Traditional uses of *Detarium Microcarpum* Guill. & Perr. (Fabaceae) and Potential for its Valorisation as Fuelwood

Théophile Abaro SINADOUWIROU (✉ tsinad@yahoo.com)

Laboratory of Ecology, Botany and Plant Biology <https://orcid.org/0000-0002-1952-0837>

Aliou Dicko

Botany and Bioinformatics of Plant Architecture: Botanique et Modelisation de l'Architecture des Plantes et des Vegetations

Samadori Sorotori Honoré Biaou

Faculty of Agronomy, University of Parakou

Eméline Assede

Faculty of Agronomy, University of Parakou

Armand Kuyema Natta

Université de Parakou: Universite de Parakou

Research

Keywords: fuelwood, sweet detar, usage patterns, user acceptance, Cultural uses, forest management decision, Benin

Posted Date: December 30th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-136026/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

**Traditional uses of *Detarium microcarpum* Guill. & Perr. (Fabaceae) and potential for its valorisation
as fuelwood**

Théophile Abaro Sinadouwirou ^{1*}, Aliou Dicko¹, Samadori Sorotori Honoré Biaou^{1,2}, Eméline Assede^{1,2},
Armand Kuyema Natta^{1,2}

(1) Laboratory of Ecology, Botany and Plant Biology, University of Parakou, 03BP 125, Parakou,
Benin.

(2) Department of Natural Resources Management, Faculty of Agronomy, University of Parakou, PO
Box 123, Parakou, Benin.

* Corresponding author:

Email : tsinad@yahoo.com

23 Abstract

24 **Background:** Forest management can be sustainable if it integrates social, cultural and economic values that
25 local communities associate with forest resources in a given area. *Detarium microcarpum* Guill. & Perr.
26 (Fabaceae), also known as small detar or sweet detar, is a common multiuse small tree of Sudanese and
27 Sudano-Guinean savannahs with high potential for use as fuelwood or fruit tree but little valued in forestry
28 programs. The present countrywide study aims to assess the compatibility of current local uses of *Detarium*
29 *microcarpum* with its promotion as fuelwood and to determine the most suitable areas for its integration into
30 forest management programs.

31 **Methods:** An ethnobotanical survey was conducted on the basis of a semi-structured questionnaire among
32 1074 people selected randomly in 10 of the 12 departments of Benin where the species is present. Factors
33 determining *Detarium microcarpum* use as fuelwood were identified through a binary logistic regression. A
34 Factorial Correspondence Analysis established the relationship between socio-cultural groups and the use of
35 *Detarium microcarpum* parts or organs.

36 **Results:** A total of 671 people (62.47%) know and use at least one part of *Detarium microcarpum*. The trunk
37 and branches are the most used organs (35.12% of respondents), primarily as fuelwood. The determinants of
38 *Detarium microcarpum* use as fuelwood are the phytogeographic district (a proxy for the resource
39 availability), gender, sociolinguistic group, and educational level. *Detarium microcarpum* is more used as
40 fuelwood by women belonging to the sociolinguistic groups Gourmatche, Kounteni, Boo, Monkole, Gando
41 and Bariba. In addition, the use of *Detarium microcarpum* as fuelwood decreases with the educational level
42 and is more pronounced in the phytogeographical districts of Borgou-Nord, Atacora chain and Borgou-Sud,
43 covering together about 63% of the national territory and representing 28% of its population.

44 **Conclusions:** This study confirms the potential of *Detarium microcarpum* as fuelwood, particularly in
45 northern Benin, and calls for further research on the species local abundance and structure, regeneration,
46 silviculture and management mode.

47 **Keywords:** fuelwood, sweet detar, usage patterns, user acceptance, Cultural uses, forest management
48 decision, Benin

49

50 Background

51 Ethnobotanical studies are useful for understanding uses of forest resources in a given region [1-3] and
52 informing forest policy. Indeed, peoples have always had traditionally rich ethnobotanical knowledge

53 through the cultural and ecological diversity of the environment in which they live [4-6]. This knowledge
54 and local uses may or may not be influenced by socio-cultural characteristics such as ethnicity, age, gender,
55 educational level, religion or occupation [7-9], and a plant perceived as highly useful by one ethnic group
56 may be considered of little use, or even useless, by another group [10, 11]. Also, knowledge of the use and
57 management of species by local populations can help improve the conservation of species at local and
58 regional levels [12] by providing basic information for the selection of the species on which the emphasis
59 should be put in management plans to meet not only the needs of populations but also to improve the
60 conservation status of species [13].

61 *Detarium microcarpum*, also called small detar or sweet detar in English, is a tree up to 10 m tall [14] that
62 occurs naturally in the arid regions of West and Central Africa, from Senegal and the Gambia to Sudan [15].
63 It is found in shrub savannas, wooded savannas and open forests [16], as well as in dry forests and fallows
64 [17]. It generally grows on marginal soils such as sandy and lateritic soils [18], thereby involving little or no
65 land use competition with agricultural crops. It is reproduced by rejection, suckers and spontaneously
66 sprouted seeds [18-19]. This capacity suggests the possibility of vegetative propagation of *D. microcarpum*
67 which is necessary for its domestication. Regarding the species growth, it can reach 50 cm in height after 1
68 year and 120 cm after 7 years [20]. *D. microcarpum* is also a species that supports cutting [21] and could
69 therefore be conducted in thickets [20]. Traditionally, the entire tree is cut during the dry season (February-
70 May) to build fuelwood stocks in anticipation of the rainy season [18]. In coppicing, farmers retain only one
71 upright stem, which they promote growth by regularly removing low leaves, lateral branches and other rejects
72 [22].

73
74 *D. microcarpum* is also known for its food, energy, veterinary, artisanal, industrial and medicinal uses [23-
75 24]. According to Kouyaté et al. [25], women classified *D. microcarpum* (fruit, firewood), *Parkia biglobosa*
76 (Jacq.) R. Br ex G. Don (fruit) and *Vitellaria paradoxa* CF Gaertn (fruit) as the three most important forest
77 species in Mali. The wood of *D. microcarpum* is particularly valued by households as firewood [21] because
78 of its high calorific value [26], which leads also to its high exploitation [21]. In Benin, the energy situation is
79 topical and it is important to identify alternative sources of energy to meet local population needs.
80 Assessing the knowledge diversity and use patterns of *D. microcarpum* could help in determining sustainable
81 management and domestication strategies of the species. The present study aims to capitalize knowledge and
82 uses of *D. microcarpum* in Benin, in order to provide the basis for its rational and sustainable management.

83 As part of our study, the following research questions are addressed: (1) Are the current uses of *D.*
84 *microcarpum* compatible with its promotion as fuelwood species to be included in natural forest or plantation
85 management programs? (2): What are the suitable geographical areas for *D. microcarpum* promotion as
86 fuelwood?

87

88 **Methods**

89 **Study area**

90 This study was conducted in ten (10) departments (i.e. Alibori, Borgou, Atacora, Donga, Zou, Hill, Couffo,
91 Mono, Plateau, Atlantic) out of the twelve (12) that Benin has (Fig. 1). The two departments of the extreme
92 south of Benin (i.e. Littoral and Ouémé) were excluded because the species was not observed during the
93 exploratory phase. In each department, the districts were chosen on the basis of the presence of the species
94 for investigations. In each district, the nearby villages (distance ≤ 10 km) of *D. microcarpum* dominated plant
95 formations were selected for ethnobotanical studies. Study villages are characterized by a strong
96 sociolinguistic and cultural diversity [27-28].

Fig.1 Study area

Ethnobotanical surveys

Ethnobotanical surveys were conducted on the basis of a semi-structured questionnaire administered to individuals belonging to different sociolinguistic groups. Preliminary sampling for the survey included 30

randomly selected people in each department. The percentage of respondents who knew at least one use of *D. microcarpum* was calculated and the number of respondents (Table 1) was determined afterward using Dagnelie [29] formula:

$$N = \frac{U^2_{(1-\alpha/2) \times P(1-P)}}{d^2}, \quad \text{Where } N \text{ is the sample size, } U^2_{(1-\alpha/2)} \text{ is the normal random variable value for a}$$

probability value $\alpha = 0.05$; $U_{(1-\alpha/2)} = 1.96$; p = the proportion of respondents who know and use parts of the species and the 8% margin of error [28, 30]. The sample size calculated for each department was then divided among different sociolinguistic groups for that department (Table 1).

Table 1 Characteristics of sociolinguistic groups surveyed on the importance of *D. microcarpum* in ten departments of Benin

D	N	GS	F	M	<30	30-50	>50	Σ
Alibori	195	Ahoussa	1	2	0	3	0	3
		Bariba	19	42	11	34	16	61
		Boo	4	5	2	7	0	9
		Dendi	12	23	7	13	15	35
		Gourmatche	0	3	2	1	0	3
		Idasha	0	1	1	0	0	1
		Kotokoli	0	1	0	1	0	1
		Monkole	6	21	5	16	6	27
		Peulh	13	27	7	26	7	40
		Yoruba	1	0	1	0	0	1
Zerma	5	9	2	10	2	14		
Atlantique	34	Adja	1	0	1	0	0	1
		Aizo	2	18	4	13	3	20
		Fon	5	8	1	6	6	13
Borgou	263	Adja	1	5	0	6	0	6
		Bariba	53	101	41	80	33	154
		Biali	7	2	3	6	0	9
		Boo	2	9	0	5	6	11
		Dendi	1	0	1	0	0	1
		Ditamari	0	1	1	0	0	1
		Fon	4	5	5	4	0	9
		Foodo	0	1	0	1	0	1
		Gando	4	15	0	12	7	19
		Goun	0	1	0	1	0	1
		Idasha	0	2	0	2	0	2
		Nago	4	13	6	9	2	17
		Peulh	2	22	5	17	2	24
		Yende	0	4	2	1	1	4
		Yom	1	0	0	1	0	1
		Yoruba	0	1	0	0	1	1
		Zerma	0	2	0	2	0	2
Mono	15	Kotafon	2	13	0	9	6	15

D	N	GS	F	M	<30	30-50	>50	Σ
Atacora	167	Bariba	6	35	10	21	10	41
		Biali	1	0	0	0	1	1
		Ditamari	9	25	8	17	9	34
		Gando	3	9	4	5	3	12
		Gourmatche	5	8	1	9	3	13
		Kotokoli	0	1	0	1	0	1
		Kounteni	1	7	4	3	1	8
		Peulh	2	9	3	8	0	11
		Waaba	15	25	6	21	13	40
		Yende	2	1	0	1	2	3
Yom	0	3	0	2	1	3		
Collines	126	Adja	1	0	0	1	0	1
		Biali	0	1	0	1	0	1
		Fon	3	3	4	0	2	6
		Idasha	17	15	7	17	8	32
		Mahi	7	9	1	8	7	16
		Nago	29	39	10	37	21	68
		Sola	1	0	0	1	0	1
Waama	1	0	0	1	0	1		
Couffo	23	Adja	3	8	1	5	5	11
		Agouna	1	10	0	5	6	11
		Fon	0	1	0	1	0	1
Donga	111	Ani	14	13	7	12	8	27
		Dendi	2	3	1	3	1	5
		Ditamari	3	3	2	3	1	6
		Kotokoli	3	10	0	8	5	13
		Lokpa	10	12	2	11	9	22
		Nago	1	1	0	2	0	2
		Peulh	3	2	1	3	1	5
		Taneka	2	5	2	1	4	7
		Yom	10	14	1	9	14	24

									Zou	87	Adja	0	1	1	0	0	1
Plateau	53	Holli	1	0	0	0	1	1			Aizo	2	0	1	1	0	2
		Mahi	1	14	1	8	6	15			Fon	45	37	19	42	21	82
		Nago	7	29	1	17	18	36			Goun	1	0	1	0	0	1
		Yoruba	1	0	0	0	1	1			Mina	1	0	1	0	0	1

114 **NB:** D=Phytogeographic district, N = Sample size, GS = Sociolinguistic group, F = Female, M = Male, <30
115 = age under 30 years, 30-50 = age between 30 and 50 years, > 50 = age over 30 years.

116

Statistical analyzes

Determinants of *D. microcarpum* use as fuelwood

To identify the socio-demographic and ecological characteristics that determine *D. microcarpum* use as fuelwood in the study area, a binary logistic regression was used under R software, version 3.4.2, with the Package MASS [31]. Specifically, we assessed whether the probability of a respondent using the species for fuelwood is related to certain sociodemographic and ecological characteristics. The response variable is the use of the species as fuelwood and is coded as 1 (uses the species) or 0 (does not use the species). Explanatory variables included phytogeographic district, sociolinguistic group, gender, age, marital status, religion, education level, and household size. Several models were compared using the Akaike Information Criterion (AIC) [32]. For the sake of parsimony, we chose the model that has the smallest value of AIC and the smallest number of terms that influence *D. microcarpum* use as fuelwood.

Relationship between sociolinguistic groups and the use of *D. microcarpum* organs or parts

To describe the relationship between sociolinguistic groups and the uses of *D. microcarpum* parts or organs, a Factorial Correspondence Analysis (FCA) was carried out under the software R (version 3.4.2) with the FactoMineR package and from a data table with socio-linguistic groups (in rows) and parts / organs of *D. microcarpum* (in columns).

Results

Frequencies of opinions regarding the use of *D. microcarpum* organs / parts

Out of a total of 1074 people surveyed, 671 people know and use at least part of *D. microcarpum* (Fig. 2a). The trunk and branches are the most used organs (35.12% of respondents), followed by fruits (28%), leaves (15.64%), roots (10.24%) and bark (10.14%). Sap and flower are the least used parts by the respondents (0.66% and 0.20% respectively).

Categories of organs' uses

Various categories of uses were identified according to *D. microcarpum* parts used. The trunk and branches of the species are more used as firewood and charcoal (respectively 47.47% and 24.80% of uses reported by respondents, Fig. 2b). The bark, leaves and roots are mainly used for medicinal purposes (respectively 97.94%, 84.85% and 95.83%, Fig. 2c, 2d, 2g). The flowers have magico-mystical role (66.67%, Fig. 3e) while the fruits / almonds are exploited in the diet (96.91%, Fig. 2f). Sap is mainly used to trap birds (54.55%, Fig. 2h).

Fig. 2 Response rates and use categories of *D. microcarpum*

Response rate by *D. microcarpum* organs use

158

159 Different uses are reported by the local populations surveyed. Roots are more used to treat stomach pain
160 (2.79% of respondents). The bark is most exploited to treat malaria (2.79%), stomach pain (2.79%) and
161 hemorrhoids (2.79%). The trunk and branches are more used as fuelwood (60.15% and 4.06% respectively.
162 As for the leaves, they are mainly used by respondents to treat malaria (13.19%), for the vigor of children
163 (4.82%), as a leaf vegetable (4.06%), to treat yellow fever (3.55%), and to treat diarrhea (2.79%). The flowers
164 are used as a lucky charm (0.48% of the respondents). Sap is more exploited as a glue to trap birds (1.27%).
165 Fruits constitute a food and are eaten raw or processed into fruit juice (64.72% of respondents). For the
166 therapeutic uses, the principal mode of use of *D. microcarpum* organs is the decoction (72.25% of the
167 respondents), followed by the infusion (24.05%), the maceration (2.50%) and milling (1.20%).

168

169 **Relations between sociolinguistic groups and organs uses**

170

171 The Factorial Correspondence Analysis between the sociolinguistic groups and the uses of *D. microcarpum*
172 organs or parts shows that the first factorial axis explains 40.45% of the total variance and the second axis
173 gives information on 23.59% of the variations (Fig. 3). Thus, the first two factorial axes account for 64.03%
174 of the total variance. These first two axes were therefore retained to describe the relationship between the
175 uses of *D. microcarpum* and sociolinguistic groups.

176

177 Axis 1 is positively correlated with leaves and roots use of *D. microcarpum* on the one hand, and with the
178 sociolinguistic groups Adja, Ahoussa, Aizo, Ani, Fon, Idasha, Mahi, Nago, Sola, and Taneka on the other
179 hand. This axis is negatively correlated with the use of sap, branch and fruit on the one hand, and then on the
180 sociolinguistic groups Agouna, Bariba, Mokole, Peulh and Yendé.

181

182

Note: Dim = Dimension (Component)

Fig. 3 Factorial map linking sociolinguistic groups to the use of parts / organs of *D. microcarpum*

Axis 2 is positively correlated with the use of the trunk and flowers of *D. microcarpum* on the one hand, and the sociolinguistic groups Biali, Dendi, Ditamari, Gando, Goun, Kounteni, Kotafon, Lokpa, Waaba, Yom, Yoruba. and Zerma. On the other hand, the exploitation of the bark as well as the sociolinguistic groups Boo, Gourmantché, Kotokoli, Koura and Serima are negatively correlated to this axis (Table 2).

Table 2 Relationship between factorial axes, use of organs / parts of *D. microcarpum* and sociolinguistic groups.

Parts/organes	Component1	Component2	Groups sociolinguistic	Component1	Component2	Groups sociolinguistic	Component1	Component2
Branche	-0.3216	-0.2688	Adja	0.5092	0.3768	Kotokoli	0.0738	-0.5328
Flowers	-0.2674	0.5826	Agouna	-0.0909	0.0426	Kounteni	-0.1352	0.1930
Bark	0.3587	-0.3588	Ahoussa	0.1087	0.0046	Koura	0.5140	-0.5320
Leaves	0.5577	0.1185	Aizo	1.4613	-0.5017	Lokpa	-0.1653	0.2930
Trunk	-0.1131	0.38760	Ani	0.4184	0.0434	Mahi	1.1094	-0.4599
Roots	0.0500	-0.0005	Bariba	-0.1269	-0.1056	Monkole	-0.1328	-0.1164
Sap	-0.0383	-0.0061	Biali	0.0177	0.4825	Nago	0.5267	0.3711

Fruit	-0.2555	0.0039	Boo	-0.0731	-0.1221	Peulh	-0.1876	-0.1327
			Dendi	-0.1874	0.1941	Serima	-0.3055	-0.4616
			Ditamari	0.0055	0.2365	Sola	0.15944	-0.0022
			Fon	1.0225	-0.2649	Taneka	0.5756	0.1528
			Gando	-0.1588	0.2178	Waaba	-0.1342	0.5973
			Goun	-0.3609	1.6185	Yende	-0.1956	0.0465
			Gourmatche	-0.1378	-0.2034	Yom	-0.0425	0.4448
			Idasha	0.7716	-0.2953	Yoruba	-0.5878	0.8176
			Kotafon	-0.3609	1.6185	Zerma	0.0600	0.1879

193

194

195 **Determinants of *D. microcarpum* use as fuelwood**

196 Factors determining the use of *D. microcarpum* as fuelwood in the study area are phytogeographic district,
 197 Gender, sociolinguistic group, and educational level (Table 3).

198

199 **Table 3** Factors determining the use of *D. microcarpum* as wood energy

Variables	Df	Deviance	Resid.Df	Resid.Dev	Pr(>Chi)
Phytogeographic district	8	193.447	852	989.20	<2.2e-16***
Gender	1	13.108	851	976.09	0.0002941***
Sociolinguistic group	32	124.059	819	852.03	8.931e-13***
Educational level	4	13.257	815	838.78	0.0100868*

200 Note: Df= Degree of freedom, Pr= Probability, Resid.Df= Residual degree of freedom, Resid.Dev= Residual
 201 Deviance, *** : p< 0.001, * : p< 0.05.

202

D. microcarpum is more commonly used as fuelwood by women (Fig. 4a) belonging to the sociolinguistic groups Gourmantché, Kounteni, Boo, Monkole, Gando and Bariba (Fig. 4b). In addition, this use for fuelwood decreases with the educational level (Fig. 4c) and is more pronounced in the phytogeographical districts of Borgou-Nord, Atacora and Borgou-Sud (Fig. 4d).

Fig. 4 Links between *D. microcarpum* use as fuelwood and the gender (a), sociolinguistic group (b), educational level (c) and phytogeographical district (d).

Discussion

The present study used the ethnobotany of *D. microcarpum* to examine the possibilities of its promotion as fuelwood in Benin. It is a multipurpose species widely used in the study area in the energy, medicinal, food and cultural fields. Ethnobotanical knowledge is indeed considered in the management of forest resources because it offers opportunities for understanding ecological processes in relation to the knowledge of local populations [28]. The conservation of a resource in an environment is strongly determined by the interaction

between the resource and the activities carried out by the local populations [33]. The most important parts of the plant are the trunk and branches, fruits, leaves, roots, bark, sap and flower. The majority of respondents mentioned that the wood (trunk and branch) of *D. microcarpum* is heavily used as firewood. This same result was obtained by Kouyaté [18] in Mali, Ricez [34-35], in Burkina and Agbo et al. [24] in southern Benin. *D. microcarpum* is used for fuelwood due to flame intensity and the small amount of smoke emitted [36]. In the present study, *D. microcarpum* is more commonly used as fuelwood by women. Women prefer their firewood to those of *Terminalia* spp., *Pterocarpus erinaceus* and *Isoberlinia doka*, because it catches fire quickly, even when it is wet [18] and is easy to split [37]. The control of the properties of fuel sources by local populations is confirmed by Cotton [38]. *D. microcarpum* is more exploited for the supply of firewood and is an important source of income for the populations [21]. Unlike the fruits, the fuelwood trade of *D. microcarpum* is well known in the south of Mali and the fuelwood store in rural areas was sold between CFAF 1000 and CFAF 3000 in 2005, depending on the middle and the season of the year [18]. The preference of *D. microcarpum* by women for home energy is confirmed in other studies [22,39]. These results are not correlated those of Dieng et al. [40] in Senegal where *Detarium microcarpum* was not among preferred species for firewood because, according to the groups interviewed, the species is not a hard-wooded tree and other species that are more suitable for this purpose were available. To some communities as M'Bèlimè, the use of *D. microcarpum* trunk as firewood is defended. This taboo is reported in many sociocultural areas in Mali could be understood as a conservator measure [18;41]. This conservatory taboo also recorded for *Combretum aculeatum*, believed to cause delirium if burned [42], and *Adansonia digitata* [43], is not noticed for *D. microcarpum* in Benin by the present study. This preference and consumption of its firewood militate in favor of the domestication of *D. microcarpum* for the production of fuelwood.

Determinants of the use of *D. microcarpum* as fuelwood in the study area are gender, educational level, sociolinguistic group, and phytogeographic district. The hypothesis following knowledge dynamics of gender and educational level [44] suggests that various individual sociocultural and demographic characteristics such as gender, ethnicity and literacy levels are correlated with the level of knowledge and use of plants by an individual [45]. Thus, women tend to know more about the local medicinal flora [45- 47], while a high literacy rate and better access to health. Formal education is often negatively correlated with knowledge of medicinal plants [47]. These same observations are made for *D. microcarpum* in the context of the use of its wood for domestic energy by the local populations.

According to Gaoue and Ticktin [48], socio-demographic characteristics are not always the only factors influencing endogenous knowledge. The present study revealed that *D. microcarpum* is more widely used in northern Benin, particularly in the phytogeographical districts of Borgou-Nord, Atacora and Borgou-Sud. For Kakudidi [49] and Gaoue et al. [44], the proximity of the resource can also influence its use. Our observations in the field confirm that *D. microcarpum* is more common in northern Benin. Further studies on the ecology of this species and its spatial distribution are needed to discuss a possible correlation between the local abundance (availability) of the species and its use for energy purposes by rural communities in the phytogeographical districts of Borgou-Nord, Atacora-Chain and Borgou-Sud. Indeed, the availability hypothesis [44] suggests that plants are more used when they are more accessible to local populations or are more abundant locally [50-51].

For others studies, wood physical characteristics are also factors of species use as firewood. A direct relationship was observed between the physical properties of the fuelwoods and their locally perceived qualities [52]. These locally perceived qualities are relative in general to ashes production, moisture fractions, flame intensity, burn time, spark or smoke production [52-53].

The ethnobotanical survey conducted in this study showed endogenous knowledge regarding the importance and use of *D. microcarpum* parts or organs and allows to classify it in the multiuse species for rural populations in Benin since all its parts are used. Apart from the high exploitation of *D. microcarpum* wood as fuelwood, its fruit is also highly consumed by local people. A fair compromise should therefore be found between the use of *D. microcarpum* as fuelwood and its exploitation as a fruit tree. Thus, data on the minimum diameter of fruiting and the diameters used for wood energy are necessary. Commercialization of the products (wood, fruits) of *D. microcarpum* can be a promising pathway and a substantial source of income for local populations, which further justifies its domestication. Given the energetic qualities of *D. microcarpum* and its preference by consumers as domestic energy source [18, 22, 24, 34, 35, 37], the marketing of its wood could contribute effectively to compensate for a large part of the domestic energy needs of both rural and urban populations in Benin. Therefore, it's necessary to evaluate the local abundance and structure, species population dynamic and management mode for sustainable harvesting of fuelwood.

Conclusions

The present study identified factors influencing the use of *D. microcarpum* as fuelwood and established the links between the uses of the species and the sociolinguistic groups in the study area. The sociodemographic

and ecological parameters that significantly influence the use of *D. microcarpum* for fuelwood in the study area are the phytogeographic district, the gender, the sociolinguistic group and the educational level of the respondents. The species trunk and branches are the most used parts, primarily for energy purposes (firewood and charcoal). It is therefore opportune to study the possibilities of promoting the species as fuelwood in Benin to alleviate energy problems. For a better management of this important wood-energy species for the local populations, certain elements will still have to be specified such as the disponibility and the structural characteristics of the species populations in Benin, the determination of the calorific value of *D. microcarpum* wood, its forestry to favor its multiplication and its ecological preferences for its better growth after planting.

Acknowledgements

We thank local communities surveyed throughout Benin for agreeing to share their endogenous knowledge on *Detarium microcarpum*.

Authors' contributions

TAS designed the study, analyzed and interpreted the data, and wrote the original draft. AD participated in the study design, provided guidance during data collection, and edited the manuscripts. HSSB participated in the study design and was a major contributor in the writing of the manuscript. EA and AKN contributed in the study design. All authors read and approved the final manuscript.

Funding

This study was funded by the Laboratory of Ecology, Botany and Plant Biology, University of Parakou (Bénin)

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

No ethics approval was needed for this study. The participants gave their oral consent to take part in the survey.

Consent for publication

The respondents were informed that their responses will be published in scientific documents and agreed with that.

Competing interests

The authors declare that they have no competing interests.

Author details

¹Laboratory of Ecology, Botany and Plant Biology, University of Parakou, 03BP 125, Parakou, Benin.

²Department of Development and Management of Natural Resources, Faculty of Agronomy, University of Parakou, PO Box 123, Parakou, Benin.

References

1. Agbogidi OM. Ethno-botanical survey of the non-timber forest products in Sapele Local Government Area of Delta State, Nigeria. *African Journal of Plant Science*, 2010; 4: 183-189.
2. de Oliveira Trindade MR, Jardim JG, Casas A, Guerra NM, de Lucena RFP. Availability and use of woody plant resources in two areas of Caatinga in Northeastern Brazil. *Ethnobotany Research and Applications*, 2015; 14: 313–330.
3. Gonçalves PHS, Albuquerque UP, Medeiros PM. The most commonly available woody plant species are the most useful for human populations: A meta-analysis. *Ecological Applications*, 2016; 26: 2238-2253.
4. Gbesso F, Akouehou G, Tente B, Akoegninou A. Aspects technico-économiques de la transformation de Borassus (Arecaceae) au Centre-Bénin. *Afrique SCIENCE*, 2013 ; 9 : 159-173.
5. Walker BH. Biodiversity and ecological redundancy. *Conservation Biology*, 1992; 6: 18–23.
6. Prance GT, Aiona K, Balick MJ, Bennett BC, Bridges K, Burney DA, Burney LP, et al. Ethnobotany, the science of survival: A declaration from Kauai. *Economic Botany*, 2007; 61:1-2.
7. Sop TK, Oldeland J. Local perceptions of woody vegetation dynamics in the context of a greening Sahel: a case study from Burkina Faso. *Land degradation & development*, 2011; 24: 511-527.
8. Souto T, Ticktin T. Understanding interrelationships among predictors (age, gender, and origin) of local ecological knowledge. *Economic Botany*, 2012; 66:149-164.
9. Brandt R, Mathez-Stiefel S-L, Lachmuth S, Hensen I, Rist S. Knowledge and valuation of Andean agroforestry species: The role of sex, age, and migration among members of a rural community in Bolivia. *Journal of Ethnobiology and Ethnomedicine* 2013; 9:83.

10. Ilumbe G. Utilisation des plantes en médecine traditionnelle par les Pygmées (Ba-twa) et les Bantous (Ba-Oto) du territoire de Bikoro, province de l'Equateur en RD Congo. Thèse Doctorat Université Libre de Bruxelles. Belgique, 2010. P.237.
11. Tardío J, Pardo-De-Santayana M. Cultural importance indices: A comparative analysis based on the useful wild plants of southern Cantabria (northern Spain). *Economic Botany*, 2008; 62:24–39.
12. Kouaro OM, Tasso F. *Lophira lanceolata* dans la Commune de Toucountouna : Entre exploitation et conservation d'une espèce naturelle à usages multiples. *Revue de géographie du Bénin*, 2010 ; 7 : 94-115.
13. Dossou ME, Houessou GL, Lougbegnon OT, Tente AHB, Codjia JTC. Etude ethnobotanique des ressources forestières ligneuses de la forêt marécageuse d'Agonvè et terroirs connexes au Bénin. *Tropicultura*, 2012; 30: 41-48.
14. Akoegninou A, van der Burg WJ, van der Maesen LJG Flore analytique du Bénin. Wageningen: Backhuys Publishers. Cotonou, Wageningen, Bénin, Pays Bas; 2006.
15. Kouyaté AM, van Damme P. *Detarium microcarpum* Guill. & Perr. In: PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands; 2006.
16. Cavin AL. Contribution à la connaissance taxonomique et chimique de fruits africains du genre "*Detarium*" (Fabaceae - Caesalpinioideae) : "*D. microcarpum*" Guill. et Perr. et des formes comestibles et toxiques de "*D. senegalense*" J.F. Gmel. 2007.
17. Arbonnier M. Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest. CIRAD; 2002.
18. Kouyaté AM. Aspects ethnobotaniques et étude de la variabilité morphologique, biochimique et phénologique de *Detarium microcarpum* Guill. & Perr (Mali). Université de GENT, Belgique; 2005.
19. Bellefontaine R. Synthèse des espèces des domaines sahélien et soudanien qui se multiplient naturellement par voie végétative. In: Fonctionnement et gestion des écosystèmes forestiers contractés sahéliens. Paris : John Libbey; 1997. p.95-104
20. Gautier D, Hautdidier B, Ntoupka M, Onana J, Perrot N, Tapsou T. Caractéristiques de l'arbre, ce qu'en font les paysans et ce qu'ils pourraient en faire ; 2002.
21. Ouedraogo A. L'effet de la coupe de *Detarium microcarpum* Guill. & Perr. sur la régénération de la végétation dans la forêt classée de Nazinon. Mémoire d'ingénieur du développement rural, Université de Ouagadougou, Burkina-Faso; 1997.
22. Wiersum KF, Slingerland M. Use and management of two multipurpose tree species (*Parkia biglobosa* and *Detarium microcarpum*) in agrosilvopastoral land-use systems in Burkina Faso, Wageningen, The Netherlands; 1997.
23. Kouyaté AM, Decaluwé E, Guindo F, Diawara H, Diarra I, N'Diaye I Van Damme P. Variabilité morphologique du baobab (*Adansonia digitata* L.) au Mali. *Fruits*, 2011 ; 66 : 247-255.
24. Agbo IR, Missihoun AA, Vihotogbe R, Assogbadjo EA, Ahanhanzo C, Agbangla C. Impacts des usages traditionnels sur la vulnérabilité de *Detarium microcarpum* Guill. & Perr. (Caesalpinaceae) dans le district phytogéographique Zou au Bénin (en Afrique de l'Ouest). 2017. <https://doi.org/10.1016/j.foreco.2005.02.061>
25. Kouyaté AM, Mayer A, van Damme P. Perceptions paysannes de *Detarium microcarpum* Guill. & Perr. dans le Sud du Mali. *Fruits*, 2002 ; 57 : 305-312.

26. Terrible M. Quelques arbres à multiplier dans les régions à longue saison sèche (savanes et sahel), C.E.S.A.O. collection, Cahiers ruraux ; 1991.
27. INSAE. *Résultats provisoires du RGPH4*, Bénin ; 2013.
28. Dicko A, Natta AK, Biaou HS. Connaissances ethnobotaniques et conservation des *Lophira lanceolata* (ochraceae) au Bénin (Afrique de l'ouest), Annales des Sciences Agronomiques, 2017 ; 21 : 19-35.
29. Dagnelie P. Statistiques théoriques et appliquées. Tome 1. Paris et Bruxelles, De Boeck et Larcier ; 1998.
30. Assogbadjo AE, Glèlè Kakaï R, Adjallala FH, Azihou AF, Vodouhê GF, Kyndt T, Codjia JTC. Ethnic differences in use value and use patterns of the threatened multipurpose scrambling shrub (*Caesalpinia bonducul.*) in Benin. Journal of Medicinal Plants Research, 2011; 5: 1549-1557.
31. Venables WN, Ripley BD. Modern Applied Statistics with S. Fourth Edition. Springer, New York. 2002.
32. Akaike H. A new look at statistical model identification. IEEE Transactions on Automatic Control AU, 1974; 19: 716-722.
33. Gandiwa E, Zisadza-Gandiwa P, Muboko N, Libombo E, Mashapa C, Gwazani R. Local People's Knowledge and Perceptions of Wildlife Conservation in Southeastern Zimbabwe. Journal of Environmental Protection, 2014; 5: 474-485.
34. Ricez T. Etude des modes de régénération à faible coût de *Prosopis africana* et *Detarium microcarpum* en forêt classée de Dinderesso. Mémoire de Master II en bioressources en régions tropicales et méditerranéennes. Université multidisciplinaire de Paris XII Val de Marne, France, 2008.
35. Kristensen M, Balslev H. Perceptions, use and availability of woody plants among the Gourounsi in Burkina Faso Biodiversity and Conservation. 2003. 12:1715-1739.
36. Tondoh J, Degrande A. Scoping study and prioritization of agroforestry species in pilot villages. Final report, executive summary. Burkina Faso: BIODÉV; 2015.
37. Bazile D. La gestion des espèces ligneuses dans l'approvisionnement en énergie des populations. Cas de la zone soudanienne du Mali. Thèse de doctorat, Université de Toulouse le Mirail ; 1998.
38. Cotton CM. Ethnobotany: Principles and Applications. New York: John Wiley & Sons; 1996.
39. Schneider P. Sauvegarde et aménagement de la forêt classée de Farako avec la participation et au profit des populations riveraines. Thèse de Doctorat. EPFZ. Zürich, 1996.
40. Dieng SD, Diop M, Faye LC, Goudiaby A, Niang-Diop F, Guiré I, Sambou S, Lykke AM, Sambou B. Characterization of Ecosystem Services Provided by *Detarium microcarpum* around the Protected Forest of Patako (Senegal). Journal of Applied Environmental and Biological Sciences, 2016; 6: 41-49.
41. Kouyaté AM, Meyer A, Van Damme P, Diawara H. Usages magico-médicinaux et vétérinaires de *Detarium microcarpum* (Fabaceae) au sud du Mali. In Systematics and conservation of African plants (pp. 367–374). Kew: Royal Botanic Garden. 2009.
42. Ganaba S, Ouadba JM, Bognounou O. Les ligneux à usage de bois d'énergie en région sahéenne du Burkina Faso : préférences des groupes ethniques. Sécheresse, 1998 ; 9 : 261-268.

43. Assogbadjo AE. Importance socio-économique et étude de la variabilité écologique, morphologique, génétique et biochimique du baobab (*Adansonia digitata* L.) au Bénin. Thèse de Doctorat. Faculty of Bioscience Engineering, Ghent University, Belgium. 2006.
44. Gaoue OG, Coe MA, Bond M, Hart G, Seyler BC, Mcmillen H. Theories and Major Hypotheses in Ethnobotany. *Economic Botany*, 2017; 71: 269-287.
45. Albuquerque UP, Soldati G.T, Sieber SS, Ramos MA, De Sá JC, De Souza LC. The use of plants in the medical system of the Fulni-ô people NE Brazil. A perspective on age and gender. *Journal of Ethnopharmacology*, 2011; 133: 866-873.
46. Torres-Avilez W, de Medeiros PM, Albuquerque UP. Effect of gender on the knowledge of medicinal plants: Systematic review and meta-analysis. *Evidence-Based Complementary and Alternative Medicine*. Hindawi, 2016; 1-13.
47. Voeks RA, Leony A. Forgetting the forest: Assessing medicinal plant erosion in eastern Brazil. *Economic Botany*, 2004; 58: 94-106.
48. Gaoue OG, Ticktin T. Patterns of harvesting foliage and bark from the multipurpose tree *Khaya senegalensis* in Benin: variation across ecological regions and its impacts on population structure. *Biological Conservation*, 2007; 137: 424-436.
49. Kakudidi EK. Cultural and social uses of plants from and around Kibale National Park. Western Uganda. *African Journal of Ecology*, 2004; 42: 114-118.
50. Albuquerque UP. Re-examining hypotheses concerning the use and knowledge of medicinal plants a study in the Caatinga vegetation of NE Brazil. *Journal of Ethnobiology and Ethnomedicine*, 2006; 2: 1-10.
51. Voeks RA. Disturbance pharmacopoeias: Medicine and myth from the humid tropics. *Annals of the Association of American Geographers*, 2004; 94: 868-888.
52. Ramos MA., de Medeiros PM, de Almeida ALS., Feliciano ALP, de Albuquerque UP. Can wood quality justify local preferences for firewood in an area of caatinga (dryland) vegetation? *Biomass and Bioenergy*, 2008; 32: 503 – 509.
53. Froumsia M, Zapfack L, Mapongmetsem P-M, Nkongmeneck B-A. Assessment of Fuel Wood Values and the Influence of Wood Cutting on the Easily Flooded Plain Woodland of the Sahelian Area, Cameroon. *Journal of Life Sciences Research*, 2016; 3(2): 18-29.

Figures

Figure 1

Study area Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 2

Response rates and use categories of *D. microcarpum*

Figure 3

Factorial map linking sociolinguistic groups to the use of parts / organs of *D. microcarpum*

Figure 4

Links between *D. microcarpum* use as fuelwood and the gender (a), sociolinguistic group (b), educational level (c) and phytogeographical district (d).