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Diversity and Regeneration Status of Woody Species: The Case of Keja Araba and Tula Forests, South West Ethiopia

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Abstract

Deforestation and habitat fragmentation are the major environmental concerns in southwest Ethiopia. Understanding woody species diversity and socio-economic factors causing destruction of natural forests is crucial in the management of the remnant forest ecosystems. However, the forest in south west Ethiopia is poorly studied. This paper examines the diversity, regeneration status, socio-economic importance of the forests in Kaja Araba and Tula forests, southwestern Ethiopia. A systematic sampling strategy was used to collect vegetation data from the natural forests, while Participatory Rural Appraisal (PRA) method was employed to generate the socio-economic data. A total of 60 square plots (30 for each forests measuring 10 m × 10 m) were established along line transects laid across the forests. Primary data were collected by field observation, semi-structured interview with key informants and discussion with relevant stakeholders. A total 51 woody species representing 25 families were found in the study area and of all the species 30 (59%) were trees, 18 (35%) trees/shrubs, and 3 (6%) shrubs. The most species rich families were Rubiaceae, Fabaceae, Euphorbiaceae and Moraceae. The Shannon diversity and evenness of woody species in Keja Araba forest are 2.81 and 0.79, respectively and in Tula forest they are 3.14 and 0.86, respectively. *Millettia ferruginea* is the most frequent and abundant species at Keja Araba natural forest, while *Vepris dainellii and Phoenix reclinata* are the most frequent and abundant woody species at Tula natural forest, respectively. The total basal area of woody species in Keja Araba forest is 2612 $m^2 \cdot ha^{-1}$ and in Tula forest the value is 3751 $m^2 \cdot ha^{-1}$. In Keja Araba forest, the species with the highest IVI value are *Sapium ellipticum*, and in Tula forest it is *Schefflera abyssinica.* The results on the importance value index (IVI) and DBH class distributions show that the species with low IVI value and poor regeneration status need to be prioritized for conservation. Data collected from the key informants reveal that the forest is the major sources of fuel wood (94%), forest coffee and spices (80%), construction material (78%), timber (60%) and farm implements (58%). The forests are also sources of medicines, animal fodder, bee forage, handles tools and household utensils. Anthropogenic factors such as expansion of agricultural land, fuel wood collection, charcoal making, land use change by investors and settlements of people are responsible for destruction of natural forest in the study area, in descending order of severity. Thus,

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it is important to give conservation priority to the last Afromontane forest remnants in southwestern Ethiopia to achieve sustainable utilization of the forest ecosystems.

Keywords

Natural Forest, Woody Species, Basal Area, IVI, Conservation, Socio-Economic Importance

Subject Areas: **Environmental Sciences**

1. Introduction

Plant species diversity is a key issue of biological diversity. The diversity of woody species is fundamental to total forest biodiversity, because woody species provide resources and habitats for almost all other forest species [1] [2]. Human population growth and the demand for natural resources have put great pressure on the biodiversity wealth of the world through deforestation and habitat fragmentation [3] [4].

Ethiopia owns diverse vegetation resources that include high forests, woodlands, bushlands, plantations, and trees outside forests. These forest resources comprise huge wealth of biological resources. Diverse topography, soil and climate are the primary reason for the high diversity of these forests [5]. However, accelerated deforestation and habitat fragmentation are major environmental threats in the country and result in several socio-economic and environmental challenges that have strongly affected the capacity of forests to provide ecosystem services [6] [7]. Agricultural expansion seems to be the number one reason for deforestation in the area, as in many tropical countries. The other major factors stated as responsible for destruction of natural forests are over-exploitation without replanting for various purposes such as fuelwood, charcoal, construction material and timber [8].

Southern and southwestern parts of Ethiopia comprise most of the remaining natural forests of the country. The forest provide food, medicine, energy, fodder, farm implement and construction materials [9]. The forests hold diverse wild animal species, which play a significant role in gene flow between coffee shade trees and adjacent forest tree populations. The forests are also important resources for non-timber products and off-farm economic activities like honey and spices [10] [11]. Despite the fact that the study areas are so important to the country and the world at large, pressure exerted by anthropogenic factors is so significant and unless appropriate and immediate measures being taken the invaluable forest resource may be lost in a very short period of time.

Better understanding on woody species diversity, composition, population structure, and other ecological perspectives is very crucial for conservation and sustainable utilization of forest resources. Moreover, knowledge on woody species diversity and population structure is important for developing management strategies and setting priorities [5].

Many studies have been conducted in different parts of the country to investigate the population dynamics and regeneration ecology of forests including [12]-[23] and [5]. Despite of all these studies, there is little scientific information available on woody species diversity in natural forest in southwest Ethiopia. The flora of southwestern Ethiopia has been among the least known in the tropical Africa until recent years, mainly due to lack of access [19]. In order to ensure the conservation, management and sustainable utilization of these forests, describing the vegetation is urgently needed. Therefore, this research is aimed at: (i) assessing the diversity of woody species in the forests; (ii) characterizing the population structure and regeneration status of woody species; (iii) investigating the socio-economic importance of the forest for the surrounding communities.

2. Materials and Methods

2.1. Study Area

The study was conducted in Tula and Keja Araba forests located in Gimbo District, southwestern Ethiopia (**Figure 1**). Gimbodistrict is found in Kaffa Zone within the Southern Nations Nationality Regional State, 460 km southwest of Addis Ababa. It is situated between 07˚00' - 7˚25'N Latitude and 35˚55' - 36˚37'E Longitude and within altitudinal range from 1600 to 1900 m. The topography is characterized by slopping and rugged areas

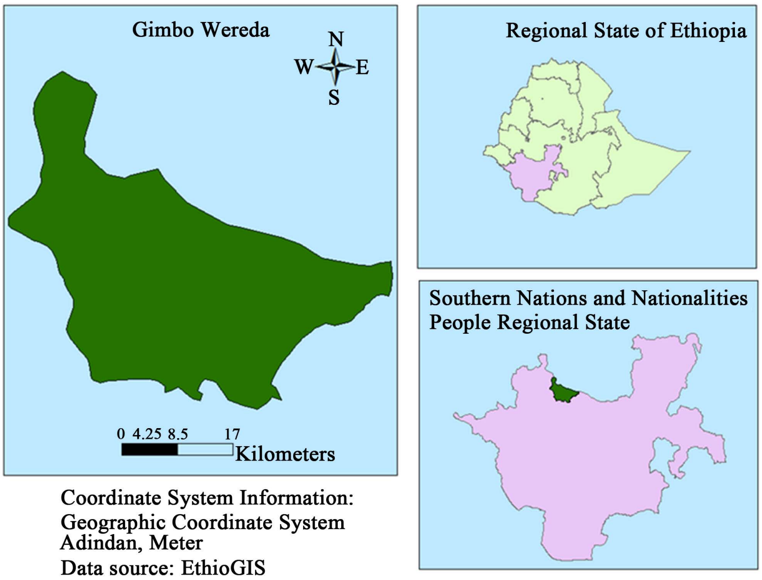

Figure 1. Map of study area.

with very little plain land. The area experiences one long rainy season, lasting from March/April to October. The mean annual rainfall ranges from 1710 mm to 1892 mm. Over 85% of the total annual rainfall, with mean monthly values in the range of 125 - 250 mm occurs in the 8 months long rainy season. The mean temperature ranges from 18.1˚C to 19.4˚C [24]. The soils of the area are deep, clay red soils with an agric B-horizon dystric-nitosols. The soils have good agricultural potentialities, good physical properties and uniform profile. They are porous, clay-to-clay loam in texture and have low base saturation with less than 5.5 pH values and well drained [25]. Forests of both sites have been designated as National Forest Priority areas (NFPA).The inhabitants of the study area are from Kaffa and Amhara ethnic group, and they speak Kafignya and Amharic language respectively. The majority of the people are Orthodox Christians and few are Catholic and Muslims. The forest ecosystem in the area makes an important contribution to the livelihoods of people in the area in a variety ways. The forest provides shade for coffee and a variety of commercially valuable spices. The forests also supply rural communities with fuel wood and timber, which they use both for household consumption and for sale.

2.2. Methods

A systematic sampling design was used in this study to collect data on woody species. Following the line transect method described by Bullock [26] parallel line transects were laid across the forests. Plots (10 m × 10 m) were established along the line transects at 300 m intervals. A total of 30 sampling plots, spaced 200 m, were laid in the forests. In each plot, all woody species were identified by their local and/or scientific names and identities that help for identification were recorded and diameter at breast height (DBH, 1.3) for all woody species ≥5 cm was measured. Within the major plots by designating "X" design, five 2 m * 2 m subplots were set up. These plots were used to collect two sets of vegetation data: 1) saplings (with dbh < 5 cm and >1.5 m in height) and 2) seedlings. Key informants and sampled HHs were used to provide local names of the encountered woody species. After vernacular names were known, scientific names were identified with the help of publications of Flora of Ethiopia and Eritrea [27]-[31].

Participatory Rural Appraisal (PRA) method was used to collect socio-economic data following Martin [32] and Cunningham [33]. Data were collected by field observation, semi-structured interview with key informants and discussion with relevant stakeholders. Field observation was made on land use types, extent of soil erosion and forest degradation, forest management systems and human impacts on the forest ecosystems. A semi-structured/open-ended questionnaire was prepared in advance. Totally twenty key informants, ten from each sites, were selected and interviewed. During the interview with key informants, emphasis was given to issues related to the forests in order to get in-depth information about the past and present status, forest management systems, utilization and major threats.

2.3. Data Analysis

Shannon-Wiener Diversity Index (H'), Simpson's diversity index (D) and Evenness or Equitability Index (E) were used to estimate the diversity of woody species in the natural forests. Shannon-Wiener Diversity Index (H') was calculated as $H' = -\sum p_i \ln p_i$, [34] where P_i is the proportion of individuals, n = Total number of individuals. Simpson's diversity was also calculated as:

$$D = 1 - \sum p_i^2$$

where P_i = as described above. The measure of evenness (E) which is the ratio of observed diversity to maximum diversity is calculated as $E = H^! / H_{max} = H^! / \ln$ [34]. The similarity in woody species composition between the forests was computed by using Sorensen coefficient of similarity (S_s) index:

$$S_s = 2a/(2a + b + c)$$

where a = number of species common to both samples, b = number of species in sample 1, c = number of species in sample 2. The coefficient is multiplied by 100 to give a percentage [35]. The density and percentage frequency of woody species were calculated. The DBH data of trees and shrubs were categorized into eight classes, and presented by using histograms. Basal area of trees and shrubs with DBH ≥ 5 cm was calculated. The Importance Value Index (IVI) [36] [37] for each woody species was computed using the following formula: Relative dominance = (basal area for a species/total basal area) × 100.

Relative density = (number of individuals of a species/total number of individuals) × 100, Relative frequency = (frequency of a species/sum of all frequencies) × 100.

Importance value Index = Relative density + Relative dominance + Relative frequency

Microsoft Office Excel Software was used for the analysis of the socio-economic data and the results of the analysis were presented using descriptive statistics.

3. Results and Discussion

3.1. Floristic Composition

A total of 51 woody species representing 25 families were identified from Keja Araba and Tula forests. Rubiaceae, Fabaceae, Euphorbiaceae and Moraceae were the most abundant families. The value of woody species richness in natural forest at Keja Araba and Tula site were 40 and47 respectively. From the total woody species, 30 (59%) were trees, 18(35%) trees/shrubs, and 3 (6%) shrubs.

3.2. Similarity

Similarity in woody species composition from the total species identified, 37 species were found in both Keja Araba and Tula forests (**Appendix**). The similarity in species composition between Keja Araba and Tula forests was 0.46. The similarity coefficient was below 0.5 (maximum is 1.0), indicating that there is low similarity among the forests and each forest has its own characteristic species. This is mainly attributed to altitudinal and the extent of disturbance difference between the two sites.

3.3. Diversity of Woody Species

In order to get better picture on extent of woody species diversity, several diversity indices were employed for study sites. The value of diversity indices in natural forest at Keja Araba and Tula site were 2.81, 0.91, 0.79 and 3.14, 0.99, 0.86 for Shannon, Simpson and Evenness respectively (**Table 1**). The results indicated that the value

Table 1. Comparison of species richness and diversity indices of woody species among Keja Araba and Tula forests, Gimbo district.

Forest	Species Richness	Diversity Index Values		
		Shannon	Simpson	Evenness
Keja Araba	40	2.81	0.91	0.79
Tula	47	3.14	0.99	0.86

of diversity indices of woody species at Tula forest were relatively higher than Kaja Araba forest. Site characteristic heterogeneity could be the reason for observed differences in woody species diversity. Agro-ecological factors such as altitude, temperature and soil quality could be a source of variation in plant diversity [38]. Besides, low human disturbance at Tula forest as it is less accessible site than Keja Araba could be another factor that generates difference in woody species diversity. Such results are consistent with study of Zegeye *et al.* [5] in northwestern Ethiopia, who reported negative effect of site accessibility on woody species diversity. Forest disturbance influences species through alteration and fragmentation of forests, which is a serious concern in the management tropical forests [39]. The evenness value (0.86) for Tula forest showed that there is more or less balanced distribution of individuals of different species than Keja Araba forest. On the other hand, the low evenness for Keja Araba forest with comparing to that of Tula indicated that there is unbalanced representation of individuals of different species because of high human disturbance as well as site and species characteristics. The reason for low evenness can be attributed to excessive disturbance, variable conditions for regeneration and over-exploitation of some species [20]. The diversity and evenness indices imply the need to conserve the forests at Keja Araba site from human disturbance.

3.4. Frequency and Abundance of Woody Species

*Millettia ferruginea*is the most frequent species recorded in 50 % of the plots at KejaA raba natural forest. It is also the most abundant woody species followed by *Phoenix reclinata* and *Sapium ellipticum* (**Table 2**). *Vepris dainellii*is the most frequent species recorded in 50% of the plots at Tula natural forest. *Phoenix reclinata* is the most abundant woody species followed by *Vepris dainellii* and *Millettia ferruginea* (**Table 3**). In addition to topographical, climatic and edaphic factors [40] [41], habitat preferences among the species, species characteristics for adaptation, degree of exploitation and conditions for regeneration could be the reasons for the variation in abundance and frequency woody species.

3.5. Basal Area and IVI of Woody Species

The total basal area of woody species in Keja Araba and Tula forests were 2611 and 3761 $m^2 \cdot ha^{-1}$, respectively (**Table 2** and **Table 3**). The reason for such variation is that Keja Araba forest highly disturbed than Tula due to its accessibility for road and town. In Keja Araba forest, the species with the highest basal area was *Sapium ellipticum* (545.49 $m^2 \cdot ha^{-1}$), followed by *Ritchie steudneri* (318.50 $m^2 \cdot ha^{-1}$), *Schefflera abyssinica* (288.44 $m^2 \cdot ha^{-1}$), *Milettia ferruginea* (232.08 $m^2 \cdot ha^{-1}$), *Dracaena steudneri* (220.22 $m^2 \cdot ha^{-1}$), *Schrebera alata*(176.71 $m^2 \cdot ha^{-1}$), *Aningeria adolfi-friederici* (176.71 $m^2 \cdot ha^{-1}$) and *Olea welwitschii* (166.90 $m^2 \cdot ha^{-1}$). Some species like *Schefflera abyssinica*, *Schrebera alata*, *Aningeria adolfi-friederici* and *Olea welwitschii* had high basal area because of their large size though they had low frequency and abundance. In Tula forest, the species with the highest basal area was *Schefflera abyssinica* (1491.64 $m^2 \cdot ha^{-1}$), followed by *Sapium ellipticum* (375.96 $m^2 \cdot ha^{-1}$), *Olea welwitschii* (296.85 $m^2 \cdot ha^{-1}$), *Ritchie asteudneri* (237.18 $m^2 \cdot ha^{-1}$), *Ficussur* (222.39 $m^2 \cdot ha^{-1}$), *Albizia gummifera* (183.48 $m^2 \cdot ha^{-1}$), *Croton macrostachyus* (171.05 $m^2 \cdot ha^{-1}$) and *Phoenix reclinata* (155.53 $m^2 \cdot ha^{-1}$). Some species like *Schefflera abyssinica and Olea welwitschii*h ad high basal area because of their large size and high abundance and frequency. To evaluate the importance of each species, the IVI was estimated for the woody species (>5 cm) recorded in the natural forest (**Table 2** and **Table 3**). In Keja Araba forest, the species with the highest IVI value was *Sapium ellipticum* (45.18), followed by *Milettia ferruginea* (37.04), *Ritchie asteudneri* (27.95), *Phoenix reclinata* (27.33), *Dracaena steudneri* (21.34), *Schefflera abyssinica* (16.40), *Croton macrostachyus* (15.21), *Olea welwitschii* (10.41) and *Cordia africana* (9.11). The high IVI value of *Phoenix reclinata* and *Cordia Africana* was because of their high relative density and relative frequency, though they had low relative dominance/basal area. In Tula forest, the species with the highest IVI value was *Schefflera abyssinica* (51.26), followed by *Phoenix reclinata* (25.15), *Vepris dainellii* (21.01), *Olea welwitschii* (16.38), *Milettia ferruginea* (15.41), *Sapium ellipticum* (14.86), *Ficussur* (12.77), *Croton macrostachyus* (12.42) and *Ficus palmata* 11.30). The high IVI value of *Vepris dainellii* and *Milettia ferruginea* was because of their high relative density and relative frequency though they had low relative dominance. On the other hand, the high IVI value of *Schefflera abyssinica* and *Sapium ellipticum* were because of its high relative basal area though it had low relative density and relative frequency. Woody species with the highest importance values are those that exist in the greatest number or are of the greatest size—these are woody species that may have the greatest effect on the community. The IVI values can be used as an input for conservation strategies to protect woody species against anthropogenic factors [17]. The results suggest that the species having low IVI value should be attention for conservation.

Table 2. Frequency, relative frequency, abundance, relative density, dominance, relative dominance and IVI of woody species (dbh > 5 cm) in Kaja Araba forest.

Species Name	Frequency	Relative frequency (%)	Abundance	Relative density (%)	Basal area (m^2/ha)	Relative dominance (%)	IVI
Albizia gummifera	2	1.67	2	1.01	29.06	1.11	3.79
Allophyllus macrobotrys	2	1.67	3	1.52	0.92	0.04	3.22
Allophyllus rubifolius	1	0.83	1	0.51	0.79	0.03	1.37
Allophylus abyssinicus	1	0.83	1	0.51	5.73	0.22	1.56
Aningeria adolfi-friederici	1	0.83	1	0.51	176.71	6.77	8.10
Canthium oligocarpum	2	1.67	2	1.01	7.36	0.28	2.96
Cordia africana	5	4.17	9	4.55	10.51	0.40	9.11
Croton macrostachyus	6	5	13	6.57	95.10	3.64	15.21
Dracaena steudneri	7	5.83	14	7.07	220.22	8.43	21.34
Ehretia cymosa	3	2.50	4	2.02	10.88	0.42	4.94
Ficus ovata	1	0.83	1	0.51	50.27	1.92	3.26
Ficus palmata	2	1.67	2	1.01	10.12	0.39	3.06
Ficus sur	5	4.17	6	3.03	28.93	1.11	8.30
Ficus thonningii	1	0.83	1	0.51	3.14	0.12	1.46
Galinier asaxifraga	2	1.67	2	1.01	2.22	0.08	2.76
Landolphia owarensis	1	0.83	2	1.01	48.91	1.87	3.72
Lepidotrichilia volkensilia	2	1.67	3	1.52	3.50	0.13	3.32
Macaranga kilmandscharica	3	2.50	3	1.52	19.87	0.76	4.78
Maesa lanceolata	1	0.83	1	0.51	4.15	0.16	1.50
Millettia ferruginea	15	12.50	31	15.66	232.08	8.89	37.04
Olea welwitschii	3	2.50	3	1.52	166.90	6.39	10.41
Phoenix reclinata	11	9.17	28	14.14	105.13	4.03	27.33
Polyscias fulva	1	0.83	1	0.51	9.62	0.37	1.71
Rhamnus prinoides	1	0.83	1	0.51	4.91	0.19	1.53
Ritchiea steudneri	8	6.67	18	9.09	318.50	12.20	27.95
Rothmannia Aurce lliformis	1	0.83	1	0.51	1.13	0.04	1.38
Sapium ellipticum	14	11.67	25	12.63	545.49	20.89	45.18
Schefflera abyssinica	4	3.33	4	2.02	288.44	11.04	16.40
Schrebera alata	1	0.83	1	0.51	176.71	6.77	8.10
Syzygium guineense	4	3.33	4	2.02	29.14	1.12	6.47
Vepris dainellii	5	4.17	6	3.03	3.51	0.13	7.33
Vernonia amygdalina	2	1.67	2	1.01	0.74	0.03	2.71
Vernonia auriculifera	2	1.67	2	1.01	1.02	0.04	2.72
Total	120	100	198	100	2611	100	300

Table 3. Frequency, relative frequency, abundance, relative density, dominance, relative dominance and IVI of woody species (dbh > 5 cm) in Tula forest.

Species	Frequency	Relative Frequency (%)	Abundance	Relative Density (%)	Basal area (m^2/ha)	Relative Dominance (%)	IVI
Albizia gummifera	5	3.01	7	2.83	183	4.88	10.72
Allophyllus macrobotrys	5	3.01	6	2.43	4	0.11	5.55
Apodytes dimidiata	2	1.20	2	0.81	13	0.35	2.36
Canthium oligocarpum	3	1.81	3	1.21	3	0.08	3.10
Celtis africana	2	1.20	2	0.81	12	0.32	2.33
Chionanthus mildbraedii	4	2.41	6	2.43	3	0.08	4.92
Clausena anisata	3	1.81	4	1.62	4	0.11	3.53
Cordia africana	4	2.41	4	1.62	7	0.19	4.22
Croton macrostachyus	7	4.22	9	3.64	171	4.56	12.42
Dracaena steudneri	6	3.61	8	3.24	18	0.48	7.33
Ehretia cymosa	4	2.41	5	2.02	8	0.21	4.65
Ekebergia capensis	2	1.20	2	0.81	62	1.65	3.67
Ficus palmata	7	4.22	9	3.64	129	3.44	11.30
Ficus sur	6	3.61	8	3.24	222	5.92	12.77
Ficus thonningii	1	0.60	1	0.40	7	0.19	1.19
Galinier asaxifraga	4	2.41	7	2.83	5	0.13	5.38
Illex mitis	4	2.41	11	4.45	33	0.88	7.74
Justicia schimperana	2	1.20	3	1.21	1	0.03	2.45
Lepidotrichili avolkensilia	3	1.81	3	1.21	58	1.55	4.57
Macaranga kilmandscharica	1	0.60	1	0.40	3	0.08	1.09
Margaritaria discoidea	1	0.60	2	0.81	50	1.33	2.75
Millettia ferruginea	11	6.63	18	7.29	56	1.49	15.41
Ocotea kenyensis	1	0.60	1	0.40	2	0.05	1.06
Olea welwitschii	8	4.82	9	3.64	297	7.92	16.38
Oxyanthus speciosus	3	1.81	3	1.21	2	0.05	3.08
Phoenix reclinata	12	7.23	34	13.77	156	4.16	25.15
Pittosporum abyssinicum	1	0.60	1	0.40	1	0.03	1.03
Polyscias fulva	4	2.41	4	1.62	58	1.55	5.58
Rhamnus prinoides	6	3.61	11	4.45	40	1.07	9.13
Ritchie asteudneri	4	2.41	5	2.02	237	6.32	10.75
Sapium ellipticum	4	2.41	6	2.43	376	10.02	14.86
Schefflera abyssinica	11	6.63	12	4.86	1492	39.78	51.26
Schrebera alata	1	0.60	1	0.40	4	0.11	1.11
Syzygium guineense	2	1.20	3	1.21	4	0.11	2.53
Teclea nobliis	4	2.41	5	2.02	5	0.13	4.57
Vepris dainellii	15	9.04	28	11.34	24	0.64	21.01
Vernonia amygdalina	3	1.81	3	1.21	1	0.03	3.05
Total	166	100	247	100	3751	100	300

3.6. Natural Regeneration and Diameter Class Distribution

Figure 2 and **Figure 3** presents the DBH class distributions of the most important woody species (having higher IVI values) in the forests. In Tula natural forest, *Ritchie asteudneri*, *Vepris dainellii*, and *Ficus palmata* was the most abundant in the lowest diameter class which suggests that they have good regeneration potential. *Millettia ferruginea* was dominated in both lowest and middle diameter classes. A seedling bank is crucial for old forests because it provides individuals that will eventually influence the composition of future plant communities [42]. In Keja Araba natural forest, *Cordia africana* was poorly represented in the middle and higher diameter classes.

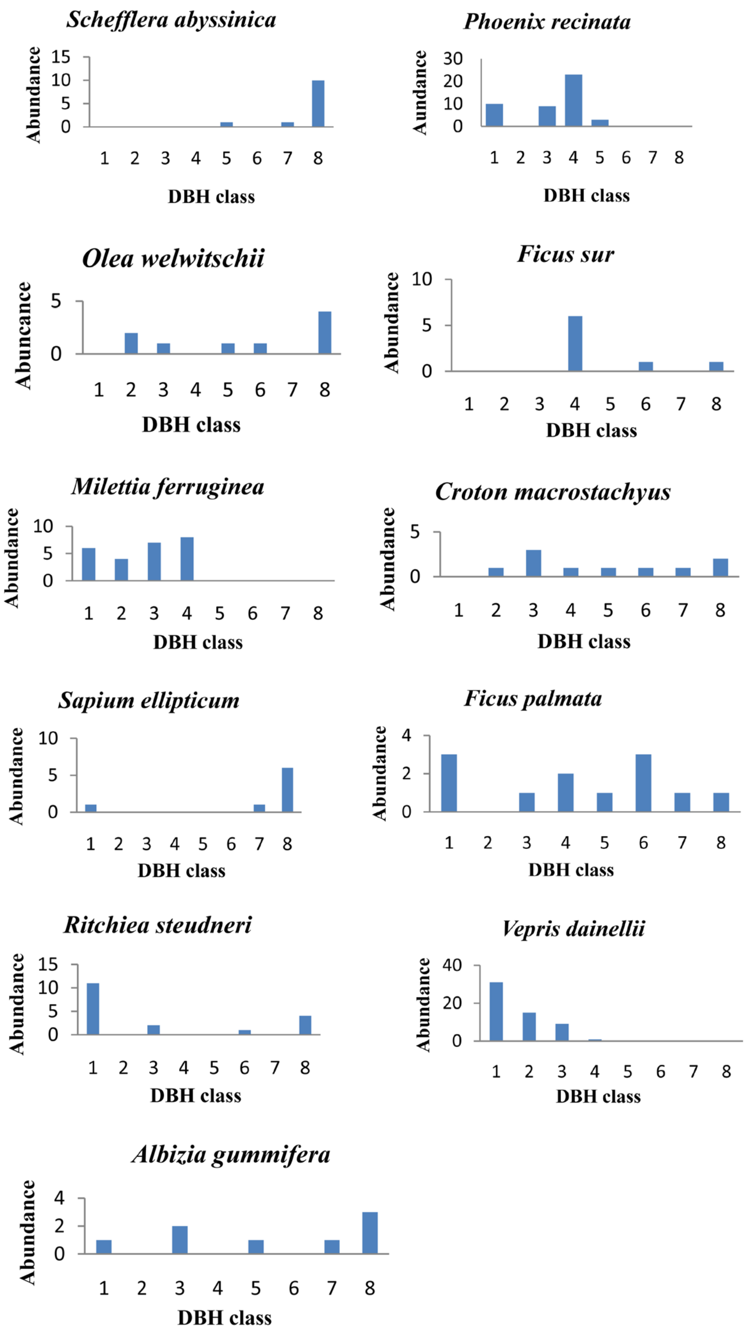

Figure 2. DBH class distributions of some important woody species (having higher IVI values) in Tula forests. (DBH classes: 1: <5 cm; 2: 5 - 10 cm; 3: 11 - 20 cm; 4: 21 - 30 cm; 5: 31 - 40 cm; 6: 41 - 50 cm; 7: 51 - 60 cm; 8: > 60).

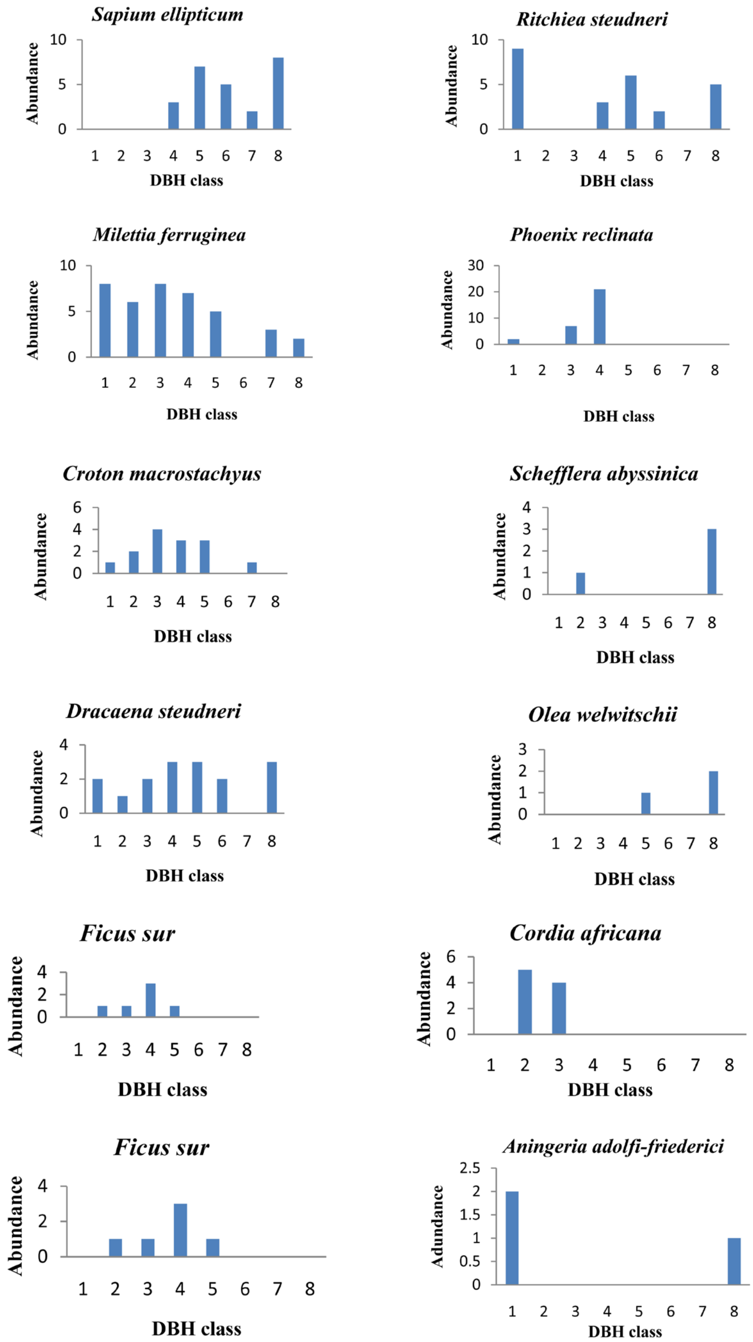

Figure 3. DBH class distributions of some important woody species (having higher IVI values) in Keja Araba forests. (DBH classes: 1: <5 cm; 2: 5 - 10 cm; 3: 11 - 20 cm; 4: 21 - 30 cm; 5: 31 - 40 cm; 6: 41 - 50 cm; 7: 51 - 60 cm; 8: >60).

This is because the removal of tree for timber and construction material and this phenomenon could lead to local extinction. *Ritchie asteudneri* and *Millettia ferruginea* were the two most abundant woody species represented in the seedling bank which suggests that they have good regeneration potential. *Sapium ellipticum*, *Olea welwitschii* and *Schefflera abyssinica* was dominated in higher diameter classes and poorly represented in the lower diameter classes. Both in Tula and Keja Arabaforest *Schefflera abyssinica*was dominated in higher diameter classes and was not represented in the seedling bank. This is could be due to epiphytic recruitment regeneration strategy of the species.

3.7. Use Value and Threats of the Forest Resources

The forest resource in the study area makes an important contribution to the livelihoods of the people. The responses from the key informants indicated that Kaja Araba and Tula forests are the major sources of fuel wood (94%), forest coffee and spices (80%), construction material (78%), timber (60%) and farm implements (58%). They are also the sources of honey production (bee forage and hang up bee hives), medicines, animal fodder, handles tools and household utensils. The forests are recognized and designated by United Nations Educational, Scientific and Cultural Organization (UNESCO) in June 2010 as a biosphere reserve [43] and they are potential sites for scientific research, education and tourism industry. However, the forest cover of the area was decreasing alarmingly. According to the key informants, the main causes of forest degradation in the study area were expansion of agricultural land, fuel wood collection, charcoal making, land use change by investors (especially for coffee and tea plantation) and settlements of people, in descending order of severity. Over exploitation of the forests for wood products has resulted in the reduction of some of the economically important tree species like *Cordia africana*, *Phoenix reclinata*, *Vepris dainellii* and *Milettia ferruginea*.

3.8. Planting and Retaining of Woody Species

In the study area, there is a tradition of retaining woody species during conversion of forestland to agricultural land. Farmers have retained different woody species in their homegardens and agricultural landscape while converting the original forest to settlement areas. The number and type of species retained by respondents differed and some species (e.g. *Millettia ferruginea*, *Vernonia amygdalina*, *Ficus sur*, *Croton macrostachyus* and *Sapium ellipticum*) were more frequently retained than others.

In addition to retention of woody species, planting of different woody species is widely practiced in the study area. The frequency of planting of these species is quite different among households and some species (e.g. *Coffea arabica*, *Albizzia gummifera*, *Persea americana*, *Erythrina* spp., *Cordia africana*, and *Eucalyptus camaldulensis*) are more commonly planted than others. Besides control of soil erosion, trees retained and/or planted in the agroforestry systems provide various products such as fuelwood, construction material, farm implements, animal fodder and bee forage. They also serve as shade for coffee and spices, and live fences. Thus, the agroforestry systems reduce the pressure on the natural forests. The indigenous resource management systems and practices are of great importance and deserve special attention since they have the potential to promote the conservation of biodiversity. The indigenous/traditional resource conservation and management systems and practices of rural communities in Ethiopia promoted the conservation of genetic resources for centuries [44].

4. Conclusion

Tula and Keja Araba forests support high species richness and diversity. The similarity in species composition among the forests is low, indicating that each forest has its own characteristic species. Tula forest has higher diversity and evenness of woody species than Keja Araba, and this is attributed to the existence of heterogeneity in site characteristics and the extent of anthropogenic factors. The diversity and evenness indices indicate the need to give attention to reduce disturbance impact as a result of overexploitation of the natural forest in the area. The IVI values reveal the most ecologically important woody species in the forests and those to be prioritized for conservation. The DBH class distributions show that some species are in poor regeneration status due to human disturbance. The species having low IVI values and poor regeneration status need to be prioritized for conservation. The forests provide various products such as fuelwood, forest coffee and spices, construction material, timber, farm implements, medicines, animal fodder, bee forage and edible fruits. Despite their socio-economic and ecological importance, at present, the forests are under increased human pressure. Tree cutting for various purposes, farmland expansion and investment activities are the major threats to the forest resources.

5. Recommendations

In order to ensure sustainable utilization of the forest resources, the following recommendations are suggested.

- Research and/or development action is needed to stimulate regeneration by those species having low IVI values and poor regeneration status.
- It is necessary to promote improved agroforestry technologies that could help farmers to get woody and non-woody forest products from their farmlands and hence, reduce the pressure on the natural forests.

- Efforts should be made to provide the local communities with energy-saving stoves and alternative sources of energy in order to reduce the dependency on the forests for fuel wood.
- Due consideration should be given to compromise the issue of investment with sustainable utilization of forest resources in the area.

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Appendix

List of woody species encountered in Keja Araba and Tula forests with corresponding family and local names, life form and spatial distribution.

Species name	Family name	Local name	Life form	Keja Araba	Tula	Keja Araba* Tula
Albizia gummifera (J.F.Gmel.) C.A.Sm.	Fabaceae	Catto	T	1	1	1
Albizia schimperiana Oliv.	Fabaceae	Koyo	T	0	1	0
Allophyllus macrobotrys Gilg	Sapindaceae	Shahiyo	S/T	1	1	1
Allophyllus rubifolius (Hochst. erA. Rich). Engl.	Sapindaceae	Gurasedo	S/T	1	1	0
Allophylus abyssinicus (Hoschs.) Radlk.	Sapindaceae	Sheho	T	1	1	1
Aningeria adolfi-friederici (Engl.) Robyns& Gilbert	Sapotaceae	Kerero	T	1	0	0
Apodytes dimidiata E. Mey-ex Am.	Icacinaceae	Wundefo	T	0	1	0
Canthiu moligocarpum Hiern	Rubiaceae	Titiribo	T	1	1	1
Celtis africana Burm.f.	Ulmaceae	Shishu	T	0	1	0
Chionanthus mildbraedii (Gilg & Schellenb.) Stearn	Oleacea	Shigio	T/S	1	1	1
Clausena anisata (willd.) Benth.	Rutaceae	Imbrito	T/S	1	1	1
Coffea arabica L.	Rubiaceae	Bunoo	T/S	1	1	1
Cordia africana Lam.	Boraginaceae	Di'oo	T	1	1	1
Croton macrostachyus Del.	Euphorbiaceae	Wago	T	1	1	1
Dracaena steudneri Engler	Dracenaceae	Yudo	T/S	1	1	1
Ehretia cymosa Thonn.	Boraginaceae	Wegamo	T/S	1	1	1
Ekebergia capensis Sparrman	Meliaceae	Ororo	T	1	1	1
Ficus ovata Vahl	Moraceae	Shetopo	T	1	0	0
Ficus palmata Forssk.	Moraceae	Shoto	T	1	1	1
Ficus sur Forssk.	Moraceae	Chapharo	T	1	1	1
Ficus thonningii Blume	Moraceae	Tigago	T/S	1	1	1
Galinier asaxifraga (Hochst.) Bridson	Rubiaceae	Dido	T	1	1	1
Illex mitis (L.) Radlk	Meliaceae	Qeto	T	1	1	1
Justicia schimperana (Hochst. Ex Nees) T.Anders.	Acanthaceae	Tumoga	S	0	1	1
Landolphia owarensis Beauv.	Apocynaceae	Gebo	S	1	0	0
Lepidotrichilia volkensilia (Gurke) Leory	Meliaceae	Keto	T	1	1	1
Macaranga kilmandscharica Pax.	Euphorbiaceae	Shakaro	T	1	1	1
Maesa lanceolata Forssk.	Myrsinaceae	Chego	T/S	1	1	1
Margaritaria discoidea (Baill.) Webster	Euphorbiaceae	Gibo	T	0	1	0
Maytenus gracilipes subsp. Arguta (Loes.)	Celastraceae	Shiko	S/T	1	1	1
Millettia ferruginea (Hochst.) Bak.	Fabaceae	Bibero	T	1	1	1
Ocotea kenyensis (Chiov.) Robyns & Wilcz	Lauraceae	Najjo	T	0	1	0
Olea welwitschii (Knobl.) Gilg & Schellenb.	Oleacea	Yahoo	T	1	1	1

Continued

Oxyanthus speciosus DC.	Rubiaceae	Aimato	S/T	1	1	1
Phoenix reclinata Jacq.	Arecaceae	Yebo	T	1	1	1
Pittosporum abyssinicum Del.	Pittosporaceae	Sholloo	T	0	1	0
Polyscias fulva (Hiern) Harms	Araliaceae	Keresho	T	1	1	1
Prunus africana (Hook.f.) Kalkm	Rosaceae	Omo	T	0	1	0
Rhamnus prinoides L' Herit.	Rhamnaceae	Gesho	S/T	1	1	1
Ritchie asteudneri Gilg,	Capparidaceae	Gabo	S/T	1	1	1
Rothmannia aurcelliformis (Hiern.) Robyns	Fabaceae	Dibo	S	1	1	1
Rytignia neglecta (Hiern) Robyns	Rubiaceae	Netacho	S/T	0	1	0
Sapium ellipticum (Hochst.) Pax	Euphorbiaceae	Shedo	T	1	1	1
Schefflera abyssinica (Hochyst. ex A. Rich) Harms	Araliaceae	Buto	T	1	1	1
Schrebera alata (Hochst.) Welw.	Oleacea	Opo	T	1	1	1
Syzygium guineense (Willd) DC.	Myrtaceae	Yino	T	1	1	1
Teclea nobliis Del.	Rutaceae	Shengaro	T	0	1	0
Vepris dainellii (Pichi-Serm.) Kokwaro	Rutaceae	Mengreto	S/T	1	1	1
Vernonia amygdalina Del.	Asteraceae	Grawo	S/T	1	1	1
Vernonia auriculifera Hiern	Asteraceae	Dengreto	S/T	1	1	1
Total				**40**	**47**	**37**

Presence and absence of species is indicated by 1 and 0, respectively, T = Trees, T/S = Tree/Shrub, S = Shrub.