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Charcoal Accessibility among Households in the Rural and Urban Areas of Trans-Nzoia and West-Pokot Counties, Kenya

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Abstract

This study determined the accessibility of charcoal among households located in the rural and urban areas of Trans-Nzoia and West-Pokot Counties. The purpose was to provide scientific data for necessary interventions like formulation of appropriate policy to enhance sustainable charcoal accessibility. The study used cross-sectional research design and multi-stage sampling technique. Stratified random sampling strategy was employed in grouping households into rural and urban households. Convenient sampling technique was used in selecting Kacheliba and Kolongolo sub-locations to represent rural areas of West-Pokot and Trans-Nzoia respectively. Purposeful sampling strategy was used in selecting Makutano and Kitale towns to represent urban areas of West-Pokot and Trans-Nzoia correspondently. Systematic random sampling was used in selecting 91, 95, 78, and 91 households in Kacheliba, Kolongolo, Makutano and Kitale. Questionnaires, interviews and observation were used in data collection. Data was analyzed through Kruskal Wallis Test, and Chi-square test of association. Only information from households using charcoal was used in the analysis. The economic measures of charcoal accessibility used in the study were households' monthly expenditure on charcoal, cost/Kilogram of charcoal, and budgetary allocation (%) on charcoal. Results indicated that average household monthly expenditure and cost/kg in Kacheliba were Kshs 1271.4 and Kshs 11.4 respectively. Average monthly budgetary allocation was 25.7% in Makutano. Common factors affecting charcoal accessibility were; land tenure system, government policies, cookstove technologies, and family size. Kruskal Wallis Test indicated that the mean ranks of charcoal average accessibility values between Kacheliba, Kolongolo, Makutano and Kitale were statistically significant [$\chi 2_{(3,95)=}13.322$, N =190, P = 0.004). Pair-wise analysis indicated that average charcoal accessibility values were significantly lower in Kacheliba than Kolongolo, Makutano, and Kitale. $\chi 2$ -test of association indicated that the associations between existing government policies and cookstove technologies with charcoal accessibility were statistically insignificant. In conclusion, while charcoal is accessible in rural areas of West-Pokot, it is inaccessible in urban areas. In Trans-Nzoia, charcoal is inaccessible in rural and urban areas. Government policies and cookstove technologies adopted in West-Pokot and Trans-Nzoia are not helping the communities increase their accessibility to charcoal. Therefore, there is need for strict implementation of current policies, or formulation of new policies. The charcoal users should be educated on appropriate usage of charcoal cookstoves to enhance their effectiveness in reducing charcoal consumption.

Keywords: Accessibility, Household, Charcoal, Budget, Expenditure.

Introduction

Energy crisis is one of the most essential factor hampering human development as well as global prosperity[1]. Therefore, nations are concerned about ensuring energy security to enhance sustainable economic and social development[2-4]. Though renewable energy sources like solar and wind energy are of greater emphasis in this concern, they can only meet 20% of world's primary energy demand, thus hydropower, biomass, municipal and agricultural wastes are important in meeting the remaining 80%[5]. Among various biomass energy sources, wood fuel that mainly comprises of firewood and charcoal have been the main source of primary energy as over 3 billion individuals globally depends on it for cooking and heating[6,7]. In developing countries, the main users of charcoal are households in urban areas, and estimates indicate that charcoal usage will increase by about 6%, a figure proportional to urbanization rates[8]. For the past 50 years, charcoal usage in Africa has grown at an annual average of 3.3%, and this is expected to accelerate due to increasing urbanization, increasing population growth, and increasing prices of alternatives[9,10]. This acceleration is expected to significantly move charcoal prices up, making it inaccessible to many households. According to Serrano-Medrano *et al.* charcoal consumption is expected to increase by about 20% from 2010 to 2030 in Africa[11]. Therefore, necessary measures are required to be put in place to ensure an increase in charcoal supply with equal proportion. In sub-Saharan Africa, charcoal provide cooking and heating energy to over 80% of urban households, and is a major income source for rural households[12].

In the past two decades, the rate of charcoal usage in Kenya has increased by about 64%, and has provided employment opportunities to over 500,000 people in urban and rural areas along its value chain[8]. Though the resource is important, over 75% of all charcoal produced in the country is produced from dry lands[13]. This depicts a shift in charcoal "hotspot" into arid and semi-arid zones, leading to clearance of woodland, bushes and now shrubs[14]. Therefore, charcoal in Kenya is being transported for long distances before reaching final consumers, translating to higher costs. For instance, the cost of charcoal escalated from about Kshs 700 to about Kshs 1300 per sack from 2010 to 2012 in major urban areas in Kenya[15]. The increasing distance and escalating charcoal prices in Kenya are clear indicators that charcoal is inaccessible to its users. The situation is worsened by counterproductive regulations as well as non-exclusive tenure situations that interact to enhance over-exploitation of forest resources[16]. As a result, this study investigated accessibility of charcoal among households located in the rural and urban areas of Trans-Nzoia and West-Pokot Counties. The study determined charcoal accessibility and potential factors affecting its accessibility. Accessibility was determined based on the amount of money that charcoal users spend on charcoal, their monthly budgetary allocation on charcoal and cost of charcoal per Kg. This research is important in helping policy-makers formulate appropriate policies to govern the charcoal sector, and increase its accessibility.

Methodology

Study Sites: The study was carried out in West-Pokot and Trans-Nzoia Counties of Kenya. The general information explaining the two counties is as indicated in Table-1.

Research Design: The study employed cross-sectional research design that involved collecting data from a representative subset only once at a specific point in time without manipulating the environment. The design was appropriate because the study aimed at comparing different populations at a single point in time.

Sampling and Sample Size: The study employed multi-stage sampling technique, where stratified random sampling was used in categorizing households into urban and rural to ensure an inclusive sample. Expedient sampling technique was used in selecting Kacheliba and Kolongolo sub-locations to represent rural areas of West-Pokot and Trans-Nzoia counties correspondently based on the easiness of access. Makutano and Kitale towns were selected based on purposeful sampling strategy to represent urban areas of West-Pokot and Trans-Nzoia Counties respectively. Systematic random sampling was used in selecting individual households as every 10^{th} households was included in sample after selecting the starting point randomly. Based on Israel 2012 sample size algorithms, 91, 95, 91 and 78 households in Kacheliba, Kolongolo, Kitale and Makutano were selected at ±10% precision, and 95% Confidence Level.

Table-1
General Information of West-Pokot and Trans-Nzoia Counties

Parameter	West-Pokot County	Trans-Nzoia County
Total area	9169.4 Km^2	2495.5 Km^2
Latitude	10° 10'N and 30° 40'N	0° 38'N and 1° 18'N
Longitude	34° 50'E and 35° 50'E	34°38'E and 35° 23'E.
Annual Rainfall	400 mm to 1200 mm	1296.1 mm
Annual Temperatures	vary from 10°C to 30°C	10°C to 30°C
Altitude	400 m to 1500 m	1900 m
Tourist attraction centers	Nasolot Game reserve and Kapenguria Prison Museum.	Kitale Museum, Mount Elgon and Saiwa National Parks
Human Population	512,690	818,757
Population density	56 persons per Km^2	328 persons per Km^2
Poverty level	69.4%	50.2%
Age dependency Ratio	100:122	100:99
Economic Activities	Pastoralism and mining	Maize, beans and wheat farming

Source: Author (2015)

Data Collection: The study employed self-administered questionnaires, key informant interviews and personal field observations in collecting data. Questionnaires were administered by 8 field officers, two in each study site (Kolongolo, Kacheliba, Makutano and Kitale). Questionnaires collected information concerning determinants of charcoal accessibility, including: no of charcoal sacks consumed per month, average mass per sack (Kg), cost of charcoal per sack, average cost of charcoal consumed per month, household's head monthly income, and households' budgetary allocation on charcoal. Other information entailed factors affecting charcoal accessibility.

A total of 10 key informants from different institutions and organizations including Kerio Valley Development Authority, Lake Victoria Development Authority, Kenya Forest Service, and National Environment Management Authority were interviewed. The information collected entailed general comments on the sources and cost of charcoal, family incomes, and factors affecting charcoal accessibility. Direct field observations were carried out to identify cooking technologies in the study area.

The dry weight of charcoal was determined by subtracting moisture content (MC) of charcoal from wet weight (Ww) (Equation-1). Charcoal MC was determined based on Laboratory Test, and calculated based on the wet-weight basis (Equation-2).

$$\mathrm{Dw} = (100\% - \mathrm{MC}\%)\mathrm{Ww} \quad (1)$$

$$\mathrm{MC} = (\frac{\mathrm{Ww}-\mathrm{Dw}}{\mathrm{Ww}})\ 100 \quad (2)$$

Where: Dw = the dry weight of charcoal, Ww = the wet weight of charcoal, MC = Moisture content.

The Ww of charcoal per household per month was calculated based on Equation-3. Household's monthly expenditure on charcoal, cost per Kg of charcoal and household's monthly budgetary allocation were determined using Equation-4, 5 and 6 respectively.

$$\mathrm{MWw} = (N * m) \quad (3)$$
$$\mathrm{C} = (N * p) \quad (4)$$
$$\mathrm{C/Kg} = (MDw/C) \quad (5)$$
$$\mathrm{B} = (C/i) \quad (6)$$

Where, MWw = wet weight of charcoal consumed by the family per month, N = total number of charcoal sacks consumed by the household per month. m = Average mass per sack of charcoal, C = total household's monthly expenditure on charcoal, P = the market price of charcoal per sack, C/Kg = cost of charcoal Per Kg of charcoal, MDw = monthly dry weight of charcoal consumed by the household, B = household's monthly budgetary allocation on charcoal, i = household's head average monthly income,

N.B in case the household buys charcoal in smaller quantities like basins, then P, (market price of charcoal per month) was determined using Equation-7.

$$\mathrm{P} = (n * c) \quad (7)$$

Where, n= number of basins that fill a sack of charcoal, c = cost of one basin of charcoal.

Charcoal Accessibility Levels: Charcoal accessibility levels based on household's monthly expenditure on charcoal, cost per Kg of charcoal and budgetary allocation were grouped and graded as 1 = very accessible, 2 = accessible, 3 = inaccessible and 4= very inaccessible (Table-2).

Average household charcoal accessibility values were determined based on Equation-8.

$$\mathrm{Ca} = (\mathrm{Ce}+\mathrm{Cc}+\mathrm{Cb})/\mathrm{n} \quad (8)$$

Where: Ca = average charcoal accessibility value, Ce = accessibility level based on monthly expenditure, Cc = accessibility level based cost/Kg of charcoal, Cb = accessibility level based on budgetary allocation, n = number of individual measures of accessibility used in determining average accessibility value.

Table-2
Accessibility Grading

Accessibility level	Grade	Cost of charcoal (Kshs)	Cost/Kg of charcoal (Kshs)	Budgetary allocation (%)
Very accessible	1	<1000	<7	<5
Accessible	2	1000-2000	7-14	5-10
Inaccessible	3	2000-3000	14-21	10-15
Very inaccessible	4	≥3000	≥21	≥15

The obtained accessibility values were finally grouped into numerical groups ranging from 1 to 4 (Table- 3) in the order of reducing accessibility as 1 means very accessible and 4 very inaccessible. Households that were found not to be using charcoal were eliminated from the calculation of charcoal accessibility level.

Table-3
Final Accessibility Level Grading

Accessibility level	Accessibility grading	Average accessibility value [Ca = (Ce+Cc+ Cb)/n]
Very accessible	1	0-1.5
Accessible	2	1.5 - 2.5
Inaccessible	3	2.5-3.5
Very inaccessible	4	≥ 3.5

Data Analysis: Significant differences in accessibility values between the study areas were tested using Kruskal Wallis Test at 95% confidence level. In case the difference was significant, pair-wise analysis using Mann Whitney *U* test was used to determine areas exhibiting significant difference at 95% confidence level.

Chi-square test of association was used in testing factors affecting charcoal accessibility by identifying factors that exhibit significant association with accessibility at 95% confidence level.

Results and Discussion

Average Monthly Expenditure on Charcoal: Figure-1 indicated that the average household's charcoal expenditure calculated in Kenya Shillings (Kshs) was high in Kitale (Kshs 2913.5).

Average Cost per Kilogram of Charcoal: Figure-2 indicated that the cost (Kshs)/Kg of charcoal was high in Kitale (Kshs 19.8) and lower in Kacheliba (Kshs11.4).

Household's Budgetary Allocation on Charcoal: Results indicated that based on household's head monthly income, monthly budgetary allocation on charcoal was higher in Makutano and lower in Kacheliba.

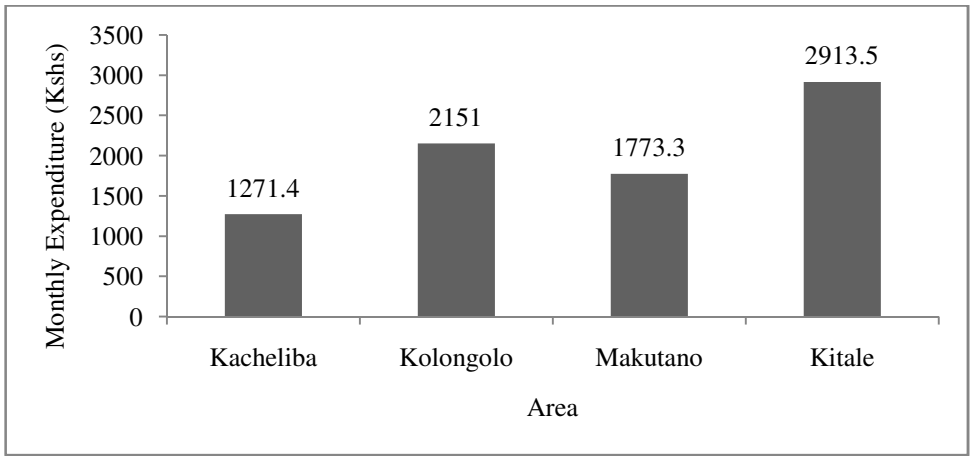

Figure-1
Household's Monthly Expenditure on Charcoal

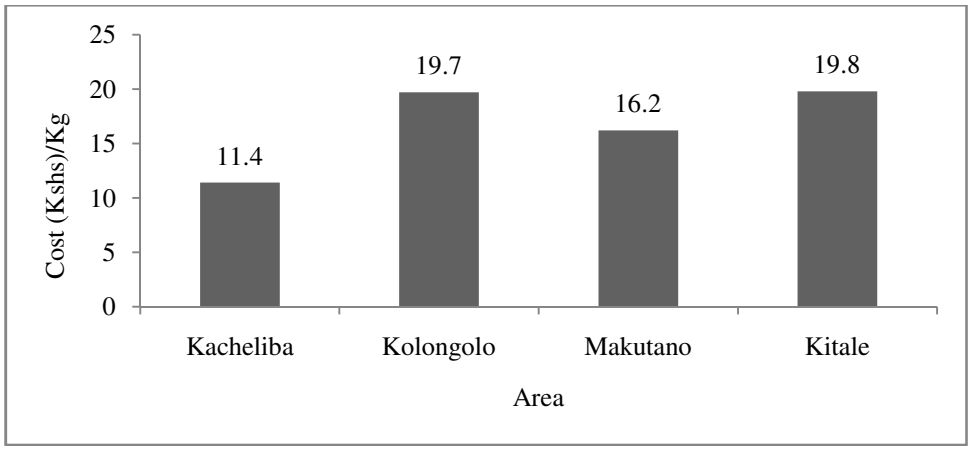

Figure-2
Cost per Kg of Charcoal among Households

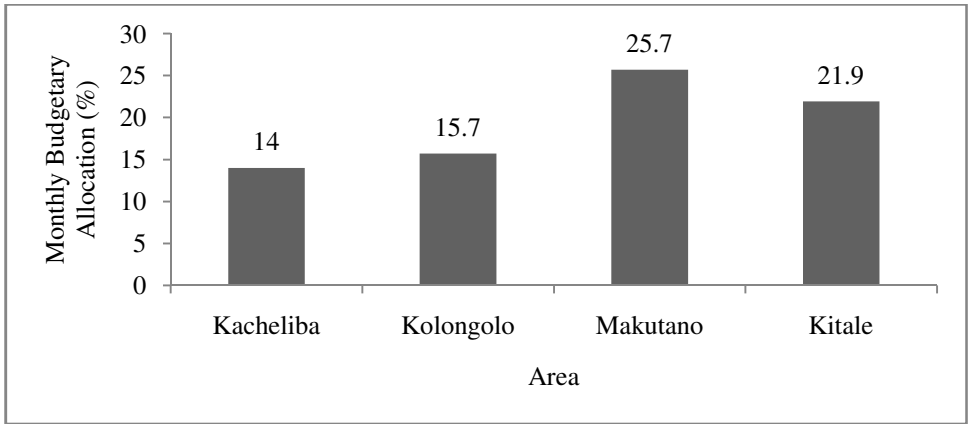

Figure-3
Household's Budgetary Allocation on Charcoal

Household's Charcoal Accessibility Levels: Table-4 indicated that charcoal is accessible in Kacheliba, but inaccessible in Kolongolo, Makutano and Kitale. The grading was based on the information in Table-2 and Table-3.

Kruskal Wallis Test indicated that the mean ranks of charcoal average accessibility values between Kacheliba, Kolongolo, Makutano and Kitale were statistically significant [$\chi^2_{(3,95)}$=13.322, N =190, P = 0.004).

Pair-wise analysis using Mann-Whitney *U* test indicated that average charcoal accessibility values are significantly lower in Kacheliba than Kolongolo, Makutano, and Kitale (Table-5).

The lower average accessibility value in Kacheliba was as a result of relatively low monthly expenditure, cost/Kg, and budgetary allocation as compared to Kolongolo, Makutano and Kitale. Low monthly expenditure and cost/Kg of charcoal in Kacheliba was due to low charcoal market prices ranging from Kshs 350 to Kshs 600 per sack. Low charcoal market prices were attributed to its location in arid regions of Kenya that contains favored indigenous tree species like Acacia species that are readily available for production of cheap charcoal. The market price of charcoal per sack in Makutano was Kshs (500-1000), Kolongolo Kshs (650-1100), and Kitale Kshs (600-1200) respectively. Relatively, low charcoal prices in Makutano were due to shorter distances that charcoal is transported. Makutano town is surrounded by arid and semi-arid regions like Kishaunet that were supplying enough charcoal to the town. Higher charcoal prices in Kolongolo and Kitale was attributed to their location in high potential areas of Trans-Nzoia, where favored charcoal producing indigenous vegetations were long cleared for agricultural purpose. Therefore, charcoal used in the region is transported long distances from other counties including West-Pokot, Marakwet and Turkana Counties. This was in line with Iiyama *et al*. that charcoal consumed in Kenya is mostly produced in dry land regions[13]. Literature also states that charcoal prices in high potential areas are high than in arid and semi-arid lands (ASALS) due to availability of charcoal in ASALs[15].

Budgetary allocations in Kacheliba were low because only high income earning households were using charcoal, while low income earners were using firewood because it was readily available. In Kitale, high budgetary allocation on charcoal was due to high charcoal prices, while in Makutano high budgetary allocation were due to low income levels. Mutua *et al*. notated that the level of income vary from region to region, leading to variations in household energy budgets[17]. In Kenya and Nigeria, households spend larger proportions of their income to charcoal because they have lower income levels[18,19].

Factors Affecting Charcoal Accessibility in West-Pokot and Trans-Nzoia Counties: The response percentages on factors affecting charcoal accessibility in Kacheliba, Kolongolo, Makutano and Kitale were as indicated in Table-6.

Table-4
Charcoal Accessibility Levels in the rural and urban areas of Trans-Nzoia and West-Pokot

Study site	Accessibility levels based on the individual variables			Average accessibility value	Accessibility level
	Monthly expenditure	Cost/Kg	Budgetary allocation		
Kacheliba	2	2	3	2.3	Accessible
Kolongolo	2	3	4	3	Inaccessible
Makutano	2	3	4	3	Inaccessible
Kitale	3	3	4	3.3	inaccessible

Source: Author (2015)

Table-5
Pair-Wise Analysis of Charcoal Accessibility Levels

Area	Kolongolo	Makutano	Kitale
Kacheliba	Mann-Whitney $U_{(1,95)}$=33.500, N=31, p=.013	Mann-Whitney $U_{(1,95)}$=110.500, N=80, p=.009	Mann-Whitney $U_{(1,95)}$=92.000, N=93, p=.001
Kolongolo		Mann-Whitney $U_{(1,95)}$=724.500, N=97, p=.197	Mann-Whitney $U_{(1,95)}$=3639.000, N=122, p=.193
Makutano			Mann-Whitney $U_{(1,95)}$=1023.000, N=110, p=.949

Table-6
Factors Affecting Charcoal Accessibility in Kolongolo

Factors		Response (%)			
		Trans-Nzoia		West-Pokot	
		Kolongolo	Kitale	Kacheliba	Makutano
Land Tenure	Customary	0.0	0.0	16.7	0.0
	Freehold	60.7	33.7	50.0	28.4
	Leasehold	39.3	61.6	33.3	71.6
	Public	0.0	4.7	0.0	0.0
Government Policies	Yes	92.9	67.0	71.4	83.3
	No	7.1	23.0	28.6	16.7
Cookstove Technology	Ordinary metallic	39.1	20.9	33.3	18.7
	Improved metallic	4.3	0.0	16.7	0.0
	Improved with inner lining	56.5	79.1	50.0	81.3
Family size	(1-3) members	35.7	22.6	16.7	54.1
	(4-6) members	42.9	47.7	66.7	41.8
	≥7 members	14.3	4.7	16.6	4.1

Analysis results in Table-7 indicated a significant association between land tenure and household's monthly expenditure on firewood in Kitale and Makutano. The association according to interviewees was attributed to family sizes. This was because individuals enjoying freehold land tenure systems in towns were rich and living with house-helps, relatives and children. Though land tenure had no significant association with any charcoal accessibility measure in Kacheliba, communal land ownership led to lower cost of charcoal due to lower cost of production resulting from availability of preferred tree species in large tracts of communal lands.

From Table-7, family size was significantly associated with household's monthly expenditure on charcoal in Kolongolo, Kitale, and Makutano. This was because the larger the family, the higher the energy demand[18], translating to higher monthly expenditure. However, the relationship between family size and households' monthly expenditure on charcoal was non-linear because households with more than 5 members opt to buy charcoal in sacks (Figure-4), implying lower cost as compared to those buying in tins, leading to lower monthly expenditure (interviewees).

Figure-4
Charcoal in Sacks in and Basin Makutano Town

Table-7
Chi-square Test of Association

Factors	Pearson Chi-Square	N	df	Exact Sig. (2-sided)
Kolongolo				
Monthly expenditure and Land tenure	7.117[a]	24	3	0.067
Monthly expenditure and regulations	3.709[a]	24	3	.308
Monthly expenditure and cookstove technology	6.900[a]	23	3	.370
Monthly expenditure and family size	13.350[a]	24	6	0.029
Cost/Kg and Land tenure	4.200[a]	24	3	.051
Cost/Kg and regulations	.273[a]	24	1	.565
Cost/Kg and cookstove technology	8.144[a]	23	2	.012
Cost/Kg and family size	6.825[a]	24	2	.038
Budgetary allocation and Land tenure	3.535[a]	24	3	.383
Budgetary allocation and regulations	.878[a]	24	2	1.000
Budgetary allocation cookstove technology	3.720[a]	23	3	.717
Budgetary allocation family size	5.730[a]	24	6	.541
Factors	Pearson Chi-Square	N	df	Exact Sig. (2-sided)
Kitale				
Monthly expenditure and Land tenure	17.578[a]	86	3	.007
Monthly expenditure and regulations	.257[a]	86	3	.984
Monthly expenditure and cookstove technology	1.837[a]	86	3	.648
Monthly expenditure and family size	44.752[a]	86	6	.000
Cost/Kg and Land tenure	2.858[a]	86	4	.499
Cost/Kg and regulations	2.975[a]	86	2	.283
Cost/Kg and cookstove technology	4.012[a]	86	2	.206
Cost/Kg and family size	3.500[a]	86	4	.354

Factors	Pearson Chi-Square	N	df	Exact Sig. (2-sided)
Kolongolo				
Budgetary allocation and land tenure	1.494E2[a]	86	3	.390
Budgetary allocation and regulations	75.580[a]	86	2	.350
Budgetary allocation cookstove technology	73.018[a]	86	3	.623
Budgetary allocation family size	1.574E2[a]	85	6	.161
Kacheliba				
Monthly expenditure and Land tenure	3.500[a]	7	3	.657
Monthly expenditure and regulations	2.917[a]	7	2	.429
Monthly expenditure and cookstove technology	4.167[a]	6	3	.800
Monthly expenditure and family size	8.250[a]	6	3	.133
Cost/Kg and Land tenure	a. No statistics are computed because Accessibility level based on cost per Kg of charcoal is a constant.			
Cost/Kg and regulations				
Cost/Kg and cookstove technology				
Cost/Kg and family size				
Budgetary allocation and land tenure	3.208[a]	7	3	.886
Budgetary allocation and regulations	1.896 [a]	7	2	.657
Budgetary allocation and cookstove technology	4.667 [a]	7	3	.600
Budgetary allocation and family size	3.000 [a]	6	4	1.000
Makutano				
Monthly expenditure and Land tenure	11.298[a]	73	3	.009
Monthly expenditure and regulations	2.690[a]	73	2	.481
Monthly expenditure and cookstove technology	1.082[a]	7		.809
Monthly expenditure and family size	35.584[a]	73	6	.000
Cost/Kg and Land tenure	.097[a]	73	2	1.000

Factors	Pearson Chi-Square	N	df	Exact Sig. (2-sided)
Kolongolo				
Cost/Kg and regulations	1.746[a]	73	2	.455
Cost/Kg and cookstove technology	1.413[a]	73	2	.545
Cost/Kg and family size	1.023[a]	73	3	.902
Budgetary allocation and land tenure	3.875[a]	73	3	.267
Budgetary allocation and regulations	.901[a]	73	3.804	.804
Budgetary allocation cookstove technology	1.507[a]	73	3	.667
Budgetary allocation family size	4.56[a]	73	6	.498

Insignificant association between cookstove technologies with charcoal accessibility in the study areas was as a result of poor workmanship and inadequate skills. Although households were using improved cookstoves in Figure-5, and Figure-6, their monthly expenditure was not significantly different from those using ordinary stoves (Figure-7).

Figure-5
Improved metallic cookstove based

Poor workmanship resulting to poor standards, coupled with inadequate technological knowhow among users to enable them gain advantages of improved cookstoves reduces the stove's efficiency. Basically, if users are not well informed about when to open and close the primary air inlet, the right quantity of charcoal per unit time, the stove's efficiency reduces. The results contradicted Vahlne and Ahlgren, and Rosa *et al*. that improved cookstoves are disseminated and adopted with the aim of reducing energy demand; hence cutting down household's expenditure on firewood and charcoal[20,21].

P-values in Table-7 indicated that government policies and regulations were not significantly associated with household's charcoal accessibility. This was because charcoal regulations like Charcoal Act 2009 and water quality Act only controls charcoal production, an activity not engaged by charcoal users as 100% of charcoal users buy charcoal. In addition, movement permits and certificate of origin among other movement requirements are only applied on large transportation of charcoal, implying that it restricts charcoal suppliers not consumers at household levels. However, Energy Act 2006 encourages adoption of improved cookstoves (ICs) at household level on a voluntary basis.

Figure-6
Improved Cookstove with Inner Lining

Figure-7
Ordinary Metallic Cookstoves

Conclusion

In West-Pokot, charcoal is accessible among rural households, and inaccessible among households in urban areas. In Trans-Nzoia, charcoal is inaccessible to rural and urban households. Monthly expenditure on charcoal is influenced by family size in the rural and urban areas of Trans-Nzoia and urban areas of West-Pokot. Land tenure on the other hand influences household monthly expenditure on charcoal in the urban areas of Trans-Nzoia and West-Pokot Counties. Government policies have no influence on any measure of charcoal accessibility among households.

Recommendations: i. The government and Non Governmental Organizations through training institutions should educate people developing improved cookstoves on required standards of ICs, and eliminate poorly constructed ICs. ii. There is need for the government and Non Governmental Organizations to educate people on how to use ICs to ensure appropriate usage. This should entail when stove users should open or close the primary air inlet. iii. Instead of waiting for natural regeneration in West-Pokot, communities should be educated and encouraged to engage in planting trees in their communal lands for charcoal production by Kenya Forest Service.

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