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Vulnerability of *Faidherbia albida* (Delile) A. Chev. Across Four Phytogeographical Sectors in Sub-Saharan Africa, Burkina Faso

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Abstract

Faidherbia albida (Delile) A. Chev. is one of the valuable agroforestry species in Sahelian agroecosystems. However, this species is currently facing pressures that make it vulnerable in its natural habitat. This study aimed to provide information on the usefulness, distribution, and vulnerability of *Faidherbia albida* (*F. albida*) to improve its management. To this end, five hundred and twenty-six (526) individuals from various socio-professional groups across the four phytogeographical sectors of Burkina Faso were interviewed about their relationship with the species. A Generalized Linear Model (GLM) with binary logistic regression, along with Multiple Correspondence Analysis, was used to better understand local ethnobotanical knowledge regarding the uses of the species' organs and its vulnerability. The results show that the most used parts of *F. albida* are fruits, cited by 34% and 31% of respondents from the southern Sudanian and southern Sahelian sectors respectively, followed by the leaves (27%) and bark (31%) in the strict Sahelian sector. *F. albida* is mainly used for fodder and traditional medicine. Regarding intensity of use, *F. albida* is weakly used according to 32.32 and 21.29% of respondents in the northern and southern Sudanian sectors respectively but highly used in the strict Sahelian sector, revealing significant variation in uses across phytogeographical sectors. The species occurs in all phytogeographical sectors but is found predominantly in older cultivated fields. *F. albida* shows a vulnerability index between 2 and 2.5 in the northern Sudanian, southern Sahelian, and southern Sudanian sectors, and ≥ 2.5 in the strict Sahelian. The vulnerability of *F. albida* is strongly linked to the use of its organs. Considering these results, an effective strategy for integrating *F. albida* in cropping systems must be initiated to ensure its sustainability.

Keywords: agroecosystems, *Faidherbia albida*, distribution, vulnerability, Burkina Faso

1. Introduction

In West Africa, mostly in the Sahelian region, some agroforestry species play a pillar rule in rural livelihoods. Indeed, such species are recognized for their ecosystem services, including the supply of fuelwood, fodder, fruits, climate regulation, support for soil fertility restoration, and cultural importance. Analyzing their vulnerability helps ensure the sustainability of rural livelihoods in the context of climate change and biodiversity loss (Moussa et al., 2024).

Among valuable agroforestry species in the Sahelian region, *Faidherbia albida* (Delile) A. Chev. (*F. albida*) is of good importance due to its multifunctional uses for human and animal feeding as well. *F. albida* species belonging to the Mimosaceae family (Arbonnier, 2019) is believed to have originated in either West or East Africa before spreading to southern Africa (Tchatchoua et al., 2025). The distinctive inverted phenology of the species, namely shedding leaves during the rainy season and regaining them in the dry season (Moyo et al., 2022), limits competition with other crops and provides organic matter for soils, improving their productivity (Rabo et al., 2024).

F. albida has long been integrated into the rural economy and is one of the main tree components of agro-sylvo-pastoral systems in Burkina Faso, known as "Faidherbia parks" (Sehoubo et al., 2023). The species benefited from special protection measures since the issuance of some decree on forest management like decree No. 2004-019-MECV. Due to its importance, *F. albida* has been studied by numerous authors. For instance, Depommier and Guérin (1996) highlighted that traditional pruning practices significantly reduce the pod production of the species. Alexandre and Ouédraogo (1993) showed that on sandy soils, the taproot of *F. albida* develops deeply, while on compact clay soils, its root system remains superficial. It was also reported that the natural regeneration of *F. albida* is limited by the short seed viability in the soil and local farming practices (Dembélé, 1994). Regarding the socio-ecological and economic aspects, *F. albida* is known to have a good contribution in soil fertility and associated crop yield improvement (Gnankambary, 2007; Sanou et al., 2025). Recent research confirms that excessive pruning for fodder remains a major threat to *F. albida* forest parklands. Shiferaw Sida et al. (2024) found that intensive and repeated pruning significantly reduces tree vigor, limits pod production, and severely hinders natural regeneration, thus increasing the risk of local dieback. These regeneration difficulties also persist in all agroecological zones with clay soils (Fekadu et al., 2024).

Although *F. albida* has been the subject of numerous studies, little research has focused on local perceptions of its vulnerability, distribution and use. Given that the biophysical environment is changing (Horowitz, 2015) and that local knowledge remains a valuable source for assessing the state of natural resources and anticipating the risks of scarcity, it would be wise to study local perceptions of the status and use of *F. albida* according to phytogeographical sectors and socio-professional groups. Such a study would not only provide a better understanding of the dynamics of the distribution and exploitation of the species among local stakeholders but also strengthen the relevance of strategies for the conservation and sustainable management of this natural resource.

The overall objective of this study was to contribute to providing a solid and up-to-date scientific basis on the status of *F. albida* across Burkina Faso to guide conservation, restoration, and sustainability strategies for agroforestry systems. Specifically, it aimed to i) assess local perceptions regarding the use and spatial distribution of *F. albida*, ii) evaluate its vulnerability to consider its integration into the various agrosystems, and iii) identify the causes and constraints to its regeneration. To this end, we hypothesize that the sustainability of *F. albida* is increasingly threatened. Specifically, we believe that i) *F. albida* is widespread in all phytogeographical sectors of Burkina Faso and ii) it is highly vulnerable in the Sahelian phytogeographical sector due to arid conditions and high livestock demand in this region.

2. Method

2.1 Study Sites

Data was collected across the four phytogeographical sectors of Burkina Faso, namely the South Sahelian, North Sudanian, South Sudanian, and Strict Sahelian sectors (Figure 1). The study sites were selected in six regions, four of which followed a phytogeographical gradient namely the Liptako ex-Sahel region (Séno province, Dori municipality) representing the Strict Sahelian sector; the Kuilsé ex-Centre-North region (Sanmatenga province, Kaya municipality) representing the South Sahelian sector; the Oubri ex-Plateau Central region (Ganzourgou and Oubritenga provinces, Zorgho and Ziniaré municipalities respectively) representing the North Sudanian sector; and the Guiriko ex-Hauts-Bassins region (Houet province, Bobo-Dioulasso municipality) representing the South Sudanian sector. Two additional regions namely Nando ex-Centre West (Sissili province, Léo municipality) and Nakambé ex-Centre East (Kouritenga province, Koupéla municipality) were included. The selection of these sites was guided by the presence of *Faidherbia albida*, as identified in the Second National Forest Inventory, and by the diversity of human activities such as agriculture, livestock, and forestry, which may influence the species' dynamics.

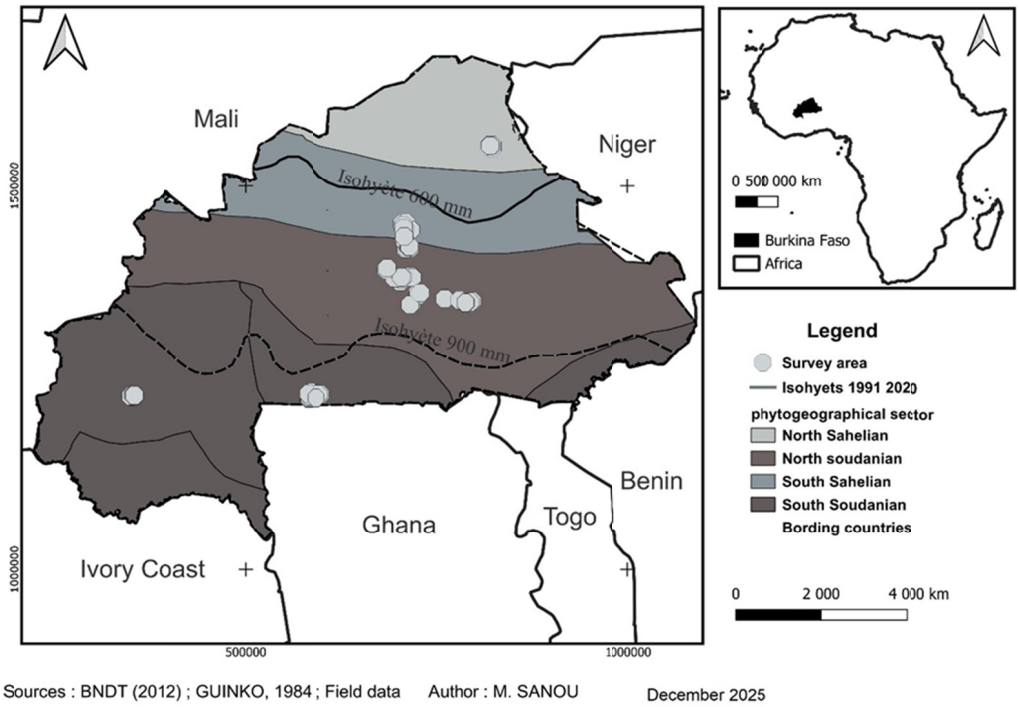


Figure 1. Localisation of the study sites within the four phytogeographical sectors of Burkina Faso

2.2 Survey

Depending on the population density of each region, various socio-professional groups, including farmers, agro-pastoralists, herders, collectors, and traditional healers, were interviewed. In total, 526 respondents participated in the survey including 223 in the North Sudanian sector, 101 in the South Sahelian sector, 168 in the South Sudanian sector, and 34 in the Strict Sahelian sector. The survey consisted of semi-structured interviews followed by focus group discussions (Tietiambou et al., 2015). A preliminary pilot survey was first conducted among different socio-professional groups to adapt and refine the questionnaire, ensuring clarity and relevance of the questions for respondents. The collected data included socioeconomic characteristics such as education level, gender, and residency status, as well as information on *F. albida*, including plant parts used, harvesting methods, collection tools, and species distribution in the locality. Each respondent was also invited to suggest strategies for integrating *F. albida* into the cropping systems. The interview-based approach was preferred over other methods because it minimizes non-responses and enhances participants' engagement with the topics discussed. A focus group discussion, complementing recommendations from a 2018 study (Sanou, 2018), was also conducted, and agents from decentralized public services were interviewed. Data were collected digitally using the Kobotoolbox platform. The overall sample comprised more than 80% men and household heads in the South Sudanian, North Sudanian, and Strict Sahelian sectors, compared with about 45% men and ~55% household heads in the South Sahelian sector. Education levels ranged from about 6% with no formal education in the Strict Sahelian sector to about 12% with higher education in the North Sudanian sector. Most respondents were natives over 80% in the North Sudanian, South Sahelian, and Strict Sahelian sectors, and around 60% in the South Sudanian sector where they cohabited with migrants representing less than 40%, compared to about 9% in the Strict Sahelian sector. The survey covered a wide range of socio-professional groups including farmers represented over 40% in the North and South Sudanian sectors, herders accounted for less than 30% across all zones, agro-pastoralists accounted for about 26% in the Strict Sahelian sector versus about 11% in the South Sudanian sector, traditional healers represented about 24% in the Strict Sahelian sector compared with about 6% in the North Sudanian sector, and collectors, processors, sellers of pods accounted for approximately 31% in the South Sahelian sector but were absent (0%) in the Strict Sahelian sector.

2.3 Data Analysis

Data analysis involved descriptive statistics such as frequency and percentage calculations to characterize the socio-demographic profile of respondents. Some qualitative variables such as phytogeographical sectors, socio-economic status, and uses were cross tabulated using contingency tables to examine their joint

distributions. The chi-square (χ^2) test of independence was applied to assess relationships between variables, with a significance threshold set at 5%. In addition, multivariate analyses, including Generalized Linear Models (GLM), were used to determine the socio-economic parameters and the effect of the phytogeographical sector on the uses of plant organs, perceptions of *Faidherbia albida* dynamics, and strategies for its future management. A Multiple Correspondence Analysis (MCA) was performed to explain the distribution and/or vulnerability of *F. albida*. This analysis included 526 individuals and 21 variables, of which five were quantitative and fourteen qualitative. All data were processed using RStudio version 2025.09.0 Build 387© 2009-2025 (Posit Software, PBC), and QGIS Desktop 3.36.3. Furthermore, vulnerability was assessed based on a three-level vulnerability scale (ranging from 1 to 3) as defined by Traoré et al. (2011) (Table 1). A score of 1 indicated low vulnerability for the specified parameter, 2 represented moderate vulnerability, and 3 indicated high vulnerability. The vulnerability index was calculated using the following parameters: (i) frequency of use (N1); (ii) types of uses (N2); (iii) plant organs used (N3); (iv) harvesting methods (N4); and (v) development stage of the species (N5). The final vulnerability index was derived from the average of these five parameters, which together represent major indicators of pressure and threat on the species.

Table 1. Criteria for assessing species vulnerability

Parameters	Species Vulnerability (VU)		
	Low (scale = 1)	**Medium (scale = 2)**	**High (scale = 3)**
Frequency of use	F.U < 20% Low	20% ≤ F.U < 60% Medium	F.U ≥ 60% High
Number of uses	Nu < 2	2 ≤ Nu ≤ 4	Nu ≥ 5
Plant part used	Leaf, latex	Fruit, branch	Wood, seed, bark, root, flower
Collection method	Gathering	NA	Picking, cutting
Development stage	Old or senescent	Adult	Young

Note. FU: Relative frequency of use of species; Nu: Number of uses; Fr: Relative frequency. VU < 2 indicates that the species is less vulnerable; 2 ≤ VU < 2.5 indicates that the species is moderately vulnerable; VU ≥ 2.5 indicates that the species is highly vulnerable; NA: Not Applicable.

Adapted from Traoré et al. (2011).

3. Results

3.1 Level of Knowledge and Use of F. albida

According to 99.81% of respondents, *F. albida* is known and used by everyone, regardless of the phytogeographical sector. However, Pearson's test showed no significant difference regarding respondents' knowledge or use of the species across the different sectors (p = 0.94). *F. albida* is weakly used, according to 32.32% and 21.29% of respondents in the northern and southern Sudanian sectors, respectively. In southern Sahelian sector moderate uses were noted according to 10.26% of respondents. In the strict Sahelian sector, according to 5.7% of the respondents *F. albida* is intensively used. These results indicate a marked difference in use across phytogeographical sectors (Table 2).

Table 2. Knowledge, use, and frequency of use of *F. albida* in Burkina Faso

Sectors	Knowledge and use (%)		Use (%)		
	No	Yes	Low	High	Medium
North Sudanian	0	42.34	32.32	2.85	7.22
South Sahelian	0	19.35	2.09	6.84	10.26
South Sudanian	0.19	31.61	21.29	5.51	5.13
Strict Sahelian	0	6.51	0	5.70	0.76
National	0.19	99.81	55.70	20.90	23.37
	$\chi^2 = 0.41$, df = 3, p = 0.94		$\chi^2 = 43.97$, df = 6, p = 0.000000075		

The parts of *F. albida* used across the phytogeographical sectors include fruits, leaves, roots, bark, wood, and flowers, with fruits being the most used part in the southern Sudanian and Sahelian sectors, as reported by 34% and 31% of respondents, respectively. Meanwhile, 19%, 22%, 26%, and 27% of respondents in the southern

Sudanian, northern Sudanian, southern Sahelian, and strict Sahelian sectors, respectively, use the leaves, while fewer than 15% use the roots. In the southern Sudanian, northern Sudanian, and strict Sahelian sectors, only about 3% of respondents use flowers. For the bark we noted over 25% of use, with the highest proportion (31%) observed in the strict Sahelian sector. Wood is used by 13%, 11%, 9%, and 8% of respondents in the northern Sudanian, southern Sahelian, southern Sudanian, and strict Sahelian sectors, respectively (Figure 2).

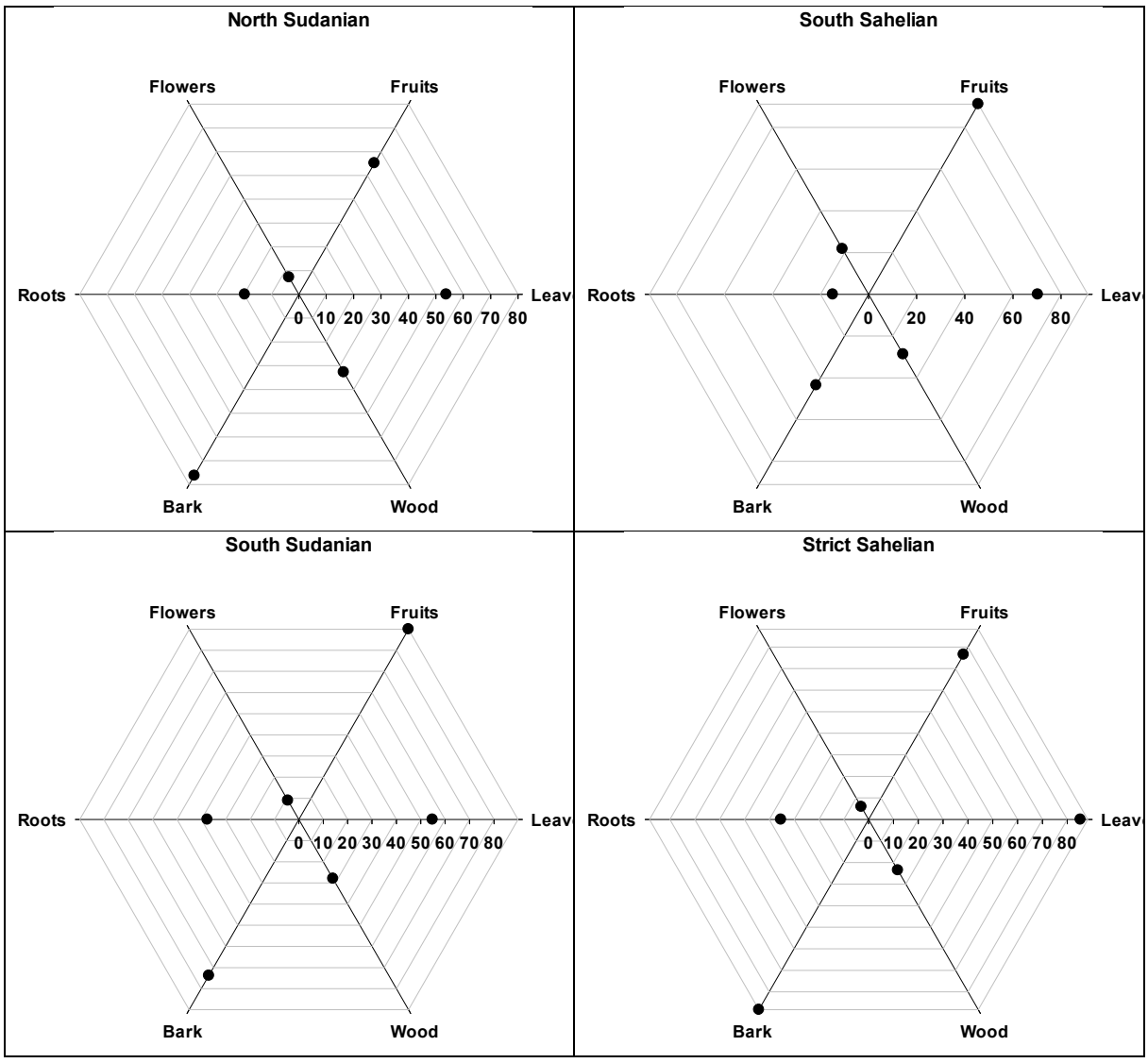


Figure 2. Parts used as a percentage of *F. albida* according to phytogeographical sectors

The types of uses vary significantly across phytogeographical sectors and socio-professional groups. With an estimate of -0.43 for phytogeographical sectors, *F. albida* is primarily used for fodder and traditional medicine, and to a lesser extent for trade and soil fertility improvement. According to socio-economic groups, the species is significantly used for human food and pharmacopoeia purposes, with an intercept estimate of 0.98 (Table 3).

Table 3. Relationship between phytogeographical sectors and socio-professional groups concerning the area of use of *F. albida*

	Phytogeogaphical sectors				Socio-professional groups			
	Est	**Std. E**	**z value**	**Pr(> |z|)**	**Est**	**Std. E**	**z value**	**Pr(> |z|)**
(Intercept)	-0.43	0.28	-1.54	0.12	0.98	0.28	3.54	0.00 ***
Human feeding	0.95	0.52	1.84	0.07.	1.64	0.63	2.58	0.01 **
Handicraft	1.99	1.09	1.83	0.07.	0.41	0.63	0.65	0.51
Trade	0.53	0.27	1.98	0.05*	0.48	0.26	1.85	0.06
Construction	-1.47	2.84	-0.52	0.60	14.65	962.0	0.02	0.99
Fodder	1.10	0.24	4.52	0.00***	-0.22	0.24	-0.92	0.36
Soil fertility	0.52	0.24	2.12	0.03*	0.13	0.24	0.54	0.59
Traditional mededine	-0.68	0.22	-3.13	0.00**	-0.71	0.22	-3.27	0.00 **
Erosion control	0.61	0.40	1.54	0.12	-0.32	0.33	-0.96	0.33
Ritual	0.54	1.24	0.44	0.66	15.47	839.70	0.02	0.99

Note. Est: Estimate; Sdt.E: Standar error; Pr: probability.

Significance: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

3.2 Distribution, Development Stage, and Location of F. albida

Although *F. albida* occurs throughout Burkina Faso, it is reported as infrequent by the majority of respondents in the Sudanian sector (76% in the southern Sudanian, 80% in the northern Sudanian sectors and 61.79% at the national level). In contrast, in the Sahelian sector (southern Sahelian and strict Sahelian sectors), it is moderately frequent, according to approximately 65% and 70% of respondents, respectively (Table 5). Regarding its development stage, *F. albida* is perceived as aging by about 70% of respondents in the strict Sahelian sector, and as adult by approximately 67% and 61% of respondents in the southern Sahelian and northern Sudanian sectors, respectively. Young individuals are almost absent in the strict Sahelian sector (0%) but are present in 26% of cases in the southern Sudanian sector. At the national level, the adult stage predominates, according to 51% of respondents (Table 5). *F. albida* occurs in a variety of environments but is primarily considered an agroforestry species by 41% of all respondents. Specifically, in the southern Sahelian sector, 73% of respondents find it in crop fields. In the southern Sudanian sector, around 59% encounter it near homesteads, while approximately 38% report finding it in forests. It is also found in low-lying areas, according to about 3% of respondents in the southern Sahelian sector (Table 4).

Table 4. Frequency of distribution, developmental stage, and location of *F. albida* according to phytogeographical sectors

Sectors	**Frequency (%)**										
	Distribution			**Development stage**			**Location**				
	H	**M**	**L**	**Yg**	**Ad**	**Old**	**Farm**	**Forest**	**Fallow**	**NH**	**LL**
Nsu	1.35	17.94	80.72	8.97	61.88	29.15	43.05	38.57	2.69	15.7	0
Ssah	19.8	65.35	14.85	3.96	67.33	28.71	73.27	9.9	0	13.86	2.97
Ssu	5.95	17.26	76.79	26.19	32.74	41.07	17.26	23.21	0.6	58.93	0
Sstr	26.47	70.59	2.94	0	29.41	70.59	50	5.88	0	44.12	0
Nat	6.08	30.23	61.79	12.93	51.52	35.55	41.06	26.04	1.33	30.99	0.57

Note. Nsu: North Sudanian; Sstr: Strict Sahelian; Ssah: South Sahelian; Ssu: South Sudanian; Nat: National; H: High; M: Medium; L: Low; Yg: Young; Ad: Adult; NH: near homes; LL: Lowlands.

3.3 Vulnerability of F. albida, Causes, and Regeneration Constraints

F. albida is moderately to highly vulnerable across the country. In the northern Sudanian, southern Sahelian, and southern Sudanian sectors, 77%, 74%, and 66% of respondents, respectively, consider *F. albida* to be moderately vulnerable, with a vulnerability index between 2 and 2.5. In contrast, 53% of respondents in the strict Sahelian

sector perceive *F. albida* as highly vulnerable, with a vulnerability index ≥ 2.5, while 47% consider it moderately vulnerable (Figure 3).

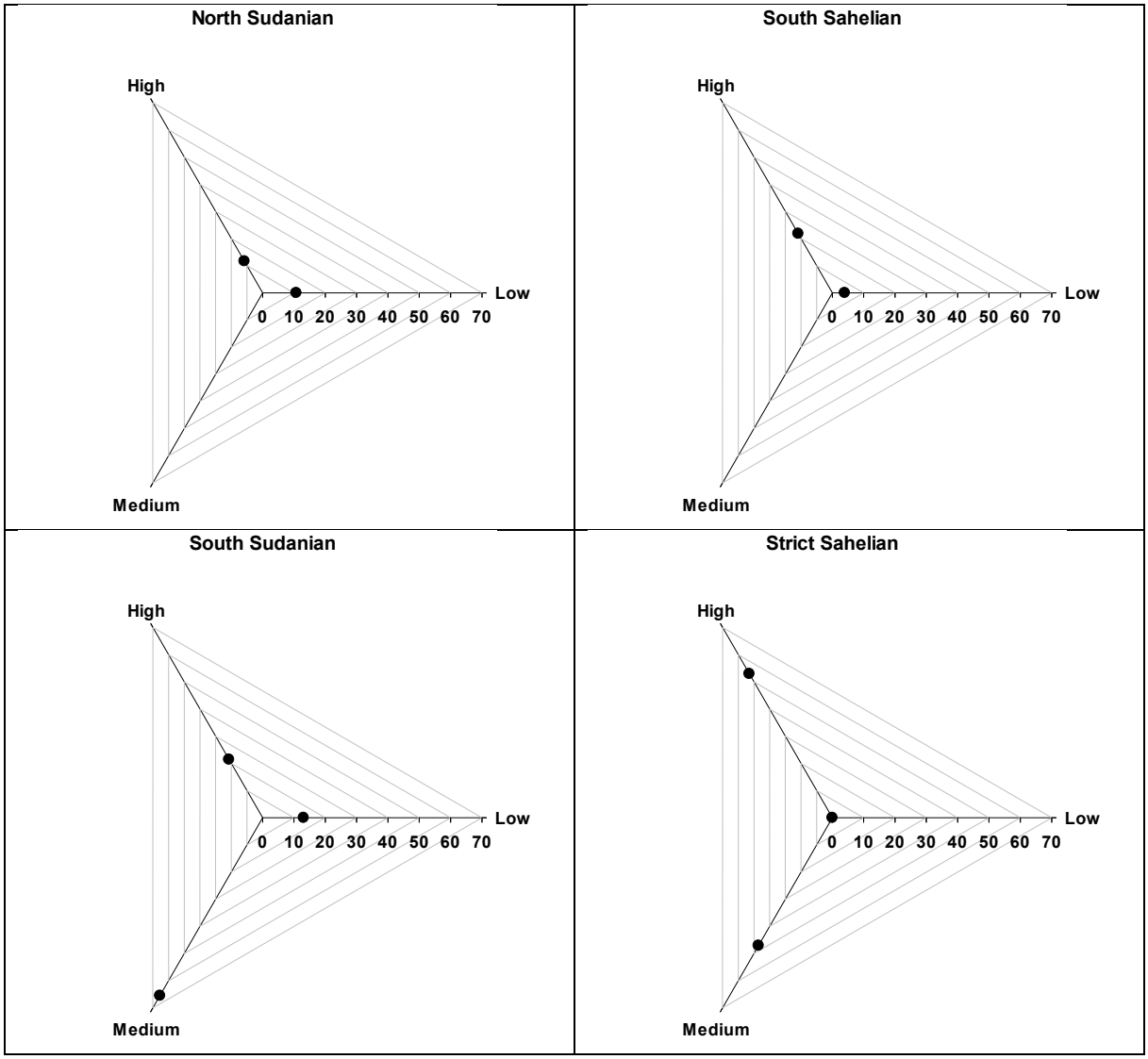


Figure 3. Vulnerability as percentage of *F. albida* according to phytogeographical sectors

Note. Low: Vu < 2; Medium: 2 < Vu < 2.5; High: Vu ≥ 2.5.

This state of vulnerability is attributed to rainfall, according to 85% of respondents, and to topography, according to 94% of respondents in the strict Sahelian sector. In the southern Sahelian sector, 52% of respondents identified soil properties as a cause of the species' vulnerability. Human pressure, and other (climate change, and the absence of seeds) were mentioned by 48% and 38% of respondents in the southern Sudanian and southern Sahelian sectors, respectively (Table 6).

The main constraints affecting the implementation of regeneration practices for the species are grazing, cited by 72%, 51%, and 46% of respondents in the northern Sudanian, southern Sahelian, and southern Sudanian sectors, respectively. Lack of knowledge about species protection techniques and unavailability of seeds were highlighted by 70% and 62%, and 97% and 91% of respondents in the southern Sudanian and strict Sahelian sectors, respectively. In addition, in the strict Sahelian sector, cultural and traditional constraints are significant according to 50% of respondents, while soil degradation was mentioned by 56% of respondents in the southern Sahelian sector (Table 5).

Table 5. Causes and constraints to the regeneration of *F. albida* in Burkina Faso

	Proportion (%)			
	Nsu	**Ssah**	**Ssu**	**Sstr**
Causes of the Vulnerability of F. albida				
Rainfall	38.57	32.67	25.6	85.29
Temperature	1.35	8.91	32.14	23.53
Soil properties	20.18	52.48	15.48	26.47
Seed morphology	30.49	11.88	22.02	0
Seed sanitary issue	1.35	0.99	1.79	2.94
Topography	19.28	4.95	7.74	94.12
Other (human climate, lack of seed)	16.14	36.63	48.81	11.76
Constraints to Implementation of Regeneration Practices				
Unsuitable Environment	1.79	0	22.02	2.94
Time to reach maturity	8.97	0.99	23.81	0
Cultural and traditional constraints	3.14	0	8.33	50
Seed size	22.87	0	34.52	0
State of soil degradation	7.62	56.44	6.55	14.71
Species adaptation issue	8.97	0	8.33	0
Land tenure	1.79	4.95	3.57	0
Lack of land	3.14	14.85	7.74	0
Grazing	72.2	51.49	45.83	11.76
Lack of knowledge	40.81	28.71	70.24	97.06
Seed availability	44.39	9.9	62.5	91.18

Note. Nsu: North Sudanian; Sstr: Strict Sahelian; Ssah: South Sahelian; Ssou: South Sudanian.

3.4 Relationship Between Variables and the Vulnerability Index of F. albida

Figure 4A shows the interactions between the four phytogeographical sectors and the value in use. Multiple correspondence analysis (MCA) highlights a clear structure of the modalities studied around two main axes. The first axis (Dim 1) strongly contrasts the modalities 'Strict Sahelian sector' and 'South Sahelian' with the modalities 'South Sudanian' and 'North Sudanian'. The second axis (Dim2) contrasts the modalities low use, high extraction, Female, Location and Other. Figure 4B shows that modalities such as strict Sahelian sector and high vulnerability have a high cos^2 (> 0.55), indicating that they contribute significantly to the structure of the plan.

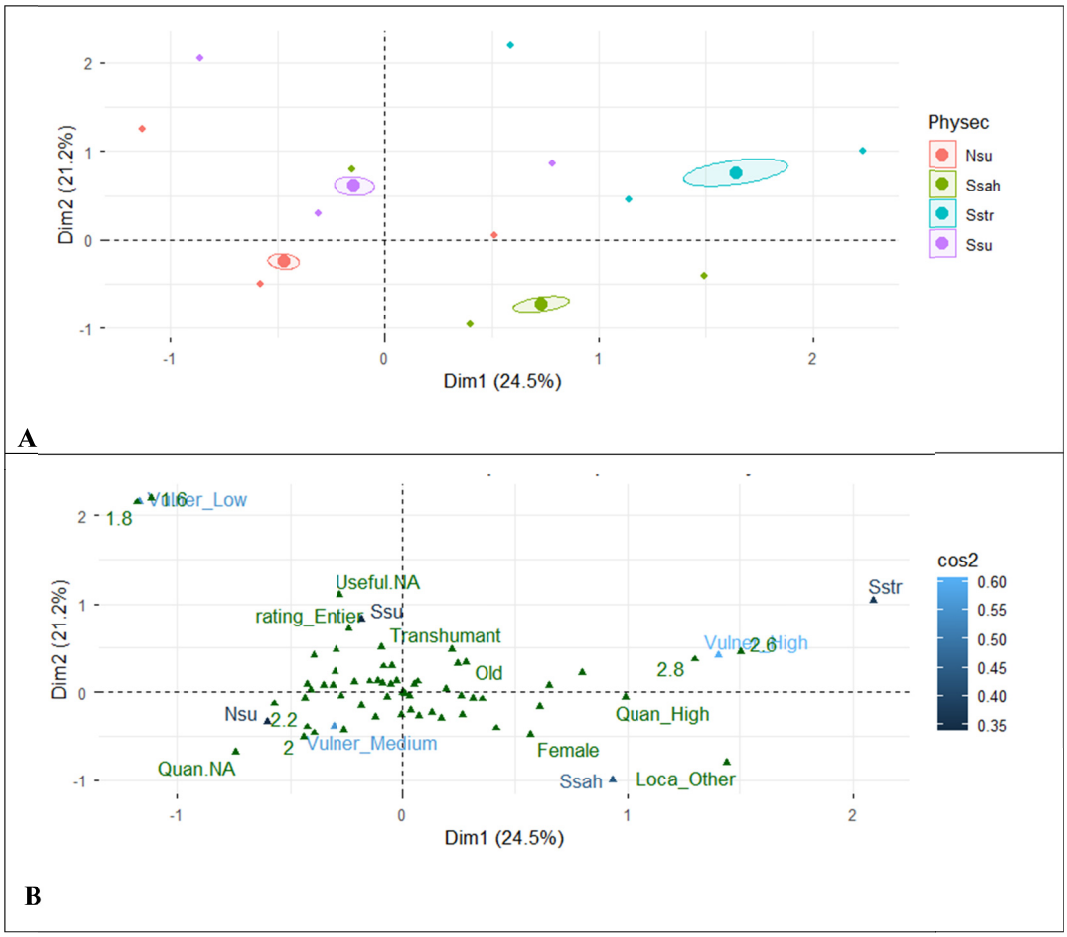


Figure 4. Projection of individuals according to phytogeographical sectors and value in use of *F. albida* (A) and Correlation between vulnerability of *F. albida* and other variables (B)

Note. Nsu: North Sudanian; Sstr: Strict Sahelian; Ssah: South Sahelian; Ssu: South Sudanian; Quan: Quantity; Rating is proportion of organ removal that was low, medium or complete (entire).

4. Discussion

4.1 Use of F. albida

F. albida is known to all socio-professional groups regardless of the phytogeographical sector. Knowledge of the species is likely since it is an agroforestry species and has long been emblematic of Sahelian agrosystems, with local knowledge about it being passed down from generation to generation. These results corroborate are in line with Tchatchoua et al. (2025), who found that *F. albida* originated in West or East Africa and then spread to South Africa. In terms of use, *F albida* is used to a limited extent in the northern and southern Sudanese sectors and to a moderate to high extent in the strict Sahelian and southern Sahelian sectors, with a significant difference between sectors. It could be assumed that users in the southern Sahelian and strict Sahelian sectors are much more pastoral and exploit species such as *F. albida* more for livestock feed and human health through its fruits, leaves and bark. These results corroborate those of Niwah et al. (2020), who found that species like *Acacia nilotica*, *Acacia* (*Faidherbia*) *albida*, *Balanites aegyptiaca*, *Moringa oleifera*, *Sclerocarya birrea*, *Tamarindus indica* and *Ziziphus mauritiana* are the most widely used local species for at least four categories of use in the far north of Cameroon. The most used parts of *F. albida* in all phytogeographical sectors are the fruits, leaves and bark, with a predominance of fruit use in the southern Sudanese, southern Sahelian and strict Sahelian sectors and leaf and bark use in the southern Sahelian and strict Sahelian sectors. The use of these three parts (fruit, leaves and bark) in the southern Sahelian and strict Sahelian sectors could be explained by the fact that they are edible (by animals and humans), important in traditional medicine and accessible, unlike the other parts. They are most abundant when conditions are favorable and very easy to harvest without causing any damage to the tree. Our results are similar to those of Houndonougbo et al. (2020), who found that agroforestry species such as

Parkia biglobosa was used much more for their fruits. The use of *F. albida* pods in cattle feed supplements and the leaves in human consumption appears to be an alternative way of improving animal production and human nutritional potential (Roessler et al., 2025; Sarr et al., 2024). In areas where climatic conditions are less favorable, the use of woody resources is essential (Koné et al., 2023). In phytogeographical sectors, *F. albida* is used in different ways for fodder and pharmaceuticals and, to a lesser extent, for trade and soil fertility management. Depending on socio-economic groups, there is a significant difference in use for human consumption and pharmacopoeia. This is because the availability of plant resources varies between phytogeographical sectors and that users do not have the same interest in different parts of the plant. Traditional practitioners are much more interested in bark than agro-pastoralists, farmers and livestock breeders are interrested in leaves and fruit. These results are in line with Gonçalves et al. (2016), who found that the use of woody species is influenced by occupation. The increased use of *F. albida* across all three parts of the plant (fruit, leaves and bark), especially for fodder and medicinal purposes in northern Burkina Faso, could have a negative impact on its distribution.

4.2 Distribution and Development Stage of F. albida

Although *F. albida* is present throughout the territory, it remains an agroforestry species in the southern Sahelian sector and a domestic species (around concessions) in the southern Sudanese sector. This wide distribution is probably due to its endozoochoric mode of distribution, as animals consume the species' fruits (Ouédraogo et al., 2021) and reject those that have escaped being crushed. These seeds can germinate and adapt effectively to the conditions they will face. Seeds infested with parasites are destroyed during digestive transit without breaking the dormancy of healthy seeds, which will be dispersed far from the mother plant. However, nowadays, it is humans who play the essential role in dispersal by transporting the sludge as amendment to the fields), making it an agroforestry species in the Sahelian sector (Lu et al., 2022). The distribution of *F. albida* is moderate in the Sahelian region (southern Sahelian and strict Sahelian sectors) and low in the Sudanian region (northern and southern Sudanian sectors). This could be explained by the fact that the distribution is dependent on soil types and climate. *F albida* is known to be a species for dry regions of tropical and subtropical Africa (Mokgolodi et al., 2011). Our results corroborate those of Traoré et al. (2022), who found that the density of *F. albida* trees increased from the Sahelian zone to the Sudanese zone in Burkina Faso. As a xerophilous species with a taproot that allowing to use groundwater, *F albida* can easily adapt to dry environments. This is in line with the study of Alexandre and Ouédraogo (1993), who found morphological variations in its roots on two types of soil (sandy and compact clay soil) in Burkina Faso. They then concluded that the taproot of *F. albida* develops deep into sandy soil, while the root system remains superficial on compact clay soil, which may contribute to its low representativeness. On hydromorphic soils such as sandy soils, *F. albida* can orient its roots deep down to absorb water and nutrients effectively. This would therefore favor its development on these soils. Furthermore, it has been reported that the presence and growth of *F. albida* are strongly influenced by water availability (Traoré et al., 2022). Furthermore, the regeneration mechanism of this plant, which is suckering (Danthu et al., 2002), could be a handicap to its wide distribution, as suckering occurs around the mother tree, preventing uniform dispersal and colonization of new areas at long distances. In Senegal for instance, if nothing is done, the distribution of *F. albida* is expected to decline (Sambou et al., 2024).

F. albida is found in an ageing state in the strict Sahelian sector and mature in the southern Sahelian and northern Sudanese sectors, with few or no young trees. This state of development could be explained by the fact that the species is much more exploited at the juvenile stage in northern Burkina Faso, where it may encounter sexual regeneration issue. These results are in line with Traoré et al. (2020), who found a regressive population dynamic for *F. albida* in phytogeographic sectors except the Sudanese sector, and that suckering, a technique little known to users, remains its most suitable regeneration mechanism for the ecological conditions. The reduction in *F. albida* population in Burkina Faso has been reported (Nikiema, 2001) and in a neighboring Sahelian country such as Niger in recent years (Tougiani et al., 2021). Indeed, the dry areas of West Africa have only one rainy season which can negatively affect the reproductive potential of certain spontaneous species that are essential to the life of local populations. In addition, a decline in *F. albida* population has been observed in south-central Niger, the causes being unknown.

4.3 Vulnerability of F. albida and Relationship With Its Organ Use

F. albida is a moderately vulnerable species in the northern Sudanese, southern Sahelian and southern Sudanese sectors, with an index between 2 and 2.5, and highly vulnerable in the strict Sahelian sector, with a vulnerability index ≥ 2.5. This could be explained by the combined use of sticks, knives and/or hands to obtain *F. albida* organs in the strict Sahelian sector. This could severely damage the tree's normal physiological system, thus preventing it from producing suckers. We also attribute this high vulnerability to overexploitation of its fruit and a lack of appropriate techniques for harvesting and regeneration. These results also corroborate those of

Baggnian et al. (2021), who found a vulnerability index of 2.5 for *F. albida* in Niger. *F. albida* has been identified as one of the ten species that contribute most to the provision of ecosystem services, in the southern Sudanese sector of Burkina Faso (Nabaloum et al., 2022). Several species of high value, such as *Vitellaria paradoxa and Parkia biglobosa*, are currently considered vulnerable, with indices above 2.5 (Yaovi et al., 2021)

In the Multiple Correspondence Analysis (MCA), modalities with 'high vulnerability in the phytogeographic sector' and a cos^2 greater than 0.5 are strongly correlated with the factorial axes. This high cos^2 level indicates their significant contribution to the structuring of the data space, meaning that they actively participate in the separation of the groups of individuals observed in the factorial plane. This reflects the high vulnerability of *F. albida*, especially in the strict Sahelian sector. These results corroborate those of Koné et al. (2023), who found that *F. albida* is one of 31 woody species used for fodder and animal and human phytotherapy in northern Mali, where it is insufficiently available, unlike in the central and southern parts of the country. Thus, Cartereau et al. (2023) estimate that 44 to 88% of tree species in hot arid environments could suffer significant decline due to increased aridity, emphasizing that woody species in arid areas may be more vulnerable than those in more humid areas due to increased water limitations. This is because people's preferences in the strict Sahelian for a given species do not depend on its availability but rather on its socio-professional importance. *F. albida* is used by several socio-professional groups for various reasons, including human consumption, crafts, trade, fodder, soil fertility, medicine, erosion control and, to a lesser extent, rituals.

5. Conclusion

The aim of our study was to provide information on the usefulness, distribution and vulnerability of *F. albida* in order to improve its dynamics in agroecosystems. It appears that the leaves, fruits and bark are the parts most used for fodder, soil amendement and medicinal purposes. The species has a wide distribution in all phytogeographical sectors of Burkina Faso but remains an agroforestry species in the southern Sahelian sector and domestic (around concessions) in the southern Sudanian sector. The majority of the species' trees are ageing in the strict Sahelian sector and mature in the southern Sahelian and northern Sudanese sectors, with few or no young trees. *F. albida* is moderately vulnerable in the northern Sudanese, southern Sahelian and southern Sudanese sectors with an index between 2 and 2.5, and highly vulnerable in the strict Sahelian sector with a vulnerability index ≥ 2.5. The study contributed to the production of up-to-date scientific data on *F. albida* to support agroforestry resource management policies in Burkina Faso and generally in the Sahel and to meet the objectives of the Rio Conventions. Considering this study, *F. albida* deserves special attention in terms of finding solutions to improve the survival rate of its seedlings to improve its dynamics and ensure its sustainability.

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Authors Contributions

Conceptualization of the study, M.S., D.I.K., I.C.E.T. and E.H.; Data collection, statistical analysis and preparation of the manuscript, M.S.; Validation, D.I.K.; All authors have read and agreed to the final version of the manuscript.

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