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HOUSEHOLD ENERGY CHOICE FOR COOKING FUEL AND UNDERLYING CIRCUMSTANCES IN NON-FORMAL URBAN SETTLEMENTS IN KENYA

Dan Oduor Oluoch[1]* and Gideon Nyamasyo[2]

*[1]*PhD candidate Wangari Maathai Institute for Peace and Environmental Studies, University of Nairobi, P.O Box 30197-00100 Nairobi, Kenya*

[2] Professor, School of Biological Sciences 'College of Physical and Biological Sciences, University of Nairobi P.O Box 30197-00100 Nairobi, Kenya ,

**[1]danoluoch50@gmail.com, [2]gnyamasyo @gmail.com.*

Corresponding author: -

Email ID - gnyamasyo @gmail.com

Abstract: - *This study investigated the choice of cooking fuel and underlying circumstances in Kibra slums in Nairobi County, Kenya. The study focused on various factors that influence household choice of cooking fuel and those which could keep household away from using other cooking fuels in non-formal settlements areas in the urban set-up. The study was both quantitative and qualitative and used questionnaires and observation schedules to collect data among targeted households. The findings suggest that various factors play crucial roles in determining household choice of improved fuel for cooking but most dominant factors were; time spent to cook a meal, ease of lighting, affordability, availability of fuel and its storage. The study also realized that lack of sufficient income has little influence on people to adopt or reject improved fuels. The paper argues that more data and necessary information need to be provided on the merits and demerits of various types of improved cooking fuel to the household in the slums and the its environs to enable the residents make better choices. The findings of this study indicated that for fuel choice at various household levels, it is still a challenge as some of the households targeted did not have any good reason why they use their eferred fuel type and have no much knowledge on any dangers associated with their cooking fuel choices apart from when they witness an incidence or incidence which could be considered as dangerous.*

Keywords: *affordability, cooking fuel, decisions, household, informal settlement*

1. INTRODUCTION

Baseline Report of Clean Cooking Fuels in the East African Community (EAC, 2015) conducted indicated that each day, three billion people cook their meals using polluting biomass fuels, including fuelwood, charcoal, dung and agricultural residues. This causes vast public health, environment and global climate change issues. According to the World Health Organization (WHO), over four million people die each year from diseases caused by Household Air Pollution (HAP) from the smoke emanating from the biomass-based cooking stoves. Hartvigsson and Ahlgren (2018) posited that over one billion people lack access to electricity in the world every single day and majority of these population are based in remote rural areas in sub-Saharan Africa and developing Asia (IEA, 2015). Bhattacharyya (2005) stated that the critical role played by energy in achieving sustainable development is now well recognized and the extreme form of disparity existing in the world in terms of production, consumption and access of energy is considered as a major concern.Sustainable Development Goals (SDG)-7 Ensure access to affordable, reliable, sustainable and modern energy for all is a global guideline for countries to achieve. According to the SDG report, it was realized that 789 million people globally lack electricity (2018) hence the need to scale up on sustainable energy. It was also noted that affordable and reliable energy is critical for households though one in four persons are not having electricity in developing countries (United Nations, Department of Economic and Social Affairs Sustainable Development).

This study, tried to understand how households in informal settlements try to meet their energy needs with unstructured living structures and their challenges. Lambe et al.,(2015) noted that 600,000 people die every year as a result of smoke inhalation and economic costs are considered in relation to the best case scenario of full adoption of higher performing biomass stoves by households and it is as high as US $36.9 billion per year. Zheng et al,.(2011) on a study on the role of both household and community biomass use indicated that population-based reduction in solid fuel use is necessary for reducing air pollution exposure and its health effects in developing country cities. According to World Energy Outlook (2015)

India makes rapid gains in bringing energy access to its people, but the world as a whole is falling short of its ambition to provide affordable, reliable, sustainable and modern energy for all. Despite the serious efforts already made, today an estimated 1.2 billion people – 17% of the global population – remain without electricity, and 2.7 billion people – 38% of the global population – put their health at risk through reliance on the traditional use of solid biomass for cooking. The newly agreed UN Sustainable Development Goals embrace a goal on energy, a move long advocated by the IEA, including the target to achieve universal access to energy by 2030. In our Outlook, the number of people without electricity falls to 800 million by 2030 and the number without access to clean cooking fuels declines only gradually to 2.3 billion in 2030(IEA,2015 p.2)

In 2000, Africa's population of around 820 million accounted for about 13% of the world's 6.1 billion people. In 2018, this share had increased to around 17%, as its population expanded at more than twice the global rate (Africa Energy outlook, 2019). Africa has the world's fastest growing and youngest population. The last two decades have seen the number of people living in cities increase by 90% and this trend continues over the next two decades. These are challenges which was realized in this study especially being carried out in an informal settlement in one of the biggest slums in Africa.

Kenya Vision 2030 (GoK, 2007) in its social pillar has indicated that commercial energy in the country is dominated by petroleum and electricity, while wood fuel provides energy needs of the traditional sector including rural communities and the urban poor. The Vison further states that the country is facing power challenges like weak power transmission and distribution infrastructure, high cost of per, low per capita power consumption and low country wide access. All this impact on household energy choices hence the need for this study.

2. Saferfuture and cooking fuel Choices

There is a lot of Literature on why households prefer certain types of cooking fuels and reject others form different parts of the globe. Many of them identify various factors in relation to individual and at times societal or environmental circumstances. One of the noted factors across by many studies is unaffordability. It is one of the crucial barriers to the successful uptake of improved fuels and it is argued that increase in income assists switching to efficient fuels (Africa Energy outlook, 2019) noted that Africa need to lift their constraints in terms of energy consumption and demands. This will go a long way in achieving of full access to modern energy by 2030. In the case of electricity, this would require tripling the average number of people gaining access per year from around 20 million today to over 60 million people. Grid expansion and densification is the least cost option for nearly 45% of the currently deprived, mini-grids for 30% and stand-alone systems for around a quarter (Africa Energy outlook, 2019).

Adam (2009) stated that there is potential in making biomass cooking energy sustainable for instance through sustainable growing and management of trees and adoption of efficient kilns with higher production such as low-cost retort kiln. In nine provinces in China, studies found that access to clean energy increased by 5.67%, (Zhang et al, 2011). Adoption of cleaner energy is influenced by household characteristics, location, knowledge and perception, fuel technology, tax and subsidy, regulation legislation, market, awareness management according to various researches.

United Nations (2015) Sustainable Development Goals-SDG 7 and the primary objective of the Sustainable Energy for All Initiative (SE4All, 2017) all focus on energy for development at household to and industrial level. Further, the reports indicate that growth in energy consumption has been identified as correlating with economic growth, for developed as well as developing countries. Apart from benefits associated with economic growth, access to electricity has also been identified as having positive impacts on education and health (Independent Evaluation Group, 2008).
Adoption of clean energy was found to depend on household's income as described by Fei and Yu, 2011. Consumption of electricity increases with household income (Wang & Hu, 2010). The relationship between household consumption of biogas and income was found to be non-linear; it is in the form of a curve (quadratic curve). The willingness to adopt biogas increased with income of households at the beginning reaches a critical value and the decrease with income. This is because the household shift to the use of other commercial fuels which are cleaner like LPG (Wu.et al., 2012). As income increases in both urban and rural households, there is a tendency to increase the use of cleaner fuels. Low-income groups pay more attention to economic costs of different fuels as opposed to comfortable, convenient consumption. With increase in income households prefer using comfortable and environmentally friendly fuels (Lu and Lu, 2006).

According to Rosenthal et al., (2018) on a study in adopting clean fuels, LPG consumption for domestic purposes was found to be growing rapidly around the world, especially over the past five years. Many countries are targeting major increases in the next decade to meet climate-related, energy modernization and other Sustainable Development Goals (IEA, 2016).

Type and permanence of housing structures influence energy use and cooking practices. For instance, Liu et al., 2013 in their study found that families in nine provinces in China East, China, middle China and west China who live in concrete structures prefer to use relatively cleaner sources of fuel as compared to household living in houses made of temporary structures. They further found that using cleaner energy increased by 5.6% if the house hold structure changes from temporary to one made of permanent materials. Household structure is related to the income and as such increase in income may result into increased use of cleaner cook energy.
Adoption of clean energy was found depend on household's income as described by Fei Liu, (2005). With increase in income households prefer using comfortable and environmentally friendly fuels (Lu et al., 2017). Location of the households influences availability and accessibility of various cooking fuels as described by Wu et al., (2012. Remote areas consume biomass because cleaner sources of energy like LPG are difficult to transport and expansive while access to electricity in remote areas is limited.

Family size, gender and age directly affect cleaner fuel adoption. Old people prefer traditional fuels as described by Wu et al., 2012. Larger size families may prefer biomass because there is enough labour. Females are the ones who do most household chores are more vulnerable to indoor air pollution if they don't use good source of cooking fuels. On the role of gender, EAC (2015) report indicated that 71 per cent of households are male headed and 29 per cent female headed. Women's groups have played an important role in the cook stove sector in Kenya in production and sales and are integral to any consumer awareness and education campaign as the primary users of cook stoves (EAC, 2015).
Information about a concept is quite crucial in all that one does and even for cooking fuels, necessary knowledge is important in choosing cleaner fuel (Wang et al., 2011). Chan and Zhen (2009) indicated that the use of cleaner sources of fuels will increase with government subsidy in various places while Wu (2012) suggested the importance of policy regulation and legislation in adoption of cleaner fuels. Thacker et al., (2014) stated that since the late 1990's over 100 cookstoves projects with improved burning efficiencies have been initiated but adoption rate has been low, because the stoves do not meet the needs of the users which vary across different regions and different households.

3. Methods

This research was carried out in Laini Saba area, Kibera Constituency, Nairobi County, Kenya. Kibera constituency has five wards that is Makina, Laini Saba, Sarang'ombe, Woodley/Kenyatta Golf Course and Lindi with 118,658 votes and an approximate population of 170,000 (Kenya Census Report, (2019). The research followed a case study approach as each and every household randomly selected in this study through household data provide by the local government offices were physically visited by the researcher, research assistants and a community leader.
Households were randomly selected at a fixed interval following their locations along selected road transects that make Laini Saba Village.

Fig1 Map of Kibera (*source Map data @2012 Google*)

In the first stage, the researcher visited the area and had a meeting with the local government officers, local leaders and other stakeholders operating in the area. This meeting help to identify households for the study. The next stage involved approaching the identified homes who were willing to participate in the study. Data was collected from 304 households using questionnaires using structured and semi structured questions. To reach the households, the researcher was guided by community leaders.

4. Study findings

The respondents for this study were 304 households living in Laini Saba, Kibera constituency, Kenya.

Table 1: Distribution of the respondents by gender

Gender	Percentage
Female	50.33
Male	48.36
Did not indicate the gender	1.32

The response was in line with chapter four part 197 of the constitution of Kenya 2010, which requires inclusion of not more than 2/3 of the same gender. The findings indicated that more women are concerned with issues of cooking fuel.

Table 2: Ranking of factors affecting Choice of cooking Energy in Kibera

	Charcoal n=109		Kerosene n=227		LPG n=49		Electricity n=49	
Parameters	***Male***	***Female***	***Male***	***Female***	***Male***	***Female***	***Male***	***Female***
Safety	1	2	4	1	1	4	3	3
Time Spent to Cook a Meal	4	2	3	3	2	1	1	4
Ease of Lighting	4	4	3	2	2	1	1	3
Can Be Left Unattended	1	1	3	2	4	4	2	3
Heating Space	1	1	3	2	4	3	2	4
Fuel Use Efficiency	3	1	2	2	1	3	4	4
Affordability	4	1	2	3	2	1	1	4
Availability of Fuel	4	1	3	2	2	3	1	4
Fuel Storage	4	1	2	3	3	2	1	4
Total Score	26	14	25	20	21	22	16	33

Household overall Ranking from Best to Worst Fuel Choice

Male	Female
Electricity	Charcoal
Lpg	Kerosene
Kerosene	LPG
Charcoal	Electricity

Table 3: Cross tabulation Electricity against Income of household head.

	Percentage
1,000 – 2,000	0.00
2,000 – 3,000	16.7
4,000 – 7,000	16.0
5,000 – 9,000	13.2
10,000 – 11,000	20.0
12,000 – 13,000	21.1
14,000 – 15,000	11.5
16,000 – 17,000	25
18,000 – 19,000	25
20,000 and above	11.1

Chi –square tests found P= 0.742 which was not significant. This implies that income of household has no influence on the choice of electricity as a cooking energy.

5. Discussions

Yuwan (2018) noted in his study in India villages that families involved in the study have more TVs than LPG stoves. Despite the fact that both are relatively new technologies, the adoption of the former is clearly more extensive than the latter. From this case, it can be argued that households do not necessarily decide to switch to efficient fuels even if they are affordable. Both the upfront and running costs for a TV are found to be higher than that of using an LPG stove for cooking. This scenario was also realized in this study through observation schedules where the researcher found that some of the houses has very expensive electronic gadgets like television sets what then influenced families to adopt expensive TVs but not LPG can be studied further.

This study found that availability is a factor that influences choice of cooking energy in Kibera slums in Kenya. Other research studies have noted that to understand a household's fuel choice decision, it is essential to understand the broader decision-making context within which families operate and make all decisions. On affordability, the response was different as per gender was much easier for men to purchase clean sources of energy like LPG rather than women. Affordable LPG was a challenge to most household because initial cost of the equipment was high and it is sold in quantities that those who rely on daily wages could not afford (Ozturk, 2010). The same study found that, growth in energy consumption has been identified as correlating with economic growth, for developed as well as developing countries (Ozturk, 2010). Haisheng Chen et al., (2008) stated that the traditional electricity value chain has been considered to consist of five links; that is fuel/energy source, generation, transmission, distribution and customer-side energy service. While Kenya Vison 2030(GoK, 2007) noted that;the petroleum industry is constrained by limited supply Facilities for fuels including LPG, domestic production of motor fuels which do no tmeet international quality standards, inadequate distribution infrastructure in the remote parts of the country which contribute to high product prices, proliferation of sub-standard fuel dispensing facilities, under-dispensing of products, including adulteration of motor fuels and dumping of export products (GoK, 2005.p.16). Sustainable Development Goal 7 encouraged universal access to clean energy and improvement in energy efficiency as a priority for sustainable development. This is in line with the findings of this study which indicated that the households in the informal settlements are on the path to using clean energy for cooking purposes as use of unclean fuels like charcoal was very minimal.

Global Alliance for cook stoves calls for adoption of clean efficient cookstoves fuels in hundred million homes by 2020.African clean Cooking Energy Solutions initiative (ACCES) is doing a lot to dissemination and adoption of clean cook stoves in Sub-Saharan Africa (SSA). Energizing Development (EnDev) is promoting access to modern energy services for households United Nations frame work on Climate change is encouraging action to conserve forests and promote renewable energy services. West African clean cooking Alliance (WACCA) provides access to efficient sustainable and affordable cooking energy in the entire The Economic Community of West African States (ECOWAS) region. Informal settlements are still much behind in realizing these goals. Access to modern energy is still low and they rely on polluting sources of energy with serious consequences on heath environment and national development.

4. Conclusion

The study found that various factors influence the choice of the cooking gas for instance, about 4.6% rated affordability of LPG as better while 6.3 rated it as better. Affordability of LPG was a challenge to most household because initial cost of the equipment was high and it is sold in quantities that those who rely on daily wages could not afford. For electricity, the study found out that relationship to household head had an influence on the choice of electricity as cooking energy. Sustainable Development Goal 7 has recognized energy worldwide as an enabler of development and universal access to clean energy is a priority to all household from heathy living.

This study is in support of Kenya's development Agenda as envisioned in Kenya Vision 2020(GoK, 2007) in placing energy as an enabler as the country is expected to use more energy as it moves toward the Forth Industrial Revolution which will realize more household demand for clean energy for domestic use.

Abbreviations

ACCES: African clean Cooking Energy Solutions initiative
CCTs: controlled cooking tests
$CO_{2:}$ Carbon Monoxide
^{0}C: Temperature
ECOWAS:The Economic Community of West African States
Endev: Energizing Development
IEA: International Energy Agency
GHG: Global greenhouse gas
GoK: Government of Kenya
HAP: Household Air Pollution
LPG: Liquefied Petroleum Gas
PM: Community Particulate matter
PPM: Parts per million
WACCA: West African clean cooking Alliance
SDG: Sustainable Development Goals
TV: Television set
WHO: World Health Organization?

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REFERENCES

[1].Adam, J. C. 2009. "Improved and more environmentally friendly charcoal production system using a low cost retort-kiln (eco-charcoal)." Renewable Energy 34 (8): 1923–5
[2].Africa Energy outlook (2019).Map of Kibera -source Map data @2012 Google Anita V. Shankar a,*,1 , Ashlinn K. Quinn b,1,2 , Katherine L. Dickinson c , Kendra N.
[3].Williams d , Omar Masera e , Dana Charron f , Darby Jack g , Jasmine Hyman h , Ajay Pillarisetti i , Rob Bailisj, Praveen Kumar k , Ilse Ruiz-Mercado l , Joshua P. Rosenthal b,2Everybody stacks: Lessons from household energy case studies to inform design principles for clean energy transitions . Elsevier. Energy for Sustainable Development.Volume 43, April 2018, Pages 186-195
[4].Elias Hartvigsson and Erik O. Ahlgren (2018) Comparison of load profiles in a mini-grid: Assessment of performance metrics using measured and interview-based data. Energy for Sustainable Development.Volume 43, April 2018, Pages 186-195
[5].Author links open overlay panel Haisheng Chena, Thang NgocCong,Wei Yang ,ChunqingTan,YongliangLia and Yulong Ding(2008)Progress in electrical energy storage system: A critical iewhttps://doi.org/10.1016/j.pnsc.2008.07.014
[6].IEA 2015. World Energy Outlook 2015. Secure Sustainable Together IEA and OECD. 2004. World Energy Outlook 2004. Paris: international Energy Agency and Organisation for Economic Co-operation and Development Energy Technology Perspectives (2020). International Technology Agency (iea). www.iea.org International Energy Agency (IEA) (2008b), World Energy Outlook 2008, OECD/IEA, Paris.
[7].IEA, 2003.*Energy Balances of Non-OECD Countries, 2000-2001*. Paris, France: International Energy Agency (IEA)
[8].IEA Assessing the challenges and opportunities of Africa's energy future5 December 2019
[9].Karekezi, S., 2002. Renewables in Africa—meeting the energy needs of the poor. Energy Policy 722 30, 1059–1069.
[10]. Kenya Vision 2030(GoK, 2007).A globally competitive and ProsperosKenya..Ministry of Planning and the National Economi and Scial Council (NESC), Office of the President.
[11]. Joshua Rosenthal, Ashlinn Quinn , Andrew P. Grieshop , Ajay Pillarisetti , Roger I. Glass (2018).Clean cooking and the SDGs: Integrated analytical approaches to guide energy interventions for health and environment goals, Energy for Sustainable Developmnt42(2018) 152-15.
[12]. Lambe , Marie Jürisoo, Hannah Wanjiru and Jacqueline Senyagwaet (2015). Bringing clean, safe, affordable cooking energy tohouseholds across Africa: an agenda for action. Background paper to the Africa Progress Panel 2015 report Power, People, Planet: Seizing Africa's Energy and Climate Opportunities. Stockholm Environmental Institute.
[13]. Ilhan Ozturk, Alper Aslan and HuseyinKalyoncu(2010).Energy consumption and economic growth relationship: Evidence from panel data for low and middle income countries*Energy Policy*, 2010, vol. 38, issue 8, 4422-4428
[14]. Malakar, Yuwan (2018). Studying household decision-making context and cooking fuel transition in rural India. Energy for Sustainable Development 43 68-74. https://doi.org/10.1016/j.esd.2017.12.006
[15]. Paul Ih-Fei Liu (2005).Energy, Technology and the Environment Illustrated Edition. American Society of Mechanical Engineers; Illustrated Edition .ISBN-10: 0791802221, ISBN-13: 978-0791802229
[16]. Subhes C. Bhattacharyya (2005).Viewpoint Energy access problem of the poor in India: Is rural electrification a remedy? Centre for Energy, Petroleum and Mineral Law and Policy, University of Dundee, Dundee DD1 4HN, Scotland, UK Available online 12 October 2005
[17]. Sustainable energy for all-SE4All (20140.Energy Access Committee Report, (http://www.se4all.org/ d.zahrer@se4all.org/s.mcdade@se4all.org: www.se4all.org
[18]. The 2009 Kenya Population and Housing Census "Counting Our People for the Implementation of Vision 2030. VOLUME IC Population Distribution by Age, Sex and Administrative Units .August, 2010
[19]. Thacker. K, Barger .M and Mattson C (2014) A Global Review of End User Needs. Establishing the Need for Adaptable cook Stoves. IEEE 2014 Global humanitarian Technology Conference.
[20]. United Nations. Department of Economic and Social Affairs Sustainable Development https://sdgs.un.org/goals
[21]. Wang, Y, Xia P. Fei Z. Biogas Construction theory and the practice question in jixi, heilongjang province, China collective economy 2012, 12, 181-182. Article ID 19
[22]. Wang, H., Wang, X., Wu, S., *et al*., Experimental study on the slagging characteristics and influential factors of the biomass briquette combustion stove. Journal ofHenan agricultural university 2008, 42, 206-209.
[23]. Wang, R.; Tao, S.; Wang, W.; Liu, J.; Shen, H.; Shen, G.; Wang, B.; Liu, X.; Li, W.; Huang,
[24]. Y.; Zhang, Y.; Lu, Y.; Chen, H.; Chen, Y.; Wang, C.; Zhu, D.; Wang, X.; Li,B.; Liu, W.; Ma, J. Black carbon emissions in China from 1949 to 2050.Environmental Science & Technology 2012, 46, 7595-7603.

[25]. Wei, W.; Zhang, W.; Hu, D.; Ou, L.; Tong, Y.; Shen, G.; Shen, H.; Wang, X. Emission of carbon monoxide and carbon dioxide from uncompressed biomass and pellet biomass fuels burned in typical household stoves in China. Atmospheric Environment 2012. 56, 136-142.

[26]. Wu Y, Shen Y, Yan F. (2012). Study on rural distributed and renewable energy selection by multi-variable regression analysis-based on the survey of Gaojiazhuang of Hebei province, Chinese Agricultural Science Bulletin 2012, 28, 248-253. *Article ID.63*

[27]. Y Lu, Y Liu, M Zhou (2017).Rebound effect of improved energy efficiency for different energy types: A general equilibrium analysis for China.

[28]. YuwanMalakar (2018).Evaluating the role of rural electrification in expanding people's capabilities in India. Energy Policy, 2018, vol. 114, issue C, 492-498.

[29]. Zheng Zhou, Kathie L. Dionisio, Raphael E. Arku, Audrey Quaye, Allison F.Hughes, Jose Vallarino, John D. Spengler, Allan Hill, Samuel Agyei-Mensah and Majid Ezzati. Household and community poverty, biomass use, and air pollution in Accra, Ghana: Proceedings of the National Academy of Sciences of the United States of America, Vol. 108, No. 27 (July 5, 2011), pp. 11028-11033: National Academy of Sciences. https://www.jstor.org/stable/27978737

[30]. Zhu Liu, Dabo Guan, Douglas Crawford-Brown, Qiang Zhang, Hao He and Jianguo Liu(2013).Energy policy: A low-carbon road map for China August 2013Nature 500(7461):143-5 Follow journal DOI: 10.1038/500143a