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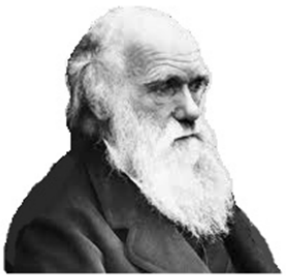

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Fuelwood Consumption and Tree Species Extinction, a Case Study of Kartala Forest in Western Mbadjini of Region of Comoros

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ABSTRACT

Woodfuel has been the most dominant fuel for cooking in households in developing countries where more than half of the world's population resides. High fuelwood consumption contributes to deforestation and forest degradation. Therefore, this study aims to investigate the rate of fuelwood consumption of households in the western Mbadjini region of Comoros. The study's approach is a quantitative/qualitative survey. Specifically, we use the weight-survey method to measure the daily fuelwood consumption per household and capita per day. The instrument for data collection was a questionnaire. Data collected were analyzed using descriptive statistics. The result revealed an average rate of 15.1 kg of fuelwood consumed daily per household (15.1 kg/household/day) given an average per capita per day of 2.0 kg and 732 kg per capita per year (2.0 kg/person/day, 732 kg/capita/year). However, different rates of fuelwood consumption were obtained in different family sizes. Minimum, maximum, and large Family sizes consumed 9.9 kg, 17.4 kg, and 18.0 kg per day. Further, the results indicated that all the respondents were using fuelwood energy sources for cooking and all of them depend on this energy source for survival. Women were the leading fuelwood collectors (53.3%), followed by children (23.7%). Further, the study revealed that most respondents (96%) preferred using fuelwood for cooking their meals. The free collection of fuelwood from the forest (60%), the rapid cooking of meals due to the use of fuelwood (25%), and the belief that the meal tastes perfect when using fuelwood (15%) were the main reasons why respondents preferred using fuelwood energy. The most preferred tree species for fuelwood were *Nuxia pseudodentata*, *Gyrostipula comarensis*, *Psidium catleanum*, and *Mangifera indica*.

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***Keywords*:** Fuelwood, Deforestation**,** Forest degradation**,** Alternative energy, Fuelwood consumption, Developing countries, Environmental issues

1. INTRODUCTION

Forest ecosystem-based products have always played a key role in life-support systems, such as energy requirements, food, fodder, shelter, clothing, and medicine (Ian and Mjeffry, 2022). These people–plant relationships contribute significantly to human welfare (Tariq**,** 2016). In the western Mbadjini region, people derive their daily fuelwood needs from the Kartala forest. Households in the Mbadjini region depend overwhelmingly on biomass for cooking. In Comoros, fuelwood serves as energy for cooking in homes in urban and rural areas where most people reside (Assoumani et al., 2021).

According to (Du et al., 2021), fuelwood is the essential biomass energy source as it is the primary energy source for more than 2 billion, primarily poor, people.

Fuelwood is essential for households, especially in developing countries where most people rely on wood for fuel. On the contrary, biomass fuels, particularly wood fuelwood and charcoal, have long been replaced by more efficient and convenient fuel sources in industrialized countries (Usman and Balsalobre-Lorente 2022). Over 80 percent of households rely on traditional fuels in sub-Saharan Africa, such as fuelwood, charcoal, dung, and crop residues (IEA, 2010). As a critical factor, widespread poverty in many rural areas of developing countries contributes to the continued dependency on biomass energy sources and the persistence of traditional and inefficient ways to use them (Baqir et al., 2012). With no requirement for complex, expensive equipment, wood has remained a dominant fuel and preferred form of domestic energy by people from undeveloped parts of the world (Khadka et al., 2003).

However, forests experience ruthless cutting of woody species in developing countries, providing 50 percent of energy sources for cooking and heating homes (Shanley and Luz, 2003). A primary reason for deforestation is the greater dependence of the bulk of the world population on forests for their energy needs (Onyeneke, 2015). Regular unchecked harvesting of woody plants for construction, fuel, and agricultural tool formation has resulted in the decline of natural populations of trees (Tariq, 2016; Onuorah et al., 2019).

2. MATERIALS AND METHODS

Study area

The Western Mbadjini region is one of the two regions of Mbadjini. It is also one of the 214 regions of Ngazidja Island, the most significant island among the four islands of Comoros (Ngazidja, Ndzouani, Maore, and Mwali). The western Mbadjini region is located at 11°53'9.10"S and 43°26'7.37"E. The Hambou region borders the area to the West and Eastern Mbadjini region to the East. The North of the Western Mbadiji region is bordered by the largest forest of Comoros (Kartala forest).

The Western Mbadiji region had a population of 28 117 in 2017 (INSEED, 2017) and 19 villages; the western Mbadjini region is one of the poorest regions in Comoros. The main activity of this remote rural area is farming.

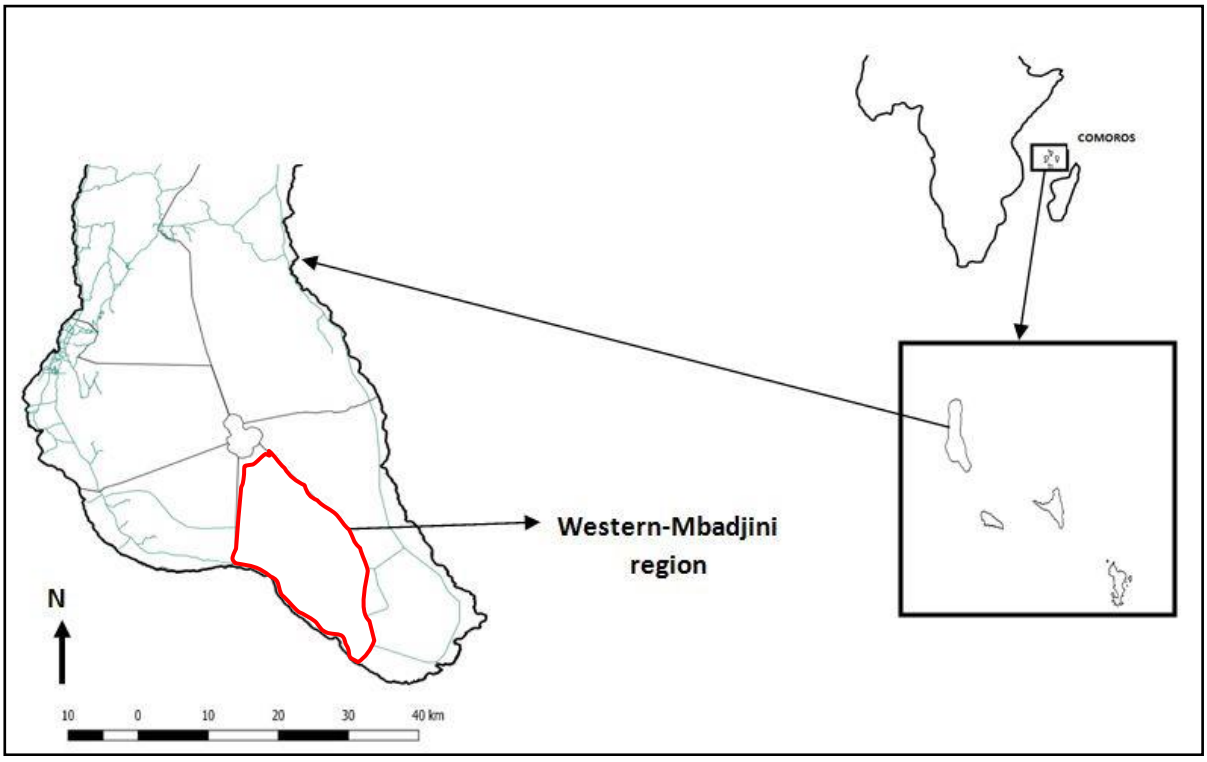

Figure 1. Study site (Ngazidja Island - Islands of Comoros).

The method adopted for fuelwood consumption

The Western Mbadjini region is composed of 19 villages and 5332 household units. Using the Cochran formula (Okareh et al., 2021), we sample 135 households to gather data on fuelwood consumption.

We grouped the households into minimum family size (up to 4 members), maximum family size (6 to 10 members), and large family size (more than ten members) to know how much quantity of fuelwood these different families were consuming. The method used to quantify fuelwood consumption was the weight-survey method (Mijitaba and Jing, 2013). The technique consists of providing three weighted wood lots (fuelwood bundles) to the households, and the household was requested and begged to burn wood only from the provided bundles in the next two days. After two days, the researcher returned to the household and measured the leftover fuelwood. The researchers settled for two days only to avoid factors that would affect consumption, such as lack of food, guest appearance, heavy meal, and weather disturbance

Method of data collection and data sources

The research used both quantitative and qualitative methods to collect data. Questionnaires provided primary data, while reports, documents, and published academic journals provided secondary data. Demographic characteristic data, including gender, occupation, family size, education status, fuelwood dependence, and fuelwood preference, were acquired by administering 135 questionnaires distributed to all the sampled households in 19 villages.

Data analysis methods

The data collected in the study were analyzed using Microsoft excel 2013 and IBM-SPSS software version 20. Precisely, descriptive statistics like mean, and percentages, were calculated and presented as graphs

3. RESULT PRESENTATION

Demographic characteristics of respondents

Age and sex of respondents

The study revealed that most respondents were male (71.9%) while 28.1% were female. The age of the respondents was split into four sections or groups such as 18-25, 26-35, 36-45, and above 46 years. The result revealed that most respondents (48.9%) were between the age of 36-45years. Although, 33.3% of respondents were between 26-35 years. In addition, 9.6% of respondents were between 18-25 years, and 8.1% of respondents were above 46 years.

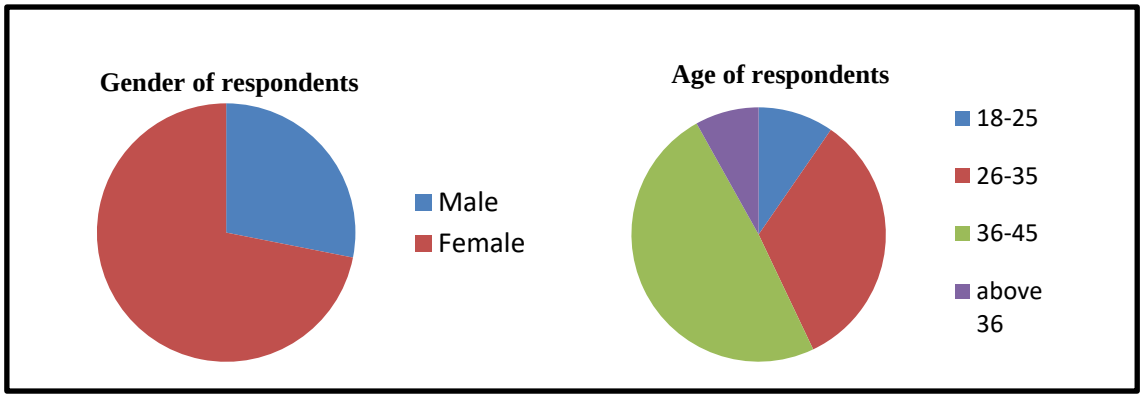

Figure 2. Pie chart showing the sex and age of the respondents

Respondents' occupation

The study revealed that 45.2 % of respondents were farmers. However, 17% of respondents were fuelwood sellers. Housewives represented 18.5%, traders represented 9.6% of respondents, and public servants represented 9.6 %. Many people in the region, especially women, were involved in farming activities from field observation.

Respondents' family size

The family sizes were divided into three groups. It includes minimum family size (up to 4 members), maximum family size (6 to 10 members), and large family size (more than ten members). The findings show that 14.1% of respondents have a minimum family size. However, 28.1% had a maximum family size, and 57.8% had a large family size. The study revealed an average of 7.4 persons/per household.

Table 1. Family size of respondents.

Family size	Frequency	Percentages
Minimum	19	14.1%
Maximum	38	28.1%
Large	78	57.8%

Education status of respondents

The education levels of the 135 respondents are as follows. 53% of respondents were illiterate, while 16% represent respondents who only knew how to write and read. Respondents who ended their education at primary, secondary, high school, and university levels were 13.3%, 6.7%, 3.7%, and 6.7%, respectively.

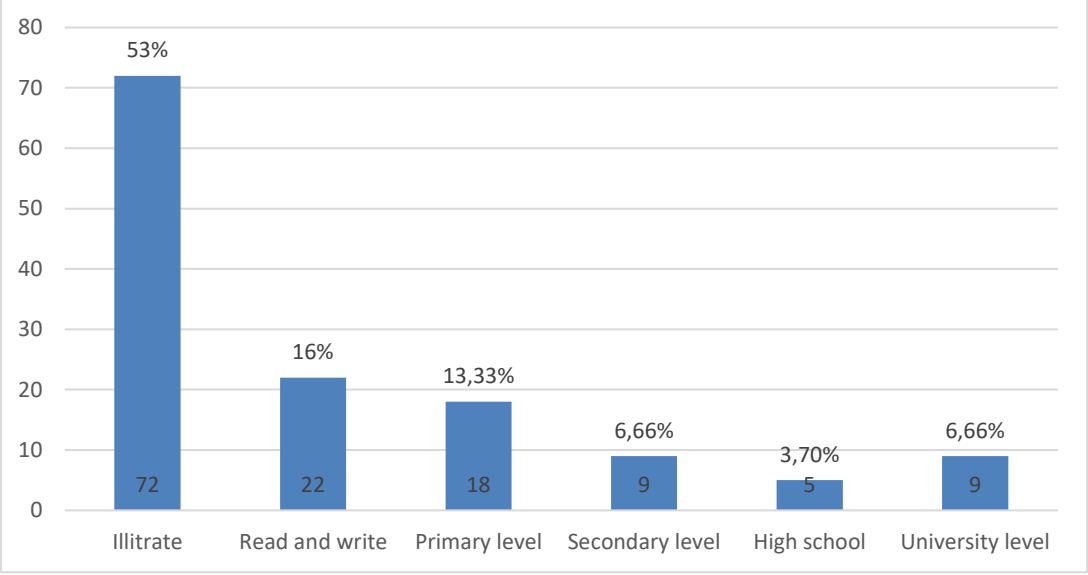

Figure 3. Education level of respondents and their percentages

Fuelwood consumption

The study shows that fuelwood consumption in minimum family size was lower than the quantity of maximum family size. Although, the consumption of maximum family size was slightly different from that of large family size. The result shows that the minimum family size consumed 9.9 kg of fuelwood per day., the maximum family size, 17.4 kg of fuelwood per day, and large household sizes 18.0 kg of fuelwood. Further, the result indicated that a household (no matter its size) consumed on average 15.1 kg. (15.1 kg/household/day). Additionally, 2.0 kg was consumed per average per capita per day (2.0 kg/capita/day).

Table 2. Fuelwood consumption by different household sizes

Family size	Fuelwood consumption per different households size		
	Kg per day	**Kg per capita per day**	**Kg per capita per year**
Minimum family size	9.9	2.5	900
Maximum family size	17.4	2.1	756
Large family size	18.0	1.5	540
Average	15.1	2.0	732

The above table shows that minimum family size consumes lower fuelwood than maximum and large family size. Maximum family size utilizes less fuelwood than large families that consume much fuelwood. In addition, the consumption of fuelwood of these three different family sizes differs from one village to another.

Table 3. Fuelwood consumption by the 19 villages.

Villages	**Distance to the forest**	**Fuelwood consumption kg/capita/ day**			
	CF = close to the forest FF = far from the forest	Min. family size	Max. family size	Large family size	**Average**
Ntsinimoichongo	CF	4.2	3.5	2.4	3.3
Makorani	CF	4	3.1	2.2	3.1
Itsoundzou	CF	2.3	2.1	1.8	2.0
Kadzile	CF	3.7	2.5	1.7	2.6
Mbounde yamboini	CF	1	1.9	0.9	1.2
Panda	CF	3.5	3.4	2.4	3.1
Dembeni	FF	1.5	2.5	1.2	1.7
Mindradou	FF	1.2	1.5	0.9	1.2
Madzissani	FF	2	1.7	1.1	1.6
Mlimani	FF	2	1.6	0.7	1.4
Dima	FF	1.7	1.1	1.2	1.3
Ouziwani	FF	3	1.5	0.6	1.7

Mdjakangnoi	FF	1.7	1.8	1	1.5
Domoni	FF	2.1	1.5	1.1	1.5
Ifoundihe chamboini	FF	1.9	0.9	1	1.2
Ifoundihe chadjou	FF	0.8	1.7	1.4	1.3
Dzoidjou	FF	2.2	1.4	1.3	1.6
Famaré	CF	3.7	3.3	2.4	3.1
Nkourani yassima	CF	4.2	3.5	2.4	3.3
Average	-	**2.5**	**2.1**	**1.5**	**2.0**

From Table 3 above, villages close to the forest, including Famara, Nkourani yassima, Tsinimwachongo, and Makorani, consume more fuelwood than those far from the forest as Mindradou and Bounde yamboini. The fuelwood consumption per capita increases when family size decreases. The average per capita fuelwood consumption for minimum family size is 2.5 kg, but for maximum and large family sizes, 2.1 and 1.5, respectively.

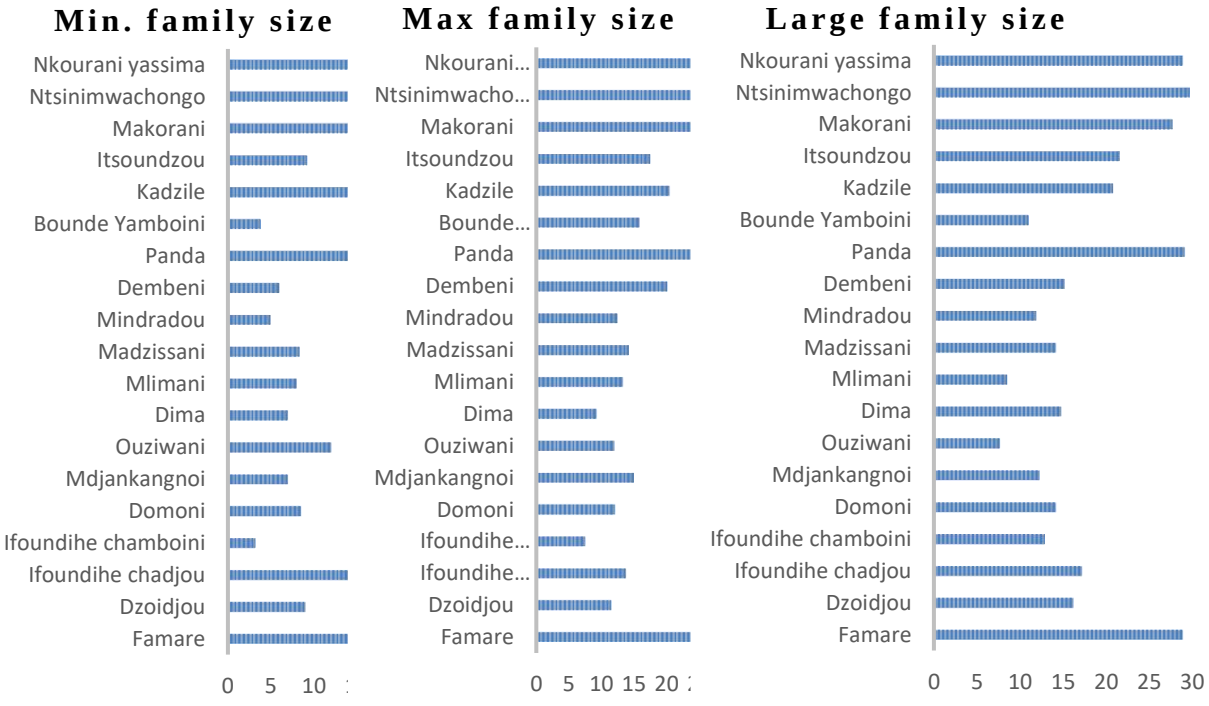

Figure 4. Fuelwood consumption in kg per day in different villages. The OX quantity of fuelwood consumed by the villages, OY is the name of the village.

Fuelwood collection and preferences.

The study revealed that 70.8% of respondents were directly collecting fuelwood in the Kartala forest, while 20% of respondents were buying fuelwood to meet their daily basis energy for cooking. Moreover, the foremost fuelwood collectors were women (53.3%). Some respondents (23.7%) indicated that children were the fuelwood collectors in their households, while 12.6% of respondents stated that men were the fuelwood collectors in their homes.

From the sample, 96% prefer fuelwood energy over other alternative fuels such as kerosene, electricity, and gas to cook their meals. The 4% of respondents revealed that they don't prefer fuelwood for cooking but had no other means to use another energy source. The reasons for those who chose fuelwood were due to free collection (60%) from the Kartala forest, and also fuelwood cooks their meal very fast (25%) with the belief that the meal tastes delicious when using fuelwood (15%).

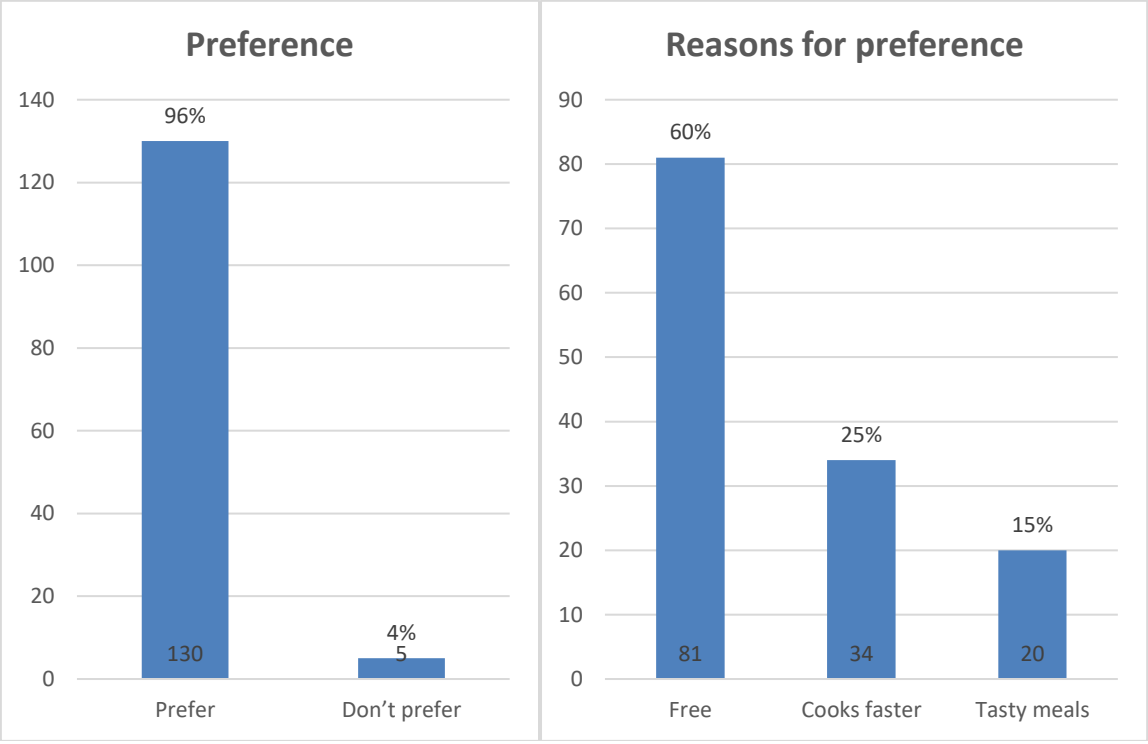

Figure 5. This figure has two components; on the left is the preference for fuelwood; on the right are the reasons for the choices.

Species used as fuelwood

Twelve tree species distributed into nine families were identified as fuelwood species that respondents used to cook their meals. These species include *Nuxia pseudodentata*, *Gliricidia sepium*, *Psidium catleanum*, *Weinmannia comorensis*, *Gyrostipula comorensis*, *Pterocarpus indicus*, *Phyllanthus sp*, *Cynamomum zeylanicum*, *Psidium guayava*, *Vilex doniana*, *Albizia glaberima*, and *Mangifera indica*. However, respondents were asked to determine their most preferred fuelwood species.

Table 4. Tree species used for fuelwood and their family names

No	Scientific names	Family name	Vernacular names
1	*Nuxia pseudodentata*	LOGANIACEAE	Mwanga
2	*Gliricidia sepium*	FABACEAE	Mgirsdia
3	*Psydium catleanum*	MYRTCEAE	Mtsoungoma
4	*Weinmannia comarensis*	CUNONIACEAE	Mdrikoundi
5	*Gyrostipula comorensis*	RUBIACEAE	Mtrakouni
6	*Pterocarpus indicus*	FABACEAE	Mbarouti
7	*Phyllanthus sp*	EUPHORBIACEAE	Mrounda tsoulé
8	*Cynamomum zeylanicum*	CANNELACEAE	Mdarassini
9	*Psydium guayava*	MYRTCEAE	Mpera
10	*Mangifera indica*	ANACARDIACEAE	Myembe
11	*Vitex doniana*	VERBENACEAE	Mfili
12	*Albizia glaberima*	FABACEAE	Mdjendjeye

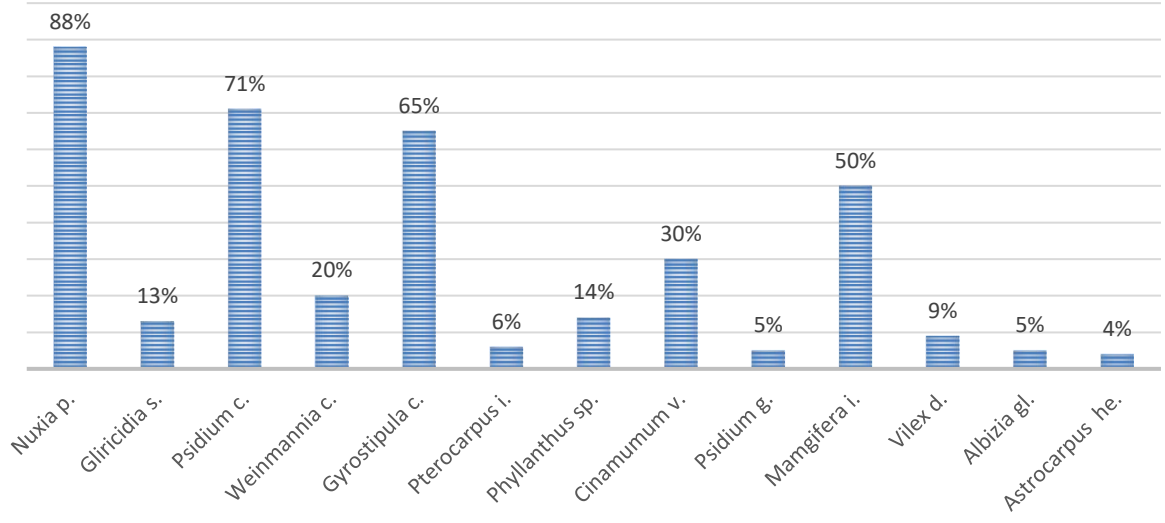

Figure 6. Fuelwood species preferences. OX shows the species and OY the percentage that prefers the species.

4. DISCUSSION

Demographic characteristic

The study revealed that most respondents were female (71.9%) between 36 – 45 years (48.9%). Fuelwood consumption. The high percentage is because women spend much time in the kitchen cooking meals using fuelwood, especially in developing. These females are mature enough to provide reliable and trustworthy information on household activities relevant to this study. This result agrees with the outcome of Berhanu, (2017), who found in his research that the majority of respondents were female (63.7%), and their age fell within the age group 25-35 years (50.4%), implying that respondents were responsible and capable of providing reliable information.

The educational level of the respondents is as follows, 54.1% of respondents were illiterate, and 18.5% knew how to read and write only. Further, some respondents ended their educational career at the primary level (10.3%), secondary level (6.7%), high school (3.4%), and university level (6.7%). Thus the result of this study indicates that the majority of respondents were illiterate and uneducated. Uneducated people are more likely to be poor. The poor people have high effects on forests, especially in developing countries where wood-based fuels remain the dominant energy source for over 2 billion poor people (Shahsavari and Akbari, 2002). These people put much pressure on forest resources which they depend on. Onyeneke (2015) found that less educated people consume much fuelwood.

About 57.8% of respondents had large family sizes, while 25.1% and 14.1% claimed their family sizes were maximum and minimum. However, this value is higher than the mean value of family size reported by Mislimshoeva et al. (2014) in Western Pamirs, in Tajikistan (6persons/hh). Berhanu (2017) reported a mean value of the family size of 7.1persons/hh, which is almost the same value calculated in this study.

In the Western-Mbadjini region, farming is the primary means of survival. This study revealed that 45.2 % of the respondents were farmers, while 17% were fuelwood sellers. Additionally, 18.5%, 9.6%, and 9.6% of respondents were homemakers, traders, and public servants. This result signifies that the majority of respondents were farmers. Onyeneke (2015) found in his study that farming activity has a relationship with fuelwood consumption, implying that farmers influence/increase fuelwood consumption. Therefore, in an area where most people are farmers, fuelwood consumption is more likely to be higher, which affects the forest.

Fuelwood consumption

Developing countries' households have mostly large family sizes, which is one of the factors contributing to the high consumption of fuelwood, which adds to deforestation and forest degradation. In this current study conducted in the Western Mbadjini region of Comoros, most respondents' households had large family sizes (57.8%), and on average, 7.4 persons were living in a household (7.4persons/hh). The result revealed that minimum family size consumes less fuelwood than the maximum and large families, as Bhatt and Sachan (2004) confirmed. They reported that large households consume more fuelwood than medium and small families. The study indicates that on average minimum family size consumed 9.9 kg of fuelwood per day while maximum and large family sizes consumed 17.4 kg and 18.0 kg of fuelwood per day, respectively. The result of Asik (2017) differs from the result of this study, but his result shows that small family sizes consumed 13 kg per day and medium and large family sizes consumed 21 kg and 34 kg per day, respectively. However, according to Munesh (2015), fuelwood

consumption with family size reduces with increasing family size from small, medium, and large family size, implying that small or minimum family sizes consume more fuelwood than medium and large family sizes. But this was based only on the fuelwood consumption per capita in those family sizes. Therefore, this study found that household consumption of fuelwood increases with increasing family size, as indicated in Table 2.

The consumption of fuelwood per capita decreases with increasing family size from minimum, maximum, and large family size, as Munesh (2015) reported. The consumption of fuelwood per capita in small family sizes should be higher than in medium and large. The total fuelwood consumption is divided by the total number of family members. Therefore, as small family size has few members, the amount of fuelwood per capita tends to be high than those of medium and large family sizes as they have many family members. This study also agrees that fuelwood consumption per capita decreases with increased family size. The study reveals 900 kg/capita/year in minimum family size, yet in maximum and large family sizes, 756 kg/capita/year and 540 kg/capita/year were calculated, respectively. Although, these values are higher than those of Munesh (2015), who found in the region of Garhwal in India that 669.58 kg/capita/year in small family size, 543.35 kg/capita/year in medium family size, and 441.88 kg/capita/year in large family size. Mehat et al. (1987) reported fuelwood consumption of 448.95 kg/capita/year for Nepal Himalaya. Dhanai et al. (2014) reported a value of 646.05 to 1091.35 kg/capita/year. In their study, Jaiswal et al. (2013) said that the fuelwood consumption was 657 kg/capita/year, which is also a low value than the value obtained in this study.

5. CONCLUSION AND RECOMMENDATION

Fuelwood is the primary fuel energy mainly used for cooking in households in the Western Mbadiji region. This study found that fuelwood consumption was high in the various family sizes, contributing to deforestation and forest degradation in the Western Mbadjini region in Comoros. Further, the study indicated that most respondents had a large family size, from ten to eighteen members, influencing fuelwood consumption. The study also revealed that *Nuxia pseudodentata*, *Gyrostipula comarensis*, *Psidium catleanum*, and *Mangifera indica* are the tree species preferred for fuelwood. Therefore, there is an immediate need to reduce the fuelwood consumption rate to reduce the pressure on forest resources.

In addition, alternative energy sources such as kerosene and cooking gas should be harnessed and provided in the region to encourage a shift from environmentally unfriendly fuelwood to a more sustainable energy source. Government and non-government organizations should embark on public enlightenment campaigns to inform and sensitize the people within the region on the consequences of fuelwood consumption, such as forest loss, climate change, biodiversity loss, and forest degradation. Therefore, we recommend regularly planting the three tree species that top fuelwood in the Kartala forest.

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