

Diversity of non-timber forest products used in the food security of Sahelian households in south-central Maradi in Niger

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1 ABSTRACT

Food insecurity remains a persistent challenge in Niger, particularly in the Sahelian regions. Non-timber forest products (NTFPs) offer a potentially significant buffer, yet underexplored, source of food. This study, conducted in the North- and South-Sahelian zones of south-central Maradi region, aims to characterize the diversity of NTFPs by ecological zones and identify the land-use zones richest in edible species, with the goal of assessing their contribution to household food security. An ethnobotanical survey was carried out in 18 villages bordering different land-use areas. Data were collected from 379 households on socio-demographic characteristics, NTFP species identification, harvesting locations and methods, access, and specific uses. A total of 42 woody species from 20 families were identified, with Fabaceae being the most frequently harvested (30.95%), particularly in the South-Sahelian zone. Capparaceae (11.90%) and Combretaceae (7.10%) families followed, with *Maerua crassifolia* and *Guiera senegalensis* as dominant species, respectively. Fields were the primary source of NTFPs (61.48%), with fruits more commonly harvested in the south (84.57%) and leaves in the north (54.7%). Human consumption was the primary use, reported by 87.85% of northern and 81.09% of southern respondents. Gathering was the main collection method, with access largely unrestricted in both zones. This study provides critical insights into the spatial distribution and food security potential of NTFPs in Niger's Sahelian zones.

2 INTRODUCTION

Non-timber forest products (NTFPs) play a crucial role in the lives of local populations, particularly in rural areas. Indeed, they are used for human and animal nutrition, pharmacopoeia and the manufacture of agricultural tools and household utensils (Belem *et al.*, 2017; Lawali *et al.*, 2018; Ouédraogo *et al.*, 2020). In the Sahel, numerous studies have highlighted people's recourse to non-timber forest products as a food

security coping strategy during periods of hunger and famine. These studies, notably in Senegal (Guèye, 2019; Sall, 2020), Benin (Coadja, 2003), Côte d'Ivoire (Kouakou *et al.*, 2017), Burkina Faso (Ouédraogo *et al.*, 2013), and Niger (Larwanou *et al.*, 2012; Douma, 2016; Djibo, 2023), highlights their essential role as subsistence foods during periods of famine and drought, as well as a food supplement during

rainy seasons. In addition, these resources are widely used to treat various ailments at low cost (Larwanou *et al.*, 2010; Hama *et al.*, 2019), and their exploitation constitutes a significant source of income for rural populations, (Hill *et al.*, 2007, Dan Guimbo *et al.*, 2012 ; Ouédraogo *et al.*, 2013 and Laouali *et al.*, 2014). However, the various removals of NTFPs can have consequences for the state of natural stands of the species that provide them (Mounkaila *et al.*, 2017). Indeed, in the Maradi region, the combination of climatic and anthropogenic factors has led to a significant reduction in local biodiversity, notably through the gradual disappearance of certain plant and animal species. This dynamic is illustrated by the southward shift of isohyet, leading to a contraction in the range of several species in the northern zones (Ozer and Ozer, 2005). Knowing the diversity of NTFPs in a context of climate change and strong pressure on wood resources could lead to rational ecosystem

management in the Sahel and Niger in particular. In south-central Maradi region, in the face of ecological pressures threatening food security and livelihoods, the government and its partners, including the World Food Program (WFP) and its affiliated NGOs, have implemented strategic interventions. These aim to strengthen the resilience of local populations by promoting sustainable approaches to adaptation and natural resource management through site restoration and development. Although numerous scientific studies have inventoried the diversity of NTFPs in Niger (Saadou, 1998; Garba, 2000; Mahamadou, 2010; Halidou, 2016), few have analysed this diversity according to an agro-climatic gradient and land use, limiting effective resource management. This study aims to characterize the diversity of NTFPs exploited by vulnerable households in different ecological zones of the Sahelian zone.

3 MATERIALS AND METHODS

3.1 Study area: This study was carried out in two agro-climatic zones following a North-South rainfall gradient in the Maradi region, which is located in the south-central part of the Republic of Niger (figure 1), at around 13.5° north latitude and 7.1° east longitude (WAEN, 2020), namely the North-Sahelian zone and the South-Sahelian zone. The South-Sahelian zone is characterized by a semi-arid climate, with annual rainfall varying between 500 and 700 mm (Soumana, 2021). The vegetation is denser than in the northern Sahelian zone, with a wooded and shrubby savate with sandy-silty soils, with good water retention capacity (Katkoré *et al.*, 2021). 10 villages were selected in this zone, including: Guidan Dodo, Rouga Bodé, Guidan

Yaro, Oumarawa, Afaram, Guertaou, Boukouzawa Magaji, Rafa, Guidan Tanko and Saje Manja. The North-Sahelian zone is the driest part of the Maradi region, marking a transition from the Sahara. It has a semi-arid to arid climate, with annual rainfall of between 300 and 400 mm (Haweï, 2020). The vegetation is composed of shrub and tree steppe, with relatively sparse ground cover and the soils are predominantly sandy to loamy, with low water retention capacity (Katkoré *et al.*, 2021). The villages selected for this second study are Kamoun, Dargaza, Dan Jirgaou, May Guizawa, Oubandawaki, , Ourafan, Kankalérou, Magaria and Také-Také.

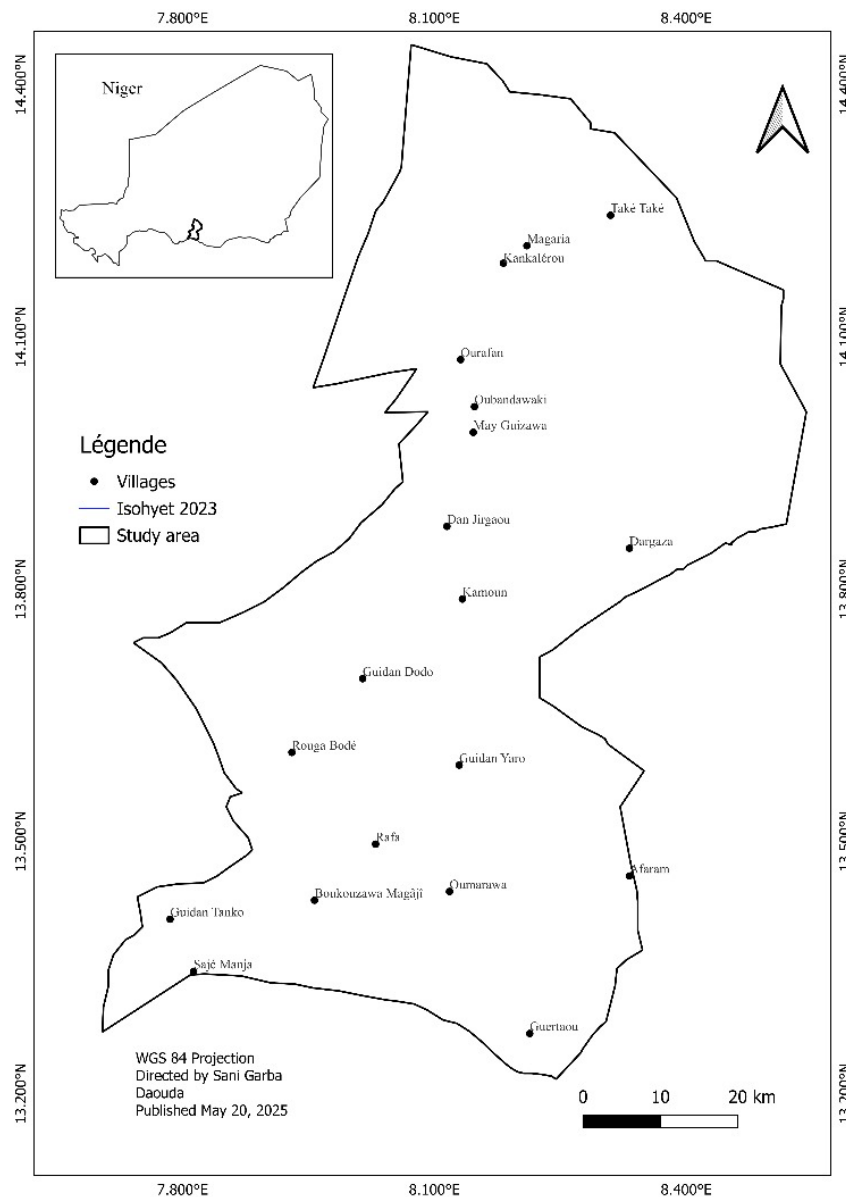


Figure 1: Location of study sites and villages in South-Central Niger

3.2 Sampling and data collection: A pre-survey was used to contact local stakeholders to obtain household data by Local area. A sample was then determined using Daniel's (2012) formula:

$$n = \frac{t^2 N}{t^2 + (2e)^2 (N - 1)}$$

Where: n = sample size; t = confidence level; N= parent population and with a 5% margin of error. Two-stage stratified sampling was adopted according to the ecological proximity of villages, which are NTFP exploitation and sociolinguistic

criteria. A total of 379 people were surveyed; all aged over 18 years. Ethnobotanical surveys were conducted using a questionnaire integrated into the KoBoCollect application (version 1.29.3). The data collected relate to respondents' socio-demographic characteristics, identification of NTFP-source woody species, harvesting sites, harvesting methods, access conditions and specific uses of each species.

3.3 Data analysis : The botanical names of NTFP-providing species were determined using the local plant names in the study area and the

book “Arbres et Arbustes du Sahel” (Trees and Shrubs of the Sahel). Preferences were determined by the frequency with which species were cited, using the open list method (Ambe, 2001). This is based on the principle that the most important species are those mentioned by

the greatest number of respondents (Issoufou *et al.*, 2025). The APG III classification (2009) was used to determine species families. Excel, STATA v14 and R studios software were used to calculate species citation frequencies and graphs respectively.

4 RESULTS

4.1 Socio-demographic characteristics of respondents: An analysis of the data shows that among the respondents, males dominate in both zones, with 64.09% in the north and 68.70% in the south, while females account for 35.91% in the north and 31.30% in the south. The 31-45 age group is the most represented (43.09%), followed by 46-60 (23.76%), 18-30 (17.68%) and over 60 (15.47%). In terms of marital status, married people are in the majority (90.87%),

both in the south and north (89.50%). Their main activity is farming, both in the north (93.92%) and south (91.96%). Among these respondents, illiterates are the most represented (41.44%) in the north, in contrast to the south, where those with primary education are the most represented (43.70%). Most respondents spoke Haoussa in the south (95.22%) and (80.11%) in the north of the study area (Table 1).

Table 1: Socio-demographic characteristics of respondents

Parameter	Proportion of the respondents (%)		
	North-Sahelian zone	South- Sahelian zone	Total
Age			
18-30	17.68	29.13	25.90
31-45	43.09	36.74	38.53
46-60	23.76	19.78	20.90
>60	15.47	14.35	14.66
Sex			
female	35.91	31.30	32.61
Male	64.09	68.70	67.39
Family size			
1-5 people	21.55	15.22	17.00
6-10 people	40.33	41.74	41.34
11-15 people	28.73	26.74	27.30
>15 people	9.39	16.30	14.35
Education (years of schooling)			
Koranic school	28.18	35.65	33.54
Illiteracy	41.44	3.26	14.04
Primary	19.79	43.70	18.41
Secondary	10.79	18.56	4.68
Higher	0.84	2.09	0.94
Main activity			
Farmer	93.92	91.96	92.51
Begging	3.87	5.22	1.09
Daily work	0.55	1.09	3.90
Animal husbandry	1.10	0.43	1.09

Official	0.55	1.30	0.47
Ethnicity			
Hausa	80.11	95.22	90.95
Fulani	12.71	1.30	4.52
Tuareg	7.18	2.17	3.59
Kanouri	-	1.30	0.94

4.2 Analysis of the diversity of woody species providing NTFPs by agro-climatic zone

: A total of 42 woody species from 20 botanical families were surveyed. The Fabaceae family is the most represented with 13 species (30.95%), with dominance in the South-Sahelian zone (19.16%) compared to the North-Sahelian

zone (11.79%). It is followed by the Capparaceae family with 5 species (11.90%), of which *Maerua crassifolia* (15.06%) is the most frequent in the north, and the Combretaceae family with 3 species (7.10%), dominated by *Guiera senegalensis* (7.53%). The other families have only two or one species.

**Table 2** Proportion of woody species providing non-timber forest products (NTFPs) by agro-climatic zone

APG Family	Scientific name	Names locals (Hausa)	Proportion of respondents (%)		
			North-Sahelian zone	South- Sahelian zone	Total
Anacardiaceae	<i>Lannea fruticosa</i> (Hochst. Ex A. Rich.) Engl.	Farou	11.72	12.20	12.06
	<i>Sclerocarya birrea</i>	<i>Dania ou Loula</i>	7.53	8.35	8.12
Apocynaceae	<i>Leptadenia hastata</i> (Pers.) Decne.	<i>Yadia</i>	-	0.16	0.12
Arecaceae	<i>Hyphaene thebaica</i> (L.) Mart	<i>Gorouba</i>	0.42	7.70	5.68
Bignoniaceae	<i>Stereospermum kunthianum</i> Cham.	<i>Sansami</i>	-	0.32	0.23
Burseraceae	<i>Boswellia dalzielii</i> Hutch.	<i>Hano</i>	-	0.16	0.12
	<i>Commiphora africana</i> (Lour.) Dandy	<i>Dasbi</i>	0.42	0.16	0.23
Capparaceae	<i>Boscia angustifolia</i>	<i>Dilo</i>	0.42		0.12
	<i>Boscia salicifolia</i> Oliv.	Zuré	0.84	0.64	0.70
	<i>Boscia senegalensis</i> (Pers.) Lam. ex Poir.	<i>Anza</i>	0.84	0.16	0.35
	<i>Maerua angolensis</i> DC.	Cicciwa	-	0.16	0.12
	<i>Maerua crassifolia</i> Forsk.	<i>Jiga</i>	15.06	3.85	6.96

Table 2(Following): Proportion of woody species providing non-timber forest products (NTFPs) by agro-climatic zone

Combretaceae	<i>Anogeissus leiocarpus</i> (DC) Guill. Et Perr.	Marké	0.42	0.96	0.81
	<i>Combretum ghasalense</i>	<i>Tsiri</i>	-	0.32	0.23
	<i>Guiera senegalensis</i> J.F. Gmel.	<i>Sabara</i>	7.53	0.64	2.55
Ebenaceae	<i>Diospyros mespiliformis</i> Hochst. Ex A.DC.	<i>Kania</i>	2.09	11.72	9.05
Euphorbiaceae	<i>Euphorbia balsamifera</i> Ait.	<i>Aguma</i>	0.84	0.32	0.46
Fabaceae	<i>Acacia raddiana</i>	<i>Kandili</i>	0.84	0.96	0.93
	<i>Acacia seyal</i> Del.	Fara-‘k’aya	0.84	0.32	0.46
	<i>Acacia sieberiana</i> DC.	Fara bagaruwa	,	0.64	0.46
	<i>Albizia chevalieri</i> Harms	<i>Kassari</i>	,	0.80	0.58
	<i>Bauhinia rufescens</i> Lam.	<i>Dirya</i>	1.26	0.96	1.04



	<i>Dichrostachys cinerea</i> (L.) Wight et Arn.	Dundu	-	0.32	0.23
	<i>Faidherbia albida</i> Del	Gao	5.02	7.70	6.96
	<i>Parkia biglobosa</i> (Jacq.) R. Br. Ex G. Don	Dorowa	-	0.16	0.12
	<i>Piliostigma reticulatum</i> (DC.) Hochst	Kalgo	8.37	6.90	7.31
	<i>Prosopis africana</i> (Guill. et Perr.) Taub.	Kiria	-	1.44	1.04
	<i>Senegalia senegal</i>	Dakwara	0.84	0.48	0.58
	<i>Tamarindus indica</i> L.	Tsamia	3.77	3.05	3.25
	<i>Vachellia nilotica</i>	Bagaroua	5.86	4.01	4.52
Lamiaceae	<i>Vitex doniana</i> sweet.	Dumnia	-	3.05	2.20

Table 2(Following): Proportion of woody species providing non-timber forest products (NTFPs) by agro-climatic zone

Malvaceae	<i>Adansonia digitata</i> L.	Kouka	7.11	2.09	3.48
Meliaceae	<i>Azadirachta indica</i> A. Juss.	Bedi	2.51	2.09	2.20
	<i>Khaya senegalensis</i> (Desr.) Juss.	Madaci	-	0.16	0.12
Moraceae	<i>Ficus platyphylla</i> Del.	Gamji	-	0.64	0.46
Moringaceae	<i>Moringa oleifera</i> Lam.	Zogala ou El makka	5.44	3.21	3.83
Rhamnaceae	<i>Ziziphus mauritiana</i> Lam.	Magaria	5.44	3.85	4.29
	<i>Ziziphus spina-christi</i> (L.) Desf.	Kourna	-	3.69	2.67
Rosaceae	<i>Neocarya macrophylla</i> (Sabine) Prance	Gawassa	-	0.32	0.23
Rubiaceae	<i>Mitragyna inermis</i> (Willd.) Kuntze.	Guiyeya	0.42	0.64	0.58
Sapotaceae	<i>Vitellaria paradoxa</i> gaertn. Syn.	Kadé	-	0.32	0.23
Zygophyllaceae	<i>Balanites aegyptiaca</i> (L.) Delille.	Adona	4.18	4.33	4.29
Total			100.00	100.00	100.00

- : Species absent

4.3 Proportion of the ten woody species by agro-climatic zone:

The ten species with the highest citation frequencies in the North-Saharan zone (Table 3) are respectively *M. crassifolia* (15.05%), *L. fruticosa* (11.72%), *P. reticulatum* (8.37%), *G. senegalensis* (7.53%), *S. birrea* (7.53%), *V. nilotica* (5.86%), *Z. mauritiana* (5.44%), *M. oleifera* (5.44%), *F. albida* (5.02%) and *B. aegyptiaca* (4.18%). In the South-Saharan zone, these are respectively: *L. fruticosa* (12.20%), *D. mespiliformis* (11.72%), *S. birrea* (8.35%), *F.*

albida (7.70%), *H. thebaica* (7.70%), *P. reticulatum* (6.90%), *B. aegyptiaca* (4.33%), *V. nilotica* (4.01%), *M. crassifolia* (3.85%) and *Z. mauritiana* (4.18%). Nevertheless, we note that some species have identical frequencies in both zones (*L. fruticosa* (11.72%) in the north and *D. mespiliformis* (11.72%) in the south). In addition, each zone has two species specific to it (*G. senegalensis* and *M. oleifera* in the north) and (*D. mespiliformis* and *H. thebaica* in the south).

Table 3: Proportion of the top ten (10) species by agro-climatic zone

North Sahelian Zone		South Sahelian Zone	
Scientific name	Citation frequency (%)	Scientific name	Citation frequency (%)
<i>Maerua crassifolia</i>	15.05	<i>Lannea fruticosa</i>	12.20
<i>Lannea fruticosa</i>	11.72	<i>Diospyros mespiliformis</i>	11.72
<i>Piliostigma reticulatum</i>	8.37	<i>Sclerocarya birrea</i>	8.35
<i>Guiera senegalensis</i>	7.53	<i>Faidherbia albida</i>	7.70
<i>Sclerocarya birrea</i>	7.53	<i>Hyphaene thebaica</i>	7.70
<i>Vachellia nilotica</i>	5.86	<i>Piliostigma reticulatum</i>	6.9
<i>Ziziphus mauritiana</i>	5.44	<i>Balanites aegyptiaca</i>	4.33
<i>Moringa oleifera</i>	5.44	<i>Vachellia nilotica</i>	4.01
<i>Faidherbia albida</i>	5.02	<i>Maerua crassifolia</i>	3.85
<i>Balanites aegyptiaca</i>	4.18	<i>Ziziphus mauritiana</i>	3.85

4.4 Influence of ethnic groups on the exploitation of plant resources by agro-climatic zones: The Sankey diagram (Figure 2) illustrates the links between ethnic groups (left) and plant species exploited (right). Each flow represents the number of times a species has been cited or used by a given group. thus observe a greater flow from the Haoussa ethnic group than from other ethnic groups.

Furthermore, certain species, such as *D. mespiliformis*, *L. fruticosa*, *M. oleifera*, *S. birrea* and *F. albida*, are shared by the Haoussa, Peul and Touareg, both to the north and south. The Haoussa are more interested in *L. fruticosa*, *D. mespiliformis* and *V. nilotica*, while the Peul are more interested in species such as *F. albida*, *Z. mauritiana* and *M. crassifolia*.

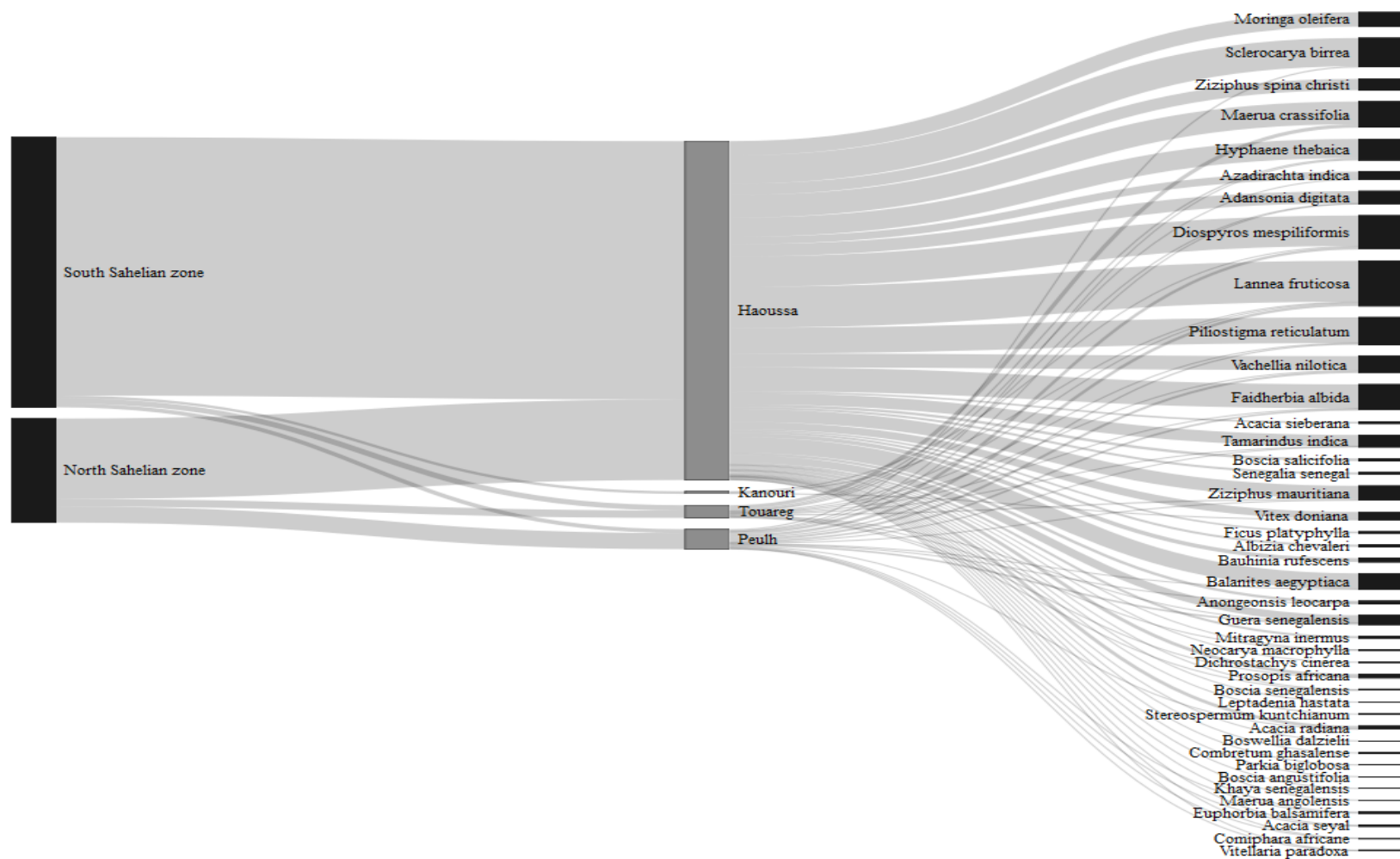


Figure 2: Sankey diagram on the exploitation of species according to ethnic groups by agro-climatic zone

4.5 Locations of collection of NTFPs by agro-climatic zone: flow and distribution of species: The Sankey diagram illustrates the distribution of NTFP harvesting sites according to agro-climatic zones (Figure 3), as well as the plant species associated with each of these zones. The main harvesting sites identified are fields, fallows, grazing areas, passage corridors, land reclamation sites and the rocky cordon. The analysis reveals that there are no flows between the northern zone and the rocky ridge. On the other hand, in each zone, most respondents harvest from fields, followed by reclaimed sites,

then field/fallow or field/ropebank combinations. However, other areas, such as grazing areas and passage corridors, are also significant sources of harvesting. It can also be observed that the thickest flows, indicating a higher frequency of harvesting, are mainly located in the southern zone rather than in the north. In addition, certain species, such as *S. birrea* and *D. mespiliiformis*, are present in several NTFP harvesting land-use types. However, *M. oleifera* and *N. macrophylla* show a more specific distribution, being found respectively only on reclaimed sites and in the rocky cordon.

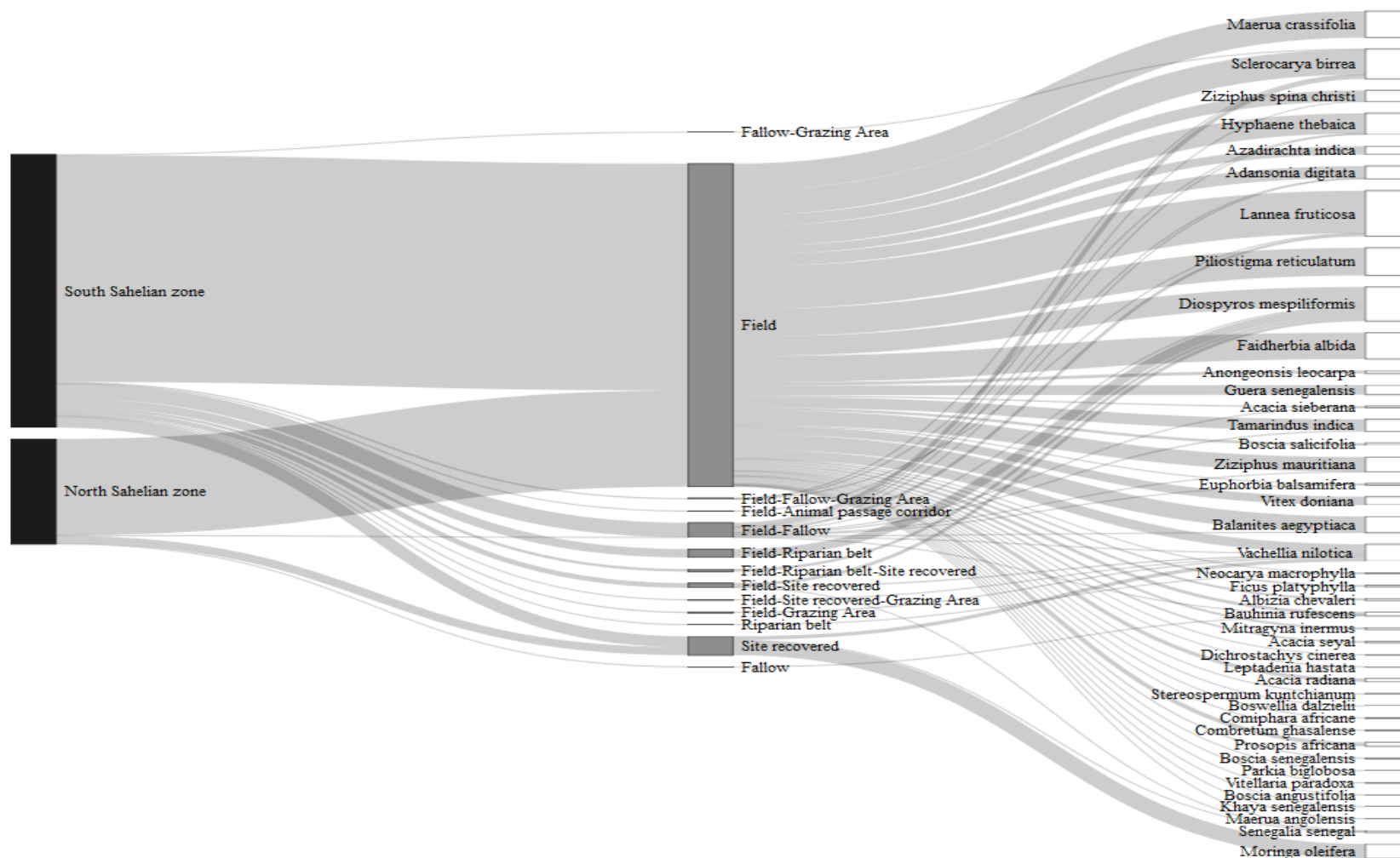


Figure 3: Sankey diagram: NTFP sampling sites

4.6 Diversity of NTFPs by agro-climatic zone: The figure (4) shows that, in the South-Sahelian zone, the most widely used NTFPs are mainly fruits (84.57%), followed respectively by leaves (28.91%), bark (9.57%), roots (1.52%) and flowers (0.87%). A similar trend is observed in the North-Sahelian zone, with the following

proportions: fruits (59.12%), leaves (54.70%), barks (5.52%), roots (1.66%) and flowers (1.66%). However, there is a marked difference in the use of fruits and leaves between the two zones: fruits are harvested more in the south than in the north, while the use of leaves is greater in the North-Sahelian zone.

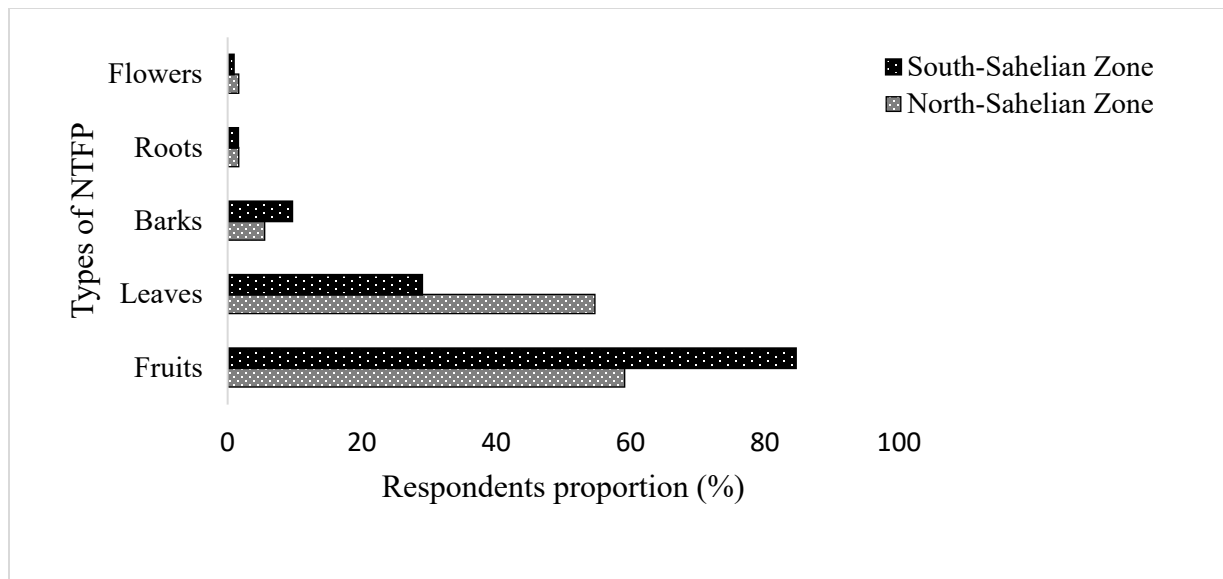


Figure 4: Typology of NTFPs by agro-climatic zone

4.7 Typology of NTFP use by agro-climatic zone: The figure 5 shows that respondents in both zones make similar use of NTFPs. However, certain differences in intensity of use are observed between north and south. Respondents in the North-Sahelian zone

use NTFPs more for food (87.85%) and construction (3.87%). In contrast, respondents in the southern zone use NTFPs more for pharmacopocia (8.7%) and as animal feed (21.52%).

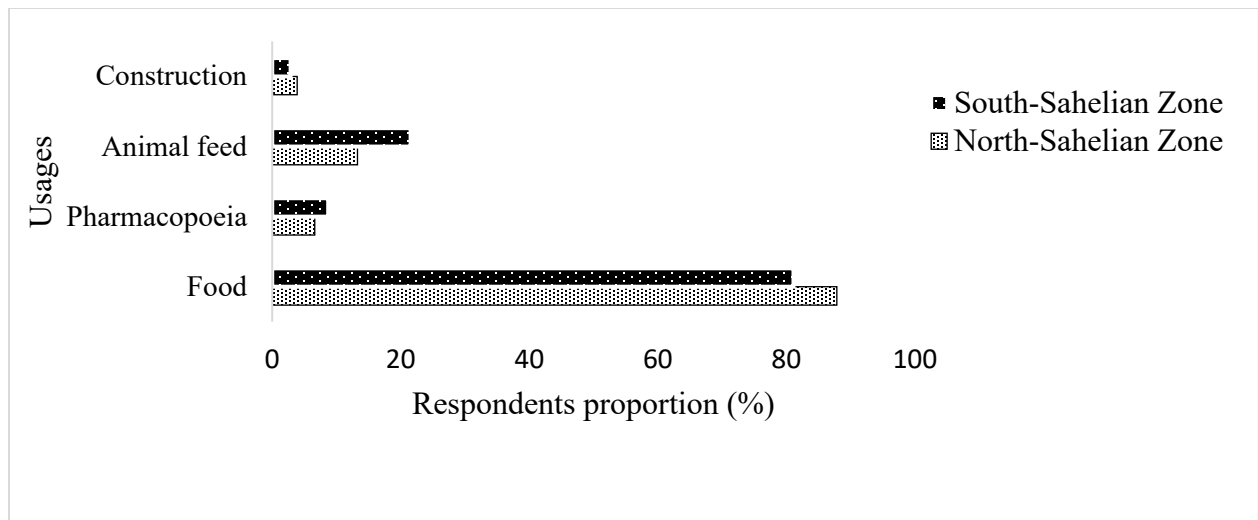


Figure 5: Typology of use of NTFPs

4.8 Access method to NTFPs: In the North-Sahelian zone, NTFP access modes, in order of importance, are: free access (67.4%), inheritance (26.52%), purchase (19.89%), permission (19.34%) and donation (9.39%)

(Figure 5). In the South-Sahelian zone, the percentages are slightly lower, with free access accounting for 65.87%, followed by inheritance (18.04%), purchase (12.39%), permission (12.39%) and donation (3.7%).

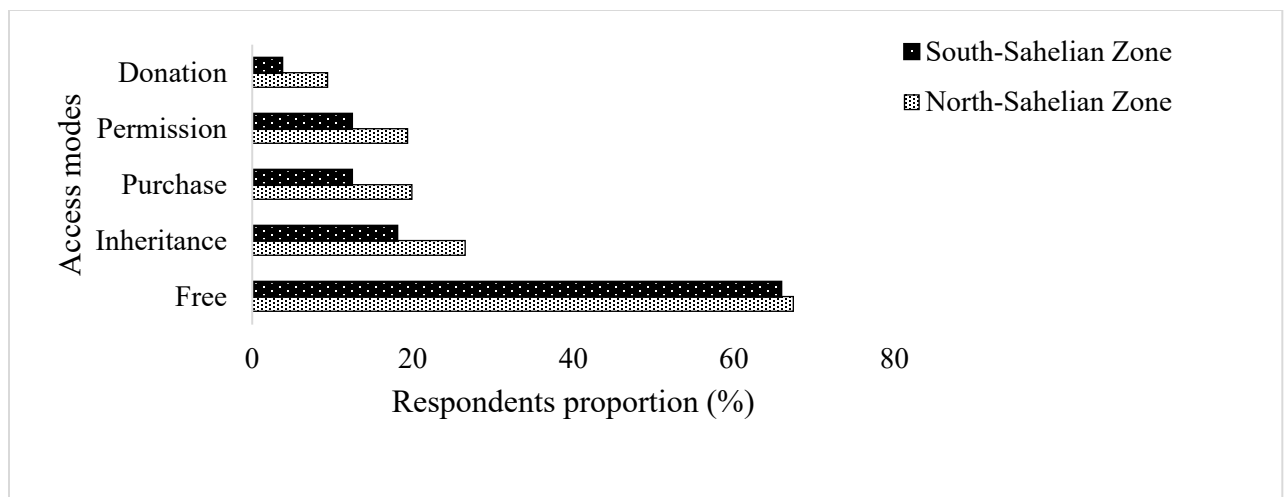


Figure 6: Mode of access to NTFPs

4.9 Methods of collecting NTFPs by agro-climatic zone: The figure (7) shows that NTFP harvesting methods are identical in both zones (North-Sahelian and South-Sahelian), although their frequency of application varies slightly. In the North-Sahelian zone, the most commonly used methods are picking (93.92%),

followed by collecting (8.29%), then in order of dominance, stump removal (7.18%), debarking (5.52%) and cutting (2.21%). In the South-Sahelian zone, NTFP gathering is even more dominant (98.04%), followed by debarking (9.13%), stump removal (7.17%), collection (5.65%) and cutting (0.65%).

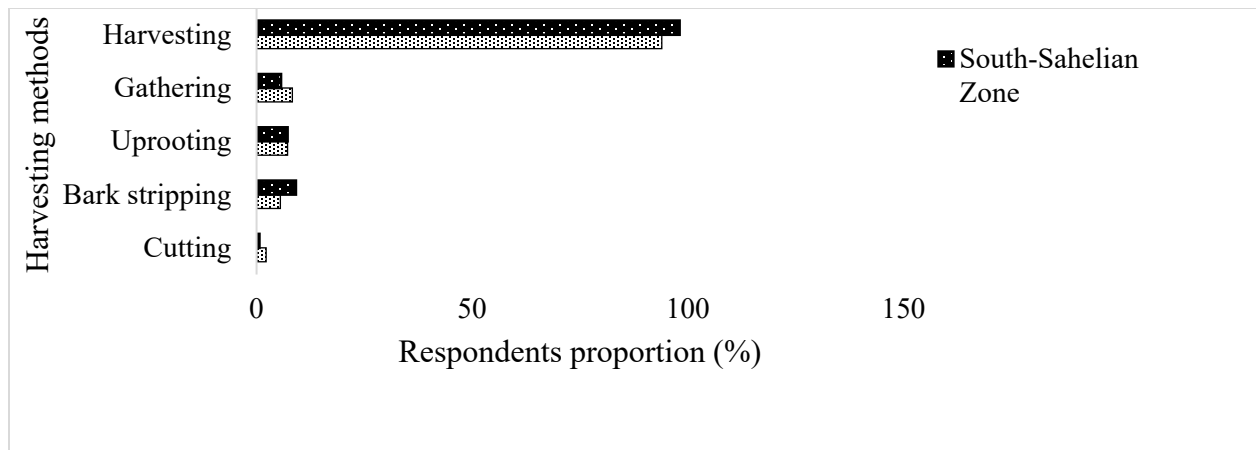


Figure 7: Methods of collecting NTFPs

5 DISCUSSION

5.1 Socio-demographic characteristics of respondents: Most respondents interested in NTFPs are married men whose main activity is farming. These respondents are a low literate population in the north, whereas in the south, they have a primary school education and are of Haoussa ethnicity. This situation can be explained by the fact that there are more men than women, and that there are more male heads of household (78%) than women (22%) in Niger (INS, 2023). But the responsibility for the household also falls on adults, who are more involved in farming activities and the sale of timber and non-timber forest products to earn income from their younger years, instead of going to school. These results are similar to those obtained by Issoufou *et al.* (2025) who reported that men are more involved in the collection and sale of NTFPs because of the physical effort involved. The majority of respondents speak Hausa, as this is a Hausa-dominated region (83%) (INS, year, 2023). Furthermore, large households (>15 people) are more common in the South-Saharan zone. This was mentioned by the FAO (2011), which noted that a higher household population can influence non-timber forest product (NTFP) harvesting strategies, as it offers both an abundant labor force and increased needs for food and financial resources.

5.2 Analysis of the diversity of woody species providing NTFPs by agro-climatic

zone : A total of 42 woody species are exploited in the study area. This diversity is lower than that found respectively by Halidou (2016) and Hama *et al.* (2019), with 50 and 66 species recorded respectively. This difference is because this study excludes herbaceous plants. The South-Saharan zone shows greater woody diversity than the North-Saharan zone, which can be explained by the degree of influence of anthropogenic activities, the effects of climate change and rainfall, which are more threatening in the north than in the south (Manzo *et al.*, 2017). These results confirm those of Koechlin (1989); Mahamane (2009) and Alhassane (2017), who pointed out that specific diversity decreases with the south-north climatic gradient.

5.3 Frequency of citation of the ten woody species by agro-climatic zone: The results show a high frequency of citations for the species *L. fruticosa* throughout the study area, which may be linked to its availability in the transition zone and its food value. Dan Guimbo *et al* (2012) noted that availability and high food contribution are key criteria for food species preference. The similar frequencies of *S. birrea*, *F. albida*, *P. reticulatum*, *B. aegyptiaca* and *Z. mauritiana* in both zones suggest a wide ecological distribution and socio-economic importance of these species (reference). The presence of *M. oleifera* in the fields of the South-Saharan zone is the result of interventions by the World Food Programme (WFP) and its partners,

but its presence in the North-Sahelian zone could indicate less dietary diversity and the population's quest for species rich in NTFPs. *D. mespiliformis* and *H. thebaica*, as well as *M. crassifolia* and *G. senegalensis*, seem to have adapted to local conditions. Indeed, our observations at the Tessaoua market reveal the sale of *P. reticulatum*, *F. albida* and *V. nilotica* pods in local units, underlining their economic importance.

5.4 Influence of ethnic groups on the exploitation of plant resources by agro-climatic zones: The Haoussas' greater involvement in NTFP exploitation is explained by their local dominance, their trading tradition and the availability of species in both zones. The common species exploited reflect their socio-economic and ecological importance, as well as their adaptation to agro-climatic conditions. The Fulani prefer species useful for pastoralism, while the Tuareg select specific plants, reflecting a specialized ethnobotany. These results confirm that species preference is primarily cultural before economic (Issoufou *et al.*, 2025).

5.5 Locations NTFP Diversity and Harvesting Practices across Agro-Climatic Zones: The absence of the rocky cordon in the North-Sahelian zone could be due to ecological constraints (Moussa *et al.*, 2015; Zounon *et al.*, 2019 and Rahamane, 2023). Woody species are diverse along the north-south agroecological gradient, and geographical factors influence species distribution (Salako *et al.*, 2018). The exploitation of NTFPs in the field aligns with studies by Zounon (2022), which highlight the importance of agricultural fields for NTFP collection. Easy access and controlled management favor the conservation of certain strains (Djoudi and Brockhaus, 2011). Harvesting on recovered sites confirms that assisted natural regeneration stimulates the growth of NTFP species (Lykke *et al.*, 2004). Ecosystem resilience facilitates the establishment of new species after land abandonment (Riedlinger and Berkes, 2001). Schreckenber *et al.* (2006) consider that this strategy limits the pressure on a single ecosystem. Finally, transhumance grazing regenerates and disperses seeds (Hiernaux *et al.*,

2009), while certain areas remain essential for forage NTFPs (Ayantunde *et al.*, 2011).

5.6 Diversity of NTFPs by agro-climatic zone: The difference in fruit and leaf use between the northern and southern zones can be explained by ecological, climatic and socio-economic factors. Fruits are the most widely used (59.10%), followed by leaves (18.93%) (Issoufou *et al.*, 2025). The abundance of fruit in the south reflects the high fruit diversity in Sudanian zones (Boffa, 1999). In contrast, the use of leaves in the North Sahelian zone reflects adaptation to arid conditions (Hiernaux *et al.*, 2009). In Sahelian pastoral systems, leaves are essential during the lean season (Ayantunde *et al.*, 2011), encouraging the preservation of evergreen species (Abasse *et al.*, 2023).

5.7 Diversity of uses of NTFPs by agro-climatic zone: Our results show a higher level of use of non-timber forest products (NTFPs) for food purposes in the North Sahelian zone (87.85%) compared to the South Sahelian zone (81.09%), reflecting a greater dependence on local natural resources due to environmental constraints. These results are consistent with those of Haule (2022), who highlighted that local communities in semi-arid areas of Tanzania rely heavily on NTFPs to improve their food security, particularly due to their vulnerability to climate-sensitive rain-fed agriculture. NTFPs play a key role in arid zones, where they constitute a survival strategy in the event of food shortages (Haule, 2022). The use of NTFPs for construction is higher in the north (3.87%) than in the south (2.83%), due to the scarcity of conventional materials (Hiernaux *et al.*, 2009). The medicinal use of NTFPs is more widespread in the south (8.7%) than in the north (6.63%), linked to greater plant diversity and the transmission of ethnobotanical knowledge (Abasse *et al.*, 2023). Finally, the use of NTFPs as fodder is higher in the south (21.52%), favoured by agroforestry.

5.8 Mode of access to NTFPs by agro-climatic zone: Open access dominates in both zones (67.4% in the north and 65.87% in the south), confirming that NTFPs are often common goods in Africa (Lykke *et al.*, 2004).

However, free access to NTFPs encourages over-exploitation (Tchatat and Ndoeye, 2006). Some species (*T. indica*, *H. thebaica*, *A. digitata* and *M. oleifera*) are exploited solely by landowners, as observed for *A. digitata* on the outskirts of Parc W (Dan Guimbo, 2012). Inheritance is a frequent mode of access to NTFPs, higher in the north (26.52%) than in the south (18.04%), linked to customary land tenure (Djoudi and Brockhaus, 2011). Purchase is more common in the north (19.89%) than in the south (12.39%), favored by the scarcity of resources (Larwanou *et al.*, 2006). Access by authorization of the holder follows a similar logic, and is more common in the north (19.34%) than in the south (12.39%). Finally, access by donation is more common in the north (9.39%) than in the south (3.7%), reflecting social redistribution during the lean season (Hiernaux *et al.*, 2009).

5.9 Methods of collecting NTFPs by agro-climatic zone: The uniformity of NTFP

harvesting methods between zones, with varying frequencies, reflects practices adapted to local conditions (Boffa, 1999). Gathering is more common in the south (98.04%) than in the north (93.92%), favoured by harvesting without felling (Boffa, 1999). Harvesting preserves wood resources (Abasse *et al.*, 2023). Debarking is higher in the south (9.13%) than in the north (5.52%), in line with the medicinal use of bark (Schmelzer and Gurib-Fakim, 2008). Stump removal is similar in both zones (7.18% in the north vs. 7.17% in the south), indicating a balanced exploitation of the roots. Collecting is widespread in both zones (8.29% in the north and 5.65% in the south) minimizing the ecological impact (Lykke *et al.*, 2004). Cutting is more frequent in the north (2.21%), reflecting dependence on NTFPs for wood (Larwanou *et al.*, 2006). The low level of logging in the south reflects awareness of sustainable management (Abasse *et al.*, 2023).

6 CONCLUSION

This study identified a diversity of woody species that are sources of NTFPs in two agro-climatic zones of the Maradi region. NTFPs from these woody species are mainly harvested in the fields for all study sites. They are more widely used for human consumption, with a high proportion of fruits in the south and leaves in the north. Furthermore, it should be noted that the different types of NTFPs, their modes of access and collection, as well as their uses, are influenced by regional climatic conditions, the transmission of traditional knowledge about the plants and the cultural uses associated with each ethnic group. Thus, an integrated and participatory approach, considering the ecological, socio-economic and cultural specificities of the territories, appears to be a promising way of guaranteeing the sustainable management of NTFPs and strengthening their contribution to the well-being of populations. So, to ensure the sustainable use and

management of non-timber forest products (NTFPs), it is recommended to develop or update local rules such as community conventions that regulate resource access and harvesting practices. Capacity building should be provided to local actors, including collectors, processors, and traders, with a focus on sustainable harvesting techniques like avoiding tree cutting and promoting partial collection. Establishing community nurseries can support the regeneration of local species, while promoting local value-added processing (such as oils, soaps, or syrups) will enhance economic benefits for communities. Moreover, a participatory monitoring system should be implemented to regularly assess resource conditions and usage trends. Finally, fostering partnerships among NGOs, forestry services, and development projects will help reinforce collaborative and integrated resource management strategies.

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