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Tamarindus Indica L. (*Fabaceae*) in ecological zone I of Togo: use value and vulnerability

Abstract

In sub-Saharan Africa, indigenous fruit trees such as the tamarind tree (*Tamarindus indica* L.) are highly used by the local population to meet their daily needs. The present study is a contribution to the sustainable management of tamarind tree in Togo. Specifically, it aims at: (i) determining the variation of indigenous use knowledge of tamarind tree according to ethnicity, gender, age and occupation, and (ii) assessing its vulnerability due to it plant parts withdrawal in ecological I zone of Togo. Data were collect throughout semi-structured individual and focus groups interviews of 451 respondents. Globally, eight (8) types of uses and 14 plant parts were categorized. According to the importance use value index (IUVIpp), the most used plant parts are ripe pulp (213.48%), leaves (185.24%), and stem bark (126.64%). The level of solicitation of the different plant parts of the species is the main cause of its vulnerability whose index was evaluated at 2.5. This value closer to the maximum scale (3) shows that the tamarind tree is very vulnerable. Awareness on the rational use and domestication for the conservation of tamarind tree are highly needed.

Keywords: Tamarind tree, endogenous knowledge, anthropic threats, Togo

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Introduction

In Africa, it is widely known that spontaneous plant species plays a very crucial role in the socio-economic balance of local populations and enable them to meet their basic needs.[1,2] This flora provides food, medicinal products, construction materials, household tools and energy sources, thus contributing to diversifying sources of income.[2] For several African ethnic groups, they contribute to poverty reduction, food security and social equity.[1–3] The use and the knowledge of plant species vary according to spatial, cultural and economic parameters.[3,4] It is also recognized that populations, especially in rural areas, have endogenous ethnobotanical knowledge thanks to the cultural, ecological and environmental diversity in which they thrive.[5] This knowledge will be very helpful in the domestication of species of particular interest for the benefit of achieving the Sustainable Development Goals (SDGs).[2,3]

The dependence of local populations on resources taken from the natural environment is proven.[2] However, the harvesting of plant resources in order to meet primary needs of human populations may represent a threat to the survival of target plants.[6,7] In order to meet their daily needs, local population exert strong pressure through the abusive exploitation of various plant parts.[8] These threats slow down the dynamic of natural regeneration and stands growth.[8] It can also weaken income, goods and services generated to local forest-dependent communities.[1] Faced the anthropogenic pressure on multipurpose useful woody species and their importance in the socio-economic life of local communities, it is necessary to assess their importance uses values and the vulnerability of multipurpose trees.

In West Africa sub-region, several studies have been focused on multipurpose useful trees likely to contribute to the resilience of human populations with a view of sustainable development and management of plant genetic resources. The most studied species are agroforestry trees. Among these agroforestry trees is the tamarind tree (*Tamarindus indica* L.), a fruit tree found in particular within the Sudanese areas of Togo, one of the priorities dietary tree species of Togo.[9] The tamarind tree traditionally serves to build the resilience of populations.[3,10] The multiple uses of this species have motivated further research on this plant in the with a view to better management for the well-being of their populations.[3,8,10,11] In Togo, although the species is well known and used by the local population especially throughout the northern part where it is found abundantly in agroforestry parklands, there is a lack of studies focused on. Only a few studies mentioned globally the species as indigenous fruit tree.[12] Nevertheless, the species is subjected to a flourishing trade and used variously by the local population.

The present study supposes that the tamarind tree is highly vulnerable due human threats. So, two main research question is enquired. What are the endogenous use values of the tamarind tree, particularly throughout ecological zone I of Togo? What is the level of vulnerability of the tamarind tree facing human threats within agroforestry parklands of ecological zone I of Togo?

The present study is a contribution to the sustainable valorisation and management of a tamarind tree in Togo. Specifically, it aims at: (1) assessing the importance use values of tamarind plant parts according to ethnicity, sex, age and profession; and (ii) evaluating the degree of vulnerability of a tamarind tree facing pressure linked to its plant parts harvesting and use by the local populations of ecological zone I of Togo.

Material and methods

Description of ecological zone I of Togo

Located in the Sudanian zone of Togo, ecological zone I[13] covers the Savannah region and partly the Kara region of Togo (Figure 1). It covers 11 prefectures, including seven (7) in the Savannah region and four (4) in the Kara region. Phytogeographically, ecological zone I is located in the Regional center of Sudanese endemism.[14]

Geomorphologically, it is essentially characterized by the Bombouaka and Dapaong plateaus, the Oti plain in the south and the Precambrian peneplain in the far north.[15,16] The climate Sudanese

marked by a rainy season from May to October and a dry season from November to April. Precipitation varies approximately between 800 and 1300 mm/year results to an unfavourable water balance due to insufficient and irregular rainfall.[17] Temperatures fluctuate between 15 ° C and 39 ° C in the dry season and then between 22 °C and 34 °C in the rainy season.

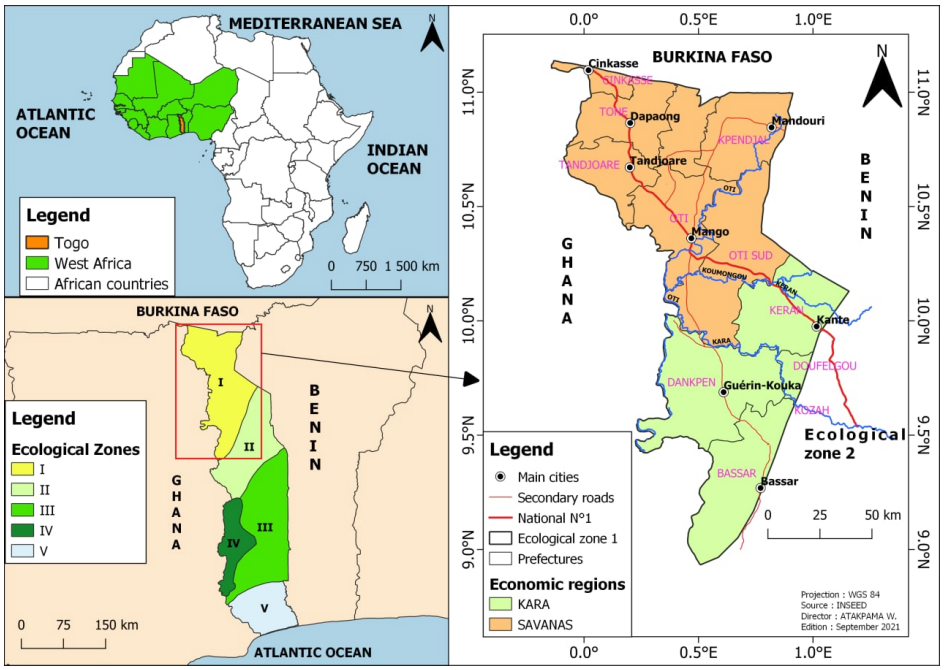

Figure 1 Location of ecological zone I in Togo and West Africa.

The vegetation is essentially dominated by agroforestry parklands. The most notable are the African locust bean, the baobab and the roast palm parklands.[18–20] There are also relics of mosaics of savannahs, dry forests, riparian forests and marshy vegetation adjacent to the hydrographic network. Plant communities of *Sterculia setigera* L. are founded throughout rocky hills.[21] Forests are mainly located in protected areas.[22] These protected areas are facing significant pressures threatening their survival.[22,23]

Data collect

Sampling design

In order to determine the size of the sampling population (N) with probable knowledge of tamarind tree uses, the non-probabilistic method was used.[5] The total sample of respondents was defined after a pre-investigation on the knowledge or not of the use of tamarind plant parts based on a test sample of 1400 respondents with a sex ratio of 1/2 randomly selected throughout the study area. The sample is made up of harvesters, processors, traders and users of tamarind tree. From the proportion (Fn) of 1238, i.e. 88% of respondents recognizing at least one use of tamarind tree plant parts out of 1400, the size of the total sample (N) with a confidence interval of 95% and a risk 5% error was calculated according to the formula of Dagnelie.[24]

$$N = \frac{\mu^2_{1-\alpha/2} Fn(1-Fn)}{\delta^2}$$

$\mu_{1-\alpha/2}$=1,96 representing the value of the normal random variable with a 95% confidence interval for a risk α equal to 5%. The expected margin of error δ for any parameter to be estimated from the survey is 3%. For this precision, N=451, the size of the sample taken into account during the study.

Three (3) levels of stratification has been adopted.[5,25] The first level is made up of 10 prefectures from the Savannah and Kara regions. The second stratum consists of 48 cantons chosen to cover all the ethnic groups present in each of the prefectures. In these cantons, 95 villages are chosen in the form of clusters, taking into account the distribution of ethnic groups. The sample size is 67% and 33% respectively in rural and urban areas.

Ethnobotanical surveys

Data were collected from September 10 to October 15, 2020. The methodology was based one semi-directive ethnobotanical individual and focus groups interviews, followed by field observations.[25] The interviews were preceded by the presentation of the aim of the study to the administrative authorities (prefects) and traditional authorities (village heads, canton chiefs, notables) in order to give their approval for carrying out the study. Respondents were selected randomly regardless of gender or age. Information sought are the use of plant parts, management methods, and harvesting of plant parts of tamarind tree.

Respondents are belonging to 13 ethnic groups. The most represented of which are the Moba (43%), the Konkomba (13%), the Lamba (10%), the Yanga (6%), and the Tamberma (6%). Men occupy a ratio of 56% against 44% of women. The most represented professions are farmers (45%), housewives (17%), traders (14%), artisans (12%). Civil servants (6%), students (3%), and herders (2%) are less represented. The proportion of illiterate respondents is 34%. Four (4) age groups of respondents were defined: 20years old, 20-39 years old, 40-59years old, and ≥ 60 years old. Respondents from 40-59 years old were the most represented (43%), followed by the 20-49years old (37%). The less represented were those under 20years (2%) and over 60years (18%).

Data analysis

Assessment of use values

The assessment of the species plant parts uses values was based on the use value indices as defined by previous studies.[25–27] The different usage parameters taken into account are as follows: the relative frequency (Fr), the reported uses (RUpp), the plant part value (PPV), the interspecific use value (VUI), Use Diversity Index (UDIpp), Use Importance Value Index (UIVIpp), and the mean reported use (RUmean).

The relative frequency (Fr) of citation of a plant part corresponds to the ratio between the number of respondents (n) who cited a target plant part and the total number of respondents (N): Fr=(n / N) x 100. It defines the most reported plant part.

The reported use for a plant part (RUpp) is the total number of citations per plant part. PPV is the ratio between the reported use of a target plant part and the sum of all plant parts reported use (PPV=(Rupp/ΣRUpp x 100). The high value value PPV is gained by the most valuable plant part.

The specific use is the use as described by respondents. The specific (SU) expresses the number of times a specific use has been reported. The Interspecies Use Value (IUV) is the ratio of the SU and RUpp.

The use diversity index value of a plant part (UDIpp) is the ratio between the number of specific uses of a target plant part i and the one of the most diversify used plant part (UDIpp=(NSUi/NSUmax)x100. The most diversified used plant part is the one obtaining the highest number of specific uses.

The use importance value index (UIVIpp) of a plant part is the sum of the relative frequency, the plant part value and the use diversity index: IUVIpp=Fr + PPV + UDIpp. This index allow to estimate the use importance of the plant part based on its use knowledge by all respondents, the plant part value and diversity of specific uses. Its maximum value is 300. The plant part with the highest value is the most valuable.

The variation in knowledge of tamarind use according to sex, age, level of education and ethnicity was based on the comparison of the mean number of specific uses reported per respondents. The statistical tests (ANOVA One-way) with the help of Minitab 16 software was done to confirm of not weather the mean reported use (RUmean) computed was significance. The level of similarity of tamarind use knowledge between ethnic groups, sex, age and level of education was measured using the Sorensen index[26,28] assessed with the help Community Analysis Package, CAP 2.15 software. The assessment of Sorensen index (SI) was used to assessed the similarity of specific uses knowledge of the tamarind tree plant part between ethnic groups. It is defined by the following formula: SI=2C/(A + B), with A and B the number of uses specific to ethnicity, sex, age group or profession 1 and 2 respectively and C, the number of uses shared by the two entities 1 and 2. Using the Hierarchical Ascending Classification according to Ward's, ethnic groups were classified based on the specific uses of plant parts.

Assessment of the species vulnerability

The vulnerability index (Vi) of the tamarind tree in the study area was determined through the ecological impact of the use of its plant parts. The vulnerability assessment parameters retained are the frequency of popularity of the species, the plant parts used, and the harvesting technics namely fruits harvesting, uprooting, barking or branches cutting.[7,29] The risk of vulnerability assessment is based primarily on the demands on *T. indica* and its plant parts, not directly linked on the rarity or abundance of the species. The parameters taken into account are: the frequency of plant parts citation use (N1), the number of plant parts use categories (N2), the harvesting technics (N3), and the used plant parts (N4). The vulnerability index is then calculated by the formula Vi=ΣNi/4, Ni the value assigned to the parameter i according to its specific level of vulnerability. the vulnerability scale evaluated varies from 1 to 3. If Vi < 2, the plant is said to be less vulnerable. If 2 ≤ Iv <2.5, the plant is said to be relatively vulnerable. If Iv ≥ 2.5, the plant is said to be highly vulnerable. The value 1 indicates a low level of vulnerability; the value 2 means an average level of vulnerability and the value 3 means an alarming level of vulnerability (Table 1).

Table 1 Parameters used for the vulnerability assessment

Parameters	Vulnerability to uncontrolled exploitation		
	Low (Scale = 1)	**Medium (scale = 2)**	**High (scale =3)**
Frequency of use (N1)	Low N1 < 20%	Medium 20% ≤ N1 < 60%	High N1 ≥ 60%
Number of uses (N2)	N2 < 2	2< N2 4	N2 ≥ 5
Used Plants Parts (N3)	Leaves, latex, sap	Fruits, Branches	Wood, Seeds, Barks, Roots, Flowers
Harvesting technics (N4)	Picking	-	Picking, debarking, uprooting, cutting

Results

Plant parts used

A total of 14 plant parts were categorized. The most reported plant parts are ripe pulp (99%), leaves (64%), stem barks (27%), and roots (27%). Root barks, leaf stems, branches, stems, young leaves and young fruits were relatively less reported (Figure 2).

Specific uses and use types

The number of specific uses reported were 71. The most reported uses were: juice (77.16%), malaria (28.60%), porridge (21.73%), stomachache (20.62%), and fodder (19.29%) (Figure 3). The use of tamarind tree as appetizers, antianemia, childbirth deliverance, against mental disorders, hernias, sexual powerlessness, children teething or for stunted growth was less reported.

The 71 specific uses were categorized into eight (8) types of usages. Dietary and pharmacopeia uses are mostly represented, respectively reported by 85% and 81% of respondents (Figure 3). The tamarind use for forage and art and and craft purposes were less reported. The fuelwood use was scarcely reported. Regardless cultural importance, within Fulani ethnic group, stick is used in ritual of adulthood passage so calling « Godja ». Nevertheless, it was reported as chewing stick.

Citation: Samarou M, Atakpama W, Kanda M, et al. *Tamarindus Indica* L. (*Fabaceae*) in ecological zone I of Togo: use value and vulnerability. *Int J Complement Alt Med.* 2021;14(6):307–315. DOI: 10.15406/ijcam.2021.14.00577

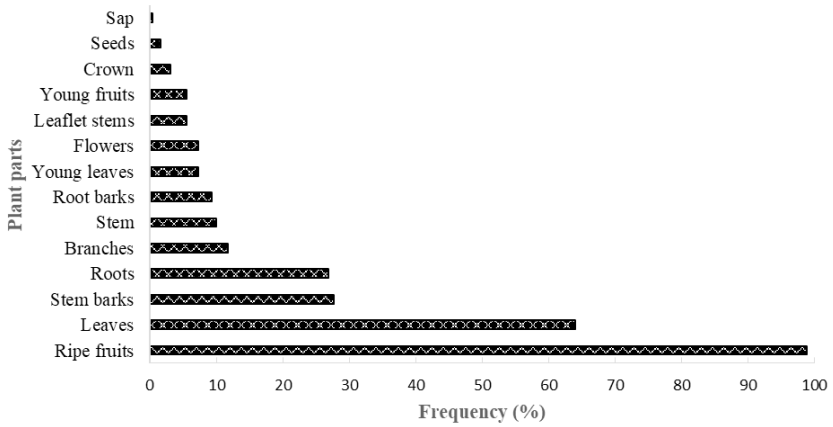

Figure 2 Frequency of citations of organ parts of tamarind tree.

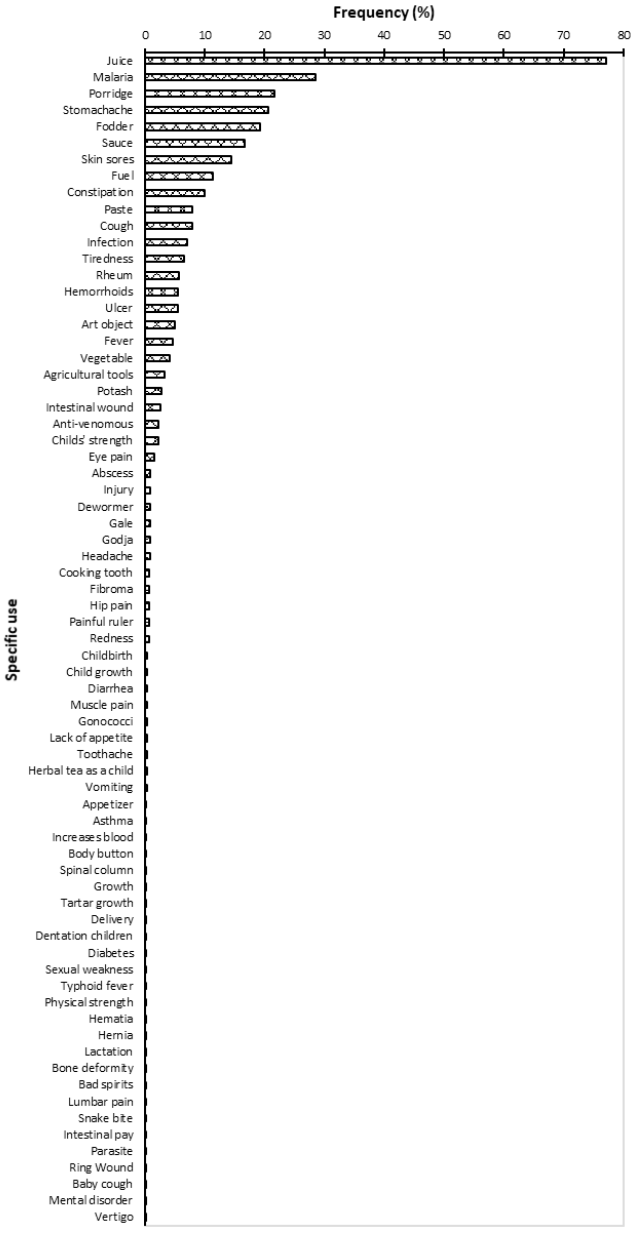

Figure 3 Uses of the tamarind tree reported in ecological zone I of Togo.

Use values of tamarind tree plant parts in ecological I zone of Togo

According to the use importance value index of plant parts (UIVIpp), ripe pulp (213.48%), leaves (185.24%) and stem bark (126.64 %) of tamarind tree are the most useful plant parts. The higher value of UIVIpp of ripe pulp depends to the high value its relative frequency showing it popular use knowledge shared among respondents. Although the use of the ripe pulp is more widely known, the leaves are found to be the most diversified in terms of specific use. The least important plant parts are the sap, crown, seeds, flowers, young leaves, and young fruits. These least used plant parts are the least known by the respondents and have the lowest diversity indices of use (Table 2).

Table 2: Importance use value index of plant parts of *T. indica*

Variation of use knowledge according to ethnic groups

The mean reported use of *T. indica* plant parts per respondent (RUmean) varies according to the ethnic group. It was higher among the Gangam (5.00±2.33), the Temberma (4.77±2.08), and the Yanga (4.03±2.75). Among the Anoufoh, Lamba, Moba, Fulani, Gourmantche and Natchaba, the RUmean it was almost identical (Table 4). The lowest RUmean can be seen among the Hausa, the Kabye, the Konkomba, and the Bassar. Statistical tests (ANOVA One-way) showed that the variation in knowledge between ethnic groups is significant ($p=0.00$) in particular between the Gangam and the Tamberma on the one hand and the Konkomba and the Bassar on the other hand (Table 3). The diversity of plant parts used, the type of use, the geographical distribution and the specific uses explains the discrimination of these groups.

Sorensen Index (SI) ≥ 0.55 among most ethnic groups illustrating that each ethnic group knows less than half of the uses known by the other (Table 4). The near-half knowledge similarities lie between the Lamba et les Gangam (IS=0.55), the Natchaba and the Gourmantche (IS=0.48), the Natchaba and the Gangam (IS=0.44), the Tamberma and the Gangam (IS=0.43), the Natchamba and the Lamba (IS=0.45), the Tamberma and the Lamba (IS=0.47), the Yanga and the Fulani (IS=0.45).

The hierarchical ascending classification of ethnic groups according to the Ward's method discriminate two main groups GI and GII, subdivided into two sub-groups each, GIa, GIb and GIIa and GIIb (Figure 5). The explanatory factors for the discrimination of groups are: the diversity of the parts of organs used, the type of use and the

specific uses. The GIa sub-group brings together the Anoufoh, Gangam, Lamba, Natchaba, Gourmantche, Tamberma ethnic groups all located in the Savannah Region. The GIb is made up of the Konkomba, the Moba, the Fulani, the Yanga ethnic groups. Geographically, the ethnic groups of the GIb group are distributed in the two economic regions of ecological zone I: Savannah (Moba, Fulani, and Yanga) and Kara (Konkomba). The GII group brings together the Bassar (GIIa) and the Hausa, the Kabye (GIIb) who are more present in the Kara region. This group is made up of ethnicities who have less knowledge of the uses of tamarind tree with a low number of reported uses. The knowledge among the Bassar and Kabye relates more to the dietary use of ripe pulp and roots for the treatment of infections.

Table 2 Importance value of organ parts of *T. indica*

Plant parts	Relative frequencies (Fr, %)	Plante parts values (PPV, %)	Use Diversity index (UDIpp, %)	Importance Use value Index (IVUIpp)
Ripe fruits	98.89	40.91	73.68	213.48
Leaves	64.08	21.17	100.00	185.24
Stem barks	27.72	9.45	89.47	126.64
Roots	26.83	8.54	60.53	95.90
Root barks	9.31	3.04	39.47	51.83
Leaflet tree	11.75	3.56	28.95	44.26
Branches	5.54	1.75	34.21	41.50
Stem	7.32	2.39	28.95	38.66
Young leaves	9.98	3.17	23.68	36.83
Young fruits	5.54	1.68	21.05	28.28
Flowers	7.32	2.52	10.53	20.37
Seeds	1.55	0.65	10.53	12.73
Crown	3.10	1.04	2.63	6.77
Sap	0.44	0.13	2.63	3.20

Table 3 Mean reported use of plant parts (RUpp) of tamarind tree according to the ethnic groups in ecological zone I of Togo

Ethnic groups	Mean reported use (RU_{mean})	Groups
Gangam	5.00±2.33	A
Tamberma	4.77±2.08	A
Yanga	4.03±2.75	AB
Anoufoh	3.77±2.01	ABC
Lamba	3.64±1.95	BC
Moba	3.54±1.76	BC
Fulani	3.29±1.74	BC
Gourmantche	3.07±1.22	BC
Natchaba	3.00±1.03	BC
Haoussa	2.83±1.72	BCD
Kabye	2.40±1.08	CD
Konkomba	1.83±0.83	D
Bassar	1.17±0.41	D

Table 4 Similarity of uses of tamarind by ethnic groups in ecological zone I of Togo based on the Sorensen index

Ethnic groups	Anoufoh	Bassar	Gangam	Gourmantche	Haoussa	Kabye	Konkomba	Lamba	Moba	Natchaba	Fulani	Tamberma
Anoufoh												
Bassar	0.06											
Gangam	**0.42**	0.06										

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Table Continued...

Ethnic groups	Anoufoh	Bassar	Gangam	Gourmantche	Haoussa	Kabye	Konkomba	Lamba	Moba	Natchaba	Fulani	Tamberma
Gourmantche	**0.43**	0.12	**0.44**									
Haoussa	0.29	0.27	0.27	0.28								
Kabye	0.33	0.13	0.39	0.32	0.32							
Konkomba	0.30	0.20	0.28	0.33	0.21	0.20						
Lamba	0.39	0.08	**0.44**	0.38	0.26	0.32	0.30					
Moba	0.33	0.05	0.27	0.37	0.18	0.20	0.25	0.34				
Natchaba	**0.43**	0.12	**0.44**	**0.48**	0.37	0.36	0.25	**0.45**	0.36			
Fulani	0.37	0.12	0.28	0.23	0.28	0.36	0.33	0.38	0.36	0.36		
Tamberma	0.40	0.09	**0.43**	**0.56**	0.30	0.30	0.24	**0.47**	0.37	0.39	0.33	
Yanga	0.27	0.08	0.39	0.37	0.25	0.35	0.26	0.38	0.40	0.40	**0.45**	0.35

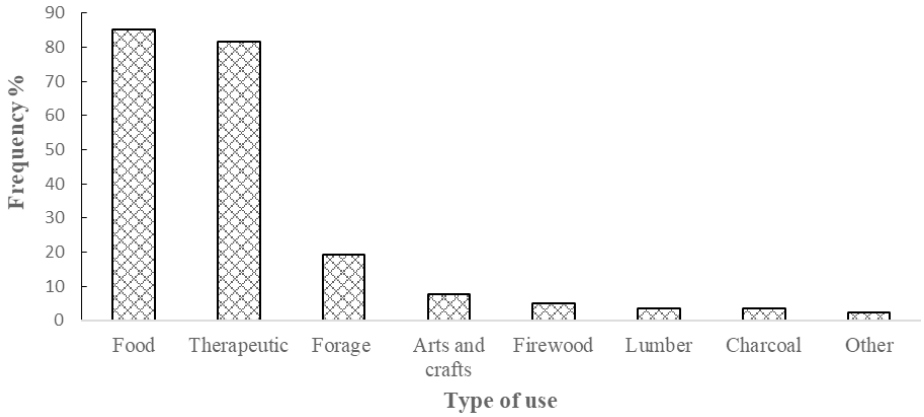

Figure 4 Type of use of plant parts of the tamarind tree in ecological I zone of Togo.

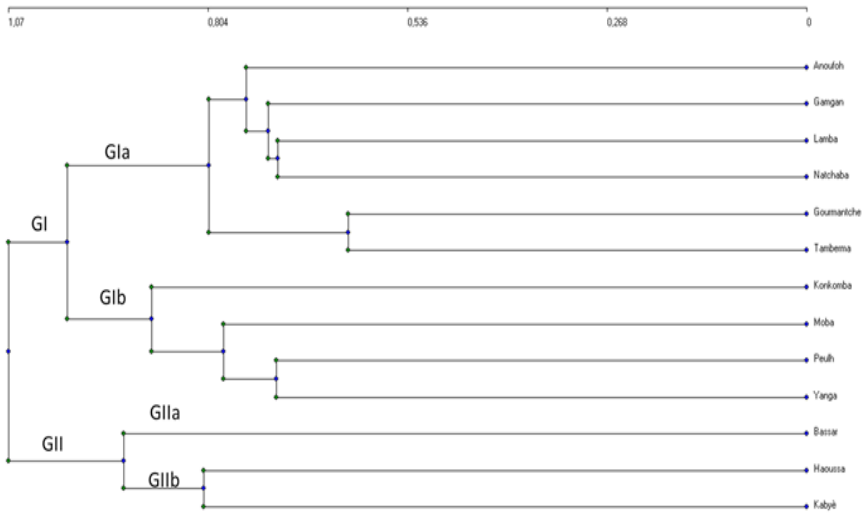

Figure 5 Relationship between ethnic groups based on specific uses of plant parts of *T. indica* in ecological zone I of Togo.

Variation of use knowledge according to age and sex

RUmean in the three (3) age groups over 20 years old are close and equal respectively to 3.40±2.04; 3.35±1.81 and 3.56±1.87. Respondents aged under 20 have less knowledge (2.56±1.13) than those aged over 20 years. However, Fisher's test ($p=0.52$) showed that there is no significant difference.

With regard to sex, RUmean for men and women are 3.57±1.00 and 3.14±1.89 respectively. Fisher's test shows a significant difference ($p=0.02$) between the men and women.

Variation of knowledge according to profession

RUmean varies according to the level of education. It is appreciably equal among university, primary, secondary school respondents of

and those with no level of education with respectively 3.04±1.65, 3.39±1.85, 3.50±1.78 and 3.87±1.93. Statistical tests (ANOVA One-way) show that the variation between educational levels is significant (*p=0.00*). Four groups can be distinguished, namely: (i) group A: made up of no education level (ii) Group AB: made up of primary and secondary levels (iii) and group BC concerned by the higher level and (iv) group B was the literate respondents. Literate respondents have a different knowledge of the uses of *T. indica* than those with no education. However, literate respondents and those who have at least a primary level and above have in common confident knowledge of the uses of *T. indica* plant parts (Table 5).

Table 5 Mean reported uses of tamarind tree according to the level of education

Education	Mean reported use (RU_{mean})	Groups
Any	3.87±1.93	A
Primary school	3.50±1.78	AB
Secondary school	3.39±1.85	AB
High school	3.04±1.65	BC
Alphabétisé	2.45±1.78	B

The specific uses of tamarind reported depend on the level of education. However, there are specific uses of which knowledge is shared. Analysis of the degree of similarity of specific uses (SI ≥ 0.40) shows that each level of education considered has nearly half of the uses known by the other. The strongest similarities lie between those who have no educational level and the one hand those with a secondary level (SI=0.62). The similarity is also important between the literate respondents and those at primary level (0.59). The weakest similarities are found between respondents with a higher level and those with no level of education (0.40)

Vulnerability of tamarind tree linked to plant parts uses

The vulnerability of *T. indica* in ecological zone I depends on the frequency of use of plant parts removed (Fr, ripe pulp=98.89%), the large number of use categories (Nu=8), the used plant parts (stems, leaves, bark, roots, fruits, flowers), plant parts harvesting technics (cutting, debarking, uprooting, and picking). The vulnerability index for *T. indica* is 2.5.

Discussion

Use knowledge of tamarind tree plant parts

This study showed that almost all plant parts of *T. indica* are valued for dietary, pharmacopeia, forage, craft, energy and timber purposes. These various use types census had also been reported in previous studies on the tamarind tree in West African sub-region.[3,10,30] However, cosmetic uses previously reported by Garba A[10] among local population of south-west part of Niger were not census in this study. This difference could be explained by cultural disparity.

The fruits are the most valuable plant part of *T. inda*, best known by almost all respondents. However, it specific uses are less diversified than those of the leaves. Ripe fruits are prized and used in juice, sweet drink, condiment and confectionery in most countries of the world.[31] The importance of tamarind fruit in the traditional diet of rural West African communities had been highlighted by scholars.[3,10] Tamarind fruits are thought to be one of the most acidic and sweetest fruits simultaneously.[31] The ripe fruits' pulp is very rich in tartaric acid and are used as a preserver in the soused fruit and vegetable industries.[30] According to these authors, although the green, hard pulp of unripe fruits are too sour to be consumed directly, however it could be used in the preparation of tasty dishes. Compared to *A. digitata* and *B. aegyptiaca*, tamarind fruits have the highest contents of total soluble sugars.[11] In northern Benin, the pulp of the fruit is mixed with a water-based drink and sweetened at will.[3] In Niger, the pulp and seeds are macerated to obtain a liquid that is traditionally used for dietary purposes including juice, porridge, sauce.[10] Consumption of 100 g of tamarind pulp by an adult covers 10.69% of the recommended daily intake of calcium, 20.49% of magnesium, 14.21% of phosphorus, 12.07% of iron, 2.61 % manganese, 1.29% zinc, 32.22% copper and 9.21% selenium.[32] These phytochemical constituents would justify the therapeutic uses reported during the study.

The therapeutic importance is emphasized in other African, Asian and American countries.[33] The use of the fruit pulp as a febrifuge seems to be linked to its laxative properties[34] explained by the high amounts of malic and tartaric acids and potassium tartrate.[35] The febrifuge properties of the fruits militate in favour of their antimalarial use. The antispasmodic activities of the aqueous macerate and decoction had been demonstrated.[36] This would partially justify the traditional use of plant parts of the tamarind tree in traditional medicine in Africa against malaria.[3,37] Consumption of soaked fruit for the treatment of constipation is also reported among rural Fulani in Nigeria[38] and others African countries.[3]

Although leaves were less reported than fruits, their specific uses are more diversified. The relative importance of leaves and bark of *T. indica* especially for wound healing had also been reported by other ethnobotanical studies.[3] Leaves and bark of the tamarind tree were also reported in the treatment of coughs and as a skin cleanser in Africa.[34] The use of leaves for fodder purposes although less reported by respondents from ecological zone I of Togo, had been reported to be appreciated by livestock in Nigeria, Burkina Faso and Senegal because the leaves are appreciated by livestock.[10,39,40]

Variation of use knowledge of tamarind tree

The use of *T. indica* was in ecological zone I of Togo differ significantly depending on ethnicity, gender and level of education. In contrast, there is no significant difference according to age. The difference in the uses of the species by ethnic groups is said to be due to cultural heritage, knowledge being transmitted from generation to generation within the same ethnic group.[10,41] The convergence of knowledge of specific uses of plant parts according to ethnic groups indicates that each ethnic group knows more than half of the uses known by the other ethnic group. These results are similar to those reported for local population of south-west of Niger.[10] Ethnic groups located in the same geographical area generally share the same specific uses of genetic resources around them.[5] Over time, ethnic groups living together exchange their knowledge through interethnic marriages and friendships.[4,10,41] The latter constitutes a channel for the exchange and transmission of ethnobotanical knowledge on forest resources.

Result of RUmean of *T. indica* are similar the one of of the study carried out on *Pentadesma butyracea* in Benin[42] and *Sterculia setigera* Del. in the Sudanese zone of Togo[43] showing that men have a better knowledge of plant resources uses than women. In contrast, the study on *T. indica* in Niger[10] reported that tamarind tree plant parts use is not influenced by sex. Likewise, studies on *P. biglobosa* and *A. digitata* in Benin and Togo reported that these plant resources knowledge are not statistically influenced by sex.[26,41]

Although the use of *T. indica* is not significantly different by age, respondents under 20years of age have less knowledge than those over 20years. The impact of age on plant knowledge is shared by Ayantunde AA[44] who have shown that the elderly has more knowledge than the young. This could be justified by the accumulation of knowledge as poeple get older[4] following experiences, travels and friendships.[26] Regarding the level of education, the variation in knowledge is significant. In contrast, Issa et al.2018 reported the lack of influence of the level of education on the knowledge of *Khaya senegalensis* plant parts uses in Togo.

Impact of use on the vulnerability of *T. Indica*

The study revealed that the most valuable plant part of tamarind tree in ecological zone 1 is ripe pulp, followed by leaves and stem bark respectively. This result confirms that the tamarind tree is a key important fruit tree and its products are subject to multiple uses.[3,10] The rather high demand for the tamarind fruits is linked to the use of the ripe pulp for various food and medical purposes.

The vulnerability index value closer to 3 shows that the species is very vulnerable in ecological zone I of Togo. The socio-economic benefits of the tamarind tree for local communities within ecological zone I of Togo place the species under pressure of exploitation. In addition, habitat degradation and loss, and the lack of conservation strategies for the species increase its vulnerability.[7,45] Human action plays a major role in the degradation of plant species habitat namely forest stands around the world.[7] The vulnerability index of *T. indica* estimated at 2.5 shows that the species is highly vulnerable. This vulnerability index justified information from the literature which underlines that *T. indica* populations are aging and undergoing poor regeneration.[45,46] The important ethnobotanical interest of the species by local populations, strongly compromises its regeneration by seed in the natural environment. Other similar studies in Benin on *Pterocarpus Santalinoides* L'her. Ex De and *Detarium microcarpum* Guill. & Perr. showed that the degree of stress on the various organs of these plants, in particular wood, turns out to be the main causes of their vulnerability.[47,48]

Conclusion

The present study has censuses the endogenous use knowledge of *T. indica* among 13 ethnic groups of ecological zone I of Togo. A total of 14 plant parts mostly used for dietary and therapeutic purposes were categorized. Globally 71 specific uses were reported. In addition, the study highlighted the impact of the use value of the species on its vulnerability for which the index (Vi) is evaluated at 2.50. Awareness-raising efforts for the rational use and domestication of the species are needed for the sustainable management of tamarind tree. Additional studies of the conservation status of the species in its habitat, allowing to improve knowledge of its vulnerability and other environmental factors affecting its survival deserves to be done.

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Conflicts of interest

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