PILOTING BIOMASS ENERGY AUDIT FOR ENERGY AND ENVIRONMENTAL CONSERVATION IN HOMA-BAY COUNTY, KENYA

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ABSTRACT

Biomass energy meets about 70% of Kenyans national energy requirements and over 90% of rural population are depended on it. However, the traditional ways of producing and utilizing the bioenergy is inefficient and therefore unsustainable. Bioenergy consumers expecially households, institutions and local enterprises lack adequate knowledge on their consumption levels, available energy conservation technologies, alternative fuels like briquettes and areas of energy wastage. Piloting biomass energy audit was undertaken in Homa-Bay County with objectives of determining the consumption trends of the consumers, the types of fuel used, sources of the fuels, utilization technologies and identify areas of energy wastage. Semi-structured questionnaire and an energy audit tool were used to collect information from the respondents. Results showed that biomass energy is the main energy type for majority of the respondents for cooking and heating. The traditional three stone and metal cook stoves are the most preferred stoves. At household level, fuelwood is sourced from own farms and neighbouring community forests while fuelwood and charcoal for institutions and domestic use are obtained from markets. On average bioenergy takes 30% of the total domestic and institutional kitchen expenditure and this has contributed significantly towards higher energy bills in institutions and at household's levels. The study shows that energy efficiency audit is critical for consumers to track their consumption trends and identify areas of energy wastage. The study recommends frequent energy audit, use of energy saving technologies and establishment of woodlots as strategies for energy conservation.

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Key words: Bioenegry, efficiency, energy conservation, audit, Homa-Bay

INTRODUCTION

Globally, biomass energy provides 10 per cent of primary energy. It is source of energy for over 2.7 billion people who rely on traditional biomass energy in form of wood fuel, agricultural residues and animal wastes for their basic energy/. Fuel wood and charcoal production contributes to 68% and 10% respectively to renewable energy sector globally and has major effects on forestry as most of these products come from forested and woodland areas especially in Africa and Asia countries (FAO 2014; WBA, 2016). While in other developing countries the demand for biomass energy has peaked, in Africa especially in Sub-Saharan Africa (SSA), the demand for biomass energy will continue to grow into the foreseeable future and the number of consumers is projected to reach almost one billion by 2030 according to world energy outlook report. This is due to demographic factors and high prices of alternative energy sources (WBA 2016). Globally, bioenegy availbilty has been know to impact nutrional secutity of communities especially in developing countries who are depended on bioenergy as basic enegry for cooking and heating. Biomass energy production and use is also associated with increased negative environmental and health impacts, with over 4 million deaths related to use of solid fuels reported in 2012 (WHO, 2014). Nevertheless, biomass energy remains critically important in meeting the primary energy needs of the people in the lowest economic ladders of countries depended on it (Githiomi *et al,* 2012). In recent years, biomass energy has also become a source of fossil-fuel free electricity especially in developed world (WBA, 2011). With increased awareness on issues contributing to climate change and energy insecurity, biomass energy has become far more important and visible as a global issue and has the potential to contribute to energy security,

climate mitigation (FAO, 2010) and sustainable rural development if efficiently and sustainably managed.

In Kenya, biomass energy accouts for 70% of the national energy requirements (GBEP report 2019). Wood fuel is the main source of energy for majority of Kenyan households for cooking and heating. Its also increasingly becoming an important energy source for institutions such as schools, hospitals, prisons and eateries. It's also an important source of energy for Small and medium enterprises (SMEs) such as agro-processing industries, the textile dying industry, metal processing industries like blacksmiths and mineral-based industries such as brick making and ceramics/ pottery also use fuel wood and other biomass in their kilns and boilers (Githiomi *at el.,* 2010; Githiomi, *et al.,* 2012; FAO, 2006). With the changing demographic factors, increased levels of poverty and limited access to modern clean fuels, there is increasing demand for biomass energy on the lower and middle levels of the traditional energy ladder such as fuel wood and charcoal. It is estimated that the national demand of charcoal is over 16 million m^3 while supply is estimated at about 13.5 million m^3 (MoENR, 2013). The current deficit is estimated to be over 60% (SOE 2014)

In Kenya, biomass fuel is largely used in rural areas, where it is regarded as a cheap source of energy, however, it is produced and utilized in inefficient devices hence the need for strategies to conserve the energy resource. Use of biomass energy conservation technologies with improved efficiency levels, can greatly reduce consumption levels and deforestation. However, there is limited knowledge and awareness on energy consumption levels among energy consumers, expecially households, local institutions and small-scale local enterprises. It is also important to undertake energy audits which will help consumers monitor their consumption trends and identify areas of wastage, available energy conservation technologies and alternative fuels including briquettes for reduced exploitation of tree/ forest resources. Energy audit entails assessment of how energy is consumed within the household, institution or enterprise. Conducting energy audit helps identify energy waste and opportunities for energy conservation or improving energy use practices (Kallbekken *et al.*, 2013). Energy audits also contribute towards reducing carbon emission and increased deforestation thus contributing to climate change mitigation.

Problem statement and justification

Homa-Bay County is endowed with vast renewable energy resources such as hydro, solar, and agricultural wastes for alternative energy sources. Yet the counties still face energy insecurity and low access to affordable clean energy (Owino, *et al.*, 2018). Energy insecurity in Homa-Bay is aggravated by increased depletion of communiy forests and woodlots that inhabitants rely on to obtain wood fuel through expansion of agricultural activities. Energy insecurity is a threat to socio-economic development given the negative health and environment effects associated with increased use of biomass energy and overreliance on other polluting non-renewable energy sources like fossil fuel. Biomass energy is the main source of energy for over 95% of the habitants of Ndhiwa Sub-County (GEP, 2015). However, production and utilization is unsustainable as the technologies used are inefficient and has significantly contributed to increased overexploitation of trees and forest resources leading to environmental degradation.. Unsustainable harvesting of tree/forest resources and continued use of inefficient technologies has also contributed high enegry consumption rates and increased emission of greenhouse gases. Adoption and use of alternative cleaner fuels such as briquettes is still low despite the availability of adequate agricultural wastes as potential feedstock for alternative bioenergy production. Green Economy Project (GEP) baseline report indicated low adoption of efficient biomass energy conservation technologies such as efficient charcoal conversion kilns, energy saving domestic and institutional stoves and low establishment of woodlots for wood fuel production, as most of the available land is being cleared for expansion of sugarcane plantations. Energy audits are important tools towards promoting conservation measures and help households, institutions and enterprises to reduce their energy consumption by contributing to savings and reduction of their carbon footprints. It also helps in identifying policy barriers to energy conservation and uptake of efficiency technologies (Gillingham, *et al.*, 2012). However, in Kenya, non-existence of energy audits at domestic and institutional level has exacerbated the problem, since consumer are unaware of their bioenergy consumption trends and areas of energy wastage. In this study, biomass energy audit as tool for energy conservation was carried out to document bioenergy fuels and technologies used in the community,determine their consumption rates, identify areas of energy wastage and potential remedial measures.

Research Objectives

The main purpose of the energy audit was to examine the energy consumption trends in the study area, energy needs, areas of wastage among households and institutions using bioenergy as source fuel and evaluate measures that can be taken to promote energy efficiency for environmental conservation and improved livelihoods .

The Specific Objectives were;

1. To identify types of fuel, production and utilization devices used in the community (domestic and institutional)
2. To determine the consumption trends per household per institution and its contribution to the overall dometic or instituioanal kitchen related expenditure.
3. To identify potential strategies to improve energy efficiency, energy conservation and improve livelihoods in the study area

The rationale of the study.

The rationale of the study was to determine the consumption trends of biomass energy in the study area, the types of fuel, sources, Production and utilization technologies used, identify areas of energy wastage and ientify potential strategies for energy conservation for improved livelihoods and environmental conservation.

METHODS AND MATERIALS

The study area

The study was conducted in selected locations of Ndhiwa sub-county, Homa Bay County. The County is located along the south shore of Lake Victoria's Winam Gulf and borders Migori to the South, Kisii and Nyamira to the east, and Kericho and Kisumu to the north east. The county also borders Lake Victoria to the north and west (Figure 1). Generally, the County is characterized by a rapidly growing population, high population density, falling food production capacity, low forest cover at less than 4 % and low resilience to climate change. The county receives two bimodal rains with the long rains starting from March to June and has 60% reliability and the short rains season starts from August to November, and range between 250 mm to 1000 mm. Ndhiwa Sub-County has an area of 711.40 km^2 and a population of 172,212 (GEP 2015, CoGH, 2013).

Sampling and Data collection.

The study area was stratified into 5 strata (wards) and 20 households randomly selected from each stratum. Semi -structured questionnaires were administered to 100 households randomly selected from the five wards. Institutional questionnaire was administered to 10 schools and 10 eateries randomly selected from each stratum. A developed energy audit tool was also used for each of the selected households and institutions to collect information on types of bioenergy and cooking stoves used and daily

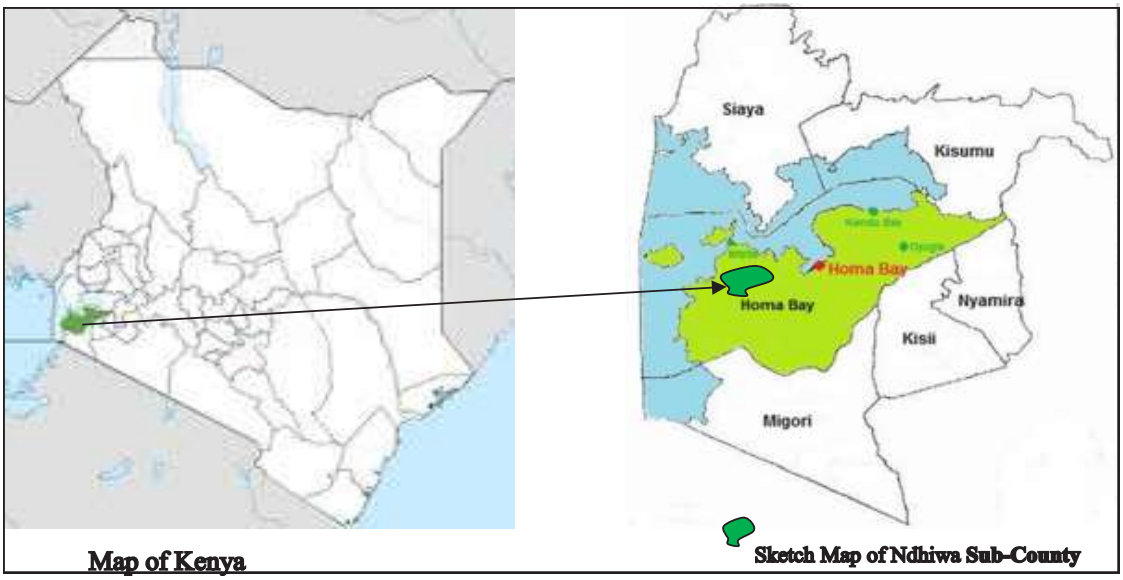

Figure 1. Homa Bay County and the GEP Project area

household energy consumption rates.

Data organization and analysis

Data was analyzed using Statistical Package for Social Scientists (SPSS) and Microsoft Excel computer packages for descriptive and inferential statistics.

RESULTS AND DISCUSSION

Socio-economic and demographic aspects of the respondents

Sources of income

Sub-sistence crop farming was indicated by majority of the respondents (60%) as the main source of incomes followed by business and formal employment as summarized in (Table I). Given the high population densities of 359 persons per square kilometre(KNBS 2019) and small land holdings as observed during the baseline survey undertaken in the project area (GEP, 2015), most of the food crops grown are for household consumption and the cash crops grown (sugarcane) is on small scale hence most of the families are financially constrained. Homa Bay County is among counties with high poverty levels at 48.4% according to economic survey report of 2014 (KNBS 2019). Bioenergy is relatively cheaper than other types of energy available, hence the high poverty levels is positively correlated to increased biomass energy use in the area.

TABLE I -MAIN SOURCE OF INCOME

Main source of income	**Frequency %**
Crop farming	59.8
Business	17.5
Formal employment	13.4
Casual labour	8.2
Livestock farming	1.0
Total	**100.0**

Family size and number of meals.

On average, majority of the households interviewed had large families with a mean of six members, higher than County average of 5.6 (KNBS 2019). Over 70% of the respondents indicated that most of the families have at least three meals per day (Figure 1), hence the need for adequate fuel to cook the food.

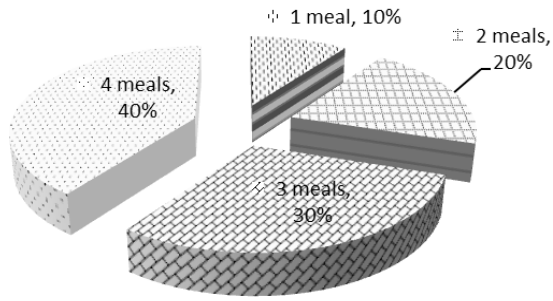

Figure 2. Number of meals per household in the study area.

Fuelwood availability has been known to contrinute to food insecurity especially in areas expiring fuelwood scarcity. In a related, study undertaken in Tigania Sub-County in Kenya, majority of the population studied resulted to cooking less number of meals or compounded meals instead of single meals, thus reducing on the number of cooking sessions per day to save on energy (Fuchakwa, *et al.,* 2020)

Types of Fuel used in the Community

Biomass energy was the main source of energy for cooking and heating for over 90% of the respondents as shown in (Table II) with only less than 10% of them using alternative fuels such as gas and kerosene for cooking and lighting and is higher than the national average which according to the 2019 Kenya Population and Housing Census, 55.1% of Kenyan Housholds use woodfuel for cooking followed by 23.9% using LPG (KNBS 2019). This concurs with KNEP (2012) and KIPPRA report 2010 which indicates biomass energy as the energy source contributing to 70% of the national energy requiremnts .

TABLE II - MOST COMMONLY ENERGY TYPES USED IN HOMA BAY COUNTY

Energy source	**% frequency**
Firewood	**50.3**
Charcoal	**35.8**
Crop residue	**6.9**
Gas	3.6
Bio-gas	1.2
Kerosene	2.3
Total	**100.0**

Availability and cost of biomass energy has always been the main reason for continued use of biomass energy. Other factors include its reneweabilty through on farm planting

and replenishment, carbon neutral if sustainably harvested and reduces wastes. Projections by the international energy agency (IEA) in 2020 for Kenya primary energy demand and GDP in the Stated Policies Scenario, 2010-2040, biomass energy will still lead providing 20 Mtoe compared to 18 Mtoe by other low carbon bergy sources (IEA, 2020).

However on a positive note, more eatries and households reported moving towards adopting clean cooking devices, mostly the 6 kg LPG stove for quick meals. In a recent related study by the ministry of Energy (MoE, 2018), the sector study report 2018, indicated that about 31% of Kenyan are adopting the 6 kg LPG stove for cooking. The gas is packaged in small cylinders which are affordable and available even to the l rural centres consumers .

Source of biomass fuel in Nthiwa –Sub-county

From the study fuel wood was either collected or produced from farms and or purchased from the market as indicated by (70.6%) and (29.4%) of the respondents, respectively (Table III). Majority of the respondents indicated that most of the fuelwood comes from farmlands and natural community forsts which are as getting depleted due to overexploitation and expansion of agricultural activities. Most of the community forests and the indigenous woodlands in the study area have been cleared for agricultural purposes (sugarcane plantations) hence the few scattered tree on farms are the only sources of fuel wood for the community. Most of the institutions especially the boarding secondary schools have to order fuelwood supplies from outside the sub-county as there no adequate tree resources to meet their demands and charcoal from the markets. The wood fuel scarcity has also forced the community members and local enterprise like jaggeries to to increasingly use raw agricultural wastes (bagasse) as source of fuel for cooking as observed during the study. Related studies on exploitation of natural resources for wood fuel production (Bailis, 2009) indicated that in most part of Kenya, exploitation of fuelwood resources far outpaces their replacement.

Apart from fuelwood, instituions are also using charcoal for cooking and heating. Charcoal is considerd to be reliable, convenient and an accessible source of energy for cooking at a stable cost when compared to other sources such as electricity and kerosene (BTG, 2010, Mugo and Ong, 2006). This scenario provides a potential ready market for charcoal briquettes produced by the community bio-energy centres using agricultural wastes such as bagasse from sugar mills situated in the in the county. Establishmnt of woodlots on farms and in schools can also be potential solution to fuel wood scarcity in the area

Type of cook stoves used in the households, institutions and eateries

The Traditional three stones stoves (64%) and Kenya Ceramic Jiko (KCJ) (32%) were the most common types of stoves available in the community as depicted in (Figure 3), while biogas is the least types of stoves used.

Although a variety of improved cook stoves are available in the kenyan market, the traditional three stone stoves still enjoys preference by the community in the study area as indicated in fig, 2 with over 60% preference. The improved energy saving stoves are available in the shops at a higher cost compared to the traditional metal stoves. Their designs, availability and costs were as summarised Table IV. In all institutions surveyed (schools, children home, and dispensary, there was a conspicuous absence of energy saving stoves. Majority of the institutions were using the three stone traditional stove and the traditional metal stoves which ae inefficient and thus consumes lots of fuel wood and charcoal. Over 30% of the eateries have modified brick mud stoves which uses woodfuel and the charcoal remains is used to keep food warm. This leads to savings on charcoal.

The three stone cook stoves which is freely available enjoy preference by the community, uses local materials (stones) which are readily available, cooks fast and can easily be

TABLE III -SOURCE OF BIOMASS FUEL IN NTHIWA –SUB-COUNTY - HOMA BAY COUNTY.

Source of biomass fuel	**% frequency**
Collect firewood from farms and neighbourhood community forests (Households)	**59.7**
Purchase charcoal from market (Institutions and Households)	21.0
Produce charcoal (Households)	10.9
Purchase firewood from market (Institutions)	8.4
Total	**100.0**

Figure 3. Type of cook stoves used in the community

assembled anywhere in the community and requires minimal skills which is passed on through generation.

In a related study undertaken in Peru, Kenya and Nepal on behavioural altitudes and preferences in cooking (Evelyn *et al., 2014*) it was noted that, the traditional cooking stoves were still preferred because the stoves are culturally accepted by the communities, are perceived to yield tasty stable food, are faster in cooking, food more pleasing to the people when associated with traditional stoves, uses locally available materials and apart from cooking, the open fire can be used for other cultural activities.

of the population still use the traditional three stone stoves (WHO/UNDP, 2005) due to a number of factors, chief among them the high cost of improved stoves and high poverty levels among users.

Economic barriers to procuring and maintaining improved cook stoves have been shown to inhibit adoption of ICS (Person B, *et al* 2012*)*. Other socio-economic barriers to adotion of the ICS include access and availability, prices of the stoves, fuel prices, awareness and household incomes levels. This explains why firewood is still the main source of energy for the household even in the study

TABLE IV - DESCRIPTIONS OF THE BIOMASS ENERGY COOK STOVES AVAILABLE IN THE COMMUNITY

Description of biomass cook stoves	**Type of cook stove**	**Design and specifications**	**Availability**	**Cost of cookstoves (KES)**
Charcoal cooking stoves	Traditional metal Stove	Metal with np clay lining	Scarce	250
	KCJ	Metal with Clay lining	Readily available	400
Fuelwood cooking stoves	Modelled Clay/ brick Stove	Clay lining	Available	500 (installation) cost
	Traditional	Three Stones stove	Readily available	Free (self installation)

Though most of the stoves mentioned by the respondents were indicated as available in the local market except the traditional metal stoves, the improved cook stoves such as Kenya ceramic stove(KCJ) and the modelled clay stoves are expensive, costing between KES 400 to 500 (Table IV). Due to low income levels, these improved stoves are out of reach for most members in the community. In a study by WHO in developing countries on why people use cookstoves, the study found that only a small fractions of the three billion people dependent on solid fuels as source of fuel use improved cook stoves. A large number

area where over 90% of the respondents use fuel wood as the main source of energy for cooking and heating all year round. Only less than 10% use charcoal for specific meals in combination with other fuels like liquefied petroleum gas (LPG) or Kerosene.

Satisfaction Levels with type of cook stove used

On satisfaction levels with the type of stoves used, over 58% of the respondents were dissatisfied with the type of the stoves used (Figure 3), which were mainly the

traditional three stone and tradition metal stoves. The stoves were indicated as heavy consumers of fueland the users have to tend to the fire while cooking as they have to keep on adding fuelwood or charcoal. The stoves are also smoky and releases alot of particulate matter (PM) and other which contribute to increased negative health impacts to users especially when used in poorly ventilated kitchens or if wet wood is used.

Globally , increased use of biomass energy is associated with increased respiratory diseases and the World Health Organization (WHO) estimates that in 2012 over 4 Million people died of diseases related to use of solid fuels in developing countries alone (WHO, 2014).

The three stone stoves are also known to have ineffficiency levels of 12-15% (KEFRI 2006). This translates to very high consumption rates of wood fuel and over 70% of the respondents indicated spending 30 minutes to over two hours (Table V) collecting firewood three times per week. On average community members spend about 4 hours per week collecting firewood.That translates to two working days of 8hrs per month. Though the adoption of improved cook stoves is still low, use of efficient improved cook stoves (ICS) can reduce the amount of wood fuel used thus less time and distance walked in search of the fuelwood resources.

Distance walked and time taken in search of firewood by households

The results showed that on average, women walk about 5 Kilometers for 1.5 hours, three times per week in search of fuel wood. A Correlation analysis between time taken and distance walked (Table VI) is significant at the 0.01 level (2-tailed).

This means, respondents have to walk away from their farms and families to the neighbourhood for many hours in search of fuel wood resources. Promoting establishment of woodlots on farm will reduce the burden women and the girl child who are the main domestic fuelwood collectors (Figure 4) have to bear.

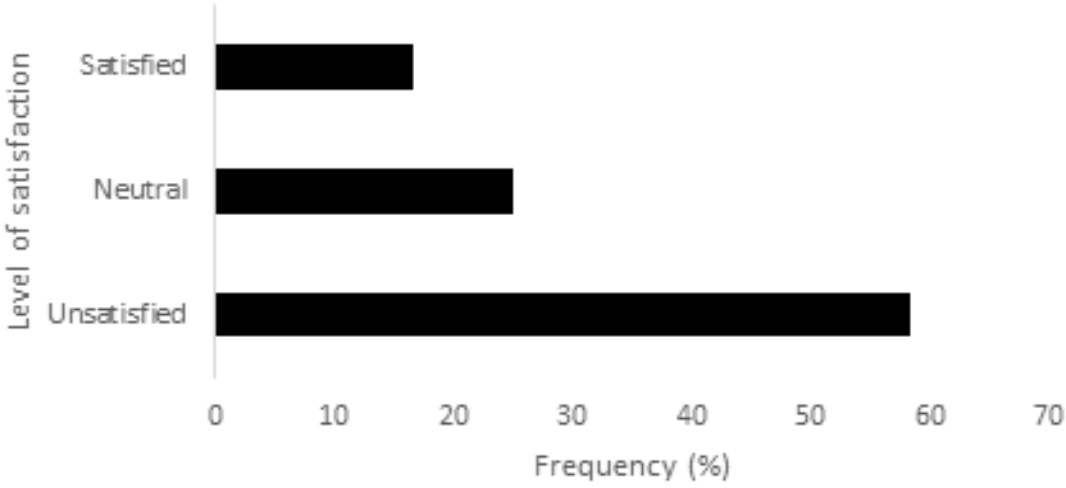

Figure 4: Satisfaction Levels with type of cook stoves used

TABLE V A CORRELATION ANALYSIS BETWEEN TIME TAKEN AND DISTANCE WALKED

		Time spent on firewood collection	Distance walked
Time spent on firewood collection	Pearson Correlation	1	-.988**
	Sig. (2-tailed)		.002
Distance walked	Pearson Correlation	-.988**	1
	Sig. (2-tailed)	.002	

**. Correlation is significant at the 0.01 level (2-tailed).

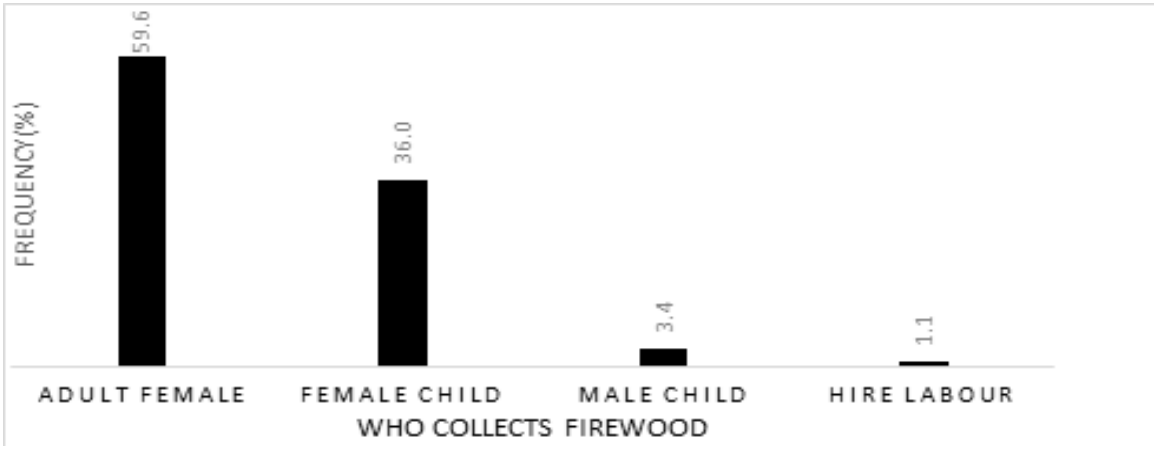

Figure 4. Firewood collectors in the cimmunity

Studies have also shown that women carry between 20- 35 kg loads of fuelwood during collection or to the market. With increased wood fuel scarcity as result of deforestation and expanding agricultural activities thus depleting wood resources, time spend and distances walked will subsequently increase thus increased negative health and socio-economic impacts to the collectors and the community at whole. Apart from the time spent and distances walked in search of fuel resources, the collectors are also sometimes exposed to insecure condition. Women and girl child are also exposed to household air pollution due to the time spent cooking and tending indoor fires in poorly ventilated kitchens or dwellings. This has affected women and girls more healthwise than men according WHO (WHO, 2014, UNDP/ WHO (2009) and related studies.

Daily household energy consumption

On average more food in terms of variety and amount was prepared during morning hours (2.23 kg) than lunch and evening hours (1.18 kg and 1.08 kg, respectively). Traditional three stone stoves which consume more fuel than other types of stoves were used more (67%) than other types of stoves. Improved stoves using firewood and charcoal were second in choice for cooking (23%) while Kerosene (7%) and gas (2%) were least used. Generally, more firewood was utilized by use of traditional stove (4.75 kg) than charcoal to prepare a standard meal. Comparison between the charcoal stoves for a standard meal preparation shows that, the improved charcoal stove used less charcoal (1.4 kg) than the traditional metal charcoal stove (1.77 kg). Thus in order to save on fuel, money and time spent in search of wood fuel, the community need to adopt biomass energy conservation technologies. From the results, majority of the household (58%) indicated spending about 3,500 per month on energy alone, which translates to almost a third or about 30 percent of the monthly expenses per household.

Daily Energy Consumption by Institutions

From the results, most the institutions indicated using biomass energy in form firewood and charcoal for cooking. Majority of them, (64%) indicated they mainly use firewood, 26 % indicated they mainly used charcoal while 10% use both fuelwood and charcoal equally for their cooking and heatingIn addition to the choice of fuel, most of the institutions (82.7 %) use the traditional cooking stoves which consume large amounts of fuel wood while only 18.2% uses improved stoves (Table VI). Only 0.1% of the respondents use solar energy mainly for lighting. Most of the institutions indicated that, use of biomass energy contributes to over 27% of the overall institutional expenditure on kitchen budget and that excludes expenses other types of energy such as electricity and generator for lighting.

TABLE VI - COOKING DEVICES USED IN INSTITUIONS

Energy device	Frequency(%)
Traditional cook stoves	82.7
Improved cook stoves (Improved institutional cookstoves and the modified brick /mud stoves	17.2
Solar energy	0.1
Total	**100.0**

Frequency of collection and use of wood fuel types.

Majority of the respondents (85%) indicated that fuel wood is procured and used throughout the year while charcoal is procured occasionally and used only at certain occasions and for specific meals like tea and rice which don't require a lot of energy to cook. From the results, about (92.3%) of fuel used in institutions is purchased from markets, most of it coming from outside the Sub-County. Only 7.7% of the respondents indicated they collect fuelwood from there own land.

and eateries surveyed used alternative type of fuel like gas in addition to biomass energy for cooking light meals and heating already cooked food. The urgency in food preparation as required in restaurants requires that they have to use fuel that can light and cook fast when food is ordered unlike in institutions where timed schedules for food preparation are followed. Though more firewood is consumed than charcoal, charcoal contributes more to the overall energy bill compared to firewood because the cost of charcoal in the market is higher (Table IX). Thus there

TABLE VII - AVERAGE COST OF ENERGY PER INSTITUTION

Type of fuel	Average units / month	Average cost of one unit	Average cost of fuel per year	% contribution to institutional food budget
Firewood	1(7tonne truck)	25,000	225,000	14 %
Charcoal	10 bags	600	60,000	13 %
Total			**285,000**	**27 %**

Daily energy consumption by restaurants and eateries

Unlike households and institutions, most of the restaurants

is need for increased adoption of energy saving stoves using firewood and charcoal such as the rocket stoves and

KCJ for reduced energy consumption in eateries.

TABLE VIII -COST OF ENERGY SOURCE

Type of fuel	Average units/year	Average cost of one unit	Average cost of fuel per year	% contribution to restutant budget
Firewood	80	150	4, 800	6 %
Charcoal	8	600	19,200	15 %
Gas	2	2,200	4,400	3 %
Total			**23,600**	**24 %**

From the study , households, institutions and eateres have the potential to reduce fuel expense and this can be achieved through establishment of wood fuel plantations or woodlots and use of energy efficient devices such as the institutional energy saving stoves. This would reduce the amount and frequency of sourcing for biomass energy locally or from the market and the subsequently reduction in the overall energy bill. There is also need to create awareness on good cooking practices for energy saving such as covering food while cooking, use of efficient cooking pots and soaking hard cereals before cooking to save on energy.

Potental strategies for Energy conservation

Through the study, the following were identified as potential strategies to reduce energy consumption for energy and environmental conservation and improved livelihoods. They included: Establishment of woodlots for wood fuel production to provided need fuel and saves time and money; Use of energy efficient domestic and institutional cookstoves that would reduced fuel consumption; use alternative sources of biofuel from forestry and agricultural wastessuch as briquettes; makes use of available forestry and agricultural wastes which would otherwise be fire, health and environmental harzard; promote use of other energy sources like solar, LPG and electricity for lighter meals; promote use of energy efficiecnt coookng devices like pressure cookers and promote efficient and safe cooking practices (e.g covering food while cooking, use cookstoves in enclosed area (avoid windy conditions), soak hard cereals before cooking.

CONCLUSIONS AND RECOMMENDATIONS

From the study, biomass energy and the tradional three stone cookstoves were indicated by majoriy as the most preffered energy types and stove. The cost of improved cookstoves which is relatively higher than the traditional stoves has forced poor rural communities with low incomes to continue using tradional stoves or adopt less efficient improved cook stoves (ICS) which are locally fabricated or installed. Increased exploitation and consumption of biomass energy using unsustainable production and utilization technologies has greatly contributed to increased energy bills both in households, institutions and eateries. This has translated to increased financial constraints or poverty at all levels. This calls for adoption of strategies that will reduce the amount of fuel purchased and consumed for cooking and heating. The study recommends: Establishment of woodlots for wood fuel production; observation of energy saving tips like use of energy efficient domestic and institutional cookstoves/ technologies; use of efficient and safe cooking practices at all levels which includes covering food while cooking, avoid windy conditions and soak hard cereals for cooking; promote diversification of fuel used or energy mix by use of other energy sources like solar, LPG and electricity for lighter meals; exploring alternative cheaper fuels like briquettes which can be readily made from available agricultural residues like bagasse and lastly, it is important to undertake regular energy audits to know energy consumption status and areas of wastage in biomass energy use. Contribute to national policies towards conservation by increasing awareneness and concienciness consumption of clean energy for cooking and heating.

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