Determinants on the Choice of the Main Source of Cooking Energy by Households in Urban Areas of Tanzania: A Case of Kiwanja cha Ndege Ward in Morogoro Municipality

Abstract

The study was carried out at Kiwanja cha Ndege ward in Morogoro Municipality by assessing determinants on households' choice of the main source of cooking energy. This study used quantitative data from primary and secondary sources. A total of 150 respondents were selected using a simple random sampling technique and involved a cross-sectional design. Primary data were collected from respondents through a structured interview method executed through researcher-administered questionnaires. The study used descriptive statistics, the likelihood ratio Chi-Square test, and binary logistic regression analysis using IBM SPSS statistics version 20 and Stata version 11. The results revealed that a large proportion of households used charcoal (84%), followed by gas (11.3%) as the main source of cooking energy. This information implies that households in urban areas prefer mostly using charcoal for cooking. Furthermore, the study's results revealed that education level, marital status, and main economic activity were the factors that determine the choice of charcoal as the household's main source of cooking energy. The study recommended that the central government, through the Ministry responsible in collaboration with local government authorities, should create awareness in society on the importance of using clean cooking fuels and technologies. The central government through fiscal policy has also to intervene to enhance the choice of cooking energy by regulating the price of modern cooking energy so that it can be affordable to many households. Likewise, it should encourage and engage the private sector to ensure that modern energy especially LPG is available in local areas.

Keywords: ***Main source of energy cooking, charcoal, households, clean cooking fuels, and technologies, cooking energy sources***

1. Introduction

Reliance on polluting cooking fuels will cause severe consequences on the environment, economic development, and health, especially for women and children, and therefore access to clean cooking fuels and technologies is vital (Stoner et al, 2021, EIA et al, 2022). Globally, from 2010 to 2020 there was an increase of 12 percent of people with access to clean cooking fuels and technologies, nonetheless parallel with this small increase 2.4 billion people on the planet had no access to clean cooking energy and technologies by 2020. The increase was a positive sign toward achieving the SDG 7 target of universal access to affordable, reliable, sustainable, and modern energy by 2030. The emergence of the Covid19 pandemic disrupted the positive trend by reverting the economic ability of individuals who had already transitioned to use modern fuels and forcing them back to traditional methods such as in Asian countries (ibid.). In the developing world, especially in Sub-Saharan Africa, the access rate to clean cooking fuels and technologies has not kept pace with the population growth, as such, despite global gains in accessing clean cooking fuels, the number of people without access increased from 750 million in 2010 to 890 million in 2018. This number may increase to 1 billion people in 2030 if no deliberate efforts are made to influence the transition to a modern source of cooking fuel (ESMAP, 2020).

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People in middle-income and lower-income countries are also faced with the challenge of reliable cooking energy sources, accounting for a large proportion of total energy consumed in those countries (Onyekuru et al, 2020). Worldwide biomass has remained a major source of cooking energy which is connected to the negative aspects on the environment and human health, and the transition pace to the use of clean cooking energy has remained lower, especially in Sub-Saharan Africa where more than sixty percent use charcoal as a source of cooking energy (Mperejekumana et al, 2021, Johanna and Leonard, 2017). The preference for the source of cooking energy shows a divide between rural and urban areas, whereby about 2.8 billion people in urban areas worldwide use charcoal while fuelwood is a major source of cooking fuel in rural areas (Sola et al, 2017). This trend is also reflected in many African countries with their population heavily relying on biomass for cooking energy (66%). In Tanzania, according to Household Budget Survey 2017-18, the main source of cooking energy is fuel wood (60.9%) followed by charcoal (28.8%) and Liquefied Petroleum Gas (LPG) by 3.2 percent (NBS 2019).

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The trend of energy consumption in Tanzania with sources reflects the large proportion of the population dwelling in rural areas in the country. Generally, biomass provides about 83% of total energy consumed in Tanzania with 70% of the population in urban areas such as Dar es Salaam city using charcoal as a major source of cooking energy (Mokveld and von Eije, 2018). There are other sources in developing countries apart from biomass such as electricity, kerosene, solar, and Liquefied Petroleum Gas, but are used by a smaller proportion of the population, and in most cases, households use multiple sources of cooking energy or fuel-stacking instead of using a single source (Choumert-Nkolo et al, 2018). Different studies have been conducted in different parts of the world in an attempt to explain the factors associated with the households' choice of energy sources for cooking purposes; however, there has been no consensus on the common factors associated with the choices of energy sources (Fidel, et al., 2016). There are different reasons given by households for preference for a particular source of cooking energy such as

faster cooking, clean cooking, better taste of food, and lower chance of fire accidents (Onyekuru et al, 2020).

Tanzania through its National Energy Policy has been striving to enable the transition of cooking energy sources by the household from biomass to electricity and promoting the use of Liquefied Petroleum Gas, however, the efforts have not resulted in the transition away from biomass, instead, most of the households use multiple fuels (fuel stacking) with fuelwood and charcoal remaining the cheapest in rural and urban areas respectively (Doggart et al, 2020). Furthermore, some households in Tanzania especially in urban areas are not willing to switch from using charcoal to alternative energy citing different reasons (Lokina and Mapunda, 2015). The reasons for preferring a certain type of energy sources choice seem to differ from one part of the globe to another, from one country to another and variations go deeper in states within the country. This situation has made the choice of cooking energy source become a growing issue of concern. For the country to transition from traditional sources to modern ones, it needs to understand the determinants of the choice of the main source of cooking energy in the local area to focus the efforts. This study assesses determinants of households' choice of the main source of cooking energy.

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2. Literature review

Clean Cooking Fuels, Technologies, and Sources

These are the sources of coking energy that do not cause air pollution and hence do not threaten the health of users. Such fuels and technologies electricity, Liquefied Petroleum Gas (LPG), natural gas, biogas, solar and alcohol fuels. Sometimes processed biomass such as wood pellets are considered clean fuels (ESMAP 2020). Access to clean fuels and technologies is related to and leads to improved cooking services. Households are said to be using improved cooking services when they meet certain standards in the Multi-Tier Framework (MTF) IEA et al. (2022).

The sources of energy as per this study refer to different energy sources from which households obtain cooking and lighting fuels. The sources can be both modern and traditional. The traditional sources of fuel include firewood. Charcoal, animal dung, and crop waste are also classified as biomass fuels. On the other hand, modern sources of cooking energy are electricity, and hydrocarbon fuels such as petroleum products such as kerosene, petro, liquefied natural gas, and coal. Their household energy sources can be divided into three categories of biomass fuels, hydrocarbon fuels, and electricity (ibid.)

The “Energy ladder” theory

His theory has been used in different cooking energy studies to explain household fuel use in developing countries (Leach 1992 cited in Yadav et al., 2021). The energy ladder indicates a transition process by which households, gradually move from using traditional fuels to modern ones as their income increases. First, according to this theory, households move from relying on biomass fuels such as firewood and charcoal and adopt intermediate fuels like kerosene, and coal, and then use modern fuels such as gas, and electricity. Switching to a certain type of fuel source depends on the improvement in the level of income and therefore, a transition from traditional sources reflects the ability to afford the price for modern sources. The theory

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describes three stages in the process of transition whereby the first stage is the reliance on biomass fuels while the second stage is characterized by adopting fuels such as kerosene and coal before finally using modern sources such as LPG, natural gas, and electricity as the household income becomes higher (Amoah 2019). One of the achievements of this theory is its ability to fit well common observations of the strong income dependency of household fuel use. It, however, cannot fully explain the transition observed in different populations in developing countries regarding switching from traditional sources of fuel to modern ones. In some urban areas for example, where electricity coverage is almost 100% such as the Msasasani area in Dare e salaam city in Tanzania a large proportion of households still use charcoal, at the same time use LPG and very few use electricity for cooking. This situation may require to use of another model that can explain the phenomenon such as the fuel stacking theory (Lokina nad Mpunda, 2915, Choumert-Nkolo et al., 2018).

The 'Fuel stacking' theory

Fuel stacking theory is also known as the multiple fuel model (Masera et al., 2000). It is the proposed alternative model to the energy ladder theory which cannot adequately describe the dynamics of households' fuel use. In developing countries, the practice is that households in both urban and rural areas use multiple fuels for cooking (Lokina and Mapunda 2015). Fuel stacking corresponds to multiple fuel use patterns where households choose a combination of fuels from both lower and upper levels of the ladder. Indeed, modern fuels may serve only as partial, rather than perfect substitutes for traditional fuels (Choumert-Nkolo et al. - 2018). Multiple fuel use arises from several reasons, such as occasional shortages of modern fuels high cost of appliances associated with using exclusively modern fuels (Davis 1998), fluctuations in commercial fuel prices (Leach 1992 in Yadav et al. - 2021), and preferences inducing households not to fully adopt modern fuels (Lokina and Mapunda 2015). The complexity of the fuel-switching process thus suggests that there are different factors apart from income that may affect fuel use, especially in developing countries. This led some authors to delve into more sophisticated modeling approaches.

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Empirical Review

In line with the theoretical discussions, it has been learned that the determinants of fuel use vary across populations depending on the level of development. For example, the reliance on biomass and solid fuels implies a low level of industrialization in the nation (Makonese et al, 2017, Choumert-Nkolo et al. - 2018). So, different pieces of literature have revealed different social and economic determinants such as education, level of income, fuel prices, household preferences, production characteristics, and energy supply factors. Empirical evidence from the study conducted in Ethiopia for example indicates that the determinant for the choice of fuel to be used in a household included, income level, family size, access to road, education level of the householder, cost of technology and distance to the market (Wassie et al. 2021). in other places the determinants of fuel choice include access to microcredits why indicate the role of income level in addition to education level as evidence suggests from northern Sudan (Mperejekumana et al. 2021). Using different approaches in the analysis of the studies related to the choice of cooking fuels evidence continues to show diverse determinants including access to the internet, possessing fixed assets and having a household member that lives in the urban area (Twumasi et

al 2021). A study conducted in Ghana by Amoah, (2019) has shown that the majority use charcoal despite the presence of Liquefied Petroleum Gas because of the perceived deadly accidents associated with the use of LPG. It was further found out that some of the household use of fuel sources is influenced by location, especially for those who are tenants who must abide by the conditions of the landlord or landlady. Moreover, the study by Abubakar et al. (2015) conducted in Nigeria on determinants of household choice and consumption pattern in developing counties established that household size, age, and nature of employment determine the choices of energy sources for cooking in rural areas. Additionally, the study conducted by (Choumert-Nkolo et al, 2018) on Ethiopia determinants of household energy demand revealed that household size, the proportion of women in households, education, owning of dwelling, and electric appliances are important factors determining the choice of energy sources for cooking.

From a policy perspective, it is not easy to identify the factors that influence the households` actions in terms of energy use. Furthermore, whatsoever these factors may be, they stated that they are highly unlikely to be the same across all cities of the Asian region Hori and Ben (2013). Their survey was conducted across five major Asian countries. Income and age also had weak positive effects on energy-saving behaviours. Social interaction was strongly linked to energy-saving behaviours, particularly in the rural areas of Dalian and Chongqing. This result indicates that community-based activities impact energy-saving behaviours. In this research, 1000 questionnaires were administered to respondents across the five Asian cities and an analysis was drawn. The estimation model employed was the Least Square Regression model. Research on energy literacy, awareness, and conservation behaviour of residential households concerning energy expenditures by Brounen, et al (2013) concluded that energy-saving behaviour by households was due to the awareness of the members of the household. Better organized, financial savers and environmentally aware households were found to be energy savers as compared to their directed opposites.

Boukary (2006) examine household energy preferences for cooking in urban Burkina Faso. Descriptive and multinomial logistic analysis was employed for the analysis. The descriptive analysis shows that the domestic demand for wood energy is strongly related to household income. The firewood utilization rate decreases with increasing household income. In other words, this fuel appears as a “transition good” for households that aim for other sources of energy for cooking that are more adapted for urban consumption. The multinomial model analyses the sociological and economic variables of household energy preferences for cooking in urban. The analysis shows that household energy preferences for cooking are determined by household. Bello (2010) investigated household energy utilized for cooking and its determinants in the Ado-Ekiti metropolitan area of Nigeria, the study uses the multinomial logistic model to analyze the determinants of the choice of energy used for cooking. Income, size of household, price of stove or cooker, head of household level of education are variables captured. Empirical results reveal that the choice of cooking energy is mainly determined by income, size of household, and level of education is another empirical work that Simple descriptive statistics and a chi-square test were employed for the analysis.

Onyekuru et al (2020) investigated the determinants of cooking energy demand in the rural households of Enugu State. A bivariate probit model was employed for the analysis. Fuel wood and kerosene were the two different cooking fuel options available to households. Occupation, family size, and level of education Shittu et al (2014) examined the demand for energy among

households in Ijebu Division, Ogun State, Nigeria. Primary data were obtained in a cross-section survey of ninety households selected across six communities in the Ijebu-Division of Ogun State.

Besides, other researches indicate that household size, sex, and education are among the factors for an individual to decide on the type of energy to use given available alternative (Justine and George, 2013; Nnaji and chukwu, 2012). Moreover, the study by Abubakar et al. (2015) conducted in Nigeria on determinants of household choice and consumption pattern in developing counties established that household size, age, and nature of employment determine the choices of energy sources for cooking in rural areas. Additionally, the study conducted by (Choumert-Nkolo et al, 2018) on Ethiopia determinants of household energy demand revealed that household size, the proportion of women in households, education, owning of dwelling, and electric appliances are important factors determining the choice of energy sources for cooking.

In Tanzania, a study on fuel choice confirmed fuel stacking with biomass fuels accounts for 83% of fuels used by the household which is influenced by a large proportion of rural dwellings. Even in urban areas charcoal accounts for 70% of fuel used in households (Mokveld and von Eije 2018). At the national level, the major source of cooking fuels is fuelwood (60.9%), charcoal (28.8%), industrial gas 3.2% and electricity 2.11% other sources such as kerosene and solar account for less than one percent (NBS, 2019). The determinants of fuel choice in Tanzania vary across regions depending on the willingness to switch from traditional to modern sources and the cost. The study conducted in Dar es Salaam by Lokina and Mapunda (2015) revealed that some households were not willing to switch from traditional fuels citing reasons such as maintaining the taste of food cooked using traditional fuel and that the modern fuels were expensive.

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Although vast research conducted on energy source choices in the body of knowledge, the reviewed literature reveals that, factors determining energy source choices vary from one nation, region, or community to another. Therefore, the ability to generalize the findings from other nations to the urban context of Tanzania is minimal and there is still insufficient literature on this topic. Factors determining the choices of energy sources for cooking in urban areas of Tanzania have been done in the largest city of Dar es Salaam. To this end, identifying factors determining the choices of energy sources for cooking in other urban areas is vital. This study was conducted in Morogoro municipality to understand the determinants of households' choice of the main source of cooking energy.

3. Materials and Methods

3.1 Study Area

The study was conducted at Kiwanja cha Ndege ward in Morogoro Municipality in Morogoro Region, ward is situated Southwest of Kichangani ward and Northwest of Uwanja wa Taifa ward, the latitudes of Kiwanja cha Ndege ward are 6.830373 South and Longitude are 37.670589. According to the population and housing census 2012 show that the population of Kiwanja cha Ndege ward was 12,203 with 5,825 males and 6,378 females (URT, 2012). Economic activities conducted at Kiwanja cha Ndege ward such as bodaboda, food vending activities, tailoring marts, oil machines, welding, and small business.

3.2 Research Design, Data Types, and Source

A cross-sectional quantitative research design was used in this study. The design was used on the ground that it allows the collection of several data from different respondents at one point in a time. The target population of this study was all households in the Kiwanja cha Ndege ward in Morogoro Municipality. This study used quantitative data which were collected from primary sources. Primary data were collected from the head of households. Secondary data were obtained from different sources such as journals, publications, and different government reports. This study used the interview method and the questionnaire tool was administered through face-to-face interviews.

3.3 Data Collection Methods, Tools, and sampling procedures

The study used the interview method to collect data from households and a questionnaire tool was used through face-to-face interviews. Also, the study employed documentary review in reviewing various published documents produced. The sampling frame was a list of all households available at Kiwanja cha Ndege ward. The sampling unit was a single household. The study area was selected purposely because it is among the urban areas where households use different cooking energy fuels. The simple random sampling technique was used to select the households to include in the study.

3.4 Sample size

The sample size was obtained by using the standard formula for an unknown population Kothari, (2004)

$n = \frac{Z_{\alpha/2}^{\ 2} pq}{e^2}$, Where Z = Critical value of desired confidence level 95 (1.96), P = Sample proportional of household, q = Probability of failure, e = Allowable error, and n = Sample size

$$n = \frac{(1.96)^2 x0.5x0.5}{(0.08)^2}$$

$$n = \frac{3.8416x0.25}{(0.08)^2}$$

$$n = \frac{0.9606}{0.0064} = 150$$

- Therefore, a total of 150 households were selected.

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3.5 Study variables

The dependent variable for this study was the main source of cooking energy which was created as a dummy variable measured in dichotomous, where 1 if a household was using charcoal as the main source of cooking energy and 0 if the household used other sources of cooking energy (gas, firewood, and kerosine). Moreover, the independent variables of the study were age, sex, occupation, education level, marital status, income level, household size, the headship of the household, and main economic activity.

3.6 Data Processing, Analysis, and Presentation

Collected data were processed and analyzed by using IBM SPSS statistics version 20 and Stata version 11. This process involved editing, coding, entry, and cleaning to remove errors. The analysis of this study involved descriptive and inferential statistics whereby the descriptive statistics were frequencies and percentages, and the analyzed data were presented using tables and figures. Inferential statistics were based on the likelihood ratio Chi–square test. This test was used to test the association of socio-demographic variables namely, economic variables namely the main source of cooking energy. This test was selected because the dependent and independent variables are categorical. Furthermore, the independent variables which were found to be statistically significant and associated with the dependent variables were used in the binary logistic regression model to check the causal relationship.

4. Results and Discussion

4.1 Characteristics of Respondent

Findings in Table 1 show that the majority of respondents 98(65.3%) were aged between 18-35 years, followed by respondents 37 (24.7%) aged between 36 - 53 and 15 (10%) aged 54 years and above. Moreover, findings revealed that 109 (72.7%) were female and 41 (27.3%) were male. Concerning education level, results showed that 81 (54.0%) attended primary education, followed by 48(32%) secondary education, 11(7.3%) Never attended school, and 2.7% had a Diploma and university education. The marital status of the respondents reveals 102(68.0%) were married, 34(27.7%) were single and lastly, were divorced. Furthermore, 76 (50.7%) of the households earned income per month less than 150,000/=, 42 (28%) earned 150,000/= to 250,000/=, and 32 (21.3%) earned greater than 250,000/=. From the literature, demographic and socioeconomic characteristics seem to influence the choice of cooking fuels even in Tanzania (Choumert et al. 2018). This part was helpful in further analysis of the factors associated with the choice of cooking energy.

Table11: Demographic Characteristics of Respondent

Characteristics	Category	Frequency	Percent
Age	18-35	98	65.3
	36-53	37	24.7
	54 and above	15	10.0
	Total	**150**	**100.0**
Sex	Male	41	27.3
	Female	109	72.7
	Total	**150**	**100.0**
Occupation	Civil servant	16	10.7
	Self-employment	85	56.7
	Unemployed	47	31.3
	Others	2	1.3
	Total	**150**	**100.0**
Education level	Never attended school	11	7.3
	Primary school	81	54.0
	O Level Sec. School	48	32.0
	A level sec. school	2	1.3
	Diploma	4	2.7
	University graduate	4	2.7
	Total	**150**	**100.0**
Marital status	Married	102	68.0
	Single	34	22.7
	Divorced	4	2.7
	Widowed	5	3.3
	Separated	5	3.3
	Total	**150**	**100.0**
Income level	Less than 150,000	76	50.7
	150,000-250,000	42	28
	Greater than 250,000	32	21.3
	Total	**150**	**100.0**

4.2 Level of the utilization of cooking energy sources among households

Results in Figure 1 revealed that the majority of respondents prefer to use charcoal (84%) as the main source of cooking energy, followed by Liquefied Petroleum Gas (LPG) (11.3%), firewood by 4.0% and kerosene (0.7%). The findings are similar to other studies done in urban areas, especially in the city of Der es Salam where 70% of households use charcoal as a major source of cooking energy (Mokveld and von Eije, 2018). This variation can be due to the availability of charcoal as well as its low price for the household in the study area. The study is also in line with various studies in other parts of Africa for example the study done in South-West Cameroon and Ghana (Pope et al, 2018 and Amoah 2019), found that charcoal or firewood is the major cooking energy in the household compared to other sources of energy.

Furthermore, the findings in figure 2 indicated that (32.7%) use gas as the alternative source, followed by firewood (26%), kerosine (25%), charcoal (14%) and very few (2%) use electricity as an alternative source. The findings particularly regarding LPG are somewhat different in the sense that the proportion of users is slightly higher compared to previous studies. According to Tanzania Household Budget Survey 2017-18 at the national level, only 3.2% reported to be using gas as one of the cooking fuels which is less compared to 11.3% in Morogoro Municipality (NBS, 2019). This may be the result of the government to increase effort to emphasize the use of clean energy and also the availability and affordability of LPG. On the other hand, the findings in figure 2 show alternative sources apart from the main source. The results have confirmed the relevance of the stacking theory whereby households do not rely solely on a sing source of fuel, instead, they use multiple fuels as was found in similar studies conducted in Dar es Salaam (Luo et al. 2021, Lokina and Mapunda, 2015).

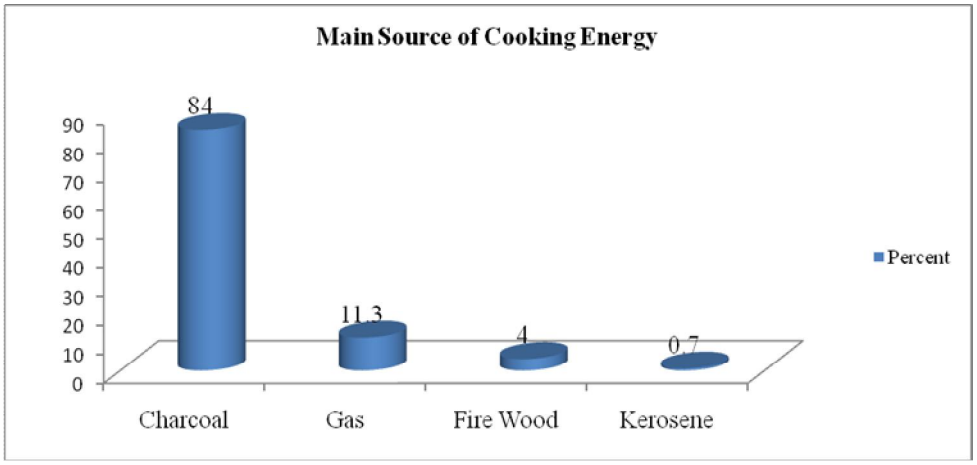

Figure 1: Main sources of Cooking Energy

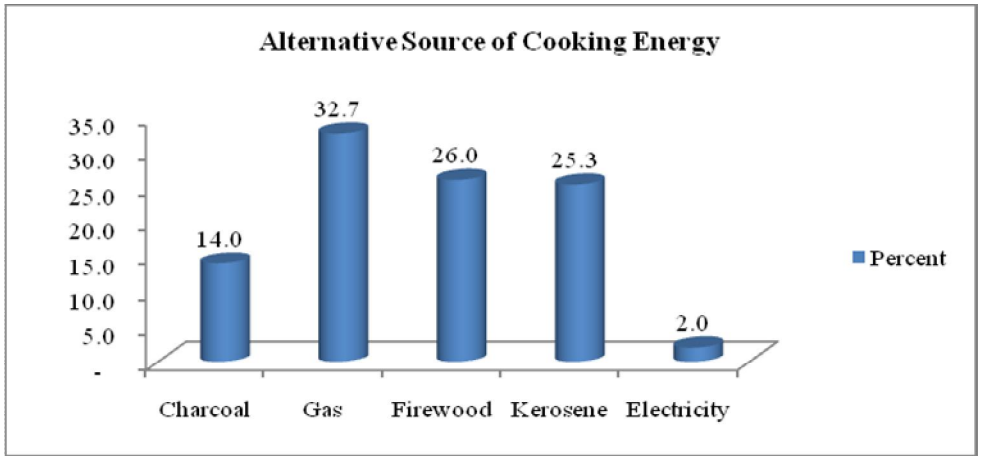

Figure 2: Alternative Source of Cooking Energy

4.3 Association between Socio-Demographic Factors and Choice of the main Cooking Energy fuel

Results from Table 2 indicate a significant association between some socio-demographic factors considered in this study and the choice of cooking energy among households. The choice of cooking energy among households was significantly associated with education level ($\chi^2 = 20.665, P < 0.05$) and Marital status ($\chi^2 = 17.835, P < 0.05$). This implies that education level and marital status are the factors connected to the selection of the cooking energy to be used in the family. This means that age, the headship of the family, and household size are not the key factors associated with the choice of cooking energy in Morogoro Municipality.

Table 2: Association of Socio-Demographic Factors and Choice of the main source of Cooking Energy

Variable	**The main source of cooking energy**				**Likelihood Ratio Chi-square tests**	
	Charcoal	Gas	Firewood	Kerosene	Value	*P-value*
Age						
18-35	80(81.6%)	14(14.3%)	4(14.3%)	0(0.0%)		
36-53	33(89.2%)	2(5.4%)	2(5.4%)	0(0.0%)	8.626	0.196
54 and above	13(86.7%)	1(6.7%)	0(0.0%)	1(6.7%)		
Education						
Never attended	11(8.7%)	0(0.0%)	0(0.0%)	0(0.0%)		
Primary	72(57.1%)	3(17.6%)	5(83.3%)	1(100.0%)	20.665	0.006***
Secondary	38(30.2%)	11(64.7%)	1(16.7%)	0(0.0%)		
Post-secondary	5(4.0%)	3(17.6%)	0(0.0%)	0(0.0%)		
Marital						
Married	90(74.4%)	10(588%)	2(33.35)	0(0.0%)		
Single	25(19.8%)	6(35.3%)	3(50.0%)	0(0.0%)		
Divorce	2(1.6%)	1(5.9%)	0(0.0%)	0(0.0%)	17.835	0.027 **
Widowed	5(4.0%)	0(0.0%)	0(0.0%)	0(0.0%)		
Separated	4(3.2%)	0(0.0%)	1(16.7%)	1(100.0%)		
Headship of the household						
Female	39(31.0%)	3(17.6%)	3(50.0%)	0(0.0%)	3.180	0.449
Male	87(69.0%)	14(82.4%)	3(50.0%)	1(100.0%)		
Household size						
1-5	114(90.5%)	16(94.1%)	5(83.3%)	0(0.0%)		
6-10	10(7.9%)	1(5.9%)	1(16.7%)	1(100.0%)	6.226	0.203
11 and above	2(1.6%)	0(0.0%)	0(0.0%)	0(0.0%)		

Note: **** Significant at 1% ** Significant at 5% levels*

4.4 Association between Economic Factors and Choice of the main source of Cooking Energy

From the findings in Table 3, based on the likelihood ratio Chi-Square test, the choice of cooking energy among households was significantly associated with main economic activities

($\chi^2 = 11.218, P < 0.1$). This may mean that the type of economic activity is associated with the choice of cooking energy and is because economic activities determine the level of income of a household. On the other hand, the findings in Table 3 reveal that income in this study area is not significantly associated with the choice of cooking fuel, this may be because the majority use biomass fuels that are of lower cost On the other side, the choice of the main source of cooking energy were not statistically significantly associated with income ($\chi^2 = 7.343, P > 0.05$), occupation ($\chi^2 = 8.295, P > 0.05$) and rent for a house ($\chi^2 = 6.173, P > 0.05$).

Table 3: Association of Economic Factors and Choice of the main source of Cooking Energy

Variable	**The main source of cooking energy**				**Likelihood Ratio Chi-square tests**	
	Charcoal	Gas	Firewood	Kerosene	Value	*P-value*
Occupation						
Civil servant	11(8.7%)	5(29.4%)	0(0.0%)	0(0.0%)		
Self-employment	73(57.9%)	7(41.2%)	4(69.7%)	1(100.0%)	8.295	0.381
Unemployed	40(31.7%)	5(29.4%)	2(33.3%)	0(0.0%)		
Others	2(1.6%)	0(0.0%)	0(0.0%)	0(0.0%)		
Income						
Less than 150,000	65(51.6%)	7(41.2%)	4(66.7%)	0(0.0%)		
150,000-250,000	35(27.8%)	5(29.4%)	1(16.7%)	1(100.0%)	4.062	0.668
Greater than 250,000	26(20.6%)	5(29.4%)	1(16.7%)	0(0.0%)		
Rent for House						
Yes	99(78.6%)	16(94.1%)	5(83.3%)	1(100.0%)	6.173	0.117
No	27(21.4%)	1(5.9%)	1(16.7%)	0(0.0%)		
Economic activities						
Food vendor	50(39.7%)	2(11.8%)	3(50.7%)	0(0.0%)		
Retailer	59(46.8%)	13(76.5%)	1(16.7%)	1(100.0%)	11.218	0.082*
Boda-boda	17(13.5%)	2(11.8%)	2(33.3%)	0(0.0%)		

Note: ** significant at 10% level*

4.5 Determinants of household choice of the main source of cooking energy

Table 4 presents the results of binary logistic regression analysis for the choice of charcoal as the main source in urban areas. The result of the overall model was statistically significant at a 5% level of significance and the independent variables were able to predict the dependent variable (Chi–square = 14.35, and P – value = 0.0259). Furthermore, education level, marital status, and main economic activity were found to be statistically significant determinants for the choice of cooking energy in the households of urban areas at 5% and 10% levels of significance. Age and household size were not statistically significant at all levels of significance.

On the other hand, the age of the head of household has a positive effect on the choice of charcoal as the main source of cooking energy, which means that as the age of the head of household increases leads to the increase in the use of charcoal as the main source of cooking energy in the households, although the effect was not statistically significant at 5% level of significance (OR = 1.0045, β=0.0045, P=0.822). In terms of household size, it also has a positive

effect on the choice of charcoal as the main source of cooking energy, this implies that the greater the household size, the increased the chance of choosing charcoal as the main source of cooking energy in the household. However, this effect is not statistically significant at a 5% level of significance (OR = 1.0421, β=0.0413, P=0.832).

For education level, the findings in Table 4 revealed that the head of household with primary education and below was (OR = 3.0942, β=1.1295, P=0.024) more likely to choose charcoal as the main source of cooking energy in the household compared to the head of household with education above primary level. In terms of coefficients, this shows that as the level of education of the head of household increases will increase the choice of charcoal as the main source of cooking energy in the household and its effect was statistically significant at a 5% level of significance.

Moreover, the household in marriage was (OR = 2.8107, β=1.0334, P=0.032) more likely to choose charcoal as the main source of cooking energy compared to the household not in marriage. This variable was statistically significant at a 5% level of significance. In terms of economic activities, retailer household was (OR = 0.3842, β= -0.9566, P=0.101) less likely to choose charcoal as the main cooking energy compared to food vending household, this category harms the choice of cooking energy however it is not statistically significant at 5% level of significance. Likewise, a household whose economic activity was motorcycle tax business (bodaboda) was (OR = 0.2717, β= -1.3029, P=0.094) less likely to choose charcoal as the main source of cooking energy compared to food vending, but was statistically significant at a 10% level of confidence.

Table 4: Binary logistic regression model for choice of charcoal as the main cooking energy in households

Variable	Response	Estimated coefficients	Odds Ratios	P - Value	95% CI (Lower and Upper)	
Age (in years)		0.0045	1.0045	0.822	-0.0343	0.0432
Household size		0.0413	1.0421	0.832	-0.3388	0.4213
Education level	Up to Primary	1.1295	3.0942	0.024	0.1494	2.1096
	Above primary (reference)					
Marital status	In marriage	1.0334	2.8107	0.032	0.0879	1.9789
	Not in marriage (Reference)					
Main economic activity	Retailer	-0.9566	0.3842	0.101	-2.1006	0.1874
	"Boda boda"	-1.3029	0.2717	0.094	-2.8272	0.2214
	Food vending (Reference)					
Constant		0.8377		0.487	-1.5255	3.2009
Number of observations = 150						
Model fitting information (Chi-square = 14.35, P- Value = 0.0259						

4.6 Discussion of the key findings in the model

The findings revealed that the age of the head of household has a positive effect on the choice of charcoal as the main source of cooking energy although the effect was not statistically significant. Also, household size has a positive effect on the choice of charcoal as the main source of cooking energy, however, this effect is not statistically significant which is in line with the study D'Agostino (2015) who found that household size is unrelated to charcoal expenditure. On the other hand, these results are contrary to Pandel et al (2018) who found that age of the respondent and household size affect the choice of energy and Das et al (2014) revealed that the age of the head of household is the driver of the choice of cleaner energy for cooking in the household. Also, Thadeo (2014) depicted that the age of the respondent of the household has influenced the choice of principal cooking energy. Desalu et al (2014), Adeyemi, and Adelereye (2016) depicted that the age of the household had a significant influence on the choice of cooking energy

The head of household with primary education and below was more likely to choose charcoal as the main source of cooking energy in the household compared to the head of household with education above primary level. Hence, as the level of education of the head of household increases it increases the choice of charcoal as the main source of cooking energy in the household and its effect was statistically significant. The results are supported by Pandael et al (2018), Das et al (2014), Nzobana et al (2021), Thadeo (2014), Disalu et al (2012), Farsi and Filippini (2007), Makonese et al, (2018) and Tumwasi et al (2021) who revealed that the education level has a positive influence on the choice of cooking energy. Furthermore, Safari et al (2022) specified that the education level of the head of the household had a significant influence on the choice of charcoal as the source of cooking energy.

The findings of this study further show that the household in marriage was more likely to choose charcoal as the main source of cooking energy compared to the household not in marriage and this category is statistically significant. The results are in line with the study by Nzabona et al (2021) who revealed that household heads who are married are more likely to use charcoal. Also finding conform to what was found by Thadeo (2014) who found that marital status influenced the choice of principal cooking energy in the household.

Results for economic activities, retailer household was less likely to choose charcoal as the main cooking energy compared to food vending household, this category has a negative effect on the choice of cooking energy however it is not statistically significant. Also, motorcycle tax business (boda boda) household was less likely to choose charcoal as the main source of cooking energy compared to food vending, and it is statistically significant. The results suggest that having income generation activity that increases the level of income of the household, increases the chance of using more clean cooking energy. This was also confirmed in the study by Choumert-Nkolo, Motel, and Roux (2018) in Tanzania.

5. Conclusion and Recommendation

5.1 Conclusion

Comment [h13]: 5.7**. Impact of excessive use of charcoal on the environment** (to be inserted)
►Your results (figure 1) indicates the use of wood (84 %) as the main source of cooking energy is a corollary of deforestation which generates global warming.
► I suggest you deepen the discussion by highlighting the plant species that are more the object of charcoal wood
► Emphasize their conservation (in situ conservation and ex situ conservation) in the context of their sustainable use.

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Comment [h14]: 5.8 Assessment of alternative cooking energy sources (to be inserted)
► Your results (figure 2) indicate as a preferred alternative source of cooking the gas which contains butane (C4H10) which is a greenhouse gas which escapes within the fossil energies which are prohibited within the framework of the measures climate change mitigation. In this perspective, electrical energy as an alternative source of cooking is better indicated.
► In view of this, I suggest that you also deepen this aspect in your discussion.

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The study found that the level of utilization of cooking energy sources among households in the Morogoro Municipality reflects the fuel stacking hypothesis. The majority of households used charcoal as the main source of cooking energy that is 84.0% of the households, followed by 11.3% of the households that used gas, 4.0% of households used firewood, and a smaller number of households used kerosene as the source of energy that is 0.7%. Despite the continued reliance on biomass fuels, alternative sources seem to include cleaner cooking fuels, especially the use of LPG. The findings in binary logistic regression analysis have revealed that education level, marital status, and the main economic activity were the factors that determine the choice of charcoal as the main cooking in the household with statistical significance.

5.2 Recommendation

Tanzania like many other developing countries is far from the prospects for the attainment of SDG 7 by 2030 that is ensuring access to affordable, reliable, sustainable, and modern energy for all. Therefore, the central government, through the Ministry responsible in collaboration with local government authorities, should create awareness in society on the importance of using clean cooking fuels and technologies. The central government through fiscal policy has also to intervene to enhance the choice of cooking energy by regulating the price of modern cooking energy so that it can be affordable to many households. Likewise, it should encourage and engage the private sector to ensure that modern energy especially LPG is available in local areas.

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Comment [h15]: : Make proposals for solutions to the Tanzanian government regarding:
► the protection of plant species that are more the object of wood-charcoal uses
► the promotion of electrical energy as an alternative source of cooking

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