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Evaluating factors influencing firewood consumption in households at the Thulamela Local Municipality, South Africa

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Abstract
A large part of the world's population still depends on firewood for domestic energy needs. If appropriately used, firewood can be considered a renewable energy resource. However, in many rural areas it is burnt in the open and in poorly ventilated kitchens, emitting smoke which is potentially harmful to those exposed to it. Interventions such as wood gasification stoves and electricity seem to have failed. This study evaluated factors influencing firewood consumption in households at the Thulamela local municipality. A household survey collected data from the selected community and it was analysed with Statistical Package for Social Scientists. The chi-square test was used to measure the degree of association between two categorical variables. The study showed a statistically significant association between the source of energy used and gender, education of the household head, employment status, income level, and energy expenditure. The chi-square test determined the association between the variables as the significance level is less than the p-value. The results also indicated that household energy consumption is influenced by level of income, gender, educational level of household head, employment status, number of members employed in a household, and energy expenditure. These factors are linked and mutually dependent. It is recommended that the use of renewable energy and modern energy technologies, such as liquefied petroleum gas, biogas and solar, should be encouraged, with the assistance of the municipality. There is also a need to raise environmental awareness. It is through education that people's perception, attitudes and behaviour towards firewood consumption practices can be changed.

Keywords: *energy poverty, low income, rural households, socio-economic factors*

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1. Introduction

Firewood consumption is an ongoing poverty-related challenge for rural areas, because most people there are still heavily reliant on it for cooking and water heating, while using electricity exclusively for lighting (Uhunamure *et* al., 2017; Mijitaba, 2013). Although electricity is regarded as efficient, clean, modern and globally favoured in comparison with alternative energy sources, firewood ranks high in terms of usage and preferences, particularly by low-income and non-electrified households (Makonese *et* al., 2017; Uhunamure *et* al., 2017).

In 2016, the World Health Organization (WHO) estimated that 2.9 billion people worldwide still depend on solid fuels – including firewood, charcoal, coal, animal dung and agricultural residues – as their main source of energy for cooking and water-heating. Current trends of solid fuel consumption are anticipated to increase unchanged, with roughly 2.3 billion people within the next decades remaining dependent on firewood for these purposes (Scheid *et* al., 2018). WHO (2016) indicated that 95% of the people who are still dependent on solid fuels are found in sub-Saharan Africa. In light of this, Semenya & Machete (2019), revealed that the use and predominance of firewood for meeting domestic needs is associated with lack of clean or modern energy such as electricity. This is supported by Masekameni *et* al. (2017), who emphasised that over three billion people lack access to electricity, which increases reliance on solid fuels. This study also indicates that in much of the Southern African Development Community (SADC) access to electricity remains a developmental challenge, with fewer countries above 66% electrification, as indicated in Table 1. The table showes that Mauritius successfully reached 100% electrification, followed by South Africa at 85%, and Botswana at 66%, whereas Malawi had the lowest electrification rate.

Worth noting is that electrification alone is not enough to address the high reliance on solid fuel energy source, as studies show that people continue to rely on biomass despite being electrified (Ismail & Khembo, 2015; Masekameni *et* al., 2017; Semenya & Machete, 2019). This is supported by literature by Ismail and Khembo (2015), Lourens (2018), Masekameni *et* al. (2017), Mbonane *et* al. (2018), Mgwambani *et* al. (2018) and Makonese *et* al. (2012), which indicated that South Africa boast high rates of electrification and progress in promotion of modern energy accessibility and usage within the residential sector for domestic purposes. Yet, South Africa remains an example of a country that is still grappling to economically provide its citizens with opportunities to completely remove themselves from the strong grip of energy poverty because, even in electrified households, over 75% of rural households remain dependent on solid fuels, particularly firewood, to meet domestic needs (Israel-Ankimbo *et* al., 2018; Masekameni *et* al., 2017). On average, firewood dependency for cooking and water-heating in rural households in South Africa varies from 75% to 100% (Nott & Thondhlana, 2017). The majority of underprivileged households use firewood to meet such tasks, while electricity is used exclusively used for lighting (Semenya and Machete, 2018; Uhunamure *et* al., 2017).

Table 1: Electrification rates of SADC countries (Masekameni *et al.*, 2017).

	Population without electricity (millions)	*National electrification rate (%)*	*Urban electrification rate (%)*	*Rural electrification rate (%)*
SADC	634	32	59	17
Angola	15	30	46	18
Botswana	1	66	75	54
Kenya	35	20	60	7
Lesotho	2	17	43	8
Malawi	15	9	32	4
Mauritius	0	100	100	100
Mozambique	16	39	66	27
Namibia	2	32	50	17
South Africa	8	85	90	77
Swaziland	1	27	40	24
Zambia	11	26	45	14
Zimbabwe	9	40	80	21

Firewood utilisation grants a much-needed help from the precursor of energy poverty, as it is centered around affordability and accessibility (Kasangana *et al.*, 2018). It is readily available, cost-effective and renewable (Uhunamure *et al.*, 2017; Kimemia, 2014; IEA, 2014). Nevertheless, the use of firewood is associated with negative impacts on both the environment and human lives. Unsustainable harvesting of firewood can lead to significant imbalances of natural resources, as it deprives the ecosystem of nutrients that are necessary for fertility and growth (Feyisa *et al.,* 2017). These imbalances of the ecosystem constitute a substantial risk to the environment as they contributes to the diminishing and degradation of the existing forest, communal savanna woodlands, and promote soil erosion, habitat fragmentation and climate change (She, 2014; Akther, 2010). Furthermore, prolonged firewood use has detrimental social implications for many households, with most of them having pernicious residual long-term consequences. Amongst them is the emission of pollutants released into the air when firewood is burned in poorly ventilated areas (Semenya & Machete, 2020; Mgwambani *et al.*, 2018). The emitted toxic gases are harmful to human beings, especially vulnerable women and children who inhales these toxic gases (Semenya & Machete, 2019; Makonese *et al.,* 2016). Household air pollution is associated with several diseases such as chronic respiratory disorder, cancer, tuberculosis, perinatal mortality, low birth weights, eye irritation and cataract, pulmonary and systemic diseases (Mgwambani *et al.,* 2018; Makonese *et al.,* 2016). Annually, respiratory diseases which are both chronic and acute are reported, with 4.3 million deaths globally being linked to poor combustion of solid fuels (Kasangana *et al.*, 2017; Masekameni *et al.*, 2017).

It is important to note that, regardless of the above-mentioned risks, associated with firewood consumption, firewood remains the main survival commodity, as majority of households cannot afford modern energy technologies (Mgwambani *et al.,* 2018; Lourens, 2018; Makonese *et al.,* 2012). Kimemia (2014) noted that 50% of South Africans are deemed 'energy poor' because they spend more than 10% of their income on energy resources to sustain themselves. These households have limited options for switching to modern energy and this has led to many poor households adopting multiple fuel use for their domestic needs (Uhunamure *et al.,* 2017).

The extent in which people utilises and consumes firewood as an energy source is influenced by several factors. A literature review indicates that poverty and socio-economic determinants, which include but are not limited to gender, employment status, academic level of household head, household size, marital status and age, are amongst other factors that motivate household fuel use (Semenya & Machete, 2019; Ateba *et al*., 2018; Mbonane *et al.*, 2018; Uhunamure *et al*., 2017).

The literature further indicates that the aforementioned factors are still much debated, as there appears to be inconsistency in the findings and conclusions of different researchers. For example, the influence of socio-economic factors as the main determinant of firewood consumption and fuel substitution is still debated. A study conducted by Semenya and Machete (2019) in Senwabarwana villages, South Africa, indicated that socio-economic factors play a significant role in the factors that influence firewood usage, and several other studies, such as Ismail and Khembo (2015), Knight and Rosa (2011), Ogwuche and Asobo (2013), Danlami (2019), and Muller and Yan (2018) support this. However, the study conducted by Song *et al.* (2012) indicated that socio-economic factors have a negative relationship with the factors that influence firewood consumption. Studies by Semenya and Machete (2019), Ateba *et al.* (2018), and Uhunamure *et al.* (2017) established that income has a positive relationship with household firewood use, whereas studies by Nnaji and Uzoma (2012), Song *et al.* (2012), Jingchao and Kotani (2011), and Masera *et al.* (2000), concluded that there is a negative relationship between income and household firewood consumption. Such divergences indicate that findings and conclusions of a particular study in a certain area should not be used to generalise for another area, due to the differences in socio-economic and household dynamics of fuel consumption.

This study set out to evaluate the factors that influence firewood consumption in households in Khubvi village in the Thulamela local municipality in Limpopo. South Africa, and to enhance knowledge about the driving factors that promote firewood consumption. It is equally important to consider the role of firewood in rural livelihoods, the extent of firewood use in comparison with electricity use and the availability of other energy resources. There is a need for intervention by the government, and policy makers to make informed decisions and strive to improve on energy alternatives that are accessible and affordable by everyone. In these ways, the research intends to contribute to the current academic knowledge that is associated with firewood consumption.

Research questions that were raised in the study are as follows:

- What is the extent of firewood use in comparison with electricity use in Khubvi?

- What is the socio-economic profile of households in Khubvi village?
- What other energy resources are available in Khubvi village?

2. Materials and method

2.1 Study area

The Thulamela local municipality, which is the focus of this study, is a Category B municipality that is situated in the eastern part of the Vhembe District and stretches to the northern region of Limpopo province, in South Africa. It lies approximately between longitudes 22° 57' S and latitudes 30° 29' E (Thulamela Municipality IDP, 2018). In terms of population,it is the second largest of all the municipalities in Limpopo, with a population of 497 237 and 130 320 households (StatsSA, 2018; Thulamela Municipality IDP, 2018). The total land coverage is 2 893.936 km^2 (Vhembe District Municipality 2019 IDP Review). The research was conducted in Khubvi village, which forms part of the municipality. Khubvi has a population of 10 271, and 2 519 households, with an area coverage of 11.50 km^2; its GPS coordinates are 22.8302 S, 30.56' 13"E (StatsSA, 2018). This area was selected because households depend highly on firewood for cooking and water-heating.

2.2 Research design and sampling

This study used the probability sampling method. In probability sampling, a representative sample is chosen from the overall population by random selection (Leedy & Ormrod, 2015). This ensures that every member of a population is given a chance to be selected. A probabilistic sampling technique called systematic sampling was used, whereby individuals are assigned according to a sequence such as an interval, e.g., each fourth or fifth case (de Vos *et al.,* 2005). In this study, the household was systematically sampled in numerical order of one in every fifth household until the enumerator's allocation was complete, that is, 50% of the total households.

The sample population was obtained as follows:

$$n = \frac{N}{1+Ne^2}$$

where n = sample size, N = population size, e = level of precision.

At 95% level of precision p = 0.05; thus

$$n = \frac{2519}{1+2519\,(0.05)^2}$$

$$= \frac{2519}{1+6{,}2975}$$

$$= 345\ households$$

Since households were systematically sampled in the interval of every fifth household, then:

$$\frac{345}{100} \times 50$$

$$= 173\ households$$

That is, a systematic sample of every fifth of the 345 households gives 173, and questionnaires were distributed to the household heads.

The survey was conducted in March 2020 to gather information on household energy use. The study utilised mixed research methods, comprising quantitative and qualitative methods adopted from a cross-sectional approach. A semi-structured questionnaire consisting of both closed and open-ended questions was used to collect data. The questions were based on demographics, the type of energy used by household for cooking, lighting and water-heating, and factors that influence energy use.

Six preliminary pilot questionnaires were given to the residents to test the methodology and if there was a need to modified the questionnaires. The piloting process also helped to check if the questions asked were too long for the respondents to answer. After the piloting process, some sections of the questionnaires were changed. The research used the same questionnaire in selected households throughout the whole process of data collection, which resulted in similar trends during data analysis. This ensured reliability. The collected data was analysed with Statistical Package for Social Scientists version 25. For cross-tabulation, the chi-square (χ^2) test was used to measure the degree of association between two categorical variables. If the p-value is less than 0.05, there is a significant association between variables – thus, the variables are dependent each other.

3. Results and discussion

3.1 Socio-economic dynamics of the sample of population

3.1.1 Age of the household head

Findings shown in Figure 1 indicated that most households are headed by people who are between 50–59 years (29.5%) followed by 40–49 years (28.9%), then by over 60 years and 30–39 years with both comprising 16.2%. The least age group is that of 20-29 years, which comprises of 9.2% who prefer the use of firewood for meeting domestic needs. It was established that as the household head ages, especially the older members of the family; they prefer to use traditional biomass such as firewood. Which according to them gives better taste to food than food that has been cooked by electricity or other energy alternatives.

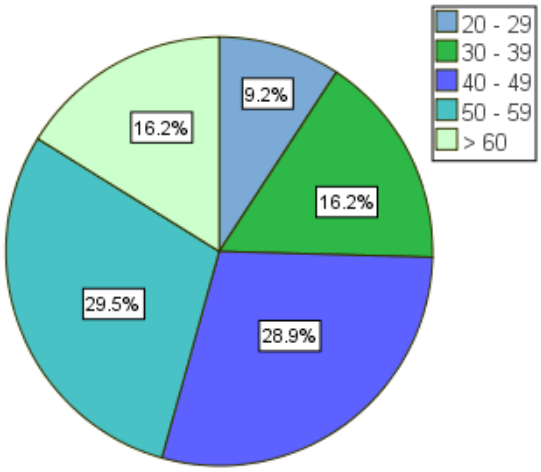

Figure 1: Age of the household head.

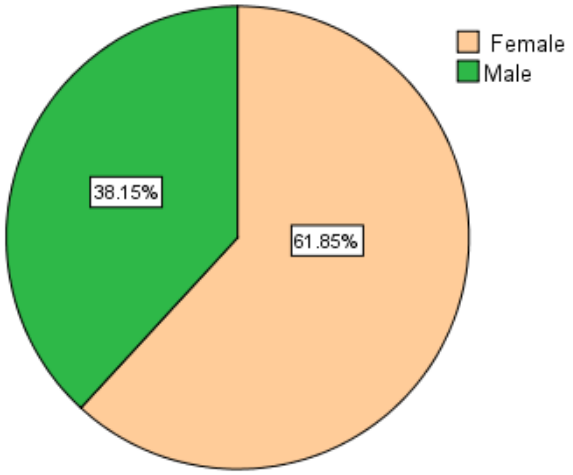

Figure 2: Gender of the household head.

3.1.2 Gender

Figure 2 shows that most people who were interviewed were females (62.9%). These results might be because females are entrusted with cooking responsibilities more than their male counterparts. The high rate of female respondents was found to be consistent with the study done by Semenya and Machete (2019), which indicated that majority of women are responsible for cooking, selecting and sourcing firewood for meeting domestic needs. This understanding was supported in a study done by Ateba *et al.* (2018), which revealed that society perceives women as people who should be accountable for cooking, harvesting firewood and performing various domestic chores around the house. Hence, these women in some case are liable for the decision-making process of energy choices within the household.

3.1.3 Marital status

Figure 3 indicates that the majority (52.0%) of participants were single, followed by married (39.3%), then widowed (8.1%), with the least number of people indicating that they were divorced (0.6%). Khubvi is thus dominated by single-headed households.

3.1.4 Educational level of household head

Figure 4 shows that the level of education within the village is adequate. Most respondents had matric (28.3%), followed by some secondary education (23.7%), then tertiary education (22.5%), then some tertiary education (9.2%). The study sought to understand if education plays a role in household energy use. Education is an important factor which influences firewood consumption, as the level of literacy of the household head affects how a house-

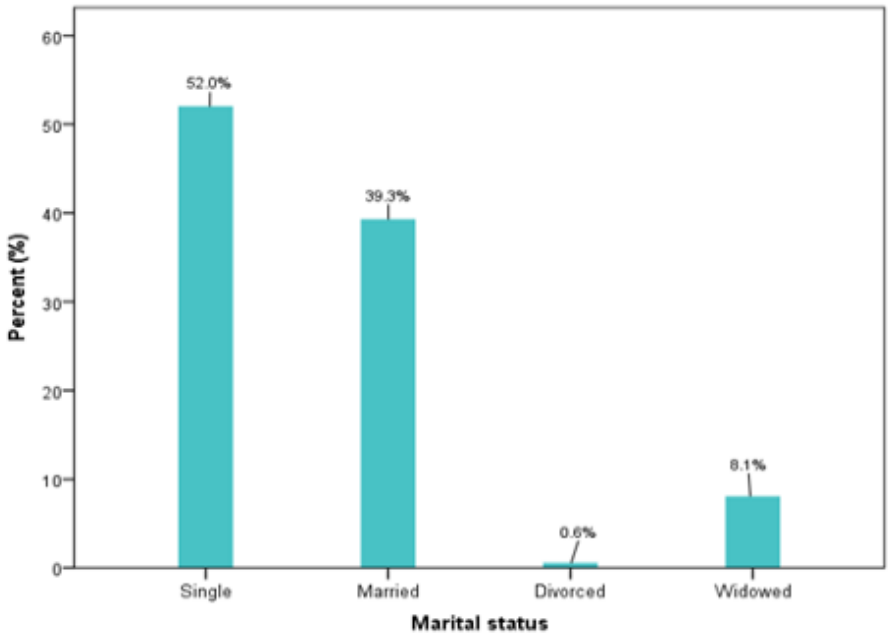

Figure 3: Marital status of household head.

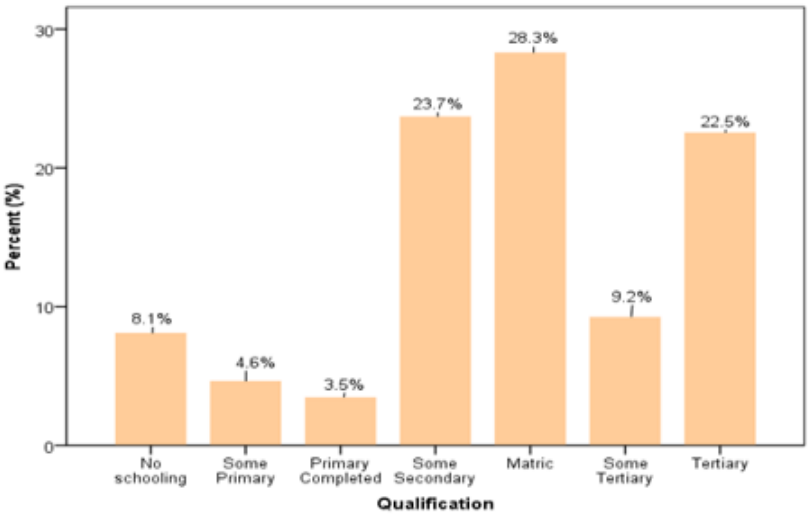

Figure 4: Education level of the household head.

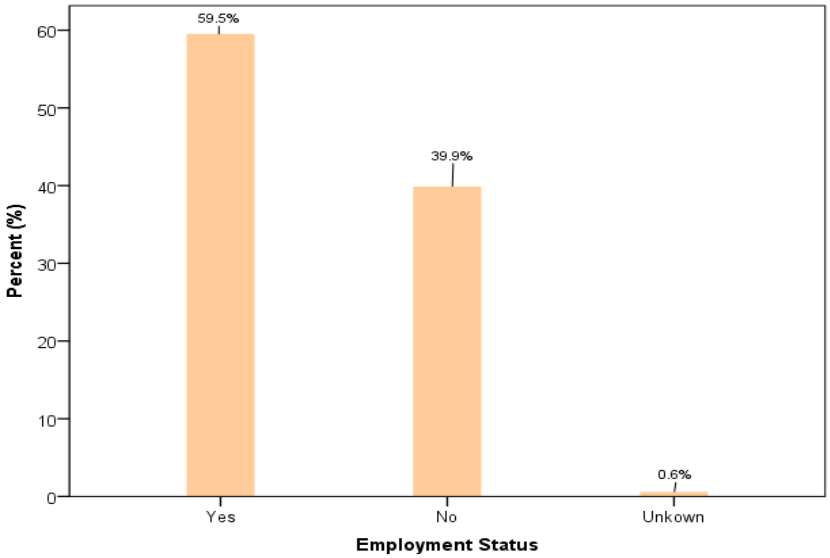

Figure 5: Employment status of the household head.

hold is informed. While it does not require a person to be educated to realise that extensive firewood consumption results in environmental degradation and promote soil erosion, findings revealed that most people who use firewood for domestic needs could read and write.

Participants have different perceptions and attitudes regarding the kind of fuel to be used by the household. Most educated participants indicated that they favoured the use of modern energy technologies and preferred to conserve and protect the natural resources for future generations. However, due to the limited employment opportunities, they are forced to use firewood. The study found that educated and employed people also still use firewood, to save money for other priorities such as education and health. Most people who use firewood for domestic purposes are fully aware of the consequences that can occur from the continual use of firewood such as accidental fires, indoor air pollution and environmental degradation from excessive clearance of firewood. It is evident that the educational background of a household head and limitation of financial incentives strongly impact on the choice of fuel to be used for domestic purposes. It can be argued that a combination of educational backgrounds and a decent income could mitigate excessive firewood harvesting.

3.1.5 Employment status

The study sought to evaluate whether employment status has an impact on the factors that influence firewood consumption. Figure 5 depicts the overall employment status of the participants. About 70% of the participants were employed. However, most of these participants were employed in primary and secondary sectors that hardly pay them enough money to sustain themselves (Figure 7). Results also indicate that most households only have one family member working (Figure 6). Participants who have

no formal employment further indicated that they rely on single or multiple grants to support themselves, whilst others rely on family members who do not stay with them for financial support. In order to meet all the energy needs of a home, most households have opted to incorporate firewood in the domestic energy mix. Firewood is the main energy source used by majority of households.

3.1.6 Number of employed members

Figure 6 shows that in most households only one member (38.7%) of the family is employed. Followed by those who are not working (31.8%), then households with two members working (21.4%) and finally followed by households with three members and more than three members, having 5.2% and 2.3% respectively. The least number of participants (0.6%) claim that they could not specify whether they are employed or not because they do odd jobs whenever they get a chance.

3.1.7 Income levels

To evaluate if income plays a role in the factors that influence firewood consumption, participants were asked personal income questions. As shown in Figure 7, 19.7% of the participants earned less than R1000; 28.9% earned between R1001 and R3000; and 9.8% earned between R3001 and R6000. The study also found that 9.2% of the participants earned between R6001 and R10 000; 7.5% earned between R10 001 and R12 000; 6.4% earned between R12 001 and R15 000; 12.1% earned between R15 001 and R20 000 and lastly, 6.4% of the participants earned above R20 000 per month.

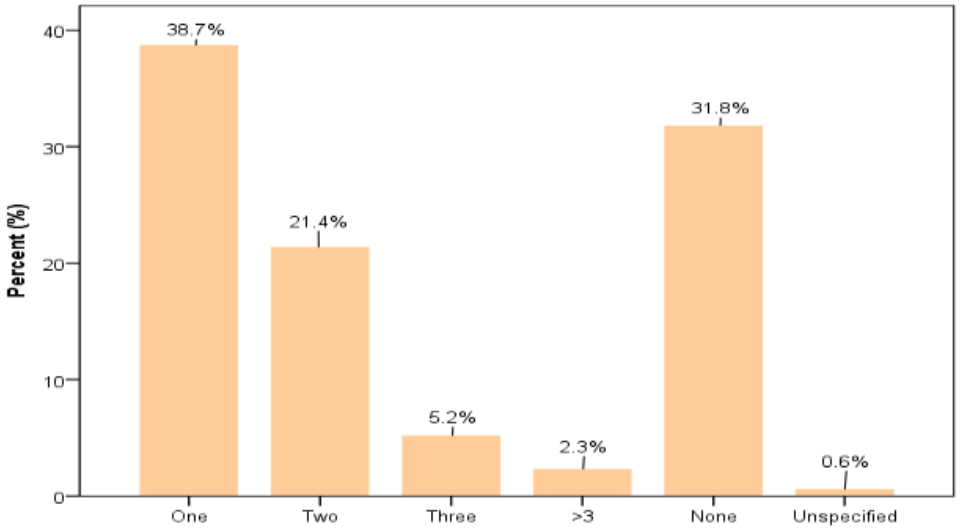

Figure 6: Number of employed members in households

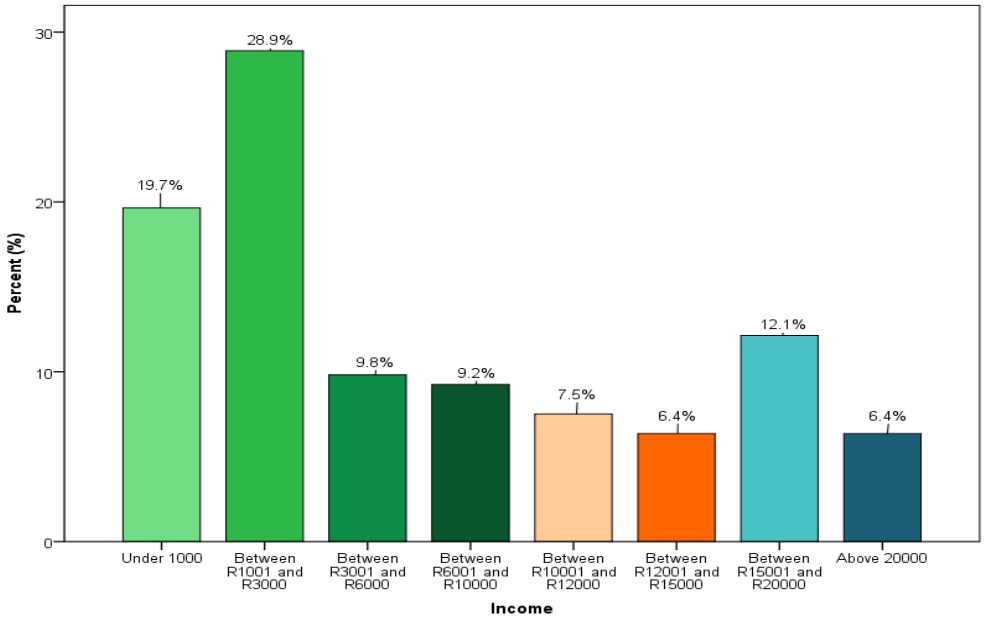

Figure 7: Income levels of the sampled population

Most of the people who earned less than R3000 per month include government grant holders and pensioners who have limited options to use other energy alternatives to meet their domestic needs. The findings of the current study are consistent with the findings from the literature review. For instance, a study by Uhunamure *et al*. (2017) revealed that firewood is generally consumed by low-income households as they have limited options and resources to switch to modern technologies fully. These limited options hinder the progress of a household from practicing sustainable measures which could save them from the looming firewood crisis. Firewood is cheap, easily accessible and can be used to generate income by selling firewood bundles to other households at a specific price.

3.2 Characterising the community energy matrix

The following sub-sections discuss the findings related to the energy mix of households in Khubvi.

3.2.1 Source of energy and frequency of use for cooking and water heating

The majority of the participants used firewood (53.9%), followed by electricity (37.2%) and LPG (3.5%) as a source of energy for meeting daily domestic needs for cooking and water heating (see Figure 8). From the results it is evident that firewood is the most preferred energy source for meeting domiciliary needs, despite the impacts it has on the environment and human life.

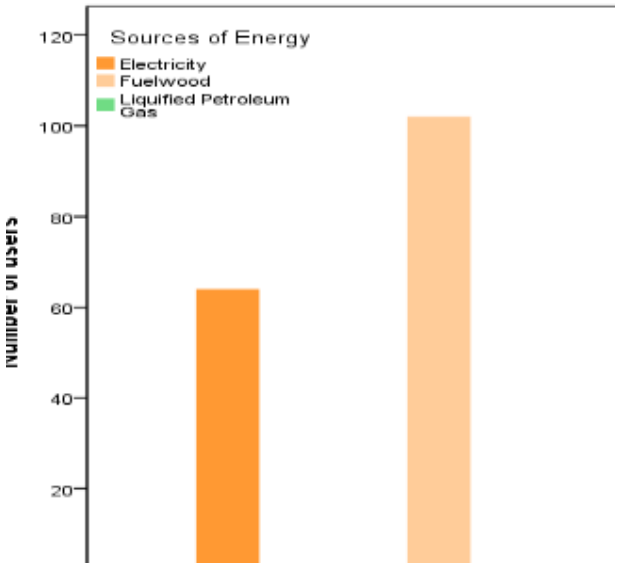

Figure 8: Source of energy and frequency of use for cooking and water-heating.

Firewood is considered an easily accessible source of energy which is always available for cooking and water heating. Figure 8 shows the frequency of energy source that is used daily for cooking and water-heating. Participants indicated that they use different types of fuel for cooking different types of food. For example, firewood and LPG were used for cooking food that takes times to prepare, whereas electricity was usually used for cooking simple foods that do not require much energy to prepare, such as cooking eggs or making tea. Additionally, participants indicated that they are struggling to switch completely to modern energy sources due to financial constraints, which is why they use electricity mainly for lighting but firewood for cooking and heating. This results in excessive harvesting of firewood and an increase in detrimental impacts such as deforestation, loss of biodiversity, soil erosion, and exposure to health and safety risks.

3.2.2 Source of energy for lighting

As indicated in Figure 9, the majority (98.3%) of the participants used electricity for lighting, and candles were seldomly used (1.7%). Candles are used mostly used by unelectrified low-income households with limited access to modern and efficient energy technologies.

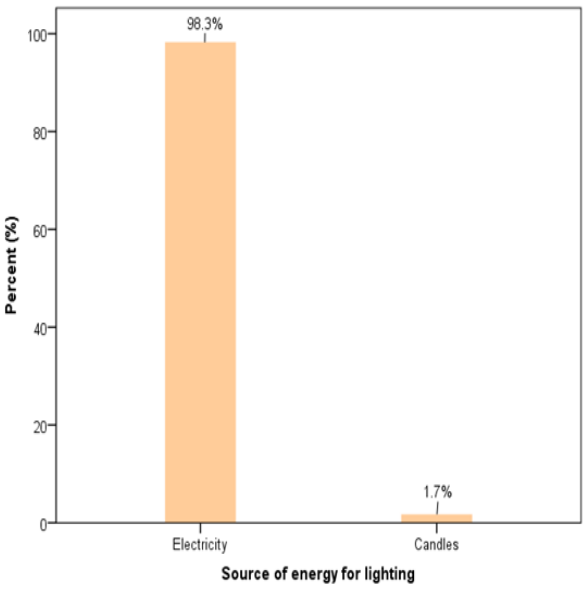

Figure 9: Source of energy for lighting.

In electrified families, candles are mainly used in extreme cases where there is load-shedding or power cuts that last for more than one day or in cases where a household is struggling to purchase electricity to limited due financial resources. One reason why candles are seldom preferred is the high number of past cases of accidental fires, which often led to burned-down houses or death of family members or death or injury to a neighbour trying to rescue family members.

3.2.3 Access to electricity

Figure 10 indicates that most members (97.7%) of the community have access to electricity. About 0.6% of participants indicated that electricity accessibility in their area is mostly unreliable due to technical problems that are related to electricity supply resulting from load-shedding, severe weather or technical issues related to their meter boxes or unaffordability of electricity. The identified reason for non-availability of electricity among households includes households not connected to the electricity grid at all (particularly in new stands).

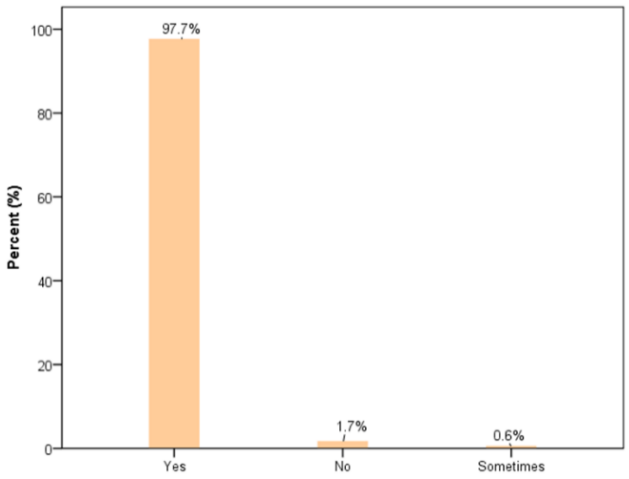

Figure 10: Access to electricity.

3.2.4 Reasons for using firewood

Figure 11 indicates that the main reason why the majority (52.5%) of households use firewood is that it is always available. Others (38.4%) indicated that firewood is cheap and affordable, which means that almost everyone can afford to use it to meet domestic needs. Although there were participants who stated that they favoured the use of firewood due to convenience (3.0%), economic value (3.0%), easy to use (2.0%), and taste (1.0%), they were in the minority.

Firewood is either bought in bundles from the firewood market (a truck is hired to deliver a load) or self-harvested. The findings of this study are consistent with the conclusions of the literature. For instance, a study by Variawa (2012) revealed that the availability of natural resources such as firewood is seen as the stronghold for the poor, as they provide a safety net against the erratic nature of poor modern energy provision as well as against energy inequalities. Firewood is cheap and always available, which reduces household energy expenditure especially among large families with limited financial resources. The reduction in energy expenditure can also favour low-income households, as they can invest the limited financial resources on other necessary revenues that can provide long-term gains such as education and health. One main strength of firewood is that it cooks faster and preserve the taste of food being cooked.

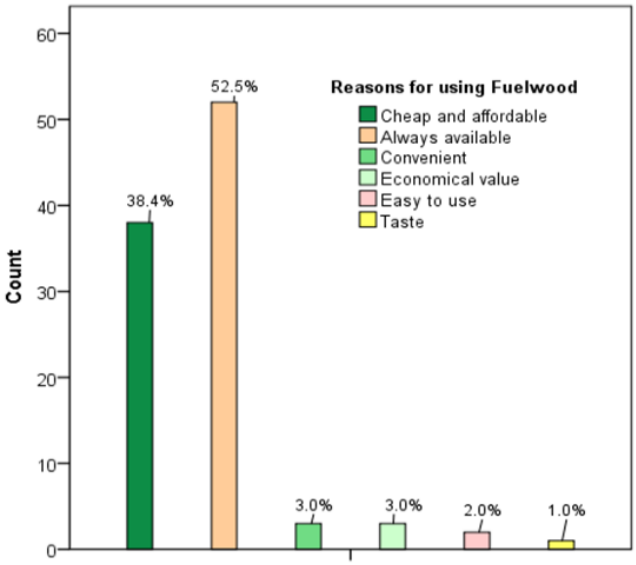

Figure 11: Reasons for using firewood.

3.2.5 Frequency of firewood use

Figure 12 shows that a majority (99.0%) of participants use firewood daily, whereas (1.0%) prefer fuel-stacking using various energy alter-natives. This is mainly attributed to the availability and accessibility of firewood.

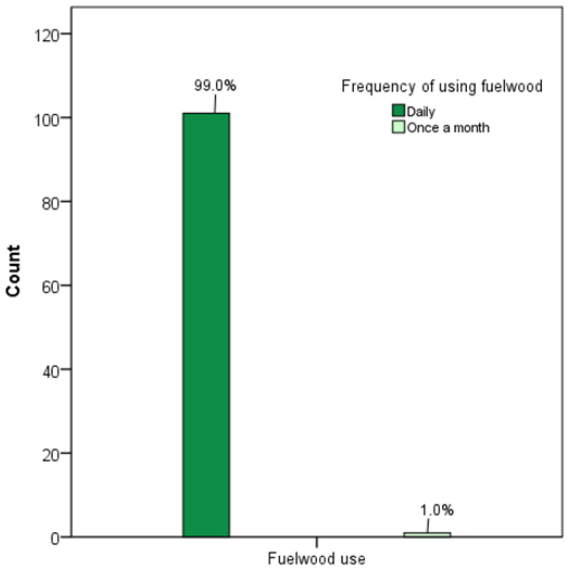

Figure 12: Frequency of firewood use

Extensive firewood consumption can lead to overexploitation of natural resources. Moreover, since firewood is consumed daily, livelihoods of local people are often adversely affected by firewood scarcity. The scarcity of firewood promotes the use of dirty and inefficient materials such as agricultural residues. It also results in households being deprived of quality time with their loved ones

as they must endure long walks. In some cases, households must spend two to three hours in search of firewood. The search of firewood in the mountains can have devastating consequences, as household members maybe be kidnapped, or injured or killed by wild animals. Additionally, the prolonged use of firewood has resulted in participants indicating that they often gasp for air due to indoor air pollution, which is associated with respiratory infections. The issue of indoor air pollution has inspired investment in energy-efficient cooking devices, such as for LPG, electricity and paraffin stoves.

3.3 Factors influencing the community energy matrix through analysis

The following sub-sections discuss the findings related to the energy mix through the analysis of households in Khubvi.

3.3.1 Age and source of energy

A chi-square test was done between age group and source of energy to determine if any relationship exists between the variables (Table 2). The test found that there is no statistically significant association between age and source of energy used (χ^2= 14.21, p = 0.076) – this is because the p-values is greater than the significance level p > 0.05.

Table 2: Relationship between age group and source of energy.

Age	*Source of energy for heating and cooking*			*p-value*
	Firewood	*Electricity*	*LPG*	
20-29	6	10	0	0.76
30-39	13	13	2	
40-49	26	21	2	
50-59	37	12	2	
>60	20	8	0	

Note: 8 cells (33%) have expected count of less than 5. The minimum expected count is .56

This implies that age does not influence the source of energy used by households. The findings contradict studies by Onyeneke *et al.* (2015) and Gatama (2014), who found that age has a positive relationship to firewood consumption. Gatama asserted that in the Ethiopian cities consumption and demand for wood increases with age. The author further explains that older people are resistant to change and prefer the use of traditional biomass as the source of energy for meeting domiciliary needs. The contradiction of results is attributed to the fact that information varies from place to place.

3.3.2 Gender and source of energy

A chi-square test was done between gender and source of energy to determine if any relationship exist between the variables (Table 3). The study revealed that there is a statistically significant association between gender and source of energy used (χ^2= 7.52, p = 0.023). This refers to the p < 0.05, the Chi-square test had determined the association between the variables as the significance level is less than the p-value, therefore gender can explain the source of energy used.

Table 3: Relationship between gender and source of energy.

Gender	*Source of energy for heating and cooking*			*p-value*
	Firewood	*Electricity*	*LPG*	
Female	71	33	2	0.023
Male	31	31	4	

Note: 2 cells (33.3%) have expected count less than 5. The minimum expected count is 2.30.

The test implies that gender plays a significant role in household energy use. Women play a huge role in acquiring household energy for domestic purposes; they are responsible for firewood harvesting, collection and transportation. The findings of the current study are consistent with the results of Danlami (2019); Semenya and Machete (2019); Ateba *et al.* (2018), and Ogwuche and Asobo (2013), which revealed that gender plays a significant role in the factors that influence firewood usage, because society perceives women as people who should be accountable for cooking, harvesting firewood and performing various domestic chores around the house. Equally important is that women and men make different decisions regarding the choice of household fuel, as stated in literature by Ogwuche and Asobo (2013). Most households are headed by men who are in charge of overseeing cash flow and are also the primary decision-makers. This compels women to use traditional biomass as they are hardly in control of financial expenditures such as purchasing energy resources (Semenya & Machete, 2019; Ismail & Khembo, 2015). Annecke (2002) cited by Ismail and Khembo (2015) argued that women who have limited control of financial resources are more prone to remain absolutely energy-poor. In support of this, Ismail & Khembo (2015) indicated that a home that is headed by a male who is a primary provider and decision-maker might differ distinctively from a household that is led by females. A household that is headed by women might favour the use of modern energy because of the constraints that are associated with firewood consumption, which often take hours to collect and

in most cases women and girls have to transport firewood with headloads. This often leads to back pain and injury. Other reason for women to favour modern energy use might include fears of accidents that can occur while collecting firewood, reduce women's work and time burden and also to improve their family lives (WLPGA, 2014). Whereas a male household head might not disregard the use of firewood because he is not in direct contact with the smoke, unlike women (Danlami 2019). As such, the role of gender in household energy use should be taken into consideration by policy makers. It can be concluded that there is a positive relationship between gender and source of energy.

3.3.3 Marital status and source of energy

The study sought to determine if marital status influence household energy use. The possibility of association between marital status and source of energy variables was determined using the chi-square test (Table 4). There is no statistically significant association between marital status and source of energy used ($\chi^2 = 7.04$, $p = 0.317$), as the p-value is more than the significance level $p > 0.05$.

Table 4: Relationship between marital status and source of energy.

Status	*Energy source preferred for cooking*			*p-value*
	Firewood	*Electricity*	*LPG*	
Single	54	32	3	0.317
Married	36	29	3	
Divorced	0	1	0	
Widowed	12	2	0	

Note: 6 cells (50.0%) have expected count less than 5. The minimum expected count is .03.

The test implies that households that are headed by a married couple are less likely to consume firewood. The non-existent relationship between marital status and source of energy can be attributed to the fact that a married couple could combine their incomes and share expenditure. Families with one breadwinner are likely to endure more socio-economic challenges than families where two or more people are working because their combined salary can make a huge difference in sustaining the home. Hence, the marital status has a negative effect on the preferences or probability to use firewood. The findings are consistent with the findings by Ismail & Khembo (2015), who established that there is a negative impact of marital status on firewood consumption due to the fact that married couple are likely to be less energy poor due to their combined income and shared expenses. Yet these findings contradict the findings of a study that was done by Onyeneke *et al*. (2015), who revealed that marital status has a positive relationship to firewood consumption because of tendencies associated with household size.

3.3.4 Education of the household head and source of energy

A chi-square test was done between education level of household head and source of energy to determine if any relationship exist between the variables (Table 5).

Table 5: Relationship between education level of household head and source of energy.

Education level	*Energy source preferred for cooking*			*p-value*
	Firewood	*Electricity*	*LPG*	
No schooling	12	3	0	0.000
Some primary	5	2	1	
Primary completed	6	1	0	
Some secondary	36	7	1	
Matric	31	12	2	
Some tertiary	3	10	1	
Tertiary	9	29	1	

Note: 11 cells (52.4%) have expected count less than 5. The minimum expected count is .24.

The study found that there is a statistically significant association between the level of education of household head and source of energy used ($\chi^2 = 50.045$, $p = 0.000$). The $p < 0.05$, the Chi-square test has determined the association between the variables as the significance level is less than the p-value, therefore the level of education of the head of the household can help explain the source of energy used. The test implies that the level of education of the head of the household influences the decision to move to cleaner energy technologies. When the head of the household is educated, they tend to be more open-minded about the sustainable ways in which firewood can be harvested. It is through education that people's perceptions, attitudes and behaviour towards firewood consumption practices can be changed. It can be concluded that there is a positive relationship between the level of education and source of energy. The study supports the outcomes of previous research by Semenya and Machete (2019), Uhunamure et al.

(2017), and Ogwuche and Asobo (2013), which revealed that education influences fuel use. The authors argued that people who have elevated educational attainment are more likely to embrace the use of cleaner energy forms which enhance the conservation of natural resources.

3.3.5 Employment status and source of energy

A chi-square test was done between employment status and source of energy to determine if any relationship exist between the variables (Table 6).

Table 6: Relationship between employment status and source of energy.

Status	*Energy source preferred for cooking*			*p-value*
	Firewood	*Electricity*	*LPG*	
Employed	47	55	4	0.000
Unemployed	55	11	2	
Unknown	1	0	0	

Note: 11 cells (52.4%) have expected count less than 5. The minimum expected count is .24.

The study showed a statistically significant association between employment status and source of energy used (χ^2= 23.34, p = 0.000). The p < 0.05, the chi-square test has determined the association between the variables as the significance level is less than the p-value, therefore employment status can help explain the source of energy used. The test implies that when unemployed members dominate a household they are faced with a great burden, resulting from household spending and income burden which result in their minimum income being far less than their needs. They are deemed both energy- and resource-poor, as they live below the poverty line. It can be concluded that there is a positive relationship between employment status and source of energy used. Employment status and firewood consumption are inextricably linked. This result concurs with the findings of the studies by Uhunamure et al. (2017) and Matsika et al. (2012), which stated that high unemployment rate influence firewood consumption.

3.3.6 Number of employed members in a household and source of energy

The possibility of association between number of employed household members and source of energy variables was determined using the chi-square test (Table 7). It was shown that there is a statistically significant association between the number of employed household members and the source of energy used (χ2= 43.663, p = 0.000). The p < 0.05, the chi-square test has determined the association between the variables as the significant level is less than the p-value, therefore the number of employed household members can help explain the source of energy used. The test implies that when there are less employed members in a household, the more household members rely on firewood consumption. Usually, when people use traditional biomass, it is due to limited financial resources. Thus, if a household can afford modern energy such as electricity, they tend to use it. It can be concluded that there is a positive relationship between the number of employed household members and sources of energy.

Table 7: Relationship between number of employed members in household and source of energy.

No. of employed members	*Energy source preferred for cooking*			*p-value*
	Firewood	*Electricity*	*LPG*	
1	38	25	4	0.000
2	14	22	1	
3	2	7	0	
More than 3	0	4	0	
None	48	5	1	
Unspecified	0	1	0	

Note: 11 cells (61.1%) have expected count less than 5. The minimum expected count is .03.

3.3.7 Income level and source of energy

A Chi-square test was done between income level and source of energy to determine if any relationship exist between the variables (Table 8). The study found that there is a statistically significant association between income level and source of energy used (χ^2= 58.999, p = 0.000). The p < 0.05, the chi-square test has determined the association between the variables as the significance level is less than the p-value, therefore income level can explain the source of energy used. The test implies that the income level of a household influences energy use. People who earn more money tend to drift away from traditional biomass, and they tend to incorporate modern energy in their domestic energy mix. Higher-income households are associated with the use of LPG and electricity for cooking and water-heating as an alternative energy source, while low-income households tend to rely on firewood and other low-cost energy sources. It can be concluded that there is a positive relationship between income level and source of energy. These finding are consistent with those of Semenya and Machete (2019) and Ogwuche & Asobo (2013), which revealed that as household income increases, households tend to shift to more appropriate fuels.

Similarly, the study done by Uhunamure *et al.* (2017) found that household income is an indication of status welfare as well as the economic development of a household.

Table 8: The relationship between income level and source of energy.

Monthly income	*Energy source preferred for cooking*			*p-value*
	Firewood	*Electricity*	*LPG*	
Under R1 000	26	6	1	0.000
R1 001–R3 000	41	8	1	
R3 001–R6 000	13	3	1	
R6 001–R10 000	4	9	3	
R10 001–R12 000	5	8	0	
R12 001–R15 000	3	8	0	
R15 001–R20 000	8	13	0	
Above R20 000	2	9	0	

Note: 11 cells (45.8%) have expected count less than 5. The minimum expected count is .38.

3.3.8 Energy expenditure and source of energy

A chi-square test was done between energy expenditure and source of energy to determine if any relationship exist between the variables (Table 9).

Table 9: The relationship between energy expenditure and source of energy

Expenditure	*Energy source preferred for cooking*			*p-value*
	Firewood	*Electricity*	*LPG*	
Under R500	92	45	5	0.017
R501–R1000	10	17	1	
R1001–R1500	0	2	0	

Note: 5 cells (55.6%) have expected count less than 5. The minimum expected count is .07.

There is a statistically significant association between energy expenditure and source of energy used ($\chi^2 = 12.044$, $p = 0.017$). The $p < 0.05$, the chi-square test has determined the association between the variables as the significance level is less than the p-value. Therefore, energy expenditure has a positive influence on the source of energy used. The test implies that as the price of energy expenditure influences the choice of energy within a house due to some energy sources being more expensive than others. Firewood is easily accessible, available in abundance, cost-effective, which means that almost everyone can afford to use it. Electricity requires more money for initial investment, acquisition and maintenance of electrical cooking appliances. As such the high expenditure that is associated with electricity influences low-income households to depend on firewood. It can therefore be concluded that there is a positive relationship between energy expenditure and source of energy. The findings are consistent with the findings of Ateba *et al*. (2018), who revealed that the amount of income that is dedicated for electrical use is more within high-income households that low-income ones. Further, they indicated that the cost of modern fuels, together with their transaction cost, are mainly high, and low-income households cannot afford payments associated with modern regular spending as well as the initial investment and maintenance of these cooking appliances.

4. 4. Conclusion

The study indicated that the use of firewood as a primary source is influenced by socio-economic factors such as gender, education level of the household head, employment status, income level, number of employed members in a household, and energy expenditure. Households in Khubvi village depend mainly on social grants of between R1000 and R3000. This amount is below the poverty line. As such, the community does not have the luxury of selecting the type of energy to use, but must rely on traditional fuels for meeting domestic needs.

Given the energy supply crisis, environmental degradation, and diseases that are associated with firewood consumption, households should be encouraged to seek the use of renewable energy in their domestic energy mix to alleviate energy poverty and reduce the heavy reliance on firewood. The use of modern energy technologies such as liquefied petroleum gas, biogas, and solar, together with improved cooking stoves, can help to reduce overexploitation of natural resources and also prevent indoor air pollution, which is associated with heart disease and mortality. Since most household are deemed energy-poor, the government should subsidise renewable energy, especially among rural households, where there are limited resources.

Renewable energy resources, which include biogas and solar, are the best option to reduce extensive firewood usage among households. Biogas is a renewable energy source that is produced from the bioremediation of organic materials such as cattle, pig, human, sheep and chicken manure, and is usually available to low-income rural households (Mukumba *et al.,* 2016; Msibi, 2015). It should be highly encouraged in rural areas since most households own livestock. Biogas energy can be used for cooking and water-heating and can also be easily converted into electricity (Msibi, 2015). Households should be trained on how to use animal dung to produce energy from

biogas technology. Solar energy is another leading potential, given South Africa's high level of solar radiation. Limpopo province has the highest sunlight radiations annually. The temperature in Thulamela local municipality can reach 45^0 C during summer, which is a great advantage for Khubvi village since solar could be used to generate energy for cooking and lighting. The adoption of solar technology could also create employment for contractors and the retail industry that would employ local residents for installating and maintaing the solar system. Moreover, the adoption of renewable energy would also improve the livelihoods of local residents, especially women and children, who remain the most deprived academically. Women and children are further exposed to indoor air pollution and have to endure long walks in search of firewood, which can even lead to being assaulted. The study was limited to the factors that influence fuelwood consumption by households, as such, air pollution due to the emission of toxic gases such as carbon dioxide, carbon monoxide, sulfur dioxide, and nitrogen oxides (NOx) was not investigated. Future research needs to cover this issue as it impacts negatively on women and children who are in direct contact with the smoke emitted from poorly ventilated spaces.

Author roles

L. Netshipise did data collection, data analysis and drafting of the manuscript. K. Semenya did data analysis, supervised the study, proofread and edited the manuscript.

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