Ethnobotanical knowledge of *Dialium guineense* Willd. in The Gambia: a way forward for sustainable use in The Gambia

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Abstract

Multipurpose tree species are valuable resources in savannah-dominated areas due to the variety of services they provide. Such species are vulnerable to overexploitation and poor management, which may jeopardize their survival. Understanding local perceptions of their uses and conservation is critical for involving local communities in their sustainable management. This study presents the case study of *Dialium guineense* in the Western Region of The Gambia. Specifically, the study (i) assesses the diversity of uses of *D. guineense*; (ii) examines their perceptions of the threats and conservation solutions. Individual semi-structured interviews were conducted with 633 local people in the Gambia. Ethnobotanical data was analyzed using Relative Frequency of Citation. The degree of correlation between the status of the *Dialium guineense* and demographic variables was ascertained using generalized linear models. The used plant parts were fruits (30%), leaves (28%), bark (17%), wood (15%), and roots (10%). The most cited use categories were food (91.2 %), medicine (81.6 %), and fodder (31 %)**.** The highest index value of useful plant part (30%) was found in its fruits. Overharvesting, bushfires, and deforestation were deemed to be the primary threat factors. According to locals, *D. guineense* is either declining (62%) or rare (28%) in the communities. This study demonstrates the significance of *D. guineense* while also highlighting critical factors to consider when successfully engaging farmers for its sustainable management.

Keywords: Conservation strategy, Local knowledge, Risk factor, Use categories, The Gambia, West Africa

Connaissances ethnobotaniques de *Dialium guineense* Willd. en Gambie : une voie vers une utilisation durable en Gambie

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Résumé

Les espèces d'arbres polyvalentes constituent des ressources précieuses dans les zones dominées par la savane en raison de la diversité des services qu'elles fournissent. Ces espèces sont vulnérables à la surexploitation et à une mauvaise gestion, qui peuvent mettre en péril leur survie. Il est essentiel de comprendre les perceptions locales de leurs utilisations et de leur conservation afin d'impliquer les communautés locales dans leur gestion durable. Cette étude présente le cas du *Dialium guineense* dans la région occidentale de la Gambie. Plus précisément, l'étude (i) évalue la diversité des utilisations de *D. guineense* ; (ii) examine leurs perceptions des menaces et des solutions de conservation. Des entretiens individuels semi-structurés ont été menés auprès de 633 habitants de la Gambie. Les données ethnobotaniques ont permis de calucler la fréquence relative de citation. Le degré de corrélation entre le statut du *Dialium guineense* et les variables démographiques a été déterminé à l'aide de modèles linéaires généralisés. Les parties utilisées de la plante étaient les fruits (30%), les feuilles (28%), l'écorce (17%), le bois (15 %) et les racines (10 %). Les catégories d'utilisation les plus citées étaient l'alimentation (91,2%), la médecine (81,6%) et le fourrage (31%). L'indice de valeur la plus élevée pour les parties utiles de la plante a été observée pour ses fruits (30%). La surexploitation, les feux de brousse et la déforestation ont été considérés comme les principaux facteurs de menace. Selon les habitants, *D. guineense* est en déclin (62%) ou rare (28%) dans les communautés. Cette étude démontre l'importance de *D. guineense* tout en soulignant les facteurs critiques à prendre en compte pour impliquer avec succès les agriculteurs dans sa gestion durable.

Mots clés : Stratégie de conservation, Savoirs locaux, Facteur de risque, Catégories d'utilisation, La Gambie, Afrique de l'Ouest

Introduction

Dialium guineense Willd. is a multipurpose tree species (Esiere *et al*., 2023) that provides various ecosystem functions for local populations. It belongs to the family Fabaceae- Caesalpinioideae and is commonly called the black velvet tamarind (Ogbuewu *et al*., 2023). It is rated among the most common wild fruit in tropical Africa and has a typical dense hairy leafy crown, smooth grey bark, whitish flowers, and thick black fruits. It is usually shrubby, low-branching and can grow to about 20-30m tall (Akoègninou *et al*., 2006). This plant does not require yearly or seasonal cultivation due to its high forage yield and resistance to drought and insects (Ogbuewu *et al*., 2023). Due to its moderate crude protein, fibre, high carbohydrate content and pharmacological effects including antioxidant and antimicrobial properties, *D. guineense* is a popular fruit snack among local communities who peel the black velvet case to eat the orange fruit pulp and its seed is widely used as a medicinal plant in West Africa (Ogbuewu et al., 2023). The fruit pulp has been scientifically investigated for its nutritional capabilities and is believed to be safe for human consumption because it does not interfere

with the normal functioning of most enzymes and metabolites in the body (Oyegoke and Oladiji, 2022). Its sweet-sour taste with stringent flavour makes it a valuable tree species for the local population as an excellent source of minerals and vitamins. Furthermore, the rich phytochemical and essential oil component of the plant makes it a good source of antioxidant and antimicrobial properties with a high amount of micronutrients such as potassium, sodium and magnesium contained in the fruit pulp of the plant (Ogbuewu *et al*., 2023). The leaves and bark of this plant are used by the local population for treating several diseases such as malaria, fever, jaundice and haemorrhoids (Ubani and Tewe, 2001). Regardless of their agreed usefulness as a traditional remedy to cure many sicknesses, there is inadequate scientific data available on their biotic potential to improve the livelihood of individuals (Adjileye *et al*., 2019). *Dialium guineense* is well recognized by local communities, as an agroforestry crop as fodder for animals and as a leguminous plant capable of fixing nitrogen in the soil (Ubani and Tewe, 2001). Additionally, its widely spread canopy is agreed to protect against unfavourable environmental conditions and can provide shelter for various organisms including humans (Nwaguala *et al*., 2021). The species has been planted or retained by farmers in traditional cropping systems based on its nutrient retention and nitrogen-fixing capacities. In addition to the socio-economic benefits of *D. guineense* including (food, income, medicine, fuel and fodder for animals), this plant also provides environmental services such as climate change mitigation, water purification and carbon sequestration, soil conservation, fertility restoration, windbreaks etc. (Esiere *et al*., 2023). However, despite the numerous ecosystem services they provide to local inhabitants in The Gambia, there is inadequate information about the abundance, distribution and conservation status in literature in the country. Therefore, understanding the utilization, risks and exploitation status of *Dialium guineense* in The Gambia is vital for promoting sustainable utilization and income generation and for addressing socioeconomic and environmental issues affecting the distribution and abundance of the species.

I. Methods

I.1. Study area

The Gambia has a tropical sub-humid eco-climatic zone characterized by two seasons, namely a wet season between June and October and a dry season between November and April. The wet season observes a precipitation range of 800 to 1200 mm yearly and the dry season is

dominated by dry and dust-laden winds blowing from the Sahara Desert in the northeast (Kargbo *et al*., 2023). The Gambia's population is 1,922,950 with 38% (730,895) living within the west coast region of the country (GBOS, 2017). This part of the Gambia occupies a total area of 1764 km^2 representing 16% of the total area of The Gambia's 11300 km^2 (ADB, 2013). The region is designated into nine districts with each of the districts comprising several villages and towns (Figure 1). For this study, five of the nine districts were randomly selected and ten villages were selected across the study area. These villages differ in size, population and their common land tenure systems characterized as periurban (Gunjur, Kassa kunda, Darsilami, Bassori, Sanyang and Jalamba) and rural (Faraba, Giboro, Bulok, Bwiam and Sanngarjor) settlements based on their location and level of development. Among the prominent communities, Sanyang and Gunjur alone have a population of 15000 of the study regions with the remaining population spread within the smaller villagers Mandinka, Fula, Wolof, Jula and Manjago are identified as the dominant ethnic groups within the region (UNHCR 2008).

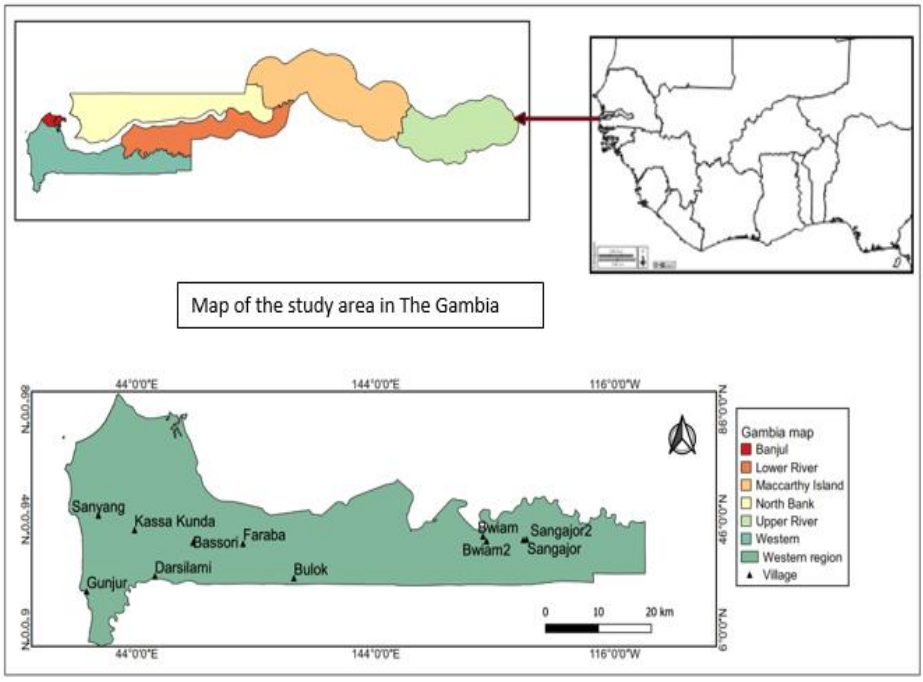

Fig 1: Map localited the study area of the 10 sampled villages in the Western Region of The Gambia

I.2. Sampling

I.2.1. Data collection

To pretest the questionnaire, a pilot study was conducted with 60 randomly chosen respondents and the data obtained were analysed to obtain a preliminary indication of the expected outcome (Dagnelie 1998). In addition, photos of the plant (Figure 2) were presented to each informant to get an appropriate presentation of the plant to the respondents. The number of respondents who know and or have used *Dialium guineense* was calculated as P = 50/100, P ≈ 0.5. With this P value, the formula $n = U21\text{-}\alpha/2[P(1\text{-}P)/d2]$ to determine the sample size (Dagnelie 1998):

where: - n is (317,787) the total respondents within a settlement;

- U1-α/2 = 1.96 for α = 0.05;

- P is the estimated proportion of the interviewed respondents in the preliminary survey.

- d is the expected error margin of any parameter to be estimated from the interviews (d is equal to 5%).

Though a minimum of 384 sample size was determined, 633 individuals in total were interviewed for this study using a semi-structured interview process. Table 1 presents the data on selected individuals per locality, ethnic group, gender and age group. The data collected during the survey include (i)- the part of the plant used, (ii)- the use forms of the species, (iii)- the perception of the species' status, and (iv)- the possible conservation strategies. The data collected also takes into account the areas of abundance, threat factors, and solutions for species conservation.

Fig 2: Photo of *Dialium guineense* tree

I.2.2. Data analysis

To determine the ethnobotanical data, Relative Frequency of Citation (RFC) formula was used.

$$RFC = \frac{RF}{\mathrm{N}} \mathrm{x}\ 100$$

Based on the Relative Frequency of Citation (RFC) values obtained, the local perceptions of the importance of the species or category studied were determined and the value was divided by the total number of respondents (N) in the study. A higher value of the RFC for a parameter measured indicates a high importance level of that parameter in that locality (Benlarbi *et al*. 2023). Furthermore, the local perceptions of the species' status, risk factors and conservation tactics were analyzed using descriptive statistics such as pie charts, bar charts and frequencies. In addition, the Generalized Linear Model (GLM) test was used to confirm the dependence between socio-demographical characteristics (district, ethnic groups, education, occupation, sex and age) of the respondents and the local perceptions of the status of the species in SPSS V21.

II. Results

II.1. Sociodemographic characteristics of local populations

In total, 633 individuals were interviewed in this study, with 203 in the Kombo South and 188 in kombo central (Table 1). A total of 633 individuals participated in this study. Among them, sixty seven percent (67%) were males, while thirty three percent (33%) were females. Most of the respondents (69%) were more than 35 years old and the majority of them were Mandinka (37%) by tribe. Madarasa had the highest informal educational status (53%), and again, the majority of respondents were farmers (26%). Regarding residential areas, 32.1% of the participants live in Kombo South (Table 1).

Table I: Sociodemographic characteristics of respondents

		Ethnic group		Sex		Age			Education					Occupation					
District	**Sample**	**Tribe**	Total	M	F	18-25	26-35	>35	T	Sec	Pri	Mad	Non	Farm	shep	Hous	CV	Trad	Other
Kombo East	120	Mandinka	36	20	16	3	18	15	3	12	4	14	3	10	0	10	8	4	4
		Fula	27	16	11	3	12	12	1	9	1	15	1	8	1	4	2	5	7
		Jola	46	26	20	9	4	33	5	11	4	12	14	26	2	4	5	5	4
		Wolof	4	2	2	0	3	1	3	0	0	0	1	0	0	0	3	1	0
		Manjago	2	2	0	0	1	1	0	0	1	0	1	0	0	0	1	0	1
		Others	5	2	3	0	1	4	0	3	0	1	1	2	1	0	1	0	1
Kombo South	203	Mandinka	106	86	20	5	31	70	20	21	8	53	4	23	2	10	19	6	45
		Fula	28	22	6	0	4	24	3	0	5	20	0	0	2	6	2	5	13
		Jola	43	37	6	4	10	29	15	9	8	10	1	12	0	3	15	0	13
		Wolof	5	3	2	0	1	4	0	0	0	5	0	0	2	2	0	1	0
		Manjago	15	12	3	0	5	10	5	5	2	0	3	1	0	2	10	0	2
		Others	6	2	4	0	0	6	2	0	0	4	0	0	0	4	2	0	0
Foni Brefet	61	Mandinka	17	13	4	0	3	14	0	3	1	10	3	10	1	3	3	0	0
		Fula	16	6	10	0	4	12	0	2	1	8	5	8	1	4	1	0	2
		Jola	21	14	7	0	1	20	4	4	4	3	6	11	0	4	5	0	1
		Wolof	0	0	0	0	0	0	0	0	2	0	3	2	0	2	0	0	1

		Manjago	5	3	2	0	0	5	0	0	1	0	1	1	0	0	0	0	1
		Others	2	2	0	0	0	2	0	3	1	10	3	10	1	3	3	0	0
Foni Kansala	61	Mandinka	12	6	6	0	1	11	2	0	2	4	4	3	0	5	2	0	2
		Fula	11	6	5	0	0	11	1	0	0	7	3	6	0	3	1	0	1
		Jola	34	21	13	0	0	34	7	2	3	3	19	14	0	9	9	1	1
		Wolof	4	4	0	0	0	4	0	0	0	3	1	2	0	0	0	0	2
		Manjago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Others	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kombo central	188	Mandinka	62	43	19	11	17	34	5	24	6	17	10	16	0	5	17	3	21
		Fula	58	32	25	8	19	31	8	7	1	22	20	5	6	12	9	3	23
		Jola	39	25	14	0	5	34	5	10	7	11	6	9	0	9	11	0	10
		Wolof	22	13	9	0	1	6	2	3	3	10	4	4	2	5	2	1	8
		Manjago	5	1	4	0	4	1	1	4	0	0	0	0	0	2	1	0	2
		Others	2	2	0	2	0	0	0	0	0	0	2	2	0	0	0	0	0

Note: Others means (Aku, Serere, Sarahule,) Education [(T=tertiary, Sec=secondary, Pri=primary, Mad=Madarasa and Non=(none)], Occupation [(Farm=farmer, shep=shepherd, Hous= housewife, CV= civil servant, Trad= trader and Other (marabouts, blacksmiths etc)]

II.2. Diversity of local knowledge on uses of *Dialium guineense* in The Gambia

Five plant parts namely fruits (30%), leaves(28%), barks (17%), wood (15%), and roots (10%), are widely used for many purposes (Figure 3).

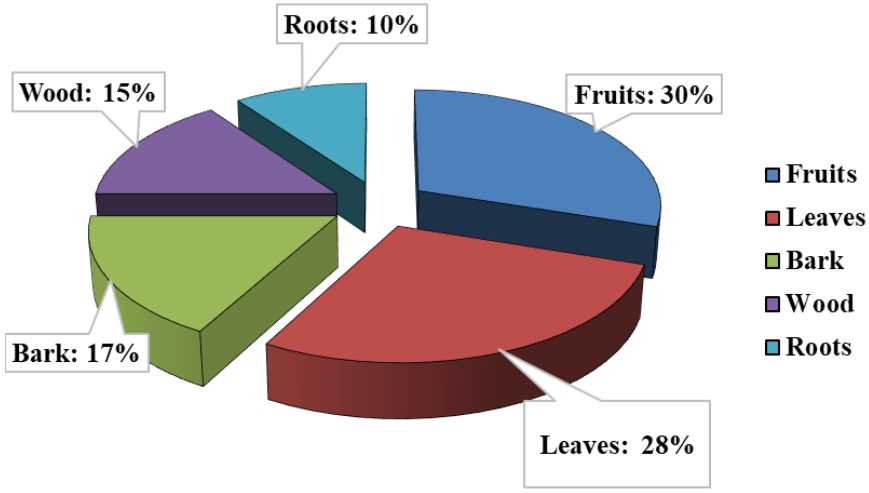

Figure 3: Relative frequency of citation of parts of *Dialium guineense* used

Locals indicated four primary uses for the cited plant parts, with its fruits having the highest index value of useful plant parts (30%). The four use patterns are food (91.2%), medicine (81.6%), fodder (31%) and others (31%) purposes (Figure 4). Others refer to the use of *Dialium guineense* as firewood and charcoal. However, *Dialium guineense* species have been utilized as fuel for household functions and income generation by the majority of the rural population in The Gambia. Hence, the use of the plant for food and medicine was the highest cited value of the uses among all the communities in this study sites (Figure 4).

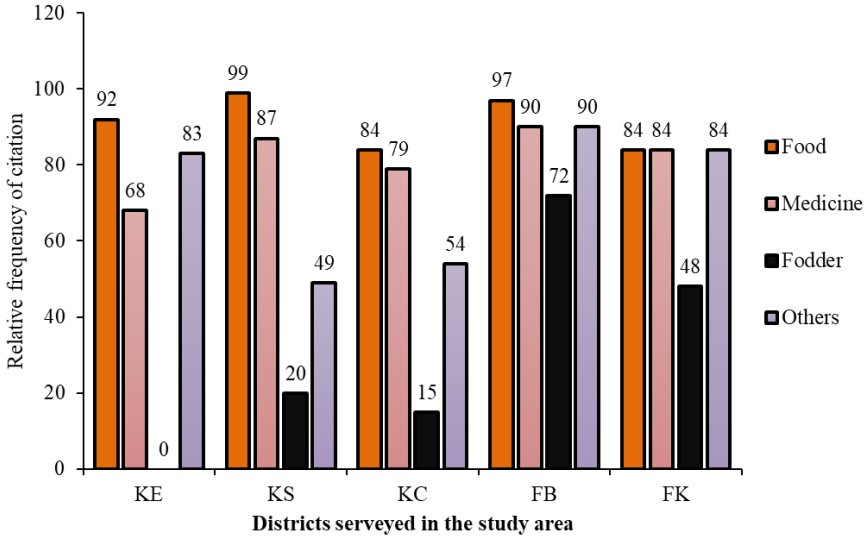

Figure 4: Local perception of current use of *Dialium guineense* in The Gambia.

Legend: KE: Kombo East, KS: Kombo South, KC: Kombo Central, FB: Foni Brefet, and FK: Foni Kansala

II.3. Local perceptions on the risk factors and factors influencing local knowledge of the status of *Dialium guineense*

About sixty-two percent (62%) of respondents stated that the population of *Dialium guineense* is decreasing in their communities both in abundance and distribution (Figure 5). While 28% of respondents cited that the species is rarely been seen in the wild in their communities, a small proportion (4%) of them think that its population of *Dialium guineense* is increasing in their communities.

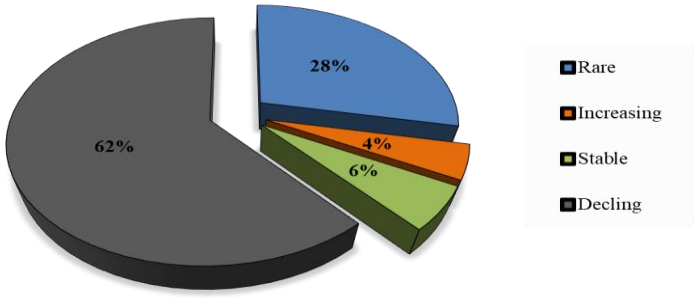

Figure 5: Perception of local people of the status of *Dialium guineense*

The main perceived threat factors contributing towards the decline and disappearance of *Dialium guineense* were the use of the species as food (82%), bush fire (74%), and deforestation (70.6%). They were reported to be among the major threat factors (Figure 6).

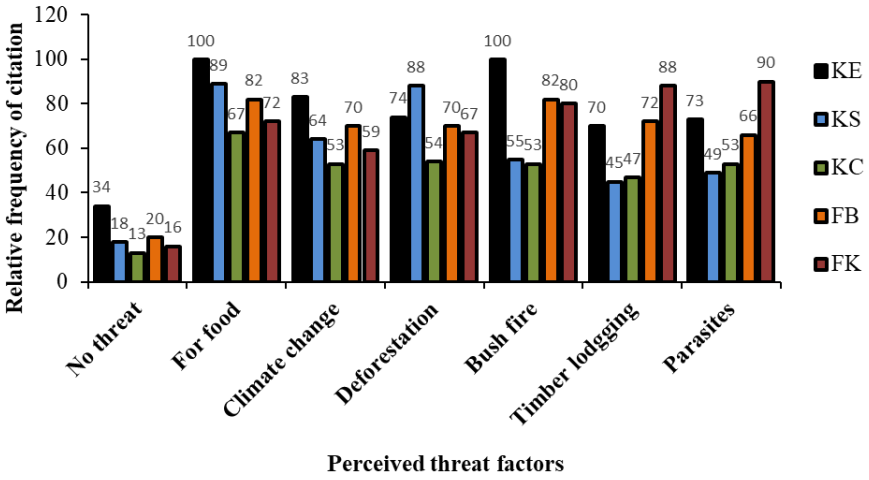

Figure 6: Local perception of risk faced by *Dialium guineense*

The Generalized Linear Models (GLM) analyses analyses of respondents' perceptions of the status of *Dialium guineense* revealed that local perception varied significantly ($p < 0.05$) according to male, tertiary, farmers, housewife, Kombo east, Kombo south and Foni brefet (Table 2).

Table II: Influence of socio-demographical factors on the status of *Dialium guineense* through *GLM*

			95% Wald Confidence Interval		Hypothesis Test		
	B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.
Gender							
Male	0.366	0.1356	0.101	0.632	7.302	1	0.007*
Female	Ref	.	.	.	.	.	.
Age							
18-25	-0.153	0.2132	-0.571	0.265	0.516	1	0.472
26-35	0.046	0.1347	-0.218	0.310	0.116	1	0.733
>35	Ref	.	.	.	.	.	.

Ethnic group							
Mandinka	-0.358	0.3413	-1.027	0.311	1.098	1	0.295
Fula	-0.463	0.3502	-1.149	0.224	1.745	1	0.186
Jula	-0.326	0.3428	-0.998	0.346	0.904	1	0.342
Wolof	-0.507	0.4005	-1.292	0.278	1.603	1	0.206
Manjago	-0.576	0.4131	-1.385	0.234	1.942	1	0.163
Others	Ref	.	.	.	.	.	.
Education							
Tertiary	0.657	0.2430	0.181	1.133	7.309	1	0.007*
Secondary	-0.157	0.1886	-0.527	0.212	0.697	1	0.404
Primary	-0.103	0.2041	-0.503	0.297	0.256	1	0.613
Madarasa	0.033	0.1574	-0.275	0.342	0.044	1	0.833
None	Ref	.	.	.	.	.	.
Occupation							
Farmer	0.348	0.1501	0.054	0.642	5.367	1	0.021*
Herdsmen	-0.061	0.3074	-0.664	0.541	0.040	1	0.841
House wife	0.532	0.1931	0.154	0.911	7.595	1	0.006*
Civil servant	-0.304	0.1935	-0.683	0.075	2.468	1	0.116
Trader	-0.055	0.2411	-0.528	0.418	0.052	1	0.820
Business	Ref	.	.	.	.	.	.
Location							
Kombo east	0.585	0.1557	0.280	0.891	14.132	1	0.000*
Kombo south	0.061	0.1400	-0.213	0.335	0.190	1	0.663
Kombo central	0.698	0.1959	0.314	1.082	12.713	1	0.000*
Foni brefet	-0.469	0.1988	-0.859	-0.079	5.561	1	0.018*
Foni kandala	00[a]	.	.	.	.	.	.

II.4. Local strategies for the conservation of *Dialium guineense*

To ensure *Dialium guineense* protection, the majority of responders (93%) recommended that to be planted in the parks.

The majority of Kombo East's proposed tactics (100%) called for avoiding bush burning and then planting activities (98%) while Foni Kansala's recommendation (90%) called for domesticating the species. Additionally, 89% of Kombo South residents said that planting exercises were the most recommended course of action. Furthermore, 87% and 82%, respectively, of the residents of Kombo Central and Foni brefet strongly advise awareness campaigns in their neighbourhoods. All of the communities covered in this study area had strong citations for other solutions, such as creating appropriate land purchase regulations (Figure 7).

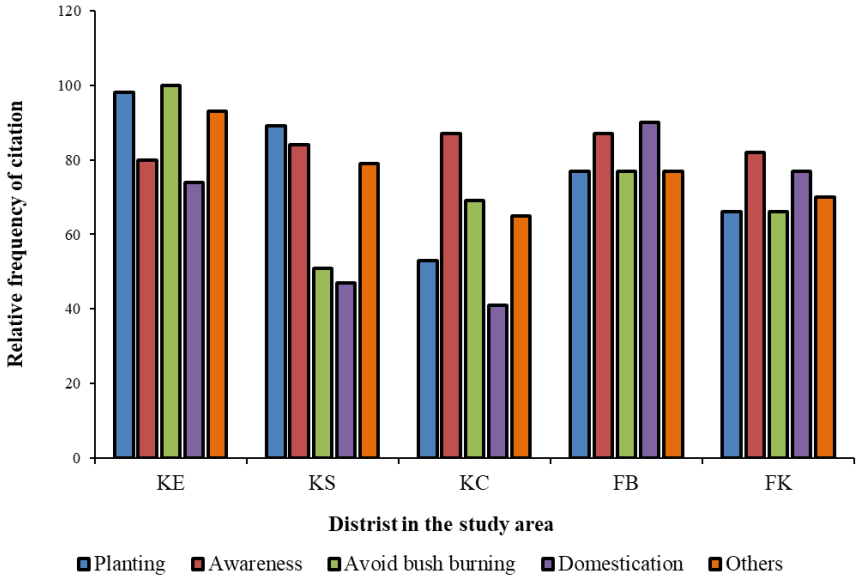

Figure 7: Propositions of solution towards the decline of *Dialium guineense*

III. Discussion

The variety of traditional uses and knowledge should be taken into account when designing regional management strategies.This study consequently confirms the multipurpose use of *Dialium guineense* but also its importance to local people in the western region of The Gambia. The investigation of the knowledge of the local usage of plants is vital for the creation of conservation strategies (Achigan-Dako *et al.,* 2011). Similar differences in local names by ethnic groups were distinguished by Dabré *et al*., (2023a) for *Celtis toka* in Burkina Faso and for *Strychnos spinosa* Lam. in Benin (Avakoudjo *et al.*, 2019). Most plant parts of the species were widely reported as being used for food,

medicinal, fodder and others. The food, fodder and medicinal use of plant parts was highlighted on *Celtis toka* (Dabré *et al*., 2023a) and on *Bombax costatum* (Zerbo *et al*., 2022) in Burkina Faso. The fruits had the highest specific use value in the Gambia. In the constract with the results of Lokonon *et al*. (2013) in Benin where the leaves had the highest specific use value. The medicinal use of *Dialium guineense* was also in South of Benin *(Latifou et al*., 2016). According to our research, this species is highly sought after in The Gambia for usage as charcoal, wood, and fuel. This result correlates with Anozie *et al*. (2021) findings as well. Most plant parts (roots to leaves) of the tree are valued and used differently by local people. *Dialium guineense* is gifted with valuable phytochemicals such as alkaloids, tannins, phenols, and flavonoids which may serve as natural substitutions to in-feed antibiotics. It has beneficial pharmacological effects including antioxidant antimicrobial properties (Gnansounou *et al.,* 2018; Ogbuewu *et al*., 2023), Antidiarrheal activity (Assiki *et al*., 2022), antibacterial, anti-ulcer, antioxidant, analgesic, anti-hepatotoxic, antimicrobial, anti-plasmodial, anti-hemorrhoidal, anti-vibrio, anti-diarrheal, molluscicidal, oral care and vitamin supplement (Besong *et al*., 2016).

Due to the socio-cultural importance of *D. guineense*, its populations are declining in the Gambia according to informants. Additionally, most interviewees said that the species distribution areas are declining in the country due to the overharvesting of the species for food, bush fire, and deforestation. Few informant stated that, the species distribution is increasing. This difference could be explained by distribution of knowledge of different ethnic groups on the current status of *D. guineese* were not homogeneous. The opposite results were also found in Burkina Faso, where the wild species *Celtis toka* were extinct in the communal area of the Sudano-Sahelian zone mainly due to pruning, climate change, deforestation, and population ageing (Dabré *et al*., 2023b). Despite its extreme importance to the survival of humanity, biodiversity has succumbed to the threat of habitat destruction, ecosystem overexploitation, disease and climate change (Ganglo *et al*., 2017).

Locals in The Gambia's west coast region are aware of alterations in *Dialium guineense* brought on by persistent human pressure. The species in the studied area is showing a downward tendency, according to our research. It is generally acknowledged that management measures based on local knowledge could ensure that the species most useful to the local societies are the ones that are prioritized (Lokonon *et*

al., 2021). Local populations have similar views on the conservation strategies to ensure the survival of *D. guineese*. The most recommended conservation strategies include planting, domestication, avoiding bush burning, and raise awareness of youth on the importance of *D. guineese* in the Gambia. The domestication of the multipurpose species was also emphasized on the critically endangered species *Celtis toka* (Dabré *et al*., 2023b), on *Afzelia Africana* (Balima *et al*., 2018), and on *Bombax costatum* (Zerbo *et al*.,2022) in Burkina Faso.

What about sociodemographic characteristics of local popualation data collect?

Conclusion

This study showed that *Dialium guineense* leaves and fruits are having multiple uses and it is well-known species among local populations in the Gambia. It has a high social value, particularly in use categories such as food, traditional medicine, and fodder, where most of its plant parts are used, resulting in a wide range of applications. The uses of its plant parts vary according to ethnic groups as well as knowledge about the uses patterns. However, locals could ascertain the plant's numerous applications, dangers, and risk concerns. They were also able to identify a potential remedy to encourage *Dialium guineense* sustainable use in their various communities. Therefore, we recommend that any efforts to restore the species take into account the priorities of the local community. This is because local communities will be more successful in conservation initiatives than those that merely rely on outside influences if they actively participate in defining their well-being.

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Data availability

The datasets obtained during and/or analyzed during the present study are available from the authors upon request.

Author contributions

AK, ZD, BD, SK and WD conceived and wrote the main manuscript text. AK and ZD contributed to data analysis and provided corrections, input, and feedback on the manuscript. BD, SK and WD contributed to the study design, revised and improved the manuscript. All authors reviewed and approved the final manuscript for submission.

Conflict of interest

Authors declare that they have no conflict of interest.

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