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Adoption of Improved Biomass Cook Stoves: Case Study of Baringo and West Pokot Counties in Kenya

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Abstract

Biomass cookstove improvement has been a global active research area for many decades and has resulted into much progress towards cleaner and more efficient energy conversion cooking devices. Irrespective of the perfection and development of improved cookstoves, many households in Kenya are still using three stone cookstoves. In Baringo County, 71.8% used three stone cookstoves. The focus of research needs to change towards adoption of improved cook stoves. A cross-sectional survey was conducted in rural, peri-urban and urban households regarding current cookstoves types in relation to fuel use categorized as improved and un-improved in Baringo and West Pokot counties. Biomass was the primary fuel in the two counties used in the form of firewood and charcoal at average of 70% and 26% respectively. The main un-improved cookstoves in the two counties were three stone and metallic jiko. The two were commonly used in Baringo County with 28.5% of the households using metallic stove. Whereas in West Pokot, Chepkube was the main cookstove used for cooking at 47.8% seconded by improved three stone at 36.6%. The use of un-improved cookstove was popular in Baringo County at 77.6% while infamous in West Pokot County at 21.7%. The results showed that West Pokot County is more conscious to energy related issues unlike Baringo County. The difference in dynamic of the two Counties in terms of land ownership, access to biofuel, social groupings, availability of cookstove installers and improved jikos could be the reason.

Keywords

Biomass Cookstoves, Emissions, Improved Cookstoves, Deforestation, Energy Conversion Devices

1. Introduction

Biomass cookstove improvement has been a global active research area for many decades and has resulted into much progress towards cleaner and more efficient energy conversion cooking devices. This is prompted by the growing interest in clean cooking which has potential benefits for human health, environmental protection, and climate change [1]. The evolution of biomass cook stove is referenced from the common un-improved traditional three stone cooking method across the globe. The three-stone fire is inefficient in conversion of solid fuels to energy and, although its performance varies greatly depending on the cook, it generally yields only 5% - 15% overall thermal efficiency [2]. Irrespective of the perfection and development of improved cookstoves that have high efficiency and low emission, many households in Kenya are still using three stone cookstoves [3].

The focus of research probably needs to change towards adoption of improved cook stoves [1] [4]. The big question is why do households feel comfortable to use threes stones for cooking even when provided with improved cookstoves. From the observation in Baringo and West Pokot counties, there exist large family sizes with high cooking power requirement who are comfortable cooking on three stone. In addition, the type of meals prepared had also direct bearing on the choice of cooking devices [5]. The commonly prepared foods in these localities include the cereals, ugali and kienyeji food types. The location and kitchen set up had also a connection on the type of cooking devices used. Many households in the two counties have kitchen outside the main house and well ventilated for cases of high emissions. Furthermore, areas of Baringo County have plenty of prosopis which is a menace hence biomass fuel availability is not an issue [6]. Finally, many households have not been connected to electricity, hence three-stone provides light during cooking time.

There exist a number of improved cookstoves with high thermal efficiencies above 50% namely; eco zoom, Envirofit and jiko koa that use charcoal as primary fuel in Kenya [2]. Other improved cookstoves that use firewood available in the market include; rocket stoves, improved Chebukube and energy saving jikos. An improved cook stove is an energy conversion device that has a liner in the combustion chamber to minimize heat losses and emissions [7]. During the baseline survey in the two counties, the aforementioned cooking devices were owned by at least 30.6% of the households interviewed. However, 50% of the households were not frequently using the improved cook stoves as much as they owned them.

Women and children inexplicably experience higher indoor air pollution exposure from unimproved cookstoves due to their often traditional roles doing indoor work, cooking, and childcare [3] [8]. International efforts to reduce indoor air pollution from cookstoves and associated health effects have been championed by the WHO, United Nations and the World Bank and other multinational partnerships such as The Global Alliance for Clean Cookstoves (GACC) [9]. Until recently these efforts have focused on the development and distribution of improved cookstoves (ICS). However, these efforts have disappointed with poor uptake and failure to demonstrate reduction in household air pollution levels or health effects [1] [4].

In Kenya the field has begun to shift focus to cleaner fuel alternatives with a particular emphasis on the promotion of ICS, liquid propane gas (LPG), biogas and electricity [10]. In line with the Sustainable Development Goal number 7 (SDG 7), Kenya has an ambitious target of achieving universal access to modern cooking solutions by 2030 [11]. These solutions include LPG (Liquefied Petroleum Gas), electricity, biogas, bioethanol and improved biofuels cook stoves. Conventionally, charcoal, firewood, paraffin, and LPG continue to be the main sources of cooking fuel but this has been reducing overtime. According to the 2019 Kenya Population and Housing Census, 55.1% of Kenyan Households use firewood for cooking followed by 23.9% using LPG [12].

Various factors and challenges are, however, affecting this shift. Cost and lagging infrastructure are broadly recognized as the main barriers, but knowledge gaps and perceptions such as beliefs about ICS technologies at the community level must also be addressed to optimize adoption and use [13]. There is no universal strategy for a successful clean cookstove campaign; decisions regarding stove adoption seem variably influenced by a complex interplay of factors including cultural appropriateness, household preferences, incentives, ICS household governance and management, and socioeconomics [14]. Understanding these attributes at the community-level regarding improved cookstoves could be the most important step to solving the puzzle of successful clean cookstove adoption.

2. Classification of Biomass Cookstoves

Biomass cookstoves are classified based on technology, draft type, type of combustion, application type, serving purpose, chimney incorporation, portability, material used for construction and type of fuel used by the cookstove as shown in **Table 1** [1]. In terms of classification types, one cookstove can be categorized differently. For instance, Envirofit is an improved, domestic, portable, uses charcoal, natural draft, mono-functional cookstove.

The examples of the types of cookstoves cited in **Table 1** are available in Kenya as observed during baseline survey in Baringo and West Pokot counties. The availability of improved biomass cookstoves available in Kenya is an evidence of the tremendous strides made to advance perfection of biomass stoves. The big issue now is the adoption of the technologies. The key areas of focus to promote

adoption of improved biomass cookstoves could be user friendliness, availability of high energy fuels like pellets and briquettes, convenience of cooking local meals, sizes of households, safety pricing and financing models. These factors need to be incorporated during design and up scaling [15].

3. Biomass Fuels

Biomass is organic matter that can be used to provide heat, make fuel and generate electricity hence referred to as fuel. Wood-fuel, being the largest source of biomass has been used to provide cooking heat for thousands of years. Other sources of biomass that are used as an energy sources include; plant residue from agriculture or forestry and the organic component of municipal and industrial wastes [16].

Table 1. Classification of Biomass cookstoves.

Biomass cookstoves		
Factors of classification	**Classification Types**	**Examples of cookstoves available in Kenya**
Technology Used	Traditional cookstoves	Three stone
	Improved/Advanced	Envirofit
Type of draft	Natural draft	Eco zoom
	Forced draft	Teri-gasifier
Type of combustion	Direct combustion	Chepkube
	Indirect/gasifier	Philips gasifier type
Type of Application	Domestic	High efficiency jiko
	Institutional	Institutional jikos
The purpose served	Mono-function	Push and pull jiko
	Multi-function	Chepkube multi-pot jiko
Incorporation of chimney	Cookstoves with chimney	Rocket stove with chimney
	Cookstoves without chimney	Jiko koa
Portability of the stove	Portable cookstoves	HEC jiko
	Fixed cookstoves	Chepkube jiko
Material used for construction	Mud cookstoves	Chepkube stove
	Metallic stoves	Metallic jiko
	Cement stoves	Rocket jiko
	Ceramic stoves	Ceramic jiko
	Hybrid stoves	Jiko kisasa
Type of fuel used	Firewood cookstoves	Three stone
	Charcoal stoves	Jiko koa
	Agri-residue stoves	Kuni mbili
	Dung cake stoves	Push and pull
	Dual fuel	Kuni mbili

Biomass fuels are the most important source of primary energy in Kenya with wood fuel that comprises firewood and charcoal accounting for over 68% of the total primary energy consumption [17]. About 55% of this is derived from farmlands in the form of woody biomass as well as crop residue and animal waste and the remaining 45% is derived from forests [18]. In spite of past efforts to promote wood fuel substitutes, the number of people relying on wood fuel is not decreasing. Consequently, wood fuel will continue to be the primary source of energy for the majority of the rural population and urban poor for as long as it takes to transform the rural economy from subsistence to commercial.

Key fuel properties include; sizes, density, moisture content, volatile matter, fixed carbon, ash content and calorific values. They provide useful information in the development of biomass cook stoves. One can get an assessment of the cooking needs by determining the amount of food cooked, efficiency and assessing how much of solid biofuels is needed to achieve [16].

Biomass fuels can also be classified based on their physical characteristics such as shape and the state of existence [19]. Conversion of biomass to energy can be achieved through the following routes: Thermo chemical conversion that includes Combustion, pyrolysis, gasification and liquefaction and Biochemical conversion that entails digestion and fermentation [20].

The aim of the research study was to document traditional cooking practices, cookstoves used based on fuels, use of an improved and un-improved cookstoves and to describe community opinions of ICS for the two communities of Baringo and West Pokot Counties in Kenya. The study considered cookstove features and functionality that are of greatest value to rural kitchens and cooks.

4. Methodology

The study was a cross-sectional survey of rural, peri-urban and urban households regarding current cookstoves types in relation to fuel use categorized as improved and un-improved in Baringo and West Pokot counties. Households from 18 villages from three sub counties in Baringo and 12 villages from two sub counties in West Pokot villages were surveyed. These villages were selected to ensure 10% of the households were surveyed in each of the selected sub county. The two counties were chosen because of increased deforestation in the area and presence of improved cookstoves based on literature hence earmarked as model counties. The research was executed by a consortium of researchers from Egerton University, Kenya Agricultural and Livestock Organization (KALRO), University of Nairobi, University of Kabianga and local staff from department of Environment in the two study counties. The survey was administered in 2020 and Primary data was collected through semi-structured questionnaires administered by trained enumerators.

The interviewers were trained local enumerators who had no conflicting affiliation with local institutions. Since the households existed in organized residential blocks, a systematic random sampling technique was employed and data

collected in 2000 households respectively in each county. The survey was conducted in a neutral manner with clear clarification of questions. When asked about stove features, participants were presented with a list from which to select their preferences. Data was then cleaned and analyzed in SPSS (v. 20.0), Stata (v.15) and MS excel.

5. Results and Discussion

5.1. Commonly Used Fuels

Biomass was the primary fuel in the two counties used in the form of firewood and charcoal at average of 70% and 26% respectively based on the sample size of 2923 respondents. This information is correct since biomass energy provides 68% of the Kenya's national energy requirement [17]. The introduction of non-taxed Liquefied Petroleum Gas (LPG) had an impact on the use and adoption of LPG thus an average of 3.8% use in the two counties. **Figure 1** indicates 64.3% of the households that were interviewed use firewood in Baringo while in West Pokot it at 75.9%. These results have a trickledown effect on deforestation, climate change as well as respiratory diseases based on the energy conversion devices used. Charcoal use was at 31.4% in Baringo and 20.7% in West Pokot. The results show that Baringo County is more developed in the use of efficient fuels compared to West Pokot probably due to demographic location. Biomass fuel is renewable energy source and therefore, it is use is a positive gesture for the planet if used conservatively having in mind of the environment and the next generation. This can be achieved by adoption of improved cookstoves that are fuel efficient and emits acceptable particulate matter and Carbon Monoxide based on Environmental Protection Act.

5.1.1. Use of Firewood

The amount of firewood used per week was an indicator of the rate of deforestation in the two respective counties. The quantity of firewood used per week was an average of 15.5 Kg in Baringo and West Pokot. The results agree with Kitui *et al.*, (2001) that shows that firewood was the main biofuel used in Kenya, mostly by rural households, who consumed the commodity at average consumption rates in the range 0.8 - 2.7 $kg{\cdot}cap^{-1}{\cdot}day^{-1}$ [21]. The average distance to the firewood source was 2.15 Km in Baringo and 1.2 Km in West Pokot. Assuming the collection is done daily, then one covers averagely 12 km a week which is tedious and time consuming especially for children who need to study. Whereas the time spent in collecting firewood was 89.5 minutes in Baringo and in west Pokot it was 68.1 minutes which is more than an hour a day.

The sources of firewood in the two counties were; open land, own farm, public forest and any other sources. Sources of firewood from own farm was the highest in West Pokot at 48.1% followed by open land sources at 35.8%. This could be the reason for consistent use of three stone cookstoves and attributed to the system of ownership of land in West Pokot. In Baringo public forest was the main source of firewood at 41% followed closely by own farm sources at 40%. The

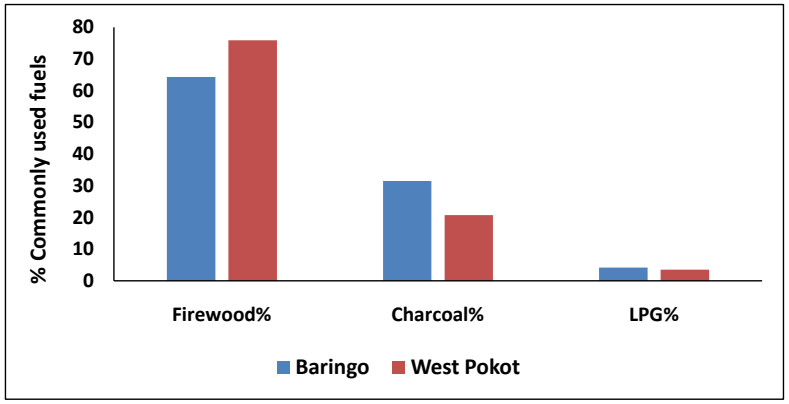

Figure 1. Commonly used fuels in Baringo and West Pokot.

reason behind this again it could be system of ownership of land and public forest governance. Public forest was the third main source of firewood in West Pokot at 15.8% with other sources apart from the selected at 0.4%. In Baringo county open land was the third main source of firewood at 18.6% with other sources at 0.4%.

Firewood access in Baringo and West Pokot counties is one of the main factor affecting the type of cookstove used. It was observed in both counties that collection as a means of firewood access was the main one at 70.2% and 69.6% in Baringo and West Pokot Counties respectively. Maybe this was the reason why there was low adoption of improved cook stoves. The used firewood that was bought was at 10.7% and 16.6% in Baringo and West Pokot counties respectively. The households that combine buying and collecting represented 19% and 13.8% of the households in Baringo and West Pokot counties respectively.

5.1.2. Use of Charcoal

In Baringo, 31.5% of the households used charcoal for cooking while in West Pokot County only 20.7% of the respondent used charcoal for cooking. This showed that Baringo County used more charcoal for cooking compared to West Pokot. This could be attributed to the types of meals cooked, availability of charcoal and modernism of the household members. It is also important to note that charcoal is a lightweight black carbon residue produced by strongly heating wood or other animal and plant materials so as to drive off all water and other volatile constituents [22]. In the traditional version of this pyrolysis process, called charcoal burning, the heat is supplied by burning part of the starting material itself, with a limited supply of oxygen. Therefore, probably there is more raw material for charcoal production in Baringo than West Pokot counties because of prosopis juliflora.

Sources of charcoal in Baringo and west Pokot counties affected adoption of improved cookstoves. Sources were distributed from hawkers, kiosk or shops, self-producer and any other sources apart from the mentioned. Hawkers were the main sources of charcoal in Baringo at 52% and West Pokot at 50.1%. The hawkers in this context imply the sellers of charcoal in open places varying from

one bag to 1 kg tin. The second main source of charcoal was the kiosk or the shops which were at 17.4% in Baringo and 39.4% in West Pokot Counties. West Pokot preferred shops or kiosk more as compared to Baringo Counties. Self-producer was another source and was ranked third with Baringo at 30.1% and West Pokot at 9.3%. Other sources apart from the aforementioned were insignificant.

It was also important to understand LPG usage in Baringo and West Pokot Counties since it an efficient form of energy. LPG was slowly penetrating in the counties especially in the urban and peri-urban areas. In Baringo, 14.4% of the respondent's households used LPG for cooking while in West Pokot the statistics was at 13.26%. This indicated a slight difference in the use of Liquified Petroleum Gas in the two counties. The steady increase in the use of LPG cylinders for cooking was as a result of non-taxation of the product which led to a reduction in the fuel prices in Kenya [23]. With adoption of improved cook stoves and modern energy cooking technologies, indoor air pollution and greenhouse gas emission is expected to reduce.

5.2. Types of Cookstoves Used

Figure 2 shows cooking energy conversion devices used by firewood for cooking. As mentioned earlier, cookstoves can be classified based on the fuel type used. Three stone was the highly used in Baringo county with 1230 respondents out of 1716 using firewood to cook with it which translates to 71.8%. Chebukube was ranked second for use with firewood at 19.6% in Baringo. Whereas in West Pokot Chebukube was the highly used stove for cooking with firewood at 47.8% seconded by improved three stone at 36.6%. Generally these figures show that households in West Pokot have adopted improved cook stoves than Baringo County. Other cook stoves that were identified to use firewood included; dual fuel Jiko, kuni mbili and clay lined jiko at 0.4%, 1.7% and 1.2% respectively in Baringo county whereas in West Pokot is at 0.2%, 0.1% and 0.8% respectively. There is a presence improved cookstoves in both counties though much can be done to create an impact.

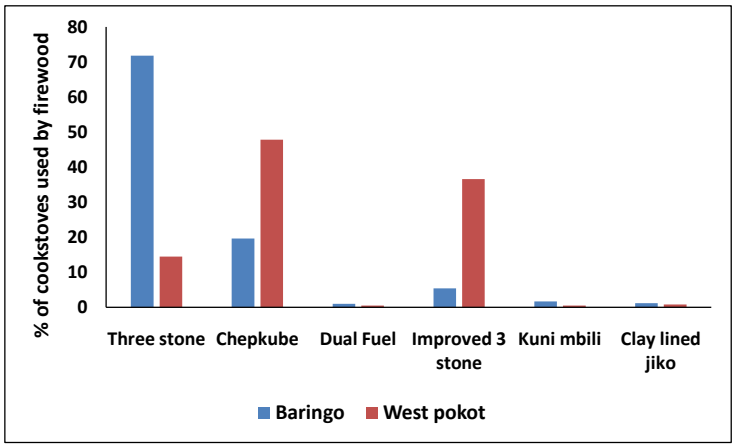

Figure 2. Stoves used by firewood.

5.2.1. Use of Unimproved Cookstoves

Cookstoves are commonly called "unimproved" if they are less efficient, emit more emissions or their performance is like the traditional cook stoves or three-stone-fires [24]. The term usually refers to stoves which are burning firewood, charcoal, agriculture residues or dung and have no lining on the combustion chamber. The use of un-improved cookstove was popular in Baringo County at 77.6% while infamous in West Pokot County at 21.7%. This is because of the adoption of chepkube technology in West Pokot which is an improved one. This could also be ascribed to fuel availability in the two counties, availability of the improved cookstoves installers and the social grouping activities. The main un-improved cookstoves in the two counties were three stone and metallic jiko.

Characteristics of three stone in the two counties had a link on its consistent use. According to baseline survey, 62% of the households in Baringo County used three stone for cooking every day unlike 15.2% of households in West Pokot. Only 0.3% households in Baringo and 0.8 households in West Pokot have never used three stones for cooking. This shows that there has been tremendous adoption of improved cookstoves over time. Another interesting group were the households that used three stone cook stove on special occasion was at 5.8% households in Baringo and 1.5% households in West Pokot. The cooking was perfect on the integration of different stoves probably because of the different cooking needs. Therefore doing completely away with three stone may not be possible at the moment.

The other important factor as to why households preferred three stone cookstove was the ease of installation. The installers were categorized based on chama, self, technician and any other apart from the mentioned. Most of the households that have three stones in Baringo and West Pokot County installed three stone themselves. In Baringo 1297 households had their three stones installed on their own while in West Pokot they were 253 households. This could be the reason for the high number of the users of the three stone cookstoves in Baringo since no cost was incurred during installation and it is convenient. It's interesting to note that there 30 households in West Pokot used chama member to install for them three stone. The type of three stone could probably be the improved ones. The number of households with technician installing the three stones was 27 in Baringo and only 2 in West Pokot.

It was also important to find out the satisfaction in the use of three stone cookstove. Out of 941 households that had three stone cookstoves, 57% of them were satisfied with the service in Baringo County. This could be the reason why there is little impact of improved cookstoves introduction in Baringo County. The satisfaction also could be attributed cultural cooking methods in relation to the cooking devices, provision of lighting while cooking, warms the house and can cook for large households. In West Pokot, 172 households out 262 were also satisfied with the use of three stone cookstove.

Another unimproved cookstove that was dominant in the two counties was

metallic jiko. The stove has no inner lining for insulation and preventing heat losses. Only 9.7% of the interviewed households in West Pokot uses metallic jiko for cooking unlike 28.48% in Baringo County. This is good news to the reduction of greenhouse gas emissions through adoption of improved cookstoves and increased productivity. On the question of frequency, only 52 households used metallic Jiko every day in Baringo and 8 households in West Pokot. Most of the households used the metallic jiko on special occasion with Baringo having 193 households and 83 households in West Pokot. It was also reported of the households that had metallic jiko but have never used. The stove were idle, Baringo had the highest number on this at 53 households and 13 in West Pokot. There was also a group of households that used metallic jiko sometimes, on this Baringo had 111 respondents household and 9 households in West Pokot.

Households that often used the metallic jiko were 79 and 4 respondents in Baringo and West Pokot respectively. This is a group that utilized metallic jiko oftenly. It was also important to find out the satisfaction realized when using the metallic jiko. Based on the results, 194 households out 304 were satisfied with the use of metallic jiko in Baringo County. This could be attributed to the low price and ease of lighting of metallic jiko. In West Pokot only 48 households out of 117 were satisfied with the use of metallic Jiko. This could be because of awareness of improved jiko in West Pokot.

Maintenance is key to adoption of any cookstove. The metallic Jiko was maintained by chama, self, technician, never broken or any other person apart from the mentioned in the two Counties. Most households did not maintain metallic Jiko because they were never broken in the first place. This was represented by 237 households in Baringo and 24 households in West Pokot. This could be the reason why most of the respondents who had metallic Jikos were satisfied with it apart from the low price. In case of a breakdown, 134 households maintained metallic Jikos themselves in Baringo County while 110 households used technician for maintenance in the same county. In West Pokot there were few users of metallic Jiko and only 57 households maintained metallic Jiko on their own and 33 respondents used technician for maintenance. Chama members were not much involved in maintenance of the metallic Jikos because they are not improved.

5.2.2. Use of Improved Cookstoves

Cookstoves are commonly called "improved" if they are more efficient, emit less emissions or are safer than the traditional cook stoves or three-stone-fires [25]. The question on whether improved Jiko was used or not was posed to the respondent. In Baringo County 30.6% households used improved cookstove. The low number could be attributed to availability of fuel therefore less demand to conserve fuel especially in Baringo South where there is heavy presence of mathenge.

West Pokot had 552 respondents using improved cookstoves out of 654 that translates to 45.8%. This shows that West Pokot County are more conscious to

energy related issues unlike Baringo County. The difference in dynamic of the two counties in terms of land ownership, social groupings, availability of land and availability improved Jikos could be the reason. The major improved cookstoves in the two counties were Chebukube and Jiko koa.

Chepkube is an improved cookstove that has inner lining and is made of clay. It's improved because it saves energy by using less fuel, safe for cooking and has less emission. Chepkube is the main cooking stove in West Pokot with 70.3% of the households that had improved cookstoves using it. This could be attributed to community training and availability of installers in the county. Unlike West Pokot, only 30.3% of the households that had improved cookstove uses chepkube in Baringo County. Again this low number could be because of less supply of the liners, availability of fuel due to mathenge menace and inadequate training on installation of the same.

In Baringo most of the users of household's users have had chepkube for about 20 months which is approximately two years. In West Pokot the length of time the users of chepkube is more at 57 months which is almost five years. It could be that chepkube in West Pokot are more durable compared to Baringo. This was validated through calibration.

The person involved in the installation of Chepkube is important for adoption and sustainability of the same. Availability of chepkube installers will make it easy for access of the cooking device. Majority of the households in West Pokot installed chepkube on their own. This was about 282 respondents that had chepkube cookstove. This could be the reason of increased adoption of chepkube in West Pokot compared to Baringo County where there were only 108 households that installed on their own.

There were also more technicians for installing chepkube in West Pokot as compared to Baringo. This gives ease access to technical know on matters installation of chepkube and again another reason for increased Chepkube use west Pokot. There were 79 households with technicians installing the chepkube West Pokot and 49 households in Baringo. Chama members and county government helping in installation is also coming out strongly especially in West Pokot.

The respondents also gave their views on satisfaction on the use of chepkube based on emissions rate, fuel consumption, time of cooking, durability, firepower and safety. Majority of the users in West Pokot and Baringo Counties were satisfied with emission rates from chepkube cook stoves. In West Pokot 298 households out of 388 who are satisfied with emissions rates and 125 out of 159 in Baringo County. Therefore through validation of this information by conducting emission measurements, greenhouse gas emissions will be reduced significantly by adoption of chepkube stoves.

Also more than 50% of the households in West Pokot and Baringo counties were satisfied with fuel consumption of chepkube. It could be that chepkube is more efficient thus using less fuel. Again majority of households in both Baringo and West Pokot counties considers chepkube faster in cooking meals probably

because of high efficiency and ease of lighting. On the question of whether it's durable, majority of the household that uses chepkube considers it durable and they have used it for more than two years. Furthermore, most of the households are satisfied with firepower of the chepkube such that it can cook sufficiently for their household's sizes. Finally, most of the households in both Baringo and West Pokot considers Chepkube safe for cooking. Jiko koa is improved stove that was also commonly used in Baringo and West Pokot Counties.

Few households in both Baringo and West Pokot used jiko koa but at least they existed on the ground. However, West Pokot is still the leading champion in the use of jiko koa at 20.8% based on the households that had improved cookstoves compared to Baringo at 5.9%. Again this could be because of the awareness of improved cookstoves in West Pokot. It is interesting to note that among the jiko koa cookstoves found in the two counties, 81% were in good working condition in West Pokot and 26% in Baringo. Jiko koa is made of stainless steel on the inner lining of the combustion chamber which is a little bit weak depending on the thickness. In West Pokot, the broken lined stoves were at 13% and 4% in Baringo. Among the existing jiko koa stoves, 6% were completely worn out in West Pokot and 1% in Baringo. Therefore, the reason behind good working condition of the stoves could be because of not using jiko koa oftenly.

The availability of cookstoves and maintenance skills are some of the key factors in the adoption of any stove. Majority of the households that had jiko koa in West Pokot acquired them through chama unlike in Baringo where none of the acquired them using the same supplier. This is a confirmation of the impact of social groups in the adoption of improved cookstoves. Non-Governmental Organizations also plays key role in creating awareness and distribution of improved cookstoves. About seven households in West Pokot acquired jiko koa through NGO and two of them in Baringo using the same channel.

As indicated earlier, maintenance is a key factor on the sustainability of improved cookstoves use project. In this case, it was observed that maintenance was done individually and by use of technicians. It was also necessary to get feedback on the pertinent attributes of and improved cookstove. Table 9 shows the characteristic perception on the use of jiko koa. Majority of the households that use jiko koa in both Baringo and West Pokot were satisfied with the emission rates. Though this is also affected by the type of fuel used and their respective moisture content, fuel consumption is directly related to vegetation cover which is an important factor in greenhouse gas emissions and climate change. Again majority of the household both in West Pokot and Baringo with the fuel consumption of jiko koa. Probably that is one of the reason they are using them.

Cooking time is important to most farmers. The faster the stove the better so that it can relive them for other activities which increases productivity. Households in Baringo and West Pokot that uses jiko koa were satisfied with the cooking rates of jiko. This shows the appreciation of any improved cookstove within the community. On the question of durability, again most of the house-

holds in the two counties were satisfied with the durability of jiko koa. Only 10 households and 6 households were not satisfied in Baringo and West Pokot respectively. Jiko koa are relatively small with low firepower, therefore based on the two counties, a considerable number of the household that had them had issues with the ability for cooking sufficiently for the big family sizes. Finally majority of the households in Baringo and West Pokot were satisfied with the safety of jiko koa.

Other improved cookstoves include environ fit, Eco zoom, push and pull, rocket stove and high efficiency jiko. The question is on whether they have them or not were posed to the respondents. 32 households in Baringo had push and pull jikos. Push and Pull jikos are made by an NGO called Sustainable Community Development Service (SCODE) and they have activities in Baringo especially in Mogotio. This could be the reason for the traces of push and pull jikos in Baringo. Their activities have not been extended to West Pokot no wonder there are no push and pull jikos in West Pokot. However, the irony of it is the existence of high efficiency jikos in west Pokot which are also made by SCODE. About 65 households in west Pokot had HEC jikos and 13 households in Baringo. Rocket stoves are almost similar to chepkube but more improved and modernized. Only 4 households had them in both Baringo and West Pokot. Environ fit and eco zoom are also improved with high efficiencies.

Cooking place has a bearing on the type of stove used. In the two communities, most of the households prepared there meals in a separate kitchen. This could accommodate most types of cookstoves both traditional and improved. Few of the households especially in urban and peri-urban cooked in the kitchen within the main house. This could complicate a little bit of adoption of chepkube if clay is used. Again those households that cooked outside may require shelter for non-portable cookstoves. Finally, the households that cooked inside the main house are at risk of health hazards related to emissions from unimproved cookstoves.

6. Conclusions

The study identified key factors that could accelerate adoption of improved cookstoves. These include awareness creation to the general public on the benefits of improved stoves. Many households in the two counties were not conscious of negative effects of the un-improved cookstoves. In addition, the designers of improved stoves should customize cookstoves based on the energy needs of a particular community taking into consideration type of meals commonly prepared, safety, convenience, perception and lighting. Access to biomass fuel and availability of improved cookstove installers were also key factor towards adoption of improved cookstoves. For instance, Baringo County households were comfortable with three stone cookstoves due to fuel availability.

Although West Pokot had adopted the use of improved cookstoves mainly chepkube and improved three stone, the quantity of fuel used was fairly the same

compared to Baringo County. This concerns the efficiency of the said improved stoves. Calibration of the household's cookstoves was necessary to validate the performance based on Global Clean Cooking Alliance protocols and standards. The results therefore document the status of cookstoves use patterns based on the fuel types in Baringo and West Pokot Counties.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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