

# Assessment of Tree Diversity and Abundance in Rashad Natural Reserved Forest, South Kordofan, Sudan

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## Abstract

This study aims to estimate the tree diversity status of Rashad Forest Reserves in the Rashad locality of the South Kordofan State of Sudan. For data collection, eight sample plots (20 × 20 m) were taken randomly, and parameters were determined: trees species diversity, composition, relative density, dominance, important value index, and species richness in the Rashad forest reserve. The results show that a total of 237 and 56 tree species, including 22 families, have been identified in the study area. Fabaceae family and species numbers have the highest number of 13 species in 8 genera, followed by Combretaceae with 8 species belonging to 3 different genera, Malvaceae with 5 species belonging to 4 different genera, Apocynaceae with 3 species belonging to 3 different genera. The Arecaceae, Burseraceae, Capparaceae, Euphorbiaceae, Meliaceae, and Rubiaceae families each had two species, and all the other 11 families had one species each. Among the 56 different tree species found within the reserve. The results also indicated that *Tamarindus indica* L. and *Ziziphus spina-christi* (L.) Desf. had the highest relative density and dominance of 4.64% and 11% respectively. *Adansonia digitata* L., *Grewia villosa* Willd, *Vepris nobilis* (Delile) Mziray had density and dominance of 4.80% and 9%. Followed by *Anogeissus leiocarpa* (DC.) Guill. & Perr, *Adansonia digitata* L., *Catunaregam nilotica* (Stapf) Tirveng. (Syn: *Xeromphis nilotica* (Stapf) Keay, *Vangueria madagascariensis* J. F. Gmel. with 3.38% and 8%, respectively. Eleven species recorded the least relative dominance of 0.42%. Shannon-Weiner diversity index (H') value stood at 3.82. And as diversity indices varied with location depending on the species available within an ecological zone, Rashad forest reserve is blessed with a moderate diversity index.

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## Keywords

Assessment, Tree Species Diversity, Rashad Natural Reserved Forest, Relative Density, Relative Dominance, Importance Value Index

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## 1. Introduction

Tropical forests are the habitat of numerous species of living things that constitute biodiversity through webs of life (Shiferaw, Lemenih, & Gole, 2018). The natural cover of Sudan is generally poor, sparse, and scanty vegetation due to its location in such arid environment of the country, except along the Nile banks and watercourses where ephemeral herbs and grasses occur after the short rainy seasons (Elsiddig *et al.*, 2007; Elsiddig *et al.*, 2011). The reserved forests consist of around 837 forests distributed all over the country (Badi, 2004). They constitute a great potential for biodiversity conservation and play a vital role as an important component of natural resources and land use. These forests, including woodland savanna, are believed to be home to more than 500 unique species of trees and 185 species of shrubs based on expert opinions. Still, this information has not yet been verified by field surveys (Mukhtar & El Wakeel, 2002). This biodiversity is increasing the importance of conservation in the production of new, highly resistant clones and genotypes. The significance of the relationship between human beings and the forest reserves has been increasing as a result of the conflict of tremendous increase of population growth and crucial pressure on natural resources. Over the years, the forest has been a continuous source of wood, charcoal, and land for agricultural purposes that have led to present depletion (Asifat *et al.*, 2019; Kunwar & Sharma, 2004). In buttressing this view, (Armenteras *et al.*, 2009) reported that trees have provided many ecosystem services such as species conservation, prevention of soil erosion, and preservation of habitat for plants and animals. However, overexploitation of floristic composition has resulted in the rapid loss of tree diversity, which has been recognized as a major environmental and economic threat around the world (Mani & Parthasarathy, 2006). In forest management operations, inventories on biodiversity are used to determine the nature and distribution of biodiversity region in the region under management. The quantification of tree species diversity is an essential aspect as it provides resources for many species (Suratman, 2012). Being a dominant life form, trees are easy to locate precisely and to count (Condit *et al.*, 1996; Adesina, 1997) and are also relatively better known taxonomically (Gentry, 1992). Therefore, information on the composition, diversity of tree species, and species-rich communities are of primary importance in the planning and implementation of biodiversity conservation efforts. This research aimed to evaluate tree diversity and abundance in Rashad Natural Reserved Forest, South Kordofan, Sudan, and to assess the distribution pattern of tree species.

## 2. Materials and Methods

### 2.1. Description of Study Area

This study was conducted in Rashad Natural Reserved Forest, South Kordofan, Sudan, which is located between (Latitudes 10°, 13° North and longitudes 29°, 33° East). It covers an area of about 7872 Km<sup>2</sup>, mostly useful for agriculture and grazing activities (Figure 1). The weather in the Rashad Natural Reserved Forest is characterized by continuous high temperatures ranging from 20°C at night and 35°C in the day. About 400 mm is the annual rainfall ranges in the northern parts and 676 mm in the southern parts of the locality (Daldoum & Massaud, 2018). The soils belong to the ferruginous tropical red soil associated with basement rocks.

The vegetation in the study area varies with pattern of rainfall. Mean annual rainfall is 372 mm and has poor to moderate vegetation, Tree species such as Acacia and short grasses and shrubs (El Ghazali, 1993). The mean annual rainfall is 712 mm, with the denser vegetation of Acacia and other trees (Pantuliano, 2005).

### 2.2. Data Collection

Eight plots of 20 × 20 m each were demarcated for identification and accurate physical measurement. The collected data in each sample included identification and counting of the number of trees, shrubs, trees, and shrubs diameter (cm) and height (m). All the woody species found in each plot were counted. The representative samples, such as leaves, fruits, and bark of trees that could not be identified in the field, were collected and taken to the herbarium for identification. Social data were collected through surveys and interviewing 150 individuals of the local inhabitants for information about focusing on species degradation, vegetal composition.

### 2.3. Data Analysis

The data were analyzed by using Microsoft excels sheet, and used the following equations:

1) Basal area: the basal area of all trees in the sample plots were calculated using the following formula:

where  $d$  = tree diameter, and  $\pi = 3.142$  (constant).

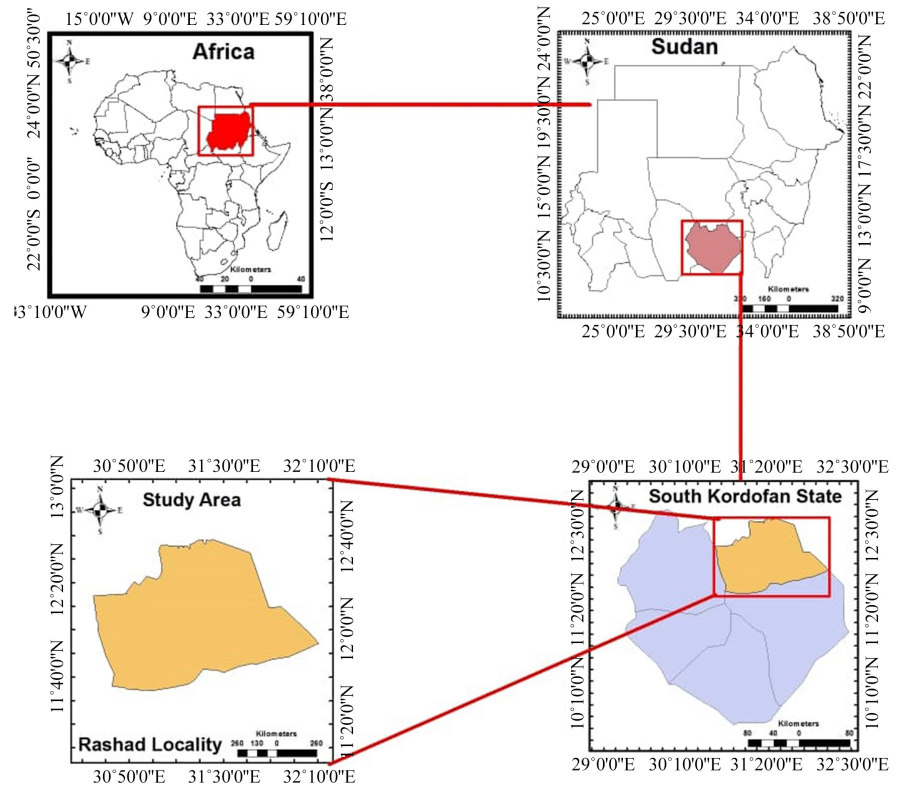
2) Species relative dominance (RDo) was computed using:

$$\text{RDo} = \left( \frac{\sum \text{Ba}_i \times 100}{\sum \text{Ba}_n} \right)$$

$\text{Ba}_i$  = basal area of individual trees belonging to species  $i$ ,  $\text{Ba}_n$  = stand basal area of all species.

3) Relative density (%) of each species was computed using the equation of (Brashears *et al.*, 2004).

$$\text{RD}\% = \left[ \frac{n_i}{N} \right] \times 100$$



**Figure 1.** Map of Study area, Source by Author.

This was used to express the share of each species in the tree community  $n_i$  = number of individual species;  $N$  = the Total number of species in the entire community.

4) Importance Value Index (IVI): This is the sum of RD and RDo divided by 2 that gave importance value index for each species.

$$IVI = \left( \frac{RD \times RDo}{2} \right)$$

Species diversity index was calculated using the Shannon-Wiener diversity index (Kent & Coker, 1992).

$$H' = -\sum_{n=1}^{\infty} P_n \ln(P_n)$$

$H'$  = Shannon-Wiener diversity index;  $\infty$  = total number of species in the community;  $P_n$  = proportion of  $S$  made up of the  $i$ th species;  $\ln$  = natural logarithm.

Shannon's maximum diversity index was calculated using the formula;  $H_{\max} = \ln(s)$

5) Species richness or variety index ( $d$ ) was determined by the formula

$$d = \frac{S}{\sqrt{N}} \quad (\text{Sharma, 2009}).$$

where  $S$  = number of species,  $N$  = number of individuals of all species.

### 3. Results and Discussion

#### 3.1. Species Diversity

A total of 237 tree stands were encountered within the eight randomly sampled plots. Fifty-six different tree species distributed within 22 families were found within the reserve. Family Fabaceae had the highest number of 13 species in 8 genera, followed by Combretaceae with 8 species belonging to 3 different genera, Family Malvaceae with 5 species belonging to 4 different genera, Family Apocynaceae with 3 species belonging to 3 different genera. Families Arecaceae, Burseraceae, Capparaceae, Euphorbiaceae, Meliaceae and Rubiaceae had 2 species each, and all the other 11 families had one species each as presented in **Table 1**.

Among the 56 different tree species found within the reserve, **Table 2** showed the relative density (RD) and relative dominance (RDo). Each of the 56 different tree species found within the reserve. The results indicated that *Tamarindus indica* L and *Ziziphus spina-christi* (L.) Desf. had the highest relative density and dominance of 4.64% and 11%. *Adansonia digitata* L, *Grewia villosa* Willd, *Vepris nobilis* (Delile) Mziray. had density and dominance of 4.80% and 9% followed by *Anogeissus leiocarpa* (DC.) Guill. & Perr, *Adansonia digitata* L, *Catunaregam nilotica* (Stapf) Tirveng. (Syn: *Xeromphis nilotica* (Stapf) Keay, *Van-gueria madagascariensis* J. F. Gmel. with 3.38% and 8%, respectively. Eleven species recorded the least relative dominance of 0.42%, which may be as a result of the over-exploitation of the woody genetic resources.

#### 3.2. Diversity Index

The diversity of the sites is shown in **Table 3**; the Shannon-Weiner diversity index ( $H'$ ) value stood at 3.82. As diversity indices varied with location depending on the species available within an ecological zone, Rashad forest reserve is blessed with a moderate diversity index, which lies within the general limits of 1.5 - 3.5.

**Table 1.** List of all tree species, family, local name and frequency in the Rashad Area.

Family	Scientific name	Local name	Frequency
Anacardiaceae	<i>Lannea fruticosa</i> (Hochst. ex A. Rich.) Engl.	Layoun	4
Anacardiaceae	<i>Sclerocary birrea</i>	Homeid	2
Annonaceae	<i>Annona senegalensis</i> Pers.	Geshta Baldia	1
Apocynaceae	<i>Adenium obesum</i> (Forssk.) Roem. & Schult.	Shagrat El Sim-	1
Apocynaceae	<i>Calotropis procera</i> (Aiton) W. T. Aiton	Ushar-Al Aushar	1
Apocynaceae	<i>Carissa spinarum</i> L. (Syn: <i>Carissa edulis</i> (Forssk.) Vahl)	Allali	4
Arecaceae	<i>Borassus aethiopum</i> Mart.	Daleib	3
Arecaceae	<i>Hyphaene thebaica</i> (L.) Mart.	Dom	3
Bignoniaceae	<i>Kigelia africana</i> (Lam.) Benth.	Um Shtoor	6
Burseraceae	<i>Boswellia papyrifera</i> (Delile) Hochst.	Umm Tragtrag	1

## Continued

Burseraceae	<i>Commiphora africana</i> (A. Rich.) Engl.	Gaffal-Luban Dakar	5
Capparaceae	<i>Boscia senegalensis</i> (Pers.) Lam. ex Poir.	Mukhait-Kursan	2
Capparaceae	<i>Maerua crassifolia</i> Forssk	Sarah	5
Combretaceae	<i>Anogeissus leiocarpa</i> (DC.) Guill. & Perr.	Sahab-Silak	8
Combretaceae	<i>Combretum aculeatum</i> Vent.	Habil Shehait	6
Combretaceae	<i>Combretum hartmannianum</i> Schweinf.	Habil Al Gabal	1
Combretaceae	<i>Combretum glutinosum</i> Perr. ex DC.	Habil	3
Combretaceae	<i>Combretum molle</i> R. Br. ex G. Don.	Habil Khrisha	3
Combretaceae	<i>Guiera senegalensis</i> J. F. Gmel.	Gubeish	1
Combretaceae	<i>Terminalia brownii</i> Fresen.	Subagk-Shaf-Darot	7
Combretaceae	<i>Terminalia laxiflora</i> Engl. & Diels	Darout-Sufaraya	5
Ebenaceae	<i>Diospyros mespiliformis</i> Hochst. ex A. DC.	Goghan	3
Euphorbiaceae	<i>Ricinus communis</i> L.	Khirui-Khrwaiae	2
Euphorbiaceae	<i>Jatropha curcas</i> L.	Jatrupha	1
Fabaceae	<i>Piliostigma reticulatum</i> (DC.) Hochst.	Kharob	2
Fabaceae	<i>Tamarindus indica</i> L.	Aradeib-Al Aradeib	11
Fabaceae	<i>Dalbergia melanoxylon</i> Guill. & Perr	Abanous-Babanous	2
Fabaceae	<i>Erythrina abyssinica</i> Lam. ex DC.	Hab Al Aroos	3
Fabaceae	<i>Acacia gerrardii</i> Benth.	Salgam	1
Fabaceae	<i>Acacia nilotica</i> subsp. <i>adstringens</i> (Schumach. & Thonn.) Roberty	Garad-Sunt Abu Arida	3
Fabaceae	<i>Acacia oerfota</i> (Forssk.) Schweinf.	Al Laout	6
Fabaceae	<i>Acacia senegal</i> (L.) Willd.	Hashab	3
Fabaceae	<i>Acacia seyal</i> Delile. var. <i>seyal</i>	Talih Ahmer	4
Fabaceae	<i>Albizia amara</i> (Roxb.) Boivin	Arad-Al Arad	4
Fabaceae	<i>Albizia anthelmintica</i> Brongn.	Girfat Addud	1
Fabaceae	<i>Dichrostachys cinerea</i> (L.) Wight & Arn.	Kadad	6
Fabaceae	<i>Faidherbia albida</i> (Delile) A. Chev.	El Haraz	7
Lamiaceae	<i>Vitex doniana</i> Sweet	Um Touglgul	5
Fabaceae	<i>Prosopis africana</i> (Guill. & Perr.) Taub.	Abu Suruj	3
Malvaceae	<i>Adansonia digitata</i> L.	Tabaldi	9
Malvaceae	<i>Grewia tenax</i> (Forssk.) Fiori	Gudaim	1
Malvaceae	<i>Grewia villosa</i> Willd.	Tikko	9
Malvaceae	<i>Thespesia garckeana</i> F. Hoffm. (Syn: <i>Azanza garckeana</i> (F. Hoffm.) Exell & Hillc.)	Al Jaghjak	4
Malvaceae	<i>Sterculia setigera</i> Delile	Al Tartar	7
Meliaceae	<i>Khaya senegalensis</i> (Desr.) A. Juss.	Mahogany	3
Meliaceae	<i>Azadirachta indica</i> A. Juss.	Al Neem Al Baldi	2

## Continued

Moraceae	<i>Ficus sycomorus</i> L.	Al Gumaiz	1
Moringaceae	<i>Moringa oleifera</i> Lam.	Al Rawag	4
Olacaceae	<i>Ximenia americana</i> L.	Umm Medeka	7
Rhamnaceae	<i>Ziziphus spina-christi</i> (L.) Desf.	Nabag-Siddir	11
Rubiaceae	<i>Catunaregam nilotica</i> (Stapf) Tirveng. (Syn: <i>Xeromphis nilotica</i> (Stapf) Keay)	El marfaaein	8
Rubiaceae	<i>Nauclea latifolia</i> Sm. (Syn: <i>Sarcocephalus latifolius</i> (Sm.) E. A. Bruce)	Karmadoda	6
Rubiaceae	<i>Vangueria madagascariensis</i> J. F. Gmel.	Kirkir	8
Rutaceae	<i>Vepris nobilis</i> (Delile) Mziray	Fideila	9
Salvadoraceae	<i>Dobera glabra</i> (Forssk.) Poir.	Mikah	4
Zygophyllaceae	<i>Balanites aegyptiacus</i> (L.) Delile	Heglleeg	5
<b>Total</b>			<b>237</b>

**Table 2.** Comparison of relative density (RD), relative dominance (RDo), Basal area (BA), and important values (IVI) of the 56 species in the Rashad area.

Scientific name	RD (%)	BA	RDo (%)	IVI
<i>Lannea fruticosa</i> (Hochst. ex A. Rich.) Engl.	1.69	0.018	2.135	1.802
<i>Sclerocary birrea</i>	0.84	0.011	1.310	0.553
<i>Annona senegalensis</i> Pers.	0.42	0.003	0.342	0.072
<i>Adenium obesum</i> (Forssk.) Roem. & Schult.	0.42	0.015	1.860	0.392
<i>Calotropis procera</i> (Aiton) W. T. Aiton	0.42	0.003	0.371	0.078
<i>Carissa spinarum</i> L. (Syn: <i>Carissa edulis</i> (Forssk.) Vahl)	1.69	0.007	0.857	0.723
<i>Borassus aethiopum</i> Mart.	1.27	0.031	3.702	2.343
<i>Hyphaene thebaica</i> (L.) Mart.	1.27	0.044	5.376	3.403
<i>Kigelia africana</i> (Lam.) Benth.	2.53	0.028	3.426	4.337
<i>Boswellia papyrifera</i> (Delile) Hochst.	0.42	0.023	2.841	0.599
<i>Commiphora africana</i> (A. Rich.) Engl.	2.11	0.008	1.027	1.083
<i>Boscia senegalensis</i> (Pers.) Lam. ex Poir.	0.84	0.003	0.342	0.144
<i>Maerua crassifolia</i> Forssk	2.11	0.008	0.997	1.052
<i>Anogeissus leiocarpa</i> (DC.) Guill. & Perr.	3.38	0.019	2.280	3.848
<i>Combretum aculeatum</i> Vent.	2.53	0.022	2.711	3.431
<i>Combretum hartmannianum</i> Schweinf.	0.42	0.031	3.796	0.801
<i>Combretum glutinosum</i> Perr. ex DC.	1.27	0.035	4.286	2.713
<i>Combretum molle</i> R. Br. ex G. Don.	1.27	0.017	1.995	1.263
<i>Guiera senegalensis</i> J. F. Gmel.	0.42	0.004	0.465	0.098
<i>Terminalia brownii</i> Fresen.	2.95	0.019	2.354	3.477
<i>Terminalia laxiflora</i> Engl. & Diels	2.11	0.025	3.075	3.244

## Continued

<i>Diospyros mespiliformis</i> Hochst. ex A. DC.	1.27	0.028	3.355	2.123
<i>Ricinus communis</i> L.	0.84	0.005	0.570	0.241
<i>Jatropha curcas</i> L.	0.42	0.005	0.638	0.135
<i>Piliostigma reticulatum</i> (DC.) Hochst.	0.84	0.012	1.424	0.601
<i>Tamarindus indica</i> L.	4.64	0.028	3.372	7.826
<i>Dalbergia melanoxylon</i> Guill. & Perr	0.84	0.008	0.997	0.421
<i>Erythrina abyssinica</i> Lam. ex DC.	1.27	0.011	1.355	0.858
<i>Acacia gerrardii</i> Benth.	0.42	0.007	0.812	0.171
<i>Acacia nilotica</i> subsp. <i>adstringens</i> (Schumach. & Thonn.) Roberty	1.27	0.025	3.007	1.903
<i>Acacia oerfota</i> (Forssk.) Schweinf.	2.53	0.003	0.314	0.397
<i>Acacia senegal</i> (L.) Willd.	1.27	0.004	0.465	0.294
<i>Acacia seyal</i> Delile var. <i>seyal</i>	1.69	0.009	1.097	0.926
<i>Albizia amara</i> (Roxb.) Boivin	1.69	0.018	2.207	1.863
<i>Albizia anthelmintica</i> Brongn.	0.42	0.004	0.432	0.091
<i>Dichrostachys cinerea</i> (L.) Wight & Arn.	2.53	0.004	0.432	0.547
<i>Faidherbia albida</i> (Delile) A. Chev.	2.95	0.028	3.408	5.033
<i>Vitex doniana</i> Sweet	2.11	0.005	0.638	0.673
<i>Prosopis africana</i> (Guill. & Perr.) Taub.	1.27	0.009	1.087	0.688
<i>Adansonia digitata</i> L.	3.80	0.084	10.211	19.388
<i>Grewia tenax</i> (Forssk.) Fiori	0.42	0.003	0.342	0.072
<i>Grewia villosa</i> Willd.	3.80	0.002	0.287	0.545
<i>Thespesia garckeana</i> F. Hoffm. (Syn: <i>Azanza garckeana</i> (F. Hoffm.) Exell & Hillc.)	1.69	0.008	1.017	0.858
<i>Sterculia setigera</i> Delile	2.95	0.012	1.424	2.103
<i>Khaya senegalensis</i> (Desr.) A. Juss.	1.27	0.032	3.892	2.463
<i>Azadirachta indica</i> A. Juss.	0.84	0.023	2.824	1.192
<i>Ficus sycomorus</i> L.	0.42	0.015	1.834	0.387
<i>Moringa oleifera</i> Lam.	1.69	0.004	0.432	0.365
<i>Ximenia americana</i> L.	2.95	0.005	0.570	0.842
<i>Ziziphus spina-christi</i> (L.) Desf.	4.64	0.003	0.314	0.728
<i>Catunaregam nilotica</i> (Stapf) Tirveng. (Syn: <i>Xeromphis nilotica</i> (Stapf) Keay)	3.38	0.009	1.046	1.766
<i>Nauclea latifolia</i> Sm. (Syn: <i>Sarcocephalus latifolius</i> (Sm.) E. A. Bruce)	2.53	0.004	0.452	0.572
<i>Vangueria madagascariensis</i> J. F. Gmel.	3.38	0.003	0.371	0.626
<i>Vepris nobilis</i> (Delile) Mziray	3.80	0.003	0.314	0.596
<i>Dobera glabra</i> (Forssk.) Poir.	1.69	0.006	0.686	0.579
<i>Balanites aegyptiacus</i> (L.) Delile	2.11	0.023	2.824	2.979
<b>Total</b>	<b>100</b>	<b>0.83</b>	<b>100</b>	<b>96.308</b>



**Table 3.** Summary of diversity measures for trees in the Rashad area.

Index	Value
Species richness or variety	56
Diversity index/Shannon Index	3.8202
Average basal area	0.827096
Percent of Dominant Species	464.10%

#### 4. Conclusion

The tree girths, tree height and species enumeration were carried out. Key Informant Interview was also part of this study in which both junior and senior forest officials were interviewed. Tree diversity indices such as Shannon Wiener index and Simpson concentration index were used. It was concluded that the forest is quite rich in terms of tree species and that some species are at risk of extinction, which may be a result of over-exploitation, climatic and/or edaphic factors. The Important Value Index revealed the most ecologically important tree species in the study area and those to be prioritized for conservation. There is a need to have inventory, information system, research and development network, and a framework of legal provisions for identification, assessment and monitoring of species diversity of trees to make the area ecologically viable as well as a source of recreation.

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#### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

#### References

- Adesina, F. A. (1997). Vegetation Degradation and Environmental Changes in the Tropics. *Ifè Research Publications in Geography*, 6, 68-78.
- Armenteras, D., Rodríguez, N., & Retana, J. (2009). Are conservation strategies effective in avoiding the deforestation of the Colombian Guyana Shield? *Biological Conservation*, 142, 1411-1419. <https://doi.org/10.1016/j.biocon.2009.02.002>
- Asifat, J. T., Oyelowo, O., & Orimoogunje, O. O. I. (2019). Assessment of Tree Diversity and Abundance in Selected Forest Reserves in Osun State, Southwestern Nigeria. *Open Access Library Journal*, 6, 1-16.
- Badi, K. H., (2004). *Changing Forest Cover and Rainfall in Central Sudan during (1930-2000)*. MSc Thesis University of Khartoum—Faculty of Forestry.
- Brashears, M. B., Fajvan, M. A., & Schuler, T. M. (2004). An assessment of Canopy Strati-

- fication and Tree Species Diversity Following Clearcutting in Central Appalachian Hardwoods. *Forest Science*, 50, 54-64.
- Condit, R., Hubbell, S. P., & Foster, R. B. (1996). Assessing the Response of Plant Functional Types to Climatic Change in Tropical Forests. *Journal of Vegetation Science*, 7, 405-416. <https://doi.org/10.2307/3236284>
- Daldoum, D. M. A., & Massaud, M. M. (2018). Regeneration and Establishment of *Sclerocarya birrea* (A. Rich.) Hochst. Subsp. *birrea* by Different Land Preparation Methods in the Dry Lands, Nuba Mountains (Rashad District). *Sudan Journal of Desertification Research* 4, 122-180.
- El Ghazali, G. E. B. (1993). A Study on the Pollen Flora of Sudan. *Review of Palaeobotany and Palynology*, 76, 99-345. [https://doi.org/10.1016/0034-6667\(93\)90077-8](https://doi.org/10.1016/0034-6667(93)90077-8)
- Elsiddig, E. A., Mohamed, A. G., & Abdel Magid, T. D. (2011). *Forest Plantations/Woodlots in the Eastern and North-Eastern African Countries of Kenya, Tanzania, Uganda, Burundi, Rwanda, Ethiopia and Sudan*. Sudan Report, African Forest Forum.
- Elsiddig, E. A., Mohamed, A. G., & Abdel Magid, T. D. (2007). *Sudan Forestry Sector Review*. Forests National Corporation and National Forest Programme Facility.
- Gentry, A. H. (1992). Tropical Forest Biodiversity: Distributional Patterns and Their Conservational Significance. *Oikos*, 63, 19-28. <https://doi.org/10.2307/3545512>
- Kent, M. C., & Coker, P. P. (1992). *Vegetation Description and Analysis: A Practical Approach*. London, British Library, 363 p.
- Kunwar, R.M. and Sharma, S.P. (2004). Quantitative Analysis of Tree Species in Two Community Forests of Dolpa District, Mid-West Nepal. *Himalayan Journal of Sciences*, 2, 23-28. <https://doi.org/10.3126/hjs.v2i3.226>
- Mani, S., & Parthasarathy, N. (2006). Tree Diversity and Stand Structure in Inland and Coastal Tropical Dry Evergreen Forests of Peninsular India. *Current Science*, 1238-1246.
- Mukhtar, M. E., and El Wakeel, A. S., (2002). Biodiversity in Forest Plant of Sudan. National Biodiversity Strategy and Action Plan (NBSAP)—(SUD/97/G31/A/IG). Higher Council for Environment and Natural Resources (HCENR).
- Pantuliano, S. (2005). *Changes and Potential Resilience of Food Systems in the Nuba Mountains Conflict* (No. 05-07).
- Sharma, C. M., Suyal, S., Gairola, S., & Ghildiyal, S. K. (2009). Species Richness and Diversity along an Altitudinal Gradient in Moist Temperate Forest of Garhwal Himalaya. *Journal of American Science*, 5, 119-128.
- Shiferaw, W., Lemenih, M., & Gole, T. W. M. (2018). Analysis of Plant Species Diversity and Forest Structure in Arero Dry Afromontane Forest of Borena Zone, South Ethiopia. *Tropical Plant Research*, 5, 129-140. <https://doi.org/10.22271/tpr.2018.v5.i2.018>
- Suratman, M. N. (2012). Tree Species Diversity and Forest Stand Structure of Pahang National Park, Malaysia. *Biodiversity Enrichment in a Diverse World*, 19, 45-56.