UTILISATION AND SUSTAINABILITY OF BIO-CENTRES IN KIBERA SLUMS, NAIROBI COUNTY

By

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Kenyatta University

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Declaration

This thesis is my original work and has not been presented for a degree or any other award in any other University.

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Dedication

This work is dedicated to my parents Fredrick Mbondyo and Loice Mutiwa for their tireless efforts towards my education.
Acknowledgement

First and foremost I thank the almighty God for His wisdom, love and protection towards the success of this project.

Secondly, I extend my appreciation to my supervisors; Dr. Peter K. Kamau and Dr. Simon M. Maingi for their invaluable guidance and support that came hand in hand in producing this project.

I wish to express my sincere gratitude to my parents for their financial commitment towards my studies. Your encouragement coupled with wise words of advice will never go unappreciated. For my entire family members, thank you so much for your prayers, help and encouragement.

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**Abbreviations and Acronyms**

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<tr>
<td>APHRC</td>
<td>African Population and Health Research Center</td>
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<td>CBO</td>
<td>Community Based Organisation</td>
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<td>CSO</td>
<td>Civil Society Organisation</td>
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<td>CSUDP</td>
<td>Civil Society Urban Development Programme</td>
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<td>GoK</td>
<td>Government of Kenya</td>
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<td>IISDA</td>
<td>International Institute for Sustainable Development</td>
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<td>KNBS</td>
<td>Kenya National Bureau of Statistics</td>
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<td>NGO</td>
<td>Non-Governmental Organisations</td>
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<td>SPSS</td>
<td>Statistical Package for Social Sciences</td>
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<td>TOSHA</td>
<td>Total Sanitation and Hygiene Access</td>
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<td>UN</td>
<td>United Nations</td>
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<td>UNDP</td>
<td>United Nations Development Programme</td>
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<td>UNESCO</td>
<td>United Nations Educational Scientific and Cultural Organization</td>
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<td>UNIFEM</td>
<td>United Nations Development Fund for Women</td>
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<td>WASH</td>
<td>Water Sanitation and Hygiene</td>
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<td>WATSAN</td>
<td>Water and Sanitation</td>
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<td>WHO</td>
<td>World Health Organisation</td>
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<td>WMS</td>
<td>Welfare Monitoring Survey</td>
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<td>WSSCC</td>
<td>Water Supply and Sanitation Collaborative Council</td>
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<td>WWDR</td>
<td>World Water Development Report</td>
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Abstract

Bio-centre technology has been applied to counter the challenges of water and sanitation resulting from high urban growth combined with urban sprawl of Kibera slums. Despite bio-centres coming handy to solve water and sanitation problems, the utilisation and sustainability of bio-centres is still wanting as human waste is still evident as one traverses Kibera. Further, despite the inception of bio-centres in 2007 which have the potential of mitigating water and sanitation issues, their use is still low within the populace. For example, from statistics it is estimated that only 2.35% of the total population in Kibera use the bio-centres (WASH News Africa, 2009). The objective of this study was therefore to examine the factors that determine utilisation and sustainability of bio-centres in Kibera slums. A total of 143 respondents were interviewed using structured and semi-structured questionnaires. In addition, 10 in-depth interviews were done to elicit a better understanding of the study objectives. Besides, an environmental checklist was used by the researcher to collect data. Data analysis was done using quantitative and qualitative methods so as to address the objectives of the survey. Specifically, Statistical Package for Social Sciences (SPSS) was used to analyse quantitative data while for qualitative data descriptive statistics of means, percentages and frequencies was used to describe and summarize data. Regression analysis (P<0.05, 95% Confidence level) was also employed to evaluate the relationship between socio-cultural factors, economic factors, design and location of the bio-centres on utilisation of bio-centre facilities in Kibera. The results of the regression analysis indicated that the village of residence, duration of stay, knowledge about bio-centre existence and the number of bio-centres were positively significant (P<0.05, 95% confidence levels). The results of this research indicated that, despite 73 percent of the respondents having knowledge of the existence of the bio-centres in Kibera, only 58 percent of the respondents have used the bio-centres while 42 percent have never used any of the bio-centres. The results of the regression analysis (P<0.05, 95% Confidence level) implicated that, the use of bio-centre facilities in Kibera is not dependent on household income but rather is dependent on the cost of the various bio-centre facilities namely bathroom, toilet, water, bio-gas and recreation facilities (P<0.05, 95 confidence levels). The results showed a positive relationship between the bio-centre closeness, cleanliness, safety to the bio-centres and the utilisation of bio-centre facilities by the respondents. In addition, the research found out the bio-centre facility is unequally distributed and usually unaffordable thus hindering its sustainable utilisation. This research therefore recommends that; Bio-centres should be well distributed in Kibera for easy accessibility by all residents in the area. From the research findings, despite the bio-centre facility being able to provide clean energy, the bio-gas has received low usage by the residents. Further research should therefore focus on how the bio-gas from the bio-centres can be stored or distributed to various household so as to maximize its economic importance. Further, the cost of bio-centre facilities should be further reduced to enhance affordability and sustainability.
CHAPTER ONE: INTRODUCTION

1.1 Background

Africa is currently experiencing urban population explosion which has resulted in slum proliferation in most African cities. In Kenya, more than 60% of Nairobi population is living in slums which have posed enormous humanitarian challenges to access of basic facilities such as water and sanitation (UNDP, 2004). The focus of this research was Kibera slum which is ranked the second largest slum in Africa after Soweto slums in South Africa.

According to the 2009 Kenya Population Census, 13 per cent of households (or 5.6 million Kenyans) have no access to toilets and defecate in the open or dispose human waste in bushes (GoK, 2009). The World Bank (1998) Water and Sanitation Programme report says Kenyans spend almost 2.5 days a year finding a private location to defecate; and much longer for women who are obliged to find a hideout for urination as well. The UN Habitat (2007) estimates that only eight out of every ten people living in Nairobi’s urban slums, which constitute 60 per cent of the city’s total population, have access to adequate water and sanitation facilities. The dignity of most urban residents occupying informal settlement areas of urban spaces is a fundamental right that can be partly fulfilled through innovative solutions to the sanitation question such as the one offered by bio-centres. Interventions such as the bio-centres are, therefore, timely in addressing issues of water and sanitation.
The multiple benefits that communities in these settlements derive from the bio-centres provide further incentive for this choice of sanitation solution. Civil Society Urban Development Programme (CSUDP) and Umande Trust are convinced that the advantage of bio-centres is no longer in question as its viability and utility is well-proven. Nevertheless, this is a solution that is yet to be widely embraced as an answer to the informal settlement sanitation question so as to uphold the dignity of the majority of Kenyans, occupying the least space in urban centres.

The area lacks basic drainage, waste disposal facilities and clean water supply (Juma, 2001). More to the conditions are cases of indoor air pollution that are rampant owing to use of unclean energy sources. Like any of the other slum settlements in Nairobi, Kibera has a large population with no access to minimum services, living largely in structures made out of temporary and recycled building materials or made out of timber, mud walling, and roofing made up of substandard materials such as sacks, carton paper and polythene. Due to lack of proper sanitation and waste management, the residents have had to use the “flying toilet” and human waste disposal at dusk to dispose their human waste for a length of time (Amunyunzu and Taffa, 2003). Further, water reticulation is limited and the road network is inadequate. Energy for heating and cooking is as well hard to come by in Kibera and most of the slum's residents use charcoal, which approximately costs 30 Kenyan Shillings for a two kilogramme tin.

The above poor slum conditions have resulted in a number of projects by Civil Society Organisations (CSOs) with the aim of improving the poor slum conditions. In 2007 specifically, the first bio-centre (Gatwekera bio-centre) was constructed in Kibera by Umande Trust and thereafter 55 more bio-centres have been operationalized in
different slums of Kenya. Currently, there are 56 operational bio-centres in Kenya out of which 53 of them are in the informal settlements in Nairobi. More specifically, Kibera slum has 16 bio-centres; Mukuru slum has 14 bio-centres while Korogocho slum has 13 bio-centres. On average, most bio-centres in Kibera have a total number of 250 users per day in exception of a few of them such as the Tosha bio-centre which records a total of 1000 users during the weekends. The average operation hours of most bio-centres are from 6.00 am to 10.00 pm which translates to 16 hours per day. Over the next few years, the bio-centre technology is anticipated to be highly practiced in Kenya.

Bio-centres as the name suggests are centres converting human wastes in to gas. A typical bio-centre consists of input unit for feeding the bio-mass, a digester where fermentation takes place, a gas holder for collecting the biogas and an output unit for removal of the slurry. The plant operates through the principle that when the waste and other organic materials are fermented in the absence of air, combustible methane gas is produced (Karekezi, 2002). In Kenya, the bio-centre concept has been applied by linking it to a comprehensive community mapping analysis which highlights specific locations in greatest need of improved sanitation. Each bio-center is different and has been customized based on the specific needs of the community: some bio-centers have restaurants, residential houses, others have free community space; some are cylindrical, others are square. Majority of the bio-centres are managed by registered community groups such as Self Help Groups (SHGs) and Community Based Organisations (CBOs) (WASH News Africa, 2009).
According to a study by WASH News Africa (2009), typical bio-centre is usually a building which has toilets and bathrooms housed on the ground floor while the first floor is used as a community kitchen, social places, and rental houses or for offices to be let out to slum-based organisations. Basically, a single bio-centre comprises of the following components:

- **A biogas digester**: Mixes water and human waste in anaerobic conditions to make biogas; remaining liquid effluent is 90% pathogen free and filtered on site.
- **Toilets and washrooms**: Located on the ground floor to ensure disabled persons access with free ‘child only’ cubicles
- **Water Kiosk**: selling affordable clean water
- **Upper Floors**: Maximizes restricted urban space, with halls and ancillary rooms for community and livelihoods activities such as cottage industries or restaurant. The upper floors also include cooking zones which provide an alternative source that is cheaper than charcoal, is more environmentally friendly and keeps their surroundings clean.

### 1.2 Problem Statement and Justification

Despite a number of bio-centres being operational in Kibera slum, the issue of “flying toilets” and other unconventional methods such as open disposal at night are still rampant as one transverses Kibera slum. Human waste can still be observed on the roads and the drainage systems in these areas which pose serious health hazards contrary to Kenya’s Vision 2030, the Constitution and Government agenda for development. Further, despite the inception of bio-centres in 2007, their use is still low
within the populace. For example, from statistics it is estimated that only 2.35% of the total population in Kibera use the bio-centres (WASH News Africa, 2009). Also, despite the bio-centres being able to generate energy, household energy still remains a major concern in the informal settlements with families directing a significant amount of their earnings in acquiring energy for cooking and lighting. Most of the households use kerosene lamps and stoves exposing themselves to risks of contracting upper respiratory tract infections (UNDP, 2004).

The research therefore focused on establishing the factors that determine utilisation and sustainability of bio-centres in Kibera slums. The findings of this study offered recommendations on the strategies that are needed to scale-up utilisation and sustainability of bio-centres. The assumption from the study is that the results obtained from Kibera slums can be replicated in other parts of the country to scale-up utilisation and sustainability of bio-centres.

1.3 Research Questions

1. Which social-cultural factors affect utilisation and sustainability of bio-centres?

2. What are the socio-economic factors that influence utilisation and sustainability of bio-centres in Kibera?

3. Does design and location of bio-centres determine their utilisation and sustainability?

4. What strategies are needed to scale-up utilisation and sustainability of bio-centres?
1.4 Objectives

The main objective of this research was to examine the factors that determine utilisation and sustainability of bio-centres in Kibera slums.

1.4.1 Specific Objectives

1. To examine the socio-cultural factors that influence the utilisation and sustainability of bio-centres

2. To examine the socio-economic factors that influence utilisation and sustainability of bio-centres

3. To evaluate the impact of the design and location of the bio-centres on their utilisation and sustainability

1.5 Research Hypothesis

1. Socio-cultural factors such as cultural beliefs, taboos, practices and level of knowledge influence utilisation and sustainability of bio-centres

2. Socio-economic factors such as household income and the cost of facilities influence the utilisation and sustainability of bio-centres

3. The design of bio-centre components such as the bio-gas, toilet and bathroom determine the utilisation and sustainability of bio-centres

4. Location of bio-centres including the distance to the nearest facility determine the utilisation and sustainability of bio-centre facilities
1.5 Significance

This research provides information for use by development agencies and the government on how to improve utilisation and sustainability of bio-centres which are important in improving poor Water and Sanitation (WATSAN) conditions in most slums.

This research has come up with findings of better understanding of this technology. Since bio-centres provide clean energy, this research has offered recommendations for promoting clean energy mechanism through bio-centre technology.

If the recommendations of the research are acted upon, they will help in changing the living conditions of Kibera and replication of the same in other slum areas and consequently enhanced utilisation and sustainability of bio-centres.

Other scholars and researchers may also use the research findings as a point of reference. In addition, this research serves as a model study of utilisation and sustainability of bio-centres and identifies further researchable areas or gaps.

1.6 Conceptual Framework

The factors that determine the utilisation and sustainability of bio-centres can be viewed as a combination of background and proximate factors that operate within the multi tiers of a social organisation (Madise et al., 2003)

The framework illustrates the wide ranging social and economic effects of WATSAN projects as determinants of environmental sustainability and poverty reduction.
The framework resonates with the findings of this research that the factors affecting WASH projects relate to the background tiers (national, community, household and individual) and have different levels of impacts. For instance at the national level, the impacts of WASH may be affected by proximate factors such as the political and legal systems governing a country which may translate into either promoting or hindering the development of WASH facilities hence resulting in either improved or reduced health of the residents. At a community level, knowledge and communication of social services may result in a community ability to utilise WASH facilities which ultimately affects the health and livelihoods of the residents. At a household level, factors such as socio-economic status and the attitude towards change may result to behaviour towards change thus ultimately affecting the health and livelihoods of the residents. At the lowest level which is the individual level, factors such as socio-cultural and economic factors may also result to outcomes such as behaviour change and therefore affecting the health and livelihood of the residents. This conceptual framework appreciates WASH development to be affected by different factors that may be viewed at the various levels and resulting to common impacts as illustrated in figure 1.1 below.
Figure 1.1 Factors Affecting Water and Sanitation Projects

1.7 Limitations of the Study

The study was limited to the answers given to the items in the questionnaires. However inferences and implications were drawn from the responses given by the respondents.

The data collection technique has a limitation. Though the researcher attempted to ensure that the data obtained from the questionnaire was valid and reliable, it could not be ruled out that a respondent may have felt compelled to provide a response that he/she considered socially acceptable rather than what they genuinely believed.

This study was carried out in all the thirteen villages in Kibera slum leaving out other slums where bio-centres exist. Furthermore, financial resources required to cater for research activities were limited. This led to selection of a representative slum for the study.

1.8 Definition of Terms

1. Flying toilets is a local slang which refers to the use of a polythene bag by someone to empty his/ her human waste and throwing it away afterwards.

2. Sanitation includes the disposal of sludge resulting from the waste water treatment process. Maintaining clean hygienic conditions that help prevent disease through services such as garbage collection and waste water disposal.

3. Sustainability is the long-term maintenance of responsibility, which has environmental, economic, and social dimensions, and encompasses the concept of stewardship and responsible management of resource use to enhance the capacity to endure.
4. Water and Sanitation includes waste water and surface collection, transportation and treatment techniques used together by populated area, industrial site or private parcel before discharge in to the natural environment.
CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction
Urban growth combined with urban sprawl has overwhelmed the capacity of local authorities to provide the population with adequate urban facilities. The state of the environment has as well been degrading owing to increased human waste disposal pressure. This has rendered the government and development agencies with challenges towards service provision for basic necessities. These challenges have resulted to innovative strategies to counter the impacts of rising urbanization especially in the urban slum areas in a sustainable manner. One such innovation is the use of bio-centres to address challenges of water and sanitation in Kenyan slum areas. The bio-centres have a lot of potential since even septic tanks which are majorly used in urban areas can be converted to bio-centres technology. Moreover, bio-centres are a solution to water and sanitation problems which have continued to impact on most of the informal settlements and therefore their sustainable utilisation is very important.

Kenya’s urban areas are continuously becoming centres of innovation, industrialization, education, science and technology and culture just as is in the case of any other developing country. Many citizens continue to be attracted to these urban areas to benefit from the attributes of modern living and facilities. Statistics show that one out of every three Kenyans lives in urban areas implying that out of the total 38.6 million population, 32.3% or 12.5 million Kenyans live in some 108 designated urban centres with populations ranging between 20,000 and 3 million (GOK, 2009). Kenya’s development blue print, Vision 2030, estimates that by the year 2015, the level of
urbanization will have reached 44.5%, and eventually it will reach 54% by 2030 with nearly 30 million people living in urban areas (GoK, 2007).

Nevertheless, these urban spaces house communities living in highly undignified conditions deprived of the very basic essentials necessary for meeting minimum living standards (AMREF, 1998). Majority of Kenyans, reside in informal settlements where they not only deal with the ever looming threat of eviction, but they also bear a heavy social and health burden coupled by the poor physical conditions they live in (UN Habitat, 2007).

The continued desire for better urban space for its citizens is evident from the various policies and legislations that Kenya continues to pass. The recognition of urban areas and cities as provided for in article 184 of the Kenyan Constitution (GOK, 2010) that enabled subsequent legislation through an Act of Parliament on Urban Areas and Cities in August, 2011. In this regard, the Bill of Rights, as enshrined in the constitution, clearly provides for respect, protection and fulfillment of human rights for all citizens regardless of their place of residence, ethnic origin, gender or any other status. It safeguards the right to food, health, education, housing, water and sanitation and a clean environment. With the provisions of article 43, the poor can claim their inalienable right to exist within the city, to access basic services and to participate in governance (GOK, 2010).

According to the WHO (2000) communities residing in the ever growing expanse of informal settlements in Kenya continue to contend with serious environmental degradation and public health concerns precipitated by increased vulnerabilities due to
exposure to unsanitary conditions. The magnitude of this concern can no longer be downplayed, especially since Nairobi alone houses more than 100 such informal settlements. It is increasingly obvious that if unchecked, these patterns are likely to undermine the country’s efforts towards achieving the Millennium Development Goals (MDGs). Nevertheless, it is encouraging to note that efforts are being made by both State and non-state actors to ameliorate the conditions, particularly in the provision of basic services, shelter and infrastructure (APHRC, 2002). One such effort that is responding to the sanitation and energy question in informal settlements being led by Umande Trust, a Non-Governmental Organization (NGO) based in Kibera, Nairobi, with support from the CSUDP and related donors (WASH News Africa, 2009).

Working through Umande Trust, communities in a number of informal settlements identified poor sanitation as a key area of concern which is compromising their quality of life. Containment of human waste in sanitized environments continues to elude inhabitants in these settlements who often lack space for the construction of appropriate sanitation facilities. Households are forced to employ risky disposal practices that have left the communities vulnerable to diseases such as diarrhoea and even outbreaks of cholera (Amunyunzu and Teffa, 2003). This situation has been exacerbated by the poorly drained surfaces in the settlements, often causing overflows into the housing units during the rainy season. The question is and remains, what technological options, commensurate with the socio-cultural and economic conditions, are available? (Amunyunzu and Teffa, 2003).

The bio-centre technology provides an important solution that Umande Trust, through the support of CSUDP and other agencies, has mobilized communities to construct.
According to Hutton (2004) the bio-centre technology provides multiple social, environmental and economic benefits to the communities residing in informal settlements. This technology answers to the call for provision of dignified sanitation and responds to the high energy demand through supply of safe bio-gas for household application and natural compost for improved urban gardening hence improving household nutrition. Biogas use, replacing conventional fuels like kerosene or wood fuel, allows for the conservation of the environment by protecting forests. In addition, the containment of human waste reduces the pollution of water bodies thereby curbing water-borne illnesses (Deublein and Steinhauser, 2010).

The green economy concept, as described by the United Nations Environment Programme (UNEP), is aimed at economic growth that reduces carbon emissions and pollution while enhancing energy and resource efficiency. Bio-centres are designed to contain human waste and transform it into energy and compost by-products for domestic application and farm input, respectively. The bio-centres are constructed by communities who contribute their labour (skilled and unskilled) and the facility yields a whole range of benefits for its users, the society and the environment in general(Nijaguna, 2006).

Bio-sanitation has closed the loop in the waste management process by turning human waste into a resource. The bio-centres apply ecological sanitation principles to ensure that human waste in ablution blocks is turned into wealth by producing gas through bio-digester systems and producing fertilizer as a by-product. One standard biodigester produces at least $12\text{m}^3$ of bio-gas whereby $1\text{m}^3$ of bio-gas will generate 4,500 – 5,500 Kcal $\text{m}^2$ of heat energy when burning effectively. This heat is sufficient to boil
100 litres of water or light a lamp with a brightness of 60-100 watts for 4-5 hours. Furthermore, 30m$^3$ of biogas is equivalent to 18 litres of diesel oil (Nijaguna, 2006).

The bio-gas is piped to a community kitchen that serves households thereby almost substituting the complete consumption of charcoal and kerosene for the households neighbouring the facility in informal settlements (Nijaguna, 2006).

Estimating an average per capita consumption of 3 kg of wood per day for energy (cooking, heating and boiling water) per household, the daily per capita demand of energy equals to about 6 kWh which could be covered by about 1m$^3$ of biogas. This translates into the conservation of trees in the surroundings of informal settlements. Biogas use, replacing conventional fuels like kerosene or firewood, allows for the conservation of the environment (Nijaguna, 2006). In addition, the containment of human waste reduces the pollution of water bodies.

A bio gas digester effectively reduces the amount of methane directly released into the atmosphere, by trapping it and facilitating its use as a green fuel. The Kenya Agricultural Research Institute (KARI) lab tests have proven that the fertilizer which comes from bio-gas digesters contains triple the nitrogen than the best compost fertilizers made through open air digestion. Bio-fertilizers are cost effective and eco-friendly supplements to chemical fertilizers (Deublein and Steinhauser, 2010). They provide a sustainable source for nutrients and healthy soils and are seen as an important input to urban farming practices evident in the informal settlements. The bio-centres are hygienically established and have provided spaces for petty trading and community
social hall space for mobilizing community savings groups (WASH Africa News, 2009).

2.2 Origin and Development of Bio-centres in Kenya

In Kenya, the development of biogas started in the 1950s with the first biogas plants (Hutchinson Model) being introduced by European Farmers (Nijaguna, 2006). During and after the 1970s oil crisis, more importation of Indian and Chinese type digesters on a larger-scale was undertaken (Deublein and Steinhauser, 2010). Of particular importance was the special energy programmes; a Ministry of Energy project aiming at introducing biogas plants on a household level in rural areas (Boerstler, 2010). Besides providing hardware components, the programme trained local artisans at Meru (Mt. Kenya) who were then send to different agro-forestry and energy centres in various parts of the country in order to disseminate the technology in an under-geographic area (Karekezi, 2002). An estimated 880 household size bio-gas digesters were installed by 1995 of which only 25% were still in use in the year 2003 (Boerstler, 2010).

The bio-centre technology therefore developed from the realisation of the importance of bio-gas technology. The bio-centre uses standard biogas-system designs commonly found in Asian countries such as China, India and Vietnam. The difference between bio-centres and bio-gas digesters is that bio-centres use human waste while bio-gas digesters use animal waste (Deublein and Steinhauser, 2010). The bio-centre is a very simple duplication of what has been used in China and India for years but for the first time, on human waste (Boerstler, 2010). Human waste is used through anaerobic conditions to produce methane gas which can be used for heating or cooking purposes.
Umande Trust as the founder of bio-centres in Kenya was guided by the mission of promoting partnerships CBOs to improve the living conditions of people in places like Kibera. The Trust first set out to build toilets and bathrooms, but had a larger vision: "Total Sanitation and Hygiene Access (TOSHA)" giving birth to the bio-centres in Kenya (WASH News Africa, 2009).

2.3 The Importance of Bio-centres

In 2009, Umande Trust (Kenya) and Goal Ireland submitted the Mukuru bio-centres project which saw them win an honourable mention in the 2009 Buckminster Fuller Challenge. According to the jury report, bio-centres offer an inclusive solution to some of the problems of urban slums such as poor sanitation, lack of clean water and unpredictable or nonexistent energy infrastructure. Bio-centres provide toilets free to children, washrooms and showers at a minimal fee, kiosks selling affordable clean water on the ground floor, and community and livelihood spaces on upper floors (WASH News Africa, 2009).

The bio-centres have a verifiable local impact in the informal settlements where they are majorly found in Kenya. The Bio-centre is a breakthrough to many development challenges such as overpopulation and endemic poverty thus encouraging good hygiene practices (Gratuit, 2011). The benefits derived from a bio-centre often relate to; improved sanitation, odour elimination, treatment on-site, and land saving technologies, useful by-products and cost effectiveness. This is because it treats human waste; offers affordable sanitation; reduces environmental degradation through its
mechanism of reducing carbon emissions and links to hygiene promotion, health and child protection services (Gratuit, 2011).

Varadarajan and Nangia (1995) explains that the bio-centre technology not only arrests the myriad of health, social and environmental problems associated with poor disposal of human waste but it also reduces the energy burden of poor communities as well as introducing new opportunities for income generation and positive socialization amongst inhabitants. In addition, bio-centres provide clean water, public space, and workspace which serves as an incubator for local businesses.

The bio-centres also offer recreational and socialization centres for locals. Bio-centres produce bio-gas which is clean energy with adverse environmental, economic and health benefits. Conducted majorly by Umande Trust, in Kenya the bio-centres enhance community water use, savings, good sanitation practices and hygiene at the household level. As part of the project, the community became owners of the bio-centres constructed by the Umande Trust and other partners provided toilet and bathroom facilities to Kibera slum settlers thus encouraging good hygiene practices (WASH News Africa, 2009).

Last but not least, the bio-centres are of economic use since the residents are able to save money from the use of cheaper and clean energy source (biogas) and indirectly from reduced sanitation-induced illnesses (Varadarajan and Nangia, 1995). The bio-centres have as well come hand in hand in solving human waste disposal and if well utilised has the potential of doing away with the common 'flying toilets' and other
unconventional human waste disposal methods such as open human waste disposal at the dark.

2.4 Socio-Economic Factors Influence on Utilisation and Sustainability of Bio-centres

According to Karekezi (2002), a further replication of biogas is only possible with donor support, government investment subsidies and, or loans owing to its high construction costs. Unemployment and inadequate wages among the employed hinder the ability of slum residents to meet their financial needs, personal and family obligations (Zulu et al., 2002). In the absence of reliable water and sanitation facilities, most families are forced to incur direct out of pocket costs so as to purchase water from vendors, store water or disinfect dirty water by boiling or chemically. The costs of buying water are considerable and affect the economic life of households (Hutton, 2004).

In developing countries, most cities are characterized by a multitude of problems including poverty among residents (Matovu, 2000). The urban poor in Kenya most likely afford housing in the slums. It is estimated that up to 50% of Nairobi’s residents live in these settlements and Kibera slum hosts the majority of the inhabitants. Income for the slum dwellers is low and about two thirds of these residents are estimated to be surviving on less than a dollar a day (Keraka and Wamicha, 2003). Unemployment is also rampant that many slum residents depend on informal sector where they work as casual labourers. The Welfare Monitoring Survey (WMS) indicated that poverty in
urban areas increased by a big margin from about 29% in 1994 to about 50% in 1997 (GOK, 2009).

The lower price of two shillings per 20 litres container is eight times that of the lowest tariff for domestic connections and four times the average tariff in Kenya (WWDR, 2003). It is estimated that in most informal settlements in Nairobi, users pay KShs 6 per 20 litres container or over KShs 500 per cubic metre during water shortage times. This is a rate which is higher than water rates practically anywhere else in the world and twenty times the amount paid for the same volume of water by those with piped connections (WWDR, 2003). The same scenario applies to WATSAN projects such as the bio-centres in which one has to pay in order to use them. Most of the bio-centres charge KShs 5 and 10 for using toilet and bathroom facilities, respectively. The costs associated with these basic WATSAN facilities may hinder utilisation and sustainability of bio-centres in most times.

Women slum dwellers in Kenyan informal settlements pay at least five times more for one litre of water than their counterparts in the United States. In Nairobi alone, the slum dwellers as well pay more for water than their non-slum peers connected to the City supply (IISDA, 2004). The economic capability of a household has a high impact in affecting the choice of decisions individuals undertake and has a direct impact on the environment and WATSAN.

Child mortality are generally more correlated with a lack of access to portable water and sewerage connections than with other commonly cited variables such as the number of households below the poverty line or the availability of health services and
some studies have established strong links between health and environment even when the socio-economic variables are held constant. However, the influence of water and sanitation is related in complex ways to these factors, and the relationship can vary from place to place (APHRC, 2002).

In most cases, a community with limited knowledge about a technology makes it difficult for adoption and sustainability of that technology (World Bank, 1998). There is always a relationship between improvements in education, health, and hygiene awareness and the demand for sanitation facilities. Households with members who have a higher level of literacy are most likely to demand and adopt safer methods of excreta disposal than those with low levels of literacy (United Nations, 1993). The higher levels of literacy are also associated with a high premium placed on health status, which leads to a demand for safer sanitation technologies. Private agencies and NGOs require strong support in the major task of social intermediation and providing extensive training and advice to the community to strengthen its ability to run its own system.

2.5 Socio-Cultural Factors Influence on Utilisation and Sustainability of Bio-centres

Eller (2009) explains culture as a learned phenomenon and ideally newborns have no culture. Basically, culture is an abstraction that we use to refer to many aspects of our ways of living. As children grow older, they learn specific behaviours and patterns of activities appropriate and inappropriate for their culture and they either adopt or reject those cultural values and morals. In fact, many psychologists agree that many
psychological processes- attitudes, values, beliefs, personality, cognition- are inherently constructed by culture, that is, they are so intertwined and infused with cultural influences that it does not make sense to understand them outside of a cultural context (Eller, 2009). Culture is therefore an adaptation response to three factors- ecology, resources and people (Matsumoto and Linda, 2012). All the three factors combine to produce ways of living. Understanding the influence of culture, therefore, requires us to adopt a relatively more sophisticated way of understanding and explaining human behavior (Matsumoto and Linda, 2012).

Cultural beliefs usually have a strong impact on sanitation and even on the possibility of talking about WATSAN. In many cultures, handling of excreta is considered as a taboo and viewed as a disgusting or dangerous nuisance to be discussed with no one willing to be associated with excreta (WHO, 2000). For instance, in some cultural background, it is a taboo to share sanitation facilities between adults and children, men and women and in-laws and outsiders in general (United Nations, 1993). Based on the understanding and cultural diversity priority in WATSAN projects can hinder the effective and efficient utilisation and sustainability of the bio-centres.

Poor social acceptance especially when animal waste or human waste is used is also considered a major limitation for the adoption of biogas as a cooking fuel (Boerstler, 2010). Taste preference when cooking with biogas was encountered through a donor supported project on the Kibungua Hills at the Kenyan coast. The women groups running the biogas plant mentioned that they did not like the food prepared with a newly installed biogas stove as it did not have a ‘smoky food taste’ (Boerstler, 2010).
Boerstler (2010) revealed that the lack of adequate information on biogas technology was the highest cause of non-adoption for farmers in Central Kenya. He also noted that majority of farmers have not been introduced to any technology promoters and therefore have no knowledge on biogas technology. There are as well unresolved questions of how visualizations actually prompt the human mind to creative thinking.

2.6 Impact of the Bio-centre Design and Location on their Utilisation and Sustainability

Despite the recognition of water as a basic and inalienable human right, that should be accessible to all individuals, access to this resource continues to elude many women around the world (WWDR, 2003). Approximately 2.2 million people in developing countries die each year from diseases associated with the lack of access to sufficient WATSAN projects (WSSCC, 2004) with the hardest hit being the women. Women unlike their male counterparts spend over 8 hours walking for long distances fetching water (UNIFEM, 2003) owing to their responsibilities. As other economic options diminish, economic desperation pushes women to rely on sexual relations to increase their economic security (Akuffo, 1987).

Gas produced in bio-centres usually does not get stored when not in use and the sludge outlet acts as a mosquito breeding ground, hence a health hazard. There is a danger of someone falling in to the dome through the sludge outlet because it is not covered. The tank should be covered with a net and a concrete/ Ferro-cement slab should also be placed upon the tanks. To prevent the breeding of mosquitoes in the sludge outlet, fish
can be added to the outlets. Engine oil can also be used for this purpose (Mula and Tilbury, 2011).

2.7 Summary and Gaps Identified

From the literature review, it was clear that there is a lot of literature on water and sanitation services in the informal settlements and its implications but little literature on the determinants of utilization of bio-centres and their sustainability. The study therefore sought to establish the factors that influence the utilisation and sustainability of bio-centres. The results of this study form background information for enhancing the utilisation and sustainability of bio-centre facilities in the informal settlements.
CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter presents detailed discussion of the area of study, the research design, and target population, sample size, sampling procedure and data collection and analysis methods used in investigating the study problem.

3.2 Area of study

The name Kibera was derived from a Nubian word “Kibra” which means “forest”. Initially Kibera grew as a village housing the Nubian soldiers of the demobilized armies of the British East Africa at the end of the Second World War (UNDP, 2004). Later as rural to urban migration increased, many people started moving in to the area where they put up temporary structures to live in. With time, initial inhabitants of the land slowly gained various forms of rights to the land and began building mud-and-wattle structures for renting.

Kibera has an estimated population of 170,070 comprising of people from all over the country and one Sudanese tribe which is the Nubians (KNBS, 2010). The cosmopolitan population has varied background, traditions and values. Kibera is situated South West of Nairobi and has a total of 16 operational bio-centres serving its 13 villages namely; Makina, Mashimoni, Line Saba, Silanga, Kambi, Mhuru, Gatwikera, Kianda, Lindi, Kisumu Ndogo, Soweto, Raila and Karanja.

This research was done in the thirteen villages of Kibera slums. This is because; the bio-centres were first practiced in Kibera before being replicated to other areas in
Kenya. Despite the bio-centres being practiced in other parts of the country, this research focused on Kibera slums only; so as to enable the researcher get adequate information in the area.

3.3 Research Design

A descriptive survey was used to examine factors influencing utilisation and sustainability of bio-centres in Kibera slums. Nichols (1991) explains a survey as “an attempt to collect data from members of a population with respect to one or more variables”. The survey design was used due to its suitability in the collection of broad data from a large sample of respondents within a short duration. According to Mugenda and Mugenda (1999) a survey design is a means that seeks to obtain information that describes an existing phenomenon by asking individuals about their attitudes, perceptions, behavior and values. In survey studies, conclusions are made in terms of associations and not about cause and effect of phenomenon and can be essential tool for assessing a situation or activity (Nichols, 1991).

Both primary and secondary data were instrumental in this research. Questionnaires (Appendix 1), in-depth interview guide (Appendix 2) and field observation check list (Appendix 3) was used to collect quantitative data. Each item in the questionnaire was to address the specific objective of the study. The instruments were pretested at Laini Saba village which is among the thirteen villages studied. It emerged during the pretesting that the language of the questionnaires lost meaning when translated in to Swahili language. The questionnaires were further revised carefully, language simplified for understanding and the questions were asked in a different manner
without distorting the intended meaning. The researcher administered the questionnaires. The meaning of the questions and key concepts were explained to the respondents in Swahili language.

3.4 Target Population

The targeted population was the residents of Kibera consisting of both men and women who have lived in Kibera since 2007 when the bio-centres begun. According to the 2009 census report, Kibera has a total of 170,070 residents (GoK, 2009) who formed the total target population for information gathering using the questionnaires. To add, the operators/ workers of the bio-centres, groups managing the bio-centres, local area chief, and institutions who have provided support in constructing the bio-centres were as well targeted as key informants.

3.5 Sample Size and Sampling Procedure

A total of 143 respondents were interviewed using the questionnaire (Appendix 1). The sample size was calculated using Creative Research Systems (CRS) software method. Creative Research Systems was founded in 1982 to provide software for market researchers, political pollsters, human resource professionals, social scientists, and others who use questionnaires to gather information. The CRS formula is used to determine how many people you need to interview in order to get results that reflect the target population as precisely as needed. You can also find the level of precision you have in an existing sample using the CRS formula. In this particular data the level of precision was 95% employed against the total population in Kibera (170,070) as per the 2009 population census resulting to a sample size of 143 respondents.
Respondents interviewed using the questionnaire was sampled using cluster method of sampling and entailed 11 people being interviewed using questionnaires from each of the 13 villages of Kibera regardless of the varying population in each of the villages. Cluster sampling is a technique used when "natural" but relatively homogeneous groupings are evident in a population. In this technique, the total population is divided into these groups (or clusters) and a simple random sample of the groups is selected (Frankel and Wallen, 2000). This method was applied so as to enable the researcher get a certain number of the respondents to be interviewed in each of the thirteen villages in Kibera. The respondents, however, were the ones who have lived in Kibera since 2007 when the bio-centres were introduced in the area.

Simple random sampling was used to select the 11 respondents from each village and entailed a random sampling of the people to be found in Kibera during data collection period. Simple random sampling is that method of drawing a portion (sample) of a population so that each member of the population has equal chance of being selected (Kerlinger, 1964). Simple random sampling was employed to enable the researcher further narrow down in getting the specific respondents in the each of the villages in Kibera with an objective of gathering highly representative information.

Purposive sampling was done with the objective of identifying the key informants to be interviewed through in-depth interview guide. Purposive sampling is where a researcher uses personal judgement to select a sample based on knowledge and specific purpose of research (Frankel and Wallen, 2000). A total of 10 key informants were sampled to provide key information. The key informants interviewed comprised of four operators/ workers from the bio-centres and four representatives from the groups
managing operations of the bio-centres in Kibera. The operators/ workers from the bio-centres and the groups managing the bio-centres represented 25% of the total number of bio-centres. The area chief was interviewed based on his experience and knowledge about Kibera. In addition, one key informant from Umande Trust was interviewed owing to their invaluable contribution to the bio-centres development in Kibera.

3.6 Data Collection Methods

Data collection included both qualitative and quantitative design to allow both statistical and non-statistical data to be collected for interpretation to give meaning of the research. Data was specifically collected using questionnaires (Appendix 1), in-depth interviews (Appendix 2) and field observation checklist (Appendix 3).

The questionnaires were employed in getting information relating to the factors that influence the utilisation and sustainability of bio-centres. Open-ended questions were particularly used to allow for a greater depth of responses and give an understanding of feelings, lifestyle, interests and decisions of the respondents. Rating of responses and measuring of attitudes and feelings was done using a 5 and 3 point scale.

A systematic interview schedule for the key informants was used to gather qualitative information using both open-ended and closed-ended questions. This provided an opportunity to discuss issues not considered in the questionnaire and the interview design to provide unique understandings to the phenomenon of utilisation and sustainability of bio-centres.
The field observation checklist involved writing of the design of bio-centres in a systematic manner to assess the condition and adequacy of the bio-centres.

The questionnaire was pre-tested to appraise the clarity of questions and to ensure that the questions are reliable and valid before carrying out the research. This was done among 10 people from the study area. The responses from the pre-test were not included in the final analysis.

3.7 Data Analysis Methods

Data gathered from questionnaires was edited, coded and subjected to descriptive statistics for calculation of frequencies, means and percentages. Specifically, Statistical Package for Social Sciences (SPSS) was used to analyse quantitative data. SPSS is an essential feature of statistical analysis for many social science researchers and can aid in quantitative data handling. Pie-charts, tables and graphs were used to present the results.

Descriptive statistical of means, percentages and frequencies was used to describe and summarize data collected through all the data collection tools. Descriptive statistics is the term given to the analysis of data that helps describe, show or summarize data in a meaningful manner through statistics and graphs.

Regression analysis was also employed to analyse quantitative data through the evaluation of the relationship between different dependent and independent variables.
CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results of the research findings and analysis of data collected in the view of the stated hypothesis. The analysis of the data has been presented under different headings grouped together according to the hypothesis of the study. The purpose of this study was to examine the factors that determine utilisation and sustainability of bio-centres in Kibera slums. Responses were received from 143 respondents (63 Male and 80 Female) and ten key informants.

4.1 Socio-Demographic Factors of the Respondents

4.1.1 Gender

The sampled population consisted of both male and female respondents. Male respondents formed 44% of the total respondents compared to 56% of female respondents. The data was collected during the day when a number of the residents are at their different work places. While the majority of the workers being the male counterparts, this might have resulted in the highest number of respondents being the female gender.

Table 4.1 Gender of the Respondents

<table>
<thead>
<tr>
<th>Gender</th>
<th>Frequency (N)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>63</td>
<td>44</td>
</tr>
<tr>
<td>Female</td>
<td>80</td>
<td>56</td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>100</td>
</tr>
</tbody>
</table>
4.1.3 Level of Education

Education is widely seen as one of the most promising paths for individuals to realize better, more productive lives and as one of the primary drivers of national economic development (GoK, 2007). The citizens and the government of Kenya have invested heavily in improving both the access and quality of education, in an effort to realize the promise of education as well as to achieve the education-related Millennium Development Goals and Vision 2030.

The findings of this research elucidated that, 51% of the population in Kibera has secondary education, 41% has primary education, six percent of the respondents has college education while only two percent has university education. The low levels of education can be associated with the indecent jobs performed by majority of the population and the low household incomes in the study area. The low levels of education may also be linked with little knowledge on the importance of proper water and sanitation procedures hence influencing the choice of using the bio-centre facilities.

Table 4.2 Highest Level of Education

<table>
<thead>
<tr>
<th>Highest level of education</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>58</td>
<td>41</td>
</tr>
<tr>
<td>Secondary</td>
<td>73</td>
<td>51</td>
</tr>
<tr>
<td>College</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>University</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>100</td>
</tr>
</tbody>
</table>

It is presumed that formal schooling is one of several important contributors to the skills of an individual and to human capital. It is well established that the distribution
of personal incomes in society is strongly related to the amount of education people have had. In an ideal society, more schooling means higher lifetime incomes which emerge over the long term.

4.2 Socio-Cultural Factors Influencing Bio-centres’ Utilisation and Sustainability

Cultural beliefs have a strong impact on sanitation and even on the possibility of discussing about sanitation. Culture refers to learned aspects which are passed from generation to generation and may include taboos, beliefs and practices (Eller, 2009). In some cultures, the possibility of handling excreta is considered a taboo and viewed as disgusting or a dangerous nuisance which should not be discussed and people do not want to be associated with excreta (WHO, 2000). This could be linked with contributing to neighbours and relatives unable to discourage the habits of disposing excreta on trenches and roads.

Ethnic background shapes a person’s interpretations, responses, options and behaviours. However, ethnic experiences are also filtered through that group’s history, religion, physical characteristics, social class and minority class experiences of persecution, oppression, discrimination, inequity, hostility or acceptance (Eller, 2009). As per information from four of the key informants, cultural beliefs, taboos and practices still play a role in determining the choice of using sanitation facilities in Kibera. Ethnic background and culture can adversely affect the choice on utilization of the bio-centres.

There are some cultural aspects for instance restrictions on sharing sanitary facilities between adults and children, men and women, in-laws and outsiders in general (United
Nations, 1993). This study focused on the cultural aspects of the respondents such as ethnic background and the social aspects such as knowledge of development projects in relation the usage of bio-centre facilities.

4.2.1 Ethnic Background of the Respondents

Ethnic and culturally sensitive practices reflect awareness that ethnic/cultural group’s history, have an impact on the way that problems arise and are solved. Ethnicity refers to a shared common identity and helps determine thoughts, feelings, behaviour in both subtle and obvious ways (McGoldrick et al., 1996). The initial inhabitants of Kibera were Nubians who were soldiers of the demobilized arms of British East Africa at the end of Second World War in 1947. The Nubians formed 10% of the study population with the rest forming representatives of dominant ethnic groups in Kenya (UNDP, 2004). Since the Kisumu-Nairobi railway passes through Kibera, this might have contributed to the Luo community forming the largest percentage (40%) of the respondents. Despite the various tribes representing a cosmopolitan society, various tribes in the Kibera formed the largest percentages in various villages. For instance, in Kisumu Ndogo, there were nine Luo respondents and two Luhya’s interviewed while in Katwekera, only one of the respondents was a non Luo out of a representation of 11 respondents per village. To add, in Soweto East village Kikuyus were the majority forming five out of the eleven respondents interviewed. Nevertheless, some of the other villages were mixed up with almost uniform tribes’ representation such as Mashimoni, Silanga, Kambi Mhuru and Kianda. Table 4.3 below represents the ethnic backgrounds of the respondents.
Table 4.3 Ethnic Backgrounds of the Respondents

<table>
<thead>
<tr>
<th>Tribe</th>
<th>Frequency (N)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamba</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Kikuyu</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>Kisii</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Luhya</td>
<td>27</td>
<td>19</td>
</tr>
<tr>
<td>Luo</td>
<td>57</td>
<td>40</td>
</tr>
<tr>
<td>Nubian</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>Suba</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Somali</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>100</td>
</tr>
</tbody>
</table>

This kind of data was important in assessing whether the different ethnic background impacted on the utilisation and sustainability of the bio-centres through cultural beliefs. The area of study is cosmopolitan as per the various tribes found in the area which resulted to 85% of the respondents noting that social and cultural factors do not affect their choice of using the bio-centres. Nevertheless, 15% of the respondents indicated that cultural beliefs have a strong impact on the choice of using the bio-centre facilities and specifically the toilet facility.

The research confirmed that aspects of culture affect sanitation and it further elucidated that the greatest contributor of human faeces on trenches is due to the cultural belief in families. Given that the children are not allowed to share the facilities with other members of their families, they end up relieving themselves on the trenches or roads. This happens even with families that have their own facilities in the compound. The same sentiments were reported by respondents who had their own facilities.
Social work practice therefore needs to be informed by knowledge of the ways in which ethnic realities influence individuals (Schlesinger and Devore, 1995). These diverse realities result in individual differences of interpreting and responding to situations, views of the “helping” professions, conceptualizations of self-efficacy and perceptions about reasonable alternatives and solutions.

4.2.2 Knowledge on Bio-centres

The research implied that 27% of the interviewed respondents did not know any bio-centre operating in Kibera while 73% percent of the respondents knew one or more bio-centres operating in Kibera. It was noted that all the respondents from Soweto West, Katwekera and Laini Saba villages knew one or more bio-centres operating in Kibera. Kisumu Ndogo and Raila villages formed the largest percentage of respondents who never knew any bio-centre operating in Kibera at the time of the interview. Kianda and Kambi Mhuru villages followed closely with almost half of its respondents not aware of any bio-centre operating in Kibera as shown in table 4.4.

<table>
<thead>
<tr>
<th>Village</th>
<th>Frequency (N)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soweto East</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Kichinjio</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Kisumu Ndogo</td>
<td>8</td>
<td>21</td>
</tr>
<tr>
<td>Lindi</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Kianda</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Kambi</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Mashimoni</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Raila</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>Makina</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Silanga</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>100</td>
</tr>
</tbody>
</table>
Awareness of facilities and development initiatives is important in determining the choice of using a facility. Initiatives to make community members aware of any development activities should be a key component in any development initiative. This will enhance the ability of the specific community members to use the facilities hence enhancing the facilities' ability to meet the laid down objectives.

4.2.3 Usage of Bio-centres

Despite 73% of the respondents having knowledge of the existence of the bio-centres in Kibera, only 58% of the respondents have used the bio-centres while 42% have never used any of the bio-centres.

The toilet facility has been the most used forming 44% usage while the bathroom is the second most used facility forming 18% of the respondent’s usage. It is worrying to note that 42% of the respondents have never used the bio-centre facilities despite 73% of the respondents having the knowledge on the availability of the bio-centres. This may be linked with the cultural aspects discussed above which limit the sharing of key sanitation facilities such as the toilet facility which has had 44% usage by the respondents. The low usage of the bio-centre facilities may be as well associated with the alternative methods that the locals have such as bathing inside the mad floor houses. The residents who bathed inside their houses said that the water made their floor soggy. Other aspects which have affected the usage of the bio-centre facilities include the long distances from the respondent’s houses to the bio-centres and the fees charged to the bio-centres as discussed in subsequent sections.
The use of the bio-gas is very low (7%) despite its contribution to reduced GHG as demonstrated in figure 4.1 below. This might be attributed by its limited space to use the utility. Most bio-gas utilities can only accommodate two users at a time.

![Figure 4.1 Usage of Bio-centre Facilities](image)

4.2.4 Relationship Between Socio-Cultural Variables and Utilization of Bio-centres

Regression analysis was employed on six variables to elucidate the relationship between Socio-Cultural variables of the respondents and the utilization of Bio-centres in Kibera. The variables investigated in the model were gender, ethnicity, village of residence, duration of stay, highest level of education, knowledge about bio-centre existence and the number of bio-centres the respondents were aware of. Among the variables investigated, the village of residence, duration of stay, knowledge about bio-centre existence and the number of bio-centres were positively significant (P<0.05, 95% confidence levels) as shown in Table 4.5 below. The results showed that village of residence were significance to utilisation of bio-centres. This can be explained by
the fact that some of the villages had more bio-centres as compared to others which did not have thereby affecting utilization of bio-centres. The duration of stay was also found to be significance mainly because this determined the knowledge about the area and availability of new developments. Knowledge about bio-centres and the number of bio-centres a respondent was aware of was also found to be significant and this compares well with United Nations (1993) which showed that the knowledge and awareness of development projects highly determines utilisation.

Table 4.5 Relationship between Socio-cultural Variables and Bio-centre Utilisation

<table>
<thead>
<tr>
<th>Utilisation of bio-centres by socio-cultural factors</th>
<th>Standard error</th>
<th>Intercept</th>
<th>Variable</th>
<th>P</th>
<th>R Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender of respondent</td>
<td>0.083</td>
<td>1.425</td>
<td>-0.0123</td>
<td>0.888</td>
<td>0.000153</td>
</tr>
<tr>
<td>Ethnicity of respondent</td>
<td>0.024</td>
<td>1.400</td>
<td>0.0055</td>
<td>0.823</td>
<td>0.000356</td>
</tr>
<tr>
<td>Village of residence</td>
<td>0.011</td>
<td>1.245</td>
<td>0.0289</td>
<td>0.008*</td>
<td>0.04825</td>
</tr>
<tr>
<td>Length of stay</td>
<td>0.007</td>
<td>1.643</td>
<td>0.0319</td>
<td>0.001*</td>
<td>0.127142</td>
</tr>
<tr>
<td>Highest level of education</td>
<td>0.059</td>
<td>1.433</td>
<td>-0.0236</td>
<td>0.690</td>
<td>0.001129</td>
</tr>
<tr>
<td>Knowledge about bio-centres</td>
<td>0.069</td>
<td>0.464</td>
<td>0.7540</td>
<td>0.003*</td>
<td>0.456267</td>
</tr>
<tr>
<td>Number of bio-centres aware of</td>
<td>0.018</td>
<td>1.775</td>
<td>0.1884</td>
<td>0.003*</td>
<td>0.434281</td>
</tr>
</tbody>
</table>

P<0.05, 95% Confidence level

The regression also showed that there was no relationship between the gender, ethnicity, and level of education for the respondents. The results were contrary to the United Nations (1993) study which found that level of literacy are most likely to
demand and adopt safer methods of excreta disposal and water than those with low levels of literacy. This can be explained by the fact that most of the residents who didn’t use the bio-centre facility as well used other excreta disposal and water methods and majority had the same services in their houses thus nullifying a significance relationship between the levels of literacy and utilisation of bio-centres. Lack of significance between the relationship of ethnicity to the utilisation of bio-centres can be attributed to the fact that the area is a cosmopolitan area. The results therefore generally elucidated that, the use of bio-centre facilities in Kibera is not dependent on the gender, ethnicity or level of education of the respondents but rather is dependent on the village of residence, duration of stay, knowledge of bio-centre facilities and the number of bio-centre facilities an individual was aware of. The results further implied that the number of bio-centres per village should be increased so that the usage of the same increases. This research also implied that there is need for more awareness on the availability and importance of the bio-centres so as to increase its utilisation.

4.3 Socio-Economic Factors Influencing Utilisation and Sustainability of Bio-centres

4.3.1 Household Characteristics
The research implied that 11% of the respondents were self-employed and engaged in small scale business such as selling second hand clothes or other items such as vegetables along the road side. On average, the household number for majority of the dwellers is four. The highest household number is six while the lowest is one comprising of single young men and women. The highest monthly household income for 46% of the respondents was between 5,001 to 10,000 Kenya shillings while two
percent of the respondents indicated that their highest monthly income range between 15,001 and 20,000 Kenya Shillings. 34% of the respondents indicated that their highest monthly income was 5,000 and below while 18% indicated that their highest monthly income was between 10,001 and 15,000 Kenya Shillings as shown below.

Figure 4.2 Total Monthly Household's Incomes

The price of using a single bio-centre facility ranges between five to ten shillings for adults, while for children it is free. This implies that assuming an average household comprising of two adults, uses five shillings each to assess one bio-centre facility such as the toilet five times in a day, the household would require 1,500 shillings on a monthly basis to pay for the services. Comparing with the household incomes, this amount is high for the residents of the slum areas which may hinder the usage of the bio-centre facilities thereby becoming difficult to attain the set objectives for the bio-centre facilities.
4.3.2 Affordability of the Bio-centre Facilities

42% of the respondents indicated that the bio-centre facilities were affordable. The most affordable facility was the toilet facility followed closely by the bathroom facility with twenty six percent and twenty five percent respectively as shown in table 4.6 below.

Table 4.6 Affordability of Bio-centre Facilities

<table>
<thead>
<tr>
<th>Facility</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathroom</td>
<td>26</td>
</tr>
<tr>
<td>Toilet</td>
<td>25</td>
</tr>
<tr>
<td>Biogas</td>
<td>21</td>
</tr>
<tr>
<td>Water</td>
<td>20</td>
</tr>
<tr>
<td>Recreational facilities</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

This results substantiates findings by AMREF (1998), indicating that high fees paid to water vendors and sanitation facilities in the slums represent a major fiscal burden on the urban poor.

4.3.3 Cost of Water in Kibera

The quantity of water delivered and used for households is an important aspect of domestic water supplies, which influences hygiene and therefore public health. To date, WHO has not provided guidance on the quantity of domestic water that is required to promote good health. WHO defines domestic water as being 'water used for all usual domestic purposes including consumption, bathing and food preparation'(WHO, 2000).
The research findings revealed that 67% of the respondents buy 20 litres of water at a cost of between five and ten shillings. The actual cost of water in the informal settlement fluctuates according to availability and locations. Assuming that each household uses 40 litres of water daily, this translates to 600 Kenya Shillings every month. On average, municipal water connection users pay a total of 200 to 400 Kenya Shillings monthly which is lower than the 60 Kenya Shillings that slum dwellers have to pay to access the same facilities.

In addition, the slum dwellers spend significantly a greater proportion of their income and time on water than do the rich. The price they pay for the water is often ten times or more of the tap price. The results on cost of water and sanitation compares with those of Thompson et al. (2002), that, residents of informal settlements spend more money on water compared to their counterparts with piped water.

4.3.4 Relationship Between Economic Factors and Bio-centre Utilization

Regression analysis was also employed on the household income and the cost of using various bio-centre facilities namely bathroom, toilet, water, bio-gas and recreation facilities to find out if each of the factors had any influence on the utilisation of bio-centre facilities in Kibera. The results showed that household income had no significant relationship with the utilisation of bio-centre facilities. On the other hand, the results showed that the cost of using the various bio-centre facilities namely bathroom, toilet, water, bio-gas and recreation facilities were all significant factors, (P<0.05, 95 confidence levels). Findings are represented in Table 4.7 below
Table 4.7 Relationship between Economic Factors and Utilisation of Bio-centres

<table>
<thead>
<tr>
<th>Utilisation of bio-centres by economic factors</th>
<th>Standard error</th>
<th>Intercept</th>
<th>Variable</th>
<th>P</th>
<th>R Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household income</td>
<td>0.0487</td>
<td>1.412</td>
<td>0.0097</td>
<td>0.8429</td>
<td>0.000279</td>
</tr>
<tr>
<td>Cost of using bio-centre bathroom</td>
<td>0.0371</td>
<td>0.155</td>
<td>-0.9136</td>
<td>0.0052*</td>
<td>0.811265</td>
</tr>
<tr>
<td>Cost of using bio-centre toilet</td>
<td>0.0348</td>
<td>0.134</td>
<td>-0.9326</td>
<td>0.0081*</td>
<td>0.839326</td>
</tr>
<tr>
<td>Cost of using bio-centre water</td>
<td>0.0521</td>
<td>0.283</td>
<td>-0.7701</td>
<td>0.0007*</td>
<td>0.607496</td>
</tr>
<tr>
<td>Cost of using bio-centre biogas</td>
<td>0.0561</td>
<td>0.338</td>
<td>-0.7295</td>
<td>0.0001*</td>
<td>0.542463</td>
</tr>
<tr>
<td>Cost of using bio-centre recreational facilities</td>
<td>0.0974</td>
<td>0.771</td>
<td>-0.3622</td>
<td>0.0003*</td>
<td>0.089324</td>
</tr>
</tbody>
</table>

P<0.05, 95% Confidence level

The findings from the regression model indicated a negative significant relationship between using the cost of various bio-centre facilities namely bathroom, toilet, water, biogas and recreational facilities. This implies that if the cost of increases, the usage of bio-centre facilities namely bathroom, toilet, water, biogas and recreational facilities reduces.

The household income had no significant relationship with the utilisation of bio-centre facilities since the some of the highest earning households had their own latrines and other facilities and rarely used the bio-centre facilities.
The results therefore generally implied that, the use of bio-centre facilities in Kibera is not dependent on household income but rather is dependent on the cost of the various bio-centre facilities namely bathroom, toilet, water, bio-gas and recreation facilities. This therefore denotes that for maximum utilisation of the bio-centre facilities, the cost of the various bio-centre services need to be reduced to enhance affordability and to increase the usage of the facilities.

4.4 Impact of Bio-centres' Design and Location on their Utilisation and Sustainability

This study focused on the distribution of the bio-centres in relation to ease of access to the facilities by the residents. In addition, this research focused on the quality and physical status of the various bio-centre facility components such as the toilet, the bio-gas, the bio-digester and the bathroom components. This also entailed questions relating to the distance taken to the nearest bio-centre facility. In addition, the research focused on the availability and reliability of the water provided by the bio-centre kiosk including the quality and quantity of water from the bio-centre. This research also focused on the type of management practiced on the bio-centre facilities. The research did not focus on the structural outlook of the facilities. The findings of the design and location of the bio-centres are as discussed below.

4.4.1 Water Sources

38% of the residents use communal municipal connection. Despite the bio-centres being a new technology, 15% of the residents use the bio-centre water kiosk as its water source. Though 93% of the residents supplement water during water shortage
through water vendors, the respondents indicated that water from the vendors is unsafe and usually at a high price. However, the respondents added that the water from the bio-centres is not reliable since it faces frequent water shortages, the bio-centre water kiosks are inaccessible, few and often far. The respondents recommended that there is need for bigger water tanks to reduce water shortages. The bio-centre water tanks range between 1,000 to 10,000 litres which limit its ability to supply water during water shortages. The bio-centres should be fitted with tanks with capacity to store water for a longer duration in times of water shortages.

![Figure 4.3 Sources of Water](image)

67% of the respondents also indicated that the bio-centre kiosks are located at far distance from their houses thereby hindering the usage of the same. The bio-centre water points are approximately 500 metres and 1.5 kilometres from the respondents’ houses. The long distances travelled to fetch water impact negatively on the usage of the bio-centre water facilities and therefore more bio-centres should be constructed to improve accessibility. The iconic image of residents carrying water on their heads is
exemplary of a lifelong burden that keeps young boys and girls from attending school, prevents women from engaging in productive work and restraints progress towards the Millennium Development Goals (MDGs) on universal primary education and gender equality.

In terms of water quality, 68% of the respondents indicated that water from city council connection was clean and safe. This was further confirmed by the researcher through field observation. Only 20% of the respondents indicated that water from the bio-centre kiosk was clean and safe while 24% of the respondents indicated that water from the direct municipal connection was clean and safe. Since 80% of the residents did not rate the water from the bio-centre kiosk as safe and clean, this may inhibit the usage of the same. This is an indication that the residents are realizing the importance of practicing good hygiene.

On contrary, 91% of the respondents indicated that water from the water vendors was unclean and unsafe for use adding that actually they were unsure of the quality of the water. It was noted that the water vendors are the major supplement during water shortage due to its availability but indicated that the water is usually sold at a high cost.
80% of the respondents used approximately 40 litres of water for a day’s activities ranging from bathing, washing clothes, drinking and preparing meals. According to the World Bank (1990), 61% of Kenyans in urban areas have no access to safe water and sanitation. As such, Kibera is no exception. Thompson et al. (2002) in the study on environment and urbanization shows that the quantity of water per capita depends on the accessibility of the water source. Those having access through a house or yard connection or through a well inside the property will use larger quantities of water than those having to fetch water from outside, even if such a source is only a few minutes from the house.

4.4.2 Disposal of Human Waste

The findings from this study show that 50% of Kibera residents use the bio-latrines to dispose their human waste. 27% of the residents use latrines which they have to pay for. The use of polythene bags in Kibera is still evident as 22% of Kibera residents still
uses “flying toilets” to dispose their human waste. The use of forest or the bush usually at night is low with only one percent of the residents using the forest or bush to dispose-off their human waste as indicated by table 4.8 below;

Table 4.8 Disposal of Human Waste

<table>
<thead>
<tr>
<th>Facility</th>
<th>Frequency (N)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio-latrine</td>
<td>71</td>
<td>50</td>
</tr>
<tr>
<td>Latrines</td>
<td>39</td>
<td>27</td>
</tr>
<tr>
<td>Polythene bags</td>
<td>31</td>
<td>22</td>
</tr>
<tr>
<td>Forest/ bush/ shrubs</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>100</td>
</tr>
</tbody>
</table>

4.4.2.1 Human Waste Disposal Before the Onset of Bio-centres

The research findings elucidated that before the onset of bio-centres in Kibera, 49% of the residents used polythene bags for human waste disposal as illustrated in the chart below.

Figure 4.5 Human Waste Disposal Methods Before the Onset of Bio-centres
With the onset of the bio-centres, the use of unconventional human waste disposal such as use of polythene bags, forest or bush and open spaces have reduced as evident by the research findings on the current usage of bio-latrines and latrines in the area as explained above. Despite the tremendous shift to usage of both latrines and bio-latrines, 57% of the respondents take a minimum of ten minutes to the nearest bio-centre while 27% of the respondents take a minimum of 20 to 60 minutes to the nearest bio-centre thereby compromising proper utilisation and sustainability of the bio-centres.

According to the Roth (1988), 2.6 Billion people around the world lack access to hygienic toilet with the United Nations hoping to halve this figure by 2015, as part of its Millennium Development goals (MDGs). This had earlier been observed by a research carried out by AMREF (1998) which showed that only ten latrines were working in Laini Saba village of Kibera with a population of 40,000 people (UN Habitat, 2007).

4.4.3 Physical Status of the Bio-centre Components

The study focused on the cleanliness, safety and the closeness of the bio-centre facilities. Safety from the study was defined as the freedom from danger, risk, or injury associated with the use of bio-centres such as theft and rape cases. Closeness was defined by the distance and the time taken to the nearest bio-centre facility. Cleanliness was defined as the neatness and free from dirt. 62% of the respondents indicated that the bio-centres are clean while 44% indicated that the bio-centres are safe. However a
90% of Kibera residents indicated that the bio-centres are not close as indicated in table 4.9 below.

**Table 4.9 Assessment of Physical Status of Bio-centres**

<table>
<thead>
<tr>
<th>Description</th>
<th>Frequency (N)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Clean</td>
<td>89</td>
<td>62</td>
</tr>
<tr>
<td>Safe</td>
<td>63</td>
<td>44</td>
</tr>
</tbody>
</table>

The limited number of bio-centres in this area, the long distances to facilities and the uncertainty of safety for the services limit the number of users of the services. According to Table 4.7 above, only 10% of the respondents could easily access bio-centres. In addition, 54% of the respondents indicated that the distance from the bio-centres dictate the frequency of visiting the bio-centre for disposing human waste. The distance travelled could be negatively contributing towards utilisation of the bio-centres. From observation and interviews, bio-centres were inadequate. One of the key informants noted that, majority of the bio-centres are located in certain slum areas and therefore inhibiting other users who are willing to use the bio-centre facilities.

From the observations made by the researcher, the sludge outlet is often left open. The sludge outlet therefore acts as a mosquito breeding ground, hence a health hazard. There is also a danger of someone falling in to the dome through the sludge outlet because it is not covered.

The bio-gas produced in bio-centres usually does not get stored when not in use and therefore losing its economic purpose. The bio-gas is designed in such a way that it can hardly accommodate large numbers of users since it has only two cooking outlets. This
makes it difficult for users since they have to wait for each other to finalise cooking.

One of the key informants recommended that, more research be undertaken to explore avenues in which the bio-gas produced could be stored in gas cylinders or how the bio-gas could be connected to the various houses for ease of usage.

4.4.4 Perception towards Bio-centres

The satisfaction of the bio-centres is relatively low with 33% of the respondents indicating that they are very satisfied with the bio-centres while 27% indicated that they are some-how satisfied. It is worrying that 40% of the respondents has inadequate knowledge about the bio-centres and therefore could not rate their satisfaction towards the bio-centres. Nevertheless, 47% of the respondents indicated that the bio-centres were important while 35% of the respondents indicated that the bio-centres were very important. Only one percent of the respondents indicated that the bio-centre was not important while 17% could not rate the importance of the bio-centres.

4.4.5 Management of Bio-centres

The manner in which a utility is managed matters a lot since this gives a sense of ownership and leadership. Proper management of facilities is essential for sustainability and proper utilization of bio-centre facilities. Comparing the management of the bio-centres by the residents and community groups, the management by groups is better than that by the residents. 72% of the respondents rated the management of the bio-centres under the community groups as good or very good as compared to the management by residents where only 33% of the respondents gave similar rating as shown in Table 4.10 below;
From observation, a number of the bio-centre bathrooms have been converted to storage areas, some storing sand and other building materials. This poses a challenge on the facilities meeting their set objectives. Eight of the ten key informants also echoed that management of the bio-centre facilities is best done by the groups.

The success of any initiative depends heavily on the effectiveness of its management. Good management makes the right decisions and ensures that a facility is able to exploit any opportunities open to it.

### 4.4.6 Relationship Between Bio-centre Design and Location on its Utilisation

Regression analysis was employed on the bio-centre design and location variables (bio-centre closeness, cleanliness, safety and the walking time to the bio-centre) to find out whether they have any relationship with utilisation of bio-centres in Kibera. All these factors were found to have a significant relationship with utilisation of bio-centre facilities in Kibera as shown in Table 4.11 below (P<0.05, 95% Confidence Level)
Table 4.11 Relationship between Bio-centre Design and Location on its Utilisation

<table>
<thead>
<tr>
<th>Utilisation of bio-centres by design and location factors</th>
<th>Standard error</th>
<th>Intercept</th>
<th>Variable</th>
<th>P</th>
<th>R Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio-centre closeness</td>
<td>0.064</td>
<td>0.8266</td>
<td>0.2684</td>
<td>0.0476*</td>
<td>0.111062</td>
</tr>
<tr>
<td>Bio-centre cleanliness</td>
<td>0.036</td>
<td>0.7959</td>
<td>0.3812</td>
<td>0.0214*</td>
<td>0.446747</td>
</tr>
<tr>
<td>Bio-centre safety</td>
<td>0.039</td>
<td>0.7364</td>
<td>0.3700</td>
<td>0.0451*</td>
<td>0.395591</td>
</tr>
</tbody>
</table>

*P<0.05, 95% Confidence level

The result shows a positive relationship between the bio-centre closeness, cleanliness, safety to the bio-centres and the utilisation of bio-centre facilities by the respondents. This implies that if the bio-centre cleanliness, closeness and safety increase, the bio-centre utilisation as well increases. This is a clear indication that the design and location of bio-centre facilities are major determinants of utilisation of bio-centre facilities in Kibera.
CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

Despite 73% of Kibera respondents being aware of the existence of bio-centres, 42% of the same respondents have never used the bio-centre facilities.

The toilet and the bathroom facilities are the most used bio-centre facilities. On the other side, the use of the bio-gas is very low despite its contribution to reduced greenhouse gas emissions which might be attributed to its inadequate cooking space which hinders its usage.

Management of bio-centres in Kibera is best done by the community groups and in situations where these has been observed, there is sustainability of the bio-centres.

The results elucidated that, the use of bio-centre facilities in Kibera is not dependent on the gender, ethnicity, culture or level of education of the respondents but rather is positively dependent on the village of residence, duration of stay, knowledge of bio-centre facilities and the number of bio-centre facilities.

The cost and distance of bio-centre facilities’ in Kibera hinder usage of the bio-centre facilities. 58% of the respondents indicated that the costs of bio-centre facilities. This research also found out that the distance covered to access the bio-centres hinders their usage. Kibera being a poor urban population set up as per the results of this study indicating that the 80% of the households earned less than 10,000 Kenya Shillings per month, the sustainability of the bio-centre facilities cannot be attained at the current
fees charged to usage of the bio-centre facilities since a particular household requires a monthly minimum of 1,500 kenya shillings to access the toilet facility.

The results also implied that, the use of bio-centre facilities in Kibera is not dependent on household income but rather is dependent on the cost of the various bio-centre facilities namely bathroom, toilet, water, bio-gas and recreation facilities.

This research found out that the water from the bio-centres is faced by frequent water shortages and that most of the bio-centres have water tanks with a capacity of 1,000 to 10,000 litres.

80% of the respondents indicated that they were not sure of water from the bio-centre kiosk was clean and safe.

The limited number of bio-centres and the long distances to facilities limit the number of users of the services.

Gas produced in bio-centres usually does not get stored when not in use.

The sludge outlet acts as a mosquito breeding ground, hence a health hazard. There is a danger of someone falling in to the dome through the sludge outlet because it is not covered.

The result as well showed that there is a relationship between the bio-centre closeness, cleanliness, safety, walking time to the bio-centres and the utilisation of bio-centre facilities by the respondents.
5.2 Conclusion

Cultural beliefs have an influence on utilization of bio-centres facilities in Kibera. This was evidence by the fact that 15% of the respondents indicated that culture affects their choice of using the bio-centre facilities. Sentiments were also gathered on the various cultural beliefs that do affect the choice of using the bio-centre facilities.

Disposal of waste in Kibera is still done by use of the commonly known flying toilets. This is evident by the fact that 22% of Kibera residents still use “flying toilets” to dispose their human waste.

Management by the community groups is the best. This is necessary for sustainability of the bio-centre facilities. 72% of the respondents rated the management of the bio-centres under the community groups as good or very good as compared to the management by residents where only 33% of the respondents gave similar rating. Eight of the ten key informants also echoed that management of the bio-centre facilities is best done by the groups.

The cost of bio-centre facilities in Kibera was prohibitive for the majority of respondents thereby making the bio-centres unsustainable and as well affecting their utilisation. The costs of bio-centre facilities’ range from five to ten shillings which translates to 1,500 Kenya Shillings to use the toilet facility only for a household with only two users which is unaffordable for the slum dwellers.

Bio-centre facilities are few and unequally distributed and therefore not easily accessible. Majority of the residents have to travel for long distances to access the
facilities there by impacting on their utilisation. For instance, the bio-centre water points are approximately 500 metres and 1.5 kilometres from the respondents’ houses.

The bio-centre water quality is uncertain to the residents and the water is usually faced by frequent water shortages. This could adversely impact on the utilisation of the water from the bi-centre facility.

The bio-centres are generally clean and safe and this is necessary for sustainability of the bio-centres.

The sludge outlet is left uncovered thus a health and safety hazard.

The water tanks (capacity of 1,000 to 10,000 litres) used in the bio-centres do not have adequate capacity to supply water for a long time during times of water shortage.

Gas produced in bio-centres usually does not get stored when not in use hence losing its economic importance.

The sludge outlet acts as a mosquito breeding ground, hence a health hazard. There is a danger of someone falling in to the dome through the sludge outlet because it is not covered.

5.3 Recommendations

The following recommendations were thus advanced from the findings of this study:

- There is need for intensive awareness on the importance of proper sanitation in the slum areas so as to counter cultural resistance in utilization and sustainability of bio-centres. Implementation of water and sanitation facilities
such as the bio-centres both in Kibera and other parts of the country should include an education component to ensure that the beneficiaries have well understood the context. This will not only enhance ownership but as well increase the levels of literacy among the beneficiaries for better sustainability.

- Emphasis on participatory kind of approach in the development and management of bio-centres should be encouraged to counter social-cultural resistance
- Community groups such as SHGs and CBOs should be encouraged to manage the bio-centres
- The cost of bio-centre facilities should be further reduced to enhance affordability and sustainability.
- More research needed on how to store gas from the bio-centre so as to maximize on its economic importance
- Policies should be put in place to support sustainability of bio-centres in the slum areas and to improve water and sanitation services
- Water quality in the bio-centre kiosk should be established and residents made aware of the same to enhance confidence in using safe and clean water
- Bio-centres should be well distributed in Kibera for easy accessibility by all residents in the area.
- Development partners should build more bio-centres in Kibera to improve accessibility.
- There is need for water tanks exceeding a capacity of 50,000 litres for use in the bio-centre water kiosk so as to reduce water shortages.
• The bio-gas facility should be extended to include more cooking space. This will enhance the number of users. The residents need to be educated on the benefits of using the bio-gas facility as well.

• The sludge tank should be covered with a net and a concrete/ Ferro-cement slab should also be placed upon the tanks. This will prevent the breeding of mosquitoes in the sludge outlet and reduce the risk of people falling in the tanks.

5.4 Suggestions for Further Research

Further studies on the other hand should focus on the following items:

i) From the research findings, despite the bio-centre facility being able to provide clean energy, the bio-gas has however received low usage by the residents. Further research should therefore focus on how the bio-gas from the bio-centres can be stored or distributed to various household so as to maximize its economic importance.

ii) A research should be conducted to further assess the sustainability of other forms of community based water and sanitation programs in other slums in Nairobi and other towns.
REFERENCES


Boerstler F. (2010). *The Potential for the Production of Bioenergy for Lighting and Cooking Using Jatropha (Jatropha curcas L. Euphorbiaceae) by Small Scale Farmers on the Kenyan Coast; Doctoral Thesis.* GRIN Verlag


UN Habitat. (2007). Towards a Regional Programme on Housing and Urban Development. London: Earth Scan Publishers


APPENDICES

Appendix 1: Questionnaire
Good morning/afternoon/evening

My name is Rosinah Mbenya. I am a master’s student at Kenyatta University. I am undertaking a research project entitled “Utilisation and Sustainability of Bio-centres in Kibera Slums, Nairobi” being a partial fulfillment of the master’s degree in Environmental Studies (Community Development). I kindly request you to be part of my research by filling in this questionnaire. This will help me in coming up with relevant recommendations aimed at improving the utilisation and sustainability of bio-centres for improved livelihoods in Kibera. The information and data obtained will be confidential and solely used for academic purposes. Your honest feedback will be highly appreciated.

1. Socio-cultural factors effect on utilisation and sustainability of bio-centres
a) What is your gender and ethnicity?

Male ☐ Female ☐

Tribe............................................. Village ..............................................

b) How long have you lived here? .................................................................

c) What is your highest level of education? .................................................

d) Do you know any bio-centres operating in Kibera?
    Yes ☐ No ☐

e) If yes in (d) above name them?
    ..............................................................................................................
    ..............................................................................................................

f) Have you used any of the bio-centres so far?
    Yes ☐ No ☐
g) If yes, what facilities in the bio-centre have you used *(tick appropriately)*

<table>
<thead>
<tr>
<th>Facility</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toilet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biogas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water from kiosk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreational facilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(specify)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others (specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

h) Does your social life affect your choice on using the bio-centres facilities named above?

.................................................................

.................................................................

i) What aspects of your culture affect your choice of utilisation of the bio-centres *(if any)*

.................................................................

.................................................................

.................................................................

2. Economic factors influence on utilisation and sustainability of bio-centres

a) Household characteristics

<table>
<thead>
<tr>
<th>Household number</th>
<th>Sex (F- Female/ M- Male)</th>
<th>Occupation</th>
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</thead>
<tbody>
<tr>
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<td></td>
</tr>
</tbody>
</table>
b) What is the total monthly household income (tick appropriately)

<table>
<thead>
<tr>
<th>Total household income (KShs)</th>
<th>Tick here appropriately</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,000 and below</td>
<td></td>
</tr>
<tr>
<td>5,000 and above</td>
<td></td>
</tr>
<tr>
<td>10,000- 15,000</td>
<td></td>
</tr>
<tr>
<td>15,001- 20,000</td>
<td></td>
</tr>
<tr>
<td>20,000 and above</td>
<td></td>
</tr>
</tbody>
</table>

c) How can you rate the affordability of the bio-centre facilities? (fill below)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Not affordable</th>
<th>Affordable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toilet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bio-gas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water from kiosk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreational facilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(specify)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others (specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Impact of the design and location of the bio-centres on their utilisation and sustainability

a) Please fill in the table below (fill where applicable)

<table>
<thead>
<tr>
<th>Sources of water</th>
<th>Quantity per day (litres)</th>
<th>Distance (metres)</th>
<th>Cost (kShs)</th>
<th>Quality/ comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct municipal connection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communal municipal connection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water vendor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water bore hole/ wells</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bio-centres water kiosk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
b) How do you supplement water during water shortage? *(Briefly explain)*


c) In your opinion, what are the causes of poor water and sanitation services?


d) In your opinion, how effective is water from the bio-centres water kiosk and what recommendations can you offer?


e) How do majority of the people in Kibera dispose-off their human waste?

- Bio-centres  
- Polythene bag  
- Latrine  
- Forest/bush  

Others (specify)  

f) Before the beginning of the bio-centres technology, how did majority of the people in Kibera dispose their human waste?

- Polythene bag  
- Latrine  
- Forest/bush  

Others (specify)  

g) Are the bio-centres; *(tick where applicable)*

Close? ........................................

Clean? ........................................

Safe? ...........................................

Others *(specify)* .................................................................

h) How are you satisfied by bio-centre services in a scale of 1-3?

1- Not satisfied  2- Some-how satisfied  3- Very satisfied

i) Approximately, how long does it take you to get to the nearest bio-centre?

..................................................................................................

j) Does the distance dictate the frequency of visiting the bio-centre for disposing your human waste?

Yes ☐  No ☐

k) How can you rate the management of the bio-centres in a scale of 1-5

*(1-Bad  2- Below average  3- Average  4- Good  5- Very good)*

Management by the groups .........................

Management by the residents .........................

l) In a scale of 1-3, rate the importance of the bio-centres

1- Not important  2- Important  3- Very important

m) What is your general comment on bio-centres utilisation and sustainability?

..................................................................................................

..................................................................................................

..................................................................................................
Appendix 2: In-Depth Interview Guide

First and foremost I wish to appreciate your time and willingness to be part of this research. My name is Rosinah Mbenya and I am a postgraduate student in Kenyatta University undertaking a master's degree in Environmental studies (Community Development). I am carrying out a Thesis entitled “utilisation and sustainability of bio-centres in Kibera”. The aim of the research is to examine the factors which determine the way in which the bio-centres are utilised and their sustainability. I therefore kindly request for your time so as to discuss a few questions regarding the research topic. This is very informal and I do assure you that the information and data obtained will be treated with utmost care and confidentiality.

Ice breaker question

Based on your experience in Kibera, what do you think are the major development challenges/concerns the residents face nowadays?

Out of these, what would you pick on as the most important and why?

What would you pick on as the second most important and why?

Major interview questions

What are the major challenges of the residents in terms of use and access to bio-centres?

What are the effects of these challenges?

How do people cope with these challenges in the community?

What kind of activities/practices do they do to manage them?

Are the communities involved in design and implementation of the bio-centres? (Explain)

What are the future plans by community and other organisations in regard to water and sanitation?
Questions for implementing organisations

What are the objectives of your organisation?

Have you achieved the objectives so far?

What challenges do you face as an organisation in performing your mandate?

What opportunities exist for sustainability of bio-centres and other related technology?
Appendix 3: Field Observation Check List

The checklist below will guide the researcher in the process of observation to provide lenience of the condition of the bio-centres

<table>
<thead>
<tr>
<th>Bio-centre facility</th>
<th>Bathroom</th>
<th>Toilets</th>
<th>Bio-gas</th>
<th>Taps</th>
<th>Upper floors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adequacy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remarks</td>
<td></td>
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</tbody>
</table>
Appendix 4: Plates

A sign board indicating when the first bio-centre (Katwekera Tosha bio-centre) was officially opened

A water tank for washing hands after using the toilet service

Bio-gas services in the bio-centre

Open sludge tank

Water storage tank for Katwekera Tosha bio-centre