Vulnerability and ecological importance of species used for the management of hypertension and diabetes in the sub-sahelian area of Burkina Faso, West Africa

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Abstract

Background: Hypertension and diabetes are major public health issues in developed and low-income countries today. The prevalence of these diseases is higher in low-income countries due to high population density, weak health care systems, and a high number of undiagnosed and untreated people. Due to these factors, the majority of patients rely heavily on herbal medicines for their management. This study aimed to assess the vulnerability and ecological importance of species of interest for the two diseases in the sub-sahelian area of Burkina Faso.

Methods: A semi-structured interview was conducted with 70 Traditional healers from the departments of *Kaya* and *Barsalogho* using a questionary. Floristic inventories followed by measurements of diameters at breast height (dbh) were conducted on 50 plots of 50m x 20m.

Results: Ethnobotanical surveys identified 36 species that are used for the management of hypertension and diabetes; 25 woody species were vulnerable (IV ≥ 2). Among these species, *Cadaba farinosa*, *Lannea acida*, *Parkia biglobosa*, *Saba senegalensis*, *Sclerocarya birrea*, *Tamarindus indica*, *Ximenia americana*, and *Ziziphus mauritiana* were highly vulnerable (IV ≥ 2.5). Consistent with the Traditional healers perception, most of these highly vulnerable species were rare (RI ≥ 80%) in the sample units. In addition, only *Combretum micranthum* and *Cassia sieberiana* had the highest importance value indices.

Conclusions: These results justify that there is a real threat to heavily used species. It appears necessary for traditional healers to apply the right methods of plant use that will not compromise the availability of local plant resources.

Background

Hypertension and diabetes are major risk factors for cardiovascular disease. These pathologies are nowadays a major public health challenges in developed and low-income countries [1,2]. Indeed, according to WHO (World Health Organization) projections, the number of annual deaths related to cardiovascular disease is expected to reach 25 million in 2030. According to the same projections, the highest incidence of hypertension will occur in African countries [3]. Researchers have estimated that hypertension currently kills 9 million people annually. The global diabetes prevalence in 2019 is estimated to be 9.3% rising to 10.2% by 2030 and 10.9% by 2045 [4].

The prevalence of these diseases is higher in low-income countries due to high population density, weak health systems, and high numbers of undiagnosed and untreated people. In addition, in Africa, there is still far too much focus on infectious diseases. Yet, the silent killers like diabetes and hypertension deserve more attention [1]. Some study revealed that diabetes and hypertension can be found in the same individual and type 2 diabetes are almost 2.5 times possibility to develop in subjects with hypertension [5].

In Burkina Faso, according to a national survey conducted in 2013, most people with a risk factor for non-communicable disease did not know their disease status. Indeed, 39.8% of people, aged between 25 and 64 had never measured their blood pressure and 94.2% had never measured their blood glucose. A hypertension was diagnosed in 16.8% of people who did not know they were sick. The survey also revealed inadequate management of hypertension and diabetes. From this point of view, the Ministry of Health in Burkina Faso is particularly interested in these two diseases. In addition, hypertension and diabetes are considered as priority diseases for research on medicinal plants.

Beyond conventional medicine, traditional medicine and pharmacopoeia remain higly appreciated by African populations who still trust in their effectiveness. Medicinal plants are precious resources for humanity, especially for the poor populations in low-income countries who depend on them [6]. Due to inaccessibility and inadequacy of health infrastructure, high costs of hospital care, illiteracy and poverty, most of the population is dependent on medicinal plants to cure various ailments such as hypertension and diabetes [7,8]. A previous study conducted in the sub-sahelian sector located in the northern part of Burkina Faso reported that some species such as *Cassia sieberiana* DC. *Balanites aegyptiaca* (L.) Delile, *Securidaca longipedunculata* Fresen, and *Ximenia americana* L. have become the main species used in traditional medicine by the population [9]. This strong exploitation may unfortunately be a cause of vulnerability or even a threat of extinction to these highly targeted species. Indeed, the use patterns of plants, the type of the organs used, the methods of harvesting, the quantity of plant material harvested and the abundance of the species in ecosystems are all factors that make the species vulnerable. Adequate knowledge of the level of threat and the factors responsible remains crucial for the development of conservation strategies. However, this information is severely limited for most species in the sub-sahelian area, particularly in the province of Sanmatenga in Burkina Faso. The general objective of this study therefor is to assess the vulnerability of species of interest for treatment of hypertension and diabetes in the sub-sahelian region of Burkina Faso. Specifically, this study aimed to (i); identify the plants used by traditional healers (THs) for the management of both hypertension and diabetes; (ii) apprehend the perceptions of THs on the availability of species of interest for hypertension and diabetes; (iii) determine the vulnerability indices of these species by field studies and (iv) determine the Importance Values and the Rarity Index of antidiabetic and antihypertensive species in the investigated area.

Material And Methods

Study site

The study was conducted in 2014 in the province of Sanmatenga, precisely in the departments of Kaya and Barsalogho located in the sub-sahelian phytogeographic sector with an area of 9,281 Km², located between 13° to 14° North latitude and 1° to 2° West longitude (Figure 1). It is limited at the north by the province of *Soum*, the south by the provinces of *Ganzourgou* and *Oubritenga*, the east by the province of *Namemtenga* and the west by those of *Bam* and *Passoré* [10]. The climate of the province of *Sanmatenga* is of the sahelian type characterized by a short rainy season that does not exceed four (04) months (June to September). The average annual rainfall over the last thirty (30) years varied between 600 and 700 mm. August is the most rainy month with a rainfall of up to 220.31 mm. May is the hottest month with an average temperature of 33.20 °C, while January is the coldest with an average temperature of 23.24 °C. The vegetation of the province of Sanmatenga is formed by steppes, tiger bushes, shrubby and tree-covered savannahs, and riparian formations. The sub-sahelian phytogeographic sector constitutes the interference zone of several ubiquitous sahelian and Sudanese species [11]. The main species observed are *Acacia seyal* Delile, *Acacia nilotica* (L.) Willd. ex Delile, *Acacia laeta* R.Br. ex Benth., *Combretum micranthum* G. Don, *Guiera senegalensis* J.F. Gmel., *Ziziphus mauritiana* Lam, *Balanites aegyptiaca* (L.) Delile, *Pterocarpus lucens* Lepr. ex Guill. & Perr, *Combretum glutinosum* Perr. ex DC., *Cassia sieberiana* DC., *Schoenefeldia gracilis* Kunth and *Loudetia togoensis* (Pilg.) C. E. Hubb.

The economic sector is mainly based on agriculture, livestock, handicrafts, and mining. A rainfed subsistence agriculture highly dependent on climatic conditions is mainly practiced in this province. Due to its high population density, this zone is experiencing serious problems of environmental degradation related to the overexploitation of its scarce resources. The main crops are cereals, cash crops and crops from market gardening. The health sector is characterized by an insufficiency of human resources and infrastructure and the distance from one health center to another does not comply with the standards published by the World Health Organization [12]. Most of the population uses traditional medicine. Indeed, in 2014 the local health services had listed 1627 THs involved in the management of various pathologies such as infectious diseases and non-communicable diseases [13].

Sampling and data collection

An ethnobotanical survey was carried out in 2014 in the departments of *Kaya* and *Barsalogho* among seventy (70) traditional healers including fifty (50) men and twenty (20) women aged between 33 and 90 years. These men and women were selected because they had a long year experience in usage of plant material for the treatment of hypertension and diabetes. The ethnobotanical survey consisted of a semi-structured interview using a questionary. No distinction was made with respect of their age, religion or gender. However, we took into account the accessibility of the study areas and the consent of the informants. During the survey, the names of the species used in the management of hypertension and diabetes, the organs used methods of collection and preparation, harvesting sites and other forms of medicinal use were collected. In addition, the perception of the informants on the availability of the plant resources used, the causes of a putative scarcity of these resources and proposals for solutions for their conservation were queried. Supplementary to the ethnobotanical surveys, diameter measurements of woody individuals were carried out in the area. For this 50 rectangular plots of 50 m x 20 m were installed according to the presence of at least one of the species [14,15] frequently cited during the surveys for the treatment of hypertension or diabetes, respectively. This investigation involved all trees with a diameter ≥ 5cm at a height of 1m30 from the soil. Species names and families were updated following Angiosperm Phylogeny Group classification [16].

Data analysis

Data were analyzed and graphs generated by Excel 2016. In order to assess the ecological impact of the use of plants in the management of both hypertension and diabetes, we determined the vulnerability index of the woody plants. The vulnerability scale used consists of three levels from 1 to 3 (Table I). A value of 1 denotes a low vulnerability species, a value of 2 represents a moderately vulnerable species, and 3 characterizes a highly vulnerable species [17]. The vulnerability index is a composite several parameters, such as the frequency of citation (Fc) of the species (N1), the number of plant organs used (N2), the type of plant organs used (N3), the frequency of uses of the species (N4), the method of organ harvesting (N5) and the relative frequency (Fr) of the species in the area (N6).

The relative frequency of citation for certain species was calculated as follows:

$Fc = \Sigma c / \Sigma C \times 100$

where Σc is the total number of citations per species and ΣC is the total number of citations for all species.

The relative frequency of species occurrence in the plots examined is given as:

$Fr = n_i / N \times 100$

Where Fr is the frequency (%) of species i; n_i is the number of plots where species i is present and N the total number of plots examined. The relative frequency is rescaled in terms of multiples of the maximum frequency (Fm) which corresponds to the highest relative frequency detected [18].

The vulnerability index (IV) is the average of the value scales of the six individual parameters (Table I). Only local woody and subwoody species of interest for hypertension and diabetes were considered in the calculation of the vulnerability index. The species that have disappeared in the area were not considered. In addition, the species whose individuals were not observed in the plots are considered low frequency species.

$$IV = \frac{N1+N2+N3+N4+N5+N6}{N}\ ;\ N=6$$

IV < 2, species is of low vulnerability, 2 ≤ IV < 2.5, the species is moderately vulnerable and IV ≥ 2.5 species is highly vulnerable [18].

Table I. Parameters used to calculate the index of vulnerability (IV)

Parameters (N=6)	**1** (Low scale)	**2** (Average scale)	**3** (Strong scale)
Frequency of de citation (N1)	N1 < 20%	20% ≤ N1< 60%	N1 ≥ 60%
Number of organs used (N2)	N2 < 2	2 ≤ N2<3	N2 ≥ 3
Type of organs used (N3)	Leaves, latex	Fruit, branch	Wood, seeds, bark, root, flowers
Number of uses of species (N4)	N4 < 2	2 ≤ N4 ≤ 4	N4 ≥ 5
Method of organ harvesting (N5)	Collection on the ground	-	Collection on the tree ; cutting
Relative frequency of species occurrence (N6)	RF ≥ 2/3 MF	1/3 MF ≤ RF < 2/3 MF	RF < 1/3 MF

RF : Relative frequency; MF : Maximum frequency

To evaluate the availability of species, we calculated the Rarity Index (RI) from the equation of Géhu and Géhu [19]. This ethnobotanical index was already used in Togo [20] and Ivory Coast [21]. It is calculated according to the following formula:

$$\mathrm{RI} = \left(1 - \frac{ni}{N}\right) x100$$

RI: Rarity index of the species i

n_i: number of plots where species i is present

N: total number of plots investigated

We have defined rarity cut-off-points for a species according to the study by Traore et al. (2011): RI < 60%, the species is very frequent in the plant formation; 60 ≤ RI < 80%, the species is moderately frequent and RI ≥ 80%, the species is rare.

The Importance Value Index (IVI) or ecological importance value, a measure of how dominant a species is in a plant community, was assessed using the following formula:

IVI= Relative Dominance + Relative Density + Relative Frequency

$$\text{Relative dominance} = \frac{\text{total basal area of the species}}{\text{basal area of all species}} x\ 100$$

$$\text{Basal area (G)} = \Sigma\pi D^2/4$$

$$\text{Relative density} = \frac{\text{number of the species individuals per ha}}{\text{total number of individuals per ha}} x\ 100$$

$$\text{Relative frequency} = \frac{\text{frequency of a species}}{\text{sum of species frequencies}} x\ 100$$

Results

Species richness and plants use patterns for the management of hypertension and diabetes

For the management of hypertension and diabetes, the traditional healers (THs) cited thirty-six (36) species. These species belonged to thirty-two (32) genera and twenty (20) families. Among these species, *Sclerocarya birrea* (6.08%), *Parkia biglobosa* (5.41%), *Khaya senegalensis* (4.73%), *Combretum micranthum* (4.05%) and *Moringa oleifera* (4.05%) are the most cited for the management of hypertension. However, for the treatment of diabetes, *Cassia sieberiana* (8.57%) and *Cassia italica* (3.81%) are frequently cited by THs (Table II). The parts of the plants mentioned are practically the same for both pathologies. However, the formulation methods differ notably from one disease to another. Indeed, the decoction (51.85%) is strongly used in the case of the preparation of anti-hypertensive recipes. Calcination is used more often for the formulation of anti-diabetic recipes (16%) than for anti-hypertensive ones (7.41%). This is also the case for infusion (10%) which is only used for the formulation of some anti-diabetic recipes (Figure 2).

Table II. Species used for the management of hypertension and diabetes in the sub-sahelian area of Burkina Faso, West Africa

Species	Family	Local name (Mooré)	Hypertension			Diabetes		
			FC	Organs	Formulation	FC	Organs	Formulation
Acacia sieberiana DC	Fabaceae	*Gonponsgo*	0.68	TB	D	0.95	TB	D
Anogeissus leiocarpa (DC.) Guill. & Perr.	Combretaceae	*Siiga*	2.7	Lv; TB	D; M	0.95	Lv	I
Balanites aegyptiaca (L.) Delile	Zygophyllaceae	*Kièglga*	0.68	TB	D	0.95	TB	D
Boscia angustifolia A. Rich.	Capparaceae	*Zigrezika*	2.03	TB	D	0.95	TB	M
Boswellia dalzielii Hutch.	Burseraceae	*Komdayouingo*	1.35	TB	M	0.95	TB	D
Cadaba farinosa Forssk.	Capparaceae	*Kinsga*	2.03	Rt	D	0.95	Rt	Ca
Calotropis procera (Aiton) R.Br.	Apocynaceae	*Putrepuga*	0.68	Rt	M	0.95	Rt	D
Cassia italica (Mill.) Lam. ex F.W.Andrews	Fabaceae	*Nontoulm-Songdré*	2.03	Lv	D; M; Po	3.81	Lv	D; M; Po
Cassia sieberiana DC.	Fabaceae	*Yâmtiiga*	5.41	Rt	M; Po; D	8.57	TB; Lv	M; Po; D
Cochlospermum tinctorium Perr. ex A. Rich	Cochlospermaceae	*Sonsga*	2.03	Rt	M	1.9	Rt	Po
Combretum glutinosum Perr. ex DC.	Combretaceae	*Koèguenga*	0.68	Lv	Po	0.95	Lv	I
Combretum micranthum G. Don	Combretaceae	*Kânga/Rannega*	4.05	Lv	D;M	1.9	Lv	I
Crescentia cujete L.	Bignoniaceae	*Wamde-Tiiga*	0.68	Lv	D	0.95	Lv	D
Daniellia oliveri (Rolfe) Hutch. & Dalziel	Fabaceae	*Aonga*	2.03	TB	D	2.86	TB	Ca
Feretia apodanthera Delile	Rubiaceae	*Finninga*	1.35	Rt; Lv	D; M	1.9	Rt; Lv	I
Ficus platyphylla Delile	Moraceae	*Kamsongo*	2.03	TB	D	0.95	Lv	D
Ficus sycomorus L.	Moraceae	*Kankanga*	0.68	TB	D	0.95	TB	D
Guiera senegalensis J.F.Gmel.	Combretaceae	*Wilinwiiga*	2.03	Lv	D; M	0.95	Lv	I
Khaya senegalensis (Desr.) A Juss.	Meliaceae	*Kuka*	4.73	TB	D; Po; M	2.86	TB	D; Po

Species	Family	Local name (Mooré)	Hypertension			Diabetes		
			FC	Organs	Formulation	FC	Organs	Formulation
Lagenaria siceraria (Molina) Standl.	Cucurbitaceae	*Kândé*	0.68	Fr	Ca	0.95	Lv	Ca
Lannea acida A. Rich.	Anacardiaceae	*Sanbtoulga*	0.68	TB; Lv	D	2.86	TB	M; Po; Ca
Lannea microcarpa Engl. & K. Krause	Anacardiaceae	*Sâbga*	0.68	TB	D	1.9	Lv; TB	M; D
Leptadenia hastata (Pers.) Decne.	Apocynaceae	*Leulongo*	0.68	Wp	D	1.9	Rt; Lv	Ca
Mitragyna inermis (Willd.) Kuntze	Rubiaceae	*Yiilga*	0.68	TB	Ca	0.95	Lv; TB	D; M
Moringa oleifera Lam.	Moringaceae	*Arzentiiga*	4.05	Lv; Fr	Po; D	0.95	Lv	Po
Parkia biglobosa (Jacq.) R.Br. ex G. Don	Fabaceae	*Roanga*	5.41	TB;Rt;Se	D; Po	0.95	Se	Po
Pennisetum glaucum (L.) R.Br.	Poaceae	*Kazui*	1.35	Se	M; Po	1.9	Rt; Se	Ca
Piliostigma reticulatum (DC.) Hochst.	Fabaceae	*Baguen-Daaga*	0.68	Lv	D	1.9	Fr	Ca; M
Saba senegalensis (A.DC.) Pichon	Apocynaceae	*Wèdga*	2.03	Rt; TB	D; M	0.95	Lv	D
Sclerocarya birrea (A. Rich.) Hochst.	Anacardiaceae	*Noabga*	6.08	TB; Lv	M; D	1.9	TB	M; D
Securidaca longipedunculata Fresen.	Polygalaceae	*Pèlga*	1.35	Rt	D	0.95	Rt	Ca
Sterculia setigera Delile	Malvaceae	*Ponsonponrgo*	0.68	Lv	Ca	0.95	TB	M
Tamarindus indica L.	Fabaceae	*Pusga*	4.05	Lv; Fr	M; Po; Ca; D	2.86	Lv; TB	M; D
Ximenia americana L.	Ximeniaceae	*Lennga*	2.03	Rt; Lv	D	0.95	Rt; TB	Po
Xylopia aethiopica (Dunal) A. Rich.	Annonaceae	*Kiparin-Sablga*	0.68	Fr	D	1.9	Fr	Po
Ziziphus mauritiana Lam.	Rhamnaceae	*Mougouniga*	1.35	Lv; TB	D	0.95	Rt	M

FC: Frequency of Citation; TB : Trunk bark; Lv : leaves; Rt : root; Fr : fruit; Se : seeds; Wp : whole plant; Tu : tuber; D : decoction; M : maceration; I : infusion; Po : powder; Ca : calcination

Traditional healers' perceptions of the availability of antidiabetic and antihypertensive species, causes of their extinction and putative solutions

Among the 36 species cited in the management of hypertension and diabetes, the THs surveyed commented on the availability of 32 species cited in the management of hypertension and diabetes. The other plants (4) namely *Lagenaria siceraria, Pennisetum glaucum* and *Moringa oleifera* that cultivated plants and *Xylopia aethiopica* (whose organs are sold) were not considered. According to the THs, 21 species or 65.62 % of the woody species cited are rare or endangered; two (6.25%) species (*Cochlospermum tinctorium* and *Daniellia oliveri*) have disappeared and 9 (28.12%) species namely *Balanites aegyptiaca*, *Combretum glutinosum*, *Combretum micranthum*, *Guiera senegalensis*, *Khaya senegalensis*, *Lannea microcarpa*, *Leptadenia hastata*, *Piliostigma reticulatum* and *Sterculia setigera* were supposed to be readily available or still quite frequent (Table III). The THs claimed that most of the rare species were formerly available even around homes, but nowadays the minimum access distance is at least five kilometers. Many causes were mentioned by the THs to explain the rarefaction or the disappearance of the species cited. Anarchic exploitation of plant organs, drought, bush fires and abusive wood cutting are the main causes. Indeed, 23.17% of the causes named are related to the exaggerated barking of trunks and the anarchic extraction of the plant roots. Drought, bush fires and abusive wood cutting were quoted with a proportion of 41.46%. According to 35.37% of the citations, the disappearance of species is linked to the combination of all the factors mentioned. However, THs were all unanimous in recognizing that the species they use require conservation. As solutions to these various factors mentioned above, the THs proposed:

(i) the actors training involved in the exploitation of plant resources on techniques for the plant harvesting organs and the production of seedlings,

(ii) the systems reinforcement for monitoring and repression of acts of non-compliance with the relevant regulations,

(iii) the strong authorities involvement in charge of environmental and health issues,

(iv) the need for each traditional healers to domesticate the species that he frequently uses and that are in danger of extinction.

Table III. Availability of species in the sub-sahelian area according to the traditional healers

Number	Available species	Rares species	Extinct species
1	*Balanites aegyptiaca*	*Acacia sieberiana*	*Cochlospermum tinctorium*
2	*Combretum glutinosum*	*Anogeissus leiocarpa*	*Daniellia oliveri*
3	*Combretum micranthum*	*Boscia angustifolia*	
4	*Guiera senegalensis*	*Boswellia dalzielii*	
5	*Khaya senegalensis*	*Cadaba farinosa*	
6	*Lannea microcarpa*	*Calotropis procera*	
7	*Leptadenia hastata*	*Cassia italica*	
8	*Piliostigma reticulatum*	*Cassia sieberiana*	
9	*Sterculia setigera*	*Crescentia cujete*	
10		*Feretia apodanthera*	
11		*Ficus platyphylla*	
12		*Ficus sycomorus*	
13		*Lannea acida*	
14		*Mitragyna inermis*	
15		*Parkia biglobosa*	
16		*Saba senegalensis*	
17		*Sclerocarya birrea*	
18		*Securidaca longipedunculata*	
19		*Tamarindus indica*	
20		*Ximenia americana*	
21		*Ziziphus mauritiana*	

Relative vulnerability of antidiabetic and antihypertensive species

Among the 36 species identified with traditional healers, 28 woody species were considered for the vulnerability assessment. Out of the 28 woody species assessed, 25 woody species (89.28%) exhibit a vulnerability index IV ≥ 2 and can therefore be classified as vulnerable. Among them, seventeen species are moderately vulnerable (2 ≤ IV≤ 2.43) and eight others are very vulnerable (IV ≥ 2.5). In this later category fall *Cadaba farinosa*, *Lannea acida*, *Parkia biglobosa*, *Saba senegalensis*, *Sclerocarya birrea*, *Tamarindus indica*, *Ximenia americana* and *Ziziphus mauritiana*. Only three species such as *Combretum micranthum*, *Combretum glutinosum* and *Guiera senegalensis* are weakly vulnerable with IV<2 (Figure 3). As the main parameters indicating vulnerability, the mode of harvesting, the nature of the organs used and the relative frequency of occurrence are generally considered. Indeed, 82.14% of the species cited for both hypertension and diabetes management are subject to intensive debarking or anarchic and exaggerated root harvesting which could lead to species extinction. This is the case for the species *Khaya senegalensis*, *Parkia biglobosa*, *Anogeissus leiocarpa*; *Securidaca longipedunculata*, *Cassia sieberiana* and *Ximenia americana*. In addition, 78.57% of the species are rated as vulnerable due to the nature of the organs used (bark, roots, leafy stems...) and 82.14% of the species are vulnerable because to their relatively low frequency of occurence (RF <.1/3 MF).

Ecological importance and rarity of antidiabetic and antihypertensive species determined by floristic surveys

The floristic surveys identified 58 woody species belonging to 42 genera and 23 families. Among the species inventoried in the plots, 21 species (36.21%) were cited by the THs for the management of hypertension and diabetes. *Combretum micranthum* (IVI= 107.92), *Cassia sieberiana* (IVI = 64.4), *Piliostigma reticulatum* (IVI= 60.14), *Combretum glutinosum* (IVI= 58.22) and *Balanites aegyptiaca* (IVI=50.24) can be classified as species of high ecological importance species due to their relative frequency (IVI > 50). *Acacia sieberiana* (IVI = 2.25), *Sterculia setigera* (IVI = 3.07) and *Mitragyna inermis* (IVI = 3.60) are the species with lowest ecological importance. According to the Rarity Index (RI), 57.14% of the plants species used for treatment of hypertension and diabetes are rare (RI ≥ 80); 23.80% are moderately frequent (60 ≤ RI < 80) and 19.05% such as *C. micranthum* (RI=20), *C. sieberiana* (RI=52), *P. reticulatum* (RI=52), and *C. glutinosum* (RI=54) are very frequent (RI < 60). Notably, most of the highly vulnerable species, namely *Lannea acida, Saba senegalensis*, *Ziziphus mauritiana*, *Parkia biglobosa* and *Tamarindus indica* are rare in the sampled localities (RI ≥ 80) (Table IV).

Table IV. Importance value and rarity indices of antihypertensive and anti-diabetic species inventoried in the plots

Species	RDO	RF	RDE	IVI	RI
Acacia sieberiana DC.	0.19	2	0.05	2.25	98
Anogeissus leiocarpa (DC) Guill. et Perr.	4.03	26	4.05	34.09	74
Balanites aegyptiaca (L.) Delile	6.27	38	5.97	50.24	62
Boscia angustifolia A. Rich.	0.71	10	0.44	11.15	90
Cassia sieberiana DC	5.44	48	10.96	64.40	52
Combretum glutinosum Per. ex DC.	4.17	46	8.05	58.22	54
Combretum micranthum G. Don.	6.22	80	21.70	107.92	20
Feretia apodanthera Delile	0.03	8	0.22	8.25	92
Guiera senegalensis J.F. Gmel.	0.24	16	1.26	17.51	84
Khaya senegalensis (Desr) A. Juss	1.95	4	0.22	6.17	96
Lannea acida (L) A. Rich.	0.36	6	0.16	6.53	94
Lannea microcarpa Engl.et K. Krause	8.36	22	1.21	31.57	78
Mitragyna inermis (Willd) O. Krze	1.27	2	0.33	3.60	98
Parkia biglobosa (Jacq.) R. Br. ex G. Don.	14.79	12	0.49	27.28	88
Piliostigma reticulatum (DC) Hochst	3.26	48	8.88	60.14	52
Saba senegalensis A. (DC) Pichon	0.17	8	0.66	8.82	92
Sclerocarya birrea (A. Rich.) Hochst.	6.82	24	1.59	32.41	76
Sterculia setigera Delile	1.01	2	0.05	3.07	98
Tamarindus indica L.	6.58	16	0.60	23.18	84
Ximenia americana L.	1.06	26	3.12	30.18	74
Ziziphus mauritiana Lam.	0.11	10	0.38	10.50	90

RDO: relative dominance; RF: relative frequency; RDE : Relative density; IVI : ecological importance value index; RI : rarity index.

Discussion

Use of plants in the management of both hypertension and diabetes and THs perceptions on their availability

The use of plants for the management of both hypertension and diabetes is evident in the sub-sahelian phytogeographic area. A similar study conducted in Chad reported that more than 43% of the plants cited by the population were used by them for both hypertension and diabetes treatment [22]. However, the number of species cited remains low compared to that reported in previous studies on the singular management of hypertension and diabetes [23,24]. This is one of the reasons why the same species are used by several THs for the management of several pathologies. Some chemical and pharmacological studies carried out on species such as *Cassia sieberiana* [25], *Khaya senegalensis* [26], *Tamarindus indica* [27], *Cassia italica*, *Daniellia oliveri* [24] and *Combretum micranthum* [28] have justified their use by THs for the treatment of hypertension and diabetes. The modes of preparation of the most known recipes remain the decoction, the maceration and the infusion but these modes can vary according to the pathology and the traditional healers [24,29].

Despite the proven importance of these plants in the daily lives of the people, the THs are still confronted with a problem of availability of plant resources. Lack of rain, logging and bush fires are perceived by most THs as being factors that negatively influence this availability of plant resources. Some THs justify the disappearance of *Daniellia oliveri* and the rarefaction of *Sclerocarya birrea*, *Anogeissus leiocarpa*, and *Parkia biglobosa* in the area by the resurgence of drought pockets. Other THs attribute it to the constant pruning during grazing by herders. According to [14], drought and grazing would prevent the establishment of young seedlings that grow during the rainy season and their transition from the juvenile stage to the adult stage. The threat of *Cassia sieberiana* disappearance is also perceived by THs as the consequence of the cutting of its fresh wood especially for commercial needs. The action of bush fires has been mentioned mainly to justify the destruction of *Cassia italica*, supporting the fact that it is one of the main factors of ecosystem disturbance [30]. The burning and felling of trees during the clearing of new fields leads to a massive and rapid destruction of vegetation and sometimes entire stands of certain species (e.g., *Anogeissus leiocarpa*), which are indicative of soils favorable to agriculture [11].

According to some THs, the disappearance or threat of disappearance of the species does not seem to be linked exclusively to the effect of a single factor but rather to the combined effect of several factors, including those mentioned above. A disturbance factor predisposes any plant formation to the action or invasion of other factors [31]. This is why fire, other abiotic factors (climate, soil...) and biotic factors must be considered as a whole.

Species vulnerability and stand availability in the surveyed sites

The method of harvesting, the nature of the organs used and the relative frequency of occurrence are key parameters of the vulnerability of a species. Indeed, the methods of harvesting (picking, debarking, cutting...) requiring the use of the pickaxe and machete traumatize woody species and make them more vulnerable. Roots, bark, seeds, flowers being very sensitive organs, their exploitation makes plants more vulnerable compared to leaves, fruits and latex. A species with a low relative frequency (number of surveys where its presence is effective) is more vulnerable than one with a high relative frequency [18]. In addition, the anarchic and frequent debarking makes the species vulnerable to parasites, arid climate and scarce water supply[32]. The factors listed above could explain the high vulnerability of species such as *Cadaba farinosa*, *Lannea acida*, *Parkia biglobosa*, *Saba senegalensis*, *Sclerocarya birrea*, *Tamarindus indica*, *Ximenia americana* and *Ziziphus mauritiana*. Indeed, almost all of these highly vulnerable species are on the red list of threatened species [33]. Combined with unfavorable climatic conditions, the different human factors can lead to changes in the floristic composition of an area [9].

Overall, the floristic inventory data are in agreement with the perception of THs on the availability of the species used. Indeed, 69.23% of the species cited as rare, show rarity index (RI) ≥ 80%. 62.50% of those cited as available have RI < 80%. In addition, no species among those cited by THs as extinct were observed in the plots. Previous studies conducted in some localities of the same phytogeographic sector had already reported the threats of extinction of most of the species cited in this work [9]. This is the case for species such as *Saba senegalensis*, *Sclerocarya birrea*, *Boscia angustifolia* and *Ziziphus mauritiana* that were threatened with extinction in the sahelian zone of Burkina Faso [34]. In addition, some studies had reported since 2000, that *Daniellia oliveri* had disappeared in the sub-sahelian phytogeographic sector [35]; which corroborates the results of the present study. Although peculiar in its biological form, *Cassia italica* amazes through the information collected on its medicinal virtues. Indeed, for some THs, this species presents properties able to cure an array of diseases. For other THs, this plant is considered a panacea and accessible even to the poor. In some area of Burkina Faso, the plant is seen as a remedy for the orphan especially since, we know that this one has not necessarily a bread-winner [36]. Its mention among the species that have become rare seems to be linked to the fact that it is a perennial sub-ligneous that gives the impression of not being able to regenerate after a bush fire. More importantly, this consideration is related to the restriction of its range and the excessive exploitation of its leafy branches for commercial purposes by herbalists. Therefore, *Cassia italica* is much more a vulnerable species. One of the most abundant species of interest in this part of Burkina Faso is *Combretum micranthum*. Thus, Thiombiano et al. [37], report that large stands of this species exist in the southern sahelian sector, but it remains one of the most valued species in the area, particularly in the energy sector.

Conclusion

This study allowed us to assess the use of medicinal plants in the management of hypertension and diabetes and to understand the availability of these plants through the perception of the THs and the floristic surveys. THs know several plants that are used both for the management of hypertension and diabetes. However, the nature of the most commonly used organs (barks, leaves and roots), their methods of harvesting and preparation are real factors of vulnerability of the plants. This probably leads to the loss of some organs or sometimes of the whole plant, thus compromising the availability of the resources of these plants. Moreover, the THs perception of species availability was consistent with the results of the floristic surveys. The species most used in the management of the two diseases, with the exception of *Combretum micranthum* and *Cassia sieberiana*, present low importance indices and very high rarefaction indices indicating their low frequency in the inventoried sites. In view of these real threats to the species of interest in the sub-sahelian, it is now up to the THs to use effective and appropriate methods that do not compromise the availability of plant resources in the short or long term. From this point of view, the results of this study should be able to serve as a reference for the sensitization and training of THs in traditional medical practice.

Abbreviations

APG: Angiosperm Phylogeny Group classification

FAO: Food and Agriculture Organization

IUCN: International Union for Conservation of Nature

WHO: World Health Organization

Declarations

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Authors contributions

SC developed the study protocol, collected the data and identified the plants. He also analyzed the data, wrote the manuscript. LO, AB and LB reviewed the manuscript. NO, SO, and AT validated the study protocol. All authors read and finalized the manuscript before submitting it.

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Availability of data and materials

The data collected were analyzed and presented in table and figure in this article. These data are available for any request

Ethics approval and consent to participate

All traditional healers participated in the study by informed consent

Consent for publication

Not applicable

Declaration of Competing Interest

The authors declare no conflicts of interest.

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Figures

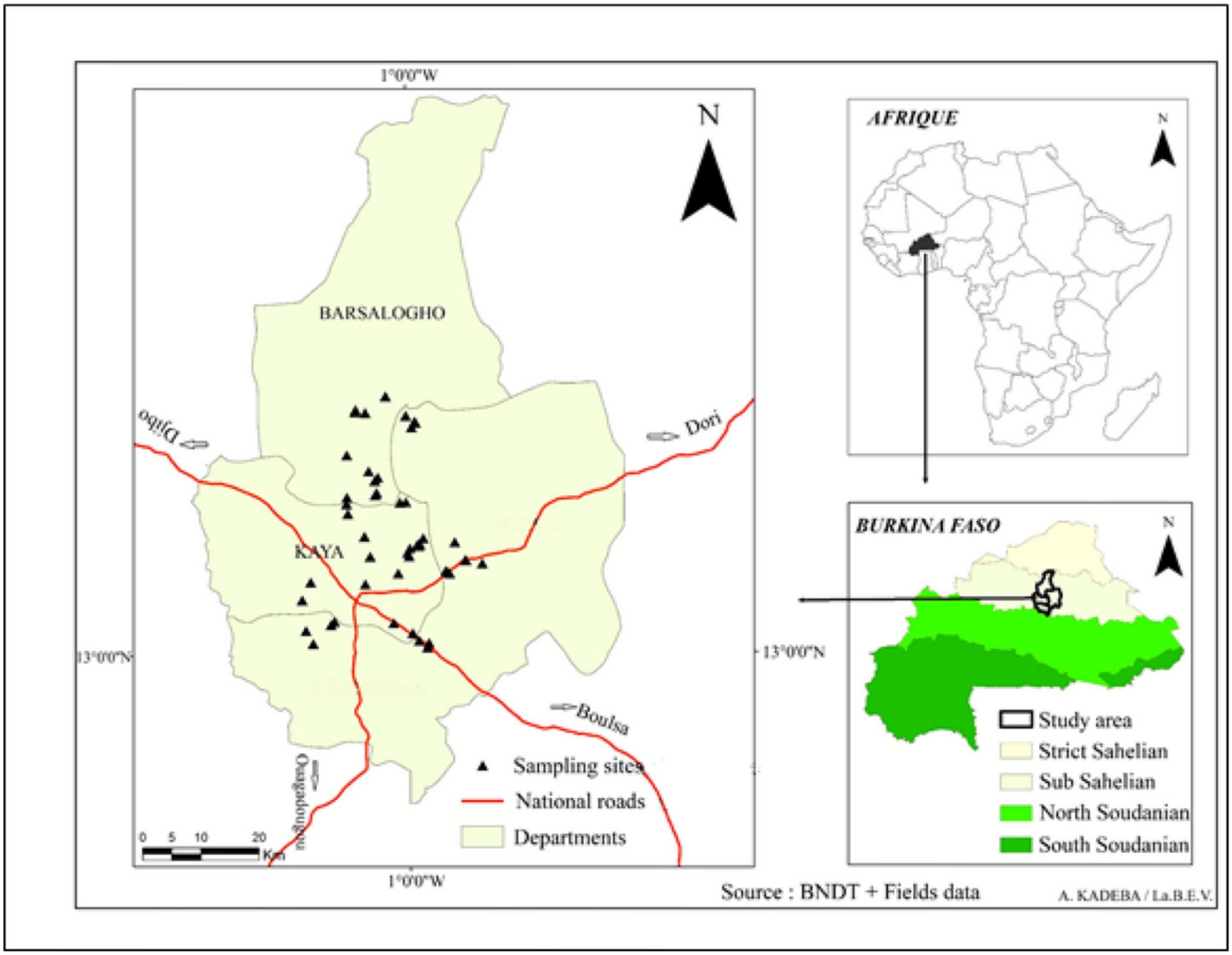

Figure 1

Location of study sites in Burkina Faso, West Africa

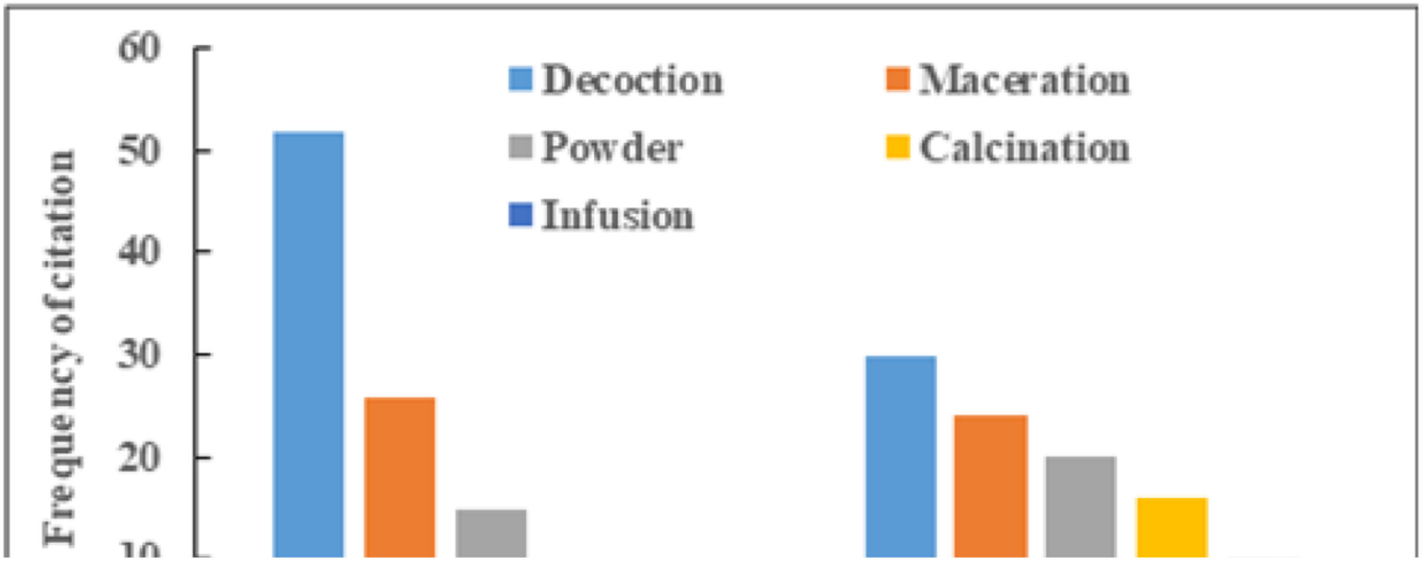

Figure 2

Distribution of formulation methods for antihypertensive and antidiabetic recipes

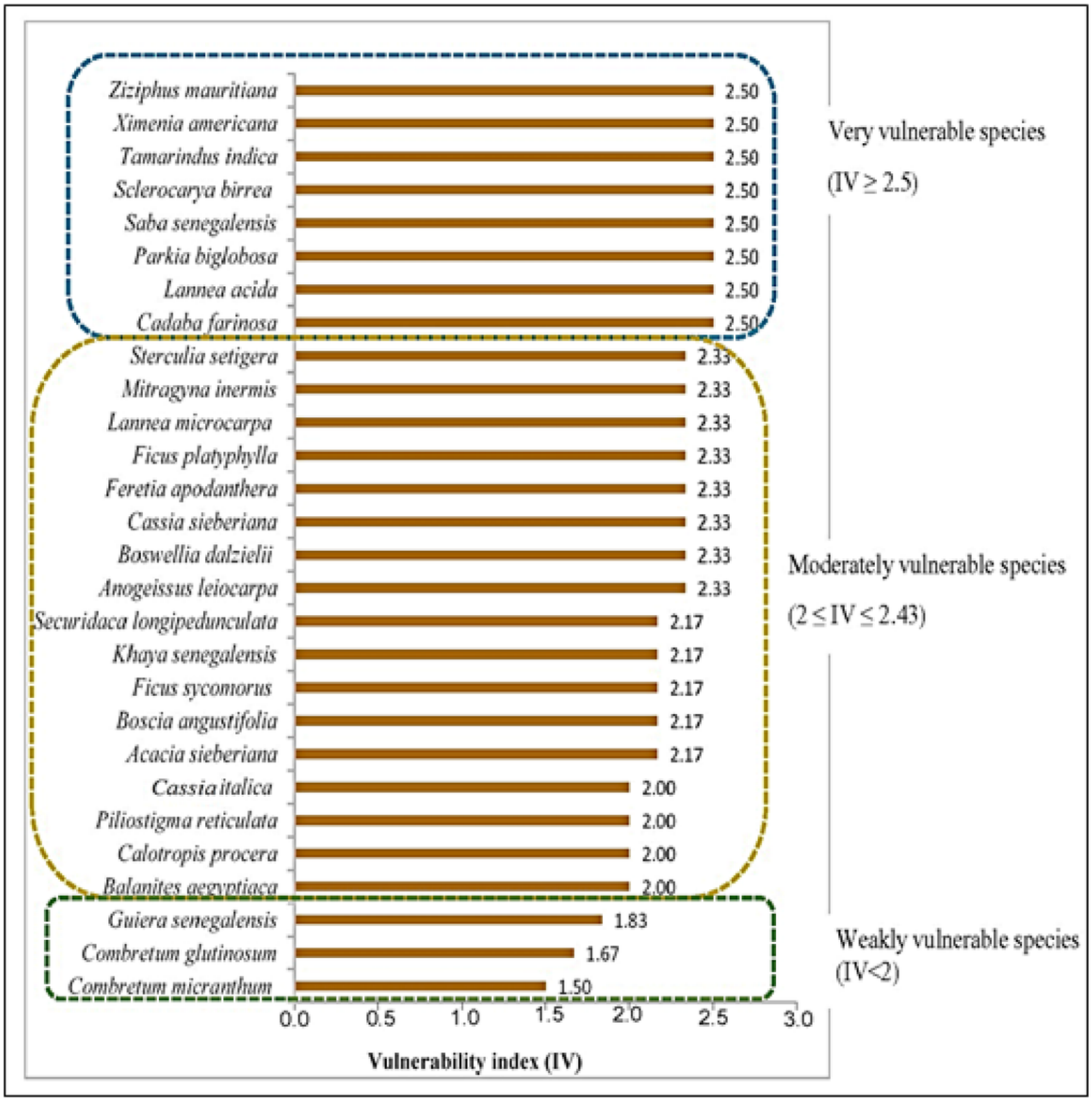

Figure 3

Weakly, moderately and highly vulnerable species in sub-sahelian area of Burkina Faso