

Anthropogenic activities on the composition and diversity of woody vegetation of Garko, Gombe State, Nigeria

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ABSTRACT: This study assessed the impact of anthropogenic activities on the composition and diversity of woody vegetation in Garko, Gombe State, Nigeria. Vegetation sampling was conducted using the Point-Centred Quarter (PCQ) method. In addition to floristic data, anthropogenic influences were evaluated through participatory rural appraisal (PRA) techniques, including direct observation, focus group discussions (10 participants each) were held with community leaders, farmers and women's groups to validate findings, and interviews using semi-structured questionnaire surveys. A total of 33 woody species were recorded, comprising 20 tree species and 13 shrub species, belonging to 9 families and 24 genera. The family Fabaceae was the most represented (14 species), reflecting its ecological dominance in the Sudan Savanna. Importance Value Index (IVI) analysis for trees showed *Isobertinia doka* (44.53%) as the most ecologically significant species, while shrubs showed *Feretia apodonthera* and *Cassia tora* (25.48%) had the highest values. Diversity indices indicated higher diversity among trees (Shannon $H' = 3.95$; Simpson's $1-D = 0.60$) compared to shrubs ($H' = 2.70$; $1-D = 0.50$). Questionnaire and FGD results revealed that Agricultural expansion, overgrazing, and fuelwood collection were highlighted as the main anthropogenic activities in the Garko Forest Reserve. Respondents emphasised declining tree cover, loss of medicinal plants and reduced availability of fodder as consequences. The study concluded that anthropogenic pressures significantly threaten woody plant diversity in Garko. Strengthening conservation strategies such as community-based forest management, controlled grazing, enforcement of logging restrictions and promotion of alternative livelihoods is strongly recommended.

Keywords: Anthropogenic activities, diversity, Garko, Importance Value Index, Sudan Savanna, woody vegetation.

INTRODUCTION

Woody vegetation plays a fundamental role in maintaining ecological stability, supporting biodiversity and providing essential ecosystem services such as fuelwood, fodder, medicine and climate regulation (FAO, 2020). In the Sudan Savanna, trees and shrubs are critical to rural livelihoods, yet they face continuous pressure from anthropogenic activities including logging, charcoal production, grazing and agricultural expansion (Adeniji *et al.*, 2022; Eze *et al.*, 2023).

Anthropogenic disturbance alters vegetation composition, reduces species richness and accelerates the loss of ecologically and socio-economically important species

(Chazdon, 2019). In Nigeria, increasing population growth has intensified the exploitation of forest resources, leading to widespread degradation, particularly in community-managed woodlands (Ajayi *et al.*, 2020).

Garko, located in Gombe State, lies within the Sudan Savanna ecological zone, where human dependence on vegetation resources is extremely high. Despite this, limited research has documented the extent of anthropogenic impacts on woody species composition and diversity in the area. While previous studies in Gombe State have documented general vegetation patterns and the impact of land-use changes, few have provided species-level

insights specific to the Garko area. This study contributes new empirical data on species composition, dominance, and diversity indices of trees and shrubs in the reserve, offering baseline information critical for site-specific conservation planning. This study, therefore, aimed to:

1. Assess the composition and diversity of woody species in Garko.
2. Examine the anthropogenic activities influencing woody vegetation structure.

MATERIALS AND METHODS

Study area

Garko is located in the Garko Local Government Area of Gombe State, Nigeria. The area lies within the Sudan Savanna zone, lying between latitude 10° 10.60' 4"N and Longitude 11° 09.84' 2" E and with an altitude of 479m above sea level in the North East ecological zone. The size of the forest covers an approximate area of 3,456 hectares (34.56km²), as obtained from the Gombe State Ministry of Environment GIS unit. It was established in 1956. Characterized and the climate is characterised by a single rainy season (May–October) and a prolonged dry season (November–April). The mean annual rainfall ranges between 800 and 1000 mm. The vegetation consists of scattered trees and shrubs interspersed with grasses, typical of the Sudan Savanna ecological formation.

Vegetation sampling

Vegetation sampling was conducted using the Point-Centred Quarter (PCQ) method (Cottam and Curtis, 1956). At systematically selected points, distances to the nearest tree and shrub in each quarter were measured. Species were identified using standard floras (Keay, 1989; Arbonnier, 2004). Relative density, relative frequency and relative dominance were computed to derive the Importance Value Index (IVI) using quantitative phytosociological methods as described by Cottam and Curtis (1956), Dix (1971), Mueller-Dombois and Ellenberg (1974) and Kent (2012). Diversity indices (Shannon–Wiener and Simpson's) were calculated following Magurran (2004).

Questionnaire and focus group discussions

A total of 120 households were randomly selected. "In addition to floristic data, anthropogenic influences were evaluated through participatory rural appraisal (PRA) techniques, including direct observation, focus group discussions (10 participants each) were held with community

leaders, farmers and women's groups to validate findings, and interviews using semi-structured questionnaire surveys. These methods provided qualitative insight into local land-use patterns and their perceived impacts on woody vegetation. They gathered information on anthropogenic activities, dependence on vegetation resources and perceived changes in woody vegetation.

RESULTS

Woody species composition

A total of 33 woody species belonging to 14 families were identified. The family Fabaceae was the most dominant (14 species), followed by Combretaceae (7 species). Major species included *Isoberlinia doka*, *Vitellaria paradoxa*, *Parkia biglobosa*, *Albizia lebbek* and *Anogeissus leiocarpa* as shown in Table 1.

Importance Value Index (IVI)

Species with the highest IVI values were *Isoberlinia doka* (43.55%), *Combretum glutinosum* (23.80%) and *Combretum mole* (23.25%), which contributed significantly to the overall vegetation structure. In comparison, trees with the lowest IVI values were *Dalbergia melnoxylon* and *Lonchocarpus sericeus* (1.92%), as shown in Table 2.

The shrub species with the highest importance value index was *Feretia apodonthera* and *Cassia tora* (25.48%) in the forest, while the lowest importance value index recorded in the forest was *Ximения americana* (3.72%), as shown in Table 3.

Diversity indices

Trees: Shannon H' = 3.95; Simpson's 1–D = 0.60

Shrubs: Shannon H' = 2.70; Simpson's 1–D = 0.50

These values indicate moderate species diversity and evenness among trees compared to shrubs.

Anthropogenic activities

Based on questionnaire and FGD responses (Figure 1):

- Deforestation for Agriculture (48%) and grazing and overgrazing (48%) were the leading drivers of tree decline.
- Firewood collection (45%), logging and timber extraction (30%) and Charcoal production (7%) also contributed significantly.

Table 1. Woody species composition identified at Garko Forest Reserve, Gombe State Nigeria.

S/N	Species	Genera	Family	Habit	Common Names	Hausa Names
1.	<i>Azadirachta indica</i> A. Juss	<i>Azadirachta</i>	Meliaceae	Tree	Neem	Darbejiya
2.	<i>Acacia sieberiana</i> D.C	<i>Acacia</i>	Fabaceae	Tree	Paper bark	Farar kaya
3.	<i>Acacia ataxacantha</i> (L.) wild	<i>Acacia</i>	Fabaceae	Tree	Flame thorn	Kwiya
4.	<i>Acacia nilotica</i> (L.)	<i>Acacia</i>	Fabaceae	Tree	Gum Arabic	Bagaruwa, Dushe
5.	<i>Albizia lebbbeck</i> (L.) Benth	<i>Albizia</i>	Fabaceae	Tree	India Walnut	Katsari
6.	<i>Anogeissus leiocarpa</i> (D.C) Guill & Perr	<i>Anogeissus</i>	Combretaceae	Tree	African birch	Marke
7.	<i>Balanite egyptiaca</i> Del	<i>Balanite</i>	Zygophyllaceae	Tree	Desert date	Aduwa
8.	<i>Cassia abbreviate</i> Muviene	<i>Cassia</i>	Fabaceae	Tree	Long tail cassia	
9.	<i>Cassia rotundifolia</i> Ijap	<i>Cassia</i>	Fabaceae	Shrub	Golden	Umfuli
10.	<i>Cassia singuenna</i> Delile	<i>Cassia</i>	Fabaceae	Shrub		Runfu
11.	<i>Cassia tora</i> L.	<i>Cassia</i>	Fabaceae	Shrub	Sickle senna	Tafasa
12.	<i>Combretum molle</i> CR.Br. ex G.Don	<i>Combretum</i>	Combretaceae	Tree	Bush willow	Wuya damo
13.	<i>Combretum aculeatum</i> Vent	<i>Combretum</i>	Combretaceae	Shrub	Bush willow	Farar geza
14.	<i>Combretum glutinosum</i> Perr ex Dc	<i>Combretum</i>	Combretaceae	Shrub	Dooki	Ciriri, Dalo
15.	<i>Combretum niroense</i> Aubrev. Ex Key	<i>Combretum</i>	Combretaceae	Shrub	Bush willow	
16.	<i>Combretum zeyheri</i> Sond	<i>Combretum</i>	Combretaceae	Tree	Bush willow	
17.	<i>Detarium microcarpus</i> Guill & Perr	<i>Detarium</i>	Fabaceae	Tree	Sweet detar	Taura
18.	<i>Diospyrous mespiliformis</i> Hochst. Ex A. DC.	<i>Diospyrous</i>	Ebenaceae	Tree	Jackalberry	Kanya
19.	<i>Dalbergia melanoxyton</i> Guill & Perr	<i>Dalbergia</i>	Fabaceae	Tree	Large African blackwood	Tabum
20.	<i>Euclea natalensis</i> A. DC.	<i>Euclea</i>	Ebenaceae	Tree	Large leave guarri	Doka, bakar doka
21.	<i>Ficus apondyterium</i>	<i>Ficus</i>	Moraceae	Tree	Pig tree	
22.	<i>Feretia apondanthera</i> Delile	<i>Feretia</i>	Rubiaceae	Shrub	Feretia	Lallen suri, kurukuru
23.	<i>Guirea senegalensis</i> J.F.Gmel	<i>Guirea</i>	Combretaceae	Shrub	Mesh medicine	Sabara
24.	<i>Gardenia erubescens</i> Stapf & Hutch	<i>Gardenia</i>	Rubiaceae	Shrub		Gaude
25.	<i>Haemastophis barberi</i> Hook. F	<i>Haemastophis</i>	Anacardiaceae	Shrub	Blood plum	Jar danya, tsamiya
26.	<i>Isoberlina doka</i> Craib & Stapf	<i>Isoberlina</i>	Fabaceae	Tree	Pigs	Doka
27.	<i>Lonchocarpus sericeus</i> (Poir.) kunth ex DC	<i>Lonchocarpus</i>	Fabaceae	Tree		Farin sansami, Shinin biri
28.	<i>Randia nilotica</i> (Stapf)	<i>Randia</i>	Rubiaceae	Shrub		Gialgoti
29.	<i>Strychnos spinosa</i> Lam	<i>Strychnos</i>	Fabaceae	Tree	Monkey orange	Kumbij
30.	<i>Sclerocarya birrea</i> (A.Rich) Hochst.	<i>Sclerocarya</i>	Anacardiaceae	Tree	Marula	Danyaa
31.	<i>Tamarindus indica</i> L.	<i>Tamarindus</i>	Fabaceae	Tree	Tamarind	Tsamiya
32.	<i>Senna subulata</i> (Griseb.)	<i>Senna</i>	Fabaceae	Shrub		
33.	<i>Ximenia americana</i> L.	<i>Ximenia</i>	Olcaceae	Shrub	Spiny plum	Tsada

Table 2. The Importance Value Index (IVI) of the tree species identified at Garko forest reserve, Gombe State, Nigeria.

S/N	Tree species	R.D	R.F	R.Dom	IVI (%)
1	<i>Acacia ataxacantha</i>	7.0	4.0	0.04	11.04
2	<i>Acacia nilotica</i>	9.0	8.03	0.5	17.03
3	<i>Acacia sieberiana</i>	4.0	6.89	5.0	15.89
4	<i>Albizia lebeck</i>	1.0	0.89	0.05	1.94
5	<i>Anogeissus leiocarpus</i>	4.0	4.0	3.0	11.00
6	<i>Azadiracta indica</i>	1.0	12.50	0.7	14.20
7	<i>Balanite aegyptiaca</i>	5.0	4.50	1.0	10.50
8	<i>Combretum aculeatum</i>	1.0	0.89	0.04	1.93
9	<i>Combretum glutinosum</i>	4.0	12.50	7.3	23.80
10	<i>Combretum molle</i>	5.0	17.85	0.4	23.25
11	<i>Combretum zeykeri</i>	6.0	5.35	0.04	11.39
12	<i>Dalbergia melanoxylon</i>	1.0	0.89	0.03	1.92
13	<i>Detarium microcarpus</i>	5.0	4.46	0.8	10.26
14	<i>Diospyrous mespiliformis</i>	4.0	3.57	1.1	8.67
15	<i>Euclea natalensis</i>	5.0	4.46	0.05	9.51
16	<i>Isobertina doka</i>	4.0	32.75	6.8	43.55
17	<i>Lonchocarpus sericeus</i>	1.0	0.89	0.03	1.92
18	<i>Sclerocarya birrea</i>	2.0	1.78	0.5	4.28
19	<i>Strychnos spinosa</i>	1.0	0.89	0.04	1.93
20	<i>Tamarindus indica</i>	4.0	14.64	1.0	19.64

Table 3. The Importance Value Index (IVI) shrubs species identified at Garko forest reserve, Gombe state, Nigeria.

S/N	Shrub Species	R.D	R.F	R.Dom	IVI
1	<i>Cassia rotundifolia</i>	1.0	2.44	8.0	11.44
2	<i>Cassia subulata</i>	1.0	2.44	8.0	11.44
3	<i>Cassia singuenna</i>	3.0	2.67	0.5	6.17
4	<i>Cassia tora</i>	1.0	20.68	3.8	25.48
5	<i>Combretum aculeatum</i>	2.0	3.0	2.0	7.00
6	<i>Combretum niroense</i>	1/0	1.72	2.34	5.06
7	<i>Combretum glutinosum</i>	2.0	2.0	3.1	7.10
8	<i>Feretia apondanthera</i>	1.0	20.68	3.8	25.48
9	<i>Gardenia americana</i>	1.0	1.32	2.0	4.32
10	<i>Guirea senegalensis</i>	2.0	8.42	11.0	21.42
11	<i>Haematostophis barteri</i>	1.0	1.5	3.0	5.50
12	<i>Randia nilotica</i>	1.0	1.72	1.0	3.72
13	<i>Ximenia americana</i>	1.0	0.89	0.5	2.39

- Respondents reported that the disappearance of valuable species such as *Vitellaria paradoxa* and *Anogeissus leiocarpa* is the most affected woody species in Garko Forest Reserve, alongside reduced availability of fodder and medicinal plants.

DISCUSSION

The findings indicate that Garko woodland harbours

considerable woody plant diversity but is under severe pressure from human exploitation. The dominance of Fabaceae aligns with findings from other Sudan Savanna reserves such as Yankari (Arhye *et al.*, 2019) and Lafia-Doma (Soule *et al.*, 2016), where legumes play critical roles in nitrogen fixation and ecosystem resilience.

The high IVI values of trees (*Isobertinia doka*) confirm their ecological and socio-economic importance. These species provide timber, fuelwood, medicine, food and income, which explains their high exploitation rates. Similar patterns

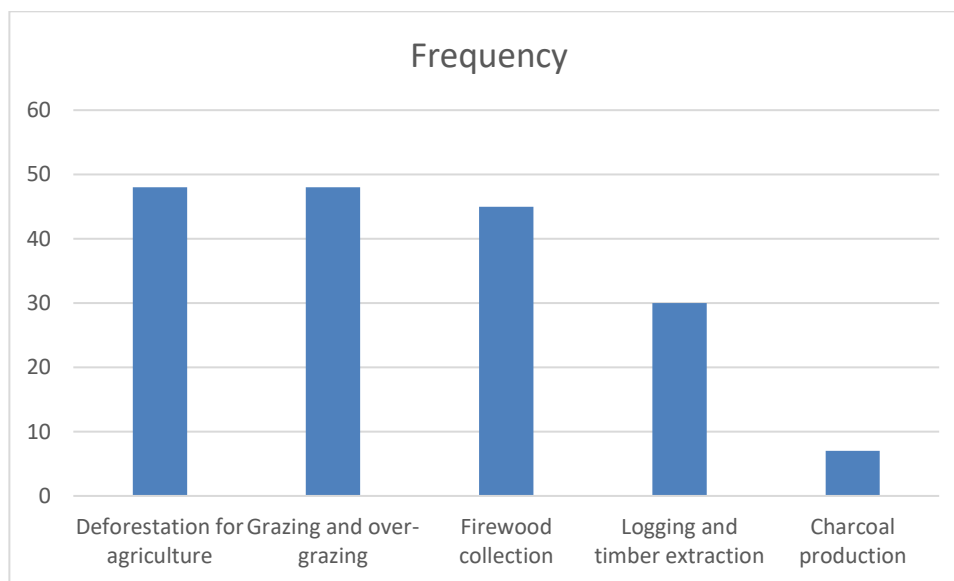


Figure 1. Anthropogenic activities.

to over-dependence have been reported in Gashaka-Gumti National Park (Meer *et al.*, 2023).

Woody species diversity

The Simpson's Index of Diversity (1-D) for trees in the Garko Forest Reserve was 0.6, indicating a moderate level of species diversity. This is relatively lower compared to other studies, such as Abba *et al.* (2022), who reported a higher diversity index of 0.9 in Gelengu Woodland, Balanga, Gombe State; Daniel *et al.* (2016), who found 0.76 in Zamfara, Nigeria; Abba *et al.* (2015) in Kanawa Forest Reserve; and Abdullahi (2010) in Yankari National Park, Bauchi State, who both recorded values of 0.98. The lower value observed in Garko likely reflects ongoing deforestation and anthropogenic disturbances, which reduce dominant species and alter the ecological balance. In contrast, the higher values reported in Yankari and Kanawa suggest more stable and mature ecosystems with minimal disturbance and complex species interactions (Magurran, 2004).

The Shannon-Wiener Index for trees was 3.95, which is considered moderately high, suggesting a relatively rich and even tree community. This value is higher than that recorded by Abba *et al.* (2022) in Gelengu but lower than Abba *et al.*, (2015), who reported 4.43 in Kanawa Forest Reserve, and Giliba *et al.* (2011), who reported 4.27 in the Miombo woodlands of the Bereku Forest Reserve. Differences in diversity indices across these studies can be attributed to variations in sampling design, plot size, DBH criteria, and environmental heterogeneity, as emphasised by Kent and Coker (1992). These

methodological differences often influence the estimation of species richness and evenness.

For shrubs, the Simpson's Index of Diversity was 0.5, also indicating moderate diversity. This is lower compared to values reported by Abba *et al.* (2022) (0.8), Abba *et al.* (2015) (0.9), and Abdullahi (2010) (0.9). The reduced diversity in Garko suggests moderate anthropogenic pressure such as grazing, fuelwood collection, and land conversion, which fragment shrub populations and hinder regeneration (Chazdon *et al.*, 2009).

The Shannon-Wiener Index for shrubs was 2.70, slightly below the value of 3.0 reported by Abba *et al.* (2022), and significantly lower than 4.27 recorded by Kumar *et al.* (2008) in the tropical forests of the Garo Hills. The relatively lower diversity in Garko's shrub layer may reflect less structural complexity and ecological heterogeneity, possibly due to selective removal or suppressed regeneration.

These findings indicate that while the Garko Forest Reserve maintains moderate diversity among its woody vegetation, it faces significant environmental pressures that may be limiting its full ecological potential. Conservation efforts should focus on reducing anthropogenic impacts and enhancing natural regeneration to sustain biodiversity.

The questionnaire and FGD findings highlight the influence of anthropogenic activities in shaping vegetation composition. Charcoal production and fuelwood harvesting remain unsustainable due to the lack of alternative energy sources; while grazing and farmland expansion continue to fragment woody vegetation. These reflect broader challenges in Nigerian drylands, where communal land tenure systems weaken enforcement of conservation

regulations (Ahmad and Adamu, 2022). These activities align with findings from recent studies in similar ecological settings, where agriculture and grazing are often the leading causes of deforestation and biodiversity loss (Curtis *et al.*, 2018; Harris *et al.*, 2020).

The respondents' observation of changes in woody vegetation composition and diversity over the past decades is a crucial indicator of environmental degradation. *Vitellaria paradoxa* and *Anogeissus leiocarpa*, being the most affected species, with *Acacia ataxacantha* being the least affected, reflect the differential susceptibility of species to anthropogenic pressures. Similar patterns have been documented in other tropical forest reserves, where certain species are more vulnerable to human activities due to their economic value and ecological roles (Newbold *et al.*, 2020).

Conclusion

"This study investigated the composition, diversity, and anthropogenic influences on woody vegetation in the Garko Forest Reserve. A total of thirty-three (33) woody species belonging to 24 genera and 9 families were recorded. Species such as *Feretia apodonthera* and *Cassia tora* (shrubs), and *Isobertina doka* (trees) demonstrated dominance.

Evidence of anthropogenic pressures—based on field observations and community input—suggests these activities may be contributing to moderate species diversity and altered vegetation structure. The findings underscore the need for: Integrated conservation planning tailored to local socio-economic realities.

Community education and involvement in forest resource governance, and Policy reform and enforcement, including participatory monitoring and sustainable land-use regulation. These strategies align with best practices in conservation and forest management within savanna and dryland forest ecosystems in Nigeria.

Recommendations

1. Establish community-based forest management committees.
2. Enforce regulations restricting uncontrolled logging and charcoal production.
3. Promote alternative livelihoods such as beekeeping and agroforestry.
4. Introduce afforestation programmes using indigenous species.
5. Integrate environmental education into local schools to enhance conservation awareness.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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