SOPRONI EGYETEM
ERDŐMÉRNÖKI KAR

Az Erdőmérnöki Kar Tudományos Kiadványa

Szerkesztette: Czimber Kornél

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SOPRON, 2023

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Tartalomjegyzék

INDIGENOUS KNOWLEDGE ON BIOMASS FUEL QUALITY AT DRY LANDS OF SOUTHERN DARFUR STATE, SUDAN

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Abstract

This study was designed to identify the perceptions of local dryland savanna communities about the characteristics of biomass fuels for energy use. The survey was conducted using stratified sampling technique. The questionnaire covered various topics related to consumers and the characteristics of biomass for energy use. For the most frequently energetically used tree species, the use value, fidelity level and the factor informant consensus of the informants were calculated. According to the highest use values, Acacia mellifera, Capparis decidua, Dalbergia melanoxylon, and Acacia nilotica were the most important energy tree species in the study area. In the manufacture of bricks, sustained combustion is most desirable, while for bakeries and domestic use rapid ignition and low smoke production are preferred. Therefore, it is necessary to support the results of this study by further investigation of the characteristics of the selected species and their verification in the laboratory.

Introduction

In recent years, there has been increasing interest in the use of biomass as an alternative energy source, as it can be used in a sustainable manner with minimal negative impact on the atmosphere (Solarin et al., 2018). Therefore, many countries around the world, including Africa, are striving to increase their biomass production for energy use. In Sudan, one of the African countries, about 87% of primary energy consumption comes from biomass (Galal, 1997). The biomass represents the main source of energy in rural areas and towns, specially that have less LPG (liquefied petroleum gas) distribution in Sudan. Biomass energy is used for numerous domestic purposes including cooking, heating, bakeries, and bricks making. The increased energy needs, due to increasing population and IDPs (internally displaced people) in Sudan, has caused significant overexploitation and depletion in forest resources and change the species used for energy as stated by United Nation Environmental Program (UNEP report, 2008). The change from conventional species, that has traditionally favourable energy properties, to new species with low energy quality may put the new species under pressure and depletion as occur with species that has desirable energy properties. Thus, rehabilitation of the degraded species is required shortly after, but before the species selection as source of biomass feedstock, is very important because of their effect on the different properties of the fuel (Gonçalves et al., 2018, Neves et al., 2011). An assessing biomass quality is therefore vital to decide on its feasibility for utilization. As combustion is a dominant feature of converting biomass fuel to energy in Sudan. There are important properties for biomass combustion we should pay attention to, such as biomass moisture content, density, and ash content. For instance, the high moisture content is effect on transport, storage and energy content therefore the proper moisture content ratio must be less than 20%; but regarding to the biomass density is correlate positively with heat value that because more material is available, many scholar recommend that the biomass density should be as high as possible (Meincken et al., 2014); while ash content should be as low as possible because it relate with materials cause gases emission which can influence seriously on the environment and human health, in addition the ash content is correlate negatively with heat value (AHMED, 2021). Along with the state plans of energy plantation appropriate species must be selected with ideal properties for efficient energy and sustainable biomass supply. Alternative sustainable approaches are needed to keep pace with the growing demand for biomass feedstock. Therefore, this study pursued ethnobotany methods to take advantages from local people knowledge about the desired properties in local species for energy production, and document them scientifically. Thus, the result and recommendations of this study will be from point of view of consumers, and this may be useful for decision makers to give them a prediction about what favourable species, most consumed, more vulnerable to deterioration species and what properties should be available in species for energy plantation.

Material and methods

The study area was selected with reference to FNC (1994), and UNEP (2008) reports which reveal biomass fuel consumption in Sudan. For the purpose of this study, we selected south Darfur state, which was reported, by FNC and UNDP, as the highest wood fuel consumption and most populous state in Sudan. The study area expands between latitudes 8°30′ to 13°′N and longitudes 23°15′to 28°E (ABAKER ET AL., 2017) in open thorn savannas with sparse arboreal cover where the dominant plants formation are acacia species. The selected area lies in a subtropical steppe climate (figure 1) where the temperature reaches 29.57 ºC, which is - 0.47% lower than Sudan’s averages, and the annual precipitation reaches about 62.49 ml.

Figure 1. Location of study area in Sudan map

A combination of qualitative and quantitative data collection methods was used to gather both primary and secondary data. The primary data were collected through field survey conducted during September 2021. A local people biomass consumption pattern (cooking, bakeries, and brick making) was our standard for target group determination. The field survey was started with key informant interviews including experts and individuals who have first-hand information about the appropriate species for bioenergy. The data collection was conducted using stratified sampling technique. About 92 questionnaires were designed to covered different issues related to the consumers and biomass characteristics for energy such as major species used for energy, preferences characteristics of biomass for energy, consumption pattern. Furthermore, group discussions were held with the local leaders to complement and verify the data collected through the consumers survey.

Data analysis

The data from questionnaires were transformed into codes. Statistical Package for Social Sciences (version 26) software was used in the analysis. Frequency distribution and percentage were calculated as a tool of analysis for interpreting the qualitative information collected from the respondents. The use value was calculated to find out the proportional importance of energy trees species to each consumer's category in the study area. It was calculated by the following equation 1:

$$\mathrm{UV} = \frac{\sum \mathrm{Ui}}{\mathrm{n}} \quad (1)$$

Where UV stands for the total use value of the energy trees species, whereas U refers to the number of use reports cited by each respondent for a given species, and n stands the total number of respondents interviewed for a given species Fidelity level (FL) was also computed to determine the FL values of the most frequently used tree species for energy it was calculated by the formula 2:

$$FL = \frac{\mathrm{NP}}{\mathrm{n}} \quad (2)$$

Where NP stands for the number of use reports cited for a given species for a particular use and N refers to the total number of use reports cited for any given energy species. Factor informant consensus (FIC) also were calculated to identify the widely tree species used for energy. The FIC can be calculated using the formula as follows equation 3:

$$FIC = \frac{\mathrm{nur-nt}}{\mathrm{nur-1}} \quad (3)$$

Where FIC = informants consensus factor, nur = number of use citation in each category, and nt = number of species used (KHAN ET AL., 2014).

Result and discussion

This study documented 18 indigenous tree species belonging to 14 genus and 11 families, which are used for energy purposes (Table 1). The plant family *Mimosoideae* contributed the highest number of energy tree species (6) followed by *Combretaceae* (3) and *Fabaceae* (2) (Table 1). Among the total documented energy tree species, respondents stated that *Acacia seyal* (60%) is the most preferred species for domestic use followed by *Calotropis procera* 22% respectively (figure 2). In spite the latter (C*alotropis procera*) have low quality than other species such as *Acacia seyal, Acacia mellifera* and *Acacia nilotica*, the main reason for utilizing them is due to the degeneration of desirable species therefore households turned into using other species (BALAT ET AL., 2003). This result agrees UNEP report (2008) stated that there is overexploitation of local tree species due to meet energy needs, this has caused significant depletion in forest resources and change the species used for energy. Results showed that *Acacia mellifera* 72%, *Acacia nilotica* 16% and *Albizia amara*12% respectively is most preferred species for bakeries (figure 2). While for brick making respondents stated that *Acacia nilotica* has got higher ratio 70% among the most preferred species for brick making, followed by *Acacia mellifera* 17% and *Vachellia tortilis* 13% respectively (figure 2). Brick making or bread making each of them are required a particular biomass property, for example about 56% of respondents mentioned that sustainable combustion is most desired property for brick making (figure 3) which is the time between flame extinction and residence time according to PRIOR ET AL., (2018) that means brick makers prefer long fuel combustion residence time. USID (2008) reported that brick makers prefer slow burning fuel because it takes much longer to cook than bread thus sometimes, they use green wood rather than dead wood. While bakeries preferred haste ignition and low smoke 52% and 27% respectively (figure 3). According to the individual interview statements ignitability is very importance property for bakeries because bread does not take long time to cooking just needs haste ignition. While high smoke due to emissions of pollutants such as NOx and SO2 during biomass combustion it may harm bakeries workers health because it causes a lung and eye irritant and others health problem (Cardoso ET AL., 2018; AHMED, 2021). People in the study area give priority for some traditional energy tree species for energy utilization. Which is *Acacia mellifera*, *Acacia nilotica*, *Acacia seyal*, *Vachellia tortilis*, *Albizia amara*, *Calotropis procera*, *Balanites aegyptiaca*, *Hayphaene thebaica* and *Dalbergia melanoxylon* (table 1). And the use values (UV) results showed that *Acacia mellifera* 0.51 followed by *Acacia nilotica* 0.42 are found to be the most important energy tree species than others local tree species (table 2).

Table 1. The common energy trees species in study area:

No	Species	Family	Local name
1	Calotropis procera	Asclepiadaceae	Oshar
2	Balanites aegyptiaca	Zygophylaceae	Higlig
3	Capparis decidua	Capparaceae	Tundob
4	Anogeissus leiocarpus	Combretaceae	Sahab
5	Combretum ghasalense	Combretaceae	Habil
6	Acacia senegal	Mimosoideae	Hashab
7	Acacia seyal	Mimosoideae	Talah
8	Acacia nilotica	Mimosoideae	Sonut
9	Acacia mellifera	Mimosoideae	Kiter
10	Albizia amara	Mimosoideae	Arad
11	Dalbergia melanoxylon	Papilionoideae	Abanus
12	Ziziphus muritania	Rhaminaceae	Sider
13	Hayphaene thebaica	Arecaceae	Dom
14	Vachellia tortilis	Fabaceae	Syal
15	Guiera senegalensis	Combretaceae	Khebash
16	Faidherbia albida	Fabaceae	Haraz
17	Prosopis chilensis	Mimosaceae	Muskat
18	Salvadora persica	Salvadoraceae	Arak

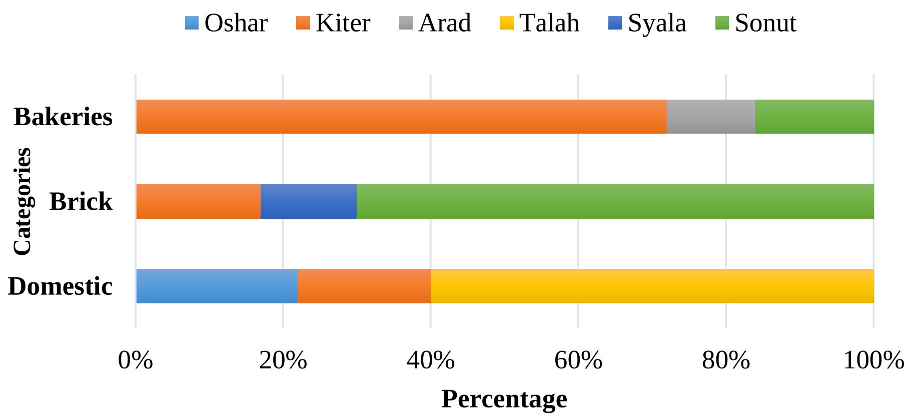

Figure 2. Preferred energy tree species according to utilization categories

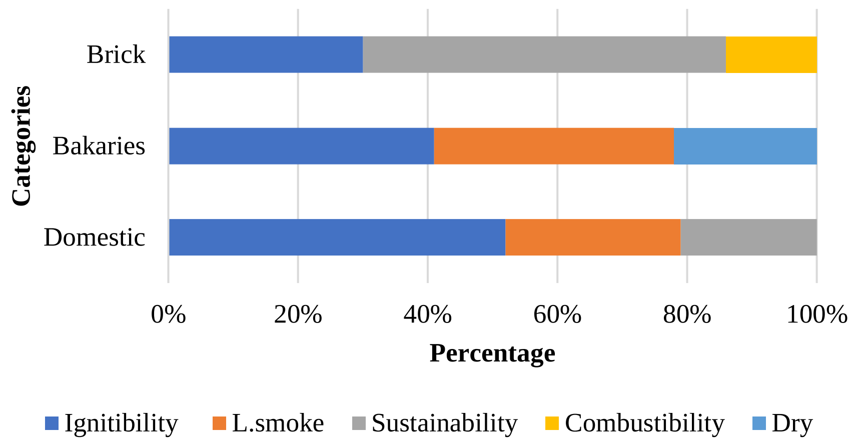

Figure3. Preferred energy tree species characteristics by utilization categories

Table 2. The use values (UV) of local energy tree species:

NO	Specie name	Number of use reports ∑Ui	Use value UV
1	Calotropis procera	27	0.29
2	Acacia mellifera	47	0.51
3	Albizia amara	23	0.25
4	Acacia seyal	1	0.01
5	Dalbergia melanoxylon	37	0.40
6	Vachellia tortilis	7	0.07
7	Acacia nilotica	30	0.33
8	Capparis decidua	39	0.42
9	Anogeissus leiocarpus	2	0.02
10	Balanites aegyptiaca	2	0.02
11	Ziziphus muritania	12	0.13
12	***Guiera senegalensis***	3	0.03
13	***Faidherbia albida***	1	0.01
14	Acacia senegal	6	0.07
15	Salvadora persica	1	0.01
16	Hayphaene thebaica	5	0.05
17	***Prosopis chilensis***	1	0.01

Informant consensus factor (FIC) results shown that sustainability scored the highest FIC value (0.89) followed by combustibility (0.88), and ignitibility was also the top recorded biomass properties preferred by informant (0.85) (table 3). High FIC value gives an indication that these properties are more prevalent in study area.

Table 3. FIC values of traditional energy trees species properties in study area:

Properties categories	Number of species (Nt)	Number of properties report (Nur)	Consensus factor
Sustainability	11	90	0.89
Combustibility	11	84	0.88
Ignitibility	9	54	0.85
Dry	3	9	0.75
Low smoke	5	12	0.64

The energy species that are widely used by the local people because of their properties have higher FL values than those that are less popular. FL values in this study varied from 34% to 83%. *Acacia seyal* has high value 83% as characterized by high combustibility followed by *Acacia nilotica* 69% and *Albizia amara* 34% which they characterized by sustainable combustion. While *Vachellia tortilis* 56% and *Acacia mellifera* 36% characterized by haste ignitability (table 4). Physicochemical properties of biomass are varied, and this variation is related to the quantity, quality, moisture content and aeration of biomass, which is due influence on their flammability. For instance, biomass quantity increases combustion, but is also likely to enhance sustainability, as more fuel takes longer to burn. While moisture content is the main influencer on ignitability, where species with higher moisture contents took longer to ignite and burnt at a slower rate (SIMPSON ET AL., 2016).

Table 4. Fidelity level value and properties of energy tree species commonly reported:

Species name	Properties category	Citation for properties	Fidelity level (%)
Acacia seyal	Combustibility	31	83%
Acacia nilotica	Sustainability	27	69%
Vachellia tortilis	Ignitibility	17	56%
Acacia mellifera	Ignitibility	17	36%
Albizia amara	Sustainability	8	34%

Conclusion

The results proven that local people exploiting their traditional knowledge to select energy species based on their properties. Among the most important of local species used for energy production was *Acacia mellifera* which is characterized by ignitibility and *Acacia nilotica* characterized by sustainable combustion, these species based on their properties are considered as favourable for all biomass energy consumers in study area whether for domestic use or brickmaking and bakeries. Therefore, the focus on these species is enormous and may lead to degrade or extinction them. Strengthening the results of this study with further research on the characteristics of the selected species and laboratory verification is required. As rehabilitate the degraded species the energy plantation and agroforestry programs should be undertaken.

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