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Livelihood Diversification in Relation to The Use of Forests Products by Local Communities of The Nuba Mountains of South Kordofan State, Sudan

Ismail Mirghani Ismail[1]; Mohamed El Mukhtar Ballal[2]

[1] *Forestry and Gum Arabic Research Centre, Agricultural Research Corporation, Khartoum, Sudan*

[2]*Freelancer (Forestry and gum Arabic expert)*

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*Corresponding author: Ismail Mirghani Ismail
E-mail: ismail.mirghani@yahoo.com
Phone: +249923339313

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ABSTRACT

The Nuba Mountains in the South Kordofan State of Sudan are endowed with a tremendous legacy of traditional knowledge and rich diversity of tree species and related products that are used for domestic purposes, as income sources, and for export. The objective of the present study was to assess the importance of traditional knowledge in the management of forests and their products for improved livelihoods of the local communities in the state. The study was conducted at the Kalogi locality in the Eastern Nuba Mountains. The area is covered by several isolated hills surrounded by clay and sandy Kalogi-clay plains characterized by a number of natural seasonal watercourses and good natural drainage. A participatory rural appraisal survey was carried out whereby focused group discussions and interviews were conducted in a number of villages. Data and information on indigenous trees, their relative importance, and values in relation to the livelihoods of the local peoples were collected. The results showed high diversity in forest types and species and a wide variety of NWFPs belonging to 24 different families. The frequency indices for a number of species range between 64-70 percent. The study has determined the number and percentage of woody species in each use category. In this respect, the study showed that the species with the highest use-value were mainly the gum-producing species, namely *Acacia senegal, Acacia seyal,* and *Acacia polyacantha,* in addition to some food and medicinal plants. Important Value Indices (IVI) as high as 0.95 for edible fruits, medicinal materials, and gum products were reached. The importance of the different tree species as measured by fidelity level for a particular usage by the local people was also determined.

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INTRODUCTION

South Kordofan State lies between latitudes 10° 25′ and 11° 15′ N; longitudes 29° 25′ to 32° E. The state covers an area of about 135,000 km^2 encompassing 16 localities, namely: Algoz, Gadeer (Kalogi), Heban, Talodi, Alleri, AbuGibeiha, Kadogli, Habela, Dalami, Alboram, Altadamon, Rashad, Alabassia, AlDalang, Eastern countryside, Um Dorein). It has a total population of about 1.4 million. The annual rainfall varies between 500-800 mm, with peak heavy rains in August. The average relative humidity is about 16% in the summer season in March and reaches up to 80% during the peak rainy season in August. The mean maximum temperature in the hot months of March, April, and May is about 39˚C, with a peak in May. The mean minimum temperature varies from 17˚C in January to more than 20˚C at the onset of the rains (SKDP, 2000).

The soil in the state is sandy in its northern parts and clayey, characterized by heavy cracks, in the southern plains of the Nuba Mountains. The sandy soils cover an area of about 50% of the cultivable land, while the clay soils cover only 40%. The sandy are deep, containing coarse to fine sand with low organic matter. The clay soils are dark vertisols, low in nitrogen and phosphorus. Interspaced silt depressions with sandy clays are prevalent in the area and cover about 10% of the total cultivable land (IFAD, 2007).

Traditional knowledge has been and is still used by rural communities, especially farmers and pastoralists in Sudan, in the management and rational use of natural resources as food, source of income, and for medicinal purposes. In this respect, some coping strategies were outlined by El Siddig (2001); Abdel Magid and Badi (2002), and Ballal et al. (2014). Examples of local community management of *Acacia senegal* for sustainable production of gum arabic and agricultural crops were given by Ballal et al., (2008). However, the existence of a huge heritage of traditional knowledge that has not been explored, especially in the Western Nuba mountains of South Kordofan state, makes the need for exploring that knowledge for revival and improvement by researchers for the benefit of the disadvantaged small farmers and collectors of forests products, of paramount importance.

Therefore, the objectives of the present study were to assess the role of traditional knowledge in improving the livelihoods of the local communities. To achieve this, frequency index (F), the use-value index (UV), and fidelity levels (FL%) for the species and products were determined.

MATERIAL AND METHODS

Study area

This study was carried out at the Kalogi district in the western Nuba Mountains of South Kordofan State (Fig.1). The study area is covered by several isolated hills surrounded by clay and Gardud plains. It is also dissected by a number of seasonal watercourses and is characterized by good natural drainage. According to Harrison and Jackson (1958), the vegetation of the area is characteristic of the so-called special areas of the low rainfall woodland savanna zone**.** The overstory is endowed with multi-purpose broad-leaved savannah woodlands. The dominant vegetation is typical of the Acacia Seyal-Balanitessavannah zone. The rest of the vegetation is characteristic of the hill catena where *Anogeissus leiocarpus*, *Combretum* spp., *Acacia senegal* and *Acacia polyacantha* cover the high lands. *Borassus aethiopum*, *Cordia africana* and *Terminalia laxiflora* typifies the vegetation of the fertile low land areas, while *Oxytenanthera abyssinica* and *Diospyros mespiliformis* are the most important species along seasonal watercourses (Ballal et.al., 2014).

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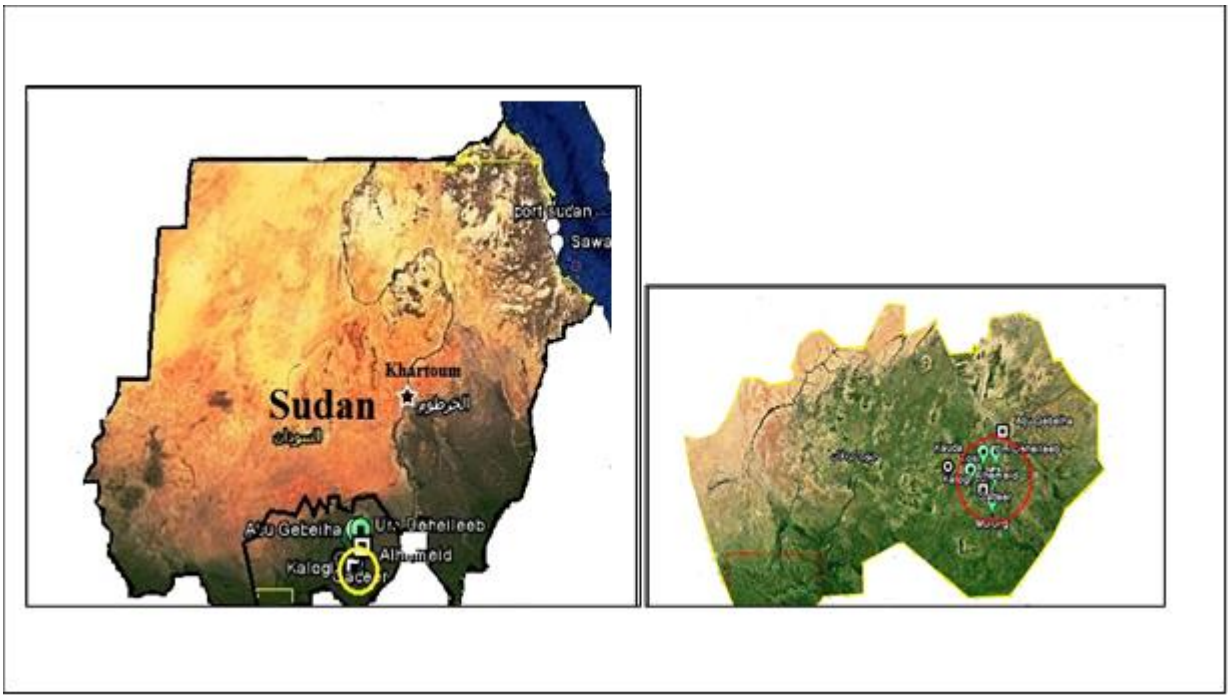

Figure 1. Map of the study area.
Source: Google Earth 2010.

Information regarding the traditional uses of forests products was collected through a social survey. A Rapid Rural Appraisal (RRA) survey was conducted with emphasis on focused group discussions and interviews. Semi-structured interviews were conducted with 65 informants from four villages, namely: Gadeer, Morong, Tosi, Umdiheileeb, including Kadogli, which is the locality capital. Before commencement of the survey, the households' respondents were enlightened about the objectives of the survey and the purpose of the mission through the leaders of the target villages in order to guarantee their involvement and agreement. The interview was designed to provide data on local names of plants and their uses and mode of utilization; the plant parts used; products collection methods; threatening factors to sustainable production; conservation efforts; and endangered species. The social information that is collected includes the names, sex, age, occupation, marital status, and education level of the interviewed persons. Samples of plants' specimens were collected for taxonomic identification and further authentication using standard keys of written floras such as Andrews (1950); (1952) and (1956); and Elamin (1990). Voucher specimens were deposited at the Herbarium of the Forestry and Gum Arabic Research Centre. The botanical names were updated according to the standards of the plant lists and plant families and arranged according to Angiosperm Phylogeny group version four (APG 4).

Data analysis

Frequency index: The frequency index is a mathematical expression of the percentage of frequency of mentioning a single botanical species by informants. The following formula was used to calculate the frequency index:

$FI = FC/N \times 100$

where FC is the number of informants who mentioned the use of the species, and N is the total number of informants (Madikizela et al., 2012).

Use-Value index (VU): Use Value (UV), developed by Phillips and Gentry (1993), is computed to provide a quantitative measure for the relative importance of species. The

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UV is calculated as the number of different uses of each species: UV = ΣUi/N. It is calculated by the total number of uses of a plant mentioned by a participant (U) divided by the total number of participants in the study.

Fidelity level (FL%): The importance of a certain plant species for a particular usage was quantified using the fidelity level (FL). FL was calculated as FL (%) = (Np/N) × 100, where Np is the number of informants that claim the use of a plant species for a particular use, and N is the number of informants that use the plants for any given use category (Tugume et al., 2016).

The statistical analysis of the data was carried out using IPM SPSS statistical package21. Ink package and Microsoft Excel 2007.

RESULTS AND DISCUSSION

Socio-demographic information

Rural communities in target villages use tremendous diversified woody flora in various aspects of their lives. This is much dependent on their rich heritage of traditional knowledge on the use of woody plants. The demographic information revealed that most (92.3%) of the informants are male. The age distribution showed that20% of the interviewees were young, with an average age of between 20-30 years. However, 27.7% of respondents were between 30 and 40 years of age, while 26.2 % were above 50 years of age. With respect to education, 18.5% of the informants had a preschool education and about a similar number attended primary schooling. However, the majority attended secondary school education and a significant number (29.2%) were university graduates (Figure 2). This high level of education in rural areas is a reflection of the recent boom in the establishment of a number of new universities and colleges in all of the States of Sudan.

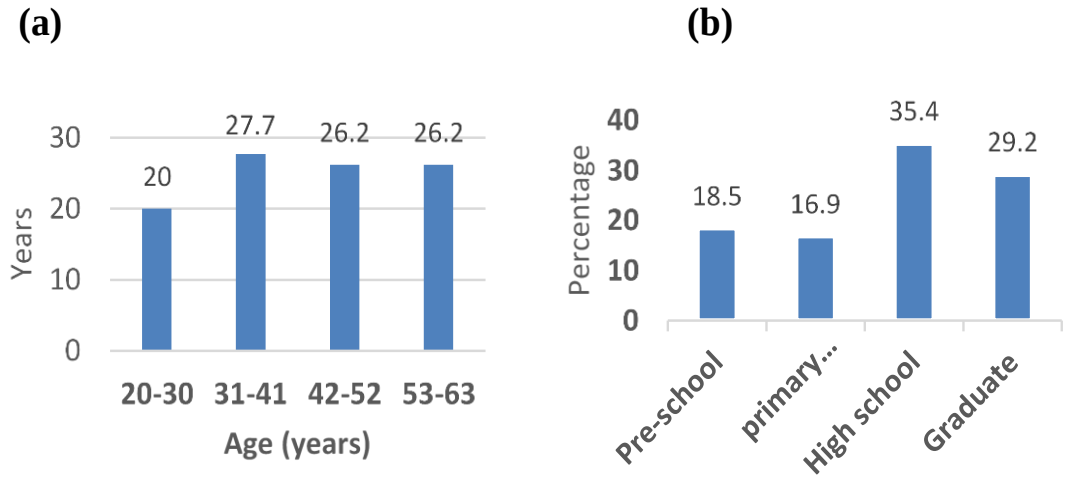

Figure 2. Age distribution(a) and Education level (b) of respondents in South Kordofan.

Taxonomic diversity and use value

A total of 60 plant species belonging to 24 different families were recorded in the current study. The family Fabaceae was the most represented family with 18 different species, followed by Malvaceae, Combretaceae, and Capparaceae where each of them was represented by four species. However, Meliaceae and Anacardiaceae were represented by three species each. On the other hand, the rest of the families were represented by less than three species (Fig. 3). Moreover, the frequency index

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calculation showed that the species with the highest frequency indices (FI) included *Balanites aegyptiaca* (78.6*%), Adansonia digitata* (70%), *Acacia senegal* (68.6%), *Acacia seyal* Del. var. seyal (67.1%), and *Ziziphus spina-christi* (64.3%) as the most frequently cited or acknowledged by the local communities (Table1). Generally, the most cited species by the local people belong to the family Fabaceae. This result is in line with the findings of Arévalo-Marín et al. (2015) with respect to high citations from this family amounting to 12 recorded species constituting 30.7% of the total number of cited species.

With respect to the use of the different species as depicted from the Use-Value index (UV), the results revealed that the species with the highest UV were: *Acacia seyal* (0.12), *Acacia senegal* (0.11), and *Acacia polyacantha* (0.11) representing the highest number of plants uses of all species documented. However, *Annona senegalensis*, *Crativa adansonii*, *Ficus thonngii*, *Oxytenanthera abyssinica, Salvadora persica, Detarium microcarpum* and *Croton zambesicus* recorded the least value (0.02) of UV and lowest number of uses and hence they were not included in the previous table that shows only the species of high FI and UV. In this respect, Ballal et al. (2014) confirmed that the high diversity in forest types and species has resulted in a wide variety of NWFPs in South Kordofan State as reflected in the wide variety of edible fruits, gums, oil seeds, medicinal materials, honey and a number of secondary forest products. These authors found a high Important Value Index (IVI) as high as 0.95 for edible fruits, medicinal materials, and gum products.

Fidelity level (FL%)

Fidelity level (FL%) is used to quantify the importance of a certain plant species for a particular usage by the local people. Accordingly, a number of woody plants with high fidelity levels were reported for diverse uses. In this respect, *Acacia senegal* (L.) Willd., Adansonia *digitata* Linn., *Grewia tenax* (Forsk.) Fiori., *Sterculia setigera* Del., *Tamarindus indica* L., and *Ziziphus spina-christi* (L.) Desf., were all reported as contributing to family food with FL% greater than 35%. The main reported medicinal plants were: *Acacia nilotica* subsp. *Adstringens, Acacia senegal* (L.) Willd., *Adansonia digitata* Linn., *Boswellia papyrifera* (Del.), Hochst, and *Tamarindus indica* L.The FL% of the medicinal plants ranges between 33.7-44.2%. However, the main species used as crafts were represented by *Bauhinia reticulata* DC., *Dalbergia melanoxylon* Guill. & Perr., *Hyphaene thebaica* (Linn.) Mart., *Sclerocarya birrea* (A. Rich.) Hochst., *Terminalia laxiflora* Engl. & Diels Monogr. However, the FL% of these wood-based crafts ranges from 20-25%. Other important and diverse tree species that are widely utilized by local communities for domestic consumption as food and for other purposes and for sale were previously highlighted by Ballal (2011).

On the other hand, various domestic uses of wood products such as timber, fuel, fodder, fence, smoke, and tannin were satisfactorily obtained from species such as *Acacia nilotica* subsp. *Adstringens* (FL%=50.0), *Acacia polyacantha* Willd. (*FL%=* 52.5) *Acacia seyal* Del. var. seyal (*FL%=* 69.8), *Balanites aegyptiaca* (L.) Delile (FL%= 45.1*), Boswellia papyrifera* (Del.) Hochst. (FL%= 50.0), *Dalbergia melanoxylon* Guill. & Perr. (FL%=79.2), *Dichrostachys cinerea* (L.) (FL%=63.4), *Sclerocarya birrea* (A. Rich.) Hochst. (FL%= 40.5), and *Terminalia laxiflora* Engl. & Diels Monogr. with FL%= 48.2.

Annona senegalensis is used as fuel, *Crativa adansonii* for crafts**,** *Ficus thonningii* as food, *Oxytenantera abyssinica* as a building material, *Salvadora persica* for crafts, *Detarium microcarpum* and *Croton zambesicus both* for medicinal purposes each species cited with FL% = 100% for its

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particular use respectively (Table 1). On the other hand, low FL% values were obtained for species with several uses such as *Adansonia digitata* (0.87) for building material, *Acacia senegal* (2.97) for hand crafts, *Anogeissus leiocarpa (4.84%)* as fodder, *Grewia tenax* (6.1) for crafts and *Acacia seyal* (5.92) for crafts and as a smoke wood for women's skin beauty. It is obvious that the FL% values decrease with the increase in plant use. These results were in line with the fact that high values of FLs (100%) are usually recorded for plants for which almost all use-mentions refer to the same purpose, that is, the plants (and their use for a particular purpose) are most preferred, whereas low FLs are generally obtained for plants that are used for many different purposes (Ong and Kim, 2014).

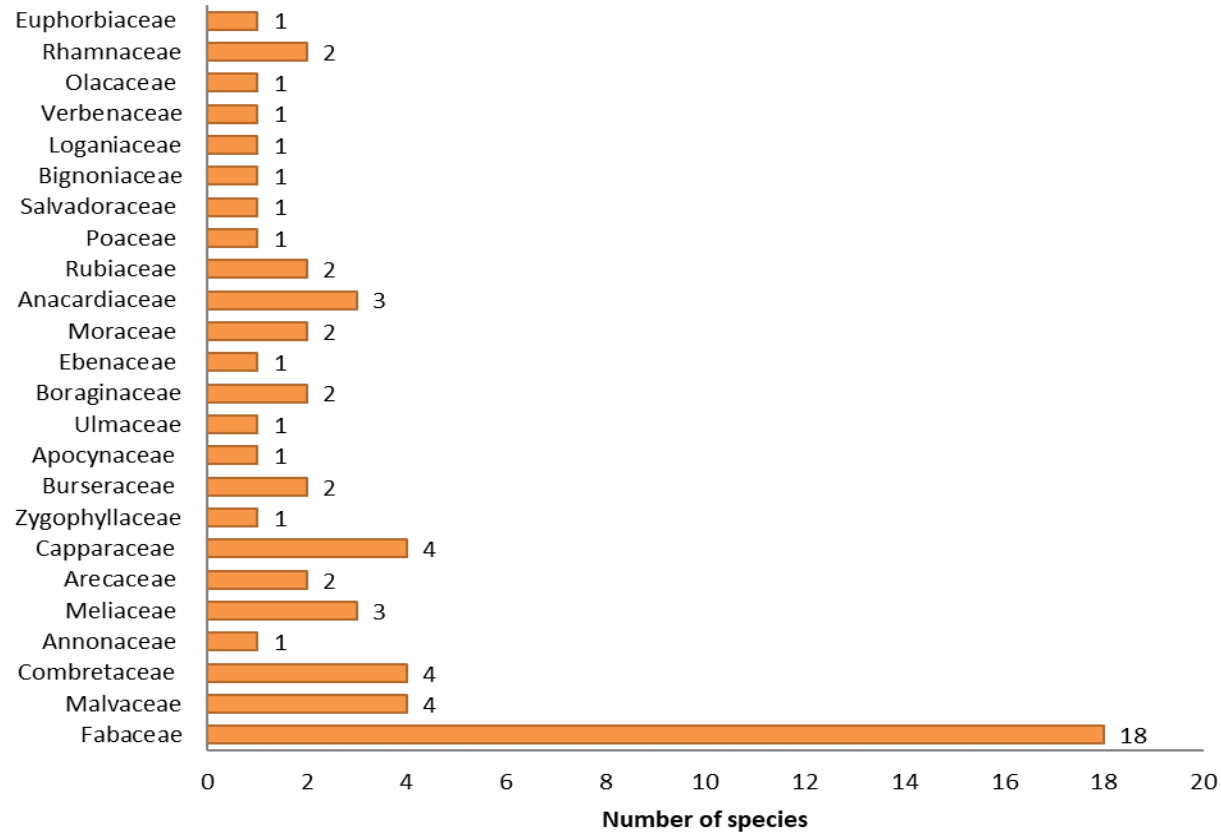

Figure 3. The relative number of species per family.

It is important to note that the majority of identified species were used for construction or building (75%), medicine (71.7), Fuel (70%) utensils and handicrafts (68.3%), food (51.7%), and Fodder (31.7%). However, small percentages were used as smoke wood (8.3%), fencing material (5%), and tannin (1.7%). Generally, most of the species (about 40 plants) produce building material for various construction purposes. About a similar number of plants were locally used as medicine, fuelwood, and in manufacturing different handicrafts. A considerable number of species, about 31, produce edible fruits for food and/or beverages. Moreover, 19 species were used as fodder while the rest (1-8.3%) were used for producing tannin, fencing material, and smoke wood for the local sauna (Fig. 4).

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Table 1. Frequency index (FI), Use value (UV), Fidelity levels (FL), and Used parts of plant species used for various uses by key informants

Species	Frequency index (FI)	Use-value (Index UVs)	Fidelity index (%0				Part(s) used
			Food	Medicine	Handcrafts	Domestic use of wood products	
Acacia nilotica* subsp. *Adstringens.	22.9	0.08		42.1	7.89	50.0	Wood, Leaves, Fruit, Flowers
***Acacia polyacantha* Willd.**	18.6	0.11	27.5	12.5	7.5	52.5	wood, Gum, Leaves, Fruits
***Acacia senegal* (L.) Willd.**	68.6	0.11	38.6	33.7	2.97	24.7	Gum, Wood, Leaves, Branches
***Acacia seyal* Del. var. seyal**	67.1	0.12	13.8	10.5	5.92	69.8	Gum, Wood, Leaves, Branches.
***Adansonia digitata* Linn.**	70	0.06	42.6	39.1	17.4	0.9	Fruits, Leaves, Bark
***Bauhinia reticulata* DC.**	40	0.09	34.7	21.3	20	24.0	Fruit, Wood, Leaves
***Balanites aegyptiaca* (L.) Delile**	78.6	0.09	22.3	22.8	9.82	45.1	Fruits, Wood, Leaves
***Boswellia papyrifera* (Del.) Hochst.**	37.1	0.06		44.2	5.77	50.0	Wood, Leaves, Bark, Gum
***Dalbergia melanoxylon* Guill. & Perr.**	18.6	0.05			20.8	79.2	Wood, Leaves
***Dichrostachys cinerea* (L.)**	21.4	0.08		31.7	4.88	63.4	Wood, Fruits, Leaves, Bark
***Grewia tenax* (Forsk.) Fiori.**	54.3	0.08	43.9	30.5	6.1	19.5	Fruits, Wood
***Hyphaene thebaica* (Linn.) Mart.**	51.4	0.09	23.8	21	24.5	5.1	Fruits, Leaves, Wood
***Sclerocarya birrea* (A. Rich.) Hochst.**	42.9	0.09	23.8	14.3	21.4	40.5	Wood, Fruits, Leaves
***Sterculia setigera* Del.**	7.14	0.06	50	25	12.5	12.5	Gum, Wood
***Terminalia laxiflora* Engl. & Diels Monogr.**	15.7	0.08		29.6	22.2	48.2	Wood
***Tamarindus indica* L.**	57.1	0.08	51.9	35.1	3.9	9.1	Fruits, Leaves, Wood
***Ziziphus spina-christi* (L.) Desf.**	64.3	0.09	28.5	22.5	15.9	33.1	Wood, Fruits, Leaves,

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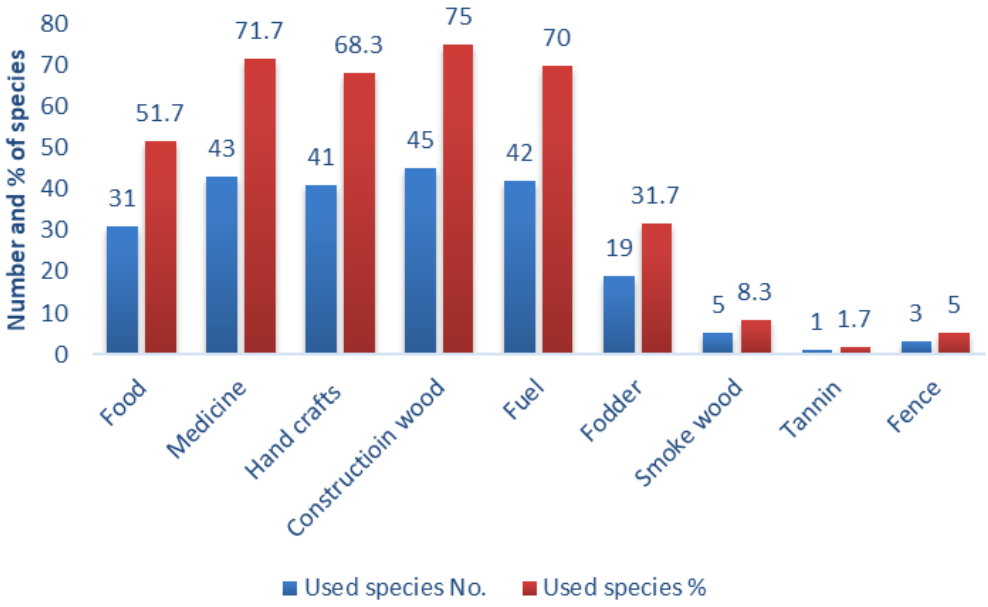

Figure 4. Number and percentage of woody species in each use category.

With respect to collection methods of usable plant parts, as stated by respondents, the results showed that the products of 37% of the woody species were obtained by full or partial cutting of plant parts for the different uses, namely: building material, domestic utensils, and crafts, and for energy, etc. The woody species referred to were: *Acacia seyal*, *Acacia seiberiana, Dalbergia melanoxylon, Faidherbia albida, Khaya senegalensis, Oxytenanthera abyssinica, Prosopis africana, Cordia africana, Pseudocedrela kotschyi,* etc., which are listed as endangered species (Fig. 5). The products of a considerable number (28) of these species were obtained by picking especially the trees that produce edible fruits such as *Adansonia digitata, Borassus aethiopum, Balanites aegyptiaca, Bauhenia reticulatum, Grewia tenax*, *Cordia afri*such as *Adansonia digitata* for making ropes, and other medicinal plants. Several woody species produced more than one used part; hence these species may be subjected to a number of collection methods at the same time.

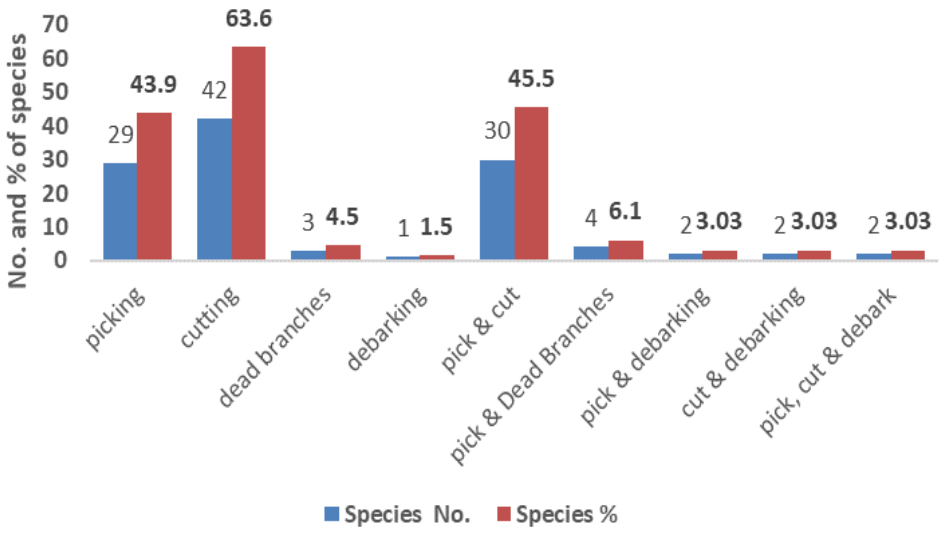

Figure 5. Collection methods for different woody species.

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CONCLUSION

The main findings of this study revealed that the species with the highest use-value were mainly the gum-producing tree species, namely *Acacia senegal, Acacia seyal,* and *Acacia polyacantha,* in addition to some food and medicinal plants. Important Value Indices (IVI) as high as 0.95 for edible fruits, medicinal materials, and gum products were reached. The importance of the different tree species as measured by fidelity level for a particular usage by the local people was also determined.

Declaration of Competing Interest

We, as the authors, declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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