



# AMERICAN JOURNAL OF ENVIRONMENTAL ECONOMICS (AJEE)

ISSN: 2833-7905 (Online)

**VOLUME 3 ISSUE 1 (2024)**



PUBLISHED BY  
E-PALLI PUBLISHERS, DELAWARE, USA

## Fuelwood Supply Consumption and Dynamic on Forest Resource in Kakuma Refugee Camp, Turkana County Kenya

Kipkemboi kandie<sup>1\*</sup>, Wilson k. Kipkore<sup>1</sup>, P. O. Odwor<sup>2</sup>

### Article Information

**Received:** March 05, 2024

**Accepted:** April 15, 2024

**Published:** April 19, 2024

### Keywords

*Fuelwood, Supply, Refugee, Camp, Dynamic, Household*

### ABSTRACT

Forestry is a source of livelihood for many farmers and rural households in developing countries, especially in sub-Saharan Africa. However, the utilization of fuelwood in Africa contributes greatly to desert encroachment and consequently has implications with regard to climate change. Its little to understand about the drivers and dynamics of fuelwood consumption in Kenya and other African countries. This study is to analyze determinants of refugee camp forest resource utilization efficiency Kakuma refugee camp Turkana county. It accomplishes two broad objectives: (1) To analyse utilization of fuelwood from indigenous tree species supplied to the camp, the profitability of firewood supplied to the local market and a growing body of evidence on the influence of utilization of fuelwood in the camp in the refugee camp, as the host community get cash from the refugees and food ration in exchange with the resource (Fuelwood) in a household's level. It embraced a mixed methods approach embedded with an explanatory research design for concurrent triangulation. The study interviewed a total of 296 respondents through HH questionnaires, the KII Tool and FGD Guide. Qualitative data was analyzed using thematic framework approach while quantitative data was analyzed using descriptive and inferential (correlations) statistics on SPSS. Results suggest that even with minimal investment in both productive and non-productive assets ( $M=2.40$ ) and  $SD=0.99$ ) from cash purchase of fuelwood from agencies, there is significant negative effect ( $r=0.139$ ) and  $P=0.05$ ) between asset accumulation and poverty reduction among targeted household. study reveals that the provision of alternative sources of energy has the potential to reduce overdependence on wood fuel by the refugees in Kakuma Kenya. Therefore, the government ought to support other cheaper energy alternatives like alternatives gadgets and energy-saving cooking technologies, while the local administrators should integrate the refugee needs in the development plans for equal distribution of resources at large

### INTRODUCTION

Energy demand at the global level is continuously increasing due to the rapid population growth and the need to use more energy for domestic and industrial purposes (Yigezu and Jawo, 2021; Molina *et al.*, 2022). Accordingly, forecast based on the International Energy Agency (IEA) and other energy sources, estimates that energy demand will rise by approximately 50-65% between 2020 to the year 2040 (Stanescu *et al.*, 2021; Manandhar *et al.*, 2022).

Forests contribute immensely to economic and social development through formal trade in timber, environmental services, non-timber forest products, safety, net spiritual and aesthetic value. Despite varied sources of energy (Asadian *et al.*, 2023), fuelwood accounts for 44.2-58.7% of all energy consumed globally (Paterson and Fleming, 2021; Rahman *et al.*, 2021), subsequently benefiting the energy needs of at least 1.7-2.1 billion peoples (Avhad, 2023).

Fuelwood is a key source of energy that has been used for millennia for cooking, boiling water, lighting and heating. Today, about 2.5 billion people depend on biomass energy for cooking and heating with 87% of this energy being provided by wood. In sub-Saharan African, more than 90% of the population relies on wood fire, that is, firewood and charcoal as their primary source of domestic energy.

Over 80% of urban householders and small industries use charcoal and firewood as their source of energy. Despite their numerous importance, Africa's forest continues to decline rapidly due to increase in agricultural practices into forest lands, population growth and urbanization, increased poverty, high dependence on natural resources for subsistence and income through forest. Most of these are applicable in lighting, heating and cooking (Singh *et al.*, 2021; Eakins *et al.*, 2023). Between the year 2018 to 2022, fuelwood consumption was approximately 45 million m<sup>3</sup> per year (Paudel, 2018; Johnston *et al.*, 2022) and is projected to increase to 70 million m<sup>3</sup> annually by the year 2030 (Romanach and Frederiks, 2021; Khan *et al.*, 2022). Fuelwood is the dominant source of energy averaging about 58% of the energy supply, and account for more than 80% in some countries, such as Burundi (91%), Rwanda and the Central African Republic (90%), Mozambique (89%), Burkina Faso (87%), Benin (86%), Madagascar and Niger (85%) as well as Malawi (81%) (Sulaiman and Abdul-Rahim, 2020; Wassie *et al.*, 2021; Sulaiman and Abdul-Rahim, 2022). (Omoju *et al.*, 2020), majority of the rural dwellers still use fuelwood due to cultural preferences, availability, economic factors and perceived lack of alternative energy sources as well as widespread poverty (Sulaiman and Abdul-Rahim, 2020; Ali, 2021).

<sup>1</sup> Department of Forestry and Wood Science, University of Eldoret, P. O. Box 1125-30100, Eldoret, Kenya

<sup>2</sup> School of Economics, University of Eldoret, P. O. Box 1125-30100, Eldoret, Kenya

\* Corresponding author's e-mail: [kandy022005@yahoo.com](mailto:kandy022005@yahoo.com)

In Kenya, fuelwood contribute about 68% to the total biomass energy need (Jepng'etich, 2020; Osano *et al.*, 2020) and provides for more than 80% of rural household energy needs (Kariuki, 2021; Mbaka, 2021). It has been previously reported that Kenya uses 34.3 million tonnes of biomass for fuelwood (Kimutai and Talai, 2021; Takase *et al.*, 2021). Majority of the rural dwellers still elect to use fuelwood due to low cost of obtaining the energy source, ease of availability, perceived lack of alternative energy sources (Osano *et al.*, 2020).

**Problem Statement**

In areas with large influx of refugees there is a disturbance of the environment, the forest resources as sources of energy has resulted in over-utilization. The cutting of trees for fuelwood, by the refugees and the host community is very high indeed.

In Turkana region where there is large conglomeration of refugees, the host community feels deprived of their livelihood from fuelwood sales.

**Main Objective**

The main objective of this study is to analyze fuelwood supply and consumption dynamics in Kakuma refugee

camp Turkana County (Kenya).

**Research Questions**

I. What quantity of fuelwood was supplied from indigenous tree species to the refugee camp between 2015 and 2019?

II. What is at the difference between fuelwood prices between the agencies (LOKADO) and local market vendors between 2015 and 2019?

III. What is the profitability of fuelwood supplied by vendors to the local market and to the refugee camp between 2015 and 2019?

IV. What are the alternative sources of energy for refugees in Kakuma Refugee camp?

**Theoretical Foundation**

This theoretical framework is based on the empirical analysis of fuelwood supply and consumption dynamics. Neoclassical economic theory focuses on supply and demand as the driving forces behind the production, pricing, and consumption of goods and services.

**Conceptual Framework**

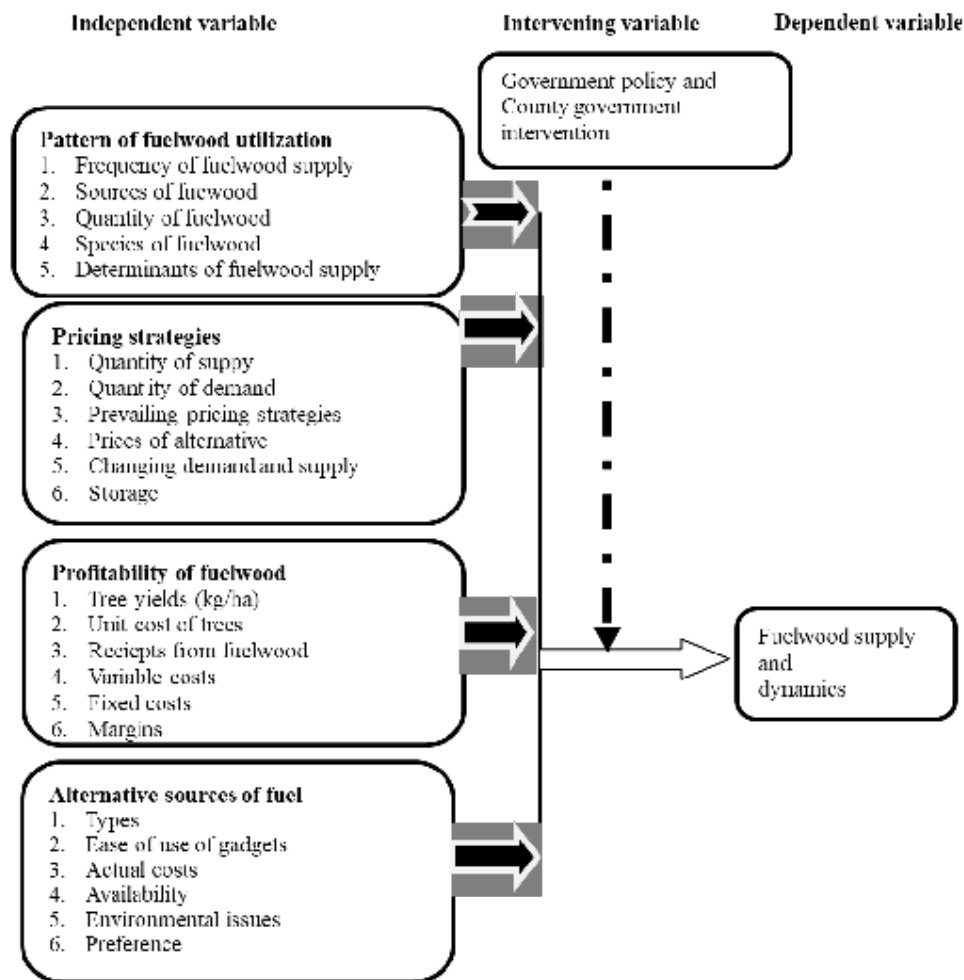


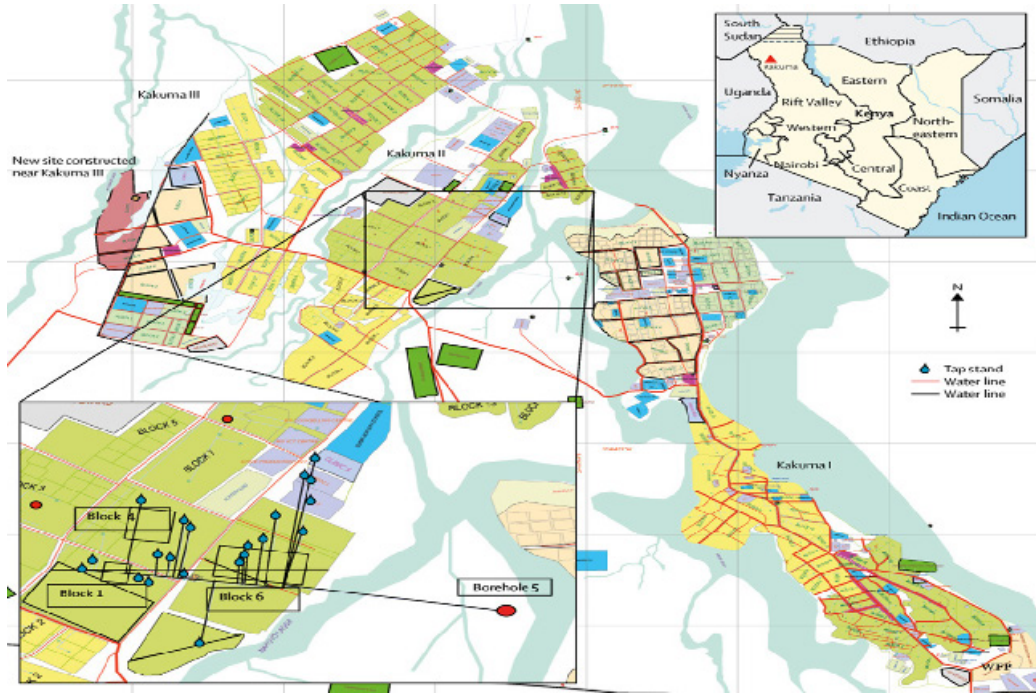
Figure 1: Conceptual framework

**MATERIALS AND METHODS**

**Study Area**

This study was conducted in Kakuma located in Turkana County within the Rift Valley Province in the north-west corner of Kenya near the South-Sudan border. Kakuma

Refugee Camp, is the second largest shelter site for refugees in the country after Dadaab. It is situated 95 km south of Lokichogio about 120 km South of the Sudan/Kenya border. It is located 3°42'59.99" N 34°51'59.99" E and almost 1,000 km Northwest of Nairobi.



**Figure 2:** Map of Kenya and Kakuma (UNHCR, 2019)  
 Source: *Layout of Kakuma refugee camp.*

**Research design**

The study involved collection of data fuelwood price, profitability of fuelwood, preference of tree species and the alternative source of energy therefore assumes both qualitative and quantitative research designs.

**Analysis of Fuelwood Supply of Dynamic Consumption**

During the study, two subsets of population were used. The first is the population of the host community. According to the latest census report, there are approximately is 168,053 (Kenya National Bureau of Statistics, 2010). From this population about 12,807 living within the area covered during this survey. It estimated that about 20% supply forest resources to the refugee camps in the region and therefore the sample size was determined from the formula  $n = z^2 \left( \frac{pq}{d^2} \right)$  (Ellen, 2012). Whereby: n = the desired minimum sample size, z = the standard normal deviation at set confidence interval (1.96), d = the acceptable range of error (0.05), p = the proportion of individuals supplying forest resources to the refugee camps (20%), and q = the proportion of individuals not supplying forest resources to the refugee camps = 1-p (80%).

$$n = z^2 \left( \frac{pq}{d^2} \right) = 1.96^2 \left( \frac{0.2 * 0.8}{0.05^2} \right) = 245.86 \approx 246$$

Therefore, the desired sample size was 246 local community members.

The second batch of the sample size is for the refugees. The number remains variable depending on the economic conditions of their parent country and estimates indicate that upto 82% of the refugees can access forest resources in one way or the other. Therefore the sample fomula was  $n = z^2 \left( \frac{pq}{d^2} \right)$  used to arrive at the sample size as: was used to arrive at the sample size as

$$n = z^2 \left( \frac{pq}{d^2} \right) = 1.96^2 \left( \frac{0.82 * 0.18}{0.05^2} \right) = 226.808 \approx 227$$

Therefore, the desired sample size for the refugees was 227.

**Data Analysis**

Both descriptive and inferential statistics was employed in the analysis of the data. Data was analysed using SPSS 23.0 (IBM Corp., Armonk, NY, USA) and Microsoft Excel 2007 (Microsoft Corporation, Redmond, WA, USA). All data was analyzed for normality and appropriate transformation methods applied in case of a significant departure from normal distribution (ZAR, 1996).

**Table 1:** Description of explanatory variables used as socio-economic factors in the binary logistic model

Variable	Description of the variables
Gender ( $X_1$ )	Gender is 1 if the respondent is male, 0 otherwise
Age ( $X_2$ )	Level is 1 = 18-25 years; 2 = 26-35 years; 3 = 36-55 year; > 55 years

Level of education (X <sub>1</sub> )	Level is 1 = None; 2 = Primary; 3 = Secondary; 4 = Tertiary
Occupation of the household head (X <sub>2</sub> )	Occupation is 1 if the respondent is a farmer, 0 otherwise
Household size (X <sub>3</sub> )	Level is 1 = 3-5; 2 = 6-10; 3 = > 10
Land size (X <sub>4</sub> )	Level is 1 = <2; 2 = 2-5; 3 = 5.1-10; 4 = >10
Farm household income (X <sub>5</sub> )	Level is 1 = <5000; 2 = 5000-10000; 3 = 10,001-20000; 4 = > 20000-50000; 5 = >50,000
Non-farm household income (X <sub>6</sub> )	Level is 1 = <5000; 2 = 5000-10000; 3 = 10,001-20000; 4 = > 20000-50000; 5 = >50,000

**RESULTS**

Questionnaires Return Rate predicting the Level of Survey-Based Research Participation, Defined by the Response Rate, is Often Difficult Due to A Variety of Impeding Factors (Woolf and Edwards, 2021). The overall response

rate as well as the response rate recorded for the host and refugees were found to be suitable for analysis and making interpretations and conclusions for this study since response rate of 60-100% his considered adequate to validate any survey based studies (Meyer *et al.*, 2022).

**Table 2:** Response rate for the host community and refugees during the study period

Respondents	Total	Returned	Response rate (%)
Host community	247	193	78.1
Refugees	227	192	84.5
<b>Total</b>	<b>474</b>	<b>385</b>	<b>81.2</b>

**Socio-Economic Status of the Respondents**

**Geographical Characteristics of the Respondents**

The geographical characteristics of the refugees and host community members are provided in Table 3. The respondents were sampled from mainly two regions in

Kakuma: Kakuma and Kalobeyei. Most of the respondents from each category were obtained from Kakuma which has larger population than that of Kalobeyei (Betts *et al.*, 2020). The vast majority of the refugees were Sudanese followed by Somalis and belonged to reguee families.

**Table 3:** Respondents’ geographical characteristics of the refugees and host community members

Variable	Response category	Host community		Refugees	
		Frequency	Percent	Frequency	Percent
Location	Kakuma	121	62.7	150	78.1
	Kalobeyei	72	37.3	42	21.9
Nationality	Sudanese	-	-	53	27.6
	Burundian	-	-	28	14.6
	Rwandese	-	-	11	5.7
	Ugandan	-	-	2	1.0
	Somalia	-	-	44	22.9
	Ethiopian	-	-	24	12.5
	Congolese	-	-	21	10.9
Category	Somali	-	-	9	4.7
	Kenyan	193	100	-	-
	Refugee family	-	-	171	89.1
	Refugee minor	-	-	19	9.9
	Host	-	-	2	1.0

**Table 4:** Socio-economic characteristics of the respondents

Variable	Response category	Host community		Refugees	
		Frequency	Percent	Frequency	Percent
Age (years)	18-35	62	32.1	69	35.9
	36-50	114	59.1	105	54.7
	51-65	12	6.2	14	7.3
	Above 65	5	2.6	4	2.1

Gender	Male	88	45.6	78	40.6
	Female	105	54.4	114	59.4
Level of education	None	142	73.6	102	53.1
	Primary	41	21.2	40	20.8
	Secondary	8	4.1	40	20.8
	Tertiary	0	0.0	7	3.6
	University	2	1.0	3	1.6
Household size	<3	21	10.9	35	18.2
	3-5	93	48.2	64	33.4
	6-10	75	38.9	83	43.2
	11-20	4	2.1	7	3.6
	>20	0	0.0	3	1.6
Household income (pm)	<5000	138	71.5	78	40.6
	5000-10000	38	19.7	90	46.9
	10001-20000	12	6.2	17	8.9
	20001-50000	5	2.6	7	3.6
Occupation	None	11	5.7	30	15.6
	Salaried employment	13	6.7	4	2.1
	Casual labour	39	20.2	70	36.4
	Self employed	5	2.6	27	14.1
	Pastoralist	103	53.4	1	0.5
	Legal business	22	11.4	60	31.3
	Illegal business	0	0.0	4	2.1

**Patterns of Fuelwood Utilization within the Kakuma Refugee**

In both cases higher percentage of the host and refugees

used firewood (>87-91%) compared to the respondents using charcoal (48-53%).

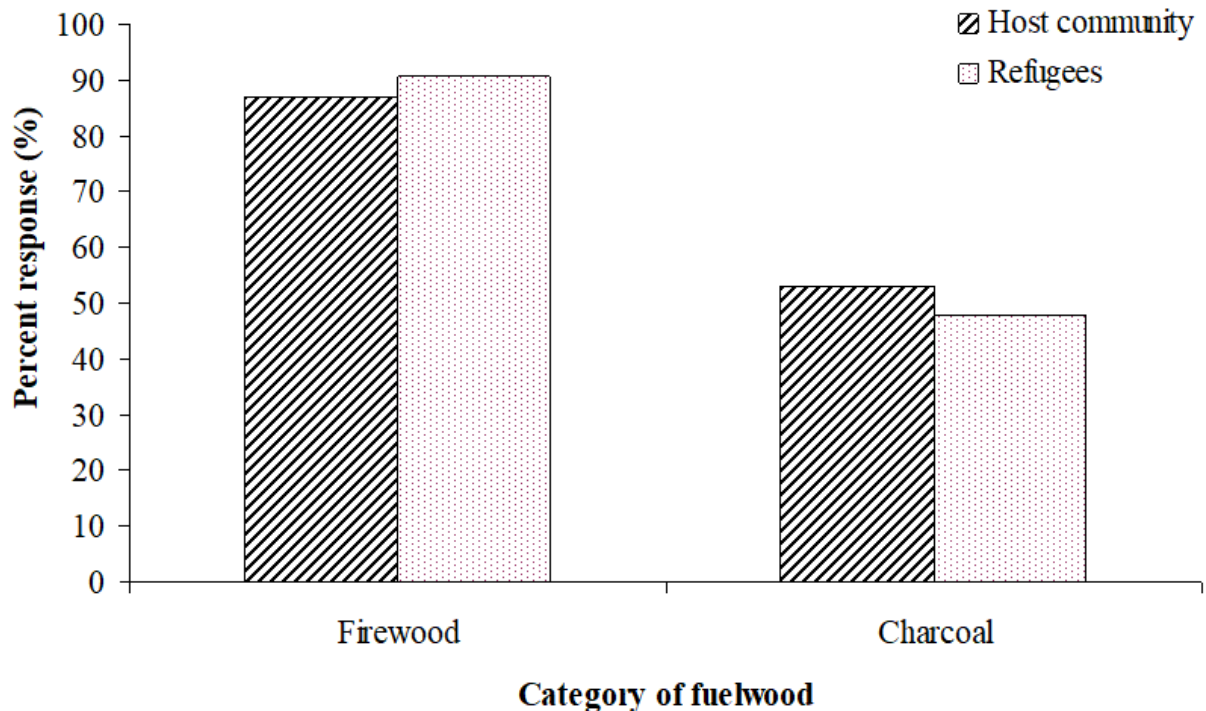


Figure 3: Proportion of fuelwood supplied and utilized in the camps

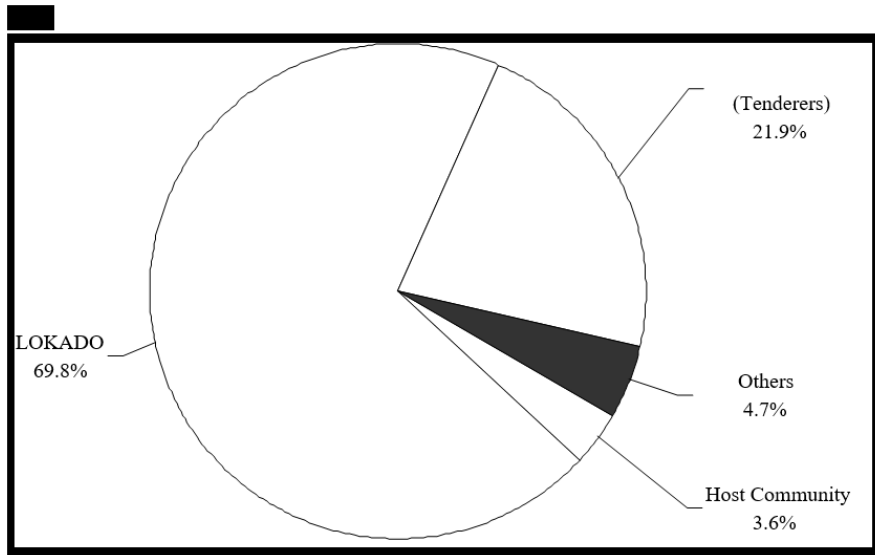


Figure 4: Source of fuelwood supplied to the refugee camps

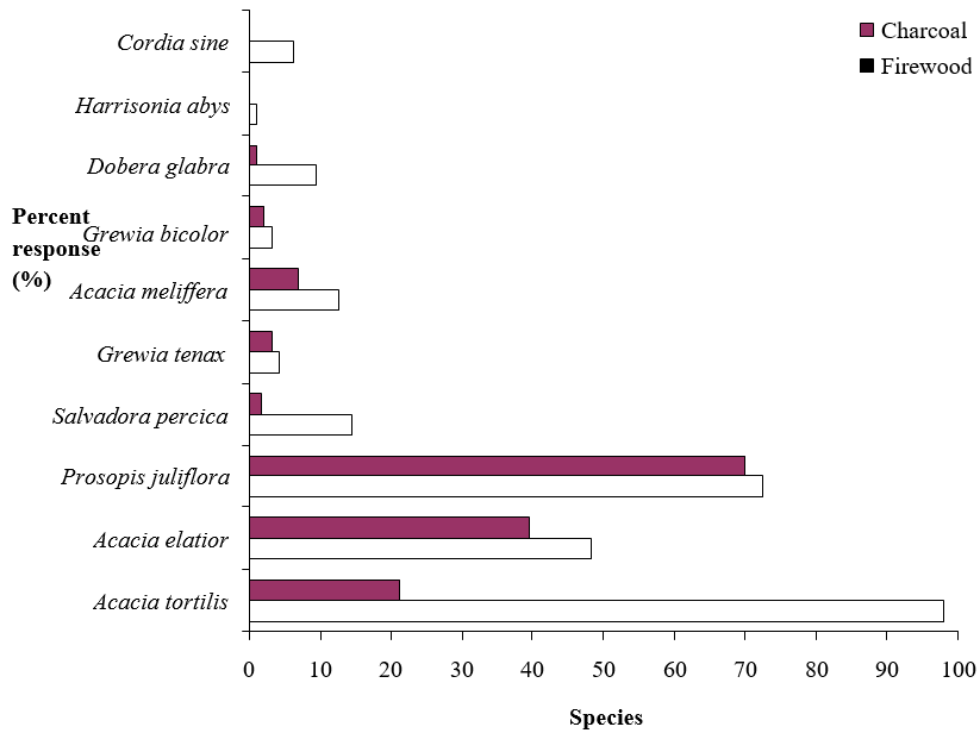


Figure 5: Species preference of tree species for fuelwood supply among the host community members

#### Factors Influencing Fuelwood Utilization Patterns in the Refugee Camps

The outcome of binary logistic regression on the relationship between socio-economic factors and supply of firewood to the camps are shown in Table 5. The

selected socio-economic factors were significant ( $B = -4.534$ ,  $Wald = 4.977$ ,  $P = 0.026$ ,  $Exp(B)[OR] = 4.011$ ) in explaining supply of charcoal to the refugee camps (Maximum Likelihood ratio = 66.393; Nagelkerker  $R^2 = 0.678$ ).

Table 5: Binary Logistic regression showing the influence of socio-economic factors on supply of firewood to the refugee camps

Variables in the Equation	B	S.E.	Wald	df	P-value	Exp(B)
Distance	-1.783	0.53	11.317	1	0.001	0.168
Gender	-0.753	0.61	1.523	1	0.217	0.471
Age	0.079	0.449	0.031	1	0.86	1.083
Level of education	0.634	0.438	2.09	1	0.048	1.885

<b>Occupation</b>	<b>0.623</b>	<b>0.275</b>	<b>5.146</b>	<b>1</b>	<b>0.023</b>	<b>1.865</b>
HHSIZE	0.128	0.49	0.068	1	0.794	1.136
<b>HHIncome</b>	<b>1.853</b>	<b>0.464</b>	<b>15.966</b>	<b>1</b>	<b>0.002</b>	<b>6.378</b>
Constant	-4.534	2.033	4.977	1	0.026	4.011

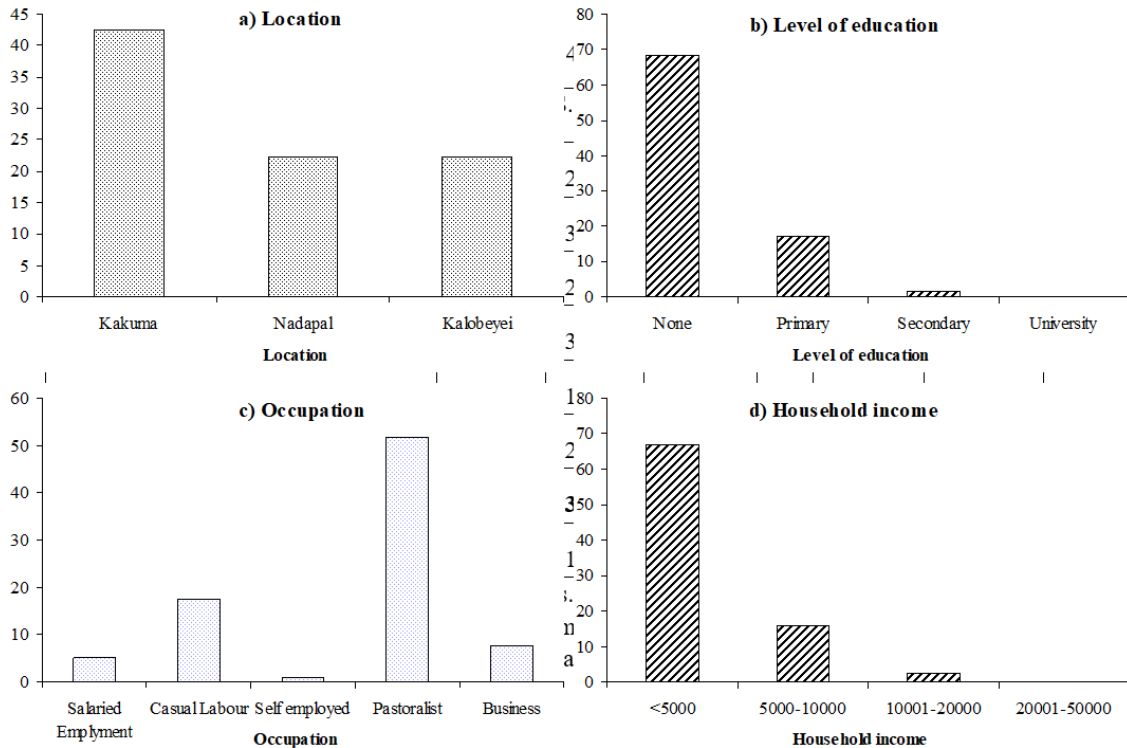


Figure 6:

Table 6:

Variables in the Equation	B	S.E.	Wald	df	P value	Exp(B)
<b>Location</b>	<b>0.236</b>	<b>0.264</b>	<b>0.804</b>	<b>1</b>	<b>0.372</b>	<b>1.267</b>
Gender	0.07	0.343	0.042	1	0.838	1.072
Age	-0.085	0.269	0.1	1	0.752	0.918
Education	-0.29	0.329	0.776	1	0.378	0.749
Occupation	0.033	0.147	0.051	1	0.821	1.034
HHSIZE	-0.137	0.277	0.245	1	0.62	0.872
<b>HHIncome</b>	<b>-1.28</b>	<b>0.381</b>	<b>11.264</b>	<b>1</b>	<b>0.001</b>	<b>0.278</b>
Constant	1.709	1.104	2.394	1	0.022	2.523

Table 7: Multiple linear regression analysis showing the relationship between socio-economic attributes and frequency of supply of firewood the refugee camps

Regression Statistics					
Multiple R	0.421				
R Square	0.177				
Standard Error	0.952				
Observations	183				
Dependent Variable: How frequent do you supply firewood					
Predictors: (Constant), Location, Gender, Age, Level of education, Occupation, Household size, Household income					
ANOVA	TSS	df	MSS	F	P-value
Regression	34.422	7	4.917	5.421	0.0000
Residual	159.660	176	0.907		
<b>Total</b>	<b>194.082</b>	<b>183</b>			

	Unstandardized Coefficients		Standardized Coefficients		
	B	Standard Error	Beta	t Stat	P value
(Constant)	2.735	0.482		5.702	0.000
<b>Distance</b>	<b>0.389</b>	<b>0.111</b>	<b>0.312</b>	<b>3.494</b>	<b>0.001</b>
Gender	0.023	0.153	0.011	0.147	0.884
<b>Age</b>	<b>0.277</b>	<b>0.123</b>	<b>0.177</b>	<b>2.264</b>	<b>0.025</b>
<b>Level of education</b>	<b>0.487</b>	<b>0.135</b>	<b>0.28</b>	<b>3.598</b>	<b>0.000</b>
Occupation	-0.086	0.066	-0.102	-1.298	0.196
Household size	0.204	0.124	0.133	1.645	0.102
<b>Household income</b>	<b>-0.491</b>	<b>0.126</b>	<b>-0.299</b>	<b>-3.906</b>	<b>0.000</b>
	<b>Correlations</b>				
<b>(Constant)</b>	<b>Zero-order</b>	<b>Partial</b>	<b>Part</b>	<b>Tolerance</b>	<b>VIF</b>
(Constant)	0.16	0.255	0.239	0.587	1.702
Location	0.052	0.011	0.01	0.845	1.183
Gender	0.204	0.168	0.155	0.764	1.308
Age	0.082	0.262	0.246	0.772	1.295
Level of education	0.001	-0.097	-0.089	0.763	1.311
Occupation	0.213	0.123	0.112	0.711	1.407
Household size	-0.132	-0.282	-0.267	0.8	1.25
Household income	0.16	0.255	0.239	0.587	1.702

**Table 8:** Multiple linear regression analysis showing the relationship between socio-economic attributes and quantity of firewood supplied to the refugee camps

<b>Regression Statistics</b>					
Multiple R	0.724				
R Square	0.524				
Standard Error	69.686				
Dependent Variable: How much firewood is supplied to the household Monthly					
Predictors: (Constant), Household income, Household size, Occupation, Level of education, Gender, Age, Location					
<b>ANOVA</b>	<b>TSS</b>	<b>df</b>	<b>MSS</b>	<b>F</b>	<b>P-value</b>
Regression	636676.4	7	90953.77	18.73	0.000
Residual	577880.5	119	4856.139		
<b>Total</b>	<b>1214557</b>	<b>126</b>			
	Unstandardized Coefficients		Standardized Coefficients		
	B	Standard Error	Beta	t Stat	P value
(Constant)	249.932	43.577		5.735	0.000
Location	8.05	12.446	0.048	0.647	0.519
<b>Gender</b>	<b>-53.965</b>	<b>13.073</b>	<b>-0.276</b>	<b>-4.128</b>	<b>0.000</b>
Age	3.872	10.100	0.028	0.383	0.702
<b>Level of education</b>	<b>24.435</b>	<b>12.998</b>	<b>0.125</b>	<b>1.88</b>	<b>0.063</b>
<b>Occupation</b>	<b>-49.284</b>	<b>5.642</b>	<b>-0.621</b>	<b>-8.735</b>	<b>0.000</b>
Household size	13.375	10.829	0.09	1.235	0.219
Household income	1.979	13.923	0.01	0.142	0.887
	<b>Correlations</b>			<b>Collinearity statistics</b>	
	<b>Zero-order</b>	<b>Partial</b>	<b>Part</b>	<b>Tolerance</b>	<b>VIF</b>
(Constant)					
Location	-0.276	0.059	0.041	0.741	1.35
Gender	-0.362	-0.354	-0.261	0.896	1.117

Age	0.067	0.035	0.024	0.742	1.348
Level of education	0.199	0.17	0.119	0.904	1.106
Occupation	-0.636	-0.625	-0.552	0.79	1.265
Household size	0.168	0.113	0.078	0.749	1.334
Household income	0.059	0.013	0.009	0.89	1.124

**Table 9:** Multiple linear regression analysis showing the relationship between socio-economic attributes and quantity of charcoal supplied to the refugee camps

Regression Statistics					
Multiple R	0.782				
R Square	0.58				
Standard Error	16.918				
Dependent Variable: How much charcoal is supplied to the household monthly					
Predictors: (Constant), Household income, Household size, Occupation, Level of education, Gender, Age, Location					
ANOVA	TSS	df	MSS	F	P-value
Regression	7515.723	7	1073.675	3.751	.0100
Residual	5437.906	19	286.206		
<b>Total</b>	<b>12953.63</b>	<b>26</b>			
		Unstandardized Coefficients		Standardized Coefficients	
	B	Standard Error	Beta	t Stat	P value
(Constant)	9.602	30.464		0.315	0.756
Location	-16.267	10.395	-0.339	-1.565	0.134
Gender	1.53	7.731	0.034	0.198	0.845
Age	-3.089	4.679	-0.126	-0.66	0.517
Level of education	6.775	5.512	0.313	1.229	0.234
<b>Occupation</b>	<b>4.831</b>	<b>3.496</b>	<b>0.308</b>	<b>1.382</b>	<b>0.0183</b>
Household size	-2.626	6.37	-0.098	-0.412	0.685
<b>Household income</b>	<b>9.043</b>	<b>5.807</b>	<b>0.373</b>	<b>1.557</b>	<b>0.0136</b>
			Collinearity statistics		
	Zero-order	Partial	Part	Tolerance	VIF
(Constant)					
Location	-0.264	-0.338	-0.233	0.471	2.125
Gender	-0.066	0.045	0.029	0.735	1.361
Age	-0.224	-0.15	-0.098	0.611	1.638
Level of education	0.557	0.271	0.183	0.341	2.933
Occupation	0.174	0.302	0.205	0.445	2.25
Household size	-0.509	-0.094	-0.061	0.392	2.552
Household income	0.501	0.336	0.231	0.386	2.592

**Price Analysis of Fuelwood in Kakuma Camp**

The second objective of the study was to determine the pricing strategies and analysis of fuelwood at the refugee camps. First, the quantity of firewood and charcoal supplied to the refugee camps over the last five years are provided in Figure 7. There were significant differences in the quantity of firewood supplied during the last five years ( $F = 34.5523$   $df = 4$ ,  $P = 0.0032$ ).

**Demand of Firewood among the Refugees During the Study**

Supply and demand curve of firewood in refugee camp.  $Q=a+bp$ . where  $Q$  = Linear demand curve;  $b$  = Slope and  $p$  = Price

Figure (7). Based on the curved, the equilibrium price was estimated at about Kshs 100 per kg

Table 7, Enterprise budget (in Kshs) of tree supplied to the refugee camps during the study. Profit=profitmargin ratio= (gross operating or net) (profit/sales)/100. Breack even is ksh 64/-

Profit=Total revenue-total expenses.

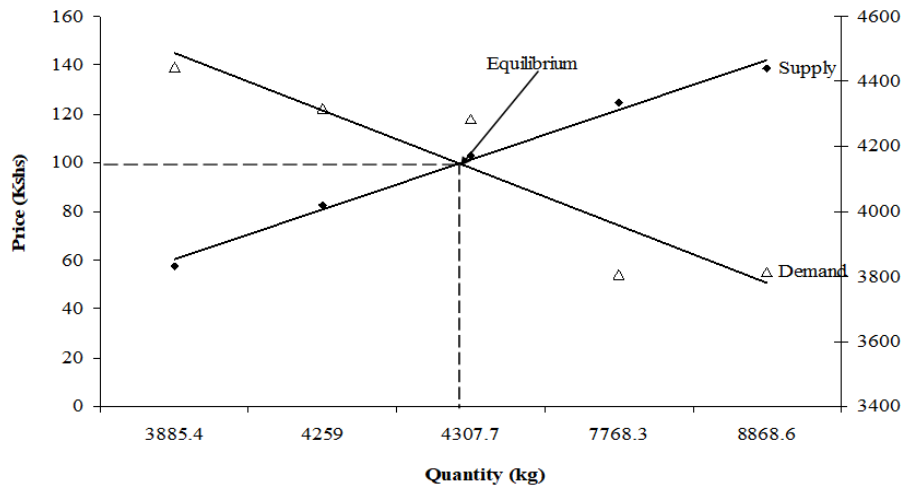


Figure 7: Supply and demand curve of firewood in refugee camps

Table 10: Fuelwood supply parameters

Parameters	Fuelwood supply
Total yield of trees (kgs/ha)	5,040
Unit cost/kg	300.00
Gross receipts	1,512,000
<b>Variable costs</b>	
Cost of harvesting	154,500
Cost of loading	145,670
Cost of transport	65,000
Cost of offloading	150,000
Miscellaneous	80,000
Sub-total variable costs	620,770
Interest on operating cost	99,323
Total variable cost (TVC)	720,093
<b>Fixed costs</b>	
Amortization	60,000
Interest on fixed cost	9000
Total fixed cost	169,000
Total cost (TC)	889,093
Net returns above TVC	791,620
Net returns above TC	622,620
Margins above TC (%)	142.84
Break even price	64.05

### Alternative Energy Sources from Fuelwood for Refugees in Kakuma Camp

The final objective of the study was to determine the alternative sources of energy within the Kakuma refugee camps. Among the local community members, the main alternative energy source was mud stove, ceramic jiko and kerosene. Meanwhile majority of the refugee used mud stove, portable maendeleo stove and Ceramic jiko as alternative energy source.

### CONCLUSIONS

The study area remains highly populated with refugee

settlements from South Sudan, meaning that pressure on wood fuel is still far from ending unless this situation is overturned in the near future. This study reports forth that the refugees used more firewood followed by charcoal, and other biomass fuels such as agricultural residues, husks, and grasses as cooking fuel. The household size categories that had a significant contribution to the collection and use of firewood were the large families.

### RECOMMENDATION

The current consumption pattern is unsustainable given high dependence and inefficient use. This threatens the existence of the preferred wood species such as *Salvadora persica*, *Acacia melifera*, and *Dobera glabra* trees and other dryland vegetation tree species as they are indiscriminately harvested to meet fuelwood needs and this will worsen the specter of the fragility of the ecosystem.

### Acknowledgement

In preparing this thesis from the conception to the final write up, several people were involved and it is with all sincerity to acknowledge them for the great role they played. First and foremost, I wish to express my deepest gratitude to my academic supervisors Dr. Paul Okelo Odwori and Dr. Wilson Kipkore at the University of Eldoret for the professional guidance, encouragement, endless support and constructive criticism and timely supervision of this work to completion.

### REFERENCES

- Aukot, E. (2002). It is better to be a refugee than a Turkana in Kakuma: revisiting the relationship between hosts and refugees in Kenya. *Refuge*, 21, 73. *Forest Products Journal*, 70(1), 4-9.
- Bartl, D. (2019). Exponential utility maximization under model uncertainty for unbounded endowments. *The Annals of Applied Probability*, 29(1), 577-612.
- Betts, A., Omata, N. and Sterck, O. (2020). Self-reliance and social networks: explaining refugees' reluctance to relocate from Kakuma to Kalobeyei. *Journal of*

- Refugee Studies*, 33(1), 62-85.
- Bhagat, A. (2020). Experimental financial inclusion as refugee management: shelter insecurities at the bottom of the pyramid in Kenya. *International Journal of Housing Policy*, 1-21.
- Cakmakyapan, S. and Goktas, A. (2013). A comparison of binary logit and probit models with a simulation study. *Journal of Social and Economic statistics*, 2(1), 1-17.
- Ceccherini, G., Duveiller, G., Grassi, G., Lemoine, G., Avitabile, V., Pilli, R. and Cescatti, A. (2020). Abrupt increase in harvested forest area over Europe after 2015. *Nature*, 583(7814), 72-77.
- Cox, D. R. (2018). *Analysis of binary data*. Routledge.
- Cramer, J. S. (1999). Predictive performance of the binary logit model in unbalanced samples. *Journal of the Royal Statistical Society: Series D (The Statistician)*, 48(1), 85-94.
- Davis, E. J., Hajjar, R., Charnley, S., Moseley, C., Wendel, K. and Jacobson, M. (2020). Community-based forestry on federal lands in the western United States: A synthesis and call for renewed research. *Forest Policy and Economics*, 111(102042).
- Dutta, H. (2022). The Environmental Aspects of Refugee Crises: Insights from South Asia, Middle East, and Sub-Saharan Africa. *Journal of International Migration and Integration*, 1-26.
- Eakins, J., Sirt, G. and Power, B. (2023). Informally sourced solid fuel use: Examining its extent and characteristics of the users in the residential sector in Ireland. *Energy Policy*, 172(113293).
- Ellen, S. (2012). *Slovin's Formula Sampling Techniques*. Fort Worth: Dryden Press.
- Fairhurst, C., Parkinson, G., Hewitt, C., Maturana, C., Wiley, L., Rose, F., Torgerson, D., Hugill-Jones, J., Booth, A. and Bissell, L. (2022). Enclosing a pen in a postal questionnaire follow-up to increase response rate: a study within a trial. *NIHR Open Research*, 2(53), 53.
- Grebner, D. L., Bettinger, P., Siry, J. P. and Boston, K. (2021). *Introduction to forestry and natural resources*. Academic press.
- Harrell, F. E. (2015). *Binary logistic regression, Regression modeling strategies*. Springer. 219-274.
- Hutton, J., Patenaude, G., Revéret, J.-P. and Potvin, C. (2017). The role of indigenous peoples in conservation actions: a case study of cultural differences and conservation priorities, *Governing Global Biodiversity*. Routledge. 159-176.
- Jepng'etich, K. S. (2020). Sustainable Fuelwood Production In Kenya: Potential Role of Community Forest Associations: 2020 *International Conference and Utility Exhibition on Energy, Environment and Climate Change (ICUE)*. IEEE, 1-6.
- Jiang, H., Zhang, Y., Lü, E. and Wang, C. (2015). Archaeobotanical evidence of plant utilization in the ancient Turpan of Xinjiang, China: a case study at the Shengjindian cemetery. *Vegetation History and Archaeobotany*, 24(1), 165-177.
- Johnston, C. M., Guo, J. and Prestemon, J. P. (2022). US and Global Wood Energy Outlook under Alternative Shared Socioeconomic Pathways. *Forests*, 13(5), 786.
- Kariuki, D. W. (2021). Socio-Economic Determinants of Household Continued Use of Solid Biofuels (Fuelwood and Charcoal) for Cooking Purposes in Sub-Saharan Africa-Kenya's Situation. *East African Journal of Environment and Natural Resources*, 3(1), 49-68.
- Kariuki, P. M., Onyango, C. M., Lukhoba, C. W. and Njoka, J. T. (2018). The Role of Indigenous Knowledge on Use and Conservation of Wild Medicinal Food Plants in Loita Sub-county, Narok County. *Asian Journal of Agricultural Extension, Economics & Sociology*, 28(2), 1-9.
- Karki, M.B. and Chowdhary, C.L. (2019). Non-timber Forest Products (NTFP) and Agro-forestry Subsectors: Potential for Growth and Contribution in Agriculture Development, Agricultural Transformation in Nepal. Springer. 385-419.
- Kenya National Bureau of Statistics. (2010). The 2009 Kenya population and housing census. Kenya National Bureau of Statistics.
- Khan, I., Zakari, A., Dagar, V. and Singh, S. (2022). World energy trilemma and transformative energy developments as determinants of economic growth amid environmental sustainability. *Energy Economics*, 108(105884).
- Kimutai, S.K. and Talai, S.M. (2021). Household Energy Utilization Trends in Kenya: Effects of Peri Urbanization. *European Journal of Energy Research*. 1(2), 7-11.
- Kumi, R. A. K., & Owusu, E. (2023). Kungu, W., Agwanda, A. and Khasakhala, A. (2020). Trends and determinants of contraceptive method choice among women aged 15-24 years in Kenya. *F1000Research*, 9(197), 197.
- Kumi, R. A. K., & Owusu, E. (2023). Monetary Valuation of the Unpaid Care Works and Experiences of Some Women in the Upper East Region of Ghana. *American Journal of Economics and Business Innovation*, 2(1), 52-62.
- Lumumba, L. G., Paul, N., Shanyisa, W. M. and Ndung'u, E. M. (2022). Relevance of cash transfer programme on promoting nutrition security among refugees in Kakuma Camp, Kenya.
- Lund, B. (2021). The questionnaire method in systems research: an overview of sample sizes, response rates and statistical approaches utilized in studies. *VINE Journal of Information and Knowledge Management Systems*, 53(1), 1-10.
- Maalim, S. A., Adwek, G. and Arowo, M. (2021). Shared energy parks as a solution to energy challenges for Dadaab Refugee Camps in Kenya. *Scientific African*, 13(e00901).
- MacDicken, K. G., Sola, P., Hall, J. E., Sabogal, C., Tadoum, M. and de Wasseige, C. (2015). Global progress toward sustainable forest management. *Forest Ecology and Management*, 352(47-56).
- Manandhar, A., Mousavi-Avval, S. H., Tatum, J., Shrestha, E., Nazemi, P. and Shah, A. (2022). *Solid biofuels, Biomass, Biofuels, Biochemicals*. Elsevier. 343-370.
- Mbaka, C. K. (2021). Spatial variation of household

- energy consumption across counties in Kenya. *African Geographical Review*, 1-32.
- Meyer, V. M., Benjamins, S., El Moumni, M., Lange, J.F. and Pol, R.A. (2022). Global overview of response rates in patient and health care professional surveys in surgery: a systematic review. *Annals of surgery*, 275(1), e75.
- Mikulewicz, M. (2018). Politicizing vulnerability and adaptation: On the need to democratize local responses to climate impacts in developing countries. *Climate and Development*, 10(1), 18-34.
- Molina, A., Mendoza, A., Lozano, F. J., Serra-Barragán, L. and Ibarra-Yunez, A. (2022). Historical Context and Present Energy Use in the Global Economy, Energy Issues and Transition to a Low Carbon Economy. Springer, 1-29.
- Molnár, Z. and Berkes, F. (2018). *Role of traditional ecological knowledge in linking cultural and natural capital in cultural landscapes*. Reconnecting Natural and Cultural Capital: Contributions from Science and Policy; Paracchini, M.L., Zingari, P.C., Blasi, C., Eds: 183-193.
- Monetary Valuation of the Unpaid Care Works and Experiences of Some Women in the Upper East Region of Ghana. *American Journal of Economics and Business Innovation*, 2(1), 52-62.
- Mouzam, S. M. (2020). UNESCAP and UNCTAD, Asia-Pacific Trade and Investment Report 2019: Navigating Non-tariff Measures (NTMs) Towards Sustainable Development, United Nations Economic and Social Commission for Asia and the Pacific and United Nations Conference on Trade and Development. SAGE Publications Sage India: New Delhi, India.
- Nato, G. N. (2020). Refugee-Environment Nexus: Socio-Cultural Acceptability of Eco-Friendly Options for Household Cooking in Kenyan Refugee Camps, Health in Diversity–Diversity in Health. Springer, 121-133.
- Nerfa, L., Rhemtulla, J. M. and Zerriffi, H. (2020). Forest dependence is more than forest income: Development of a new index of forest product collection and livelihood resources. *World Development*, 125(104689).
- Odwar, F. N. A. (2020). Conflict influenced by geography: analysis of Kenya's geographical position to explain the Somali and North-Eastern Kenya's unrest, Bursa Uludağ Üniversitesi.
- Omata, N. (2021). Refugee livelihoods: a comparative analysis of Nairobi and Kakuma Camp in Kenya. *Disasters*, 45(4), 865-886.
- Omoju, O. E., Li, J., Zhang, J., Rauf, A. and Sosoo, V. E. (2020). Implications of shocks in energy consumption for energy policy in sub-Saharan Africa. *Energy & Environment*, 31(6), 1077-1097.
- Osano, A., Maghanga, J., Munyeza, C., Chaka, B., Olal, W. and Forbes, P. (2020). Insights into household fuel use in Kenyan communities. *Sustainable Cities and Society*, 55(102039).
- Pagdee, A., Kim, Y.-s. and Daugherty, P. J. (2006). What makes community forest management successful: a meta-study from community forests throughout the world. *Society and Natural resources*, 19(1), 33-52.
- Pape, U., Beltramo, T., Fix, J., Nimoh, F., Sarr, I. and Rivera, L. A. R. (2021). Understanding the Socioeconomic Differences of Urban and Camp-Based Refug