Analysis of Green Energy Adoption on Household Development in Kenya: Case of Kibera Slums

Gongera Enock George*, Esther N. Gicheru*

Professors, School of Cooperative& Community Development at The Cooperative University of Kenya

ABSTRACT

Green energy technology adoption has been a major problem in urban poor (slums dwellers) in developing countries. The government and other major stakeholders in the energy sector often fail to address these issues due to poor policy and high cost of technology. The presence of NGO's whose programmes of equipping the slum dwellers especially Kibera slum in Nairobi Kenya have done very little in addressing the problem. The use of green energy technology has grown tremendously in semi-arid areas. However little is known about the adoption, awareness and use of such household scale technologies by slums dwellers in Kenya. The general objective of the study was to analyze the green energy adoption in Kenya, case of Kibera slum which is the largest of its kind in Africa. Recent empirical evidence showed that renewable energy adoption is growing in the world's emerging economies nearly twice as fast than in industrialized nations. Not only are renewable energy technologies now cost competitive with fossil fuels in many developing nations, but they are often more reliable, safer, and at times cheaper than conventional grid power. This study examined the cost of green energy, size of family income, energy sector reforms. The researcher used descriptive analysis to assess the awareness and adoptions of green energy technology. In particular the study used logit and probit models to examine the variables of green energy adoption and intensity use of green energy technology on household scale respectively. The study used data collected via personal interview using pretested questionnaires in all the 17 villages of Kibera slums. This area was selected because of its relevance to the study. It used probability proportion to size sampling technique to collect information from 449 respondents. The study finds high awareness (76 percent) of green energy technology among the Kibera slums dwellers. However, this has not translated into high adoption. Only 10 percent of the respondents have adopted green energy technology. Results indicate high usage in the villages supplied with the technology by the NGOs than the rest of the study areas. Results of the regression analysis indicates that family income, the cost of green energy technology, lack extension officers, and distance to the green energy enterprises /dealers affects the adoption of green energy technology. Intense of adoption of green energy technology on the other hand is affected by membership to youth or women group, distance to the nearest enterprises with physical and financial assets. Lastly, a finding of this study also implies that adoption of green energy technology can spur good physical well-being and productivity of household members, improve welfare of such households and reduces deaths caused by pollution related disease. Therefore there is need to formulate and implement Energy sector reforms to encourage access to clean and affordable energy services by slums dwellers.

Key Words: Green Energy Adoption, Household Development, Kibera Slums in Kenya.

1.0 Background Information

In many developing countries, the majority of people rely on biomass fuels and kerosene to meet primary energy needs. These fuels offer poor performance and have negative consequences on human health (such as respiratory disease and eye damage) and the environment (such as air pollution and loss of forest cover). A total of 1.6 billion people are deemed to suffer from "energy poverty" and 85% of rural and 49% of urban populations in Africa have no access to electricity. Accessing clean, reliable and affordable energy is considered fundamental to sustainable development, and to achieving the seven Millennium Development Goals (MDGs).

Energy adaptation has been classified into direct and indirect household responses (Damte et al. 2011). Hyde et al (2008) provides a summary of studies that have examined common concerns about energy scarcity for the period of 1985 to 2006, and in all these studies too, limited attention was given to energy scarcity issues in urban areas. Kumar & Hotchkiss (1988) in a rural Nepal study noted that households cope with fuel wood scarcity by increasing the time spent on its collection. Similarly, Cooke (1998) concludes that when households are faced with shortages, as measured by shadow prices, they spend increasing amounts of time collecting these environmental goods, without affecting agricultural productivity, such that the reallocated time must come from other activities. Cooke et al. (2008) further note that in times of fuel wood scarcity, households change their

cooking habits due to a reallocation of labour away from food preparation, and change the amount and kind of fuel used.
Brouwer, Hoorweg, & van Liere (1997) found that households economize on wood use and increase the number of collectors while Veld, Narain, Gupta, Chopra, & Singh (2006) noted that households are less likely to collect from common areas at all, and are more likely to use privately produced fuel.
Current energy use patterns and demands are unsustainable in the face of increased demand and the pressing need to address social, economic and environmental objectives. Although Kenya is the largest economy in East Africa, less than 20 percent of Kenyans have access to electricity. People without access to grid power, often renewable are the cheapest option. Most Kenyans use kerosene for lighting, paying $0.92 per liter. For the average Kenyan family that makes less than $2 per day kerosene is not only a costly extravagance, but also an unhealthy and polluting one. This makes off-grid solar an economical and healthier choice. Around 744 buildings from health centers to schools have been hooked up to solar through Kenya's 2009 Rural Electrification Master Plan.

Centralized approaches to distributing energy via national grid networks often fail to meet the needs of large segments of the population, particularly rural people and those with lower incomes. Harnessing renewable energy at a local scale is identified as an approach to meet energy needs, reducing the negative human and environmental costs associated with energy use and permitting decentralized, market based dissemination. A number of renewable technologies are technically feasible on a small scale, including solar, wind, mini hydro and biogas.

The idea that developing nations can "leapfrog" to adopt clean and efficient alternatives is widely discussed but often face technical, organizational and institutional challenges leading to limited uptake. Such barriers include economic bias towards existing technologies, high capital cost of renewable alternatives, shortage of finance to end-users, low awareness, lack of suitable business models and lack of market support infrastructure. Identifying the specific challenges, and strategies to address them, is a crucial step in addressing energy poverty and securing a sustainable energy future.

1.1 Patterns of Energy use in Kibera Slums

According to the past studies conducted by Kenya Power Lighting Company; Charcoal, kerosene, electricity and, to a lesser extent, LPG appears to have elaborate energy distribution networks in Kibera although the distribution network of LPG is not as extensive as that of the other three energy options, it appears to be relatively good. This demonstrated by the fact that most of the LPG users in Kibera indicated that they only need to travel a maximum of 1 kilometer to refill their cylinders. The four fuels are appealing to the urban poor as they are relatively affordable (if the upfront cost of both electricity and LPG is not considered) in comparison with their average incomes. The cost of the energy sources are as follows: US$ 0.08 per kWh for electricity; US$ 5 per 36 kg sack of charcoal; US$ 13 to refill a 6kg cylinder of LPG; and US$ 0.85 per litre of kerosene.
Biomass energy is mostly used in the form of charcoal. Urban households like charcoal because it does not produce a lot of smoke and its calorific value is twice as much as that of wood and therefore last longer, especially when used with improved cook stoves. Charcoal is considered to be relatively affordable, economical and convenient. Charcoal is sold on average, at about US$ 5 per 36 kg bag. It's relatively low price and an extensive distribution network ensures its availability within Kibera making it a popular fuel of choice for cooking food that requires a lengthy duration of boiling.
Kerosene is the most common fuel among poor urban households who use it for cooking, lighting, water heating. Kerosene is also used in the formal sectors of the economy for industrial and commercial purposes. Kerosene is popular among the urban poor population because they consider it quick and easy to use. According to the survey findings, about half of Kibera residents interviewed depend on kerosene for lighting services. For household cooking, about one-third of the respondents use kerosene. In Kibera, kerosene resellers (mainly consisting of kiosks and informal pump stations) form the dominant channel through which the fuel reaches the households. Most of the resellers purchase kerosene in bulk from formal fuel stations.
In the urban areas of Kenya, LPG is used as a supplement to electricity (among those who can afford it), kerosene and charcoal. In spite of the high upfront cost of LPG, its penetration has recorded some significant level of success, albeit among the middle and high income urban households. About one-third of the urban residents use LPG as a source of energy. LPG is packaged in cylinders of sizes ranging from 3kg to 15kg for domestic applications, with the smaller cylinder sizes (3 and 6kg) being the most common sizes among the urban poor such as those living in Kibera. LPG is mainly used for cooking and lighting. Other major uses of LPG at the domestic level include heating water. LPG has a relatively elaborate distribution channel which is demonstrated by the fact that about half of the LPG users claimed that they get their LPG refills within a radius of 1 km.

While Electricity is recorded the lowest level of access among poor residents of Kibera, it is considered to be the best energy option as it can be used for multiple applications. Among the few users of electricity found in Kibera, they mainly use it because they find it cheap and affordable and that it is always available whenever they want to use it. However, there are several factors that hamper the wide scale use of electricity among the urban poor population in Kibera. Chief among them is the high upfront cost of components such as meter board, circuit breakers and cabling.

1.1 Statement of the Problem

According to Global Report on Human Settlement (2003: 103) the current status of kibera slum is pathetic: poor shelter; joblessness; tenure insecurity; diseases; police harassment; evictions and lack of reliable sources of energy. More than half of the world's population and more than seventy percent of the world's poor are found in slums/rural areas and an equal fraction is women (World Bank, 2004; Cabraal et al, 2005). As will be contended, slums poverty may be alleviated through improved energy provision in a variety of ways. In the context of rural development, however, energy has traditionally been looked at as having two converse uses; residential (or consumptive) and productive. In the former case, the uses of energy were expected to improve quality of life or slums living standards, whereas productive uses were expected to increase productivity, enhance economic growth, boost employment, and thereby stem up migration of the rural poor to urban areas.

Kibera slums dwellers are facing problems of accessing clean, reliable and affordable energy. This is considered to pose negative impacts on social, economic and environmental objectives in realizing sustainable development. There are NGOs providing this service but still many people living in Kibera are using kerosene and primary fuel wood as a major source of energy both for lighting and some for cooking, hence the justification of the study.

2.0 LITERATURE REVIEW

2.1 Energy and Development

Two events have, perhaps more than anything, contributed to putting energy on the poverty alleviation and development agenda. Those events are the United Nations Conference on Environment and Development (UNCED) in 1992 and the World Summit for Sustainable Development (WSSD) ten years later. The World Summit motivates International NGOs, donor organizations and various branches of the United Nations to prepare documents, which state the institutions' respective stances on energy's role in development and alleviation of poverty (UNDP, 1992; ESMAP, 2000).

According to Mukwaya (2016), energy demand patterns of urban households, especially the poor, largely revolve around household energy end-uses such as cooking and lighting as well as energy services for home-based commercial and productive activities. It was found that charcoal (34.9%) was the dominant energy source for cooking followed by kerosene (25.0%) and fuel wood (20.6%). Many of the research findings, proposes and illustrate important roles for energy in improving Third World livelihoods through facilitated water access, health and education services, as well as through the enhancement of agriculture and preservation of biodiversity.

With the widespread adoption of the Millennium Development Goals (MDGs), there is crucial links between energy services and the accomplishment of those goals (McDade et al., 2005; DFID, 2002b; UN-Energy, 2005). Over time, research has indicated increasing realization, as pronounced in (DIFID, 2002b), that energy in a developing country context needs to be understood as not primarily being about technology provision, but of understanding the impact of energy on the livelihood opportunities of the poor and how the poor value and use energy. Yet, in many such researches there is no clear proposed links between energy and development have been substantiated or are simply hypothesized. However, quite a few studies do exist, which present evidence of a number of development impacts, although the specific causal relationships are rarely disclosed.

2.2. Evidence cited in previous literature studies

Although a number of accounts of case studies can be found in the existing literature on welfare impacts from energy interventions, the hard empirical evidence that captures the direction of links between Renewable energy and adoption is rather limited. Before turning to case studies, the focus turns to four reviewed literature surveys that covered work on impacts from renewable energy interventions in developing countries. While compiled for individually different purposes that also differ somewhat from ours, all four studies indicate the potential for modern energy as a driver of poverty alleviation (Meadows et al., 2003; Toman et al., 2003), (Martinot, *et al.*, 2002); Cabraal, *et al.*, 2005).

One important general feature of the perceived benefits from energy interventions in all case studies is that benefits appear to be highly context specific. This notion can be exemplified by results from three different studies that are accounted for by (Martinot *et al.,* 2002). In the first, little evidence was found that Solar Home Systems had an impact on poverty alleviation (GTZ, 2000). Rather it was found that households did not buy such systems in order to reduce energy costs, but for the purposes of longer TV viewing and better lighting quality. However, in the second study from Inner Mongolia, improved energy access through small-scale wind turbines led to household investments in various types of equipment, substantially increased incomes, time saved for women, as well as TV and radio allowing households to access language instruction, information about weather, commodity prices and new farming methods (Richter and Meunier, 1997). The third study, from Bangladesh, showed that community solar-powered cell phones, produced up to $200/month in revenue for the local village operators (Urmee and Wimmer (1999), Barua (2000)).
The financial benefits on behalf of the villagers from learning about commodity prices, exchange rates, market trends, and from verifying cash deliveries made by relatives clearly exceeded the per minute connection charges. Furthermore, while lack of access to modern energy is often characterized as a barrier to development, consensus seems to exist that removing this barrier alone, does not necessarily result in socio-economic development. In previous literature studies emphasis is often made of the role of energy in concert with other interventions. Thus, modern energy should be viewed as one of a set of critical enabling factors that individually and/or jointly contribute to the creation of an environment conducive to development. Hence, the assessment of the significance of modern energy relative to that of other enabling factors, for specific types of development outcomes in particular circumstances, is perceived as critically important.
All four literature surveys highlights the shortage of experience and published articles that analyze welfare improvements from the provision and use of modern - particularly renewable - energy in developing countries. Agreement exists on the need for better data; a clearer picture is needed of the needs among beneficiaries and the modern energy services that can meet those needs efficiently and effectively. The field thus deserves much greater attention from donors, development agencies, and governments (Meadows *et al* (2003), Toman and Jemelkova (2003), Martinot *et al* (2002), Cabraal *et al* (2005)).

2. 3 Productive uses of energy for Slums development
One of the richest recent surveys of relevant literature by far is that of Cabraal *et al* (2005). The authors make a strong case for the revision of the concept of “productive uses of energy”, into a concept which also appreciates energy’s productive role in achieving development objectives, such as the MDGs. More than half of the world’s population and more than seventy percent of the world’s poor are found in slums, rural areas and an equal fraction is women (World Bank, 2004. As will be contended, slums/ rural poverty may be alleviated through improved energy provision in a variety of ways. In the context of rural development, however, Mary *et al* (2012) argue that energy has traditionally been looked at as having two converse uses; residential (or consumptive) and productive. In the former case, the uses of energy were expected to improve quality of life or slums/rural living standards, whereas productive uses were expected to increase productivity, enhance economic growth, boost employment, and thereby stem up migration of the rural poor to urban areas.
Customarily perceived productive uses would refer to electricity principally used for farm machinery such as water pumps, fodder choppers, threshers, grinders, and dryers in agriculture-based industries. However, Gongera *et al* (2014) argue that productive use should take into account the effects of improved energy services on income, education, health, and gender issues. In summary, lighting improves productivity and extends business hours for rural non-farm businesses, electricity in rural homes accumulates and protect human capital by increasing education levels and reducing both morbidity and mortality, for example from indoor air pollution or kerosene accidents. Hence, since educated and healthy individuals will be equipped with greater income generation potential than those comparatively unhealthy and uneducated, uses are considered productive and developmental.

Perceived “consumptive” uses of energy may in fact not be so. Recent study in Bangladesh found that women in households with electricity were better informed about gender equality and women’s empowerment related issues. Almost two thirds of the women in electrified households cited television – the viewing of which is traditionally considered a consumptive use – as their chief source of information Cabraal et al (2005). They build their case on empirical substantiation in each of the four areas of poverty, education health and gender equality specifically on women’s empowerment. With respect to income generation, the aforementioned “traditionally perceived” productive uses show raise in rural incomes according to Sachs (2005). The authors also point to research that shows other beneficial impacts on income from modern fuels. If replaced by modern energy, dung of substantial monetary value could rather be used as fertilizer to increase income in India (IEA (2002); Njie (1995)). Through access to improved stoves and modern cooking fuels, the rural poor can reallocate time to income- generating activities than collecting fuel wood, dung, and water (Barnes et al (2002), ISDOUS (2003)).

Time saved, for example by improved stoves and modern cooking fuels, has shown to increase the amount of time spent in school by children, primarily girls (World Bank, 2003; Kammen, 1995; Barnes, Openshaw, Smith, and van der Plas, 1994). Numerous studies also show the benefits for education of children's ability to do their homework by electrical light at night, rather than by candles or kerosene. Electric lights in schools and homes permit evening study and classes. These greatly encourage adult education because adults are busy during the day (ESMAP, 2002a).Also distance learning facilities rely on energy to run radio and television sets (Estrada and Brown, 2003; Calderoni 1998). One plausible field of health improvement in which distance learning can have an impact is that of combating AIDS and other diseases. Other health areas in which modern energy service has proven effective is that of exposure to biomass smoke, which is a significant cause of health problems such as acute respiratory infections, chronic obstructive lung diseases, lung cancer, and pregnancy-related outcomes (Perez-Padilla et al (2002), Kammen et al(2000)). Indoor air pollution is estimated to kill 2 million women and children every year: about 500,000 deaths of women and children in India, about the same in China, and the other million in other developing countries. ((2002b)). A study in Guatemala referred to by Cabraal *et al* (2005) shows that average exposure levels to particulates are three and a half to four times as high, per 24 hours and cubic meter, in households that cook over an open fire as compared to those that use an improved "plancha" stove or LPG (World Bank, 2005).

Rural health clinics in the developing world cater to fight diseases and promote health in rural communities. Cabraal *et al* (2005) identify a number of conceivable positive impacts if such clinics have access to electricity, modern fuels, clean water, or telecommunications.12 Evidence is provided from *inter alia* studies in Ghana, Cuba and Bangladesh. In the first case, a rural primary health facility evolved into a district hospital from the introduction and expansion of primarily PV systems and LPG for heat and sterilization (World Bank, 1996b). In Cuba a similar intervention is reported to have increased the quality of life and decreased the regional infant mortality rate (Stone, 1998). One of the most striking impacts on health from electrification originates in the study from Bangladesh. Comparing electrified and non-electrified households in electrified villages, the results indicate that the infant mortality rate in households with electricity is 25% less than the national average and 35% less than the national rural average. Estimates were that if access to electricity is expanded to 100% of rural households, on average 101 infant deaths could be avoided per day (Barkat, 2003).

2.4. Energy and Poverty

One of the primary distinguishing features about the world's poor is their lack of access to modern, clean energy sources. Globally, 2.5 billion people meet their primary energy needs through the consumption of biomass (TERI, 2008) and1.6 billion people still do not have access to Electricity (UNDP, 2007). The World Health Organisation (WHO) reports 2.5 million deaths per year due to indoor air pollution the emission of particulate and smoke matter due to inefficient combustion of fuel (WHO, 2009).

Understanding the nature and dynamics of poverty is important if one is to assess the way in which energy adoption affects it. Poverty is a multi- dimensional issue affecting human life and goes beyond the narrow conception of the absence of income (Silva & Nakata, 2009; UN-DESA, 2010; Bhide & Monroy, 2011). At its most fundamental level, poverty may be thought as deprivation on people's choices to access certain material goods, assets, capabilities, freedoms and opportunities" (Pachauri et al., 2004:2084). It describes a "condition of people that are denied the opportunities for a tolerable life" (Bhutto & Karim, 2007:58). Invariably, 'a tolerable' life is open for subjective interpretation. However, it is common understanding that a Life of poverty implies the denial of the most basic human needs of access to shelter, water, health care, education and transportation. While energy is not a basic need in itself, it is the means by which the most basic of human needs can be satisfied (Silva & Nakata, 2009). Its transformative power in lessening the burden of poverty (Batliwala & Reddy, 2003) has been recognized by intergovernmental bodies and development agencies alike (Vera & Langlois, 2007).

Income poverty, hunger, disease, exclusion, and Lack of infrastructure and shelter – while promoting gender equality, education, health, and environmental sustainability" (UNDP, 2005:7). The MDGs do not explicitly mention energy as a Quantifiable target; however, it is acknowledged that energy is an essential ingredient in achieving all of the MDGs (Silva & Nakata, 2009).

Scholars refer to the concept of 'energy poverty' when describing the interrelationship of the two terms. It appears however that there is no hermeneutic consensus on the precise Meaning thereof. Silva and Nakata (2009) describe it as "the condition where people cannot Afford access to a sustainable energy supply" (Silva & Nakata, 2009:3097). According to Barnes et al. (2011:894) energy poverty is "the point at which people use the bare minimum energy (derived from all sources) needed to Sustain life". There are different approaches to measuring energy poverty, all centered on quantifiable thresholds such as per-capita annual quantity of energy or energy expenditure as a proportion of household income. The latter approach is called 'fuel poverty' by Sefton and Chessire (2005), who regard it as "households which require 10% or more of their income to attain WHO standards" in order to maintain ambient indoor climate (Liddell & Morris, 2010:2988).

2.6 The Nexus of Energy and Poverty

"Without access to, and the transition to, affordable forms of clean appropriate energy, many of the world's poor are 'locked into' livelihoods, which are often unnecessarily environmentally damaging, unhealthy and uneconomic" (Howells et al., 2010:2730). This quote to A large extent contains within it the core of the nexus between energy and poverty, in that the denial of energy is a contributor and indeed, entrencher of poverty in all its related dimensions. As was seen in Section 2.3, the relationship between energy and poverty is one of mutual causation (Pachauri Et al., 2004). On The one hand higher levels of Poverty are reflected in the energy consumption patterns of households – with poorer households relying on a predominance of traditional fuels, burnt in inefficient appliances. On the other hand, the provision of clean and reliable energy sources can be a catalyst for human development, as recognized by many international agencies and Development practitioners alike. Following is a review of some of the direct poverty entrenching and alleviating affects that energy ha on human wellbeing.

2.6.1 Health

The Adverse health implications due to inferior energy usage may be attributable to fuel types and appliances that are used. The effect of poor indoor air quality, through the emission of smoke and other particulate matter, is one of the greatest threats to the health of poor people. The Combustion of biomass, such as fuel wood, coal, dung and wood residues on inefficient stoves or open fires is a major contributor towards health complications, especially if used in poorly ventilated or confined spaces (Elias & Victor, 2005; Siddiqui Et al., 2005; Bhutto & Karim, 2007). The Effect of inefficient cooking appliances exacerbates this problem, since they imply longer cooking times. In a study of the eye and Respiratory symptoms amongst women in southern Pakistan, Siddiqui et al. (2005) Found that wood users were up to 10.1 Times more likely to experience eye and nasal congestion, throat-related symptoms and coughs, compared to LPG users. According to the WHO, 21% of Lower respiratory infection deaths, 35% Chronic obstructive pulmonary deaths and 3% Of lung cancer deaths worldwide are a result of indoor smoke from solid fuels, 64% Of which occurring in developing countries (WHO, 2009). Indeed, The WHO Ranks indoor air pollution as the second largest environmental health risk (after Water and sanitation) (Elias & Victor, 2005) Contributing towards an estimated 2 Million deaths annually (WHO, 2009). Prolonged exposure to ambient airborne emission has also been linked to "tuberculosis, Parental mortality (stillbirths and deaths in the first week of life), low birth weight, cataracts and other serious health problem" (Elias & Victor, 2005:18). In a review of fuel poverty studies in developed countries, Liddell and Morris (2010) found significant reported correlations between child and adult mental health ailments, adverse family relations, absence from school and decreasing life expectancy as a result of insufficient fuels to keep the ambient environment warm in winter (Liddell & Morris, 2010).

The Appliances used by poor people can also have devastating health implications. In South Africa, It is estimated that 46,000 Dwelling are razed annually due to fires, many of which as a result of inferiorly designed paraffin stoves and lamps which are prevalent in informal settlements (Peck et al., 2008). Paraffin is purchased in small quantities in non-standardized, clear containers. Children often mistake these storage containers to be cold drink bottles leading to fatal poisoning. In a study of the poison ingestions at King Mshinyeni Memorial Hospital in Durban, South Africa, 54% of the sampled 426 cases of poisonings were due to paraffin ingestion, two-thirds of which under the age of 2 years (Paulsen, 2010).

Access to modern energy can have direct health benefits for poor communities. The Supply of electricity can enable health clinics to refrigerate vaccines, operate medical apparatus and sterilize instruments properly (Saghir, 2004; Bhutto & Karim, 2007; Bhide & Monroy, 2011). Coupled With improved lighting, workers can enjoy medical attention outside of work hours (Obeng & Evers, 2009).

2.6.2 Demographics: Sex and Age

The Absence of clean, modern energy sources has a disproportionately adverse effect on women and children, who are predominantly responsible for fulfilling household chores that involve energy. Women are tasked with the burden of collecting large loads of firewood, an increasingly scarce commodity in many areas of the world (Saghir, 2004). In a study on the average household energy sources and activities conducted in Pura (India) it was found that 14% of human energy was spent on the collection of fuel wood alone (Batliwala & Reddy, 2003).

The collection of firewood in outdoor areas carries with it the risk of bites, stings, allergic reactions and fungal infections (Elias & Victor, 2005). The need for large families (previously required for agricultural labour) to fulfill basic chores, including the collection of firewood, perpetuates poverty for it traps mothers in the cycle of child-bearing and rearing. In So doing, they forgo the prospect of education or productive enterprise.

The Household fuel mix is a matter of personal choice, and as such is influenced by demographic factors that include gender (Bhide & Monroy 2011; Clancy et al., 2008). Oftentimes men decide which appliances to purchase first. Some might “choose Televisions to watch soccer and refrigerators to keep their beers cold” (Annecke, 2008:307), as opposed to appliances which would undoubtedly benefit the household most. Since women and children spend the bulk of time at home, it is they that predominantly get affected by the choices that men can easily avoid (by going to work or a bar), such as an insufficient heating or a polluted indoor environment. Furthermore, it is women that have the added emotional stress of not meeting the family’s energy needs.

2.6.3 Economic opportunities

The opportunity cost of foregone productivity, through the time cost involved in sourcing traditional fuels, is a major expense to poor people (Pachauri et al., 2004). This is time that could be spent either furthering education, leading to more profitable pursuits, or through the creation of small home enterprises. Improved lighting extends the workday, providing the opportunity of increased production output as well as extended trading hours (Obeng & Evers, 2009). Access to energy has the ability to create new income opportunities, to expanding existing activities and to realize cost savings on current practices (Practical Action, 2010). Furthermore, poverty costs governments money. At the macro-economic scale, improving the economic self-reliance of poor people eases the fiscal burden of subsidized service delivery (Price, 2000; Bhutto & Karim, 2004). Energy service provision in conjunction with pro-poor related policies can help poor people to access the formal economy, turning them into a tax-paying as opposed to welfare-absorbing citizenry. Small and medium enterprises are especially reliant on reliable energy services and are a vital source of employment for the poor (Saghir, 2004; Clancy et al., 2008).

2.6.4 Social Cohesion

Schuller (2000) defines social capital as “networks, norms and trust, and the way these allow agents and institutions to be more effective in achieving common objectives” (Schuller, 2000:2, italics original). Such an objective might be survival or lessening the burden of Poverty through the employment of mutual and shared Livelihood strategies. “The absence of commercially supplied energy in a society, especially electricity, tends to accentuate the existence of social asymmetry in conditions of living” (Kaygusuz, 2011:937). This breakdown of social capital can be remedied through the introduction of modern energy sources, which have the ability to encourage social interactions and wellbeing of communities. The lighting of park places can increase the neighborhood through creation of safer public Spaces (Obeng & Evers, 2009). Furthermore, networks of trust and affiliation are created through the exchange of fuels. Whilst not the safest fuel (albeit an improvement over biomass), paraffin is a ‘social lubricant’ in many informal settlements (Mehlwana, 1997:13). The fuel is regarded as a household basic shared between households on a frequent basis, and forms the platform for further commodity exchanges.

2.12 Research Gap

The previous study undertaken by AFREPREN/FWD on behalf of GNESD was an initial regional assessment of the urban energy situation in East Africa and focused on Kenya and Uganda. The study identified viable and proven policy options that can assist in providing cleaner and more sustainable energy sources to the rapidly growing urban population in the context of a rapidly reforming energy sector. The study further assessed whether the energy policy reforms address the challenges or contribute to the growing problem of inadequate energy sources. The focus of the study was on ongoing and planned energy policy reforms addressing the questions of how likely they are to lead to improved, cleaner and more sustainable energy sources for the poor, and how the processes can be improved to promote better access to cleaner energy sources from the poverty alleviation, environmental and productive use of energy point of view. Global Network on Energy for Sustainable Development (GNESD) also principally studied objectives of assessing modern energy sources available, identified the cost of energy sources and subsidies offered and policies promoting energy access among the urban poor. Therefore the current study sort to scrutinize challenges facing household scale adoption of green energy in Kibera slums, Kenyan.

3.0 METHODOLOGY

3.1 Research Design

The study adopted a case study approach research design that seeks to investigate the study variables without manipulating any of them or tampering with them in an attempt to understand, describe and explain well adoption and use of green energy in Kibera slums. A research design is the conceptual structure within which research is conducted. According to Mugenda et al (2003), research design is a systematic inquiry into which the researcher does not have direct control of the independent variables because their manifestation has already occurred. The study used an Ex Post Facto Survey design where measures of the proposed determinants of acceptance are taken once in cross sectional study of the respondents (Hopkins, 2000). The target population for this study was Kibera slum with population of 300,000 inhabitants whose sample size constituted 10% of the target population. Logistic regression model was used to address the first objective namely, that of adoption and use green energy technology in Kenya Kibera slums. Following Maddala (1983, 2001), the probability, p, that a household uses green energy is given by;

$$P=ez/1+ez \quad (1)$$

Central to the use of logistic regression is the logit transformation of p given by Z

$$Z=ln(p/1-p) \quad (2)$$

Where

$$Z=Z(f, z, a, k) + \varepsilon \quad (3)$$

Where Z is a laten variable that takes the value of 1 if the resident use green energy technology in Kenya Kibera slums, and 0 otherwise, f is a vector of the resident characteristics, z is a vector of the resident level variable, a is a vector of a asset specific variables, k is a vector of regional variables and ε is the stochastic term assumed to have a logistic distribution. The empirical model estimated contains the following variables (letters in parenthesis indicate related category variables from the conceptual model):

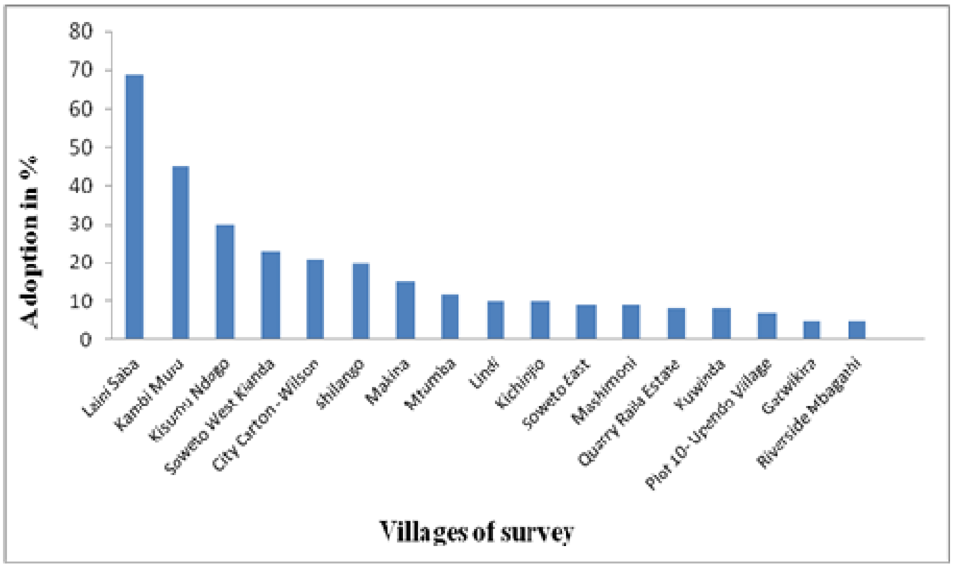
1) Resident specific variables (f) = age, age squared, gender
2) Resident specific variables (z) =
3) Asset endowment characteristic (a)
    a. Physical asset (income, current value of asset)
4) Regional variables(k): district

4.0 FINDINGS

4.1 Cost of green energy and size of family income

In assessing the effects of cost of green energy, the respondents were asked to indicate whether cost was a challenge and if they had acquired any of green energy technology apparatus (solar cooker, solar lamps, etc)? The study found that 20%) of the residents had not acquired technology because it was expensive. Findings indicated more residents in Laini saba village adopted and use green energy technology than the other 16 villages. Indeed, Laini saba is the only village where there were more users of green energy technology (68%). Two factors explain this scenario; availability of NGOs who provides them with renewable energy technology equipments and services with a prolonged period of weekly payment of 50 kshs. Secondly, more than 15 existing youth and women groups, these groups enable them to access many other things such as provision of health services, green energy technology. They are able to use group resources and also easily get donations. Thirdly the residents of Laini saba had better family income than the rest of the villages. This is attributed to the youth and women groups engaged in small business. This therefore enables Laini Saba residence to adopt green energy technology.

Figure 1: Adoption of green energy technology per village



Source: survey results, 2013

4.2.1 Determinants of adoption of green energy technologies among slums dwellers
In order to examine factors explaining the adoption of household scale green energy technology, bi
nary depend variable was used (that take the value of 1 if the Respondent is an adopter and 0

4.2 Determinants of adoption of green energy technologies among slums dwellers
In order to examine factors explaining the adoption of household scale green energy technology, binary dependent variable was used (that take the value of 1 if the Respondent is an adopter and 0 otherwise) to fit a logit regression model. The results of the fitted regression model are shown in table 2. The LR statistics shows that the model fitted the data well (p-value =0.000). As hypothesized, distance to the Distance to the nearest energy centre and Energy retailers played a critical role in adoption of household scale green energy technology. The distant away the resident is from the energy centre, the less likely was the adoption of technology. These findings indicate that household green energy technology has great potential to reduce the exclusion from access to reliable clean affordable sources of energy.

Study also confirms that among the Kibera Slum resident on specific characteristics, gender affects likelihood of adoption of household scale green energy technology adoption. Residents who have gone through years of formal education also influenced the likelihood of adopting household green energy technology. The finding relating to education support the earlier argument that literacy affected the awareness and use of green energy technology. Results further shows that social capital engagement on youth and women group, also affects the likelihood of adopting household green energy technology. This finding is in line with those of previous studies that indicated energy as a transition process (Foster, 2000; Rehman et al, 2010).

Table 2: Drivers of adoption of household green energy technology by slums dwellers: Logit regression

Variable definition			Marginal effects	
Dependent variable=adoption of household green energy technology	coefficient	p- value	coefficient	p- value
Resident specific variables				
Gender	0.54	0.041	0.123	0.036
Age (Years)	0.03	0.118	0.059	0.118
Residents specific variables				
Distance to the nearest energy centre (km)	-0.01	0.642	-0.003	0.642
Energy retailers (km)	0.31	0.001	-0.094	0.001
Household size	-0.09	0.159	-0.023	0.149
Asset endowment Variable				
Natural log of current value of asset	0.11	0.028	0.029	0.022
Natural log of total household income	0.24	0.005	0.063	0.002
Education (years of formal education)	0.19	0.000	0.048	0.000
No of years using green energy technology	-0.03	0.032	-0.004	0.032
Group membership	0.71	0.007	0.157	0.003
Regional variable				
District(1=Langata0=otherwise	0.32	0.452	0.18	0.376
constant	-1.13	0.000		
No of observation:450 PseudoR^2:0.29 p- value:0.001 Log likelihood:207.29				

Source: Survey results, 2016

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

Slum dwellers or poor urban residents have a problem in accessing household green energy technology in developing countries. Poor policies, high cost of technology, lack of accurate and sufficient information changes the general uptake of technology.
The study also found out that the awareness of green energy technology did not vary much among the study region apart from Laini Saba village had NGOs group providing them with the green energy technology services and products.

Social capital as “networks, norms and trust allow agents and institutions to be more effective in achieving common objectives” (Schuller, 2000). Such an objective of survival lessens the burden of Poverty through the employment of mutual and shared livelihood strategies. “The absence of commercially supplied energy in a society, especially electricity, tends to accentuate the existence of social asymmetry in conditions of living” (Kaygusuz, 2011). This breakdown of social capital can be remedied through the introduction of modern energy sources, which has the ability to encourage social interactions and wellbeing of communities. The lighting of park places can increase the neighborhood through creation of safer public Spaces (Obeng & Evers, 2009).

The study also found out that the cost of green energy and size of family income plays a major role in household scale adoption of green energy.10 percent of those who had adopted technology were more financially stable than the rest of the respondents and who had acquired formal education. Therefore, the null hypothesis that the cost of green energy and size of family income plays a major role in household scale adoption of green energy was accepted. The studies discovered that the government of Kenya has not come up with the policies that would encourage the private sector to provide affordable, renewable, clean lighting, off-grid lighting units to poor urban people living in slums. It was also discovered that energy policies and strategies developed at national level did not encourage adoption of household green energy at regional level. The null hypothesis that energy sector reforms would lead to improved access to clean and affordable energy services by slums dwellers therefore was accepted.

5.2 Recommendation

The implications of these findings is that, there is need to expand the household adoption of green energy technologies in slums areas since it resolves idiosyncratic failures slum residents face namely; access to clean lighting and cooking energy sources. Renewable, clean lighting, off grid lighting units provide an example of commercial sound, affordable and effective way of providing clean energy lighting technology to all. Short distance to the nearest energy specialist extension officers (2km) as opposed to the nearest commercial traders (20km) implies reduction in the cost of accessing green energy technologies. This can spur green energy technology adoption and improvement in household welfare (household income). Increased adoption of technology means that slum dwellers are more able to participate in the market economy. Findings also highlight the importance of improving slum education level of the slums communities. Education empowers the slum people with information about new technologies thus influencing their decision making process especially regarding relatively complex technologies. This calls for more investment in formal and informal education among the slums communities. There is also need to improve in the technology information flow and exchange among relevant and interested parties including the slum dwellers, mobile phone services providers and government energy centers extension officers. In addition develop pro-poor energy strategies, including financing and support programs like soft loans and grants. In hence, there is need for policy makers and private sectors to invest in linking poor urban population with the green energy technology providers.

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