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# Assessment of the Biomass Status of Some Selected Trees Species with High Calorific Value Used For Charcoal Production in Toro Lga

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**ABSTRACT**

The abysmal decline of trees species with high calorific values in the state and the rising demand of fuel wood and charcoal with corresponding raise in the price of fusil fuel (PMS, AGO, Kerosine and Gas) informed this study.The study investigated the status of trees with high calorific value in Toro Local government and compare the result with the previous record of 2013 and 2015. Point Centre Quarter Method (PCQ) was used for the vegetation inventory in Lukshi forest reserve Toro Local government. Data obtained was analysed using vegetation indices and inferential statistic. The result indicated that their is a declined of about 36% of trees with high calorific value in Toro Local government compared to number obtained 10 years ago (2013). The result further revealed that Anogeisus leocarpus, (14.4%), Isoberlina doka(9.8%) are the most predominant specie and of high calorific value. Deuterium microcarpum (17%) and Vetellaria paradoza (1.15%) were also common and of high calorific value in the reserve. The result of the basal area analysis reveal also that their is a significant reducation In the volume of wood produced per tree in the study area, Isoberlina doka, Anogeisus leocarpus and Lennea acida had 15,200cm3,11,700cm3 and 5,400cm3 in the year 2013, and the volume of similar species dropped to the 9700,cm, 6,900 and 8500 in 2023. The study concluded that the negative trend of tree species with high calorific value population in the study is associated to increased on anthropogenic activities, change in luggers cutting preference and poor administrative and management practices of the reserve. The study recommended improve education and awareness campaign to the inhabitant of Toro and the state at large on the implication of deforestation and lost of biodiversity among others.

## I. INTRODUCTION

Biomass is a term for all organic material that stems from plants (including algae, trees and crops). Biomass is produced by green plants converting sunlight into plant material through photosynthesis and includes all land- and water-based vegetation, as well as all organic wastes. The biomass resource can be considered as organic matter, in which the energy of sunlight is stored in chemical bonds Awe, (2015). When the bonds between adjacent carbon, hydrogen and oxygen molecules are broken by digestion, combustion, or decomposition, these substances release their stored, chemical energy. Biomass has always been a major source of energy for mankind and is presently estimated to contribute of the order 10–14% of the world's energy supply (Adeniji, 2016).

The conversion of biomass into energy can be achieved in a number of ways. To provide a fuel suitable for direct use in spark ignition gas engines (s.i.g.e.), the fuel must be provided in either a gaseous, or a liquid form. Production of a gaseous fuel from biomass can be achieved by the application of a number of technologies, each with its specific requirements, advantages and disadvantages (Adejumobi, 2016)

The value of a particular type of biomass depends on the chemical and physical properties of the large molecules from which it is made. Man for millennia has exploited the energy stored in these chemical bonds, by burning biomass as a fuel and by eating plants for the nutritional content of their sugar and starch. More recently, fossilised biomass has been exploited as coal and oil. However, since it takes millions of years to convert biomass into fossil fuels, these are not renewable within a time-scale mankind can use. Burning fossil fuels uses ‘‘old’’ biomass and converts it into ‘‘new’’ $CO_2$;

which contributes to the ‘‘greenhouse’’ effect and depletes a non-renewable resource (Massey, 2015).

However in Africa charcoal production is considered as the major driver for deforestation, almost all charcoal is produced in rural areas, especially in forested area surrounding the urban centers (Chidumayo, 2016 BTG, 2015).

Toro local governmenat area has the highest demand for the use of forest tress for charcoal production this has led to high level of deforestation. Thus varieties of trees species are used for charcoal production with no preferences to quality of the wood. Hence trees are being failed indiscriminately.

One area in which this can be reduced to minimal is by changing the pattern and use of all kinds of trees as source of wood for charcoal to those plants species that can produce the desire energy for specific purpose in the study area.

Trees (wood plants) hence different calorific contents on previous research findings have identified some plants species with high calorific value in Toro local government area (Chidumayo, 2015) but their biomass status in the wild were not known to science in the study area this research is inform with the need to minimize or provide possible solution by establishing the biomass status of those trees with high calorific value used in the study area for charcoal production thereby preventing unnecessary destruction of the forest.

Toro local government has a high demand for the use of forest tree for charcoal production, this has led to a high level of deforestation, which has serve as a motivation factor for this study, to proffer solution to the indiscriminate falling of trees in the study area

**OBJECTIVE**

- To identify plant species with high calorific value in Toro LGA
- To determine the abundance (distribution) of tress with high calorific value in the study area
- To evaluate the biomass content of trees with high calorific value in Toro LGA

## II. MATERIAL AND METHODS

The study area (Toro LGA) was stratified based on the administrative divisions of namely; Toro, Jama’a and Lame districts. Lukshi forest reserve, one among five (5) other reserve in the local Government was selected for the study. Plant species with high calorific values were randomly searched in the forest using plotless method of vegetation inventory, point centre Quarter method (PCQM) along 10 parallel established transect of 100 meter length. For plant species with high calorific values references were made to the existing literature with that obtained in the forest. This will enable the researcher draw inferences.

**Method of Data Collection**

The data of this research were collected by assessing the existing literature/published data on three species with high calorific value in Toro Local Government.

The published species identified in the literature were evaluated in the field with the view to determining its status, density and abundance in the wild, using appropriate field technique (PCQM).

**Sample Size**

A minimum of 10 sample sites were chosed for the inventory of plant species along established transects of 100 meters in lukshi forest Reserve of Jama’a District. 10 sample sites are considered minimum for adequate coverage for all possible species (Sutherland, 1997; Comesky, 2001)

**Check list of Plant Species by Family in Lukshi forest Reserve, Toro Local Government Area**

Table 1 shows the check list of plant species in Lukshi forest reserved (FR) a total 27 species existed in the forest belonging ten (10) families and their distribution across the studies plot (site). Fabaceae family has the highest individual followed by Comretaceae with four (4) individual species and Annonaceae, Apocynacee, Blighiasapida, Hymenocardiacea, Vitellaria paradoxa, Logniaceae, Olacaeae have the least individual in the study site.

**Table 1: Check list of Plant Species by Family in lukshi forest Reserve, Toro Local Government Area**

| S/N | Family | Spices name | Common name | Transect 1 | Transect 2 | Transect 3 | Transect 4 |
|---|---|---|---|---|---|---|---|
| 1 | Fabaceae | Isoberlina | Farardoka | ✓ | ✓ | | ✓ |

International Journal of Advances in Engineering and Management (IJAEM)
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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | tomentosa | | | | | |
| | // | Pseducedreallar koskii | Tunas | ✓ | | ✓ | ✓ |
| | // | Daniellia Oliveri | Maje | ✓ | | | |
| | // | Dichrostachus cineria | Dundu | ✓ | | | ✓ |
| | // | Isoberlina doka | Bakarkardoka | ✓ | ✓ | ✓ | |
| | // | acacia Senegal | Dakwara | | | | |
| | // | Afromosia laxiflora | makarho | | ✓ | | |
| | // | Acacia paradoxa | Farar kaya | | ✓ | | |
| | // | Detarium microcarpum | Taura | | ✓ | | |
| | // | Piliostiqma recticulatum | Kargo | | | ✓ | ✓ |
| 2. | Comretaceae | Anogeissus leocarpus | Marke | ✓ | ✓ | ✓ | ✓ |
| | // | Terminallia avicennioi | Baushe | | ✓ | ✓ | ✓ |
| | // | Combretum Molle | Wuyandamo | | ✓ | | |
| | // | Terminalia laxiflora | Zindi | | | ✓ | ✓ |
| | // | Cumbretum gluctinosum | Faringanye | ✓ | ✓ | ✓ | ✓ |
| | // | Cumbretum nigirca | Gwanja | ✓ | | | |
| 3. | anocardiaceae | Lannea acida | Farinfaru | ✓ | | ✓ | |
| | // | Lennea microcarpa | Bakin faru | ✓ | ✓ | | ✓ |
| 4. | Rubiaceae | Gardenia aqualla | Gaude | ✓ | ✓ | | |
| | // | Crossopteryx febrifuga | Kashinawaki | | | ✓ | ✓ |
| 5. | Annonaceae | Annona senegalensis | Gondar daji | | | ✓ | ✓ |
| 6. | Apocynacee | Carrissa edulis | Lemon tsuntsu | | | | ✓ |
| 7. | Sapindaceae | Blighia sapida | Gwanja | ✓ | | | |
| 8. | Hymenocardiaceaa | Hymenocardia acida | Jan yaro | ✓ | | | |
| 9. | Sapotoideae | Vitelleria paradoxa | Kadanya | | ✓ | | |
| 10. | Logniaceae | Strychnos spinosa | Kokiya | | ✓ | | |
| 11. | Olacaeae | Xymenia americana | Tsada | | | ✓ | |

**Source: Field Survey. (2022)**

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**Table 2: Relative Abundance of Plant Species in Lukshi Forest Reserve, Toro Local Government. Objective three (3): Relative Abundance of Plant Species in Lukshi Forest Reserve, Toro Local Government.**

Table 2 shows the relative Abundance of plant Species with high calorific value in the study Area (Lukshi forest). Anogeissus leocarpus have 14.4% Cumbretum gluctinosum. 13.29% Isoberlina tomentosa 10.9% while Isoberlina doka and Gardenia aqualla have 9.8% occurrences respectively. The remaining species have percentages occurrences ranging from 0.5-8.09%.

**Relative Abundance of Plant Species in Lukshi Forest Reserve, Toro Local Government.**

| S/N | Specie | Frequency | Relative Abundance |
|---|---|---|---|
| 1. | Sclerocoya birrea | 1 | 0.5 |
| 2. | Anogeisus leocarpus | 25 | 14.4 |
| 3. | Isoberlinia tomentosa | 19 | 10.9 |
| 4. | Isoberlina doka | 17 | 9.8 |
| 5. | Lennea acida | 2 | 1.15 |
| 6. | Cumbretum gluctinosum | 23 | 13.29 |
| 7. | Pseducedrellar Koskii | 4 | 2.3 |
| 8. | Lennea microcarpa | 14 | 8.09 |
| 9. | Dichrostachus cineria | 2 | 1.15 |
| 10. | Cumbretum nigrican | 1 | 0.5 |
| 11. | Danellia oliveri | 5 | 2.8 |
| 12. | acacia senegal | 4 | 2.3 |
| 13. | Gardenia aqualla | 17 | 9.8 |
| 14. | Hymenocardia acida | 3 | 1.7 |
| 15. | Terminallia avicennioide | 8 | 4.6 |
| 16. | Combretum Molle | 5 | 2.8 |
| 17. | Afromosia laxiflora | 1 | 0.5 |
| 18. | Vitellaria paradoxa | 2 | 1.15 |
| 19. | Acacia paradoxa | 1 | 0.5 |
| 20. | Strychno saspinosa | 1 | 0.5 |
| 21. | Detarium microcarpum | 3 | 1.7 |
| 22. | Annona senegalensis | 2 | 1.15 |
| 23. | Piliostiqma recticulatum | 3 | 1.7 |
| 24. | Terminalia laxiflora | 1 | 0.5 |
| 25. | Xyminia americana | 1 | 0.5 |
| 26. | Crossopteryx febrifuga | 6 | 0.5 |
| 27. | Cariesa soplis | 2 | 1.15 |
| | Total | 173 | |

Source : Field Survey, (2022)

**Table 3: Plant Species with High Calorific Values in Toro Local Government Area.**

Data obtained from the secondary sources indicated 17 species belonging to 6 families with high calorific values ranging from 13.47mj/kg Adamu (2013) – 21.58 Adedeji (2015).

**Calorific value of plant species in lukshi forest reserve, Toro Local Government.**

| S/N | Species | Calorific Value | Source |
|---|---|---|---|
| 1. | Acasia albida | * 13.47 mj/kg | Adamu, 2013 |
| | | ** 13.29 mj/kg | Adedeji, 2015 |
| 2. | Acacia nilotica | * 12.37 mj/kg | Adamu, 2013 |
| | | ** 12.42 mj/kg | Adedeji, 2015 |

| | | | |
|---|---|---|---|
| 3. | Anogeisus leocarpus | *21.58 mj/kg<br>** 21.49 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 4. | Balanite egyptiaca | *10.72 mj/kg<br>**10.98 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 5. | Detarium macrocarpum | * 15. 32 mj/kg<br>**15.29 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 6. | Diopyrus spilitoruis | * 17.80 mj/kg<br>** 17.90 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 7. | Khaya senegalensis | * 15:01 mj/kg<br>** 15:00 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 8. | Parkia biglobosą | *12.72 mj/kg<br>**12.70 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 9. | Prosopis Africana | * 16.14 mj/kg<br>**16.16 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 10. | Zyziphus – spina –christi | *12.40 mj/kg<br>**12.42 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 11. | Vitellaria paradoza | *19.73 mj/kg<br>**19.71 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 12. | Burkia Africana | *15.63 mj/kg<br>**15.57 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 13. | Pterocarpus erinaceus | *19.31 mj/kg<br>**19.25 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 14. | Isoberlina doka | *19.80 mj/kg<br>**20.200 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 15. | Afzelia Africana | *18.71 mj/kg<br>**18.69 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 16. | Peterocopsis laxiflora | *14.21 mj/kg<br>**14.30 mj/kg | Adamu, 2013<br>Adedeji, 2015 |
| 17. | Terminalia glaucoscens | *20.15 mj/kg<br>**20.76 mj/kg | Adamu, 2013<br>Adedeji, 2015 |

**Key: *Adamu, (2013); ** Adedeji; (2015).**
**Source:** Adopted and Modified Adamu, (2013) and Adedeji; (2015)

**Table 4: Status of Plant Species with High Calorific Value in Lukshi Forest Reserved Toro Local Government**

Table 4 shows the status of plant species with high calorific values in the Lukshi Forest reserved Toro Local Government area with their relative percentage occurrences. The result indicated that a total of Six (6) species belonging to 3 families exited in the forest reserved this include Cumbretacea, Fabaceae and Rubiaceae. Anogeisus leocarpus have the highest percentage occurrence of 14.4%, Isobarlina doka have 9.8, other species have percentage occurrence of 0.5 – 4.6% in the forest reserved .

**Table 4: Status of Plant Species with High Calorific Value in Lukshi Forest Reserved Toro Local Government**

| S/N | | Species | Frequency | Relative percentage occurrence |
|---|---|---|---|---|
| 1 | Cumbretacea, | Anogeisus leocarpus | 25 | 14.4 |
| 2 | “ | Detarium macrocarpum | 3 | 1.7 |
| 3. | “ | Vitellaria paradoza | 2 | 1.15 |
| 4. | Fabaceae | Afromosia laxiflora | 1 | 0.5 |
| 5. | “ | Isoberlina doka | 17 | 9.8 |
| 6. | Rubiaceae | Terminalia laucoscens | 8 | 4.6 |

Source: Field Survey, (2022)

**Table 5: Absolute Density of Plant Species with High Calorific Value in Lukshi Forest Reserved (2,600Ha=2.6km) Toro Local Government.**

Table 4 shows the absolute density of plant species with high calorific value. The result indicated that Cumbretaceae represented by two species Anogeisus leocarpus, Deterium macrocarpum andVitellaria paradoza have an absolute density of 9.6, 1.2 and 0.8 while Fabaceae family represented by two species namely Afromosia laxiflora and Isobalina doka have absolute density of 0.4 and 6.5. Rubiaceae represented by one species have an absolute value of 3.1 per $km^2$.

**Table 5: Absolute Density of Plant Species with High Calorific Value in Lukshi Forest Reserved (2,600Ha=2.6km) Toro Local Government.**

| **S/N** | | **Species** | **Frequency** | **Absolute Density/$Km^2$** |
|---|---|---|---|---|
| 1 | Cumbretacea, | Anogeisus leocarpus | 25 | 9.6 |
| 2 | “ | Detarium macrocarpum | 3 | 1.2 |
| 3. | “ | Vitellaria paradoza | 2 | 0.8 |
| 4. | Fabaceae | Afromosia laxiflora | 1 | 0.4 |
| 5. | “ | Isoberlina doka | 17 | 6.5 |
| 6. | Rubiaceae | Terminalia laucoscens | 8 | 3.1 |

Source: Field Survey, 2022

**Table 6: Plant Species Relative Basal Area (BA) in Lukshi Forest Reserve Toro LGA**

Table 6 shows total basal area of plant species in Lushi Forest Reserve. The result indicated that Isoberlinia doka, Anogeissus leioearpus and Lennea acid have the highest basal area of 15, 200; 9, 700 and 5, 400cm. Gymnospria senegslensis and Terminalia lexiflora are the species with least basal area of 25cm and 75cm. However, species basal area with high calorific value (Adamu, 2013; Adadeji, 2015) in the study site include Anogeissus leioearpus 9, 700cm$^3$ Isoberlinia eloka 15,200cm$^3$, Terminallia avicenniodes 850cm$^3$, Afromosia Laxiflora 1950cm$^3$, Detorium microcupum 1450cm$^3$.

**Table 6: Plant Species Relative Basal Area (BA) in Lukshi Forest Reserve. Toro LGA**

| | SP Scientific Name | SP Common Name | Dbh | BA(cm$^3$) |
|---|---|---|---|---|
| 1 | Sclerocoya birrea | Danya | 9 | 450 |
| 2 | Anogeisus leiocarpus | Marke | 194 | 9700* |
| 3 | Isoberlina tementosa | Farar doka | 138 | 6900 |
| 4 | Isoberlina eloka | Bakar doka | 304 | 15200* |
| 5 | Lanea acid | Farin faru | 17 | 850 |
| 6 | Cumbretum gluetinosum | Farin gauge | 77 | 3850 |
| 7 | Pseducedrellar coskaii | Tunas | 54 | 2700 |
| 8 | Lennea acid | Bakin faru | 108 | 5400 |
| 9 | Dichrostachus cineria | Dundi | 6 | 300 |
| 10 | Blighia sapida | Gwanja | 6 | 0.5 |
| 11 | Danellia Olinner | Maje | 12 | 600 |
| 12 | Acalia Senegal | Dakwara | 47 | 3240 |
| 13 | Gardenia aqualla | Gaude | 26 | 1300 |
| 14 | Hymenocardia acida | Jan yaro | 91 | 4550 |
| 15 | Terminallia avicenniodes | Baushe | 17 | 850* |
| 16 | Conbreturn Mollea | Wuyan damo | 73 | 3650 |
| 17 | Afromosia Laxiflora | Makarho | 39 | 1950* |
| 18 | Vitellaria Paradoxa | Kadanya | 10 | 500* |
| 19 | Acacia paradoxa | Farar kaya | 2 | 100 |
| 20 | Strychuosa spinosa | Kokiya | 8 | 400 |
| 21 | Detorium microcupum | Taura | 1 | 1450* |
| 22 | Annona seneglensis | Goudar daji | 29 | 1450 |
| 23 | Piliostigma recticulatun | Kargo | 12 | 600 |
| 24 | Terminallia lexiflora | Zindi | 23 | 1150 |
| 25 | Gymnospria seneglesis | Tsada | 15 | 75 |
| 26 | Crossoporyx febrifuga | Kashin awaki | 5 | 25 |
| 27 | Carrisa edulis | Lemon tsantsu | 82 | 4100 |

**Source:Field Survey, ( 2022).**

## III. LITERATURE REVIEW

### Concept of Charcoal

Charcoal is a lightweight black carbon residue produced by strongly heating wood (or other animal and plant materials) in minimal oxygen to remove all water and volatile constituents. In the traditional version of this pyrolysis process, called charcoal burning, the heat is supplied by burning part of the starting material itself, with a limited supply of oxygen. The material can also be heated in a closed retort (Himraj, 2017).

This process happens inadvertently while burning wood, as in a fireplace or wood stove. The visible flame in these is due to combustion of the volatile gases exuded as the wood turns into charcoal. The soot and smoke commonly given off by wood fires result from incomplete combustion of those volatiles. Charcoal burns at a higher temperature than wood, with hardly a visible flame, and releases almost nothing except heat (Massey, 2018).

**Charcoal**, impure form of graphitic carbon, obtained as a residue when carbonaceous material is partially burned, or heated with limited access of air. Coke, carbon black, and soot may be regarded as forms of charcoal; other forms often are designated by the name of the materials, such as wood, blood, bone, and so on, from which they are derived. Charcoal has been replaced by coke for reducing metal ores in blast furnaces and by natural gas as a source of carbon in making certain chemicals, but it is still employed in making black gunpowder and in case-hardening metals. Formerly, charcoal production from wood was an important source of acetone, methyl alcohol, and acetic acid, all of which are now produced from other raw materials. (Etukudo, 2018).

The use of special manufacturing techniques results in highly porous charcoals that have surface areas of 300–2,000 square metres per gram. These so-called active, or activated, charcoals are widely used to adsorb odorous or coloured substances from gases or liquids, as in the purification of drinking water, sugar, and many other products, in the recovery of solvents and other volatile materials, and in gas masks for the removal of toxic compounds from the air. They also are used as catalysts in making certain chemicals (e.g., phosgene, sulfuryl chloride) or as supports for other catalytic agents (Himraj, 2017).

**Production of Charcoal**

The production of wood charcoal in locations where there is an abundance of wood dates back to ancient times. It generally begins with piling billets of wood on their ends to form a conical pile. Openings are left at the bottom to admit air, with a central shaft serving as a flue. The whole pile is covered with turf or moistened clay. The firing is begun at the bottom of the flue, and gradually spreads outward and upward. The success of the operation depends upon the rate of the combustion. Under average conditions wood yields about 60% charcoal by volume, or 25% by weight; small-scale production methods often yield only about 50% by volume, while large-scale methods enabled higher yields of about 90% by the 17th century. The operation is so delicate that it was generally left to colliers (professional charcoal burners). They often lived alone in small huts to tend their wood piles. For example, in the Harz Mountains of Germany, charcoal burners lived in conical huts called Köten which are extant today (Massey, 2017).

**Charcoal Production Methods**

Charcoal has been made by various methods. The traditional method in Britain used a clamp. Rabier, (2016) this is essentially a pile of wooden logs (e.g. seasoned oak) leaning in a circle against a chimney. The chimney consists of 4 wooden stakes held up by some rope. The logs are completely covered with soil and straw allowing no air to enter. It must be lit by introducing some burning fuel into the chimney; the logs burn very slowly and transform into charcoal in a period of 5 days' burning. If the soil covering gets torn or cracked by the fire, additional soil is placed on the cracks. Rabier, (2016) once the burn is complete, the chimney is plugged to prevent air from entering. The true art of this production method is in managing the sufficient generation of heat, by combusting part of the wood material, and its transfer to wood parts in the process of being carbonised. A strong disadvantage of this production method is the huge amount of emissions that are harmful to human health and the environment (emissions of unburnt methane) (Bailey 2018). As a result of the partial combustion of wood material, the efficiency of the traditional method is low.

Modern methods employ retorting technology, in which process heat is recovered from, and solely provided by, the combustion of gas released during carbonization (Bailey, 2018).

**Types of Charcoal**

i. Common charcoal is made from peat, coal, wood, coconut shell, or petroleum.
ii. Sugar charcoal is obtained from the carbonization of sugar and is particularly pure. It is purified by boiling with acids to remove any mineral matter and is then burned for a long time in a current of chlorine to remove the last traces of hydrogen. Ogunsanwo, (2018) it was used by Henri Moissan in his early attempt to create synthetic diamonds (Bailey, 2018).
iii. Activated charcoal is similar to common charcoal but is manufactured especially for medical use. To produce activated charcoal, common charcoal is heated to about 900 °C (1,650 °F) in the presence of a gas (usually steam), causing the charcoal to develop many internal spaces, or "pores", which help the activated charcoal to trap chemicals. Impurities on the surface of the charcoal are also removed during this process, greatly increasing its adsorption capacity (Hines, 2019).
iv. Lump charcoal is a traditional charcoal made directly from hardwood material. It usually produces far less ash than briquettes.
v. Japanese charcoal has had pyroligneous acid removed during the charcoal making; it therefore produces almost no smell or smoke when burned. The traditional charcoal of Japan is classified into three types:

International Journal of Advances in Engineering and Management (IJAEM)
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a. White charcoal (Binchōtan) is very hard and produces a metallic sound when struck.
b. Black charcoal
c. Ogatan is a more recent type made from hardened sawdust.

vi. Pillow shaped briquettes are made by compressing charcoal, typically made from sawdust and other wood by-products, with a binder and other additives. The binder is usually starch. Briquettes may also include brown coal (heat source), mineral carbon (heat source), borax, sodium nitrate (ignition aid), limestone (ash-whitening agent), raw sawdust (ignition aid), and other additives (Hines, 2019).

vii. Sawdust briquette charcoal is made by compressing sawdust without binders or additives. It is the preferred charcoal in Taiwan, Korea, Greece, and the Middle East. It has a round hole through the center, with a hexagonal intersection. It is used primarily for barbecue as it produces no odour, no smoke, little ash, high heat, and long burning hours (exceeding 4 hours).

viii. Extruded charcoal is made by extruding either raw ground wood or carbonized wood into logs without the use of a binder. The heat and pressure of the extruding process hold the charcoal together. If the extrusion is made from raw wood material, the extruded logs are subsequently carbonized (Rabier, 2016).

**Uses of Charcoal**

Charcoal has been used since earliest times for a large range of purposes including art and medicine, but by far its most important use has been as a metallurgical fuel. Charcoal is the traditional fuel of a blacksmith's forge and other applications where an intense heat is required. Charcoal was also used historically as a source of black pigment by grinding it up. In this form charcoal was important to early chemists and was a constituent of formulas for mixtures such as black powder. Due to its high surface area charcoal can be used as a filter, and as a catalystor as an adsorbent (Himraj, 2017).

**Calorific Value (Heating Value)**

Calorific value is defined as the amount of calories generated when a unit amount of substance is completely oxidized and is determined using the bomb calorimeter. The calorific value of coal represents gross calorific value ($H_G$), which contains the latent heat of water vaporization. When the latent heat of water vaporization is not included, the calorific value is called net calorific value ($H_N$). The relationship between gross calorific value and net calorific value is expressed by the following equation:

HN = HG – 600 (w + 9h) -- for (1)

where w is the moisture content and h is the hydrogen content under a constant moisture base.

The technology of taking briquettes as a kind of fuel has been widely used in many countries for both domestic and industrial purposes.

Briquette technology, as an important recycling system for the agricultural and industrial waste, has always contributed to offset forest and fossil fuels, bio-residue management problems and reduce toxic emissions from incomplete carbonization besides energy production development.

Common types of briquette now used are biomass. coal and charcoal, etc.

An important characteristic of the fuel briquette is its calorific value, according to the Dictionary of Mechanical Engineering (2014), the calorific value of a fuel (or heat of combustion or heating value or heat value) is defined as “the energy released per unit mass of fuel in complete combustion with oxygen.” Briefly for shortness, that is, the amount of energy (per kg) it exudes during combustion.

The calorific value determines the briquette efficient carbonization and heat value.

Although briquettes, as with most solid fuels, are priced by mass or volume and ease of handling, market forces set the price of each fuel according to its energy content.

Thus, the calorific value can be used to evaluate the competitiveness of a processed biomass fuel in a given market situation. The production cost of briquettes is, however, independent of their calorific values. The Calorific Value is constantly monitored, and it is a condition of the Gas (Safety) Management Regulations 1996 that alterations in the declared Calorific Value (CV) are publicly made known. It is customary to quote the Gross (Upper) CV rather than the Net (Lower) CV. The difference between the two represents the heat contained in the latent heat of vaporization of the water vapour in the products of combustion which can only be recovered in condensing appliances. The ratio of net/gross CV is about 90%, reflecting the high hydrocarbon/carbon ratio for gas. The range of declared CV (gross) is 38–39 $MJ/m^3$ with a typical value of 38.63 $MJ/m^3$. This latter figure represents a net CV of 34.88 $MJ/m^3$.

## IV. SUMMARY OF THE FINDINGS

The result obtained indicated that, there were 17 species of trees with high calorific value in Toro Local government (Adamu, 2013 and Adedeji, 2015), Field investigation reviled six (6) species with high calorific value. Anogeisus leocarpus has the highest percentage accorance of 14.4% followed by Isoberlina doka with 9.8%. Other species with high calorific value includes Detarium microcarpum, Vitellaria paradoza with 1.7 % and 1.15% respectively. Correspondently, the aforementioned species have the highset absolute density in the reserved. Anogeisus leocarpus led the density of 9.6, Isobarlina doka led 6.5, while Deuterium microcarpum 1.2 and Terminalia leucoscense 3%, species with highest relative dominance recorded include also Anogeisus leocarpus, 21.53 cm3 and Isoberlina doka 13.73cm3. From the field of investigation, Isobarlina doka, Anogeisus leocarpus, and Leanea species have a basal area value ranging from 9700cm, 6900cm and 850cm cumulatively, indicating low basal area (Juveniles trees) compare to the study area conducted by Adamu (2013) and Adedeji (2015) of matured trees with high calorific value of 15,200cm3, 11,700cm3 and 5,400cm3 of the similar species from the same study area of Bauchi south.

## V. CONCLUSION

Filed investigation further revealed that the preponderance of species with high calorific value in the reserve was in connected with the reproductive potentials of the species producing eight sexually or bia sexually (Seed and vegetation). However, the existence of these species in the reserved further exposes the reserve to continues human perturbation. The plorifulation of species with low calorifi value in the reserve further sustained the reserve and maintained its ecological integrity. Also discovered during the field investigation include, the present of loggers, Cattle grazing and local mining in the reserve. Aiding and abiding by the forest guard for loggers to continue their nefarious activities in the reserve threatened the validity of the reserve status.

Finding of this study indicated that there is a shape decline of about 78.8% of the total plant species with high calorific value in Toro Local government as compared to the number obtained 10 years ago (Adamu,2013) and Eight (8) years ago Adedeji (2015). The negative trend is associated to increased anthropogenic activities in and around the reserve, change in logging preference by logger targeting species with high calorific value increase in charcoal production, mining and over greasing were some of the associated threat factors disturbing the reserve. In addition, poor management practices in the reserve further compounded the problem over the years. Similarly the result further shows abysmal net negative trend on other species with low calorific value with significant reduction in density, and basal area covered. The study also revealed that Lukshi forest reserve still have the potentials of sustaining itself looking at preponderance of plant species with good regenerative potentials if adequate protection is given.

## VI. RECOMMENDATION

The conservation and sustainable utilization of these resources are crucial. These time in other to alleviate this challenges it may be better to take the following measures.

1. The study recommended the improve eduration and awareness campaign to the inhabitant of Toro and the state at large on the implication of deforestation and lost of biodiversity among others

1. There should be aggressive campaign regulating the impact of forest trees destruction for charcoal production especially Anogeisus leocarpus, Isoberline doka etc.

2.Expansion of alternative energy source to reduce the dependency on charcoal should be provided

3.Massive afforestation program need to be carried out in the study area in form of planting more indigenous trees species

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