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An Integrated Energy Source Management: A Solution to the Dwindling Forest Resources

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Abstract: *Over 70 % of the Nigerian population recites in the rural areas and depends solely on fuel wood for domestic cooking, this has resulted in the disappearance of our fragile forest resources. A study on testing the effectiveness of a designed and constructed fuelwood stove for domestic energy consumption has been carried out in Gombe State. Fuel wood and Cornstalk were used as the available energy sources. Three types of fuel wood namely mahogany (Khaya senegalenses), mark (Annogeissus leoicarpus) and Tifirmi (Combretum nigricans) and cornstalk were used as energy sources in comparative tests of the designed stove vis-à-vis the traditional stove. The results indicated an average daily consumption of 231.47 MJ and a per capita consumption of 43.52 MJ with a standard deviation of 13.0 between the two energy sources for the traditional stove against the respective values of 194.67 MJ and 36.65 MJ and a standard deviation of 5.1 between the two energy sources for the improved stove. Thereafter, 20 households were randomly selected and the same procedure was repeated. The result obtained indicates great fuel wood saving using the improved stove because the per capita daily energy consumption of households varies from 14.4 to 25.60 MJ with an average daily consumption of 19.40 MJ giving a fuel wood savings of (44.60 %. The Analysis of Variance (ANOVA) and the two sample t-test shows significant difference between energy used in 20 households before and after intervention at 5 % level of significance. For WBT, the results indicated that it took less time, meaning less amount of wood, to boil water in the order (Mahogany, Mark and Tifirmi). The time taken for each are 7.10, 13.50 and 16.80 minutes respectively, thus indicating an energy equivalent of 2636.92 kJ (0.73 kWh), 6984.25 kJ (1.94 kWh) and 1825.56 kJ (0.51 kWh) respectively. Results for CCT, using rice and beans followed the same pattern. It took less time to cook both rice and beans using Mahogany than Mark and Tifirmi. The times for each were: 18.50, 30.50 and 34.50 minutes respectively for rice and for beans the order was: 24.50, 36.50 and 39.50 minutes respectively. The SC was found to be 0.002 of fuelwood per each kg of food cooked using Mark and 0.0031 of fuelwood per kg of food cooked, using Mahogany. The fuel burn rate per cycle was found to be 0.01 kg/min with a cycle time of 35 minutes. This designed and constructed stove is good, saves cooking time, wood used in cooking and can be made available to rural dwellers at affordable cost per unit. The stove efficiency using WBT was found to be 65.45 %. It is therefore recommended that government should encouragement massive production of this type of improved stove for use especially in the rural areas of Gombe State to reduce pressure on the already depleted forest resources in the State. It would also save time and energy used by women and children in gathering fuelwood in the rural areas.*

Keywords: *Fuelwood, Efficiency, Effectiveness, Domestic, Energy and Consumption*

1. Introduction

The utilization of all forms of energy in a sustainable manner has been a global concern over the years. Sustainability can be understood either as using a resource in such a way that it continues to be available (Botkin and Keller, 1998) or ensuring that future generations have equal opportunities to it. It is certain that we must learn how to sustain our environmental resources so that they continue to provide benefits for people and other living things on our planet (Langa and Ododo, 2011). For instance, global, regional and national

been expressed on environmental impacts of hydropower generation, nuclear power generation, particulate matter from farming, demolition, construction, cement factories and photochemical emission from automobiles (Gebelein, 1997). This implies that the more we produce or use energy, the more we add emissions of products such as (Co_2, Co, No_2, No, So_2) etc that are harmful to life and plants and thus the more we degrade the environment. The solution to this is for us to compromise and select alternative energy sources that have low pollution tendencies in an integrated energy management system.

The World Energy Council (WEC) views affordable energy access as a precondition for fostering economic development, improved health and welfare, and social equity. For the developing nations this means the need to make the transition from the predominant consumption of primary biomass energy (traditional fuels) in the rural communities to some sort of clean, convenient, and affordable commercial energy. Affordable electricity, from a distributed generation, or a decentralized approach, can help in the development of the rural areas, and above all, it will reduce the in-door pollution health hazards, which particularly affect the health of mothers and children (WEC, 2004).

Renewable energy can be considered as a new unlimited supply of energy if one considers the energy needs of humanity compared with the energy flows to the earth from the sun. However, renewable energy will remain a small component of energy supply in industrialized countries as a complement rather than a replacement for fossil fuels and nuclear power (WEC, 2003). Their roles in meeting the rapidly growing demand for reliable and affordable energy in developing countries will grow in importance, principally in rural areas, with targeted, temporary subsidies to support their use.

Over 70% of the Nigerian population live in the rural areas and depend solely on fuel wood as their major energy source (World Bank/UNDP, 1993). The high rate of population increase (3.2%, NPC, 2006) coupled with rapid urbanization has placed a strain on energy resources in Nigeria. In Sahel Savannah of Nigeria, studies (World Bank and UNDP, 1993) have shown that this trend will lead to an energy crisis. Today about 2.5 billion people live in the rural areas of the world and of this number, 85 % are in developing countries, with much of their energy needs on both modern and traditional energy sources (Alabe, 1995). The findings of Umaru and Wamako (1998) on price increase on fuel wood because of deregulation attest to this fact that household rely more on fuewood whenever there is an increase on the price of kerosene. This, along with the erratic power supplies, has gradually drawn consumers away from kerosene and natural gas back to local wood stove for cooking their food and other essential domestic activities (Umaru and Wamako, 1998).

Nigerians, especially in the northern part of the country, consume more than a million tones of fuel wood per annum. Wood production in the country is quite meager, with each hectare yielding a little more than an estimated 0.77 m^3 of wood annually (FAO, 1999). In

Northern Nigeria, forests have almost completely disappeared raising serious questions about fuel wood price hike and shortage in the future (Amadou 1994). The contribution of fuel wood consumption to environmental degradation can be associated with population pressure and rapid population growth, availability of alternatives, cheap and readily available energy sources such as coal, kerosene, gas and policies of reforestation of degraded large lands (Okaiyeto 1990).

This present study is designed to investigate the effectiveness of a designed and constructed improved stove for domestic use in Gombe State, Nigeria using an energy mix between fuel wood and cornstalk. The objective of this study is to survey and examine the use of agricultural residues as a means of suplementing the use of fuel wood as a domestic energy source. This will reduce the quantity of wood consumed thereby introducing some level of conservation on our forest resources.

Forests in the developing countries are shrinking by more than 15 million hectares a year. The ratio of forests-to-people is less than half what it was in 1960. For most, there is little alternative to burning wood -- wood energy is here to stay. In fact burning wood is no bad thing: the efficient use of wood fuel is much more eco-friendly than more efficient and convenient fuels like kerosene and natural gas (LPG). LPG emits 15 times more CO_2 (carbon dioxide) per kg than wood (FAO-RWEDP, 1997), and kerosene nearly 10 times as much. CO_2 is the main source of global warming. And as long as wood burning is sustainable and doesn't cause deforestation, its CO_2 emissions are neutral -- the CO_2 released in the fire simply gets recycled back into more trees (FAO-RWEDP, 1997). Fuel wood seems to be the major source of fuel in the region that loses an estimated 4 km^2 of useful land every year in addition to threats of drought and that other sources of energy such as kerosene and electricity are not readily available due to inadequate supply. Adeyemi and Asere (2007) showed that there is an over dependence, (>90 %), on fuel wood as a household fuel, and stands as a function of availability and cost.

The use of agricultural residues such cornstak, cotton stalk and cow droppings as a source of energy has been in practice for centuries. Langa and Ododo, (2011) opined that 98 % of households in Gombe State uses Cornstalk for lighting purposes. If these energy sources can be propery harnessed and used in an integrated manner, over dependency on fuel wood as aq domestic fuel can be reduced. This will translate to a reduction in deforestation, hence saving our forest reserves.

2. Materials and Methods

2.1. Area of Study

Gombe State, which was created on October 1, 1996, is located in the northeast geo-political zone of Nigeria. It is bounded in the north by Yobe State, in the south by Taraba and Adamawa States, in the east by Borno State and in the west by Bauchi State. It has a population of about 2.1 million people (NPC, 2006) and occupies a total landmass of 20,265 km^2 , State Economic Empowerment and Development Strategy (SEEDS, 2006).

Statement of the Problem

Gombe State is one of the frntline States bedeviled by deforestation because of over dependence on fuelwood as a source of energy (UNDP/World Bank,1993). Forests in the State have disappeared giving rise desert encroachment especially in the northern part of the State. This trend if left unchecked will affect the agricultural products, which will in turn affect the annual income of our teeming farmers and will translate into an economic backwardness and desert encroachment.

The efficient use of energy resources available in Nigeria and indeed Gombe State has not been effective. Also, the use of fossil fuels and its consequent effects on our fragile environment have increased the level of concerns shown by environmental scientists in the globe on the need to protect the environment from degradation (Garg and Prakash, 1998). The abundant cornstalk and agricultural farm residues energy available with high energy-end-use values has not been utilised to advange. This paper seeks to discover how the use of cornstalk mix with fuel wood as energy sources in Gombe State can be utilised to advange.

c) Purpose of Study

The purpose of this empirical work is to:

i) Determine the consumption patterns of biomass, gas and charcoal in households in Gombe State,

ii) Determine the most prefered energy options for domestic cooking, heating and lighting,

iii) Determine energy options per activity as used by respondents, and

iv) Determine whether level of income of respondents really affects their choice of energy use in relation to price.

2.2. Means of Assessing Wood Stove Performance

Stove performance is usually evaluated through the use of three standard tests in wood stove designs, the test tests are Kitchen Performance Test (KPT), Water Boiling Test (WBT) and Controlled Cooking Test (CCT). They are discussed as presented below.

2.3. The kitchen performance test (KPT)

The Kitchen Performance Test (KPT) is the principal field–based procedure to demonstrate the effect of stove interventions on household fuel consumption. There are two main goals of the KPT:

i. To assess qualitative aspects of stove performance through household surveys and,

ii. To compare the impact of improved stove(s) on fuel consumption in the kitchens of real households.

To meet these aims, the KPT includes quantitative surveys of fuel consumption and qualitative surveys of stove performance and acceptability. This type of testing, when conducted carefully, is the best way to understand the stove's impact on fuel use and on general household characteristics and behaviors because it occurs in the homes of stove users (Lilywhite, 1984; VITA, 1985). However, it is also the most difficult way to test stoves because it intrudes on people's daily activities. In addition, the measurements taken during the KPT are more uncertain because potential sources of error are harder to control in comparison to laboratory-based tests. For this reason, the protocol for the KPT is quite different from the protocols for the Water Boiling Test (WBT) and the Controlled Cooking Test (CCT).

2.4. Materials

The materials used for the construction of an improved wood-burning stove were purchased locally in Gombe, the capital of Gombe state. These include: the design mould, a special local clay, a wire mesh, binding material (Millet/Rice husk), separator (millet ash), a 3 inch metal pipe, a granulated powder of broken pots (Grog), a wooden spatula, scissors, and a ½ inch metal flat bar. These materials are discussed as follows:

i. Clay: Is the main ingredient of the construction,
ii. Millet/Rice husk: Serves as binding materials in the clay,
iii. Ash: This is a separator between the clay, hand and mould,
iv. Grog: This serves as an anti-cracking agent in the clay mixture,
v. Moulds: Two (2) moulds required for this design. The first Mould is the top of the stove which is a flat rectangular wood (or metal), as shown in Figure 6 a. The base is 80 cm in length and 36 cm in breath. It has three (3) openings of diameter, 28, 24 and 6 cm respectively. The first and second holes stands for the two (2) pots, while the last one is an opening for the chimney. The second mould is called the chimney mould which is hollow and cylindrical in shape.

2.5. Design Specifications

The specifications for the design parameters of the improved double-hole wood-burning stove are presented as follows:

a) Wood Form Work $80cm \times 36cm$

b) Wire Mesh length 90 cm

c) Wire Mesh Width $w = \frac{54cm}{2} = 27cm$

However, the width used in this design was 22 cm, based on the calculation done using the Winiarski's model for a rectangular stove of pots diameters, 28 cm, 24 cm.

d) The wire mesh was double folded to form the shape of the modified improved stove.

e) The 1" metal flat bar was bend into a u-shape of dimension, 22 cm x 36 cm x 22 cm, 3 in number and are inserted at 3 points to serve as reinforcements.

2.6. Calculations of Stove Parameters (for a rectangular improved cook stove)

The stove parameters considered in this design are computed using the equations detailed as:

i) Area of the combustion chamber for a square or rectangular combustion chamber:

$$A = l \times w \tag{2.1}$$

where A = area, L = length, 80 cm and w = the width, 36 cm

ii) The needed gap at the edge of the combustion chamber, first we determine the circumference of the area that the hot gases will pass through, the distance from centre of the combustion chamber to the centre;

$$C = 2 \times \pi \times r_C \tag{2.2}$$

where

r_c is the radius of the combustion chamber, and

C is its circumference,

$$r_C = \frac{1}{2}\sqrt{l^2} \times w^2 \tag{2.3}$$

r_c = 1440 cm

iii) The needed gap for effective heat transfer to the pot is ;

$$G = \frac{A}{C} \tag{2.4}$$

where

G = needed gap between the bottom of the pot and the top edge

of the combustion chamber.

iv) To determine the optimal gap at the edge of the pot, we measure the circumference of the pot (C_p)

$$C_p = 2\pi r_p \tag{2.5}$$

where

r_p is the radius of the pot.

v) The required pot gap was therefore obtained as

$$G_P = \frac{A}{C_P} = \frac{A}{2\pi r_p} \tag{2.6}$$

3. Results and Discussion

3.1. Introduction

The chapter presents the results obtained for the modified improved vented mud (IVM) cook stove.

3.2. Data Analysis

This section presents data obtained from the field in tabular form and the analysis of these data as it affects the study.

Table 1 is a 3-day KPT for three households each consisting of 6, 5 and 5 family members all in Gombe state using the traditional stove (before intervention) and their energy sources was fuel wood and corn stalk. The result indicates a difference in the total energy consumed per household varies from 209.30 to 249.20 MJ while their respective energy per capita varies from 41.58 to 47.18MJ. The average daily consumption was found to be 231.47 MJ, and the corresponding consumption per capita was 43.52 MJ with a covariance (CV) of 6 % and standard deviation of 13.0 between the households. This analysis assumes that the wood used has a calorific value of 19 MJ/kg and the cornstalk has a calorific value of 15 MJ/kg.

Table 1: Data from a 3-day KPT in One Gombe Household Using Fuelwood and Corn/Stalk

(Before Intervention)

Daily Results		Wood Consumption (mark) (kg)				C/Stalk Consumption (kg)				Energy (MJ)	
	No. of adult equiv	Wet wood used per day	Wet wood used per capita per day	Dry wood used per day	Dry wood used per capita per day	Wet C/Stalk used per day	Wet C/Stalk used per capita per day	Dry C/stalk Used per day	Dry C/Stalk used per capita per day	Total Energy	Per capita Energy
Day 1	6	5.8	0.97	4.50	0.75	1.50	0.30	1.4 0	0.20	249.20	41.52

Day 2	5	5.2	1.04	4.00	0.80	1.20	0.20	1.10	0.20	209.10	41.86
Day 3	5	6.0	1.20	4.60	0.92	1.20	0.50	1.10	0.50	235.90	47.18
Overall Results:		Wet wood	Wet wood	Dry wood	Dry wood	Wet C/Stalk	Wet C/Stalk	Dry C/Stalk	Dry C/Stalk	Total	Energy
Avg Daily Fuel		5.67	1.07	4.70	0.80	1.30	0.33	1.20	0.30	231.47	43.52
Standard deviation		0.4	0.2	0.3	0.1	0.5	0.1	0.5	0.1	13.0	4.8
CV (SD/Avg)		7 %	19%	6 %	12%	38%	30 %	42 %	33 %	6 %	11 %

C/Stalk = Corn Stalk Avg = Average

Table 2 is a 3-day KPT for three households each consisting of 6, 5 and 5 family members all in Gombe state using the improved stove (after intervention) and their energy sources was fuel wood and corn stalk. The results indicates differences in the total energy consumed per household varies from 183.50 to 205.00 MJ while their respective energy per capita varies from 34.17 to 39.10 MJ. The average daily consumption was found to be 194.67 MJ and the corresponding consumption per capita was 36.65 MJ with a covariance (CV) of 3 % and standard deviation of 1.1 between the households. This analysis assumes that wood has a calorific value of 19 MJ/kg and cornstalk has a calorific value of 15 MJ/kg. The high calorific value of 15 MJ/kg for cornstalk should be utilised to advantaged.

Variation in data is typically measured by the coefficient of variation (CV), which is the ratio of the standard deviation to the mean. The Data reported in reports on stove-testing shows that WBT and CCT tests usually have a CV between 5 and 15 %. However, data collected from the KPT can have a CV of 45% or more (Baldwin, 1986; FAO, 1993). However, the data of Table 2 indicate a lower value both for covariance (CV) and standard deviation (SD) meaning a good stove performance indices.

Table 3 is a KPT data from 20 households in Gombe State that were randomly selected. It was observed that, the per energy consumption between households varies from 14.4 and 25.6 MJ and their average energy consumption of both fuel wood and corn stalk was 19.4 MJ. The standard deviation was 3.0 while the covariance (CV) was found to be 15 %. This also suggests an improvement over the traditional stove.

A comparison of Table 1 (before intervention) and Table 3 (after intervention) indicates and average per capita energy consumption of 43.52 MJ and 19.4 MJ respectively. These indicate an energy saving of 24.12 MJ per household representing an average wood savings of 55.42 %. This also implies time and money savings when we use this newly constructed improved stove for domestic cooking.

When adequate fuel is provided to participating families, the results of the KPT indicate the impact of the modified stove relative to the traditional stove in a situation of adequate fuel wood, which may not reflect actual conditions. However, if the same amount of fuel is provided for use in both the modified and traditional stoves, then the test will indicate the relative difference between the two stoves, which is an important outcome.

Table 2: Data from a 3-day KPT in Gombe (One Household) Using Fuelwood and Corn Stalk (C/Stalk) (After Intervention)

Daily Results		Wood Consumption mark (kg)				C/Stalk Consumption (kg)				Energy (MJ)	
	No. of adult equiv	Wet wood used per day	Wet wood used per capita per day	Dry w wood used per day	Dry w wood used per capita per day	Wet C/Stalk Used per day	Wet C/Stalk used per capita per day	Dry C/Stalk Used per day	Dry C/Stalk used per capita per day	Total Energy	Per capita energy
Day1	6	4.8	0.80	3.70	0.61	1.50	0.25	1.40	0.23	205.00	34.17
Day2	5	4.5	0.90	3.50	0.70	1.10	0.20	1.00	0.20	183.50	36.07
Day3	5	4.5	0.90	3.50	0.70	1.50	0.30	1.40	0.20	195.50	39.10
Overall Results:		Wet wood	Wet p/c	Dry wood	Dry wood p/c	Wet C/Stalk	Wet C/Stalk p/c	Dry C/Stalk	Dry C/Stalk p/c	Total Energy	Energy
Avg Daily Fuel		4.60	0.87	3.57	**0.67**	1.37	0.26	1.27	0.24	194.67	36.65
Standard deviation		0.2	0.1	0.1	0.0	0.2	0.0	0.2	0.0	5.1	1.1
CV (SD/Avg)		4 %	11.5%	3 %	0 %	15 %	0.0 %	16 %	0.0 %	3 %	3 %

P/C = Per Capita CV = Covariance SD = Standard deviation Avg = Average

Table 3: Data set from 20 Gombe State Households Using Fuelwood and Corn Stalk (C/Stalk)

	Before Intervention			After Intervention		
HH No.	Per cap wood Consumption (kg)	Per cap C/Stalk Consumption (kg)	Per cap energy consumption (MJ)	Per cap wood Consumption (kg)	Per cap C/Stalk Consumption (kg)	Per cap energy consumption (MJ)
1	0.89	0.31	21.6	0.69	0.24	16.8
2	1.02	0.40	25.4	0.92	0.30	22.1
3	0.71	0.41	19.6	0.59	0.38	17.0
4	1.02	0.33	24.4	0.52	0.38	15.5
5	1.13	0.36	26.8	0.58	0.40	16.9
6	1.18	0.35	27.7	0.88	0.31	21.4
7	1.24	0.45	30.3	0.78	0.24	18.4
8	0.87	0.25	20.3	0.77	0.47	21.7
9	0.94	0.45	24.6	0.60	0.20	14.4
10	0.82	0.27	19.7	0.69	0.39	18.9
11	1.18	0.40	28.6	0.73	0.34	18.9
12	0.75	0.47	21.3	0.54	0.43	16.8
13	0.79	0.52	22.7	0.99	0.46	25.6
14	0.79	0.39	23.7	0.97	0.34	23.6
15	0.94	0.38	23.6	0.78	0.23	18.4
16	1.32	0.49	32.4	0.89	0.27	20.9
17	0.81	0.39	21.2	0.90	0.28	21.3
18	1.08	0.51	28.1	0.77	0.42	20.9
19	1.17	0.32	27.1	0.64	0.28	16.3

20	1.22	0.29	27.5	0.85	0.41	22.3
Average	1.00	0.39	24.8	0.75	0.34	19.4
SD	0.18	0.08	3.7	0.15	0.08	3.0
CV	18%	20%	15%	19%	24%	15%

Per Cap = per capita , C/Stalk = Cornstalk, SD = Standard deviation, CV = Covariance

4. Summary

The results has two components comprising of data obtained using the traditional stove and improved stove as contained in Table 1 and 2. It was discovered that households consumed more fuel wood and corn stalk with average daily consumption of (231.47 MJ) and a per capita energy consumption of 43.52 MJ using the traditional stove and a standard deviation and covariance of 13.0 and 6 % respectively. On the other hand, households consumed less fuel when they used the modified improved stove. The average daily energy consumption was 194.67 MJ, and a per capita energy consumption of 36.65 MJ respectively, with a standard deviation and covariance of 5.1 and 3 %. It was also observed that in both the WBT and CCT tests conducted using the new stove; it takes lesser time to boil water and lesser time to cook rice and beans of a given quantity (0.5 and 0.60 kg respectively) when compared to the traditional stove which takes between 45 minutes to 1 hour to cook these same food items. This implies that it saves cooking time, energy and money for buying of wood. The specific fuel consumption was found to be 0.002 of wood per kg of food cook for rice and 0.0031 of wood per kg of food cooked for beans. This is far less when compared to that of traditional stove.

4.1. Conclusion

We have been able to achieve the following in this research work:

i. Designed and constructed a modified improved Multipot cook stove of two (2) holes,
ii. Determined the efficiency of the modified improved cook stove, which was found to be 65.45 %,
iii. Performed Water Boiling Test (WBT) using three wood samples Mark, Tifirmi and Mahogany and found that it takes between 7.00-16.8 minutes to boil (2250 cm^3) of water from 32.50 °C to 98.00 °C, and the energy required also varies from 1825.56 to 6984.25 kJ,
iv. Also, Controlled Cooking Test (CCT) was carried out on two food samples (Rice and beans), it shows that it takes 30.5 mins for mark, 34.5 mins for Tifirmi, and 18.5 mins for mahogany to cook rice. For beans, it takes 36.5 mins for mark, 39.40 mins for tifirmi and 24.5 mins for mahogany,
v. The specific fuel consumption was found to be 0.0031 for mark and 0.002 for mahogany using rice as food sample,
vi. A comparative analysis between the traditional stove and the modified improved cook stove, using wood and corn stalk in 20 selected households, the results shows, a covariance of 1.7 and a standard deviation of 1.1 between households, and a fuel savings of 55.42 % ,

vii. The cost implication for unit of the modified improved stove is N3,700.00,

viii. Achieved an energy savings of about 24.12 MJ in a household,

viii. Achieved a percentage difference 55. 42 % between the traditional stove and the modified improved stove.

ix. The repeated use of the same stove by different households may introduce some variations which we have not taken into consideration.

Some of the advantages of this design include:

i. Easy to light and is not affected by wind,
ii. Emits less smoke,
iii. Cook food faster, and
iv. Uses less fuel

4.2. Recommendations

With the shrinking forest resources, high dependence on fuel wood as a primary source of energy and the consequential land degradation evident by desert encroachment, the Researcher wishes to recommend as follows:

i. Government should put in place a strong legal framework to regulate the issuance of fire wood permit to fire wood dealers,
ii. Government should approve the massive production of this model of stove and be distributed free of charge especially to rural communities of Gombe State,
iii. As a matter of necessity henceforth stop the deforestation of any available forest reserve in Gombe State;
iv. An integrated energy mix should be encouraged in domestic energy consumption rather than total dependence on fuel wood as domestic fuel;
v. Radio and TV jingles be encouraged as a means for community mass mobilization against excessive exploitation of the available forest woods in Gombe State; and
vi. Government should spearhead massive aforestation program and provide incentive to individuals who plant and nurture 2 or more trees in a year.
vii. Future studies be carried out on more wood samples (5-10), since there so many wood varieties in Nigeria.

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