AN ASSESSMENT OF CLEAN ENERGY USE FOR COOKING IN GATWEKERA OF KIBERA, NAIROBI COUNTY

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DECLARATION

This research project is my original work and has not been presented for a degree in any other university or any other award.

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This research project has been submitted for examination with our approval as university supervisors.

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DEDICATION

I dedicate this research project to God Almighty for by His grace and mercy, I have been able to accomplish this work. To my beloved parents without whose support I would not have made it this far. To my siblings Purity and Joshua for their moral support.

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God bless you all.

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ACRONYMS / ABBREVIATIONS

AFREPREN/FWD	Africa Energy Policy Research Network
CBOs	Community Based Organizations
CFCs	Chlorofluorocarbons
CO_2	Carbon (IV) Oxide
EIA	International Energy Agency
EU	European Union
GHGs	Greenhouse gases
GoK	Government of Kenya
KIPPRA	Kenya Institute of Public Policy Research and Analysis
KW	Kilowatt
LPG	Liquid Petroleum Gas
MW	Megawatt
NGOs	Non-Governmental Organizations
PV	Photovoltaic
SDGs	Sustainable Development Goal
UNDP	United Nations Development Programme
UNEP	United Nation Environmental Programme
VAT	Value Added Tax
WHO	World Health Organization
MoE	Ministry of Energy
AD	Anaerobic Digestion
KWh	Kilowatt hour

ABSTRACT

Energy is essential in meeting most of the basic needs of households such as cooking, lighting and heating. It is also necessary for good health if the sources are clean, as this reduces exposure to health damaging pollutants and the consequent implications as energy can be clean or dirty. Clean cooking energy is any source of power that does not pollute or cause harm to the environment when used in cooking. Examples are biogas, electricity and Liquid Petroleum Gas (LPG). Dirty or unclean energy sources such charcoal and kerosene when used for cooking cause indoor air pollution that leads to respiratory diseases and mortality. It is for this reason, initiatives have been made to promote use of clean cooking energy. The main aim of this study was to assess the use of clean cooking energies among households of Gatwekera in Kibera, Nairobi County. This was done by identifying the cooking energies used by the households, assessing the factors that influence the use of clean cooking energy and finding out the benefits of using clean cooking energy. Systematic random sampling technique was used to select 99 households for the study. Data collection was done by the use of questionnaires and interview schedules for two key informants. The findings of the study revealed that LPG, electricity, ethanol and biogas, were the clean energies used by Gatwekera households for cooking. Charcoal and kerosene were the unclean energies used for cooking. Though charcoal is unclean energy it was preferred as the main cooking energy because it is affordable, accessible and faster in cooking and provides warmth and lighting together with the cooking purpose. The study further revealed that the cost of energy, household head education level, household head gender and household income were the factors that influenced the use of clean energy for cooking. The benefits of using clean energy were reduced cost of energy in the long run, saving on time spent while cooking, enhancing education of the children and improved health conditions during use. Some respondents added that clean cooking energy use generates employment hence reducing poverty and preserves trees which would have been cut for firewood and charcoal. The study recommended the sharing of knowledge of the benefits of using clean cooking energies by the government, Non-Governmental Organizations and the households.

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study Problem

Energy is an important aspect of sustainable development and its enhanced access is essential in increasing its role in the well-being and standard of living of the population; whether directly or indirectly (Nyamboki, 2012). There are many variations in the use of energy by households. While an exact breakdown on how households use energy is difficult, energy use by households found in developing countries is mainly for cooking, for heating and lighting (Oyekale & Dare, 2012). This study concentrated on household cooking energy, which is a major part of the total energy consumed at home.

According to Emagbetere & Oreko (2016) households use different types of cooking energy sources which are classified as traditional (animal waste, agricultural residues and fuel wood); intermediate (charcoal and kerosene) or modern (biogas, Liquid Petroleum Gas, ethanol and electricity). Electricity is mainly used to provide light and used in small appliances rather than for cooking. Nyamboki (2012) argues that the major source of cooking energy in developing countries is biomass, which is used by about two billion people around the world and accounts for 80% of the total energy usage in Africa. However, as modern energies are becoming available and affordable in many developing countries, households are switching from traditional fuels to modern fuels such as LPG, biogas and electricity. This pattern of changing fuel type is commonly known as the 'energy ladder', where the ladder steps represent upgrading in the quality of energy services.

Energy supplies are classified as either renewable or non-renewable (Alrikabi, 2014). Furthermore, energy is categorized as clean or dirty energy. Clean or "green" energy means energy obtained from renewable resources without creating environmental debt. It is any source of power that does not pollute or cause harm to the environment. Clean energy gets its name because the byproduct that it creates does not harm the environment. Clean energy can meet the needs of people today and not have a negative impact on future generations to come. Examples of clean energies are biogas, hydroelectricity, solar energy, LPG and wind energy, among others. Clean energies are renewable energies but not all renewable energies are clean energies. Clean energy can be differentiated from renewable energy in that clean energy is focused on carbon emission reduction as a way of counteracting "dirty" energy as a main goal whereas renewable energy would be, by definition, focused on the ability to reuse a resource as an ultimate goal (Max, 2014).

Dirty or unclean energies are those which their byproduct causes harm to the environment and living things. They release carbon emissions to the environment that affect the environment and are associated with harmful effects to human beings. These sources of energies are responsible for air pollution. Example of sources of dirty energy is coal and some petroleum product which when they burn releases carbon emission. Firewood and charcoal are also some of unclean energies. According to World Health Organization (WHO), about1.5 million premature deaths yearly are as a result of indoor air pollution which comes with the use of unclean solid fuels.

Use of unclean energies has led to unsustainable cooking practices which have affected the environment negatively in terms of land degradation, air pollution and deforestation on a small scale because most of the communities gather their fuel wood from the roadside and trees outside the forests but not in the natural forests. Many households get charcoal from the forests and the unsustainable production of charcoal so as to meet the high demand in urban areas, mainly in sub-Saharan Africa, has led to strain on the available biomass resources hence localized deforestation (Malla & Timilsina, 2014). According to Karekezi (2010) replacing the use of charcoal with electricity or LPG or both of these by households should be one of the measures for reduction of cutting down of trees so as to burn charcoal and reducing health issues caused by indoor pollution.

Kibera is one of the largest informal settlements in the world and is located in Nairobi, Kenya where many urban poor live. The area has been faced with high rate of environmental pollution due to use of unclean energies for cooking. This has attracted Non-Governmental Organizations (NGOs) which have intensified adoption of clean energies technologies. These NGOs have been involved in raising clean energies awareness, manufacture and distribution of green energy technologies (George & Gicheru, 2016). A study conducted in Kibera in Nairobi by George & Gicheru (2016) revealed that charcoal, kerosene, electricity and to a small extent LPG appears as the main cooking energies used in Kibera. These four fuels are appealing to the urban poor households as they are relatively affordable. However, most of the urban households in informal settlements rely mainly on charcoal to meet their basic cooking energy needs. There are many reasons why households prefer charcoal compared to other energy sources; charcoal produces less smoke when used, its calorific value is twice that of wood and it lasts longer especially when used with the modern cooking stoves. Moreover, charcoal is found to be affordable, economical and convenient and has an

extensive distribution network that ensures its availability in informal settlements (Mwampanda & Chilardi, 2013).

1.2 Statement of the Research Problem

Energy is a very key resource for households for it is used to provide lighting, for cooking, boiling of water and heating. It also enables achievement of good health if it is obtained from clean sources because this reduces exposure to health damaging pollutants and the consequent implication (Isara & Aigbokhaode, 2014). In Kenya just like in many developing countries, modern cooking energy such as LPG and electricity tend to be expensive and this is a major constraint for household fuel preferences. This is further worsened by the poor economic condition where only a few can afford modern forms of energy. This has resulted to use of biomass as major source of energy for cooking by the people.

Smoke from biomass and kerosene when used as source of energy for cooking causes indoor air pollution that leads to respiratory diseases and mortality. Children and the women who spend a large section of their time at home especially in the kitchen are exposed to smoke which leads to death of many of them in developing countries, from acute infections of the lower respiratory tract, tuberculosis, pneumonia and other diseases which include asthma, non-communicable diseases such as heart disease, stroke, cataract, lung cancer and other cancers (World Health Organization, 2010). These are major obstacles which limit the attainment of Sustainable Development Goals (SDG) 4, 5 and 6. On addition to these, when developing embryos are exposed to indoor air pollution from the unclean energy sources, this may contribute to perinatal mortality and low birth weight, which is a major risk factor for a variety of diseases experienced during childhood (Schirnding et al., 2012).

Despite health implication, carbon emissions from unclean energies for cooking are responsible for global warming and use of charcoal leads to deforestation. However, initiatives have been made to promote use of clean energy for cooking as a remedy to the aforementioned problems associated with use of dirty energies. Green energy technology aimed to intensify use of clean energies has been adopted in Kibera. A study conducted by George & Gicheru (2016) in Kibera revealed that 10% of the households had adopted the technology. This shows there is limited adoption of clean energy among the households and this formed the focus of the study with the aim of identifying the factors influencing the use of clean cooking energies.

Another study conducted in Gatwekera and Kisumu villages of Kibera by Yonemitsu et al (2015) revealed that charcoal, woody biomass, kerosene and charcoal briquettes were major sources of energy for household cooking. Furthermore, Karekezi (2010) revealed that kerosene is the main modern energy used by the poor in Kibera for both lighting and cooking. Charcoal and LPG were consumed by a relatively small section of the urban poor. However, there is less knowledge on the extent to which households use clean energies for cooking in Kibera, hence there is need for firmer empirical bases for the many questions regarding the factors influencing the use of clean cooking energy in Gatwekera. The research in essence was meant to contribute to the ongoing endeavors in Kenya to bring about change in the management and use of clean cooking energies. It will contribute in addressing energy challenges and inefficiency as well as developing appropriate environmental sound management practices for energy management and appropriate policies for sustainable energy management.

1.3 Research Questions

The study addressed the following research questions:

1. What are the types of cooking energies used by households in Gatwekera?
2. What are the factors that determine the use of clean energy for cooking by households in Gatwekera?
3. What are the benefits of using clean cooking energy in Gatwekera?

1.4 Research Objectives

The overall objective of this study was to assess clean energy use for cooking inGatwekera households in Kibera. The specific objectives were:

1. To identify the different types of cooking energy used by households in Gatwekera.
2. To assess the factors that determine the use of clean energy for cooking by households in Gatwekera.
3. To find out the benefits of using clean cooking energy in Gatwekera.

1.5 Research Hypotheses

The study sought to test the following null hypotheses:

1. H_O: The cost of energy does not influence the main type of cooking energy used by the households.

H_1: The alternative.

2. H_O: The education level of the household head does not influence the main type of cooking energy used by the households.

H_1: The alternative.

1.6 Justification of the Study

The use of unclean cooking energies such as charcoal, kerosene and firewood is increasing due to rapid population growth in developing countries. As a result, deforestation and changes in the ecosystems are happening as well as climate change due to the carbon emissions from these energies when used. Human health is also impacted negatively due to the emissions which eventually cause diseases. Therefore, use of clean cooking energies can help in mitigating climate change and reducing the health hazards especially in women and children.

The findings of this study are intended to contribute to a better understanding of the adoption of clean cooking energies, the households' perceptions towards clean cooking energies and the constraints faced with clean energy consumption. Additionally, the findings of this study could be used as inputs for decision making by NGOs, planners, policy makers and implementers of clean energy technologies. For example, the findings can facilitate formulation of well-informed policies in reducing environmental hazards and health implications as result of using unclean energies for cooking.

Following the establishment of the Energy Regulatory Commission in 2007, the findings of this study could expose some areas which need improvements as clean cooking energy technologies are concerned. Moreover, the findings will provide additional knowledge on the present literature on clean cooking energies and the findings would also stimulate interest on more researches in the field of clean cooking energies.

1.7 Scope of the Study

The study was restricted in assessing extent to which people living in Gatwekera village of Kibera use clean energy for household cooking, factors determining use of clean energies and benefits of using clean energies. Gatwekera was selected as the area of study because it is one the villages with a high population (30, 000 people) and it's in this area where the first biogas plants were established by NGOs. Gatwekera hosts the majority of biogas plants compared to the other villages in Kibera.

1.8 Operational Definitions and Concepts

Clean energy: This is energy that is obtained from renewable resources and does not pollute the atmosphere when used. Examples include, hydropower, LPG, solar, wave, wind and tidal energy.

Renewable energy: This is energy gotten from the replenishing currents of energy occurring in the natural environment. An example is solar energy.

Non-renewable energy: This is energy produced from static stores of energy that stay bound unless released by human interaction. Examples include; nuclear fuels and coal, petroleum and natural gas.

CHAPTER TWO: LITERATURE REVIEW

The section presents a review of literature that is related to the study objectives. The thematic areas discussed in this section are: clean cooking energies in the world; cooking energy sources by Kenyan households; factors influencing use of clean energy at household level and impacts of clean cooking energy use. The review concludes with a summary of the gaps of knowledge that the study intended to fill. Finally, a conceptual framework showing the link between the independent variables and dependent variable has been presented.

2.1 Clean Cooking Energies in the World

There are various energy sources with little to no health implication to people and the environment. Clean energies measures that are used today include energy efficiency, which means using less energy amount which ends up providing better service to the energy user in an economical and efficient manner. Energy efficiency measures involve various technologies that can be used across all major energy consuming sectors and may end up affecting all energy sources (Mulholland, 2012).

Solar power is the most common type of renewable clean energy in which technology is used to obtain sunlight and turn it into energy. It is the simplest route for electricity production from sunlight. Direct solar energy can broadly be produced using the solar photovoltaic (PV) technologies, where photovoltaic cells obtain energy from the sun and change it into electrical energy and solar thermal technologies, which directly use energy from the sun for purposes such as cooking, heating and drying. On a small percentage, solar energy is used by households to provide lighting, for cooking and for heating (Magill, 2017).

Solar energy is convenient to use because it does not produce noise or pollution when it is used. Solar photovoltaic cells and thermal systems are usually fixed on buildings' roof tops to harness solar energy. In the year 2013 and early 2014, large solar plants were commissioned to many countries in the world such as Saudi Arabia, Jordan, the United Arab Emirates and Kuwait and their governments were made to sign purchase agreements or launch tenders on these plants (Energy Digest, 2014). Many solar thermal technologies have been implemented in many African countries and these technologies include solar stills, solar dryer, solar water heaters and solar cookers. Some governments have subsidized the cost of solar water heaters but even with this, the use of these systems has been at a slow rate. In sub-Saharan Africa, not much of organized data on usage of these systems is available. For example, data gathered in Botswana shows that about 15,000 domestic solar water heaters have been installed and in Zimbabwe about 4,000 solar water heaters are in use.

Households with high incomes, large institutions and large commercial facilities such as hotels and game lodges largely use solar water heaters. According to Theuri (2012) Kenya has high potential of solar energy due to her proximity to equator. Currently in Kenya, about 140,000 solar water heaters are been used in different parts of the country. Direct solar energy has the potential of serving much of Kenya's heating, cooking and lighting needs (Theuri, 2012).In Kenya, there are barriers which limit the use of solar energy. These barriers include high costs of the solar tapping facilities, low awareness to the people on the use of the energy and economic benefits which come with the use of these solar technologies. In 2013, the Kenyan government reintroduced 16% VAT on solar PV, solar products and accessories with an assumption of tax collection being disbursed to relevant government institutions for implementation of sustainable programmes (Energy Digest, 2014).

Apart from solar energy, there is **wind power** which is a clean energy. Air flowing on the earth's surface can be made to push turbines with stronger winds producing energy. High altitude areas and those areas which are just offshore are the best areas to capture the strongest winds because of their locations. In sub-Saharan Africa, South Africa has been found to have the highest wind potential in the region with wind speeds ranging 7.2 to 9.7 m/s which have been recorded around Cape Point and Cape Alguhas. However, land-locked nations in sub-Saharan Africa experience low wind speeds because of their locations. The North African Coast experiences strong winds and due to this large-scale wind power generation projects that will exploit these abundant winds are been established in Morocco (Mukasa & Mutambatsere, 2013). Eastern and southern Africa experience winds of low speeds and the many wind machines found in these areas are used for pumping water rather than generating electricity for heating and cooking.

In Africa, there has been little development of modern wind turbines and this is attributed to low wind speeds compared to many parts of Europe, Asia and the America. In addition, the people are not technically skilled and aware of the benefits and potential of wind technology. A few wind energy projects have been established in Africa and there is only limited experience of wind energy generation (Mukasa & Mutambatsere, 2013).

The third clean energy is **hydropower** also known as hydroelectric power. Hydropower is harnessed through the earth's water cycle which includes moisture evaporating from the earth's surface, rain falling, tides occurring and the speed of water running through a dam (Heinberg & Fridley, 2016). Hydropower offers the greatest potential for cost effective clean energy generation in developing countries with adequate water supply. However, very large scale

hydropower schemes have far reaching environmental, social, cultural, technical, financial and economic impacts. This means there should be mitigation measures put in place for these impacts (Ljung, 2007).

Africa has a huge hydropower potential and only less than 7% has been exploited. However, in many African countries, plans are on progress to exploit some of this potential. Mozambique, for example, is on the process of carrying out studies, which will help in the construction of a large hydroelectric dam on the Zambezi River. The dam is set to produce 2000-2500MW. In Democratic Republic of Congo, there is another large hydropower project which is involving the extension of the Inga river hydroelectric scheme which is estimated to generate 50,000MW of power (Wat, 2013). In overall terms, most of the countries in eastern and southern Africa rely heavily on hydroelectric power. However, most of these hydro power projects are associated with huge loans, which lead to very high external debt levels. These projects are also attached to corruption allegations especially the large scale ones. Silting of dams is a major challenge associated with hydropower projects and it limits the electricity amount that can be produced over time. Another challenge of hydropower production is drought, which leads to significant reduction in electricity generation. For example, Kenya experienced a severe drought in 2000 which affected electricity production (Ljung, 2007).

There is increasing support for future development in hydropower sector in Africa as there are many upcoming hydropower projects in the continent. For example, in 2013, Alstom in France was given a contract for construction of eight 375 MW turbines at the Grand Renaissance Dam in Ethiopia. The World Bank is providing funds for construction of regional Rusumo Falls plant (80 MW) under its new Great Lakes Regional Initiative, which will aid in increasing power supply for the citizens of Tanzania, Rwanda, and Burundi (Energy Digest, 2014). Majority of the households in the world use hydropower for cooking, lighting, warming and communication (Karekezi, 2010).

Geothermal energy is another source of clean energy which is obtained from the mantle of the earth in underground parts. Large amounts of steam collect underground at high temperatures ranging 150 to 400^{o}c and this steam when tapped can be used to drive turbines that generate geothermal energy. Thermal energy in the earth is distributed between the constituent host rock and the natural fluid that is contained in its fractures and pores at temperatures above ambient levels. At the international level about 8,100 MW of geothermal power is generated out 60,000MW potential in the world (Bronicki, 2001). According to Lund & Boyd (2015) direct use of geothermal energy is only found in few countries where good

geothermal resources are met with high energy demand that can easily be served by the resource, such as in Iceland, and in areas where geothermal heat has been used in both industry and social traditions such as thermal baths in Japan, Turkey, and Italy. In Europe, there has been a recent effort to improve the use of geothermal energy across all sectors, specifically balneology (spas, swimming pools), which may not have been fully reported before. District heating uses a relatively minor amount of geothermal heat capacity in Hungary accounting for (19%), Turkey (30%), and Italy (10%) but very substantial shares in France (81%), Iceland (80%) and Germany (77%) (Energy Digest, 2014).

With the modern geothermal technology, Africa is able to produce 9,000 MW of energy from the mantle. From this, only 57MW has been exploited in Kenya and less than 2MW has been tapped in Ethiopia (Karekezi & Kithyoma, 2003). Geothermal exploration and research has been undertaken in various African countries such as Zambia, Eritrea, Malawi, Uganda, Tanzania and Madagascar but the potential for grid connected electrification is highest in Ethiopia, Kenya, Uganda and Tanzania. Kenya was the first country in sub-Sahara Africa to exploit and make use of geothermal energy in a great way (Karekezi & Kithyoma, 2003).Kenya is one of the fastest-growing geothermal power markets in the world. In 2013, the country added 36 MW of capacity at the Olkaria III complex. A further 16 MW was added to Olkaria III in early 2014 and by the end of the year, Kenya had another 280 MW of geothermal power capacity under construction (Energy Digest, 2014).The government and NGOs are planning to increase exploitation of geothermal energy to 576MW by the year 2019 (Omenda & Teklemariam, 2010). Some geothermal plants produce both electricity and thermal output for various heat applications such as cooking and heating (Energy Digest, 2014).

2.2 Cooking Energy Sources Used by Kenyan Households

The mainly used cooking energies by Kenyan households are fuel wood and charcoal which are part of biomass, petroleum, biogas, electricity and to a small extent coal (Karekezi, 2010). Just like in many sub-Saharan African countries, in Kenya, biomass is the dominant energy supply and about 70% of the population relies on it (Nyamboki, 2012). Biomass fuels include materials of organic origin such as wood, charcoal, maize cobs, coffee husks and animal wastes. Biomass can be burned and used as an energy source or transformed into biofuels which are clean energies (Nyamboki, 2012). In majority of urban households in Kenya, biomass energy is commonly used in the form of charcoal because its use does not produce a lot of smoke and its energy value is more than that of wood and it’s found to last longer, especially when used with improved cook stoves. Charcoal is considered to be economical, relatively affordable and convenient to use when compared with other energy sources (IEA,

2007). In Kenya, charcoal is sold on average of about $ 5 per 50-kg bag which is relatively affordable to most of the households. Indeed, charcoal remains the cheapest cooking fuel available in urban areas and its transportation to cities and towns is much easier than that of firewood hence, it is used by most of the low-income urban households.

Part of biomass sources include natural materials such as sawdust and combustible waste from agricultural activities which can be converted into energy with very little emissions of greenhouse gases compared to petroleum fuels. This is because biomass contains stored energy from the sun. Concerns about sustainable energy supplies and commitments to the Kyoto Protocol have been major influences on the promotion of such type of biomass use. Renewability and versatility are among many other advantages of biomass energy source (Nyamboki, 2012). Apart from burning biomass to get energy, sometimes these renewable organic materials are transformed into fuels such as biodiesel and ethanol (Park, 2016).Biomass is mainly used for heating and cooking by households.

Kerosene is a refined petroleum product which is used for cooking, to provide lighting and for heating in the households. In Kenya, about 83% of the urban households use kerosene mainly for cooking and for lighting (Kamau, 2013). Kerosene is considered as an affordable energy source but due to a large number of middle men, who are involved in its distribution, the transport and distribution costs accrue on it and it ends up being a high cost fuel. Kerosene is a common cooking energy source among the urban poor households for they find it fast and easy to use (Jacobson, 2013).

In the past, kerosene stoves and lamps were considered a cleaner-burning alternative to traditional solid fuel for cooking, heating and lighting. But recent scientific studies have shown that, depending on the design of the device (cook stove, lamp), household use of kerosene can emit troubling amounts of health-damaging pollutants such as particulate matter, carbon monoxide, and formaldehyde that have been shown to impair lung function and increasing illnesses such as tuberculosis and cancer (Lam et al., 2012). Kerosene use in cooking also poses a number of health and safety risks in and around the home, including poisoning and burns (Mills, 2012).

Liquefied Petroleum Gas (LPG) is another energy source used by Kenyan households for cooking to supplement charcoal, kerosene and hydro-electricity (for those who can afford it). Even though LPG is a relatively expensive energy source especially because of the cylinders and appliances, there has been some increase of its use in the middle and high-income urban

households. In Kenya, about a third of households in urban areas use LPG as a source of energy. LPG is provided in cylinders of different sizes ranging from 3kg to 15kg for domestic applications, with the smaller cylinder sizes of 3kg and 6kg being the most common sizes among the urban poor households. LPG is mainly used for cooking, lighting and to a lesser extent, for heating water (George & Gicheru, 2016).

Biogas energy is a modern cooking energy used by households in Kenya. Biogas technology was introduced in Kenya in the mid-1950s by white settler farmers. The technology is a viable supplementary source of energy for cooking and lighting while the slurry can be used as a source of manure. It is estimated that about 1,100 biogas units have been installed in Kenya (Karekezi & Kithyoma, 2005). But due to poor construction and maintenance of the biogas digesters, it is estimated that only about 25% or less of the installations are currently operational in the country. Even though biogas is not a large-scale used energy, the Kenyan government together with Non-Governmental Organizations (NGOs), private investors and international donors have pushed for the development of this type of energy since the 1980s. Biogas presents the advantage of being generated from agro-processing waste or cut flowers and might be a good opportunity in terms of power generation. One of the main advantages of biogas production is the ability to transform waste material into a valuable resource.

Electricity comes mainly from hydro though part of it can be harnessed from wind, solar, and geothermal hence get connected to the main national grid. Electricity is the least used cooking energy among the urban poor. There are several factors that hamper access to electricity among the urban poor population and the main one is the recurrent cost of its use. High upfront cost of components such as meter boards, circuit breakers and cabling also pose a challenge to some households. Electricity is used for cooking, heating water, warming the houses and lighting (Karekezi & Kithyoma, 2005).

On solar energy, the country receives an estimated 4 to 6 kWh per square meter per day of solar insolation (GoK, 2004). This is equivalent to about 300 million tons of oil equivalent per day. However, only a tiny fraction of this resource is harnessed for commercial and household use including crop and animal products drying, water heating for cooking, water pumping, lighting and entertainment (Karekezi & Kithyoma, 2005). Today, solar energy is utilized in different ways in the country. Some of the solar technologies both for lighting and thermal that have been disseminated in Kenya include solar photovoltaic systems, solar water heaters, solar cookers, solar stills and solar dryers (Karekezi, 2002). Solar PV technologies are mainly used for providing off- grid electricity in urban and rural areas, which are considered to be too far

away from and too costly to extend grid lines to. It is estimated that there are 120,000 units of solar PV systems that have been disseminated across the country (MoE, 2004).

In spite of wind being a very significant energy resource in the country, very little of it has been harnessed and utilized so far. Kenya has a wind energy potential of 3 - 10 m/s (MoE, 2004). Wind energy has been harnessed and used in the country, mainly for pumping water in remote rural areas. It has also been used, but to a very limited extent, for electricity generation with limited installations based in Ngong hills in Nairobi and in Marsabit, North Eastern province. The wind generators installed in the country generate only, an estimated 0.55 MW of electricity that is transmitted to the national grid, representing less than 1% of the total electricity generated (Karekezi & Kithyoma, 2005). However, there is an ambitious 30 MW wind power project that is currently being implemented at Kinangop in Nyandarua District by Kenya Electricity Generation Company (KENGEN), a 70% Government owned electricity generation company, and is expected to inject a further 30MW of electricity to national grid upon completion (Karekezi & Kithyoma, 2005).

The technical potential of geothermal has been estimated at about 3,000 MW across the whole Kenyan Rift Valley. In Kenya, geothermal energy has mainly been used for electricity generation and to a limited extent, for greenhouses heating. Geothermal energy is arguably, the most successfully exploited renewable energy source in the country. The country's experience in the development of the technology has not only made Kenya a market leader in geothermal related issues in the region, but also a world leader. Its implementation started in the early 80's with a 45 MW installation and has gradually grown with time to produce about 130 MW of electricity; about slightly over 10% of the total electricity generated in the country (Karekezi & Kithyoma, 2005).

Fuel briquettes are made from recycling of materials such as charcoal dust, paper, dry twigs among others are becoming popular type of fuel in urban households and their use is helping in waste management. In Kenya, the use of fuel briquettes is becoming popular in both the urban and rural households and there is a high possibility for the briquettes to become an affordable cooking energy (Njenga & Karanja, 2012). Charcoal briquettes are considered to be of benefit to the environment because when used they produce small amounts of smoke, increase the total cooking energy by over 15% and their use saves trees that would have been cut to provide charcoal. The valuing of services given by energy is significant for government policy planning and for improving the socio-economic conditions and environments of households (Yonemitsu et al., 2015).

With regard to Kenya's National Energy Matrix, total final energy consumption in Kenya in 2009 was 14,353.80 thousand tons of oil equivalent while the total primary energy supply was 18,215.99 thousand tons of equivalent (Karekezi, 2010). In 2009, petroleum fuels accounted for about 28.57% of the total national energy consumption while electricity and combustible renewable accounted for about 3.11% and 67.65% of the total energy consumption (Karekezi, 2010).

Kenya is among the 190 countries that participated in Paris Convention and agreed on climate actions through adaptation and mitigation, limiting the effects of global temperature increase. In this Paris Convention countries agreed to implement technical interventions that lead to use of less polluting energies. In Kenya measures have been taken for manufacture and distribution of 1 million units of solar PV-based lanterns and improved cook stoves respectively collectively referred to as "Clean Energy" technologies or solutions (United Nations Development Programme, 2016). However, a study conducted in Kibera by George & Gicheru (2016) revealed that only10% of the respondents have adopted green energy technology despite high awareness of 76%, which aim to intensify use of clean energy technologies. The study further revealed that family income, the cost of green energy technology and distance to the green energy enterprises affected adoption of green energy technology in Kibera.

2.3 Factors that Influence Clean Cooking Energy at Household Level

2.3.1 Cost and Pricing of the Energy

According to Shen (2015) price is the exchange value of goods and services of money. A firm must set a price for the product so that it can earn profit. The factors influencing the setting of the price include economic factors, social factors, political factors, cost factors, firm objectives and level of competition. In areas where governments are in charge of ownership and operation of the energy facilities, energy prices are set by the agency and in private sectors, the relevant companies set their own prices in depending on market conditions, but these prices are always subjected to government regulation.

Given growing concerns about global warming, industrialized countries have placed increased emphasis on the use of clean energy. However, according to Ljung (2007) the costs of many of these energies have long remained well above the cost of fossil fuel based alternatives. A major market failure in pricing fossil fuels is that their prices generally do not have an adequate reflection all associated costs. This results to these fuels being utilized above social

optimum (Gillingham & Sweeney, 2010) and a negative environmental externality comes up because the social costs of greenhouse gases (GHGs) exceed the private costs of emission. Consequently, fossil fuels substitutes, which mainly include renewable energies tend to be underutilized if incentives to invest in alternatives are not made available by mitigating external costs. Therefore, the lack of associated costs with the use of a clean energy or energy efficiency project should be put in consideration when it comes to comparing them to the costs of traditional fuels and projects using traditional fuels (UNEP, 2007).

There is always a large variation in countries in the consumption of households' energy expenditures. In the poorest countries, biomass and kerosene are often highly used while in the wealthier countries, electricity is the main energy source on which much money is spent. Among the cooking fuels, LPG and kerosene tend to be the energy sources where most of the fuel budget is spent by rich households though such households may spend as much or more on wood and hydrocarbons (Hetberg, 2003). Price of energy influences the household energy choice and the amount of energy consumed in the urban poor households. As price increases, the amount of energy consumed decreases and fossil fuels which are cheaper than the clean energies get to be highly used (Heltberg, 2003).

According to Ljung (2007) the problem of access to clean energy among the urban poor households is mainly due to high costs and this means that the focus of government policies and programs should be on improving access to energy services in the most cost-effective manner possible.

2.3.2 Education and Training

Educating the public about clean energy is vital for it enables people to be aware of their costs and the benefits, through education, the political support necessary for enactment of appropriate legislative measures is put in place and people get aware of the different options available to them (UNEP, 2007). This education should begin at the primary level and continue as a part of professional and technical training for those whose jobs will involve energy-related decisions. Education is important to everyone including the residents, politicians or government officials and traders among others so as for them to be aware about the laws that have been put in place to promote carbon level reductions, the costs and the benefits which are attached to use of different energy sources. It is important that all the citizens including the sellers, those who install the clean energy technologies and those who maintain the systems should understand the benefits of clean energy use (UNEP, 2007).

Governments should carry out the education through creation of legislative framework for this task and allocating the funds for doing so by staff through workshops, conferences, use of media to educate public and relevant stakeholders. Non-Governmental Organizations advocating for clean energy use also perform a key role part with their educational efforts. Household head education level and the type of energy used in the household are related (Kohlin & Mekonnen, 2009). There is a high probability of using clean energy in a household if the head has a high education level.

Research by Nyembe (2011) in the preferences for households' cooking energy in urban areas in Zambia found out that households with a head that had higher education level had lower firewood adoption than household with a head with lower education level. Another study by Hetberg (2003) in Guatemala found out that highly educated household heads didn't prefer use of wood and encouraged use of LPG in their houses, which is a clean energy. Knowledge reduces uncertainty and therefore increases adoption of clean cooking technology. For most poor households, there are difficulties in installing the clean energy equipment such as the solar panels and heaters, wind mills compared to the simplicity of buying energy such as the fossil fuels. According to UNEP (2007) this is because of inadequate trained personnel in the clean energy sector and due to this many households opt to use the fossil fuels.

2.3.3 Age and Gender of Household Heads

Age has influence on the likelihood of consuming particular energy type. Households with younger heads are most likely to consume non-wood fuels than wood fuels. A research in Ethiopian cities by Kohlin & Mekonnen (2009) found out that households headed by older people are more likely to use wood and kerosene than electricity as demand of wood increases with age. This was attributed to the fact that older people favor traditional energy sources and resist change for they grew up with wood as the main source of energy. Gender can influence adoption of a technology positively or negatively depending on gender responsibilities and ownership of resources (Gatama, 2014). Different gender responsibilities can be reflected in different tasks among men and women regarding energy supply and management systems. Research by Nhembo (2003) found out that if a technology to be adopted is expected to reduce women workload, then women may prefer to adopt it.

2.3.4 Household Size

Household size has been found to have a key influence on the energy type consumed in the household. An assessment on how households consume energies revealed that the choice of energy used by households is influenced by many factors such as: the size of the household,

income of the household, temperature and precipitation of the area and the implemented legislation on energy. Large sized households consume mostly unclean cooking energies more than small sized families because they seem to be relatively cheaper (Debbi, 2014).

2.3.5 Government Policies in Energy Interventions

Many countries favor energy policies that promote access to cheap energy, although this may often be balanced with concerns regarding the negative externalities of energy production and use (Gillingham & Sweeney, 2010).It is for this reason that various policy interventions and strategies across the world have been used to improve accessibility, ensure security in supplying affordable energy and to achieve efficiency of energy. Many government policies stress the need for increased use of cleaner cooking fuels in order to mitigate the negative effects of traditional biomass energy use; particularly indoor air pollution which is linked to respiratory diseases. Sub-Saharan African governments have inadequate policies that could support the development of clean energy technologies (Karekezi, 2010).

Without government policy intervention, emissions from fossil fuel combustion are not priced at social optimum due to the public good character of clean air and the environment and these results to the unpriced costs or negative externalities of fossil fuels. The absence of an adequate price for fossil energy fuels results in these goods being consumed above social optimum (Gillingham & Sweeney, 2010). Therefore, government policies and programs should focus on improving access to clean cooking energy services in the most cost-effective manner possible so as to increase the consumption of clean energies among the households.

The Kenya Vision 2030 notes that growth of energy generation and increased efficiency in energy consumption will be achieved through continued institutional reforms in the energy sector, including a strong regulatory framework, encouraging private generators of power, and separating generation from distribution, as well as securing new sources of energy through exploitation of geothermal power, renewable energy sources and connecting Kenya to energy-surplus countries in the region. Furthermore, the Constitution of Kenya 2010 guarantees a clean and healthy environment (Articles 42, 69, and 70). This promotes the use of clean cooking energies. Mitigation of GHG emissions and improvements in noise, air and healthcare related pollutants resulting from wood burning for cooking and lighting are also guaranteed under articles 42, 69, and 70 in protection of the environment.

2.4 Impacts of Clean Cooking Energy Use

Clean energies play a critical role in promoting economic development, environmental sustainability and in achieving most of the Sustainable Development Goals related to poverty alleviation, education and health. The following are impacts of clean energy use.

2.4.1 Social Impacts

Access to electricity leads to changes in human behavior, which involve change in their social and cultural interactions. Access to electricity brings a significant change in the household's daily routine. For example, the use of electric light makes people feel safer. With electricity, children learn more effectively, not because they study longer at home, but because electricity at school means better educational facilities and also attract more teachers. With electricity at home, people are able to watch television and are able to get a broader view of the world and one's own horizons hence prompting many people to aspire to an urban lifestyle (Rodriguez, 2012).

On health, use of clean energy by households reduces emissions of harmful gases and particulates into the atmosphere, thus helping to reduce the incidence of lung and eye disorders, particularly in women and children. Research done in the past has shown that there is increasing evidence of health problems associated with indoor air pollution including, tuberculosis, cataracts, lung cancer, still births, heart disease and low birth weight. Research carried out in China revealed that lung cancer and chronic obstructive pulmonary diseases have significantly reduced due to introduction and use of modernized coal stoves in the late 1970s (Chapman & Lan, 2002).

In developing countries where households rely on firewood, women and children are responsible for collection which is a time consuming and exhausting exercise. Fuel wood load can make women suffer serious long term physical damage (IEA, 2006). Use of clean energy in cooking saves time which could have been used in collection of firewood and reduces the physical damage from the strenuous work of carrying fuel wood load.

Under suitable circumstances, solar thermal cookers have been able to save on time spend cooking meals and money in the long run hence the need cleaner fuels. Research has shown that the use of solar cookers in Nepal, especially in the refugee camps and in the small villages in the Himalayas has helped in reducing money and time for cooking and respiratory diseases in the camp (UNEP, 2007).

2.4.2 Environmental Impacts

Research has shown that there are significant positive effects of clean energy use on the environment. For example, clean energy use reduces emissions of greenhouse gases and this helps in reducing global warming. Use of fossil fuels such as petroleum, hard coal and lignite converts carbon which has been kept for many years in the earth's surface and it escapes into the atmosphere as carbon dioxide. Increased concentration of carbon dioxide in the atmosphere leads to global warming because carbon dioxide is one of the greenhouse gases (Tsoutsos, 2005). The use of biogas also leads to release of CO_2 although when compared to fossil fuels, is that the carbon produced by biogas is taken up from the atmosphere by plants' photosynthetic activities. This leads to closure of the biogas carbon cycle within a very short time (Tsoutsos, 2005).

On generation of solid waste, clean energy technologies produce little or no solid waste while producing electricity hence their use helps in keeping the environment clean. For example, with biogas production waste is converted into a valuable resource. There are so many countries in the world faced with problems of overproduction of organic wastes, which come from industries, agricultural activities and households hence it is necessary to use clean energy such as biogas so as to convert these wastes into energy (Akella, 2009).

Clean energies requires limited land resource for their use, for example, photovoltaic systems require a small piece of land for they are mainly placed on already build structures. Solar thermal technologies may require a significant amount of land, depending on the type of technology of solar thermal used. Together with limited land resource use, solar and wind energy technologies do not cause damage on the land they occupy. In addition, clean energy use contributes to European Union energy and environmental targets. Fighting the global warming challenge is one of the main objectives of the European energy and environmental policies. The European targets of producing renewable energy, reducing the GHG emissions and managing waste in a sustainable manner are based on the commitment of the member states in EU to implement appropriate measures to reach them. The production and use of clean energy can help in compliance with all these targets (UNEP, 2007).

2.4.3 Economic Impacts

Most developing countries continue to play a limited role with regards to the manufacturing of clean energy equipment and components. However, there is greater employment potential in the downstream linkages, particularly in the distribution, sales, installation, operation and

service of such systems (Energy Sage, 2016). The potential for employment opportunities and income generation is considerably enhanced when clean energy projects are well integrated with local commercial activities, either through up-scaling of existing small businesses or the creation of new ones. For example, production of biogas from anaerobic digestion (AD) requires work power for production, collection and transportation of AD feedstock, manufacture of technical equipment, construction, operation and maintenance of biogas plants. This means that the development of a national biogas sector contributes to the establishment of new enterprises, some with significant economic potential hence increasing the income to many people and creating new jobs (Energy Digest, 2014).

An idea of the economic benefits of access to clean cooking energy can be obtained from the examination of what happens if the energy supply is interrupted. For example, in Bangladesh, the average industrial enterprise experiences power blackouts lasting about two and half hours per day. The resulting financial loss due to these interruptions is estimated at around US dollars 780 million or 11-12 % industrial value added (Nexant, 2003).The economy wide cost of blackouts in Pakistan in the mid 1909s was estimated by the World Bank (1995), at US dollars 950 million (World Bank, 1995).

According to report of (EIA, 2010) the proposed wind energy power generation facility is expected to generate 300 megawatts of power at full capacity from 150 wind turbines. The company is expected to invest $750 million where $712.5 million should be in tangible personal property (machinery and equipment) while $37.5 million should be in real property construction. At its capacity, the facility should provide employment to 19 people with an average annual wage in excess of $100,000–more than double the median wage in North Carolina. According to Environmental and Energy Study Institute (EESI) (2006) due to use of sustainable energies, gross revenues more than $900 billion and 8 million jobs in 2006 were created in the world. Access to sustainable energy services is key to every country because through this jobs are created hence reducing the poverty levels of many hence improving urban livelihoods (UNDP/ WEC, 2004). Creation of jobs starts from the generation of these energies because after their connection to the main grids they finally end up used as electricity for cooking in the households. Employment as well comes with the distribution and selling of the clean cooking energy appliances.

2.5 Conceptual framework

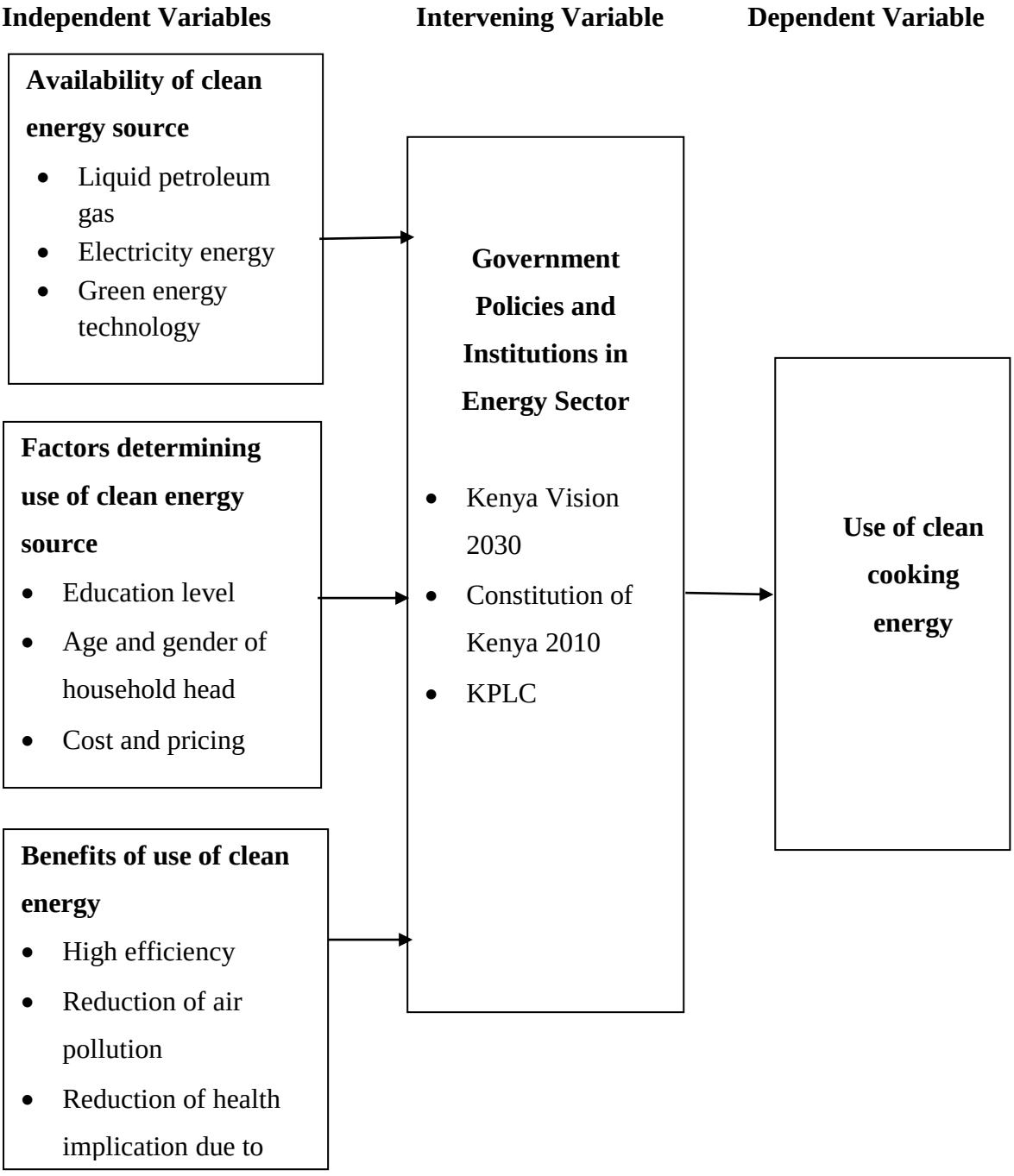
Sustainable Development Concept

According to Emas (2015), sustainable development means any development that meets human development goals while at the same time sustaining the ability of natural systems to provide the natural services and resources upon which the economy and people depend on. With sustainable development, societies make use of available resources without compromising the stability of the natural systems. The development of the concept lays emphasis on economic development, social development and protection of the environment for generations to come.

Sustainable development of energy systems is helpful to policy and decision makers in the world (Santoyo-Castelazo & Azapagic, 2014). The main global policy objectives include growth of economy, achievement of energy supply security and reduction of climate change effects. Meeting these policy aims requires integration of all three sustainability aspects of energy systems: environmental, economic and social. Many decision and policy makers in the world are recognizing the need for integration of these three aspects. The use of clean energy sources is able to contribute to developments in economic and social sectors and enables environmental energy sustainability. The clean energy technology improves access to energy by many people, lowers local and global pollutants emissions and creates local socio-economic opportunities for development (Jaramillo, 2010). The use of unclean energy such as firewood, charcoal and other sources that pollute the environment does not promote sustainable development. This is because they emit greenhouse gases which cause global warming and some gases which lead to ozone depletion, endangering our environment sustainability for future generation (Ganda & Ngwakwe, 2014).

In terms of economic aspect the use of unclean energy leads to high cost in long term in terms of mitigating the effects. While in terms of social aspect many health implication as a result of using dirty energy are a risk to human existence. Moreover, the younger generation and women are vulnerable to indoor pollution due to long hour exposure to use of unclean energies for cooking. The pollution causes many respiratory diseases, a risk to continuation of human species especially when women and younger children die as a result of indoor pollution due to use of dirty energy for cooking (Gujba & Mulugetta, 2011).

Figure 2.1 Conceptual framework



Source: Researcher (2017)

There are three independent variables in this study that affect the dependent variable. The first independent variable is availability of clean energy source. This is when households have access to clean energy source such as electricity and LPG that can be used for cooking. The second independent variable is factors determining use of clean energy source. Factors such as education level of household heads, gender of the household head and energy cost greatly influence the use of available clean energy sources for cooking. The third independent variable is benefits of use of clean energy. Households only use clean energy for cooking if there are benefits accrued. There are many benefits which come with the use of clean energies.

The intervening variable is government energy policies and institutions in energy sector. Apart from the three independent variables which affect use of clean cooking energy by a household, government energy policies and established institutions greatly influence the frequency with which families use clean energy. For example, government's policies such as the 2010 Kenyan Constitution stresses the need for increased use of cleaner cooking fuels in order to mitigate the negative effects of traditional biomass energy use, this may increase the consumption of such energies. Governments' policies and institutions in energy sector also influence the pricing and availability of clean energies and this influences the rate of consumption of the energies. For example, Kenya Power and Lighting Company (KPLC) is responsible for transmission of electricity from the national grid to consumers and sets the cost of this electricity as well. The dependent variable in this study is use of clean energy for cooking that is determined by the independent and intervening variables in this study.

CHAPTER THREE: RESEARCH METHODOLOGY

This chapter outlines the research methodology applied by the study. It starts by presenting background information on the study area in terms of its geographical, physical, demographic and socio-economic characteristics. It then describes the target population, sampling procedure, sources and methods of data collection and data analysis techniques.

3.1 The Study Area

3.1.1 Location of the Study Area

This study was conducted in Gatwekera village of Kibera in Nairobi County, Kenya (see Figure 3.1). Gatwekera is located in longitudes 36º 45’ East and latitudes 1º18’ South in southwest of Nairobi and about five kilometers away from the city center (Muema, 2016). In Kibera, where Gatwekera is found, on the southern border, there is the Nairobi River and the Nairobi Dam, which is an artificial lake that provides water to the residents of the area. A contemporary map of Nairobi shows the southwestern suburb of Kibera is a collection of minor streets just south of the Ngong Road and west of Nairobi's Wilson Airport.

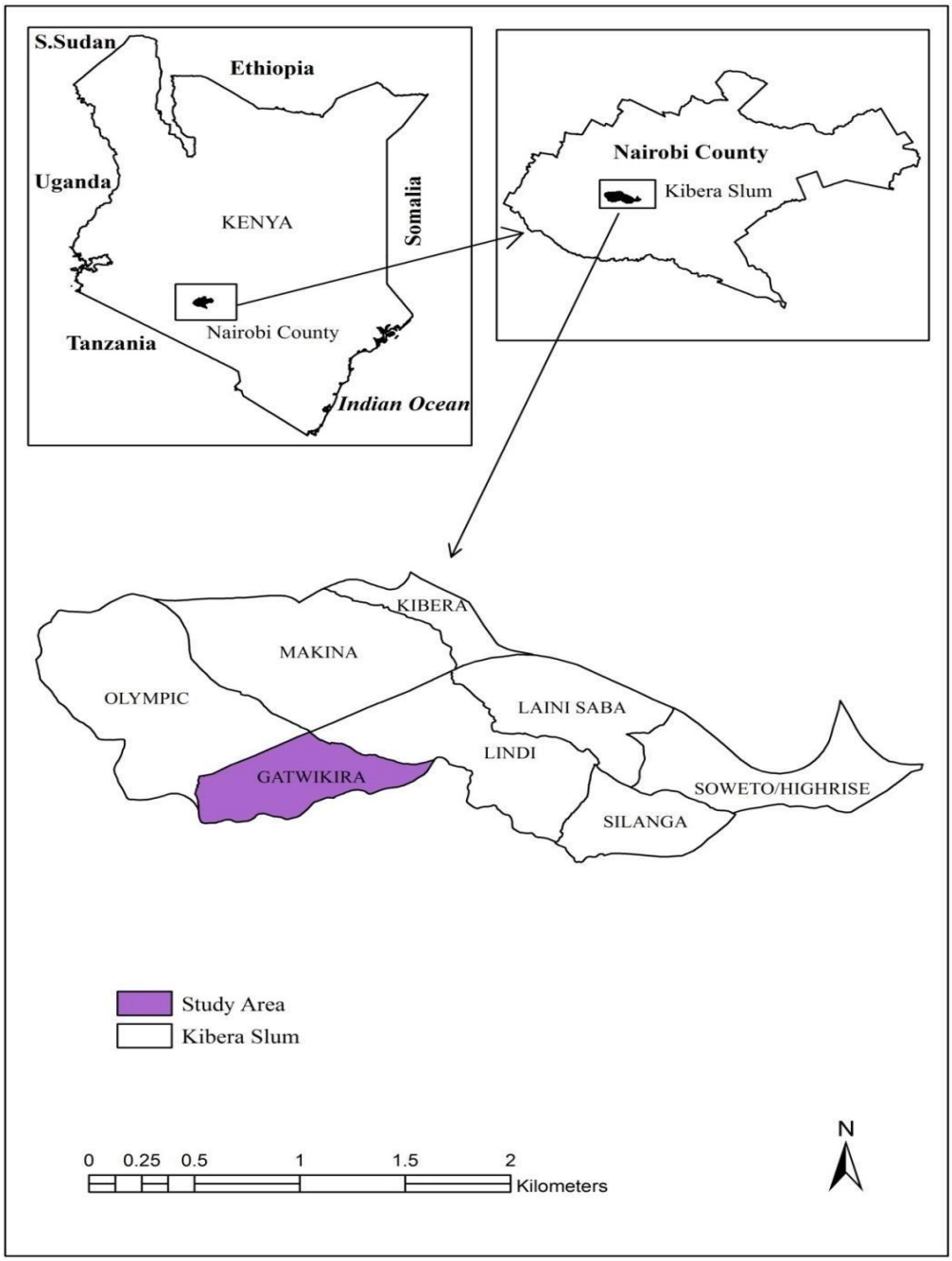
3.1.2 Physical and Topographic Characteristics

Gatwekera is mainly a plain and bordered by Nairobi National Park to the east and Ngong Forest to the south (Muema, 2016). The main rivers within the area are Nairobi and Ngongrivers which are highly polluted because open sewers from the area and industrial waste is directed towards them. Nairobi dam, which is built along the Ngong River and Jamhuri dam are significant water reservoirs in the area. The main type of soils in Gatwekera is the black cotton and red soils that are found in different sections of the study area. In addition, Gatwekera is near the Ngong Road Forest which supplies wood fuel to the households.

3.1.3 Drainage

Much of Kibera is drained by Muitini River and its tributaries, some of which have become open sewerages due to rampant waste disposal in the area. Gatwekera suffers shortage of water and the drainage and garbage collection services are poor (Achieng, 2004). A few open-earth drainage systems are available between the houses and most of the time they get clogged by solid waste materials which are dumped by the residents. There are no proper garbage collection services in the area and the residents have been forced in some places to organize means of handling their waste through community participation (Muthoni, 1999).

Figure 3.1: Location of Gatwekera in Kibera, Nairobi County



Source: Survey of Kenya (2015)

3.1.4 Climate

The study area experiences sub-tropical highland climate and the altitude is 1,795 meters above sea level. In the June and July season, the evenings are mostly cool and the temperature a times gets to 10 ℃. December to March is the time of the year when it's sunny and warm and the temperatures range in the mid-twenties at day time. The mean maximum temperature during this time is usually 24 ℃ (Climate Data. Org, 2013). There are two rainy seasons. The long rains fall from March to May with a mean rainfall amount of 899 mm, while the short rain falls from October to December with a mean of 638 mm. The areas mean annual rainfall is 786.5mm. This rainfall amount has favored the growth of the Ngong Road Forest which supplies wood fuel to Gatwekera households.

3.1.5 Population

Gatwekera is one of the villages in Kibera with relatively high population density (30,000 people) compared to the other villages (Muthoni, 1999). The general population exhibits gender imbalance with over half of the population being males. The household sizes are generally large. Gatwekera has a total population of 30,000 people and 8,000 households (Kenya Population Census, 2009). The village is composed of temporary residents who came to the city to look for employment and are tenants and the permanent residents who include the original Nubians and the landless (Achieng, 2004).

3.1.6 Housing

Just like many slum areas, Gatwekera building structures are uncontrolled and are in poor state as some of the houses occupy unsuitable lands such as the valleys of Nairobi River. Most of the houses in Gatwekera are made up of mud, wattle and corrugated iron sheets and are mostly one-room structures. Majority of the housing units are limited to dimensions of five square meters and have little or no spacing in between them. The houses are overcrowded with average capacity of up to ten members per household (Achieng, 2004).

3.1.7 Employment and Economic Activities

Kibera's unemployment rate is well above 55%, which has trapped many households into poverty and therefore unable to afford clean energy. Many people are in temporary employment in various industries in Nairobi's industrial area, while some are running small scale informal businesses (Achieng, 2004). Just like the entire Kibera informal settlement, Gatwekera village is over-crowded with sub-standard housing, unreliable water supply, poor sanitation and minimal social services.

3.2 The Study Methodology

3.2.1 Sample Size and Sampling Procedure

The target population consisted of 8,000 households. Out of these households, a sample size of 99 households was selected for this study using the following formula by Nassiuma (2002):

Sample size (n) = $(NCv^2) / [Cv^2 + (N-1)\ e^2$

Where:

N = target population

Cv = coefficient of variation (0.5)

e = tolerance at desired level of confidence (0.05) at 95% confidence level.

As such: $n = 8000\ (0.5^2) / [0.5^2 + (7999)\ 0.05^2] = 98.78 \sim 99$ households.

Systematic random sampling was then used to get the 99 households. A central location was identified randomly and after which a sampling transect was identified using geographical direction – East, West, South and North. Every fifth household was selected in the different directions until the 99 households were determined.

3.2.2 Sources and Methods of Data Collection

The survey made use of both primary and secondary data. Primary data was collected by use of key informants' interviews (see Appendix 2 & 3), observations and through a pre-coded questionnaire (see Appendix 1) that focused on getting information on available cooking energies in the area; factors that influence the use of these energies and the benefits of the use of clean cooking energies. Secondary data was obtained through use of existing literature on the thematic area of study.

3.2.3 Data Analysis Techniques

Analysis of data was based on 90 questionnaires as nine questionnaires were excluded due to lack of adequate information from the respondents. The completed questionnaires were first edited, then coded before entering the data into the Statistical Package for the Social Sciences software platform. This was then used to generate frequency distributions (tables and figures) and cross-tabulations that were used to describe the sample data. Hypothesis testing was done using the chi-square test.

CHAPTER FOUR: RESULTS AND DISCUSSION

The overall objective of this study was to assess clean energy use for cooking in Gatwekera households in Kibera, Nairobi County. This chapter presents the study results and discussion based on the three objectives: 1) to identify the different types of cooking energy used by households in Gatwekera; 2) to assess the factors that determine the use of clean energy for cooking by households in Gatwekera; and 3) to find out the benefits of using clean cooking energy in Gatwekera. However, the chapter starts by giving an overview of the social-economic characteristics of the respondents and sampled households.

4.1 Social-Economic Characteristics of Sampled Respondents and Households

There were more females (57.8%) who participated in the study as respondents than males (42.2%). This is because women are mostly left at home and involved in domestic duties while men move out daily in search of income to meet the family's needs. In terms of level of education half of the respondents had achieved primary level of education while 43.3% had achieved secondary education and above and a small section of 6.7% had not received any formal education. According to Uematsu & Mishra (2010) people who have acquired higher education have better access to information and knowledge that is beneficial in their domestic activities. This means that the higher the education level, the higher the likelihood a person will adopt use of clean energy source for cooking.

Half of the respondents reported that they have lived in Gatwekera for more than 10 years, 13.3% between 6 and 10 years, 20% between 1 and 5 years and another 13.3% for less than one year (Table 4.1). According to Phillips (2011) attachment to a place is positively related to length of time spent in the area.

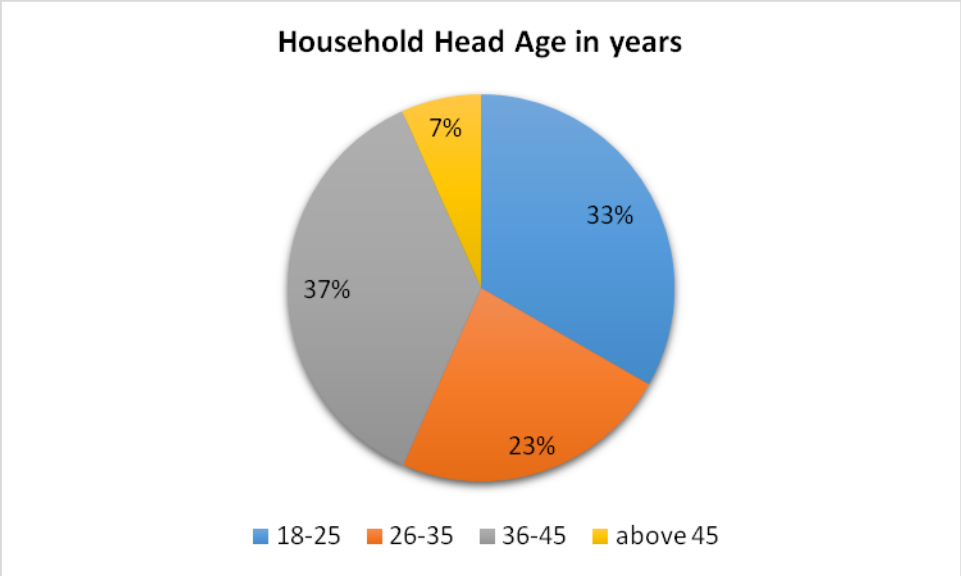
Table 4.1: Period of Stay in Gatwekera

	(N)	**(%)**
Less than 1 year	12	13.3
Between 1 and 5 years	18	20.0
Between 6 and 10 years	12	13.3
More than 10 years	48	53.3
Total	**90**	**100.0**

Source: Field Data (2017)

All the household heads were 18 years old and above. However, the dominant age-groups were of 18-25 and 36-45 years (Figure 4.1). According to Gitonga (2014) age positively influences green energy adoption for cooking.

Figure 4.1: Age of Household Heads



Source: Field Data (2017)

Financial status is a determinant of probability of a household to afford use of clean energy for cooking. According to Table 4.2, 40% of the households had a monthly income of over Kenya Shillings 15,000, while 23.3% earned 1,000-5,000.

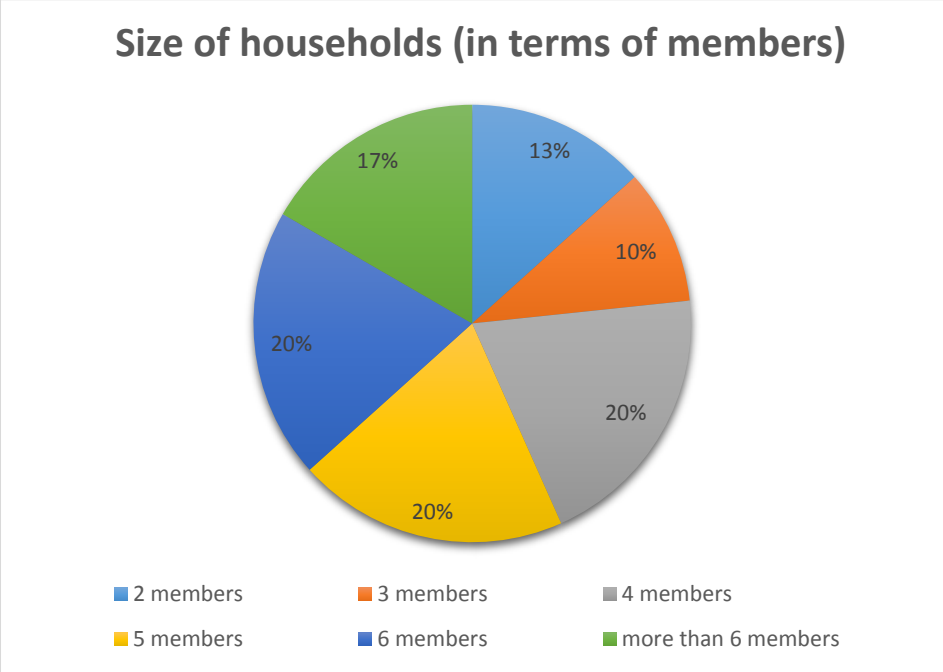
Table 4.2: Household Monthly Income

	(N)	**(%)**
1000-5000	21	23.3
5001-10000	12	13.3
10001-15000	21	23.3
More than 15000	36	40.0
Total	**90**	**100.0**

Source: Field Data (2017)

Sixty percent of the households had between four to six members. Another 17% had over six members, 13% had two members each and 10% had three members (Figure 4.2). According to Gitonga (2014) family size is positively related to use of clean energy because of their high efficiency in releasing energy for cooking.

Figure 4.2: Household Size



Source: Field Data (2017)

4.2 Households' Main Types of Cooking Energy

Households in Gatwekera use both clean and unclean types of energy for cooking. Table 4.3 reveals that the available clean energies used for cooking were biogas (16.7% of the households), LPG (23.3%), hydro-power (13.3%) and 3.3% use ethanol produced from biogas plants used through Safi cookers.

Table 4.3 Types of Households' Main Cooking Energy

	(N)	**(%)**
Biogas	15	16.7
LPG	21	23.3
Electricity	12	13.3
Ethanol	3	3.3
Charcoal	30	33.3
Kerosene	9	10
Total	**90**	**100.0**

Source: Field Data (2017)

According to one of the key informants, an Administrative Officer in one of the Biogas Plants, use of ethanol produced from the biogas plants is limited in the area because many of the households cannot afford the Safi cookers which use the ethanol and buying the ethanol is expensive for most of them. From the interview conducted, the key informant said the Safi cooker costs about Ksh

4,000 and a litre of ethanol costs Ksh 100. Additionally, it was revealed that biogas and ethanol use is still low among the households even with the efforts which NGOs have put by setting up about seven bio-plants in Gatwekera because many people associate these energies with the waste produced from.

The unclean energies used for cooking are charcoal, used by 33.3% of the households and kerosene used by 10% of the households (Table 4.3). Households using charcoal for cooking gave a number of reasons. The reasons ranged from a single purchase lasting for a relatively longer period, accessibility and ease of finding it, being faster in cooking to providing warmth and lighting besides being used for cooking.

4.3 Factors Determining the use of Clean Energy for Cooking

4.3.1 Cost of Energy

A large majority of the respondents "agreed" and "strongly agreed" (73.3%) that the cost of energy influences the type of energy used for cooking (Table 4.4). According to Gatama (2014) and Nyakwea (2011) cost of energy influences the household energy choice and the amount of energy consumed by the urban poor households.

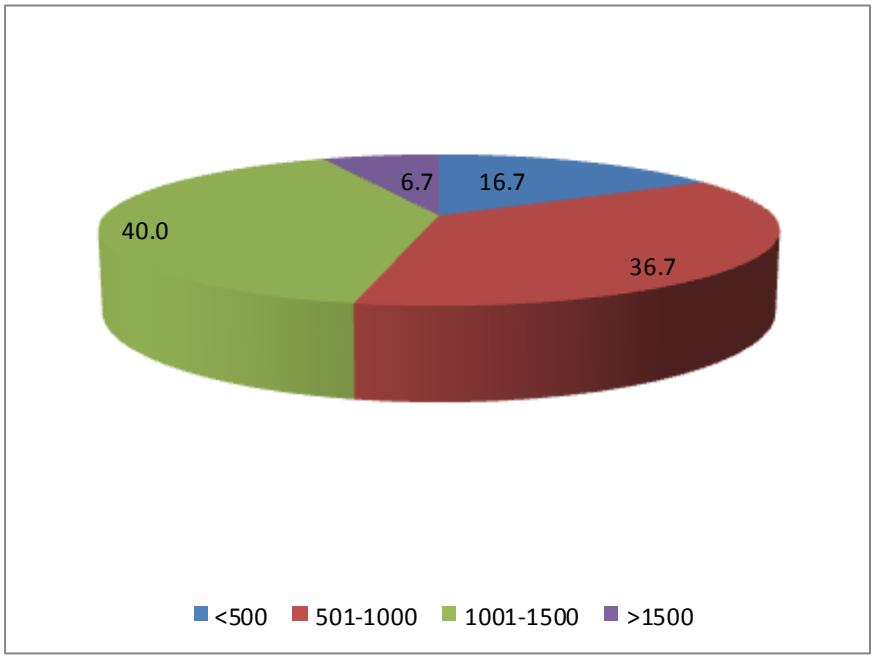
Table 4.4: Cost as an Influence on Use of Energy Type

	(N)	(%)
Strongly agree	51	56.6
Agree	15	16.7
Strongly disagree	6	6.7
Disagree	3	3.3
Do not know	15	16.7
Total	**90**	**100.0**

Source: Field Data (2017)

Previous studies have shown that there is a relationship between the cost of energy and energy type used in cooking. In Gatwekera, 40% of the households spent Kenyan shillings 1001-1500 on energy monthly, 36.7% spent Ksh 501-1,000, 16.7% spent less than 500 and 6.7 % spent more than Ksh 1,500 (Figure 4.3). According to one of the key informants, many households in Gatwekera use charcoal and kerosene because they could easily afford them compared to the cleaner fuels.

Figure 4.3: Monthly Expenditure on Main Cooking Energy (in Kshs; %)



Source: Field Data (2017)

The first null hypothesis of this study was: "The cost of energy does not influence the main type of cooking energy used by the households". According to the chi-square out-put (Table 4.5), the cost of energy significantly predicted the main type of cooking energy. As such, the null hypothesis is rejected. Research done in the past show that the higher the cost of energy, the higher the likelihood that particular energy will not be used for cooking, especially for the poor households in informal neighborhoods.

Table 4.5: Chi-Square Output for Hypothesis 1

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	31.240	12	.002
Likelihood Ratio	30.109	12	.003
N of Valid Cases	90		

4.3.2 Education Level of Household Head and Clean Energy Awareness

Table 4.6 reveals that household heads without formal education and those with only primary level of education tend to use charcoal and kerosene as their main source of cooking energy. On the other hand, household heads with diploma/degree and those with secondary level of education will tend to use LPG as their main cooking energy. According to Uematsu & Mishra (2010) people who have acquired higher education have better access to information and knowledge that is beneficial in their domestic activities. This means that the higher the education level of household head, the cleaner the cooking energies used.

Table 4.6: Level of Education and Choice of Cooking Energy

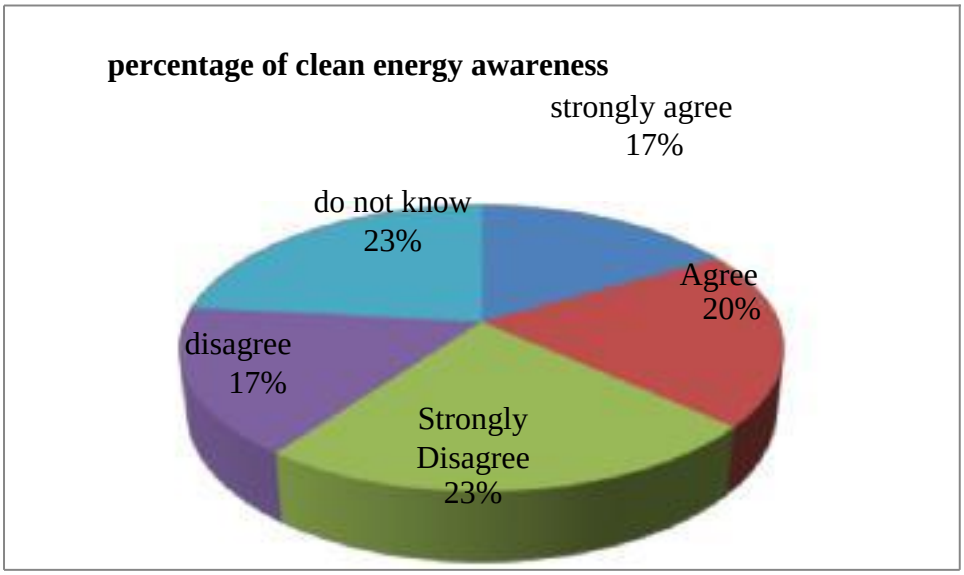
Education level	**Energy Type**					**(N)**
	Biogas	**LPG**	**Hydro-power**	**Charcoal**	**kerosene**	
Primary	3	2	1	24	15	45
Secondary	0	12	5	6	13	36
Diploma/Degree	0	3	0	0	0	3
No formal education	0	0	0	3	3	6
Total	**3**	**17**	**6**	**33**	**31**	**90**

Source: Field Data (2017)

About three-quarters of the respondents (73.3%) were aware of clean cooking energies while the rest were not. The information on clean energy awareness of the majority may be misleading because even where the households said they were aware of clean energy, many could not give an example of a clean energy. The knowledge of clean cooking energies came from different sources: neighbours; the area biogas plants; schools; and mass media such as radios, televisions and newspapers.

In regard to this statement; "majority of the households in Gatwekera are aware of various clean energies and their benefits'' the respondents had various responses. The responses varied from 23% strongly disagreed, 23% did not know, 20% agreed, 17% strongly agreed and 17% disagreed (Figure 4.4). This indicated that the awareness of clean energies and their benefits is low in the study area.

Figure 4.4: Awareness of Clean Energy for Cooking



Source: Field Data (2017)

The second null hypothesis of this study was: "The education level of the household head does not influence the main type of cooking energy used by the households". According to the chi-square out-put (Table 4.7) education level predicted the main type of energy for cooking. As such, the null hypothesis is rejected.

Table 4.7: Chi-Square Output for Hypothesis 2

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	58.641	12	.000
Likelihood Ratio	71.477	12	.000
Linear-by-Linear Association	.584	1	.445
N of Valid Cases	90		

4.3.3 Gender of Household Head

Both the male and female household heads use different cooking energies. However, Table 4.8 reveals that female-headed households tend to prefer the unclean energies for cooking such as charcoal and kerosene. This is basically because of their easy availability, lower cost and for others convenience. Due to their involvement in domestic chores, women are the most affected by indoor air pollution by the use of unclean energies.

Table 4.8: Gender of Household and Choice of Cooking Energy

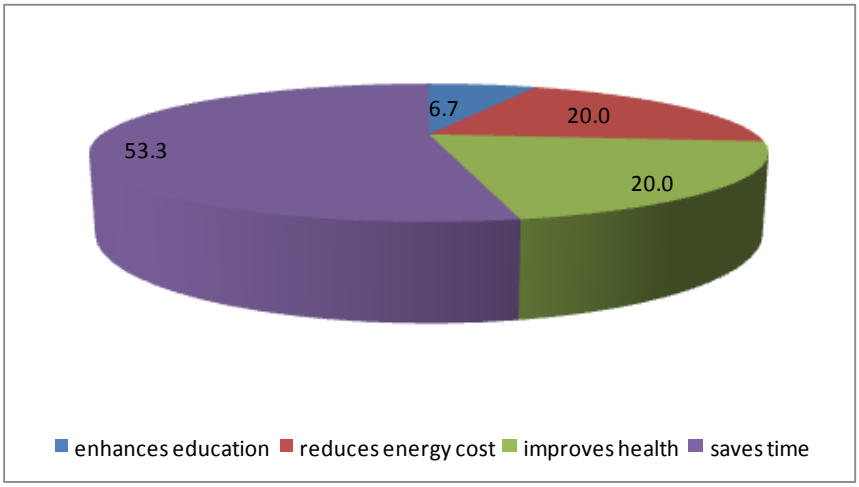
Gender of Household head	Main cooking energy					(N)
	Biogas	LPG	Hydro-power	Charcoal	kerosene	
Male	3	6	3	12	14	38
Female	0	11	3	21	17	52
Total	**3**	**17**	**6**	**33**	**31**	**90**

Source: Field Data (2017)

4.4 Benefits of Using Clean Energy for Cooking

According to United Nations (2005), clean energy use helps in achieving most of the Sustainable Development Goals related to poverty alleviation, education and health. The respondents in Gatwekera had the opinion that the use of clean cooking energy saves time and prepares meals much faster (53.3% of the households); improves human heath because of reduction in pollution and other related health problems (20%); reduces energy cost because they are cheaper in the long-run than unclean energies (20%); and enhances education of children (6.7%) (Figure 4.5). According to Podmore (2015), use of clean energy reduces the amounts of harmful gases and particulates emitted to the atmosphere and this helps in reducing the incidence of lung and eye disorders, especially in women and children.

Figure 4.5: Benefits of Using Clean Cooking Energy (%)



Source: Field Data (2017)

Some of the respondents also added that the use of clean energy can lead to generation of employment opportunities and reduction of poverty to the individuals, CBOs and NGOs engaged in the manufacture of the clean energies (for example the Biogas Plant workers). Furthermore, it may also preserve the forests by a reduction in the use of charcoal and firewood. A number of youth in area have been engaged in the Biogas Plants, selling of LPG and cylinders, as well as selling the Safi cookers.

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

This chapter contains the findings summary, conclusion and recommendations based on the three objectives of the study: 1) to identify the different types of cooking energy used by households in Gatwekera; 2) to assess the factors that determine the use of clean energy for cooking by households in Gatwekera; and 3) to find out the benefits of using clean cooking energy in Gatwekera.

5.1 Summary of Findings

Household Cooking Energy in Gatwekera households

Households in Gatwekera village of Kibera use both clean and unclean energy for cooking in varied degrees, intensities and choices. The main cooking energies in the area are charcoal, kerosene, LPG, electricity, ethanol and biogas. Households tend to prefer the unclean energies for cooking (charcoal and kerosene) because they are affordable**,** accessible and faster in cooking and provides warmth and lighting together with the cooking purpose.

Factors Influencing the Choice of Household Cooking Energy

The main factors determining the choice of household cooking energy were cost, employment, household head level of education, and gender of household head. The cost of energy influences the type of energy used by the households in the study area and therefore many households used charcoal and kerosene because they could easily afford them compared to cleaner fuels. Those employed in casual labour used charcoal and kerosene in their households because of low and irregular income. Household heads with low levels of education tend to use charcoal and kerosene as their main source of cooking energy, while those with high education levels are more likely to use clean energy. Female-headed households tend to use charcoal and kerosene as their main source of cooking energy.

Benefits of Clean Cooking Energy

According to Gatwekera residents, clean energy saves time during meal preparation, are pollution-free and therefore improves human heath, reduces cost of energy in the long-run, and enhances education of children. In addition, clean energy has the potential – directly or indirectly – to create employment opportunities, reduce poverty and conserve the environment.

5.2 Conclusion

The research sought to identify the cooking energies in the study area, the factors influencing the choice of cooking energy and the benefits received due to the use of the clean cooking energies. The results were; Gatwekera households use both clean and unclean energies in cooking. Unless major policy interventions are introduced, charcoal and kerosene are expected to remain the main cooking energies of the urban poor households for years to come because the poor find cleaner cooking energies such as LPG and electricity expensive. Despite Gatwekera been an area where NGOs have established bio-plants, the consumption of biogas and ethanol for cooking is low. This is because the households find them expensive and the perception of their production from human waste limits the consumption. To increase the level of use of clean cooking energies, there is need to make these fuels available, affordable and create awareness about their existence and benefits.

5.3 Recommendations

To Policy Makers

1. Involvement of government and NGOs in energy related activities in order to facilitate sustainable energy use, for example, in the provision of funding to support energy related projects.
2. Creation of awareness on the available clean energies, their benefits and making them affordable and available to households.

To the Gatwekera Community

1. Should be encouraged to create groups (chamas) so that they can access credit and bargain for prices of clean energy technologies
2. Knowledge sharing about clean energies and their benefits in the area. This will help in creating awareness of the benefits of clean cooking energies hence increased adoption.
3. Households should be sensitized on socio-cultural aspects that hinder adoption of clean cooking energies.

To Future Researchers

1. There is need for further research on households' awareness and understanding of the health implications of unclean cooking energies.
2. There is need for further research on the role of NGOs and CBOs in the provision, advocacy and creating awareness of use of clean cooking energy.
3. A sample size of 99 households was used for the study and other studies need to be done with a larger sample size to find out if the same results will be obtained.

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APPENDICES

Appendix 1: Research Questionnaire

University of Nairobi

Department of Geography and Environmental Studies

Name: Grace Mwikali Ndolo

Year: 2017

Section 1: General Information

Date…… Questionnaire number…….

1. For how long has this household lived in Kibera ?

Less than 1 year ☐ 1 – 5 Years ☐

6 – 10 Years ☐ More than 10 Years ☐

2. How many members does the household have? (All adults plus children)

One ☐ Two ☐ Three ☐ Four ☐

Five ☐ Six ☐ More than six ☐

3. Fill in the needed information by ticking what matches your answer.

	Gender	**Age**	**Education level**
Household head			
Spouse			
	male ☐ female ☐	18- 25 years ☐ 26-35 years ☐ 36- 45 years ☐ Above 45 years ☐	Primary ☐ Secondary ☐ Diploma/degree ☐ Masters ☐ Other (s) specify ☐

4. What is the household's main source of income?

☐ Self-employment Formal employment ☐

☐ Casual labor Other (specify) ☐

5. What is the household's monthly income?

Less than kshs 1,000 ☐ Between kshs1,000 to kshs 5,000 ☐

Between kshs 5,001 to kshs 10,000 ☐ Betweenkshs 10,001 to kshs 15,000 ☐

More than kshs 15,000 ☐

6. What kind of dwelling unit does your household occupy?

Single room/ bed sitter ☐ two rooms ☐

Three rooms ☐ more than three rooms ☐

7. Which meals do you take regularly in a day? (Breakfast, lunch, super)

One ☐ two ☐ all ☐

8. If you do not take all the three meals, what is the main reason for not taking all the meals?

Low income /lack ☐ no time to prepare all ☐ by choice ☐

Section 2: Information on the energy used for cooking

9. What type of energies do you use for cooking in your household? (Tick the main in each set)

Energy set 1

a) Bio gas ☐

b) Solar energy ☐

c) Wind energy ☐

d) LPG ☐

e) Geo-thermal energy ☐

f) Hydro-electric power ☐

g) Other (specify) _____

Energy set 2

a) fire wood ☐

b) charcoal ☐

c) kerosene ☐

d) other (specify) _____

10. From the two energy sets above, which energy do you use most for cooking in the household? _____

11. Why do you prefer using _____ more than the other energies for cooking in your household? (Tick the main reason)

It is affordable ☐ It is within reach ☐

It does not cause pollution ☐ It is faster in cooking ☐

Highly recommended by government/NGOs ☐ Any other (specify) _____

12. Given a choice, which energy would you prefer for cooking? (Tick in the order of priority)

	1.most preferred	2. preferred	3.least preferred
Charcoal			
Firewood			
Kerosene			
LPG			
Solar			
Biogas			
HEP(electricity)			
Wind power			

Section 3: factors influencing household energy use in cooking

Cost of the energy

13. How much money does the household spend on the cooking energies per month?

Less than khs 500 ☐ Between khs 501 to 1000 ☐

Between 1001 to 1500 ☐ More than 1500 ☐

14. What is your level of agreement on this statement: "cost of energy influences the energy type used for cooking by households"

Strongly agree ☐ Agree ☐ Strongly disagree ☐

Disagree ☐ Do not know ☐

Awareness on clean energy

15. Have you ever heard of 'clean energy'?

Yes ☐ no ☐

16. If yes: i) where did you first hear or learn about clean energy? _____

ii) List down all the clean energies you are aware of;

_____

_____

iii) According to your own understanding, what do you think clean energy means?

_____

iv) What are some of the major challenges experienced in this area in regard to clean energy sourcing and usage? _____

v) What do you think the government can do in order to solve any of these challenges?_____

vi)What role can the households play in solving any of these challenges? _____

17. Are you aware of any type of information from the government or environmental organizations which advocates for use of specific energy for cooking?

Yes ☐ no ☐

18. If yes; i) what was/is the source of the information?

Through radios ☐ through televisions ☐

General print publications ☐ through chief barazasothers ☐

ii) Who was/is the author of the information?

NEMA ☐ ministry of energy ☐ ministry of health ☐

Individuals ☐ others (specify)

iii) What are some of the energies advocated for?

_____

19. What is your level of agreement on this statement;"majority of the households in this area are aware of various clean energies and their benefits when used"

Strongly agree ☐ agreestrongly disagree ☐

disagree ☐ do not know ☐

Section 4: Information on benefits

For households using either biogas, LPG or HEP as their cooking energies:

20. For how long have you used any of the above as your cooking energy?

Less than a year ☐ 1- 2 years ☐ 2-3 years ☐ over 3 years ☐

21. Do you think your household has obtained any benefits from the use of any of the above energies for cooking?

Yes ☐ no ☐

22. If yes, tick the main benefit obtained;

Enhances education of my family

Reduces the money spent on energy / cost?

Improves the family health

Saves time

Any other (specify)_____

23. Apart from benefiting your household, do you think cooking clean energy has helped in achieving the following? (tick where appropriate)

Reducing poverty in the country

Creating employment

Preserving forests

Appendix 2: Interview Guide for Gatwekera Administrator

1. What type of energies are used for cooking in this area?

2. Which is the mostly used energy for cooking in this area?

3. According to your opinion, what do you think are the factors that influence the choice of energies used by the households for cooking in this area?

4. What is clean energy according to your understanding?

5. What are the advantages of using clean energy in cooking?

6. What are some of the measures the government has put in place to encourage people to use cooking clean energy in this area?

Appendix 3: Interview Guide for Biogas Plant Administrator

1. What is clean energy?

2. Apart from biogas, what are other types of clean energies you are aware of?

3. What are the factors that led to the establishment of biogas plants in this area?

4. What benefits do these biogas plants offer to the people of this area?

5. What challenges do the area households face in relation to use of biogas produced in these plants for cooking?

6. Are there strategies put in place to encourage the use of cooking clean energy to the area's households?