Diversity of ethnomedicinal plants and traditional knowledge in Lagawa district, West Kordofan State, Sudan

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Research

Abstract

Background: In Sudan, traditional medicinal plants play a critical role in healthcare, particularly in remote rural areas. This study explores the traditional medicinal plant knowledge, usage, and demographic factors influencing ethnobotanical practices in Lagawa district, West Kordofan State, Sudan.

Methods: Data was gathered from 120 female and male informants, comprising 75% non-healers and 25% healers aged 20 to 79 years, using semi-structured questionnaires and group discussions. Quantitative analyses included use value (UV), informant consensus factor (ICF), fidelity level (FL), and Jaccard index (JI).

Results: A total of 61 medicinal plant species from 27 families were documented, with Fabaceae being the most represented family. Trees were the dominant growth form, followed by shrubs. Fruits were associated with the highest number of medicinal species and ailments. Jaundice and diabetes were the most frequently treated ailments. Maceration was the primary preparation method, and oral administration was the most common route. Among the documented species, *Adansonia digitata* had the highest use value. Demographic factors significantly influenced traditional medicinal knowledge, which was predominantly transmitted through inheritance.

Conclusion: The study sites are rich in traditional ethnomedicinal plants and associated knowledge. However, this cultural heritage and its biological resources face threats and require urgent conservation through systematic documentation and resource protection.

Keywords: Taxonomy, Ethnobotany, Traditional medicine, West Kordofan State, Sudan

Background

Since prehistoric times, indigenous communities worldwide have relied on wild plants as a primary source of traditional medicine to cure various ailments (Asif *et al.* 2021). This local medicinal knowledge is dynamic, shaped by historical, social, and environmental factors. The consolidation of ancient and indigenous cultures, the process of trial-and-error learning, and the accessible diverse vegetation resources has significantly enriched and evolved the ethnomedicinal knowledge. According to the World Health Organization (WHO 2023), traditional medicine, often referred to as folk or indigenous medicine, is defined as "the sum of the knowledge, skills, and practices based on the theories, beliefs, and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health and the prevention, diagnosis, improvement, or treatment of physical and mental illness."

In developing countries, plants play a crucial role in providing medicinal resources, reflecting their sociocultural, and spiritual importance (Senthilkumar *et al.* 2013, Tugume *et al.* 2016). The practices of harvesting, processing, and applying medicinal plant remedies are deeply rooted in tradition and have been passed down through generations. This intergenerational transfer of indigenous knowledge has contributed significantly to its conservation and improvement over time (Musa *et al.* 2011). Traditional medicine is not only affordable and locally accessible but also culturally accepted within these communities (Dossou *et al.* 2021, Semwal *et al.* 2021). Despite advancements in modern medicine, traditional medicine remains indispensable, particularly in remote rural areas where modern medical facilities are inaccessible and expensive. Additionally, mistrust of Western medicine further restrict access to formal healthcare services and necessitate reliance on traditional practices (Rahmatullah *et al.* 2009, Salih & Ali 2014).

Studies indicate that approximately 80% of the population in developing nations depends on traditional medicine, mainly derived from plants, for their primary healthcare needs (Eisawi *et al.* 2022, Hosseini *et al.* 2021, Hussain *et al.* 2020). Traditional medicine is also gaining traction among urban populations in both developing countries and immigrant communities in developed nations, often driven by spiritual and cultural motivations rather than poverty or limited healthcare options (van Andel & Carvalheiro 2013). Several traditional herbal medicines have been recognized as valuable sources of bioactive compounds, contributing to the development of modern pharmaceuticals (Hosseini *et al.* 2021). However, the wealth of traditional knowledge is under threat due to its predominantly oral transmission and poor documentation (Dutta *et al.* 2024, Mahwasane *et al.* 2013). Rapid sociocultural changes, driven by modernization and Western influences, have further undermined traditional values, particularly among younger generations (Musa *et al.* 2011). In Sudan, a country rich in both flora and cultural diversity, the documentation of traditional medicinal plant knowledge remains limited (Issa *et al.* 2018). This knowledge is particularly vital given the recurring challenges of armed conflict, widespread poverty, and the remoteness of healthcare services. Documenting such knowledge is crucial to preserving it and making it accessible to broader potential beneficiaries currently and in the future. In West Kordofan State, though rich in indigenous flora, little research has been conducted on the traditional use of medicinal plants. This study, therefore, aims to explore and document the diversity of medicinal plants and the associated ethnobotanical knowledge in the Lagawa district of West Kordofan State, Sudan. Additionally, the study investigates the influence of demographic factors, such as gender, age, education, and profession, on the retention and application of local medicinal knowledge.

Materials and Methods

Description of the study Sites

The study was conducted in three villages, Tabaldico (11.426027° N, 29.051270° E), Meiheila (11.329915° N, 29.085170° E), and Kangaro (11.282707° N, 29.281857° E), located in Lagawa district of southeastern West Kordofan State, Sudan (Figure 1). The district is characterized by a semi-arid climate, with temperatures ranging from 25°C in winter to 42°C in summer. Annual rainfall varies from 400 mm in the northern part to 800 mm in the southern part. The soil composition in the region includes light sandy soil in the northern areas, fertile clay soil in the south, and sandy clay in the transitional zone between these two soil types. This diversity in soil types supports a wide range of vegetation and contributes to the region's rich biodiversity of animal and plant species.

Economic activities in Lagawa district primarily revolve around traditional practices. Shifting agriculture, for both self-sufficiency and production of cash crops, is widely practiced. Pastoralism is also a dominant activity, reflecting the reliance of the local population on livestock and agriculture for their livelihoods (Hamad *et al.* 2024).

Data collection

A total of 120 informants were selected for this study, comprising 30 non-healers and 10 healers from each of the three selected villages. Among the non-healers, equal representation of gender and age groups was ensured by including five females and five males from each of the three age categories 20-39, 40-59, and 60-79 years. This stratified sampling approach was employed to capture diverse perspectives across age, and gender.

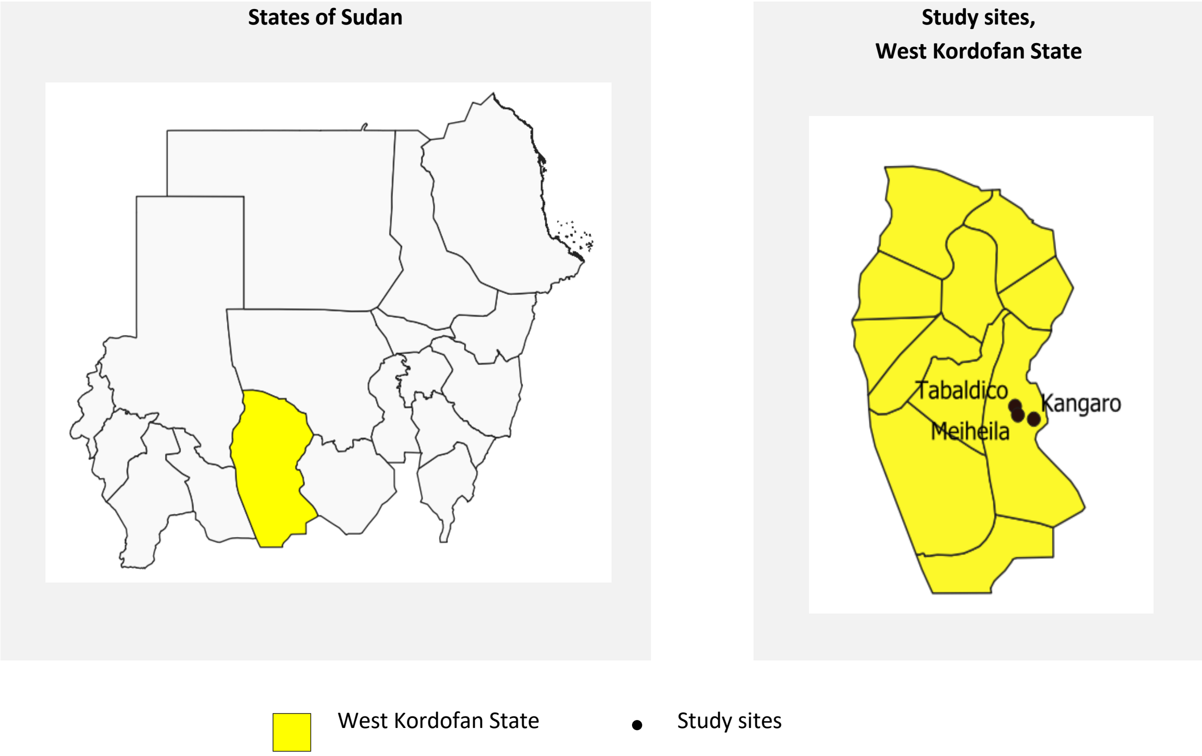

Figure 1. Map of Sudan showing states, West Kordofan districts and study sites.

The primary data on medicinal plants was collected through semi-structured questionnaires and focus group discussions. The information gathered included local names of the plants, growth habits, and therapeutic details such as ailments treated, plant parts used, modes of preparation, application methods, and routes of remedy administration. Additionally, the questionnaire incorporated personal demographic data, including the informants' name, age, gender, educational level, and occupation.

Ethical considerations

Prior to fieldwork, the study team contacted the heads of villages, Agriculture Office, and local administrators in the district to gain permission and explain the purpose of the research. An official correspondence from the Forestry and Gum Arabic Research Centre, Agricultural Research Corporation, Sudan was handed to the different concerned authorities.

The study adhered to the ethical guidelines of the International Society of Ethnobiology (ISE 2006). All participants were informed that the study was conducted for academic purposes, and verbal or written consent was obtained before initiating interviews. The villages' cultural norms and tradition were adhered to maintain modesty, respect, and cultural propriety.

Plant specimen collection

Field surveys were conducted with the assistance of key informants to confirm the diversity and abundance of medicinal plants within the study sites. During these walks, specimens of medicinal plants were collected, and their vernacular names, as provided by the informants, were recorded. To determine the botanical species and families of the collected plants, taxonomic keys from authoritative Sudanese floras (Andrews 1952, Andrews 1956, El Amin 1990) were consulted. The nomenclature was subsequently verified and updated in accordance with the latest taxonomic frameworks and references, including the Angiosperm Phylogeny Group (2016), Darbyshire *et al.* (2015), and Cole *et al.* (2017).

Data analysis

Jaccard Index (JI): The JI was used to measure the similarity of medicinal plant species between different localities using the formula: JI (%) =C×100/ (A+B−C) where A represents the total number of medicinal plant species in the study area, B is the total number of medicinal species in a comparison area, and C is the number of shared species between the two areas (González-Tejero *et al*. 2008).

The quantitative analyse of the relative importance of medicinal plants, preferred medicinal plants, and consistency of informants' responses were assessed using the following indices:

Use Value (UV) Index: The UV index was utilized to assess the relative importance of medicinal plants. The UV was calculated according to the formula: UV=ΣUR/N where ΣUR is the total number of use reports for a specific plant mentioned by informants, and N is the total number of informants (Phillips *et al.* 1994).

Fidelity Level (FL) Index: The FL index was calculated to identify the most preferred medicinal plants for treating specific ailments. The FL was calculated following the formula: FL (%) = IpIu×100 where Ip is the number of use reports for a species to treat a particular ailment, and Iu is the total number of use reports for that species across all ailments (Friedman *et al.* 1986).

Informant Consensus Factor (ICF): The ICF was applied to evaluate the consistency and homogeneity of the informants' responses. It was calculated using the formula: ICF=(Nur−Nt)/Nur−1 where Nur is the total number of use reports for each ailment category, and Nt is the number of species used for that category. The ICF value ranges from 0 to 1, with higher values indicating stronger consensus among informants (Trotter & Logan 1986).

Results and Discussion

Demographic variables and their effects on traditional medicinal knowledge

As summarized in Table 1, the 120 informants were categorized by gender, age, education, occupation, and their roles as healers or non-healers.

The demographic variables explored in this study, along with findings from previous research (Muhakr *et al.* 2024, Weckmüller *et al.* 2019, Zaidi *et al.* 2022), reveal a significant influence on traditional medicinal knowledge. In this study, elders and females demonstrated greater knowledge of medicinal plants compared to younger individuals and males, respectively (Figure 2). This aligns with existing literature, where the cumulative experience of elders contributes to their extensive traditional knowledge (Tadesse *et al.* 2024, Kamsani *et al.* 2020, Tamene *et al.* 2024). Similarly, the traditional family roles often assigned to females result in their deeper familiarity with medicinal plants, as highlighted by Zaidi *et al.* (2022).

Table 1. Demographic profile of informants in the study area

Demographic feature	Category	Number of Informants	%
General informants	Female	45	37.5
	Male	45	37.5
Key informants	Female	0	0
	Male	30	25
Age	20-39 years old	30	25
	40-59 years old	30	25
	60-79 years old	60	50
Education level	Illiterate	43	35.83
	Basic	48	40
	Secondary	22	18.33
	University	7	5.83
Profession	Student	9	7.5
	Unemployed	19	15.83
	Government Employee	7	5.83
	Farmer	38	31.66
	Merchant	17	14.16
	Healer	30	25

Another notable finding is the inverse relationship between educational attainment and knowledge of traditional medicine (Figure 3). Individuals with higher education levels tended to exhibit less familiarity with medicinal plants. This phenomenon may be attributed to a shift away from traditional practices in favour of modern lifestyles among the educated population. In contrast, less-educated individuals are more likely to adhere to traditional ways of life, preserving their knowledge of medicinal plants.

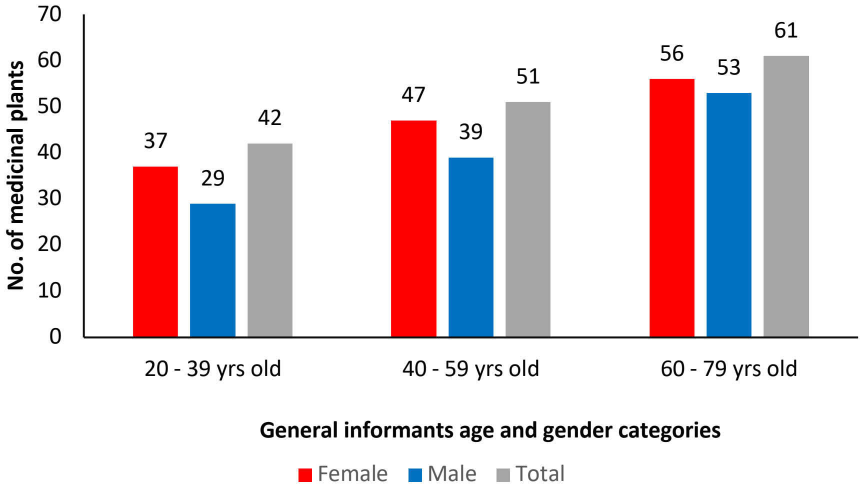

Figure 2. Number of medicinal plants reported by females, and males in different age categories in the study sites.

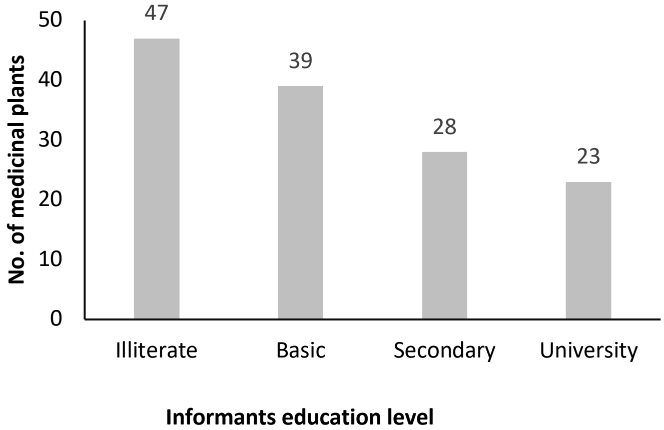

Figure 3. Number of medicinal plants reported by informants from different education categories in the study sites.

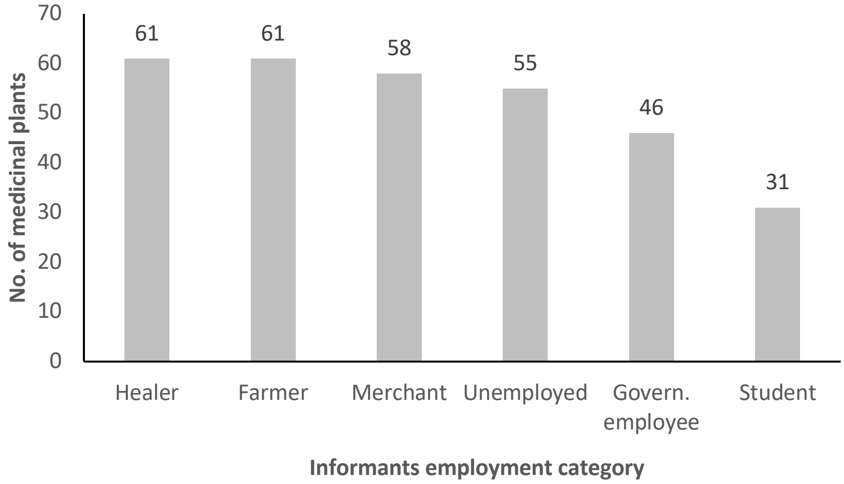

Figure 4. Number of medicinal plants reported by informants from different employment categories in the study sites.

The results also indicate that healers and farmers possess more extensive knowledge of medicinal plants compared to other professional groups (Figure 4). Notably, healers often engaged in secondary occupations such as farming and trading, in addition to their primary role in traditional healing. This is consistent with the study of Muhakr *et al.* (2024), who observed that traditional medicine was not the primary livelihood for healers in Darfur State, Sudan. Urbanization and the increasing prevalence of formal medicine have significantly impacted the financial viability of traditional healing practices. As a result, many traditional healers are compelled to diversify their sources of income, reducing their reliance on traditional medicine as a full-time occupation. This trend also affects the trade of medicinal plants, as healers face challenges in sustaining their practices within a changing socio-economic landscape.

These findings highlight the intricate relationships between demographic factors and the preservation of traditional medicinal knowledge, emphasizing the need for targeted strategies to sustain this cultural heritage amidst modern influences.

Sources of traditional medicinal knowledge

The findings of this study revealed that traditional medicinal knowledge is predominantly inherited from ancestors and transmitted orally from elders to younger generations. About 73% of the informants reported inherited knowledge, whereas 26.66% of informants acquired their knowledge through a combination of inheritance and self-learning. Notably, none of the participants reported relying solely on self-learning as a source of their medicinal plant knowledge (Figure 5). The self-learning described in this study involved trial-and-error experiments, knowledge exchanges with other healers and community members (both within and across regions), and incidental learning experiences. These processes complemented the inherited knowledge base, enriching the overall understanding of medicinal plants.

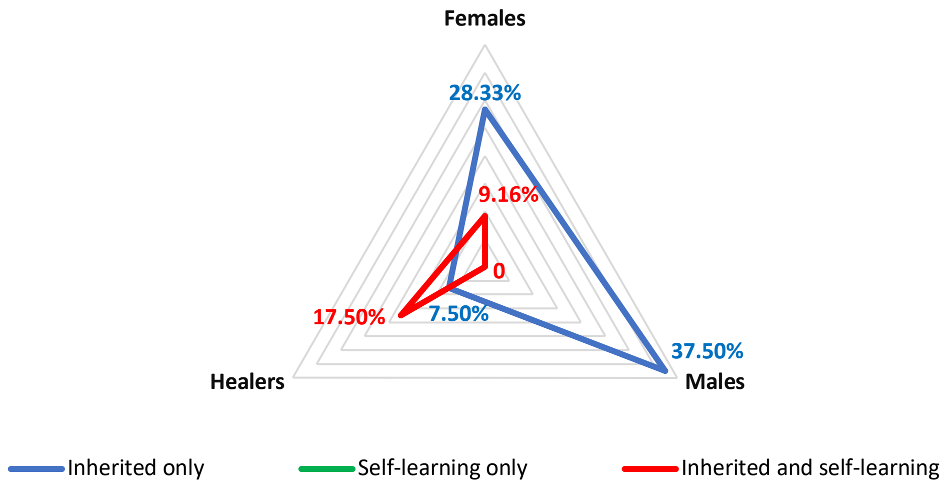

Figure 5. Sources of traditional medicinal plants knowledge and percentage of informants (females, males, and healers) adopting each source in the study sites.

These findings are consistent with prior studies, which have also highlighted inheritance as the primary mode of knowledge transfer in traditional medicine. This mode involves the systematic and sequential transmission of information from one generation to the next, ensuring the preservation of medicinal plant knowledge over time (Issa *et al.* 2018, Ssenku *et al.* 2022). The reliance on inheritance and oral transmission underscores the cultural and social dimensions of traditional medicinal practices. It highlights the importance of familial and community networks in maintaining this invaluable knowledge amidst changing socio-economic and environmental contexts.

Taxonomic diversity of medicinal plants

Beyond demographic influences, the diversity of local flora plays a crucial role in shaping traditional medicinal knowledge. The rich vegetation of Lagawa District serves as a vital source for traditional medicine, as reflected in the data provided by informants. A total of 61 medicinal plants, representing 54 genera and 27 families, were identified in this study (Table 2).

Table 2. Botanical families, species scientific name, vernacular names, growth habits, treated ailments, part uses, and the mode of preparation and application of traditional medicinal plants used in the study sites.

Family Species	Vernacular name	Growth habit	Treated Ailments	Part used	Mode of preparation and application	UV
Acanthaceae						
Blepharis linariifolia Pers.	Begheil	Herb	Kidney problem	Bark	Maceration/Drink	0.34
Anacardiaceae						
Lannea fruticosa (Hochst. ex A. Rich.) Engl.	Layoun	Tree	Kidney problem	Bark	Maceration/Drink	0.24
Sclerocarya birrea (A. Rich.) Hochst.	Humeid	Tree	Stomach-ache	Bark	Maceration/Drink	0.64
Apocynaceae						
Calotropis procera (Aiton) W. T. Aiton	Ushar	Shrub	Snake bite	Leaf latex	Squeezing/Rubbing	0.10
Carissa spinarum L.	Alali	Shrub	Cough	Root	Infusion/Drink	
Leptadenia arborea (Forssk.) Schweinf.	Shaaloub	Climber	Urine burning	Root	Decoction/Drink	0.45
Arecaceae						
Borassus aethiopum Mart.	Daleib	Tree	Stomach-ache	Fruit	Fresh raw/Eaten	0.29
Hyphaene thebaica (L.) Mart.	Dom	Tree	Rheumatism	Fruit	Burn/Smoke fumigant	0.53
Asteraceae						
Dicoma tomentosa Cass.	Um Sinainat	Herb	Jaundice	Root	Maceration, infusion/Drink	0.06
Burseraceae						
Boswellia papyrifera (Delile) Hochst.	Tragtrag	Tree	Cough	Gum	Maceration/Drink	0.26
Capparaceae						
Boscia senegalensis (Pers.) Lam. ex Poir.	Mukhait	Shrub	Toothache	Bark	Raw/Chewing	0.71
Maerua crassifolia Forssk.	Sarah	Shrub	Jaundice	Root	Maceration/Drink	0.34
Combretaceae						
Anogeissus leiocarpa (DC.) Guill. & Perr.	Sahab	Tree	Jaundice	Bark	Decoction, maceration/Drink	0.38
Combretum glutinosum Perr. Ex. DC.	Habeel	Tree	Rheumatism	Wood	Burn/Smoke fumigant	0.83
Terminalia brownii Fresen.	Sobag, Darot	Tree	Rheumatism	Wood	Burn/Smoke fumigant	0.28
Guiera senegalensis J. F. Gmel.	Gubeish	Shrub	Jaundice	Leaf	Maceration/Drink	0.84
			Diabetes	Leaf	Maceration/Drink	
Compositae						
Geigeria alata (Hochst. & Steud. Ex. DC.) Benth. & Hook. fil. ex Oliv. & Hiern	Gudgad	Herb	Diabetes	Leaf	Maceration/Drink	0.26
Cucurbitaceae						
Citrullus colocynthis (L.) Schrad.	Handal	Climber	Rheumatism	Seed	Powder/Poultice	0.35

Ebenaceae						
Diospyros mespiliformis Hochst. ex A. DC.	Goghan	Tree	Stomach-ache	Bark	Maceration/Drink	0.16
Euphorbiaceae						
Chrozophora plicata (Vahl) A. Juss. ex Spreng.	Argassi, Troub	Herb	Sinus infection	Seed	Burn/Smoke inhalation	0.16
Jatropha curcas L.	Jatropha	Shrub	Eczema	Seed	Oil squeezing/Rubbing	0.24
Ricinus communis L.	Khirwi	Shrub	Swellings	Leaf, seed	Powder mixed with oil/Rubbing	0.22
Fabaceae						
Acacia gerrardii Benth.	Salgam	Tree	Swellings	Leaf	Powder/Poultice	0.64
Acacia nilotica subsp. *adstringens* (Schumach. & Thonn.) Roberty	Garad, Sunt	Tree	fatigue	Fruit	Powder mixed with oil/Rubbing	0.63
			Cough	Fruit	Maceration/Drink Raw/Sucking	
			Cold/flu	Fruit	Burn/Smoke fumigant	
Acacia senegal (L.) Willd.	Hashab	Shrub	Kidney problem	Gum	Maceration/Drink	0.79
Acacia seyal Delile var. *seyal*	Talih	Tree	Rheumatism	Wood	Burn/Smoke fumigant	0.63
Albizia amara (Roxb.) Boivin	Arad	Tree	Swellings	Leaf	Powder/Poultice	0.63
			Kidney problem	Leaf	Decoction/Drink	
Cassia sieberiana DC.	Um Kasho	Tree	Snake bite	Leaf	Powder/Poultice	1.00
Dichrostachys cinerea (L.) Wight & Arn.	Kadad	Shrub	Wounds	Bark	Powder/Sprinkle	0.55
Faidherbia albida (Delile) A. Chev.	Haraz	Tree	Stomach-ache	Bark	Maceration/Drink	0.34
*Piliostigma reticulatum (*DC.) Hochst.	Kharob, Abu-Khameira	Shrub	Hypertension Diabetes	Fruit Fruit	Squeezing/Drink Squeezing/Drink	0.53
Prosopis africana (Guill. & Perr.) Taub.	Abu Suruj	Shrub	Wounds	Bark	Powder/Sprinkle	0.34
Senna alexandrina Mill.	Senna-senna, Snamaka	Herb	Constipation Stomach-ache Jaundice	Fruit Fruit Fruit	Decoction/Drink Decoction/Drink Decoction/Drink	0.46
Senna tora (L.) Roxb	Kawal	Herb	Jaundice	Seed	Powder mixed with yogurt/Eaten	0.30
Tamarindus indica L.	Aradeib	Tree	Malaria	Fruit	Infusion or maceration with Hibiscus flowers and *Acacia nilotica* pods	0.63
Lamiaceae						
Ocimum basilicum L	Rehan	Herb	Eye infection	Seed	Eyewash and drops	0.28
Lythraceae						
Lawsonia inermis	Henna	Shrub	Dandruff	Leaf		0.41

					Powder mixed with water/Rubbing hair skin	
Malvaceae						
Adansonia digitata L.	Tabaldi	Tree	Dysentery	Leaf/Fruit	Infusion, maceration/Drink	1.08
Hibiscus sabdarifa L.	Karkade	Herb	Cold and flu	Flower	Maceration/Drink	1.00
			Cough	Flower	Maceration/Drink	
			Hypertension	Flower	Maceration/Drink	
Grewia mollis (Forssk.) Fiori	Gregadan	Shrub	Anaemia	Fruit	Infusion/Drink	0.19
Grewia tenax (Forssk.) Fiori	Gudaim	Shrub	Anaemia	Fruit	Infusion/Drink	0.53
Grewia villosa Willd.	Tikko	Shrub	Abdominal problems	Fruit	Decoction/Drink	0.44
Waltheria indica L.	Irg el Nar	Herb	Snake bite	Root	Powder mixed with water/Rubbing	0.50
Meliaceae						
Azadirachta indica A. Juss.	Neem	Tree	Fever	Leaf	Maceration/Wash	0.78
				Leaf	Fresh raw/Lay on mattress covered with leaves	
			Malaria	Leaf	Infusion, maceration/Drink	
Khaya senegalensis (Desr.) A. Juss.	Mahogani	Tree	Malaria	Bark	Maceration/Drink	0.39
Moraceae						
Ficus sycomorus L.	Gumaize	Tree	Snake bite	Bark	Maceration/Wash	0.16
Moringaceae						
Moringa oleifera Lam.	Moringa, Rawag	Tree	Diabetes	Leaf	Decoction/Drink	0.34
			Stomach-ache	Leaf	Decoction/Drink	
Olacaceae						
Ximenia americana L.	Um Medeka	Shrub	Rheumatism	Bark	Burn/Smoke fumigant	0.25
Poaceae						
Cymbopogon schoenanthus (L.) Spreng.	Maharaib	Grass	Kidney problems	Whole plant	Decoction/Drink	0.46
Rhamnaceae						
Ziziphus spina-christi (L.) Desf.	Nabag, Sidir	Shrub	Diarrhoea	Bark	Maceration/Drink	0.91
			Abdominal problems	Bark	Maceration/Drink	
Rubiaceae						
Catunaregam nilotica (Stapf) Tirven.	Shagarat ElMarfaein	Tree	Jaundice	Root	Decoction/Drink	0.06
Gardenia ternifolia Schumach. & Thonn.	Abu-Gawi	Shrub	Jaundice	Root	Decoction/Drink	0.04
Sarcocephalus latifolius (Sm.) E.A.Bruce,	Karmadoda	Shrub	Diabetes	Fruit	Squeezing/Drink	0.43

Vangueria madagascariensis J. F. Gmel.	Kirkir	Shrub	Hypertension	Fruit	Squeezing/Drink	0.24
			Diabetes	Fruit	Maceration/Drink	
			Hypertension	Fruit	Maceration/Drink	
Scrophulariaceae						
Anticharis senegalensis (Walp.) Bhandari	Shagarat elwaram	Shrub	Swellings	Root	Powder/Poultice	0.41
Striga hermonthica (Delile) Benth.	Bouda	Parasite	Diabetes	Aerial part	Maceration/Drink	0.04
Solanaceae						
Solanum forskalii Dunal	Dayoug	Herb	Dandruff	Fruit	Powder mixed with oil/Rubbing hair skin	0.22
Solanum incanum L.	Gubein	Herb	Stomach-ache	Fruit	Decoction/Drink	0.33
Family: Vitaceae						
Cissus quadrangularis L.	Salalla	Climber	Haemorrhoids	Aerial part	Powder mixed with oil/Anal Rubbing	0.38
Zygophyllaceae						
Balanites aegyptiaca (L.) Delil	Higleeg, laloub	Tree	Bilharzia	Seed	Powder dissolved in water/Drink	1.00
			Diabetes	Seed	Powder dissolved in water/Drink	
			Constipation	Fruit	Maceration/Drink	
					Raw/Sucking	
			Abdominal problems		Maceration/Drink Raw/Sucking	
Tribulus terrestris L.	Direisa	Herb	Kidney problems	Seed	Decoction/Drink	0.50

The Fabaceae family contributed the highest number of medicinal plants (13 species), followed by Malvaceae (6 species), Rubiaceae and Combretaceae (4 species each), and Apocynaceae and Euphorbiaceae (3 species each). Seven families were represented by two species each, while the remaining 14 families (51.85% of the total) were represented by a single medicinal plant species. The dominance of Fabaceae in traditional medicine is well-documented in Sudan (Eisawi *et al.* 2022, Issa *et al.* 2018, Muhakr *et al.* 2024, Musa *et al.* 2011) and across Africa (Tadesse *et al.* 2024, Tugume *et al.* 2016). The widespread use of this family in herbal medicine can be attributed to its ecological adaptability and biological traits. Members of Fabaceae are well-suited to thrive in nutrient-poor soils due to their symbiotic relationship with nitrogen-fixing bacteria and their extensive root systems, which enable them to access deep soil nutrients and moisture (Tadesse *et al.* 2024).

The diversity and ecological adaptability of medicinal plants in Lagawa District underscore the significance of local floristic compositions for traditional medicine. These findings highlight the correlations between biodiversity, ecological resilience, and the preservation of traditional medicinal knowledge.

In comparison to previous studies conducted in West Kordofan (Doka & Yagi 2009), South Kordofan (Eisawi *et al.* 2022), North Kordofan (El-Kamali 2009), North Darfur (Muhakr *et al.* 2024), and Blue Nile State (Musa *et al.* 2011), the present study documented a higher number of medicinal plant species (Table 3). The study of Issa *et al.* (2018) conducted in south Kordofan showed a higher number of medicinal plants compared to our and the other studies (Table 3).

The greatest number of shared medicinal plants and the highest Jaccard Index (JI%) were observed between this study and those by Eisawi *et al.* (2022) and Issa *et al.* (2018), both conducted in South Kordofan (Figure 6 and Table 3). This substantial overlap in medicinal plant species is likely due to the geographical proximity of South Kordofan to the study area, as both regions share similar ecological and environmental conditions. The eastern border of the study sites directly adjoins the regions investigated by Eisawi *et al.* (2022) and Issa *et al.* (2018), facilitating the exchange of plant resources and traditional knowledge between these areas.

These findings highlight the influence of geographical and ecological factors on the distribution and use of medicinal plants, as well as the interconnection of traditional medicinal practices across neighbouring regions.

Table 3. Total number of medicinal plant species in the present and other studies in Kordofan region, the number of common plant species and Jaccard Index of similarity (JI %).

Number of common plants   JI %

Region	**Study**	No. species	Present study	Doka & Yagi (2009)	Issa *et al.* (2018)	Eisawi *et al.* (2022)	El Kamali (2009)	Muhakr *et al.* (2024)
W. Kordofan	Present study	61		27.90%	31.35%	50%	25.28%	29.03%
W. Kordofan	Doka & Yagi (2009)	49	24		21.19%	29.63%	10.23%	14.89%
S. Kordofan	Issa *et al.* (2018)	94	37	25		25%	16.39%	24.39%
S. Kordofan	Eisawi *et al.* (2022)	56	39	24	30		35.06%	27.77%
N. Kordofan	El Kamali (2009)	48	22	9	20	27		15.05%
N. Darfur	Muhakr *et al.* (2024)	59	27	14	30	25	14	

The greatest number of shared medicinal plants and the highest Jaccard Index (JI%) were observed between this study and those by Eisawi *et al.* (2022) and Issa *et al.* (2018), both conducted in South Kordofan (Figure 6 and Table 3). This substantial overlap in medicinal plant species is likely due to the geographical proximity of South Kordofan to the study area, as both regions share similar ecological and environmental conditions. The eastern border of the study sites directly adjoins the regions investigated by Eisawi *et al.* (2022) and Issa *et al.* (2018), facilitating the exchange of plant resources and traditional knowledge between these areas.

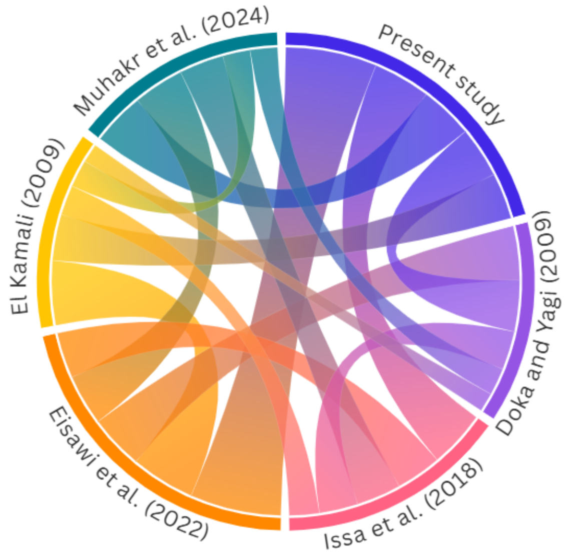

Figure 6. Overlapping of medicinal plants between the current study and other studies.

These findings highlight the influence of geographical and ecological factors on the distribution and use of medicinal plants, as well as the interconnection of traditional medicinal practices across neighbouring regions.

Growth forms of medicinal plants

The medicinal plants identified in this study comprised 23 trees (37.70%), 21 shrubs (34.42%), 12 herbs (19.67%), 3 climbers (4.91%), and one grass and one parasite (1.63% each) (Figure 7). Trees emerged as the most commonly used growth form, consistent with other studies conducted in Sudan (Musa *et al.* 2011, Eisawi *et al.* 2022) and Africa (Maroyi *et al.* 2013, Idu *et al.* 2010).

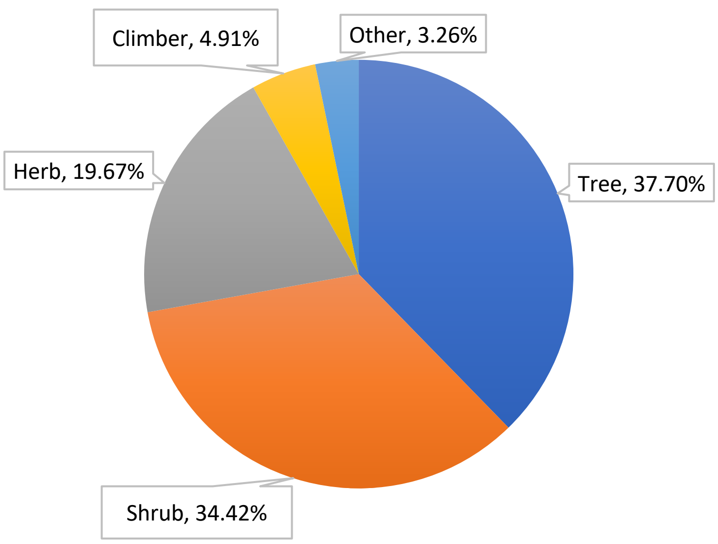

Figure 7. Growth habit of the medicinal plants used in the study sites.

The prevalence of trees and shrubs in traditional medicine may be attributed to their perennial nature, making them available year-round. Their drought resistance and minimal susceptibility to seasonal climatic variations enhance their reliability as a source of medicinal materials (Maroyi *et al.* 2013). Moreover, the extended lifespan of woody plants provides communities ample time to observe, document, and refine knowledge about their medicinal properties.

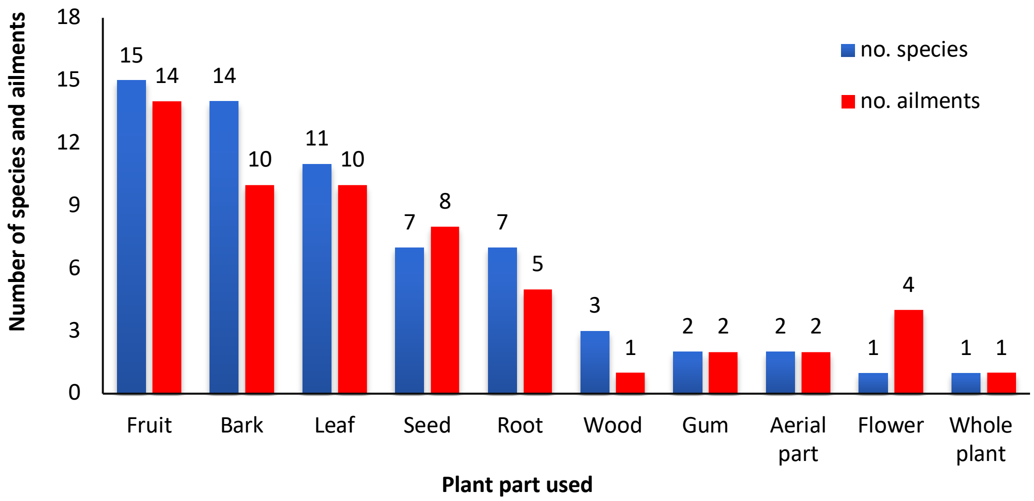

Figure 8. Parts of the medicinal plants and their associated numbers of medicinal species and ailments in the study sites.

Plant parts used in traditional medicine

In this study, nearly all parts of medicinal plants were utilized for preparing traditional remedies. The distribution of medicinal plant parts, along with their corresponding numbers of species and associated ailments, is presented in Table 2 and Figure 8. Consistent with the findings of Eisawi *et al.* (2022), fruits emerged as the most frequently utilized plant part in this study. Similarly, Muhakr *et al.* (2024) reported fruits and bark as the predominant plant parts used in traditional medicine.

In contrast, other studies conducted in Sudan (e.g., Musa *et al.* 2011, Doka & Yagi 2009) and internationally (e.g., Idu *et al.* 2010) identified stem bark as the most commonly utilized part for herbal preparations. In South Kordofan, Sudan, roots and stems were reported as the primary plant parts used (Issa *et al.* 2018), while studies from South Africa highlighted roots, followed by leaves, as the most frequently employed parts (Mahwasane *et al.* 2013, Wanjohi *et al.* 2020).

The preference for fruits in traditional medicine could be attributed to their palatability, ease of collection, and straightforward preparation. Wild fruits have been extensively documented for their bioactive properties, including antioxidant, anti-inflammatory, antimicrobial, and anticancer activities (Li *et al.* 2016). These attributes position wild fruits as potential candidates for functional foods and pharmaceuticals targeting chronic diseases (Li *et al.* 2016).

From a conservation perspective, the harvesting of fruits and leaves is more sustainable compared to the collection of roots, bark, or wood, which can harm plants and lead to mortality when overharvested (Tugume *et al.* 2016). However, certain studies, such as that by Delvaux *et al.* (2009) in Benin, West Africa, highlighted the recovery capabilities of some medicinal plants following bark harvesting. For instance, *Khaya senegalensis* demonstrated complete wound recovery and resistance to insect attacks. In the current study, 14, 7, and 3 medicinal plants were subjected to bark, root, and wood harvesting, respectively.

Notably, the same plant part was often associated with the treatment of multiple ailments. Examples include the fruit of *Senna alexandrina*, used for stomachache, constipation, and jaundice. The leaves of *Moringa oleifera*, applied for stomachache and diabetes. The flower of *Hibiscus sabdariffa*, used to treat cold and flu, cough, and hypertension. The bark of *Ziziphus spina-christi*, utilized for abdominal pain and diarrhea.

In rare cases, different parts of the same plant were reported to treat the same ailment. For example, the fruits and leaves of *Adansonia digitata* were both used to treat dysentery. The seeds and leaves of *Ricinus communis* were employed to reduce swelling. Additionally, wood from various species was linked to the treatment of rheumatism. This multifaceted utilization underscores the depth of traditional medicinal knowledge and highlights the need for sustainable harvesting practices to preserve these invaluable resources.

Diversity of treated ailments and associated number of medicinal plants

This study identified 27 distinct medicinal uses for the reported medicinal plants (Table 2). The majority, 50 plants (81.96%), were associated with a single medicinal use. Seven species; *Azadirachta indica*, *Moringa oleifera, Piliostigma reticulatum*, *Albizia amara*, *Sarcocephalus latifolius*, *Vangueria madagascariensis*, and *Ziziphus spina-christi* were noted to have two medicinal uses each. Three plants, *Acacia nilotica*, *Hibiscus sabdariffa*, and *Senna alexandrina*, were attributed three medicinal uses, while *Balanites aegyptiaca* was reported to have the highest medicinal uses, with four medicinal uses (Table 2).

The predominance of medicinal plants associated with a single use aligns with findings by Tadesse *et al.* (2024), suggesting a focus on specific applications in traditional practices. However, the tendency for medicinal plants to be used for multiple ailments has been more common in other studies conducted in Sudan (Eisawi *et al.* 2022, Issa *et al.* 2018, Muhakr *et al.* 2024).

This variation may reflect differences in regional practices, ecological factors, or the breadth of ethnobotanical investigations. Further comparative analysis across regions could provide deeper insights into the factors influencing the multiplicity of medicinal uses associated with specific plant species.

Cross cultural uses of medicinal plants

Similarities in flora are expected in areas with comparable edaphic and climatic conditions. However, the extent of overlap in traditional medicinal knowledge across regions is influenced not only by flora but also by socio-cultural structures and practices (Faruque *et al.* 2018). In this study, several medicinal plants cited in other regions were found to have similar or distinct traditional uses. For instance, *Balanites aegyptiaca* was reported in this study to treat bilharzia, abdominal problems, constipation, and diabetes. In other regions, it has been cited for worm expulsion (Eisawi *et al.* 2022); dysentery, diarrhea, jaundice, stomachache, and rheumatic pain (Muhakr *et al.* 2024); diabetes, hypertension, bilharzia, and jaundice (Issa *et al.* 2018); malaria, kidney and bladder ailments (Doka & Yagi 2009); and as an antispasmodic for stomach pain and diabetes (El-Kamali 2009). Similarly, *Hibiscus sabdariffa* was associated in this study with the treatment of cold and flu, malaria, and hypertension. Other studies reported overlapping and additional uses, such as cold and flu, and hypertension (Muhakr *et al.* 2024); hemorrhoids, cold and flu, and hypertension (Issa *et al.* 2018); and headache, snake bite, and scorpion sting (El-Kamali 2009). Different geographical locales may use different plant parts from the same medicinal plant species to treat the same ailment; in this study *Cassia sieberiana* leaves were mentioned to cure snake bites, whereas Doka & Yagi (2009) mentioned roots, instead, of the same plant to treat the same condition in a different location.

Although similar ethnomedicinal uses for a plant species across different locations suggest its potential, this is not always a reliable indicator of its efficacy. Rigorous validation through bioactive and pharmacological studies is essential. Karar & Kuhnert (2017) confirmed the effectiveness of 16 medicinal plants described in this study, highlighting their phytochemical, bioactive, and pharmacological properties. Conversely, *Striga hermonthica*, traditionally identified as an anti-diabetic remedy in this and other studies (Alamin *et al.* 2015), was found ineffective in lowering blood glucose levels (Yagi & Yagi 2018, Alamin *et al.* 2015). These findings emphasize the need for an integrative approach that combines traditional knowledge with scientific validation to ensure the safety and efficacy of medicinal plants.

Mode of remedy preparation, route of administration, and dosage

As summarized in Table 2 and Table 4, maceration was the most commonly employed method of remedy preparation, accounting for 30.95% (26 plants). Conversely, the combined method of maceration and decoction were the least utilized, each associated with only one plant (1.19%). Remedies were primarily administered orally (67.57%), followed by topical application to the skin (30.95%), and rarely anally (1.19%). The specific mode of administration often depended on the nature of the plant part used and the ailment being treated (Feyisa *et al.* 2024). Orally administered remedies were predominantly applied through drinking, accounting for 52 plant species (61.90%), followed by sucking (3 species, 3.57%), eating (2 species, 2.38%), and chewing (1 species, 1.19%). Topical applications included smoking and rubbing (7 species each, 8.33%), poultices (5 species, 5.95%), washing (3 species, 3.57%), sprinkling (2 species, 2.38%), and laying on (1 species, 1.19%). Among the remedies administered anally, rubbing was the sole method reported, involving 1 plant species (1.19%). The laying-on method, mentioned specifically for malaria treatment, involves covering a mattress with fresh neem leaves, upon which the patient lays on.

The widespread use of maceration, both in this study and in others (e.g., Issa *et al.* 2018, Musa *et al.* 2011), can be attributed to its proven effectiveness as an extraction method, through generations of traditional practice. Oral administration was the most frequently reported route, consistent with findings from other ethnobotanical studies in Sudan (Musa *et al.* 2011, Issa *et al.* 2018, Muhakr *et al.* 2024) and other countries (Giday *et al.* 2009, Yirga 2010, Aniama *et al.* 2016). The anal route was rarely employed; *Cissus quadrangularis* was the sole plant administered via this method in the study area.

Table 4. Mode of preparation of remedies used in the study sites.

Mode of preparation	Oral	Topical	Anal	Total

Maceration	24	2	-	26 (30.95%)
Powder	3	12	1	16 (19.05%)
Decoction	13	0	-	13 (15.47%)
Squeezing	5	2	-	7 (8.33%)
Burning	7	0	-	7 (8.33%)
Raw	5	1	-	6 (7.14%)
Infusion	3	1	-	4 (4.76%)
Maceration/ infusion	4	0	-	4 (4.76%)
Maceration/ decoction	1	0	-	1 (1.19%)

To enhance palatability and mitigate the bitterness of certain remedies, additives were frequently incorporated into orally administered medicines (Issa *et al.* 2018, Faruque *et al*. 2018, Ralte *et al.* 2024). For instance, *Senna tora* seed powder was traditionally consumed with yogurt to improve its taste. The most commonly mentioned additives included honey, sugar, yogurt, and milk. Water was the predominant extraction solvent, aligning with findings by Issa *et al.* (2018).

Most remedies in this study were prepared from a single plant source, with the exception of malaria treatments, which is treated using a mixture of *Tamarindus indica* fruits, *Acacia nilotica* pods, and *Hibiscus sabdariffa* flowers. Such polyherbal formulations have also been reported in other studies (Issa *et al.* 2018, Muhakr *et al.* 2024, Faruque *et al.* 2018, Donkor *et al.* 2023) and are believed to enhance therapeutic efficacy through complementary or synergistic effects (Musa *et al.* 2011, Faruque *et al.* 2018).

Dosage and measurement units

Accurate dosage and measurement are critical for ensuring the efficacy and safety of traditional remedies. In this study, traditional measurement units for orally administered remedies included finger lines, cups (e.g., coffee, tea, and glass cups), and spoons (teaspoons and tablespoons). Similar methods were noted in the study by Yirga (2010). Cordero *et al.* (2022) further identified handfuls, hand lengths, foot lengths, pinches, drops, slices, spoons, glasses, and numerical counts as traditional units of measurement.

Variabilities in dosage units, prescribed durations, and administration times for the same ailment were observed among informants. Many traditional healers acknowledged a lack of precise knowledge regarding dosage and expressed regret over this limitation. The healers and non-healers acknowledged the dependence of dosage on patient's age, physical fitness, illness severity, and pregnancy status, and the presence of other diseases. This lack of standardization in dosage remains a major barrier to the formal recognition and integration of traditional medicine (Yirga *et al.* 2010).

Quantification of medicinal plant data

Quantifying medicinal plant data provides insight into the social and medicinal significance of plant species and their associated ailments. Differences in the accessibility, availability, use multiplicity, and popularity of medicinal plants are reflected by variations in UVs. In this study, use values (UVs) for medicinal plants ranged from 0.04 to 1.08 (Table 2). The five species with the highest UVs were *Adansonia digitata* (1.08), *Balanites aegyptiaca*, *Hibiscus sabdariffa*, *Cassia sieberiana* (1.00 each), and *Ziziphus spina-christi* (0.91). In contrast, *Gardenia ternifolia* and *Striga hermonthica* had the lowest UV recognition.

High informant consensus factor (ICF) and fidelity level (FL) values (Table 5) indicate strong agreement among informants on the importance of specific plants for treating particular ailments. Despite being associated with the highest number of ailments (4 ailments) and achieving a high UV (1.00), *Balanites aegyptiaca* was predominantly recognized as a remedy for bilharzia. Interestingly, this plant showed a relatively low FL (69%), even though no other plants were cited for treating bilharzia.

Table 5. Ailment categories, number of species, number of use-cited, informant consensus factor (ICF), preferred species, ailment, and fidelity levels (FL%).

Ailment category	No. species	No. of uses-cited	ICF	Preferred species	Ailment	FL (%)
Pain	1	85	1	*Boscia senegalensis*	Toothache	100
General health	1	76	1	*Azadirachta indica*	Fever	85
Nasal diseases	1	20	1	*Chrozophora plicata*	Sinus infection	85
Eye diseases	1	10	1	*Ocimum basilicum*	Eye infection	100
Parasite infections	4	267	0.99	*Khaya senegalensis*	Malaria	87
				Balanites aegyptiaca	Bilharzia	69
Abnormalities	4	235	0.99	*Anticharis senegalensis*	Swellings	100
				Ricinus communis	Swellings	100
Urinary system disorders	7	460	0.98	*Leptadenia arborea*	Urine burning	100
				Tribulus terrestris	Kidney problems	100
				Cymbopogon schoenanthus	Kidney problems	100
Musculoskeletal system	7	367	0.98	*Acacia nilotica*	Fatigue	96
				Citrullus colocynthis	Rheumatism	100
Cardiovascular system and hematological disorders	6	269	0.98	*Grewia tenax*	Anaemia	100
				Hibiscus sabdariffa	Hypertension	100
				Sarcocephalus latifolius	Hypertension	100
Skin diseases	5	249	0.98	*Jatropha curcas*	Skin eczema	100
				Lawsonia inermis	Dandruff	100
				Solanum forskalii	Dandruff	100
				Prosopis Africana	Wound	80
Animal bites	4	212	0.98	*Cassia sieberiana*	Snake bites	100
				Ficus sycomorus	Snake bites	100
Respiratory system	4	182	0.98	*Hibiscus sabdariffa*	Cough	100
				Hibiscus sabdariffa	Cold and flu	100
Digestive disorders	18	434	0.96	*Cissus quadrangularis*	Haemorrhoids	100
				Senna alexandrina	Constipation	100
				Grewia villosa	Abdominal problems	100
				Faidherbia albida	Stomach-ache	100
				Moringa oleifera	Stomach-ache	100
				Borassus aethiopum	Stomach-ache	100
				Senna alexandrina	Stomach-ache	100
				Solanum incanum	Stomach-ache	100
				Senna tora	Jaundice	100
				Senna alexandrina	Jaundice	100
				Gardenia ternifolia	Jaundice	100
				Maerua crassifolia	Jaundice	100
				Adansonia digitata	Dysentery	97
				Ziziphus spina-christi	Diarrhoea	85
Endocrinological system	8	178	0.96	*Sarcocephalus latifolius*	Diabetes	100
				Moringa oleifera	Diabetes	100
				Striga hermonthica	Diabetes	100

Factors influencing quantification values

Several factors influence quantification values, such as the therapeutic efficacy and accessibility of medicinal plants (Mbuni *et al.* 2020). Additional contributors include the frequency of ailment occurrences, and adoption of formal medicine. For example, the relatively low FL of *Balanites aegyptiaca* for bilharzia treatment could be due to the low incidence of the ailment in the study region. Notably, the prevalence of type 2 diabetes in Sudan rose significantly from 7.7% in 2013 to 19.1% in 2015 (Adam *et al.* 2021, Elmadhoun *et al.* 2016, IDF 2013), however patients seem to follow the formal medications in addition to traditional medicine. Similarly, ailments associated with only one or a few medicinal plants tend to boost ICF values. The disadvantage of UV comes from its limited distinguish between plants used for single or multiple purposes. The extent of knowledge sharing, and the number of plants associated with specific ailments could be additional influencing factors.

Conservation challenges

Medicinal plant species with high UVs are at risk of overexploitation due to their extensive use for medicinal and other purposes. Conversely, plants with low UVs may face extinction due to neglect or insufficient attention. Such trends could erode traditional knowledge and discourage the continued practice of traditional medicine. This underscores the need for sustainable practices and efforts to preserve both medicinal plants and associated traditional knowledge.

Conclusion

This study contributes to the growing body of traditional knowledge regarding the ethnomedicinal uses of plants in West Kordofan State, Sudan. It highlights the influence of socioeconomic factors on traditional knowledge and the limitations of quantification indices in interpreting ethnomedicinal data. The systematic documentation of plant-based ethnomedicine, alongside efforts to foster appreciation and awareness among younger generations, is vital for safeguarding and enhancing the role of natural resources in primary health care systems.

Declarations

List of abbreviations: UV: Use Value; UR: Use Reports; ICF: Informant Consensus Factor; FL: Fidelity Level; JI: Jaccard Index

Ethics approval and consent to participate: This study was approved by the Forestry and Gum Arabic Research Centre, Agricultural Research Corporation, Sudan. All participants provided oral prior informed consent.

Consent for publication: Not applicable.

Availability of data and materials: All data collected during the field survey are presented in this paper.

Competing interests: Not applicable.

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Authors' contributions: Hamad EM and volunteers conducted the field survey and collected the data. Hamad EM and Salih NK-EM analyzed the data and drafted the manuscript. Gibreel HH supported plant species identification and contributed to manuscript preparation. Gibreel HH and Salih NK-EM designed the study and supervised the work. All authors reviewed and approved the final manuscript.

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Literature cited

Adam HMI, Elmosaad YM, Ahmed AE, Khan A, Mahmud I. 2021. Dietary knowledge, attitude and practice among type 2 diabetes mellitus patients in Sudan: a hospital-based cross-sectional study. African Health Science 21(1): 32-40. doi: 10.4314/ahs.v21i1.6

Alamin MA, Yagi AI, Yagi SM. 2015. Evaluation of antidiabetic activity of plants used in Western Sudan. Asian Pacific Journal of Tropical Biomedicine 5: 395-402.

Andrews FW. 1952. The flowering plants of the Anglo-Egyptian Sudan, vol. 2. Arbroath: Buncle Co., Ltd.

Andrews FW. 1956. The flowering plants of the Anglo-Egyptian Sudan, vol. 3. Arbroath: Buncle Co., Ltd.

Angiosperm Phylogeny Group 2016. An update of the classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Socisty 181(1), 1-20. doi: 10.1111/boj.12385

Aniama SO, Usman SS, Ayodele SM. 2016. Ethnobotanical documentation of some plants among Igala people of Kogi State. The International Journal of Engineering and Science 5(4): 33-42.

Asif M, Haq SHM, Yaqoob U, Hassan M, Jan HA. 2021. Ethnobotanical study of indigenous knowledge on medicinal plants used by the tribal communities in tehsil “Karnah” of District Kupwara (Jammu and Kashmir) India. Ethnobotany Research and Applications 21: 02. Retrieved from https: ethnobotanyjournal.org/index.php/era/article/view/2401/1171

Cole TCH, Hilger HH, Stevens P. 2017. Angiosperm phylogeny poster flowering plants systematic. The Botanical Journal of the Linnean Society 7-13. doi: 10.7287/peerj.preprints.2320v4

Donkor MN, Donkor AM, Mosobil R. 2023. Combination therapy: synergism among three plant extracts against selected pathogens. BMC Research Notes 16(1): 83. doi: 10.1186/s13104-023-06354-7.

Cordero CS, Meve U, Alejandro GJD. 2022. Ethnobotanical documentation of medicinal plants used by the indigenous Panay Bukidnon in Lambunao, Iloilo, Philippines. Frontiers in Pharmacology 12: 790567. doi:10.3389/fphar.2021.790567

Darbyshire I, Kordofani M, Farag I, Candiga R, Pickering H. 2015. The plants of Sudan and South Sudan, an annotate checklist, Kew Publishing, pp 145-147.

Delvaux C, Sinsin B, Darchambeau F, Van Damme P. 2009. Recovery from bark harvesting of 12 medicinal tree species in Benin, West Africa. Journal of Applied Ecololgy 46(3): 703-712. doi: 10.1111/j.1365-2664.2009.01639.x

Doka IG, Yagi SM. 2009. Ethnobotanical Survey of medicinal plants in West Kordofan (Western Sudan). Ethnobotanical Leaflets 13: 1409-1416.

Dossou AJ, Fandohan AB, Djossa AB, Assogobadjo AE. 2021. Diversity and knowledge of plants used in the treatment of snake bite envenomation in Benin. Ethnobotany Research and Applications 21: 1-20. doi: 10.32859/era.21.48.1-20

Dutta B, Gantai S, Hansda S, Das AK. 2024 Documentation of indigenous medicinal knowledge of select tribal communities of west bengal. Journal of Data Science Information and Citation Studies 3(3): 349-355. doi: 10.5530/jcitation.3.3.34

El Amin HM. 1990. Trees and Shrubs of the Sudan. U.K: Ithaca Press Exeter.

Elegami AA, ElNima EI, El Tohami MS, Muddathir AK. 2000. Antimicrobial activity of some species of the family Combretaceae. Phytotherapy Research 16: 555-561. doi: 10.1002/ptr.995.

Eisawi KhA, Gibreel HH, He H, Shaheen T, Abdalla OM, Yassin EH. 2022. Ethnobotanical study of medicinal trees and shrubs from the Rashad District of Southern Kordofan, Sudan. Egyptian Journal of Botany 62(2): 337-357. doi: 10.21608/ejbo.2021.81264.1708

EL-Kamali HH. 2009. Ethnopharmacology of medicinal plants used in north Kordofan (western Sudan). Ethnobotanical Leaflets 13: 89-97.

Elmadhoun WM, Noor SK, Ibrahim AA, Bushara SO, Ahmed MH. 2016. Prevalence of diabetes mellitus and its risk factors in urban communities of north Sudan: Population-based study. Journal of Diabetes 8: 839-846. doi:10.1111/1753-0407.12364.

Faruque MO, Uddin SB, Barlow JW, Hu S, Dong S, Cai Q, Li X, Hu X. 2018. Quantitative Ethnobotany of medicinal plants used by indigenous communities in the Bandarban District of Bangladesh. Frontiers in Pharmacology 9: 40. doi:10.3389/fphar.2018.00040

Feyisa K, Yismaw MB, Yehualaw A, Tafere C, Demsie DG, Bahiru B, Kefale B. 2024. Medicinal plants traditionally used to treat human ailments in Ethiopia: A systematic review. Phytomedicine Plus 4(1): 100516. doi:10.1016/j.phyplu.2023.100516.

Friedman J, Yaniv Z, Dafni A, Palewitch D. 1982. A preliminary classification of the healing potential of medicinal plants, based on a rational analysis of an ethnopharmacological field survey among Bedouins in the Negev Desert, Israel. Journal of Ethnopharmacology 16 (2-3): 275-287.

Giday M, Asfaw Z, Woldu Z, Teklehaymanot T. 2009. Medicinal plant knowledge of the Bench ethnic group of Ethiopia: an ethnobotanical investigation. Journal of Ethnobiology and Ethnomedicine 5: 34. doi:10.1186/1746-4269-5-34

González-Tejero MR, Casares-Porcel M, Sánchez-Rojas CP, Ramiro-Gutiérrez JM, Molero-Mesa J, Pieroni A. 2008. Medicinal plants in the Mediterranean area: synthesis of the results of the project Rubia. Journal of Ethnopharmacology 116: 341-357. doi:10.1016/j.jep.2007.11.045

Hamad EM, Salih NK-E, Gibreel HH. 2024. Traditional use of wild edible plants in Babanosa and Lagawa Districts, West Kordofan State, Sudan. Human Ecology 2024. doi:10.1007/s10745-024-00475-8

Hosseini SH, Bibak H, Ghara AR, Sahebkar A, Shkeri A. 2021. Ethnobotany of the medicinal plants used by the ethnic communities of Kerman Province, south east Iran. Journal of Ethnobiology and Ethnomedicine 17:31. doi: 10.1186/s13002-021-00438-z.

Hussain W, Batool S, Bahar S, Shahida B, Bangash B, Ali A, Hussain H, Ali I, Ali M, Bussmann RW. 2020. Ethnopharmacological survey of herbal remedies used in the treatment of hepatitis. Ethnobotany Research Applications 20: 1-29. doi:10.32859/ERA.20.24.1-29

IDF (International Diabetes Federation) 2013. IDF Diabetes atlas 6th edition. International Diabetes Federation Brussels. https://diabetesatlas.org/media/uploads/sites/3/2025/02/IDF-Atlas-6th-Edition-EN.pdf

Idu M, Erhabor JO, Efijuemue HM. 2010. Documentation on medicinal plants sold in markets in Abeokuta, Nigeria. Tropical Journal of Pharmaceutical Research 9 (2): 110-118.

ISE. 2006. International Society of Ethnobiology Code of Ethics (with 2008 additions). https://www.ethnobiology.net/code-of-ethics/

Issa TO, Yagi S, Ahmed RH, Najeeb TM, Makhawi AM, Khider TO. 2018. Ethnobotanical investigation on medicinal plants in Algoz area (South Kordofan), Sudan. Journal of Ethnobiology and Ethnomedicine 14: 31. doi: 10.1186/s13002-018-0230-y.

Kamsani K, Franco FM, Slik F. 2020. A comparative account of the traditional healing practices of healers and non-healers in the Kiudang area of Brunei Darussalam. Journal of J Ethnopharmcology 256: 112788. doi: 10.1016/j.jep.2020.112788

Karar MGE, Kuhnert N. 2017. Herbal drugs from Sudan: Traditional uses and phytoconstituents. Pharmacognosy Reviews 11: 83-103. doi:10.4103/phrev.phrev_15_15

Koko WS, Galal M, Khalid HS. 2000. Fasciolicidal efficacy of *Albizia anthelmintica* and *Balanites aegyptiaca* compared with albendazole. Journal of Ethnopharmacology 71: 247-252. doi: 10.1016/s0378-8741(00)00172-0

Li Y, Zhang JJ, Xu DP, Zhou T, Zhou Y, Li S, Li HB. 2016. Bioactivities and Health Benefits of Wild Fruits. International Journal of Molecular Sciences 17(8): 1258. doi: 10.3390/ijms17081258. PMID: 27527154.

Mahwasane ST, Middleton L, Boaduo N. 2013. An ethnobotanical survey of indigenous knowledge on medicinal plants used by the traditional healers of the Lwamondo area, Limpopo province, South Africa. South African Journal of Botany 88: 69-75. doi:10.1016/j.sajb.2013.05.004

Maroyi A. 2013. Traditional use of medicinal plants in south-central Zimbabwe: Review and perspectives. Journal of Ethnobiology and Ethnomedicine 9: 31. doi:10.1186/1746-4269-9-31

Mbuni YM, Wang S, Mwangi BN, Mbari NJ, Musili PM, Walter NO, Hu G, Zhou Y, Wang Q. 2020. Medicinal plants and their traditional uses in local communities around Cherangani Hills, Western Kenya. Plants 9:331. doi: 10.3390/plants9030331.

Muhakr MAYM, Ahmed IM, El Hassan GOM, Yagi S., 2024. Ethnobotanical study on medicinal plants in Melit area (North Darfur), Western Sudan. Journal of Ethnobiology and Ethnomedicine 20(1): 3. doi: 10.1186/s13002-023-00646-9.

Musa SM, Abdelrasool FE, Elsheikh A, Ahmed LAMN, Mahmoud AE, Sakina MY. 2011. Ethnobotanical study of medicinal plants in the Blue Nile State, South-eastern Sudan. J Medicinal Plants Research 5 (17): 4287-4297.

Phillips O, Gentry AH, Reynel C, Wilkin P, Galvez DBC. 1994. Quantitative ethnobotany and Amazonian conservation. Conservation Biology 8: 225-248.

Rahmatullah M, Noman A, Hossan S, Rashid H, Rahman T, Chowdhury MH, Jahan R. 2009. A survey of medicinal plants in two areas of Dinajpur district, Bangladesh including plants which can be used as functional food. American-Eurasian Journal of Sustainable Agriculture 3(4): 862-876.

Ralte L, Singh YT. 2024. Ethnobotanical survey of medicinal plants used by various ethnic tribes of Mizoram, India. PLoS ONE 19(5): e0302792. doi: 10.1371/journal.pone.0302792

Salih NKE, Ali AH. 2014. Wild food trees in Eastern Nuba Mountains, Sudan: use, diversity, and threatening factors. Journal of Agriculture and Rural Development in the Tropics and Subtropics 115.

Semwal R, Joshi RBS, Semwal DK. 2021. Mini review: Health benefits and limitation of rutin- A natural flavonoid with high nutraceutical value. Photochemistry Letters 46: 119-128. doi:10.1016/j.phytol.2021.10.006

Senthilkumar K, Aravindhan V, Rajendran A. 2013. Ethnobotanical survey of medicinal plants used by Malayan Tribes in Yercaud Hills of Eastern India. J Natural Remedies 13: 119-132. doi: 10.18311/jnr/2013/105

Ssenku JE, Okurut SA, Namuli A, Kudamba A, Tugume P, Matovu P, Wasige G, Kafeero HM, Walusansa A. 2022. Medicinal plant use, conservation, and the associated traditional knowledge in rural communities in Eastern Uganda. Tropical Medicine and Health 50: 39. doi: 10.1186/s41182-022-00428-1

Tadesse D, Masresha G, Lulekal E. 2024. Ethnobotanical study of medicinal plants used to treat human ailments in Quara district, northwestern Ethiopia. Journal of Ethnobiology and Ethnomedicine 20: 75. doi:10.1186/s13002-024-00712-w

Tamene S, Negash M, Makonda FB, Chiwona-Karltun L. 2024. Influence of socio-demographic factors on medicinal plant knowledge among three selected ethnic groups in south-central Ethiopia. Journal of Ethnobiology and Ethnomedicine 20(1): 29. doi:10.1186/s13002-024-00672-1

Trotter RT, Logan MH. 1986. Informant consensus: a new approach for identifying potentially effective medicinal plants. In: Etkin NL, editor. Plants in indigenous medicine and diet. Bedford Hills: Redgrave Publishing Company.

Tugume P, Kakudidi EK, Buyinza M, Namaalwa J, Kamatenesi M, Mucunguzi P, Kalema J. 2016. Ethnobotanical survey of medicinal plant species used by communities around Mabira Central Forest Reserve, Uganda. Journal of Ethnobiology and Ethnomedicine 12: 5. doi: 10.1186/s13002-015-0077-4.

van Andel T, Carvalheiro LG. 2013. Why urban citizens in developing countries use traditional medicines: the case of Suriname. Evidence-based Complementary and Alternative Medicine 687197. doi: 10.1155/2013/687197

Wanjohi BK, Sudoi V, Njenga EW, Kipkore, WK. 2020. An Ethnobotanical study of traditional knowledge and uses of medicinal wild plants among the Marakwet Community in Kenya. Evid-Based Complement. Alternative Medicine 3208634. doi:10.1155/2020/3208634.

Weckmüller H, Barriocanal C, Maneja R, Boada M. 2019. Factors affecting traditional medicinal plant knowledge of the Waorani, Ecuador. Sustainability 11(16): 4460. doi:10.3390/su11164460

WHO. 2023. WHO Traditional Medicine Strategy 2014 - 2023. World Health Organization, Geneva, Switzerland. https://iris.who.int/bitstream/handle/10665/92455/9789241506090_eng.pdf?sequence=1

Yagi S, Yagi AI. 2018. Traditional medicinal plants used for the treatment of diabetes in the Sudan: A review. African Journal of Pharmacy and Pharmacology 12(3): 27-40. doi: 10.5897/AJPP2017.4878

Yirga G. 2010. Assessment of indigenous knowledge of medicinal plants in Central Zone of Tigray, Northern Ethiopia. African Journal of Plant Science 4(1): 6-11. http://www.academicjournals.org/AJPS ISSN

Zaidi SF, Saeed SA, Khan MA, Khan A, Hazazi Y, Otayn M, Rabah M, Daniyal M., 2022. Public knowledge, attitudes, and practices towards herbal medicines; a cross-sectional study in Western Saudi Arabia. BMC Complementary Medicine and Therapies 22(1): 326. doi: 10.1186/s12906-022-03783-y.