as this scheme ensures that nothing is wasted. In kibera for instance, as a result of the introduction of public toilets that are connected to bio digesters, the problem of 'flying toilets' has partly been dealt with. It should however be noted that while biogas from human excreta can be used as an alternative energy source, there are still a raft of taboos associated with it in many societies hence the need for continued education on the subject is important.

Biogas stoves reduce HAP and associated diseases as measured by averted disability-adjusted life years (aDALYs) (Smith et al., 2015). Each year, household air pollution (HAP) is estimated to cause 4 million deaths worldwide (World Health Organization , 2012). The health benefits are greatest for women and children who are present when cooking occurs. Other health benefits can be found with the reduction of volumes of rotting organic waste and associated pathogens, as this waste is used to produce biogas ((IRENA, 2016a).

For the case of Kibera, many people — many of them women and children — continue to suffer from indoor air pollution mostly caused by burning smoky fuels including wood, kerosene and charcoal. The Dirty cooking sources have caused respiratory and skin ailments, among other health problems, exacting what (Hamayun, 2016) called a 'crazy human cost.' Similarly, since biogas slurry does not attract flies or other vermin, the vectors for contagious diseases, for humans and animals alike, are reduced. Furthermore, eye infections and respiratory problems, attributable to soot and smoke from the burning of dried firewood, have been mitigated in Kibera.

Even though household biogas digesters have high upfront costs, in the range of USD 500 to USD 1 500 (Putti et al., 2015), they have one of the lowest annualised costs of all technology options for cooking in developing regions such as sub-Saharan Africa (Kammila et al., 2014), including both capital and operating costs. They also can improve the livelihoods of rural households by raising the productivity of agriculture through by-products of biogas production such as slurry and fertiliser. Biogas digesters greatly reduce the amount of time that women and children need to spend collecting wood, creating more time for women to work in productive enterprise and for children to study ((Kammila et al., 2014).

For Kibera, the gas produced has helped households save huge amounts of money that they would otherwise have spent on medical needs. The saved money is channelled into other sectors of the families such as paying school fees and purchase of food which in turn enhances their human development index.

2.3 Biogas Usage in Kenya

In the mid-fifties, first attempts were made to use biogas technology to gain energy from coffee pulp in Kenya. In the following 25 years, more than 100 plants of varying types were sold mainly to large-scale farmers by private entrepreneurs. After the energy crisis, interest in this technology boomed. A number of Indian floating-drum plants and Chinese fixed-dome plants were installed particularly for public institutions, like schools and other education centres by private organizations often with foreign support. However, not only did the technical quality leave much to be desired, but also the social and economic conditions were not taken into consideration during implementation of the plants. Therefore, the plants themselves soon were no longer filled and/or were out of operation due to technical problems (Ministry of Energy Kenya, 2018).

In the context of the Special Energy Programme (SEP) Kenya in 1983/4 several craftsmen were trained in the construction of biogas plants by German Cooperation (GIZ) short-term experts. They went on to build around 40 biogas plants in the Mount Meru region. However, it was soon evident that training craftsmen in the construction of plants alone was not sufficient to guarantee permanent function of the plants or the extension of dissemination into other regions. Lacking

quality assurance, no advice for the customer on how to operate the biogas plant and no dissemination strategy were the main short-comings. To alleviate this, a long-term expert was employed to provide advice in Kenya in 1985. Around 250 floating-drum plants were installed in various regions by the SEP in cooperation with the Ministry for Energy by 1988. Plastic tube digesters (PTD) were introduced in Kenya in the early 1990s. Their low price made them an attractive alternative to the masonry biogas digesters. After initial difficulties, the technology seemed to be on the way to maturity by the end of the 2010s (Ministry of Energy, 2017).

2.4 Barriers to deployment of biogas

Many countries have realised that biogas as a source of energy is an important component for sustainability transition. However, the total production volume of biogas is still relatively low. Such slow development raises a fundamental question—what are the current barriers hindering the wider uptake of biogas as a source of energy? In Kenya the production potential of domestic biogas has not been fully exploited despite the numerous merits discussed in this section. The deployment barriers related have established that range from technical, economic, market, institutional, socio-cultural, and environmental in scope.

Technical barriers are one of the main barriers to the deployment of biogas both globally and in the Kenyan context. In developed countries, this primarily affects the transport sector, i.e. limited access to refuelling stations. In Sweden, wide-spread implementation of biogas refuelling infrastructure is significantly more expensive than for liquid fuels. In India, a lack of training and education for householders—especially women—is an important barrier in relation to the

maintenance of digesters. Training in the use of digesters as well as their maintenance is important for ensuring efficient delivery of energy to households. It is considered to be a necessary means of informing users about biogas benefits, its correct operation, and the maintenance, limitations, and safety of biogas plants. Many authors outline frequent need for repair and lack of attention paid to maintenance of biogas plants as barriers to its uptake. In developing countries, inadequate expertise for the construction and maintenance of biogas plants create additional constraints to its use. As explained by Ghafoor et al., a lack of technical knowledge during installation and operation has led to failed biogas plants in many parts of the world especially in the developing world. For Kibera, the lack of trained artisans and skilled labour force to oversee the repair and maintenance of the bio gas centres has seen their collapse and subsequent closures.

Economic considerations play a major role in the choice of energy source. Biogas installations require high investment costs. The inadequacy of government incentives contributes to the low adoption rate of biogas technologies. In Bangladesh, some initiatives to promote community-based biogas are unable to gain traction because no financial support programmes exist. In the case of sub-Saharan Africa, installation costs for conventional biogas systems are unaffordable for many potential users because of insufficient credit schemes and other financial support. For many urban slums like Kibera, getting the initial cost of constructing bio centres is very high. This, for the case of Kibera has meant that not everybody in the slum can access the gas since some people live very far from the bio centres. The available bio centres have only been set up in a few select locations. Owing to this fact, the development of such ventures has been left to the non-governmental sectors that source for funds mostly abroad to build the centres.

In terms of market barriers, existing literature notes that lower prices of fossil fuels and a high price of biogas are critical market barriers. In kibera however, the reality is that while fossil fuels are not as cheap as the biogas provided by the proprietors, fossil fuels are readily available and thus the community relies on them heavily. On the institutional barriers front, the literature review found that governmental involvement remains essential. In many cases, there is little or lack of political support and specific programs to promote biogas technologies. The energy sector has not received significant attention in policy debates within developing countries. Kamp and Forn point out that an incomplete network of actors and the highly centralised and hierarchical nature of programmes hinder the contribution of the private sector. Bureaucratic issues are still need to overcome in order to receive financing for biogas enterprises. Too many formal requirements, complex administrative and legal procedures create difficulties and slow down the process of installing biogas plants.

Several authors defined a lack of private sector participation and poor coordination between the public and the private sectors as challenging factors to biogas uptake. This is an essential point because private sector plays a key role in promoting biogas energy to the market and making it commercially stable. For the case of Kibera, there has been no any form of government support in terms of finances or pushing for the adoption of biogas as a clean source of energy for cooking. For the available biogas plants they have been carried out by development partners.

From a social cultural view, this literature review established that a lack of public participation and consumer interest is the most critical socio-cultural barrier. For instance, in Ghana,

unfamiliarity with the technology is a barrier to biogas uptake. In Malaysia, social awareness and acceptance about the importance of waste segregation, and of green and sustainable development, is missing as Malaysians often prefer cheaper options.

Society specific factors, such as stigmatisation, have an impact on biogas dissemination. Some biogas projects failed because they were incompatible with local beliefs. Family-sized biogas plants are disregarded due to usage of dung for cooking. Local populations cannot accept the use of biogas because of their traditional beliefs, as it is produced from manure, dung, or some other kind of faecal matter. Gebreegziabher et al. point out that some religions in sub-Saharan Africa have very strict rules with respect to cleanliness, to a large extent in connection with humans but also with animal excrement. In Zambia, women could not collect cow dung as it was against their traditions. In Kenya, some households expressed doubts over the "cleanliness" of biogas coming from some types of waste. This could also lead to problems regarding the management of feedstock and slurry, as many users are not willing to do the daily dung mixing required, considering it a dirty job.

2.5 Biogas System Failures

Despite the many deployment barriers, the government of Kenya, the private sector and donors have been able to put up biogas systems in many parts of the country. Even with this efforts however, the systems have many a times failed. The failures have been attributed to, poor maintenance, poor dissemination strategy by promoters, poor planning and monitoring by promoters, poor construction or design leading to gas pressure problems, acceptance problems-recharging seen as dirt by some beneficiaries, and weak technical support.

In the event that these systems have failed, the users have always gone back to using firewood and other non-clean energy sources and hence are exposed to the many disadvantages that come with them.

2.7 The Kenya Energy Policy and legislative framework

The first attempt to prepare a policy paper on energy was made in 1987, to, among other things; mitigate the adverse effects of oil importation on the domestic economy and balance of payments. New challenges associated with liberalization of the economy in the 1990s, including deteriorating balance of payments, economic stagnation, rising population, rising poverty, electricity rationing and outages, dwindling official development assistance, deforestation and the recently observed phenomenon of climate change called for a new energy sector development strategy based on prudent integrated policies consistent with broader government policies on socio-economic development.

In keeping with the Government's Economic Recovery Strategy for Employment and Wealth Creation, the Session Paper No. 4 of 2004 on Energy was developed. The Energy Act 2006 has provisions for promotion of renewable energy, which includes biogas. However, the necessary legal and regulatory framework for biogas still needs to be put in place. Kenya climate Smart Agriculture Strategy (KCSAS) 2017 – 2026 recognises use of appropriate technologies like use biogas as a strategy to mitigate greenhouse gas emissions.

The policies and legislative frameworks are multi-pronged but it is aimed at coming up with a scenario upon which Renewable energy technologies (RETs) are obtained in a cost-effective, affordable and adequate quality. The policies recognize that the energy resources are a key driver to the success of government socio-economic development agenda[4] (Kenya Vision 2030, 2015). The policies similarly call for a wider uptake of renewable energy sources and technology and in turn enhance their role in Kenya's energy matrix (Policy, 2014). These include; the Constitution of Kenya 2010, the Environmental Policy of 2018, the Energy Act, Climate Change policy, Climate Change Act, Agricultural and Food policy, the forest act, Public health Act, and the respective sectors strategies.

This study intended to interrogate these policies and legislative frameworks to ascertain their synergy, overlaps, contradictions and gaps that may cause challenges in promoting biogas as a major source of energy in the densely populated peri urban areas.

2.8 Theoretical Framework

2.8.1 Diffusion of Innovation Theory

In this research, the Diffusion of Innovation theory by Rodgers E.M (1962) was employed. The theory seeks to explain how, with time, new innovation gains traction and spreads in a certain population/social system. The theory is in line with the thinking that adopting a technology, and in keeping with (Abukhzam & Lee, 2010), depends on numerous elements which purpose a targeted user to adopt or reject. They include; perceived usefulness and ease of use, facilitating conditions e.g. availability of government support and managerial support, technology readiness and social influence. (Davies, 1989) also argues that the successful implementation of any

innovation is primarily determined by the users' attitude. Policy and legislative framework have been found to be key and instrumental factors affecting users' attitude towards adoption or rejection of a particular technology.

The final result is normally that people that form this given social system take up the new innovation and begin to use it in their daily lives while leaving behind their old ways of doing the same activities. Rodgers posits that for any innovation to be adopted it must be perceived as something new. In the diffusion of innovation theory, it is presented that there are five categories of persons who determine the success or the failure of a given innovation. First it is the innovators. These are people that are venturesome and are attracted by new ideas. They are risks takers and are ready to put their skills and resources on the line to see a new innovation come to fruition. The second category is the early adopters; they most of the times represent the opinion leaders in a society. In the case of a new innovation, they are always informed on the need to change the way certain things are done and as such adopt the new ideas faster. They do not need much information in order to adopt a new innovation. Key strategies that can be used to attract such people in the case of a new innovation is the availing of user manuals and information sheets on implementation.

The third category of persons espoused by this theory is the early majority. These people are rarely leaders but they adopt new ideas faster compared to the average person. For this category of persons to take up a new innovation they need evidence that the innovation truly works. To appeal to such a population with a new innovation, one needs to present to them success stories and proof of the innovation's usefulness.

The other group of individuals that is identified by the theory is the Late Majority. These people are characteristically sceptical of change. They will only adopt a new innovation in the event that that it has been widely used and taken up by a wide majority in the social system. To appeal to such people, Rodgers posits that the innovators must provide them statistics of how many people are using the innovation already.

Finally, the last group of people that the school thought identifies are the laggards. Key features of such persons are that they are bound by traditions and are very conservative. They are the hardest lot to convince to take up a new idea/ innovation. Mechanisms to influence these populations include the use of statistics, fear appeals, and pressure from people in the other adopter groups. Given that different people adopt a new innovation differently, the proponents of this theory argue that for one to ensure that their new idea is taken up effectively there is need for them to understand the behaviours of their target populations before commencing presenting their innovation to them.

2.9 Conceptual Framework

This conceptual framework is based on the Diffusion of Innovation Theory. As advanced by (Rodgers, 2005)the uptake of a new innovation by a given population depends to a large extent on the behaviors of the target population (social and economic factors). For this case, the behavior of the people of Kibera towards biogas is influenced by the knowledge and level of awareness that they are availed with concerning the new innovation which for this case is the biogas technology.

The knowledge and perception of the people in turn influences the type of energy policies that the government puts in place. The knowledge and perception in turn influences the type of energy that they use. Similarly, the type of energy used somewhat depends the level of awareness that the people using it have towards it.

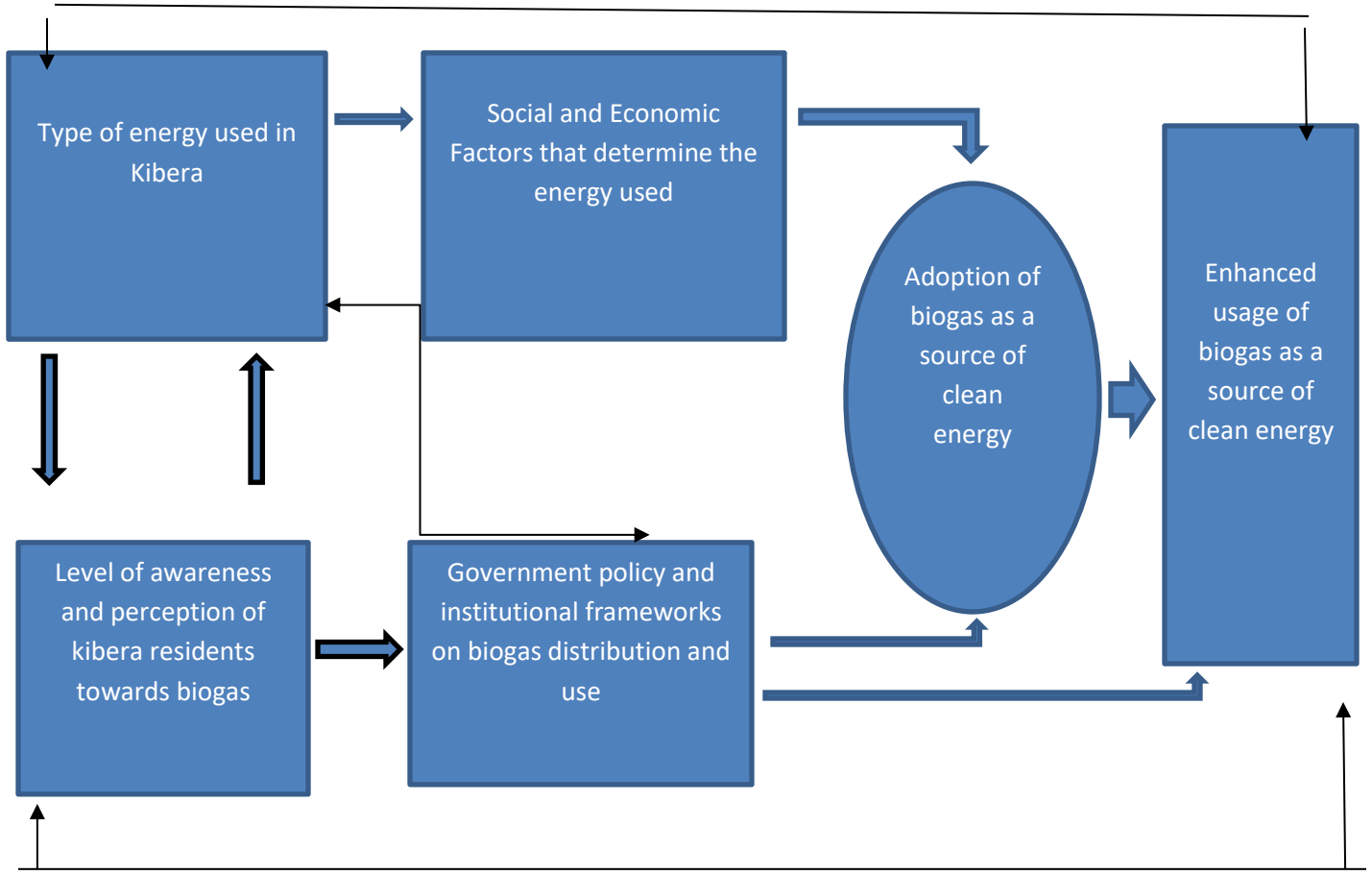

Figure 2.1 Conceptual Framework

Source: Author's construct

CHAPTER THREE
STUDY METHODOLOGY

3.0 Chapter Overview

This chapter presents the methodology that was used to conduct this study. It provides detailed information of the area where the study was undertaken where it analyses the socio-economic factors of the area. The chapter further goes ahead to discuss the approach that was employed in conducting the research, here it discusses all the methods that were used to collect the data and the data analysis process. The section further expounds on the ethical consideration that were considered in the conduct of the data collection process. The chapter closes by discussing the limitations that had been foreseen and how they were overcame.

3.1 Study Area

This research was conducted in Kibera. Kibera is found on the south west of Nairobi, the capital city of Kenya, approximately 6.6 km from the Central Business District (CBD) and covers an area of 550 acres (Bodewes 2005). The coordinates of the area are 1.3115° S, 36.7879° E. It is surrounded by the royal Nairobi golf club to the northeast Nairobi dam to the southeast, and Ngong forest to the southwest[5] It is subdivided into ten villages namely, Soweto East and west, Makina, Katwekera, Raila, Kisumu Ndogo, Laini Saba, Kambi Muru, Lindi, Siranga and Mashimoni. The villages have borders that are not clearly defined but mostly consist of natural boundary makers like paths, railway tracks with each village housing people from different ethnic backgrounds though each one has a dominant ethnic group. In addition to serving the people living in Kibera in the morning and in the evening when they are going to work, the single railway track is also

5 "Kibera to Nairobi". Google Maps. Google. 2017.

used as the main pedestrian and commercial path when then train is not in service (Rahbaran & Herz, 2014).

Kibera started in 1912 when the British government settled the Nubian soldiers who had been part of the King's African Rifles on an area that came to be known as Kibra meaning forest in the Nubian language (Bodewes, 2005). However, by the late 1950s large new ethnic groups of settlers started moving into area, the Nubians welcomed these new settlers and invested in the inflow of these new migrants by extending their houses and building new structures for their rental purposes. This resulted in growth and densification that lacked planning and infrastructure and set the stage for emergence of the slum structure (Rahbaran & Herz, 2014). The breakdown of Kibera people ethnic groups and their gender is Kikuyu: 7.9% (male), 6.4% (female); Kamba: 7.5% (male), 10.3% (female); Kisii: 6.4% (male), 2.2% (female); Luo: 34.9% (male), 35.4% (female); Luhya: 26.5% (male), 32.5% (female); Nubian: 11.6% (male), 9.1% (female); Other: 5.2% (male), 4.1% (female) (UN Habitat, 2017).

Kibera hosts people from different tribal and regional settings, with some areas of the slum settled by a majority of people from one ethnic composition. For instance, Laini Saba area is highly settled by people from the Kamba extraction. In spite of this, Kibera locals in most instances live as a family having tight social bonds. The main languages of communication are the national languages, namely Kiswahili and English. In areas where a majority of people from a particular ethnic extraction live, they speak their mother tongue. In addition to these main languages, 'slang language (sheng) has propped up as a more convenient language for communicating in the area.

In terms of population, the 2009 Kenya census placed Kibera's population at approximately 170,070 people; a finding that trashed previous reports that had indicated the area to be having a population ranging from between 500,000 to 1,000,000 people (Karanja, 2017). Other sources however hold that the population of Kibera is between 500,000 to one million people depending on which villages one is considering when defining the geographical location of Kibera (Emmanuel MUTISYA and Masaru YARIME, 2011). Recent population projections by the Kenya National Bureau of statistics have projected the area to have a population of three hundred thousand to three hundred and fifty thousand persons. For this study, Kibera is the region found in the valley below the railway line and the southern by pass.

Figure 3.1 Aerial view of Kibera

Source: House-hold survey July 2019

The social composition of the area mostly is made up of people that have rented houses (shacks) and owners of the structures who in most cases are absent from the slum. A few people that live here own the structures that they live in, this is mostly for the Nubian community. The structure owners are so referred to as they can only claim possession of the shacks or 'structures' that they have been able to build and rent out. They do not meet the criteria of being called landlords since

they do not have legal claim to the land their structures are built on. The people renting the structures make up the high number of the residents of the areas, they make 92 per cent of the entire population, while those that own their own houses constitute for a mere 5 per cent (Research International, 2015). The big percentage of people renting structures compared to people who own the structures makes Kibera slum not to qualify as a conventional squatter settlement as somebody may want to assume. In place of a squatter, the area is a rental business of some sort where people with some considerable amount of money in the area make huge income profits by leasing out structures that are in are not in good condition for human settlement (Neuwirth, 2005).

Part of the community members engage in well-structured saving plans where they give consented amount of cash for an agreed time frame with the sole purpose being getting sufficient finances for personal and other related development project. In most cases, it is mostly women that engage in such schemes. The saved finances are as well used to act as a group collateral to the members for them to get loans from small money lending organisations. Additionally, some of the people that stay in Kibera have formed welfare groups where they give money monthly to cater for expenses incurred by any of their members either through sickness, death or any other related calamities.

Women in this area can be part of ‘chama’ merry-go-round groups. In addition to being places for social engagement, chamas many times put together financial resources and distribute them to individual members in turns; say for instance on a weekly basis. The money gotten can be used as capital for starting small business ventures or to stand in for more urgent needs. These groups

ensure that social and economic safety nets to dwellers of Kibera who otherwise live without any form of structured social welfare have a fall-back.

The dire economic condition shown by low-income levels of the residents of Kibera slum has led to a 'residence work syndrome' (Jain, 2009). Many informal settlements have grown in areas where the inhabitants enjoy closeness to their places of work. With very minimal income that wouldn't guarantee conventional public transport means, they choose to live at walking distance from the places where they derive their livelihood. These areas are many times in close proximity to industrial areas, busy commercial spaces and 'poshy' living neighbourhoods. This is true for most of the locations of the slum settlements in Nairobi. The residents have close proximity to their places of work; this helps them save a lot on transport costs. For instance, Kibera slum in Nairobi is located along the capital's industrial belt and the expansive leafy suburbs of Langata from where the residents go to seek for menial sources of livelihood. Still, hundreds of other slum dwellers have to trek for miles to get to the areas where they get their daily bread. The phenomenon of residence work syndrome has had a big effect on the historical development of the city of Nairobi and consequently, on the structuring of slums like Kibera.

The most common way of earning a livelihood among the people living in Kibera is both formal and informal employment (Bodewes, 2015). It has been approximated that only a mere seventeen per cent of the people that live in Kibera are in formal employment (Syagga et al., 2012), with the remaining lot engaged in informal employment. Those that are formally employed are in the industries and offices found in the environs and beyond. Sections are given jobs in the construction

industries and others as domestic workers in the neighbouring rich palatial/residential estates. This has greatly contributed to the unending expansion of Kibera slum from all perspectives and sides.

Economic convenience appears to be the number one reason for many individuals to end up staying in Kibera: for most inhabitants, it is the only place in the city that they can afford (Bodewes, 2005). The tough and often unresolved difficulties faced by slum dwellers makes them to develop a survivalist way to urban living, the effects of which could spread to mainstream urbanity. One such survivalist approach to city poverty is the 'kadogo' economy phenomenon. 'Kadogo' is the Swahili word for small. This economy, which is synonymous amongst many Kenyan informal settlements, is featured by the repackaging and setting of new prices of primary commodities like food and water, and other edibles into small sizes that are in line with the paying ability of slum residents, whose small and erratic finances do not give possibility for bulky buying or one-off post-paid bills. It came with the repackaging of industrial consumables into small packs, usually by entrepreneurs within the informal settlements.

One of the leading factors for entrepreneurs in the kadogo economy way is the spread effect and overall profit margins that come with it. Marketing strategies have capitalised on this even for mainstream consumption where products and services are more readily available in their smaller repackages than in their bulky packages. The recent division of some large shops situated in the Nairobi city centre into tiny stalls is one such example. These business premises presented are cheaper spatial modules for small-scale traders who cannot rent conventional large space shops and the associated business overheads involved in engaging in commercial activities in the city's commercial district. The existence of mobile health clinics in the slums is yet another such perfect example, indicating the desire by health service practitioners and providers to enlarge their market

base area and take care of many people without having to have a centralized place where such services are offered.

While the kadogo economy idea works as a cheaper survival approach for the urban poor, some of its features could be seen as illegal—for example, the reconnection of power from the mains and redistributing among slum residents. Moreover, while providing the benefit of immediate affordability, the consumables packed in smaller quantities are not in essence less dear in the longer run, given the smal price mark-ups that come with the repackaging. There are also health and safety hazards linked with the opening of larger consumable consignments and packing them into smaller packages with the goal of enhancing their affordability. Packing of the goods into smaller packs of consumables and their opening up often takes place not within the official certification, verification and inspection of the relevant government agencies.

Kibera is widely known for its lack of essential services like clean water, toilets, power and health services. Ailments arising from poor hygiene are prevalent in the area as well increased numbers of persons affected by HIV (Gatabaki-Kamau, 2004). Most homes in Kibera have no piped water, pushing the residents to purchase their water from private vendors who charge expensively in comparison to what those residing outside the informal settlement pay for water. Many a times the water water is not well stored or treated, leading to a widespread of contaminated water related diseases (Shofco, 2017).

Housing structures in Kibera are squeezed, don’t provide sufficient protection, not linked to essential infrastructure like accessible roads and generally, they are in unhealthy living conditions.

Many households live in a one house structure, each measuring less than 9 square meters on average (UN Habitat, 2017). They are made of weak material, consisting of mud and wattle with corrugated iron sheet roofs. The single houses are used for various of functions which include; sleeping, cooking, socializing, leisure living, and, in some instances, home-based businesses. There is no space specialization as a various of activities are carried out at the same time within the same available space.

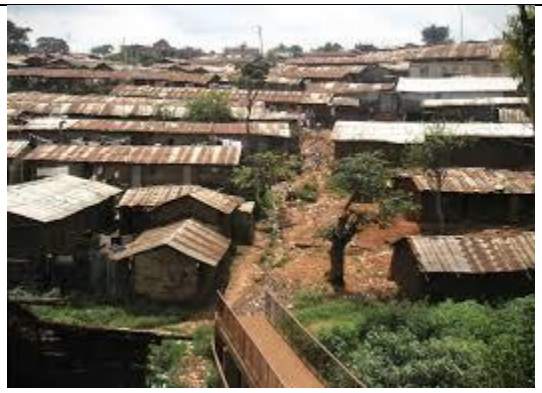

Figure 3.3: Houses in Kibera

Source Household survey, 2019

Many houses have only one entrance and one ventilation in the name of a window, these limits both light and ventilation. The poor ventilation is made worse by the dirty fuels that are used for lighting and cooking. Due to the absence of grid power connections in some houses, most residents depend on paraffin tin lamps (nyangile) for lighting. The main source of fuel is charcoal, while firewood and kerosene stoves are as well used for cooking. All these produce a lot of carbon iv oxide and leads to the pollution of the environment and impacts negatively on the health of the inhabitants. The open flames of the stoves also lead to fire outbreaks in the slum. The room occupancy patterns vary depending on a number of factors. On average, a household comprising

of a man, woman and four kids would reside a single room. For bigger household units and where relatively cheaper, a close room is rented for the older children. In such a case, the two rooms can be accessed separately and are not connected from inside. This is meant to enhance privacy. In other situations, the extra room hosts several single young males that cost-share the rent. The number of men housed by the single room could rise to six or eight. These structure inhabitance patterns show both lack of space and unguaranteed personal space. Most of the structures are used mostly at night as many inhabitants are at work during the day and the children are at schools that provide meals hence no need of coming back home.

In terms of outdoor space in the settlement, there is no any formal order and is not regulated by any pre-established planning layout. The housing structures are densely placed with no regard for open spaces. It has been approximated that there are two hundred and fifty housing structures in one hectare of the greater Kibera slum in comparison to twenty-five houses per hectare in middle-class estates and ten units per hectare in high-income areas (UN Habitat, 2017). The spaces for moving around are constricted alleys which as well serve as spaces where people meet for any forms of gathering. The same narrow spaces are used for services installation.

New tenants mainly access these houses through informal means, usually relying on acquaintances with knowledge of vacant rooms. Recently, however, some quasi-real-estate agencies with physical addresses in the settlement have emerged to identify vacant houses for would-be tenants at a fee. Outdoor space use in the settlement lacks any easily recognizable formal order and is not guided by any pre-established planning layout. The housing structures are densely arranged at the

expense of open space. It has been estimated that there are 250 housing units per hectare in Kibera, compared to 25 housing units per hectare in middle-class estates and 10 units per hectare in high-income areas. The spaces for circulation are narrow alleys that also function as social spaces and are used for services installation.

Environmentally, Kibera is highly polluted by human waste, garbage, dust and other varieties of wastes. Some places are polluted by human and animal excrement due to the existence of open sewers. This in most cases is along the railway tracks where people practice open defecation at night. Non-governmental organizations dealing with matters health and nutrition have developed activities that aim at enhancing public health in the area; a case in point is the Umande Trust that has constructed communal toilets for the residents. From the toilets, the NGO employs technology to convert the human waste into biogas that is pumped into communal kitchens and sold to the locals (Shimanyula, 2014).

For this study, the researcher focused on Sarangombe and Lindi wards where biogas plants have been put up by Umande Trust. The populations of the two villages are 9678 and 8253 people respectively. The figure below shows the map of Nairobi. From the map of Nairobi, the map of Kibera with the respective villages is show as below.

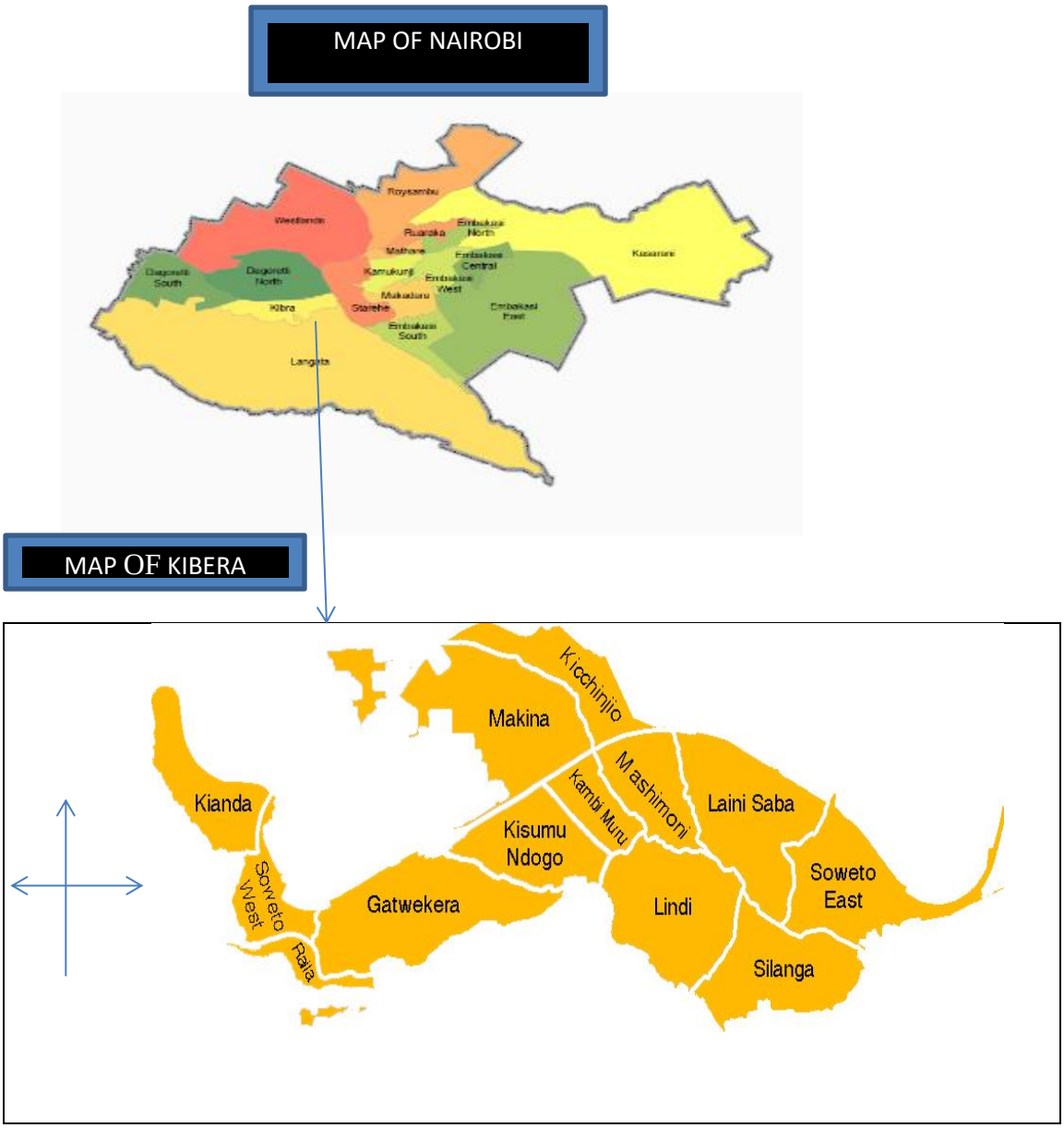

Figure 3.4: Map of Africa, Nairobi and Kibera

Source: Internet sources

3.2 Study Approach

This was a cross sectional study that aimed at obtaining both qualitative and quantitative data. Data collection methods entailed the use of literature review, household survey, key informant interviews, focus group discussions and direct purposive observation. These instruments were developed on the basis of the research objective and reviews of literature related to the adoption of technology which were pretested before the actual field survey. For ease of understanding, the

questionnaires and interviews were conducted in English, Kiswahili and/or sheng. Relevant information for this study was gathered from unpublished and published research which elicited the secondary data.

These methods and the steps undertaken are discussed in the subsequent sections below in details. These instruments were developed on the basis of the research objective and reviews of literature related to the adoption of technology which were pretested before the actual field survey. For ease of understanding, the questionnaires and interviews were conducted in English, Kiswahili and/or sheng. Relevant information for this study were gathered from unpublished and published research which elicited the secondary data.

3.2.1Literature Review

Literature review helped to show that the investigator had read related body of information and is acquainted with the key information and proceeding arguments on the subject. In this research, the literature review served to give a theoretical and intellectual background to the study and provided a logical framework for the research. As Mouton (2001) argues, literature review in this study was useful in helping the researcher to avert repetition of already existing information. The literature review highlighted in this research helped to provide direction of the research towards coming up with the research questions regarding the uptake of biogas by low income households in urban slums.

3.2.2 Household survey

To obtain quantitative data, the study used household surveys where the target was the household heads in the villages that were targeted in the study. The households were randomly selected and visited by the researchers based on the sampling frame described in section 3.3. For households that did not understand the English language, the researcher in collaboration with the assistants translated the questions to the would-be respondents. In the event that the household head was missing, any person above 18 years old was interviewed on behalf of the household head.

The study used three research assistants who were trained and a pilot study undertaken during the training. Thereafter, they were supervised by the principal researcher in conducting the actual research. The questionnaires were researcher administered and validated by the principal researcher for quality assurance.

3.2.3 Key Informant Questionnaires

As argued by Flick (1998), certain open-ended questions must be used in the interview situation as a form of interview guide. The semi-structured interviews were administered to key persons in Kibera with the aim of eliciting required information. This study conducted a total of twelve key informant interviews to come up with most of the information needed for the study. The key informants were from: Government of Kenya Officials from the ministries, state departments, and government agencies; these included in relevant of Energy, Public Health and sanitation, Environment and interior and coordination (Kibera local administration). In addition to the government officials, the researcher interviewed development partners, Civil Society Organizations, Community Based organizations and private organizations dealing with matters related to biogas promotion, production, distribution and usage. These interviews helped to provide

information regarding both the effectiveness and sustainability aspects of the biogas as a source of cooking energy as already implemented by different stakeholders in the area of the study.

For the key informants, the researcher booked an appointment with the key persons that they intended to interview. This was done through friends and acquaintances that worked with these people. One of the key informant interviews during this study was conducted via the phone since the key informant was not in office when the research went to interview them. Questions concerning the subject of study were presented to the informants. This led to in-depth discussions around the subject. The research deduced from the discussions only the parts that he felt was important to the study.

3.2.4 Focus Group Discussion

Focus group discussions came in handy in terms of paying attention to particular subject. Morgan (1997) asserts that focus group discussions give the chance to see a big amount of interaction on a given subject in a short time. It helped provide direct evidence about similarities and differences in the participants 'opinions and experiences as opposed to reaching such conclusions from post hoc analyses of separate statements from each interviewee.

For this research, six focus group discussions were conducted with local administrators in the area including chiefs being grouped together with civil society organizations representatives, a group consisting of youths ranging from 16-25. The reason for this age group was because in Kibera children especially boys moved out of their parents houses ones they attained the puberty age. The other group consisted of women aged between 26-35. Similarly, there was another group that comprised women above 35 years. Men aged 26 and above similarly had their own focus group

and the last group comprised men and women who had been employed to be the sales people of the gas.

Questions focused on matters associated with biogas production, distribution and usage.

On the day of the focus group discussion, the researcher introduced himself and his team to the discussants and explained to them why he had invited them for the discussion. After getting consent from the gathered discussants, he went ahead to explain that he aimed to assess the uptake of biogas and hoped to learn things that the government and the biogas proprietors can learn from your views and better the delivery of the gas. He assured the gathered discussants that the information they would give would be completely confidential, and we will not associate any names with anything said in the focus group discussions. He also reminded the participants that they should ensure their own confidentiality too in the sense that after the discussions were over, no information discussed should be shared outside with anyone and especially, they should not associate names to the topics discussed no matter how wrong or right one many feel a particular discussant was. The researcher similarly informed the participants that in the event that one would feel uncomfortable with the discussions, they were free to walk out and no one would question their actions. The room to ask questions was given to the discussants.

The research then sought to know if any one among the discussants had participated in a focus group discussion before. All the discussants present indicated that they had not done that before. The research thus explained to the discussants that focus group discussions were being used more to conduct research by both the state and non-state actors. He noted that FGDs were gaining prominence because from them, the researcher learns from the discussants both positive and negative aspects about a given subject. He also noted that through focus group discussions, the

aim is to gather as much information as possible concerning a particular subject, in this case biogas adoption and not reaching a consensus. The aim is not to look for what is right but to understand the main priorities of the people.

He explained to the discussants that for this particular research, they were doing both questionnaires and focus group discussions. The reason for using both of these tools is that we can get more in-depth information from a smaller group of people in each focus group. This allows us to understand the context behind the answers given in the written survey and helps us explore topics in more detail than we can do in a written survey.

The researcher then explained the logistical component of the focus group discussion. He noted that the focus group will last for utmost one hour and thirty minutes. The discussants were encouraged to be free and reminded on the need to maintain confidentiality especially after the discussions were over.

The research with the discussants then set the rules of engagement during each select session. It was highlighted that everyone should participate as no one had a monopoly of knowledge. Discussants in each focus group were asked to turn off their cell phones or put on silent mode. They were reminded to focus on their groups and to avoid the temptation of engaging in side discussions. Lastly, the researcher asked the discussants to have fun in the process. After the rules everyone in the focus groups introduced themselves as they signed an attendance sheet (attached in the appendix section).

The discussions then began with lead researcher, asking questions. He gave people time to think before answering the questions. After the researcher was satisfied with the responses that were provided, he proceeded to the next question. This was mostly the case he began hearing repetitive responses to the question asked.

To probe the discussions and keep it lively, the researcher touched on the salary of the discussants, the benefits/demerits the respondents derived from the biogas provided, he probed the discussants cultural beliefs related to human waste and food. He similarly probed the distances the discussants lived from the nearest biogas outlet station. After all the questions were discussed conclusively, the researcher thanked all the people that had participated in the discussion for sharing their thoughts and ideas. The discussants then dispersed.

3.2.5 Direct Purposive Observation

In this study, direct observation was used to gather data related to the construction of the biogas centres, the channelling from the toilets to the bio digesters and the kitchens where community members cook. The researcher took pictures of the structures. A proprietor of the biogas centre took the researcher around showing him all the structures and the designs that were used to construct the building.

3.3 Study Design and Sample Size for the household survey

This was a cross sectional study focusing on the population of kibera living in the villages where the technology was introduced (Katwekera and Lindi). According to Alreck and Settle, 1995, it is necessary to sample more that 10% of the population so long as the resultant sample is not less than 30 and not more than 1000 units. For a population size of 1000, 5000 and 10,000 a sample size of 100, between 100 to 500 and 200 to 1000 is appropriate respectively. The populations of

the two villages are 9678 and 8253 people respectively. Hence, total population was 17,931. The sample size for the respondents was determined as shown below using the given equation;

$$\textbf{Sample} = \frac{z^2 pqN}{e^2 (N-1) + z^2 pq}$$

Whereby,

N= Population size

p = Proportion in the target population (96%) estimated to have the required information.

q = **1-p**

e = Estimated error (0.05) of **+ or - 0.05**

z =Standard normal deviate (1.96) at the required confidence level (Kothari, 2004)

Total number of respondents is thus:

$$\frac{1.96^{\wedge 2} \times 0.96 \times (1-0.96) \times 17931}{0.05^{\wedge 2}(17931-1) + 1.96^{\wedge 2} \times 0.96 \times (1-0.96)}$$

=**572 households**

To determine the type of energy used in Kibera, household heads formed the target population. Respondents were sampled through random sampling. The sample size therefore comprised of 572 respondents. During a pre-visit survey, the researcher with the help of biogas proprietor agents in the area aided in identifying bio-centres in the target locations. The number of respondents was evenly distributed in the two villages under study.

3.4 Data Collection procedures

Both primary and secondary data were useful for the research. Primary data was collected through questionnaires and interviews with household heads while secondary data was synthesized from existing literature relevant to the study.

To assess the factors influencing adoption of biogas technology, a research survey was carried out Household survey, focus group discussions and Key informant interviews were used to collect field data. The researcher carried out four focus group discussions in two centres; Sarangombe and Lindi wards. Each focus group discussion consisted of 6-8 members. The participants were guided by the researcher who was the moderator by introducing topics for discussion. Results were taken down in summary form that reflected participants' opinions evenly and fairly.

Figure 3.5: Focus Group on going in Katwekera

Source: Survey July 2019

3.5 Data Entry and Analysis

Data entry was done using open data kit (ODK) tool. Later the data was imported to Microsoft Excel for analysis. Statistical Package for Social Scientist (SPSS), MS Excel and STATA were used for data analysis such as descriptive statistics analysis focusing on trend analysis, frequency distribution, percentages and means. Also, inferential statistics such as multiple regression analysis was used to infer the numerical relationship between independent variables and the dependent variable of the study.

3.6 Ethical Considerations

Before a researcher settles on a specific research design, he/she needs to consider a fundamental issue relating to the ethical considerations related to that particular research. Mugenda and Mugenda note that in the case of ethical issues awareness will protect the integrity of the researcher and also ensure honest results. On their part, Kombo and Tromp argue that because more often than not researchers use people or animals who may suffer pain and distress in the process, attention must be given to ethical issues.

The key ethical principles that this research considered included voluntary participation, informed consent, risk of harm and confidentiality. The principle of voluntary participation requires that people are not coerced into participating in research. Therefore, participation in this research by the respondents was on voluntary basis. Closely related to the notion of voluntary participation is the requirement of informed consent. This required that prospective research participants were fully informed about the objectives of the research and were then requested to give their consent to participate.

Similarly, ethical standards also require the researcher not to put participants in a situation where they might be at risk of harm both physically and psychologically. This research was thus designed to guarantee participants confidentiality -- they were assured that identifying information was not be made available to anyone who was not directly involved in the study. Moreover, while presenting findings of this study, the researcher abided by the principle of anonymity by not refereeing to the respondents by their names.

3.7 Study Limitations

This study had foreseen a scenario where a number of such respondents may not be comfortable discussing honestly some issues concerning their households without being paid as in many instances; researchers give a token of appreciation to respondents in Kibera. This posed a big challenge during the data collection phase as some potential respondents declined to be part of the exercise. Nonetheless, the researcher enlisted research assistants that were well known in the target locations to help in the data collection process. The enlisted research assistants were trained on how to be persuasive and convincing enough. They were able to clearly explain to the respondents the reason of the research and the significance it might have if policy recommendations that would be recommended in the study could be taken up and implemented.

Another key limitation of the study was that it was primarily premised in Kibera. To avoid the temptation of biasness and generalization of issues, the researcher conducted extensive literature review of existing writings about the subject in other areas that would somewhat have similar characteristics of the area of study. This ensured that all conclusions derived were compared and not just based on Kibera. Case studies of areas with similar features like Kibera were analyzed from India, Indonesia and Cameroon.

CHAPTER FOUR
RESULTS AND DISCUSIONS

4.0 Overview

This chapter presents the findings of the study based on both secondary and primary data collected. The primary and secondary data collected outlines the main findings on the on the uptake of biogas as a source of clean energy by low income households in urban informal settlements. The chapter further presents the socio-economic factors that determine the energy used by the residents of Kibera, the levels of awareness and perception on the use biogas by the residents of Kibera, as well as the Kenyan Government policy and institutional framework on production, distribution and use of biogas in the urban and peri urban environments of the country.

4.1 Social demographics of the Respondents

Social-economic and demographic information of respondents was enquired. These characteristics included information on gender, age, education, income, and distance from bio centre per household and household size. These features were then analysed to study whether they had significance influence on biogas technology adoption. In this study it had been hypothesized that social-economic factors at the household level significantly influenced rapid adoption of biogas technology.

In the study, 572 respondents were interviewed. 70% of the respondents were female while 30% were male. a majority of the household heads were between 18-35 years, followed by 35-55 years, 0-18 years and the lowest number of respondents were those households whose heads were over 55 years. This study similarly assessed the education level of the respondents in each household. 40% had the primary level education, 30% had attained secondary level of education, 24% had

reached the tertiary level while 6% had not attained any level of education. In terms of household size, a majority were between 1-3 members, followed by 3 to 5 members respectively. See table 1 below

Item	Characteristic	Percentage (%)
Gender	**Male**	**30%**
	Female	**70%**
Education level	**None**	**6%**
	Primary	**40%**
	Secondary	**30%**
	Tertiary	**24%**
Age in years	**0-18**	**14%**
	18-35	**52%**
	35-55	**27%**
	Over 55	**7%**
Household size	**1-3 members**	**40%**
	3-5 members	**31%**
	Over 5 members	**29%**

Table 1: Social demographic characteristics of the respondents Source: Household Survey, July 2019

Gender

The higher percentage in female respondents in this study is because of the gendered dimension associated with cooking. While the male figure was considered the head of the house, on matters concerning cooking, the female was the one responsible. There was a clear division of responsibilities amongst the genders in the households surveyed. Women were responsible for the

general welfare of the families. This included cooking and thus having the responsibility over the source of energy used to cook.

Education Level

The reason for a high number of attainments of primary education (40%) is due to the fact that for a long time due to gender reasons, the girl child was only limited to getting the basic education in the family. As such after taking of the primary school national exams many parents preferred taking their boys to high-school while the girl child was not taken. Where the girl child was taken to high-school, most of the time it was in day schools in the slum and a majority would not complete their studies due to early pregnancies. After one gave birth, many opted to be married. 55% of the respondents that had attained secondary and post-secondary education were of the male gender. This finding is in line with the Uweza Foundation reports that have over the years stated that the boy child has been favoured in terms of educational access compared to the girl child.

Age

For this study, owing to the nature of the houses of Kibera where many families live in one room made of iron sheets, mud and sticks, once children reach adolescent age, most parents prefer renting a separate room for their children more so boys. This explains why in this study there were respondents in the age category of 0-18 years old. In such houses, they occupants normally eat in their parents' houses but have some energy source to cook light foods like tea.

The large percentage of the people that respondent to the survey can be termed as youthful, between 18-35 years old. This is because, locally, the settlement is referred to as a 'bus stop' since

many people arriving from the countryside tend to stay there briefly as they look for work opportunities and identify other settlement areas (Bodewes, 2005). The transient nature of the population is further evident in the internal relocation of people within the settlement. Using data sets from the monitoring of cell phone traffic, it was established that 50 per cent of the population migrates every month to other parts of Kibera or elsewhere (Wesolowski & Eagle, 2010). Given the extremely high levels of population movement within and out of the settlement, it has been suggested that Kibera acts more as a filter than a sink, implying that it is merely a holding ground for people awaiting entry into the formal sector and middle-class neighbourhoods rather than a place where people settle permanently. As such, it provides a transitional phase (Wesolowski & Eagle, 2010). Most people living in Kibera maintain strong links to their places of origin in the countryside, often making occasional trips to visit their families (Bodewes, 2005).

Household Size

While for many writings it has been assumed that poor people tend to have many children, it was established that for many households in Kibera, a majority was between 1-3 members. These smaller number of households' members was associated with the high living costs in the city hence many people preferred being less so as to make ends meet. Majority of the residents in Kibera have left their families in the countryside to fend for them in the city. The high cost associated with maintaining families in the settlement is prohibitive and unaffordable. By implication, the residents tend to relocate their earnings to the countryside where they invest in anticipation of retiring there later. This transitory status and the consequent absence of a sense of belonging have had an impact on the current state of the built environment. There is a tendency among residents to remain indifferent even to basic environmental shortcomings that could possibly be addressed given the

will. For instance, the handling of solid waste could be greatly improved if all the residents were to view Kibera as their long-term settlement. Other than for the financial considerations, some residents choose to reside in Kibera for social convenience. The perception is that the society there is more receptive and accommodating.

4.1.1 Level of income of respondents and Energy Preference

The levels of income of the households were surveyed. A number (138) earned between 10,000 to 20,000, followed by (103) who earned below 10,000, then 78 who earned above 20,000 but not exceeding 30,000. Only 34, out of the total 572 respondents earned above 30,000 Kenya shillings.

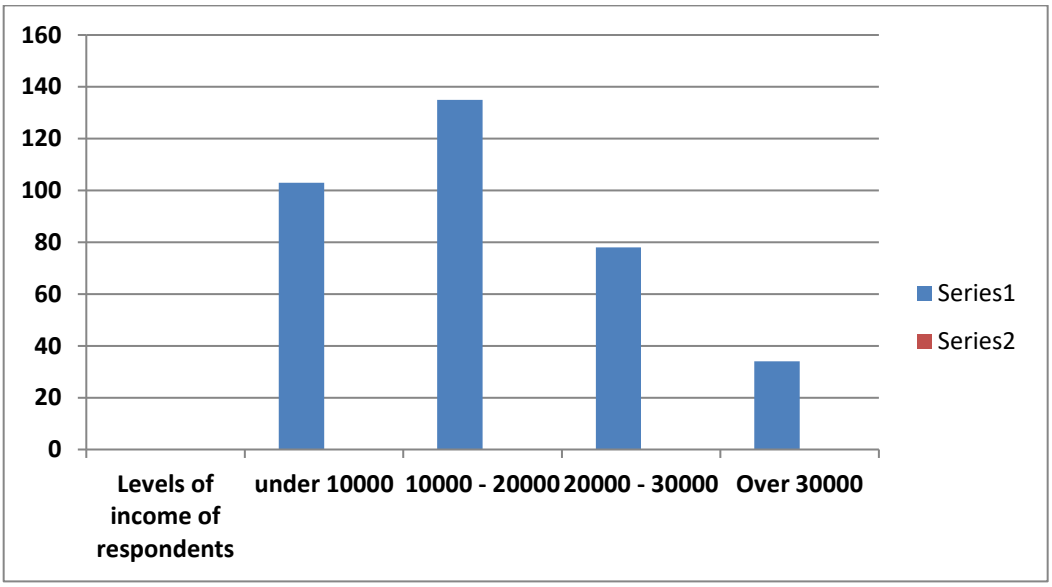

Figure 1.1: Level of income of respondents

Source: Household survey July 2019

36% of the respondents in this study preferred charcoal as the first option energy source for cooking followed by LPG (30%), kerosene (27%), electricity (7%). No respondent indicated that biogas was their first option energy source for cooking. Most of the respondents who indicated

that they preferred charcoal as their first were of those households that were over 3-5 and above members. This was mostly the case where they had children in the family.

Those families who indicated that they preferred kerosene on the other hand were similarly of the same household size and earned below Kenya shillings 10,000 in a month. They mostly only cooked ones, at night. During the day, most of the times the household members would either be at school or at work. Kerosene was similarly preferred because of its convenience and ease to use. For those that mentioned that LPG was their first choice, a majority of them had attained post-secondary education. Most were not having families but they would be staying with their friends where they cost shared the bills of the house.

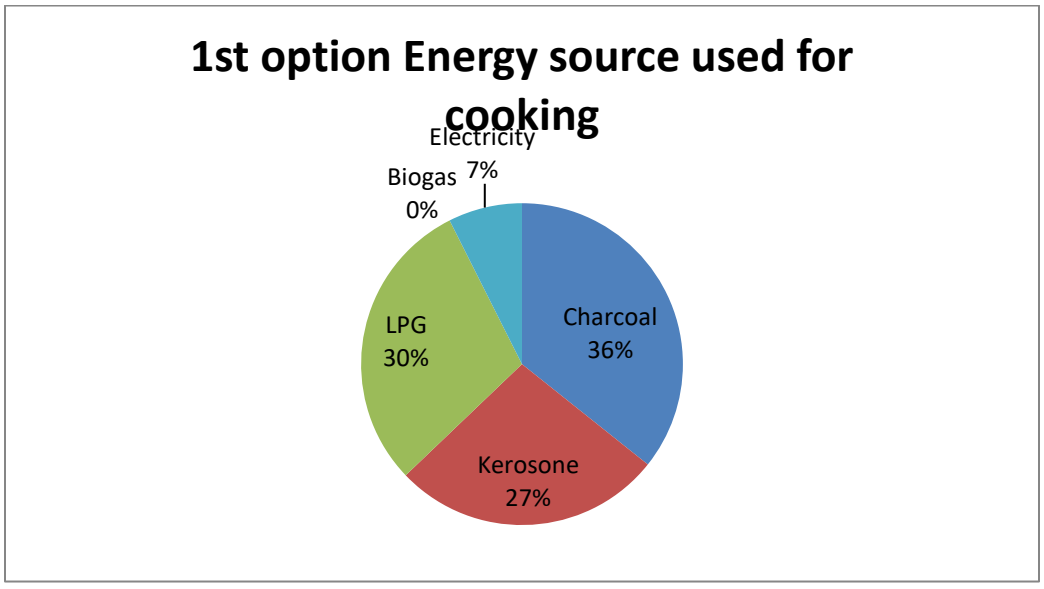

Figure 4.2: Energy source preference

Source: Household survey July 2019

Majority of the respondents (54%) spent approximately 2000-4000 for their energy needs per month. 34% spent approximately Kenya shillings 2000 while 12% spent below Kenya shillings 2000. The majority who spent between 2000-4000 had children and the reason for this amount was that they cook multiple times hence the need for more energy source. Similarly, charcoal was their first option choice energy source. Those spending 2000 were mainly those in the category of 18 and below years. In such households, there were minimal cooking activities and the first option energy source was LPG.

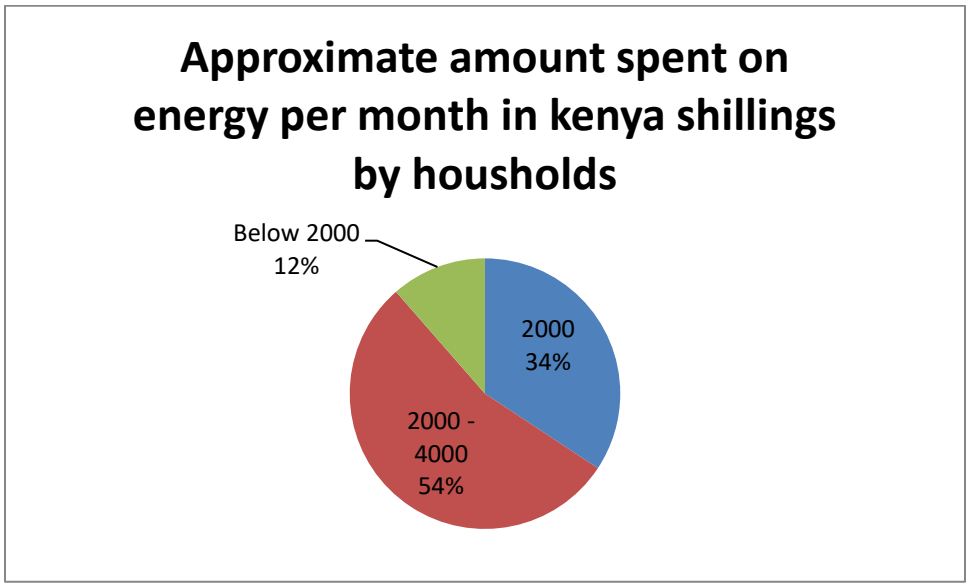

Figure 10: Amounts spent on energy respondents
Source: Household survey July 20194.1.2 Descriptive Analysis

4.1.2 Energy used for cooking in Kibera

This study established that in Kibera, various energy sources are used for cooking. In all the households that this study assessed, it emerged that at least two energy sources were being used for cooking. The type of energy used by different people varies greatly. This variance, the study

established, is determined by numerous factors that range from the age, gender, monthly income, level of education of the household head as well as the size of the household.

The energy mix that was found to be predominant in the entire households surveyed consisted of charcoal, kerosene and LPG. Kerosene has been greatly replaced by the LPG. This, the study found that is because LPG is easily available and relatively cheap. A six-kilogram gas cylinder of LPG goes for utmost one thousand Kenya shillings. Local vendors of the LPG are however availing the gas at even cheaper rates that are in the range of seven hundred to nine hundred Kenya shillings. The quality of the gas availed however is doubted by many.

Charcoal is still predominantly being used by households that are relatively big. Households with three to five members prefer using charcoal in their energy mix. This especially, is used in cooking large amounts of food or hard foods like githeri (mixture of maize and beans). The reason for the usage of charcoal and not LPG to cook such foods is because they take long to cook and hence end up using a lot of the gas. The charcoal prices, the study established, have been increasing over the years. This study found that in 2008, the price of one can of charcoal (the 2-kilo gram can used to pack cooking fat) went for fifteen Kenya shillings while the price for the same amount of charcoal is between sixty to eighty in 2019. The continued call by the government to protect forests as well as the burn by the national government on logging has contributed heavily to the sky rocketing of the charcoal prices.

From the focus group conducted in Lindi, the below was said by one of the discussants:

"…I don't think any one here can confidently say that they rely purely one energy source for cooking. We mix many times the energy sources. The food one is cooking determines the energy source that one is using. Also, the time when one is cooking will determine what source you will use. Consider for instance you have just woken up in the morning and you want to go to work, there will be possibility for you to start lighting the jiko to prepare tea, in such instances, we mostly run to our kerosene stoves that are easy to use and boils water very fast. Another example is when you have children in the house and you give them the responsibility to cook. You don't give children the chance to cook on LPG cylinders. This is because due to their playful nature, they might not be on the lookout of when the food is already cooked and hence end up wasting most of the gas which translates to huge losses…"

FGD discussant from Lindi ward

4.1.3 Biogas production in kibera

The deplorable sanitation systems that many thousands of people living in the Nairobi slum of Kibera, often called Africa's biggest slum, has been well-documented (Bowdes, 2016). Less discussed is the problem of family energy for the residents. Non-governmental organizations have come in the slum to try and alleviate the residents of Kibera from this scourge. Examples of initiatives by non-governmental organizations for this course is the Tosha Bio Centre found in Katwekera and run by the Umande Trust, a non-governmental entity supplying energy from human excreta in the form of biogas. It is a place for clean energy generation, a place for people to hold meetings in and an income generating venture for its operators.

The Trust began by building toilets and private places where people could shower, while at the same time harboring a bigger vision: TOSHA, "Total Sanitation and Hygiene Access", was unveiled. The center boosts private toilets and bathrooms on the ground floor – the flushable toilets are linked to a bio-digester using large pipes, with a dome-shaped holding tank where biogas is generated. Raw human excreta from the toilets flows in the tank, and bacteria acts on it leading to a breakdown that releases methane gas which collects at the top of the domed tank. The gas is piped to collective stoves one the first floor of the building - and is normally enough for community members to cook on the entire day. They are charged a small fixed amount (20 Kenya shillings) for using the stoves.

The pictorial below captures the biogas plant construction to the final stage when the gas is produced and used for cooking.

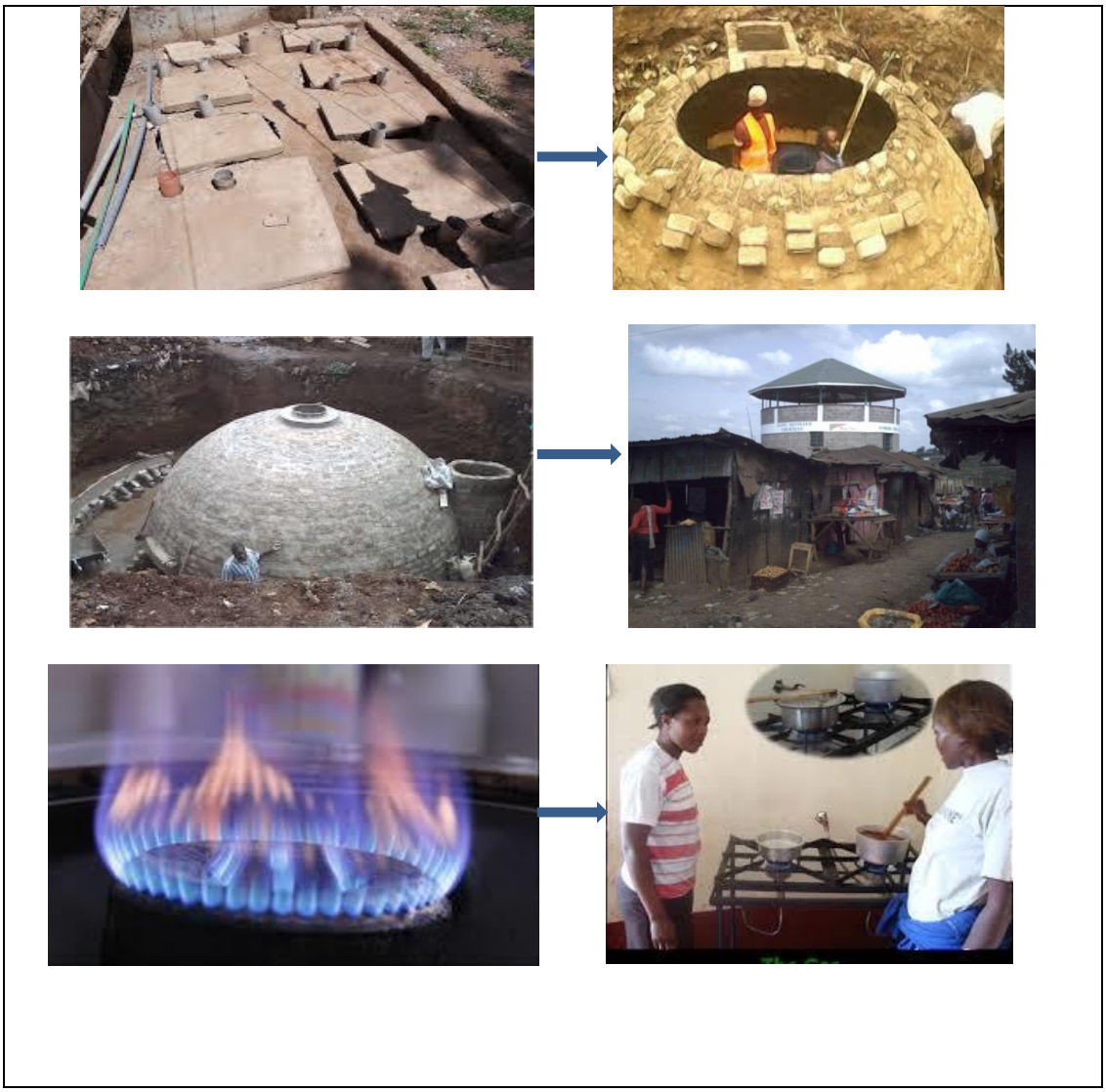

Fig 11: Pictorial of Umande Biogas production

4.5 Socio-Economic factors that determine the energy used by the residents of kibera

The study had an objective of finding out the factors leading to the adoption or non-adoption of biogas by the residents of Kibera. Socio-economic factors are unique attributes of a person and his/her household that make them to take up or or not take up a certain technology. Socio-economic conditions are based on household education level, household income, occupation and social status (interactions with society members, group association and community view of the household)

(Damarest *et al.,* 1993). In a revisit of social and economic attributes influencing adoption of biogas digesters in countries on the south of the Sahara Desert (Smith, 2005) notes that a majority of factors influencing take up were linked to price and capcity to purchase; household income, size of farm, cost of construction, conventional fuels and the presence of loan facilities. Other factors impacting technology adoption include; literacy levels, know how, how old or young one is and whether household heads are male or female. These features dictate a person's capacity to get information, knowledge and attitude towards the technology merits which in turn have an effect on one's choice to adopt or not to adopt. It has widely been argued that higher literacy levels aid in improving beliefs and habits which in turn provides conducive mental perception for taking up of new practices (Omer & Fadalla 2003). Higher literacy levels similarly increase information getting ability thus availing awareness knowledge to new technologies and beneficial practices becomes very easy.

Being informed about a new technology also contributes majorly in technology uptake and vice versa. Arthur *et al.,* (2011) asserts that absence of information about biogas technology in Ghana greatly led to the low uptake of the systems. Success or failure stories of previous installations can similarly in a good or a bad way affect uptake. According to Gitonga (1997) information from contented users on how effective their systems are working is sufficient to make other woulbd be users to want to have their own. Where the systems break down, uptake will be less as potential persons who may be having the desire to have the technology will get discouraged and source for alternative technology.

Household income is another essential element that affects the adoption since it is only with enough money that one will be able to afford the technology costs (Mwirigi *et al.,* 2009). Lack of capacity of farmers to bear the entire cost of biogas plant installation is a major setback to biogas uptake in Ghana (Arthur *et al.,* 2011). In agreement with this position, Bensah and Brew-Hammond (2011) posit that lack of ability to get funds to cater for installation costs by farmers continued to be a big drawback to biogas technology uptake in Ghana. Research from many African states show that the upfront cost of even the smallest biogas plant is prohibitive for most poor African rustic families (Karekezi, 2002).

Gender role in the households can as well in good or a bad way dictate the adoption of a technology. The gender roles can be in the form of who does what in the house and who owns what resources in the family set up between men and women. In many African households, women play a critical function in the availing and usage of household energy for cooking or heating. Their energy needs are in line with the search for alternative options that would off set them of tiresome repetitive functions (Denton 2005).

The below section provides an in-depth discussion on how these factors influenced biogas adoption in Kibera.

4.5.1 Education and Biogas Adoption in Kibera

This study established that education level had an impact on the energy that a household used. Higher education levels translated to low uptake of biogas provided in the study area. Advancement in literacy levels was positively linked with adoption of LPG gas and not biogas.

52% of the respondents who had attained tertiary level education (specifically university education) preferred using LPG and not other energy sources. As indicated in the chart below, 11% of respondents who had not attained any form of education.

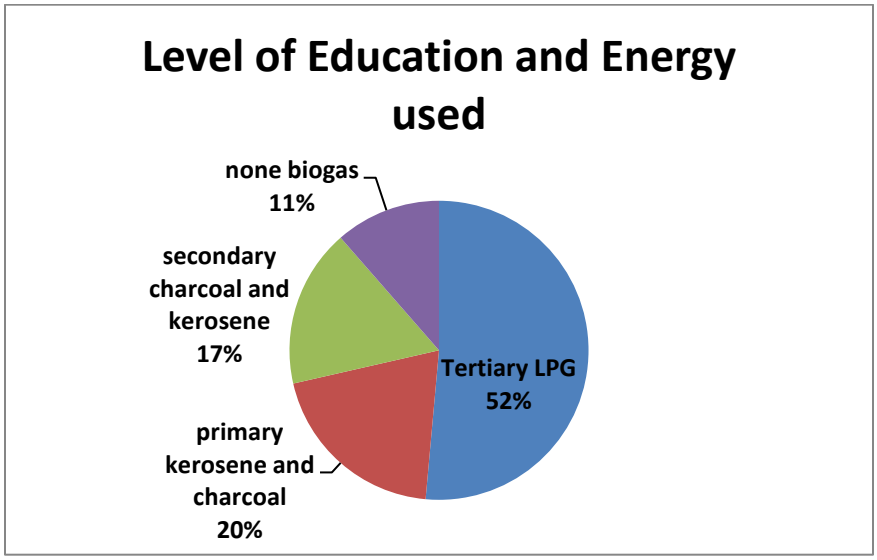

Fig 12: Education level in relation to energy used by respondents
Source: Household survey July 2019

This finding is converse to the general belief that education contributes in bettering beliefs and habits which as a result brings about favourable mental perception for acceptance of new practices. The belief that advanced education increases analytical capability of information and

knowledge necessary to effect new technology was as well thwarted by the study as only 13% of the respondents who had attained tertiary education had used the biogas. These results contradict those that were found by Mwakaje (2008) which stated that the chances of uptake of biogas energy technology increased with increased years of formal education of the head of the family in Tanzania. Had it been that this assertion is true, then one would have expected the adoption of biogas to be higher in the category of persons that had attained tertiary education. The results are represented in the below pie-chart.

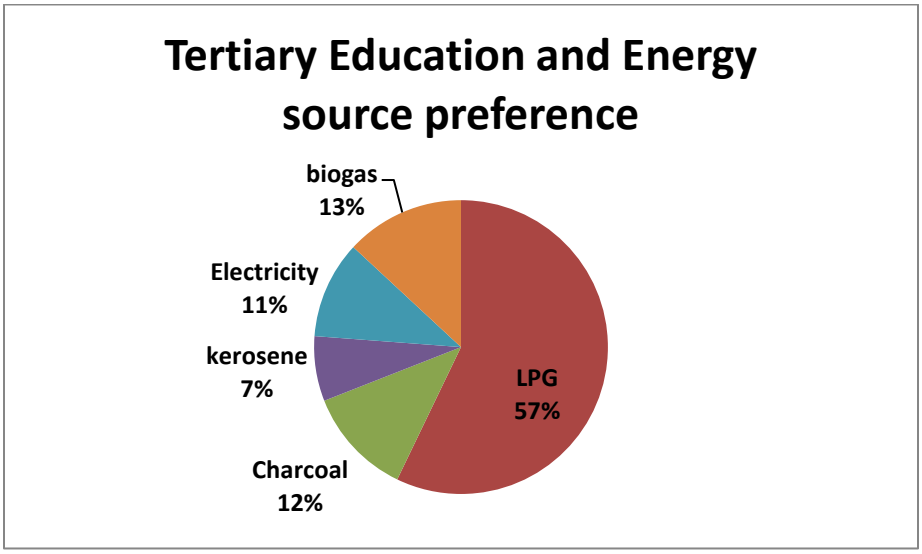

Fig 13: Tertiary Education and energy preference
Source: Household survey July 2019

From the focus group discussion that was conducted, the below was captured;

"…We go to school with the hope of getting good jobs that will help us live better lives and not struggle with issues of smoke. With the little money I get, I prefer buying LPG gas and using it. It is convenient for me and very reliable. I only resort to kerosene in the event that I am very broke but generally I don't use it owing to the information that I have concerning the health hazards it has on people…"

FGD Discussant from Lindi
The Discussant is a recent graduate from one of the local universities in Kenya

4.5.2 Income and Biogas adoption

The link between household income and biogas adoption was as well found to be evident in this study. Higher incomes were associated with low uptake of biogas. Households that had higher incomes preferred using LPG and not biogas or any other energy sources. This study established that this bestowed unto such families a sense of prestige. Households that mainly relied on LPG were considered to be 'rich'. Most of the people that had used biogas were those that earned Kenya shillings 10,000 and below as captured in the chart below. 25% of the respondents who earned between 10000 to 20000 had adopted biogas usage while only 6% of those who earned above 20,000 to 30,000 had adopted its usage.

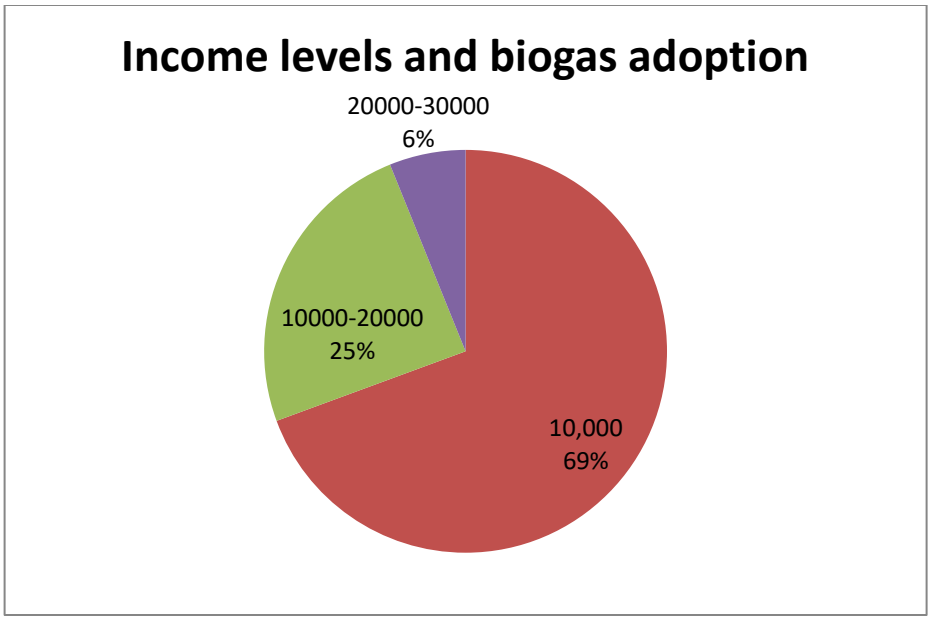

Figure 14: Income levels of respondents
Source: Household survey July 2019

4.5.3 Gender

A high percentage of households in the sampled persons were female headed with 70% and 30% male. The contrast between the gender of the household head and biogas uptake in this research is looked at from the angle of influence and responsibility of male and female gender on household energy. Gender influence on biogas adoption was not essentially significant in this study. This is due to the fact the choice to use or not to use biogas was together with male and female adult of the house.

4.5.4 Age

The study established that age has a significant influence on biogas adoption. Majority of the persons who had adopted biogas usage were those above 35 years old and above. In this study, it was found that only 3% of the respondents within the age range of 0-18 years old had adopted

biogas as a source of energy for cooking. Respondents whose ages ranged between 35-55 years had adopted biogas as an alternative source of energy for cooking in their households. The figure below summarizes the findings.

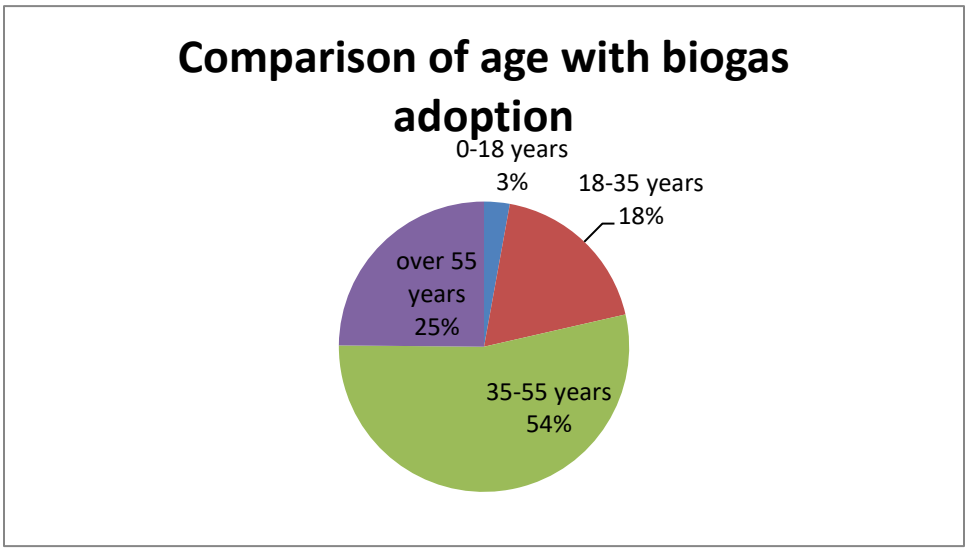

Fig 15: Relationship of age and biogas uptake
Source: Household survey July 2019

4.5.5 Household size

While taking the size of the household in consideration, a high percentage of families,65%, had between below 3-5 members. Household size had implication on the energy needs a household required. Family size however did not to a large extent determine whether a family would take up biogas or not since some households used biogas regardless of their family sizes.

4.5.6 Communal Kitchens and Biogas Adoption

This study established that Umande Trust had in addition to packaging the biogas they produced; they had constructed communal kitchens that community members would use to cook together. From the focus group discussions conducted, it was established that the idea of communal kitchens was not well taken in Kibera. For most of the residents, they preferred cooking in privacy hence

communal kitchens would not work for them. Similarly, most families cooked mostly in the night as during the day most of the family members had either gone to work or school where lunch time meals are provided.

4.5.7 Distance from Bio Centre and Biogas adoption

Most of the respondents in this study lived 250 meters away from the bio-centers that generated the biogas. The study established that a high percentage of households that had adopted the biogas and continued to use it were those that lived in close proximity to the bio-centres. This was mostly driven by the desire of the adopters to try out the energy that was being produced in their neighborhoods. Most of the households that adopted the biogas though had not abandoned their other sources of energy. Similarly, they did not use the gas for long periods, it was more or less a test and see affair.

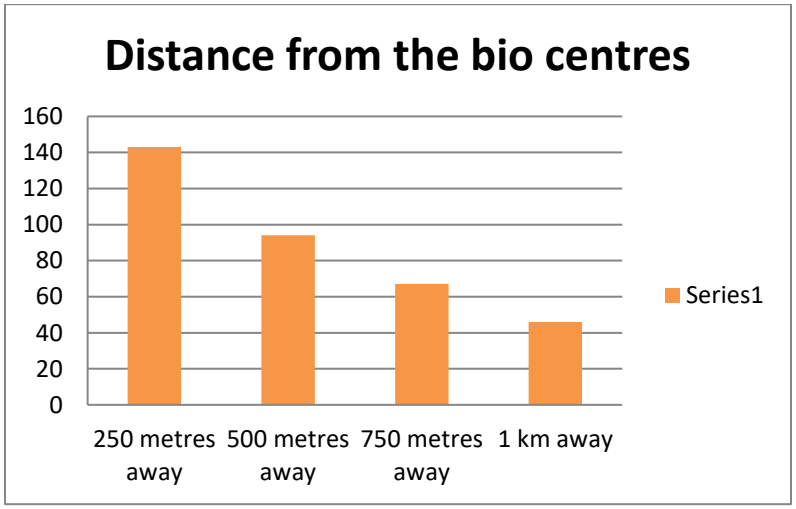

Fig 16: Relationship between distance from biogas source and uptake
Source: Household survey July 2019

In terms of adoption of biogas in relation to proximity to the biocentre, 61% of those who lived approximately 250 metres from the bio-centre had adopted biogas usage. Only 5% of the respondents who lived one kilometer away from the biocentres had adopted the usage of biogas in their energy mix. The chart below summarizes the findings.

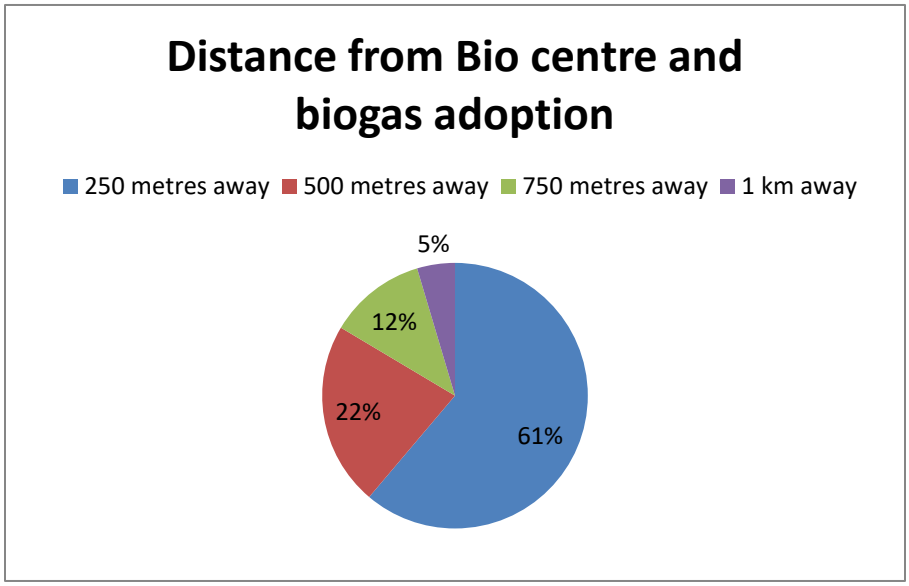

Fig 17: Analysis of distance from bio centre and bio gas adoption

From the focus group discussions, the below was deduced;

> *"...**Now imagine me having to walk for over a kilometre to come and cook here at night. It does not make sense at all. There is a possibility that I can be mugged or even reach home when the food is already cold. I also prefer cooking with my children with me. Walking with them such long distances to come and cook in these very small spaces would not work for me. Maybe if I lived near here I would try coming to cook here…"***
>
> ***FGD Discussant from Lindi Ward***

4.6 Biogas Awareness and Perception in kibera

The study also sought to establish awareness level of the respondents. Out of all the 572 respondents only 27% of households not using biogas were not aware of the technology. All the others (73%) responded by saying that they were aware of this technology and when asked how they learnt about biogas most of the respondents indicated having learnt from friends and NGO staff (Umande Trust). Others indicated that they had attended awareness creation seminar organised at by Umande Trust. Therefore, awareness alone did not have a significant influence on the adoption of technology in the study area since one would have expected high adoption levels in an area where 73% of the selected sample was aware.

Moreover, awareness alone is not sufficiently adequate to induce adoption decision. Rogers (1995), defines technology awareness as just the first stage of adoption process followed by accumulation of knowledge which in turn influences peoples' view on the new proposed technology. People that had stopped using biogas produced were then required to give the reasons as to why they had stopped using it yet 73% of them were aware of the technology. The results are tabulated in Table 2 below.

One hundred and eight indicated that cultural reasons had barred them from continued use of the biogas while 95 indicated that the awful smell of the biogas had barred them from continuing to use it. Another 73 cited the fact that since the gas had been produced by a non-governmental organisation, it belonged to the poor. 85 had not visualized the merits of biogas as their household sizes were very small ranging from 2-3 members where not all were present always hence didn't

find household fuel as a major challenge. A combination of LPG and kerosene served such households well.

The results on awareness are recorded in the Table 2 below.

Table 2: Reasons for non-adoption of biogas

REASON FOR NON-ADOPTION	FREQUENCY
Don't see its benefits	**85**
Wrong perception about the energy (for poor people)	**73**
Cultural reasons	**108**
Awful smell	**95**

One respondent in a focus group discussion had this to say when responding as to why he did not use the biogas.

"…I have learnt from my neighbours' experience who used biogas in the year 2013 that this is a very appropriate technology for every one of us. I have personally witnessed my neighbour reduce charcoal and kerosene usage and other fuel expenses as we used to go gathering buy charcoal together. Nevertheless, my culture cannot allow me to use human waste to cook food that I will eat. It does not make to sense to me at all……'

FGD Discussant from Sarangombe Ward

Another stated if only the awful smell of the gas was eliminated then he would consider using it. There were suggestions that a sweet smell can be added to the gas to make it attractive. Similarly, another participant in the FGD noted that he was not able to use the gas as he wasn't aware of any prominent personnel that had installed the same in their houses. This assertion is in line with Rodgers (2003) assertion that the use of prominent personnel to promote a new innovation would go a long way in increasing its chances of being taken up.

Results of this research are in tandem with findings of Bensah and Brew-Hammond (2011) that who asserted that culture was a key fact that slowed the fast adoption of biogas plants in Ghana. Gebreegziabher (2007) similarly established that the lack of capacity of new technology proprietors to demystify some cultural beliefs associated with a particular invention hampered the widespread circulation of biogas technology in Ethiopia. An assessment carried out by (Mwakwaje, 2008) in Tanzania produced similar findings that urban schools were willing to install the systems but they were barred from doing so by cultural beliefs of the students' parents.

4.7 Policy and institutional framework on production, distribution and use of biogas in kenya

The Kenya Ministry of Energy and Petroleum underscored the fact that there is high dependence on biomass energy for cooking and heating in the country. The Ministry similarly acknowledges that firewood and charcoal are the most commonly used biomass fuel, and as a result affecting negatively on the environment and the users, more so women and children who in many instances are the ones found in the kitchen during the cooking times.

The ministry through government plans and strategies have been holding several promotional efforts in conjunction with development partners and private stakeholders since the 1980s have been engaging in promotional activities to promote the uptake of biogas. The spread of the technology has however remained to be very low.

A feasibility study, '*Promoting Biogas Systems in Kenya'*, sponsored by Shell international in 2007, noted that a high proportion of the biogas digesters that had been installed in different parts of the country were not being maximumly utilized, were not active or had completely fallen to disuse after they were put up. The study similarly showed that a meagre thirty percent of the over two thousand biogas units earlier put were fully operational at the time of the study. Up to today, it is approximated that the country has close to twenty thousand biogas units. While this is a improvement, there is still much potential in the sector.

There are several policies touching biogas production and usage in Kenya. These are contained in the Constitution of Kenya 2010, the Environmental Policy of 2018, the Energy Act, Strategies, Climate Change policy, Climate Change Act, Agricultural and Food policy, the forest act, public health act, and the water act. These policies, frameworks and strategies are discussed as follows.

4.7.1 Constitution of Kenya 2010

The Kenya constitution 2010 emphasises environmental conservation and sustainable development. The preamble states that "We, the people of Kenya –Respectful of the environment, which is our heritage, and determined to sustain it for the benefit of future generations." … denotes that as a country, the government intends to put implement strategies that will see that the environment is protected. Therefore, the promotion of biogas as a source of green energy is one way of ensuring environmental protection in terms of reducing emissions to the environment as well as enhancing sanitation and the management of waste. The Kenya Energy policy framework of 2004 notes that despite the potential of biogas, its penetration in the country is still very low. Previous studies have shown that close to 30% of the biogas centres that were introduced in the country in the 1980s have fallen to disuse. This turn of events has been due to high initial costs of putting up the bio digesters, poor management and weak technical support among others.

While all the policies propagate the advancement of biogas technology in the country; much attention is focused on the rural sectors and the use of animal and agricultural waste as the raw materials for the production. This approach overlooks the fact that human waste which is predominantly available in urban and peri-urban environments can be used to achieve the same purpose as well as enhance the hygiene and sanitation of targeted areas.

4.7.2 National Energy Policy 2018

The policy aims at ensuring the availability of non-pollutant, sustainable, cost friendly, competitive, dependable and safe energy services at affordable prices while safeguarding the environment for present and future generations. The policy recognizes that clean energy, generated from the naturally existing resources including solar, wind, oceans energy, geothermal, hydro, solar, biomass, biofuels, biogas and municipal waste can supply our energy needs and those of future generations in a sustainable way if effectively harnessed through careful planning and advanced technology. Additionally, the policy framework recognizes that green energy has the ability to promote energy security, mitigate climate change, act as an income generating avenue, be a source of employment and bring to a country foreign exchange earnings.

The policy similarly notes that various pilot and small income generating biogas units used for heating purposes and generation of electricity have been introduced in many parts of the country. These biogas projects have substituted the use of fuel oil in operating middle size boilers. In two thousand and eleven the Ministry of Energy started pilot projects for electricity production from wastes of cut flowers in Kiambu and Kajiado counties with a goal of enlarging the generation of electricity (National Energy Policy, October 2018, other biogas sources). In a bid to reduce over dependence on biomass, the government has introduced incentives to enhance the use of Biogas. Studies to ascertain the usefulness of the project carried out under this initiative realized that the country has the potential to put up over six thousand five hundred every five years. To this effect, a number of biogas projects are being implemented by MoE and REA in public institutions. The private sector is also constructing a number of such activities all over the country.

In its bid to enhance biogas uptake in the country, the policy notes that there have been a number of challenges that need to be dealt with. The challenges include; lack of knowledge on the people

on the potential and merits of biogas technology, inadequate Research Design and Development on biogas technologies, expensive initial costs of home use and for sale biogas plants as well as the equipment. Lack of sufficient capacity and know-how on biogas contractors in Kenya and non-sufficient legal and regulatory mechanisms for biogas contracts have as well been cited as the key challenges facing the sector.

4.7.3 Energy Act 2019

The Energy Act, 2019 was passed in response for the need to put together the laws relating to energy; enhance green energy production and uptake; catalyse exploration, recovery and commercial utility of geothermal energy; control midstream and downstream petroleum and coal activities, among others. It is anticipated to come up with an enabling environment for the Government's Big Four Agenda.

The Act, provides for a Feed-in Tariff ("**FiT**") Mechanism that aims at speeding up the production of electricity through renewable energy technologies; encouraging locally distributed generation thereby bringing down demand on the network and technical losses related with transmission and distribution of electricity in long distances; encouraging uptake of, and encouraging innovation in, renewable energy technology; and reducing greenhouse gas emissions. The Cabinet Secretary, Ministry of Energy has the authority to pass guidelines to actualize the Feed in Tariff System. The regulations for the administration and actualization of the FiT System are not yet in place but may include regulations on: the technical and operational requirements for connection to the grid; duration of the feed-in-tariff approval; tariff to be paid by distribution licensees to licensees under

the FiT System; and the priority of purchase by distribution licensees of electrical energy generated using renewable energy sources.

4.7.4 Strategies to enhance biogas uptake in Kenya

In a bid to enhance the biogas uptake in the country, this study found out that, the national government through the ministry of energy has proposed a raft of policies and strategies. The policies and strategies include; Development and implementation of public awareness programs on the merits and utility of biogas resources, undertaking and promoting research, design and development of biogas energy technologies, provision of necessary monetary incentives for local production of biogas units and facilities, production of biogas in large volumes, storage and distribution. The government has begun training programs on biogas technology in schools.

Additionally, the government has developed and enforced legal and regulatory requirements on biogas as well as support domestic and community-based biogas plants among urban, rural population and institutions. The government has similarly promoted the use of biogas as an option to wood fuel and kerosene for home use and commercial energy needs and implemented biogas programs to supply the remaining government institutions including schools, hospitals and prisons, as well as biogas packaging plants across the country.

4.7.4.1 The Kenya Biogas Program

Through three key informant interviews that were conducted under this research with the ministry of energy officials, it was established that although there are several many bio-digesters initiatives implemented in Kenya, most of them operate below the target capacity or are currently non-functional due to management, technical, socio-cultural or economic problems. The study

established that biogas is widely used in institutions such as schools and prisons due to their high potential of waste utilization for biogas generation. Several biogas programs have been established in different parts of the country.

In 2009, the Kenyan Government set policies to support biogas plants but there were no supporting policies, standards or financing to support the policy to move the sector forward. The Kenyan Biogas Program (KIB) implemented by the Africa Biogas Partnership Programme (ABPP) is the driving force behind the biogas program in Kenya.

The Kenya Biogas Program has come up with a marketing strategy that focuses on putting in place effective marketing and business development models for the biogas sector, the approach is referred to as the Biogas Marketing Hub model (BMH).

The BMH strategy entails focusing bio-digester knowledge, capacity building, sales, extension and marketing efforts around structured target markets that already have common interest or service for agricultural households. Through the BMH approach, over 25 Hubs have been set up in Kenya around Dairy, coffee and Tea Farmer Cooperatives and SACCO's, which are more advanced in terms of farmer cooperation.

CHAPTER FIVE
CONCLUSIONS AND RECCOMENDATIONS

5.1 CONCLUSIONS

While reflecting on all informal settlements in Kenya, but using Kibera informal settlements as a case study area, this research sought to find out factors affecting the uptake of biogas by low income households. The research hypothesis adopted argued that there is low uptake of biogas in urban slums and this is greatly tied to socio-economic factors as well as insufficient awareness and poor perception about the gas especially the source.

Based on the findings, the study concluded that adoption of biogas as a source of energy for cooking was low (15%). Kibera dwellers of the study area primarily depend on, charcoal, kerosene and LPG for their household cooking energy. Biogas was not an energy of choice for many of the respondents of the study. This was mostly tied to the fact that it was gotten from human excreta. Many people associated human excreta to many cultural taboos and thus shunned from adopting it and had many myths on its demerits. To the contrary however, biogas technology not only supports national economies and the environmental protection, but as its main outcome for the local population it provides for a wide range of improvements in overall living conditions. Sanitary and health conditions improve and the quality of nutrition is enhanced by improved energy availability. Charcoal use on the other hand is not only expensive, but also destructive to the environment. Environmental degradation comes with a raft of challenges that affect both the present and the future generations.

This study concluded that while there was adequate awareness of the technology used the biogas the uptake was very low. This thus implies that, as espoused by Rodgers in the Diffusion of Innovation theory, awareness alone is not sufficient to enhance the uptake of a new technology. More emphasis needs to be put on changing the perception of the people about the technology being advanced. While the technology might be very useful to the target populace, if the perceptions are not changed then it might not see the light of the day.

This study concluded that while the government is aware of the benefits of using biogas, much emphasis has been on production of the gas from animals' waste and agricultural refuse. Where attempts have been made to use human excrete as the raw material for biogas production, this has only been in institutions like prisons and schools. There has been no focus on the production of biogas in urban settings (slums) using human excreta. Similarly, key ministries that ought to incorporate biogas strategies in their works have not done so. A key example is the ministry of public health whose policy does not touch on biogas production and usage.

In terms of operations and maintenance, the study concluded that while the proprietors of biogas centres had the idea of setting up communal kitchens in Kibera, this was not in line with the way of life of the people of Kibera. Privacy when cooking was a key feature in all the households that were surveyed. The absence of the privacy in the communal kitchens made many people not to opt to using the gas provided. Similarly, the distance that an individual had to cover to reach the bio centre site played a key role in determining whether the gas was adopted or not. Also, the study concluded that the with distance to be covered sometimes the energy source would not be reliable

especially when it rained or when an individual wanted to cook late in the late or very early in the morning. The bio centres would be closed in such hours and thus inconveniencing people.

5.2 Recommendations

The empirical evidence presented in this study underscores the need for caution and intense public participation when developing an innovation targeting individuals. To make biogas more attractive to low income households, sustainable and therefore acceptable, appropriate economic and social cultural aspects must be included. The study recommendations include the following:

1. **Promotion of human excreta for energy production**

Although most of the policies analysed mention biogas as an important energy source, the emphasis has been the use of cow dung and agricultural waste substrates. But there is evidence that in densely populated areas there is need to promote the use of human excreta as the major substrate to produce biogas. This would be a double win for providing both appropriate sanitation and energy accessibility. In such areas, the main resource for the biogas production will constantly remain to be available. This can be achieved through ensuring that all relevant ministries that deal with any matters related to public health, Environment, Energy specific government agencies can incorporate the policies of biogas production in their broader policy frameworks.

2. **Sensitization, Awareness creation and Education**

Culture is a way of living, thinking, and behaving. Culture is learned within the family and guides the ways they solve problems and live their daily lives. Culture plays an important role and influences the choices we make in our daily life.

From the findings of this study, it was evident that culture cannot be overlooked. It played a major a role in affecting negatively the uptake of biogas in Kibera. Cultural taboos linked to human faeces was a key hindrance to the adoption of biogas. To avert the problem of culture it is vital for governments and the proprietors of such ideas to enhance sensitization awareness and education on the subject of biogas especially on the disassociation of the raw materials (faeces) and the final product (the gas produced). This can be achieved through conduction of campaigns that will signal out the benefits of biogas produced from human excreta as well demystify any fallacies that might have been created on the subject matter. Electronic media can similarly play an important role in churning out programmes that will be loaded with information on the merits of using the said biogas.

Prominent and personnel of influence can as well be used to discuss the subject with people. This could help in attracting many people to using the gas. Examples of such personnel include, politicians, outstanding sports men and women, leaders from the clergy among others.

3. **Operation and maintenance**

A key factor that negatively influenced the uptake of biogas in Kibera is the distance from the bio centre. This study recommends that to avert this challenge, the implementers should try to incorporate a piping system to enhance the distribution of the gas to a wider public. Similarly, they

should ensure that the gas will always be reliable in that when one will want to use it, he or she will be assured that it will be available. In one of the focus group discussions this was a key factor;

> ***"…Sometimes you walk all that distance and you come here to find that the gas is not available or if it is available it is packaged in very expensive big cylinders that we cannot afford. The absence of the gas when needed and its provision in bigger cylinders that we cannot afford is a huge turn off for many of us…"***
>
> ***FGD Discussant from Sarang'ombe ward***

Owing to the 'kadogo' nature of the economic status of the residents of Kibera and other areas of similar nature, it would be prudent for the implementers to consult the would-be buyers of the gas to under the exact amounts they think a majority can afford comfortably. Similarly, since some of the respondents alluded to the fact that there is always a foul smell that comes from the gas when cooking, it is recommendable that the proprietors of the biogas technology to incorporate the use of sweet-smelling perfumes to take away the foul smell.

Connected to the above it is that from the study, it was evident that people shunned away from cooking from the communal kitchens that the bio-centers provided because such kitchens did not guarantee the privacy that the people needed. With this fact that therefore, it would be better if the proprietors of such ideas would ensure that the gas is piped into nearby houses and connected to the gas stoves that the people can use to cook privately from their houses. This, the study observed that, it would increase the uptake of biogas as the privacy that is key to many people when cooking shall be assured.

4. **Public participation**

There is need to enhance public participation when developments such as the one assessed by this study are carried out. Through this, the intended beneficiaries of the projects are able to share their facts, experiences, knowledge, ideas, preferences, hopes, fears, opinions, and values. This way when the bio centres are made, they are able to take into considerations the needs of different people and also debunk any myths that the intended beneficiaries may be having towards the project being implemented. In a nutshell, public participation will help ensure that there is mutual education of everyone involved; implementers will be able to get additional information more easily so that they can tailor make the project to suit the intended beneficiaries needs.

To achieve this, a community led development approach should be adopted. Community-led Development (CLD) is the development approach where the proprietors of a given idea/ technology work together with the intended beneficiaries to come up with the desired outcomes. It is a planning and development strategy that is premised on core principles that ensures visions are set collectively with the communities/ intended beneficiaries, local voices lead the development process. The strategy builds on local strengths, and collaborates across sectors, it is intentional and adaptable, and works to achieve systemic change rather than short-term projects.

5. **Provision of Subsidies and Tax Breaks**

The material needed to construct bio gas plants that utilizes human excreta are quite expensive. For this reason, therefore, the government should ensure that proprietors that want to supply this type of energy are exempted from certain taxes for a given period of time and provided the

materials at subsidized costs. This will see many people want to venture in this business as one of the key factors that make people not to venture into any business idea is the initial capital, especially in the circumstance that it is too dear. This can be achieved through the government asking potential proprietors of such ventures to apply for a special permit that will allow them to buy tax free goods from designated government vendors. Similarly, the government can provide tax grace periods to such implementers; this is to mean that after the construction is completed and the gas is being sold, the proprietors should be allowed an agreed upon number of years in order to recoup their monies that they had invested in the projects.

6. Trainings of Artisans

With the government of Kenya's continued push for people to enrol in Technical and Vocational Training institutes, they can incorporate biogas production technologies as one of the courses for people to be trained in. Different people would train in different sectors related to the generation of the gas i.e artisans to undertake the construction works, this will ensure that locally available labour will always be used in the construction process and in case of break downs, there will always be available skilled man power to rectify the breakdown. This will in turn be in line with Government's development agenda such as the Big Four, which aims to enhance the manufacturing sector in the country and promote job creation for the citizens.

7. Use of proper Biogas Marketing Strategies

How a product is marketed plays a key role in determining how it will be taken up, the same applies to the uptake of biogas technology. Owing to the economic conditions of many people that live in densely populated urban and peri-urban settlements, the need to market biogas as an energy

alternative that will help save the users a lot of money is important. In the marketing strategy, proprietors should include strategies informing the potential users of the health benefits such as the reduction of diseases like bronchitis infections, the benefit of saving large amounts of money as the biogas is cheaper compared to other energy sources like charcoal or paraffin. The need to link the biogas to the environmental benefits such as the enhancement of hygiene and sanitation of the areas they live in. Provision of statistics and data of how the energy has revolutionized people's lives in other areas that have almost similar features like the target areas.

When conducting the marketing also, the economic condition of the people targeted should be taken in consideration. This can be achieved through conducting survey to ascertain what costs people would be willing to pay for the gas provided and what quantities would best suit their needs. With these factors at hand, the implementers can be able to develop products with their customers in mind. With places such as Kibera, the proprietors can take up the 'Kadogo economy' approach and provide the gas in smaller quantities that the people can easily buy.

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LIST OF APPENDIXES

Appendix 1: Household Questionnaire

UNIVERSITY OF NAIROBI

Assessing the uptake of biogas as a source of clean energy for cooking by low income households in Kibera, Kenya

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HOUSEHOLD QUESTIONNAIRE

My name is Juma Ignatius Maiyah, from the Centre for Advanced Studies in Environmental Law and Policy (CASELAP), University of Nairobi. I am conducting a research on renewable energy uptake in the country by low income households. My topic of study is: **Assessing the uptake of biogas as a source of clean energy for cooking by low income households; a case of Kibera**, Kenya. The aim of the research is to understand biogas uptake in Kibera, the levels of awareness and perception of the residents of Kibera on the source of biogas as well as looking into the existing policies on biogas use. I will be asking you some questions in the next minutes**.** The information you share and data collected from you will be confidential and purely used for academic purposes particularly for thesis writing which is part of the requirements to complete a Masters of Arts in Environmental Policy at the Center for Advanced Studies in Environmental Law and Policy (CASELAP), the University of Nairobi.

Date……	
County……	**Signature……..**

Ward ……..	

Section 1: General information

1. Gender of respondent (household head) (please tick one)

i. Male ( )
ii. Female ( )

2. Age of the respondent (please tick one)

i. 0-18 years
ii. 18-35 years
iii. 35-55 years
iv. over 55

3. Education level of the respondent (tick one)

a. Primary level	
b. Secondary	
c. Tertiary level	

4. Household size

a. 1-3
b. 3-5
c. Over 5

5. What do you use for cooking in your household? Tick all that apply

	Source	

a	Kerosene	
b	Charcoal	
c	LPG	
d	Electricity	
e	Biogas	

6. Which is the most used source of energy in your household?

	Source	
a	Kerosene	
b	Charcoal	
c	LPG	
d	Electricity	
e	Biogas	

7. What is your average monthly income for your household in Kenya shillings?

a. Under 10,000

b. 10000 -20000

c. 20000 -30000

d. Over 30000

8. What is the approximate amount of money do you use for energy needs per month (tick one).

a. Under 2000	( )
b. 2001 – 4000	( )
c. 4001 – 5000	( )
d. Above 5000	( )

9. Explain the type of house you live in

a. One room made of iron sheets, mud and sticks
b. One room made of iron sheets, mud and cement
c. Two rooms made of mud, iron sheets and sticks
d. Two rooms made of iron sheets, mud, sticks and cement

10. What are the challenges of any energy you use in your household

a. They are costly

b. Sometimes not easily Available

c. Sometimes it does not suit my needs accordingly

d. Other challenges…please explain

Section 2: AWARENESS ON BIOGAS AVAILABILITY, USE AND PERCEPTION

1. Are you aware of biogas as a source of energy for cooking?

a. Yes

b. No

2. Have you used it?

a. No…

b. **Why**?

c. Yes

3. Is it the first priority source of energy you use?

a. Yes

b. No

4. If no, why is it not first the priority?

5. If Yes, why is it the first priority?

6. Do you know the source of the biogas in your neighborhood?

a. Yes
b. No

Biogas - Non users

7. Why don't use the biogas produced in your neighborhood?

a. I can't use gas from human excrete
b. Its smell is awful
c. It is sold in small portions that I find expensive
d. My culture is against such sources of energy.
e. I am not informed how it works
f. Nobody has communicated to me the benefits of using neither the biogas nor its availability

8. Are there any aspects of the biogas provided that you think if improved would make you to use it?

a. Yes
b. No

9. What aspects specifically? Tick all that apply here

i. Getting a solution to the foul smell the gas produces when burning
ii. Educating masses on the advantages compared to other energy sources
iii. Proper marketing of the biogas and better delivery mechanisms
iv. Educating the public on how the gas is produced from human excrete
v. Bringing on board influential personnel to speak about the production and use of the gas
vi. Convincing people to abandon retrogressive cultures

Bio Gas users

10. Why do you prefer using the gas in your energy mix?

a. I have been informed about its benefits

b. It is easily accessible

c. It is pocket friendly

d. It is convenient in that it does not produce much smoke like other sources

e. Other reasons …explain

11. Are the people using the biogas involved in the inception phase of the biogas plants or any other stages?

a. Yes

b. No

c. Partly

12. If yes/partly, in what ways are you involved?

a. We are told about the benefits of the gas and selecting the location for setting up the bio centers

b. We are involved in the marketing of the gas

c. We are involved in the construction process

d. Other ways…please explain

THE END

Focus Group Discussion Guide

Thank you for agreeing to participate. We are very interested to hear your valuable opinion on how the biogas being produced here.

- The purpose of this study is to assess the uptake of biogas as a source of clean energy by low income households. I hope to learn things that the government and the biogas proprietors can learn from your views and better the delivery of the gas.

- The information you give us is completely confidential, and we will not associate your name with anything you say in the focus group.

- I would like to tape the focus groups so that we can make sure to capture the thoughts, opinions, and ideas we hear from the group. No names will be attached to the focus groups and the tapes will be destroyed as soon as they are transcribed.

- You may refuse to answer any question or withdraw from the study at anytime.

- I understand how important it is that this information is kept private and confidential. We will ask participants to respect each other's confidentiality.

- If you have any questions now or after you have completed the questionnaire, you can always contact a study team member like me, or you can call the Uganda project team leaders whose names and phone numbers are on this form.

- Please check the boxes on page 2 and sign to show you agree to participate in this focus group.

Introduction:

1. **Welcome**
   My name is Juma Ignatius Maiyah, from the Centre for Advanced Studies in Environmental Law and Policy (CASELAP), University of Nairobi. I am conducting a research on renewable energy uptake in the country by low income households. My topic of study is: **Assessing the uptake of biogas as a source of clean energy for cooking by low income households; a case of Kibera**, Kenya. The aim of the research is to understand biogas uptake in Kibera, the levels of awareness and perception of the residents of Kibera on the source of biogas as well as looking into the existing policies on biogas use. I will moderate this discussion.

2. Explanation of the process
   Ask the group if anyone has participated in a focus group before. Explain that focus groups are being used more in research.

3.About focus groups

- We learn from you (positive and negative)
- Not trying to achieve consensus, we're gathering information
- No virtue in long lists: we're looking for priorities
- In this project, we are doing both questionnaires and focus group discussions. The reason for using both of these tools is that we can get more in-depth information from a smaller group of people in focus groups. This allows us to understand the context behind the answers given in the written survey and helps us explore topics in more detail than we can do in a written survey.

4.Logistics

- Focus group will last about one hour
- Feel free to move around

5. Ground Rules
- Everyone should participate.
- Information provided in the focus group must be kept confidential
- Stay with the group and please don't have side conversations
- Turn off cell phones if possible
- Have fun

6. Introductions
- Let everyone introduce themselves

Discussion begins, make sure to give people time to think before answering the questions and don't move too quickly. Use the probes to make sure that all issues are addressed, but move on when you feel you are starting to hear repetitive information.

Questions:

1. Let's start the discussion by talking about what makes this gas good to use. What are some of the positive aspects of the gas?

2. What are some things that aren't so good about this gas?

3. Have you considered not using the gas? If so, why? What factors contributed to your decision to want to leave and to your decision to stay?

4. What would keep you in this job longer? What suggestions do you have to improve the working environment here so that you would want to stay in your job?

Probes for Discussion:

- *Salary*
- *Benefits*
- *Culture*
- *Proximity to facility*

That concludes our focus group. Thank you so much for coming and sharing your thoughts and opinions with us.

Appendix 2: Pictorial of bio Centre construction to the production of biogas for cooking

Source: Umande Trust

Appendix 3: Pictorial of life in Kibera

People clearing sewage to pass

Alleys of Kibera

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Aerial view of Kibera

A man emptying a latrine that is full