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Woody Species Structure and Regeneration Status in Kafta-Sheraro National Park Forest, Tigray Region, Ethiopia

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Abstract

The natural vegetation study was conducted in Kafta-sheraro national park (KSNP) North, Ethiopia to explore floristic composition, structure and regeneration of woody species in the home of African elephant. In the park, the above information is not well documented which is necessary for conservation. Data were collected From August to December 2018. The vegetation data were collected from 161 quadrats of size 20m×20m, 5mx5m for shrub/ tree, sapling and seedling respectively. Individual trees and shrubs DBH >=2.5cm and height >=2m were measured using Tape meter and Clinometer respectively. DBH, frequency, density, basal area, and IVI were used for vegetation structure. A total of 70 woody species 46 (65.7%) trees, 18 (25.7%) shrubs and 6 (8.6%) tree/shrub) were identified. The total basal area and density of 79.3 m^2 ha^{-1}, and 466 ±12.8 (S.E.) individuals ha^{-1} were calculated for 64 woody species. Fabaceae was the most dominant family occupied 16 species (23.0%) followed by Combretaceae 8 species (11.4%). *Acacia mellifera* and *Combretum hartmannianum* were the most dominant and frequent species. Abnormal patterns of selected woody species were dominantly identified. Regenerating status all the woody plant species was categorized as "Fair" (18.75%), "Poor" (7.81 %) and "None" (73.44%). However, there is good initiation for conservation of the park; still the vegetation of the park was threatened by firewood collection, charcoal production, fire, intensive farming, mining and over grazing. Therefore, the study area as the habitat for the population of the African elephant; the KSNP should be recommended the highest conservation priority and studied the soil seed bank of species having poor regeneration condition.

Key words: Kafta-sheraro national park; woody species structure; regeneration status

1. Introduction

Ethiopia is considered as one of the top twenty five biodiversity richest countries in the world (WCMC, 1994). It is estimated to around 6000 species of higher plants, of which about 10%

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endemic plants) (Ensermu and Sebsebe, 2014).The flora is very heterogeneous and has a rich endemic element owing to the diversity in climate, vegetation and terrain. While six endangered endemic plant species are found in Ethiopia especially in the Ogaden region of the ecosystem only, this is floristically the richest in endemism of species in the country (Ensermu *et al*., 1992).

Population structure is the distribution of individuals of each species in arbitrarily to provide the overall regeneration profile of the forest based on tree density, height, frequency, diameter at breast height, species importance value and basal area (Getachew *et al*., 2002; Shibru and Balcha, 2004). Examination of patterns of species population structure could provide valuable information about their regeneration and/or recruitment status as well as viability status of the population that could further be employed for devising evidence-based conservation and management strategies (Abiyou *et al*., 2011).

Regeneration is a central component of forest ecosystem dynamics and restoration of degraded forest lands. Sustainable forest utilization is only possible if adequate information on the regeneration dynamics and factors influencing important canopy tree species is available (Getachew *et al*., 2010). The regeneration status of species in a community can be accessed from the total population dynamics of seedlings and saplings in the forest community (Getachew *et al*., 2002; Duchok *et al*., 2005). The overall pattern of population dynamics of seedlings, saplings and adults of a plants species can exhibit the regeneration profile, which is used to determine their regeneration status (Tamrat, 1994). A population with sufficient number of seedlings and saplings depicts satisfactory regeneration behavior (Pokhriyal *et al*. 2010), while inadequate number of seedlings and saplings of the species in a forest indicates poor regeneration condition (Tripathi and Khan, 2007). Moreover, Regeneration status of a forest is poor if number of seedlings and saplings are much less than mature individuals (Kedir *et al*., 2015). The anthropogenic disturbances (illegal fire, over grazing, intensive farming and firewood collection) revealed high degradation of population structure and regeneration status of the trees in the studied forest ecosystem (Getaneh *et al*., 2019). Assessment of soil seed banks, seedling banks and population structure has some practical importance in forest conservation and management (Haileab *et al*., 2011).

Most of the vegetation resources of the world are concentrated in protected areas (IUCN, 1994).The country's protected areas, such as national parks are rich with distinctive flora and fauna

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(Yalden and Largen, 1992). Protected areas play a vital role in biodiversity conservation (Molla *et al.*, 2010). However, the vegetation resources of Ethiopian protected area are being destroyed at an alarming rate, because of habitat degradation or loss, fragmentation due to livestock encroachment, illegal settlement, agricultural expansion, deforestation, burning of vegetation for cultivation and mining, land-use and border conflicts of local communities. Moreover, vegetation cover is being converted for subsistence and commercial agriculture, timber used for fuel wood and construction, protected grasslands used for livestock grazing, and wetland destruction leads to the decline of vegetation and vegetation resource (Malede and Girma, 2015; Getachew and Weldemariam, 2016).

Kafta-Sheraro National Park (KSNP) is a newly established as a park while formerly named Shire wildlife reserve in Tigray region which was established in 1965e.c (Source: information obtained from local informants). The park is rich in natural vegetation and great wildlife resources particularly the home of mega herbivores of African elephant. Therefore, for effective management and conservation of the park, there is an urgent need to develop a sound management plan, and this required detailed base line information on the general stand structure and seedling and sapling status of woody species. However, KSNP currently lacks scientific and essential base line information on vegetation that is fundamental for sustainable management and conservation of the park tree species. The aim of this study focused on stand structure and regeneration status of the woody species.

2. Materials and Methods

2.1 Study Site

Kafta-Shirero national park is located in Kafta-humera and Tahtay-adeyabo weredas of Western and North-western Zones of Tigray region 1356km far from Addis Ababa and 490km of Mekelle City. The park is situated in the northwest of Ethiopia between latitude 14^0 05'-14^0 27' N and longitude 36^0 42'-$37^0$39' E. The park bordered by Eritrea in the north through Tekeze River (**Figure 1**). The elevation of the park varies from 539 to 1130 m.a.s.l. The landforms of the areas are heterogeneous in nature and consist of flat plain, undulating to rolling, some isolated hills and ridges, chain of mountains and valleys.

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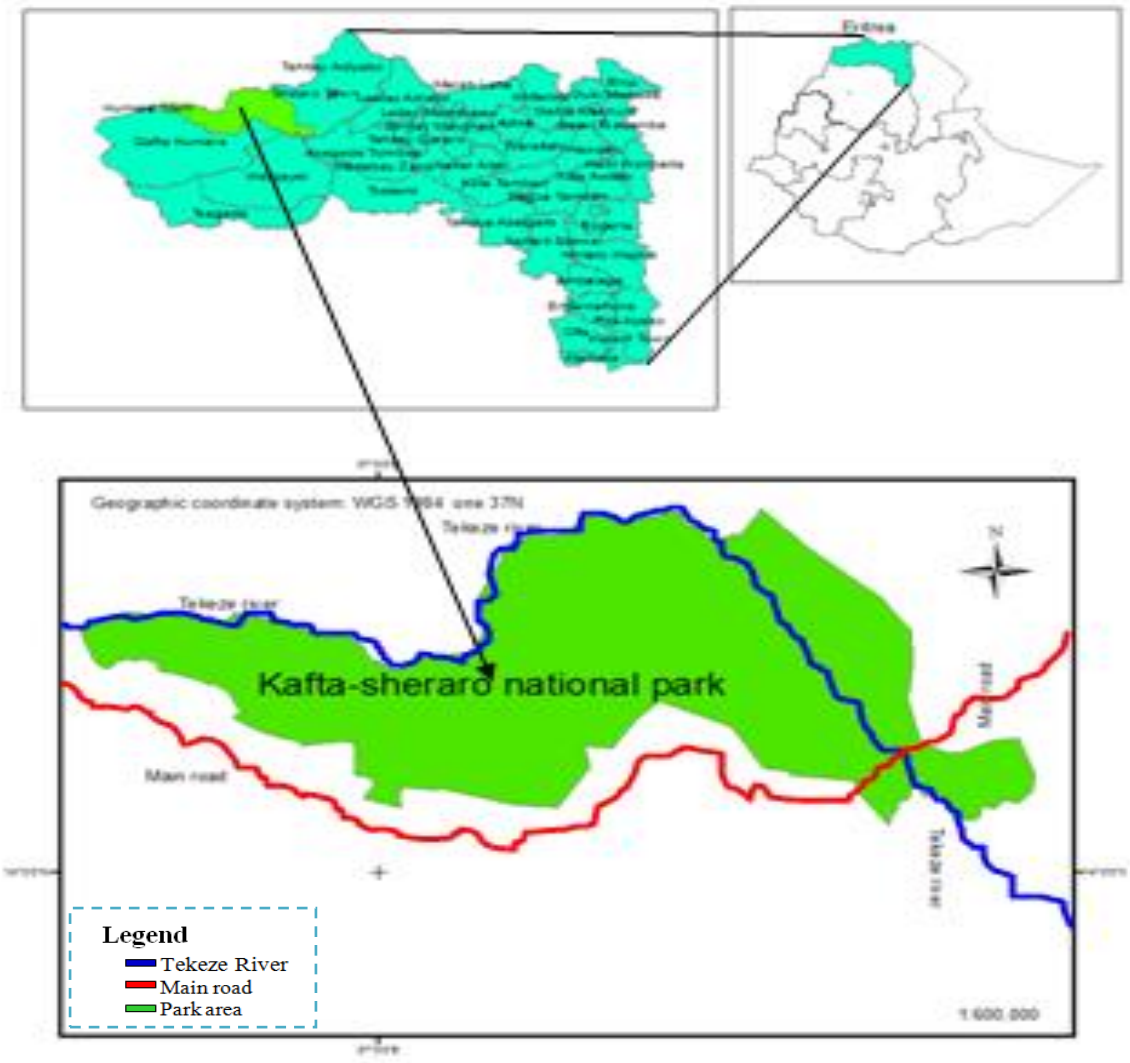

Figure 1: Location of the study site

Climate: The mean monthly temperature ranges from 28.35°C to 35.1°C. The coolest temperatures occur from July to September while the warmest temperatures occur from March to May. The maximum mean monthly temperature ranges from March to May while the minimum ranges both in August and January, respectively. The rainfall pattern is bimodal with two distinct seasons. The short rains occur during May to mid June and September whereas the long rains occur during July and August. The nearby stations of Humera and shiraro district of meteorological center data (1966-2016) were used (Figure 2).

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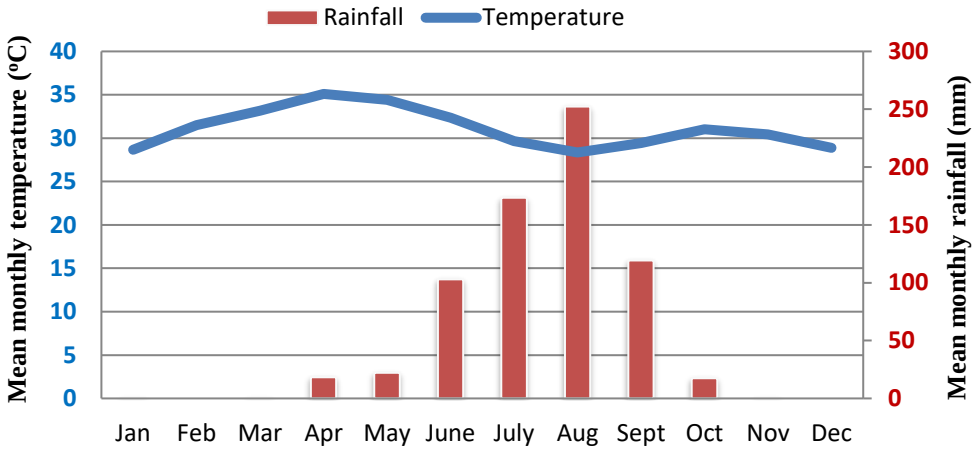

Figure 2: Mean monthly Rainfall and Temperature of Humera and Shiraro Meteorological Center from 1966-2016 (Ethiopian National Meteorological Agency, 2018)

2.2 Sampling design

A reconnaissance survey was taken from August, 18 to 25-2018 in order to have an impression of the forest sites and systematic sampling design was applied following (Kent and Coker, 1992). According to Cain, (1959,1938) and McIntosh, (1985) **species-area curve (minimal area)** concept; the plot size was decided. Then a quadrats size of 20mx20m (400m^2) were established along a line-transects following (Muller-Dombois and Ellenberg, 1974; Kumlachew and Tamrat, 2002; Getaneh *et al*., 2019). A total of 161 plots and adjacent 32 transects were placed at a distance of 200m and 300m apart respectively following (Kflay and Kitessa, 2014; Tiwari *et al*., 2010). All transects and plots located on the ground using compass and GPS navigation system.

2.3 Data collection

The detail vegetation data were collected during flowering and fruiting season from August, 26-30 December, 2018. **Trees and shrubs:** In each the main sample plots (400m^2); individual plants (stems) of all tree and shrub species with diameter at breast height (DBH) ≥2.5 cm abudndance were counted and recorded their circumferance (diameter). Height of individual trees and shrubs ≥2m were recorded for every woody individual plants having DBH >=2.5 cm (Gemedo *et al*., 2006; Hasan *et al*., 2011; Tesfaye *et al*., 2017b). Diameter and height were measured using tape meter and clinometer respectively. Trees with **multiple** stems arising from the ground level were measured individually and developed a common DBH of all stems by summing up their square roots following (Brundrett *et al*., 1996).

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Sapling and seedlings: To collect data on abundance of sapling and seedling of each woody plant species, sub-plots of 5 m x 5 m ($25m^2$) were set up within the main plot. Height of each samplings and seedlings measured using tape meter. Saplings are young woody plants with DBH < 2.5 and height >1m<2m where as seedlings as woody plants with DBH < 2.5 cm and height ≤ 1m (Chauhan *et al*., 2008a; Abyot *et al*., 2014).

Plant species identification: was started in the field by recording the local name through asking to local elders and referring the scientific name identification using Flora of Ethiopia and Eritrea Volume-1 toVolume-8 (Hedberg and Edwards, 1989; Edwards *et al*., 1995; Phillips, 1995; Edwards *et al*., 1997; Hedberg et *al*., 2003; Mesfin Tadesse, 2004; Hedberg *et al*., 2006, 2009a, 2009b). Specimens of identified and unidentified species were collected, pressed and dried properly, following standard Herbarium procedures, and taken to the National Herbarium (ETH) at Addis Ababa University for further confirmation and for identification of specimens of those species which could not be identified in the field.

2.4 Data analysis

a. Woody species structure

Diameter at breast height, height, basal area, tree density, frequency and important value index describes woody vegetation structure of a given forest. The following formula were utilized in Microsoft Excel spreadsheet programme and presented in descriptive statistics.

Diameter at breast height (DBH): diameter of woody species arbitrarily arranged in diameter class intervals by referring (Mligo, 2015; Tesfay *et al*., 2019). Diameter of trees/ shrub plant species of KSNP was classified into nine classes of 10cm interval (2.5-10,10.1-20, 20.1-30, 30.1-40, 40.1-50, 50.1-60, 60.1-70, 70.1-80 and >80.1cm).

Height: height of individuals' trees/shrub plant species were arbitrarily defined by height class intervals (Tesfaye *et al*., 2013; Ermias *et al*., 2010). Height of KSNP was classified into seven classes of 5m interval (<=4, 4.1-9, 9.1-14, 14.1-19, 19.1-24, 24.1-29 and >29.1).The densities of individuals falling in the DBH or height classes were summed up.

Frequency of species: is defined as the probability or chance of finding a species in a given sample area (Kent and Coker, 1992).

$$\text{Frequency (F)} = \left(\frac{Number\ of\ plots\ in\ which\ a\ species\ occurs}{total\ number\ of\ plots\ laid\ out\ in\ the\ study\ site}\right)x100 \quad (1)$$

$$\text{Relative frequency (RF)} = \left(\frac{frequency\ of\ \ a\ single\ species}{total\ frequency\ of\ all\ species}\right)x100 \quad (2)$$

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Finally frequency was summarized by class interval following Lamprecht (1989). The frequency of KSNP was arranged into seven classes of 15 % intervals (<=5, 5.1-20, 20.1-35, 35.1-50, 50.1-65, and 65.1-80 and >80.1%).

Density of species: is a count of the numbers of individuals of each species within the quadrat (Kent and Coker, 1992). The sum of individuals per species is analyzed in terms of species density ha^{-1} (Mueller-Dombois & Ellenberge, 1974; Martin, 1995).

$$\text{Density (D)} = \frac{number\ of\ aboveground\ stems\ of\ a\ species}{Number\ of\ quadrat * quadrat\ area} \quad (3)$$

$$\text{Relative density (RD)} = \frac{Density\ of\ a\ single\ species}{Total\ density\ of\ all\ species} \quad (4)$$

Density was arranged by class intervals following (Tesfay *et al*., 2019) dry forest study. KSNP forest was classified in to five density class intervals: <=2, 2.1-10, 10.1-50, 50.1-100 and >100.1 stems ha^{-1}.

Basal area: is the area outline of a plant near ground surface and expressed in m^2 ha^{-1} (Kent and Coker, 1992; Martin, 1995).

$$\text{Basal area (BA)} = \frac{\pi d^2}{4} \quad \text{Where, } \pi = 3.14 \text{ and d =DBH (m)} \quad (5)$$

Dominance: the degree of coverage of species as an expression of the space at ground level (Mueller-Dombois and Ellenberge, 1974)

Dominance = the mean basal area per species * abundance (no) of the species (6)

$$\text{Relative dominance (RDO)} = \left(\frac{dominance\ of\ a\ sinle\ species}{total\ dominance\ of\ all\ species}\right)x100 \quad (7)$$

Importance Value Index (IVI): Indicating the relative ecological importance of a given woody species a particular site (Kent and Coker, 1992; Martin, 1995).

IVI= Relative density (RD) + Relative frequency (RF) + Relative dominance (RDO) (8)

b. Woody species regeneration

The regeneration status of KSNP woody species was computed by comparing seedling and sapling with matured trees density data by applied (Khumbongmayum *et al*., 2006 ; Dhaulkhandi *et al*., 2008; Chauhan *et al*., 2008a; Chauhan *et al*., 2008b; Tiwari *et al*., 2010) techniques.

If seedling > sapling > mature tree ("**good**" regenerating); mature tree > sapling > seedling ("**fair**" regenerating); if a species survives only in the sapling stage ("**poor**" regenerating) (even saplings <, >, or = to mature); if a species is absent both in sapling and seedling stages but present as mature ("**none**" regenerating); if a species has no mature, but only sapling and/or seedling stages ("**new**" regenerating).

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3. Result

3.1 Floristic Composition

A total of 70 woody species belonging to 50 genera and 34 families were identified in Kafta-sheraro national park (KSNP) forest. From these species, 46 (65.7%) trees, 18 (25.7%) shrub, 6 (8.6%) tree/shrub. Fabaceae was the most dominant family occupied 16 species (23.0%) followed by Combretaceae 8 species (11.4%); Tiliaceae and Rhamnaceae 4 species (11.42%); Capparaceae and Anacardiaceae 3 species each (8.58%); Burseraceae, Ebenaceae, Asclepiadaceae and Apocynaceae 2 species each (11.44 % from total) and the rest 24 families represented one species each (34.23% from total species) (**Appendix 1**). Out of 70 species 64 were used for next analysis and six species were outside plots utilized for composition list only.

3.2 Density and frequency

The total density KSNP woody species was 466±12.8 stems ha^{-1}. *Acacia mellifera* was the most abundant species with abundance value of 446 individuals and a density of 69.7 stems ha^{-1}. *Acacia mellifera*, *Combretum hartmannianum*, *Balanites aegyptiaca*, *Acacia oerfota*, *Boswellia papyrifera* and *Acacia Senegal* were above 150 individuals while *Dicrostachy scinerea* and *Combretum molle* have densities 100 stems ha^{-1}and above. The relative density ranged between 0.03 and 15%, the highest being for *Acacia mellifera* (**Table 1**). The woody species density was classified in to five class intervals: <=2, 2.1-10, 10.1-50, 50.1-100 and >100.1 stems ha^{-1}. 48.4% and 3.13% species occupied density class <=2 and 50.1-100 respectively (**Figure 3**).

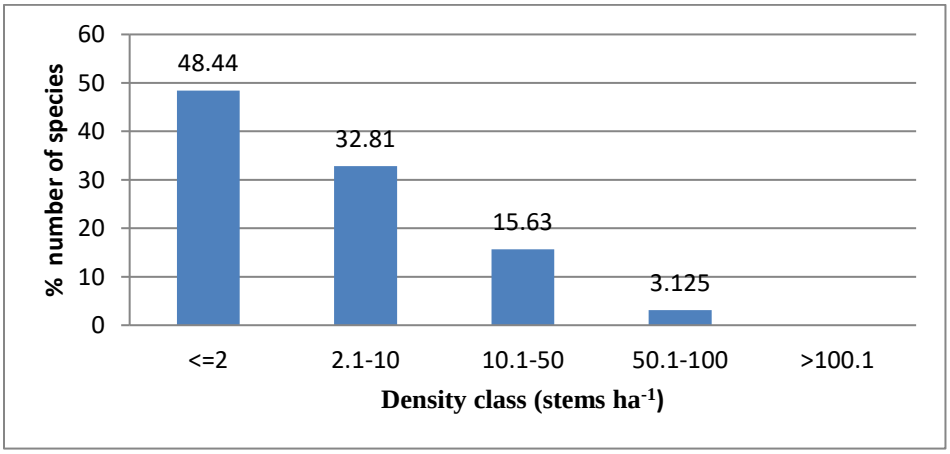

Figure 3: Density of all woody plant species by size class in KSNP

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The most frequent woody species in the study area were *Acacia mellifera* (71.4%), followed by *Combretum hartmannianum* (59%), *Terminalia brownii* (57.8%), *Balanites aegyptiaca* (46.0%), *Acacia senegal* (42.2%) and *Acacia oerfota* (35.4%), *Boswellia papyrifera* (29.8%), *Dicrostachy scinerea* (29.2). While *Acacia albida*, *Parkinsonia aculeate* and *Otostegia ellenbeckii* each having frequency (0.62%) was rarely observed. The relative frequency of species was between 0.09 and 10.6% with similar orders as their frequencies (**Table 1**). KSNP were arranged in six frequency classes: (1=65.1-80, 2= 50.1-65, 3=35.1-50, 4=20.1-35%, 5=5.1-20, and 6= ≤5%). The woody plant species dominantly concentrated in frequency class 6 (<5%). In 1(65.1-80%) frequency class the number of species was one (**Figure 4**).

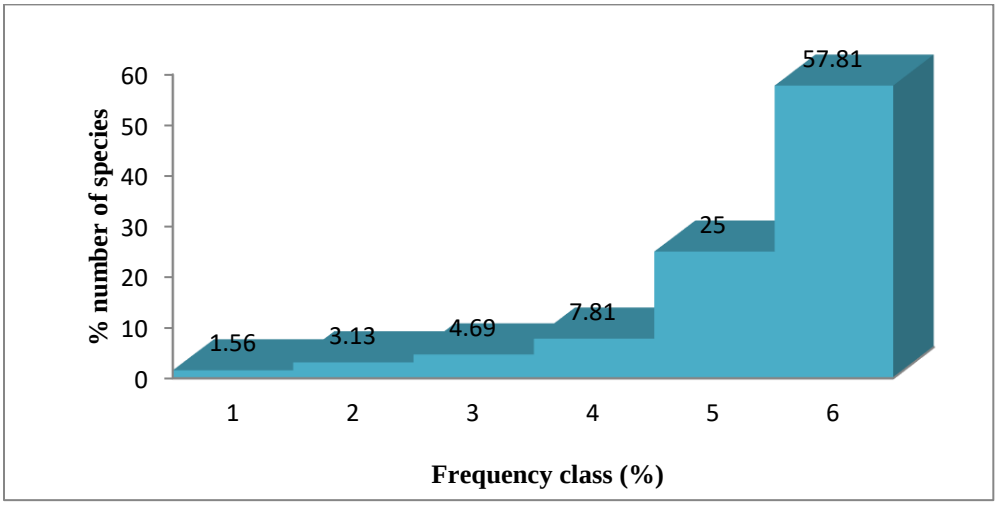

Figure 4: Woody plant species frequency classes' distribution of KSNP (1=65.1-80, 2= 50.1-65, 3=35.1-50, 4=20.1-35%, 5=5.1-20, and 6= ≤5%).

3.3 Basal area (BA)

The total basal area of KSNP of woody species with DBH ≥ 2.5 cm was 79.3m^2ha^{-1}. Interms of species *Adansonia digitata* contributed the highest basal area (35.5 m^2ha^{-1}) followed by *Sterculia Africana* (7.86 m^2ha^{-1}), *Tamarindus indica* (5.52 m^2ha^{-1}), *Anogeissus leiocarpus* (4.09m^2ha^{-1}), *Ficus sycomorus* (3.63m^2ha^{-1}), *Acacia lahai (*3.57 m^2ha^{-1}), *Balanites aegyptiaca* (2.90 m^2ha^{-1}),*Ziziphus spina-christi* (2.87 m^2ha^{-1}) (**Table 1**).The lowest value was recorded in shrub species of *Senna sinqueana* (0.002 m^2ha^{-1}), *Buddleja polystachya* (0.003m^2ha^{-1}) .

3.4 Importance value index (IVI)

The importance value index of woody species in KSNP ranged from 0.13 to 30.8. The highest IVI was documented for *Adansonia digitata* (30.8). *Balanites aegyptiaca*, *Acacia mellifera*, *Terminalia brownii* and *Combretum hartmannianum*, *Anogeissus leiocarpus*, *Tamarindus indica*,

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Ziziphus spina-christi, *Sterculia Africana*, *Acacia Senegal*, *Boswellia papyrifera* and *Acacia oerfota* had IVI value above ten were the most important species (**Table 1**).

Table 1: Woody species structure and importance value in Kafta-Sheraro National Park: (AD=Average diameter (cm), AB =Abundance (individual stems), D=Density (Abundance ha^{-1}), RD= Relative density (%), F=Frequency (%), RF=Relative frequency (%), BA=Basal Area (m^2ha^{-1}), DO=Dominance, RDO=Relative dominance (%), IVI=Importance value index (%))

Species	AD	AB	D	RD	F	RF	BA	DO	RDO	IVI
Acacia senegal	4.6	159	24.8	5.33	42.2	6.26	0.05	0.301	0.222	11.8
Combretum hartmannianum	9.4	342	53.4	11.5	59	8.74	0.19	2.584	1.911	22.1
Dalbergia melanoxylon	8.4	46	7.19	1.54	17.4	2.58	0.14	0.262	0.194	4.31
Balanites aegyptiaca	38	188	29.4	6.3	46	6.81	2.9	19.59	14.49	27.6
Acacia oerfota	4.1	169	26.4	5.67	35.4	5.24	0.03	0.222	0.164	11.1
Dicrostachy scinerea	3.9	143	22.3	4.79	29.2	4.32	0.03	0.17	0.126	9.24
Grewia bicolor	2.5	31	4.84	1.04	9.94	1.47	0.01	0.016	0.012	2.52
Anogeissus leiocarpus	45	71	11.1	2.38	24.8	3.68	4.09	11.62	8.591	14.7
Sterculia africana	62	42	6.56	1.41	14.9	2.21	7.86	13.2	9.763	13.4
Acacia seyal	5.5	34	5.31	1.14	9.94	1.47	0.06	0.08	0.059	2.67
Maytenus senegallensis	5.6	6	0.94	0.2	2.48	0.37	0.06	0.015	0.011	0.58
Acacia mellifera	4.2	446	69.7	15	71.4	10.6	0.03	0.623	0.46	26
Adansonia digitata	134	27	4.22	0.91	10.6	1.56	35.5	38.31	28.33	30.8
Acacia albida	17	2	0.31	0.07	0.62	0.09	0.56	0.045	0.033	0.19
Jasminum abyssinicum	5.2	8	1.25	0.27	2.48	0.37	0.05	0.017	0.012	0.65
Ziziphus spina-christi	38	87	13.6	2.92	23	3.4	2.87	9.989	7.387	13.7
Tamarindus indica	52	59	9.22	1.98	19.9	2.94	5.52	13.03	9.634	14.6
Casuarina equisetifolia	5.2	69	10.8	2.31	15.5	2.3	0.05	0.149	0.11	4.72
Capparis decidua	4.6	4	0.63	0.13	1.24	0.18	0.04	0.007	0.005	0.32
Grewia villosa	3.6	11	1.72	0.37	4.97	0.74	0.02	0.011	0.008	1.11
Salvadora persica	2.8	5	0.78	0.17	1.86	0.28	0.01	0.003	0.002	0.45
Ziziphus mauritiana	9.8	4	0.63	0.13	1.24	0.18	0.19	0.03	0.022	0.34
Feretia apodanthera	7.5	3	0.47	0.1	2.48	0.37	0.11	0.013	0.01	0.48
Hyphaene thebaica	17	96	15	3.22	21.1	3.13	0.61	2.352	1.74	8.09
Calotropis procera	6.9	14	2.19	0.47	5.59	0.83	0.11	0.064	0.047	1.34
Boswellia papyrifera	11	178	27.8	5.97	29.8	4.42	0.25	1.794	1.327	11.7
Terminalia brownii	36	205	32	6.87	57.8	8.56	2.06	13.28	9.82	25.2
Grewia flavescens	5.5	13	2.03	0.44	6.21	0.92	0.06	0.033	0.025	1.38
Moringa stenopetala	5.8	4	0.63	0.13	1.24	0.18	0.11	0.018	0.013	0.33
Acacia lahai	42	6	0.94	0.2	2.48	0.37	3.57	0.857	0.634	1.2
Diospyros mespiliformis	13	30	4.69	1.01	9.32	1.38	0.35	0.42	0.311	2.7
Burkea africana	37	21	3.28	0.7	7.45	1.1	2.67	2.243	1.659	3.47
Ficus sycomorus	43	2	0.31	0.07	1.24	0.18	3.63	0.291	0.215	0.47
Combretum glutinosum	8	27	4.22	0.91	5.59	0.83	0.13	0.136	0.1	1.83
Combretum molle	6	117	18.3	3.92	11.2	1.66	0.07	0.335	0.247	5.83
Nerium oleander	2.5	3	0.47	0.1	1.24	0.18	0.01	0.002	0.001	0.29
Cadaba farinosa	5.4	6	0.94	0.2	1.24	0.18	0.06	0.014	0.01	0.4
Leptadenia lanceolata	4.6	3	0.47	0.1	1.86	0.28	0.03	0.004	0.003	0.38
Terminalia laxiflora	8.7	10	1.56	0.34	1.24	0.18	1.05	0.419	0.31	0.83
Solanum incanum	2.6	7	1.09	0.23	1.86	0.28	0.01	0.004	0.003	0.51

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Species	AD	AB	D	RD	F	RF	BA	DO	RDO	IVI
Grewia mollis	4.8	4	0.63	0.13	1.86	0.28	0.04	0.007	0.005	0.42
Lannea microcarpa	11	23	3.59	0.77	8.7	1.29	0.25	0.232	0.172	2.23
Commiphora boranensis	7.2	32	5	1.07	4.35	0.64	0.72	0.922	0.682	2.4
Stereospermum kunthianum	6.9	21	3.28	0.7	6.21	0.92	0.1	0.08	0.059	1.68
Pittosporum viridiflorum	9	17	2.66	0.57	3.73	0.55	0.42	0.047	0.034	1.16
Boscia angustifolia	6.4	7	1.09	0.23	1.86	0.28	0.08	0.022	0.016	0.53
Acacia sp.	11	11	1.72	0.37	2.48	0.37	0.25	0.109	0.08	0.82
Ziziphus mucronata	2.9	17	2.66	0.57	6.21	0.92	0.02	0.011	0.008	1.5
Acacia polyacantha	5.9	46	7.19	1.54	4.35	0.64	0.07	0.126	0.093	2.28
Acacia etbaica	11	5	0.78	0.17	1.24	0.18	0.22	0.045	0.033	0.38
Acacia tortilis	12	8	1.25	0.27	1.86	0.28	0.27	0.088	0.065	0.61
Parkinsonia aculeata	8.4	1	0.16	0.03	0.62	0.09	0.14	0.006	0.004	0.13
Ricinus communis	4.1	4	0.63	0.13	0.62	0.09	0.03	0.005	0.004	0.23
Melia azedarach	4.6	3	0.47	0.1	1.24	0.18	0.04	0.005	0.004	0.29
Carissa edulis	5.4	11	1.72	0.37	1.86	0.28	0.07	0.033	0.024	0.67
Combretum sp.	8.9	27	4.22	0.91	2.48	0.37	0.16	0.174	0.129	1.4
Sclerocarya birrea	19	15	2.34	0.5	3.11	0.46	0.7	0.419	0.31	1.27
Terminalia sp.	7.6	7	1.09	0.23	1.24	0.18	0.11	0.032	0.024	0.44
Diospyros abyssinica	8	14	2.19	0.47	2.48	0.37	0.30	0.226	0.167	1
Brucea antidysentrica	15	3	0.47	0.1	1.24	0.18	0.12	0.053	0.039	0.32
Plumbago zeylanica	2.5	5	0.78	0.17	1.86	0.28	0.01	0.002	0.002	0.45
Otostegia ellenbeckii	2.5	2	0.31	0.07	0.62	0.09	0.004	0.008	0.006	0.16
Senna sinqueana	2.5	1	0.16	0.03	0.62	0.09	0.002	0.007	0.005	0.13
Buddleja polystachya	2.6	2	0.31	0.07	1.24	0.18	0.003	0.011	0.008	0.26
Total	-	**2984**	**466**	**100**	-	**100**	**79.3**	-	**100**	**300**

3.5 Population structure of KSNP forest and selected tree species

The general DBH and height class distribution of woody species density in the KSNP showed an Inverted-J shaped structure. The distribution of trees and shrubs was categorized into nine DBH class: (2.5-10cm; 10.1-20cm; 20.1-30cm; 30.1-40cm; 40.1-50cm, 50.1-60cm; 60.1-70cm; 70.1-80cm and >80.1cm). The majority of individuals are distributed in the first DBH class 2.5-10cm (**Figure 5a**). Three species of twenty individuals of *Anogeissus leiocarpus*, *Sterculia Africana*, *Adansonia digitata* had a DBH of 70 cm and above.

In KSNP the highest DBH was recorded for fourteen individuals of *Adansonia digitata* (110-146cm). While Tree height distribution was classified in seven classes: <=4m; 4.1-9m; 9.1-14m; 14.1-19m; 19.1-24m; 24.1-29m and >29.1m. There is higher number of trees/shrubs individuals in the height class below 14m which accounts 81% of the total population height classes. *Anogeissus leiocarpus*, *Adansonia digitata*, *Tamarindus indica*, *Sterculia Africana*, *Diospyros*

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mespiliformis and *Balanites aegyptiaca* had 39 individuals having above 15m height. The highest height was recorded for *Anogeissus leiocarpus* (30m) (**Figure 5b**).

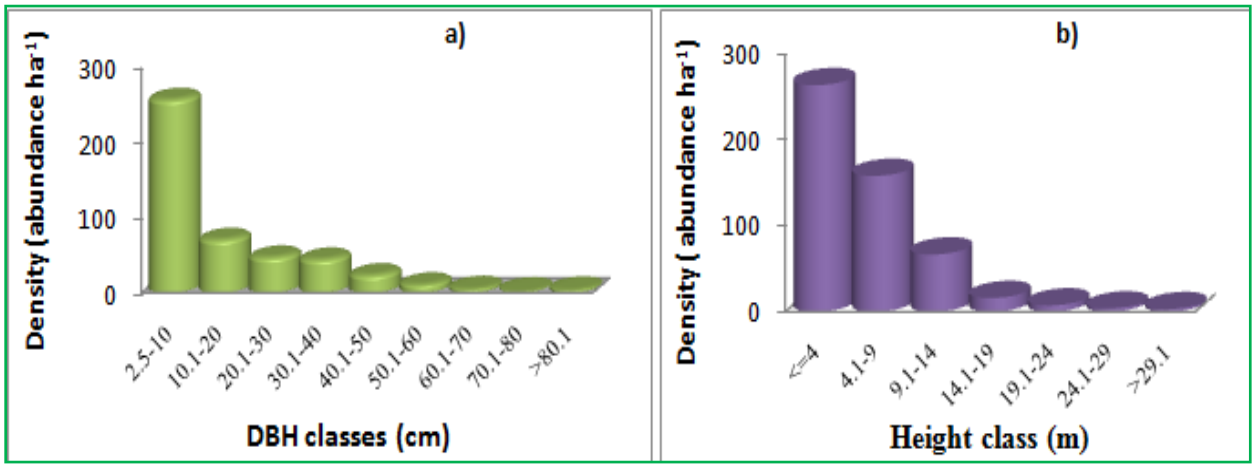

Figure 5: Woody species diameter (a) and height (b) classes of Kafta-sheraro National Park

The analysis of population structure of Kafta-sheraro national park individual tree species in nine DBH classes dominantly showed eight patterns of population structure. **First pattern** consists of individual species concentrated only in the first DBH class (2.5-10cm) but absent in the rest classes and represented by *Acacia mellifera* (F.g.6a). Species in this group are *Acacia senegal, Dalbergia melanoxylon, Acacia oerfota, Dicrostachy scinerea* and *Acacia seyal*. **Second pattern** occupied both first (2.5-10cm) and second (10.1-20cm) DBH classes and represented by *Combretum hartmannianum* and *Boswellia papyrifera* (F.g.6b). **Third pattern** was an Inverted-J shaped in which the highest number of individuals was present in lower DBH classes and *species Anogeissus leiocarpus* only (F.g.6c). **Fourth pattern** was J-shaped in which a higher proportion of individuals were present at higher DBH classes and the trend decreased towards lower DBH classes. Species of this pattern was *Ziziphus spina-christi* and *Tamarindus indica* (F.g.6d). **Fifth pattern** was **bell shaped** in which a higher proportion of species were present in intermediate DBH classes and the trend decreased in lower and higher DBH classes. Species in this category were *Balanites aegyptiaca* and *Terminalia brownii* (F.g.6e). **Sixth pattern** occurred in the second DBH class (10.1-20cm) and the only representative species is *Diospyros mespiliformis* (F.g.6f). **Seventh pattern** shows **irregular distribution** over diameter classes. Some DBH classes had small number of individuals while other DBH classes had large number of individuals and even some were missed. The known species is *Sterculia Africana* (F.g.6g). **Eighth pattern** the DBH occurred only

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in the large class. *Adansonia digitata* was the only representative species that occur in the ninth (>80.1cm) DBH class (F.g.6h).

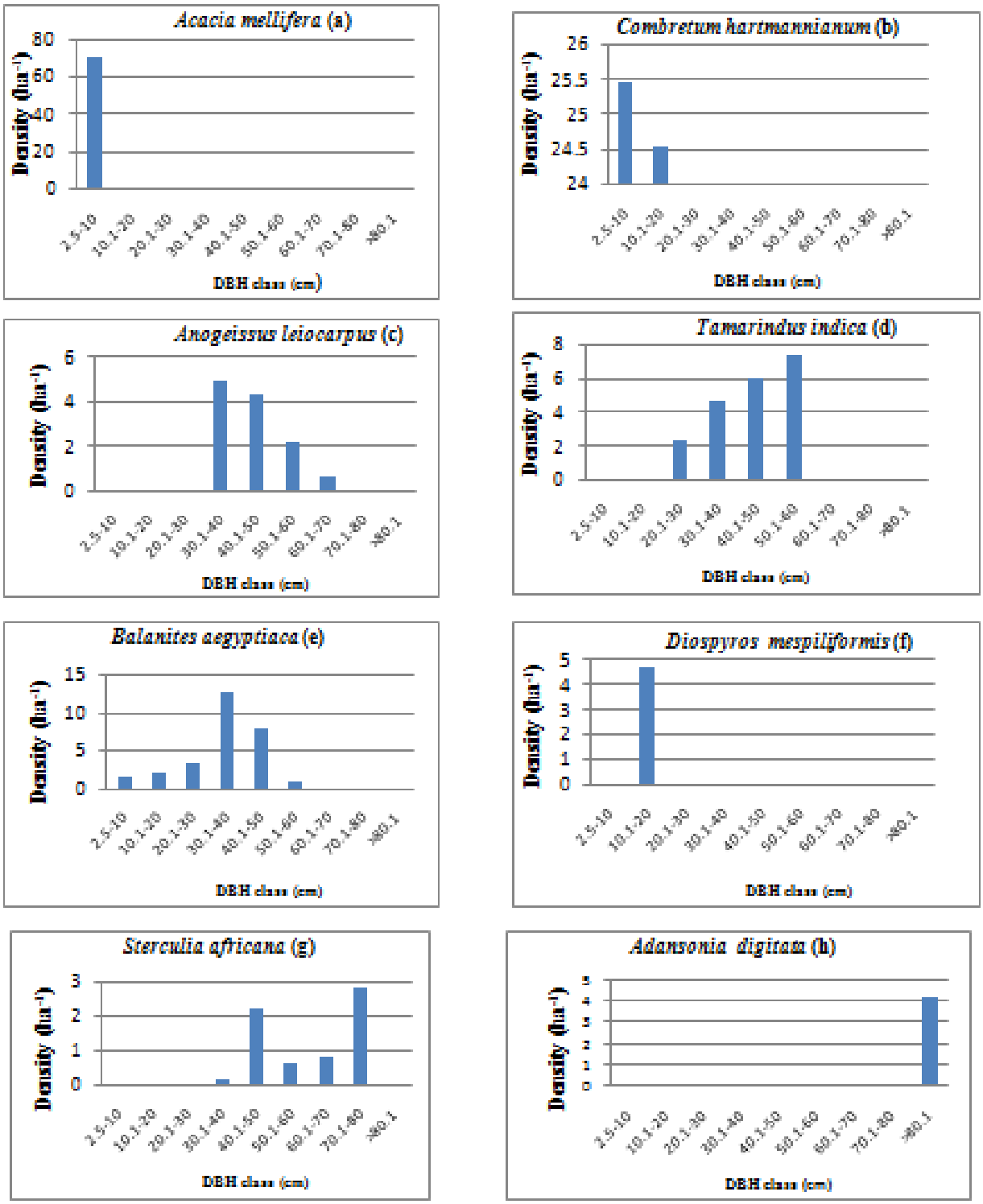

Figure 6: Representative population structure patterns of each tree species in KSNP

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3.6 Regeneration status of KSNP woody species

A total of 378 individuals of seedling 68 (2.023%) and saplings 310 (9.22%) belonging to 64 woody species were counted from all quadrats. Twelve woody species had sapling and seedling, five species had only sapling while 47 species lack both stages. Woody species having seedling were *Acacia senegal*, *Combretum hartmannianum*, *Balanites aegyptiaca*, *Acacia oerfota*, *Dicrostachy scinerea*, *Acacia mellifera*, *Ziziphus spina-christi*, *Casuarina equisetifolia*, *Hyphaene thebaica*, *Boswellia papyrifera*, *Terminalia brownii* and *Acacia polyacantha* (Appendix 1). The total density of seedling and sapling had 10.7 and 48.6 individuals' ha^{-1} respectively (**Figure 7a**). Relatively higher sapling density was exhibited by species like *Hyphaene thebaica* (16.1%) *followed Balanites aegyptiaca* (15.8%), *Dicrostachy scinerea* (13.17%), *Casuarina equisetifolia* (8.64%), and *Acacia Senegal* (7.82%) (Appendix 1).

In Kafta-sheraro national park forest 18.75% of tree/ shrub species showed 'fair regenerating' while 7.8 % and 73.45% showed 'poor regenerating' and 'none regenerating' condition respectively. But "good" and "new" regenerating status of the tree species was absent (**Figure 7b**). *Dalbergia melanoxylon*, *Acacia seyal*, *Grewia villosa*, *Combretum molle* and *Plumbago zeylanica* had 'poor' regenerating woody species.

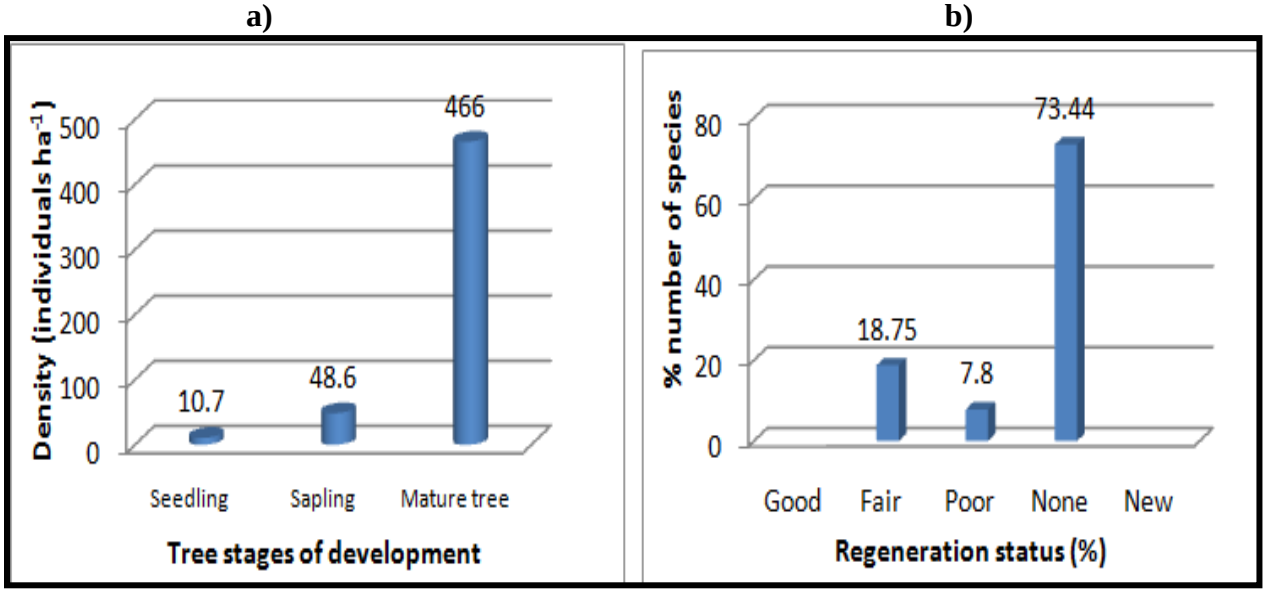

Figure 7: Density of seedling, sapling & mature tree species (**a**) and regeneration status of woody plants in KSNP forest (**b**)

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4. Discussion

4.1 Woody species structure

***Density*:** Species-abundance measures are ways of expressing not only the relative richness but also evenness and assessing diversity (Barnes *et al*., 1998).The total density of woody species of the study was 466±12.8 individuals ha^{-1} (64 species) which is lower than Babile elephant sanctuary:1319 individuals' ha^{-1} (67 species) (Anteneh *et al*., 2011); Nechisar Park: 887 stems ha^{-1} (118 species) (Samson *et al*., 2010); Yemrehane Kirstos Church forest (506.6 stems ha^{-1}, Amanuel and Gemedo, 2018); Zege Peninsula (3318 stems ha^{-1},(113 species) Alemnew *et al*., 2007); (1845 stems ha^{-1}, Abyot *et al*. 2014); Tara Gedam and Abebaye (3001 stems ha^{-1} and 2850 stems ha^{-1} (143 species) Haileab *et al*., 2011); Kahtasa forest (505 stems ha^{-1},Getaneh *et al*., 2019) ; Wof-Washa forest (698.8 stems ha^{-1}) (Gebremicael *et al*., 2013) in Ethiopia and in other tropical forests (515 stems ha^{-1}) (Chauhan *et al*., 2008a).The densities of tree species variation in forests was reported due to variation in species composition, age structure (Ademoh *et al*., 2017) and the degree of disturbance (Sharma and Chaudhry, 2018).

Acacia mellifera, Combretum hartmannianum, Terminalia brownii, Combretum molle, Balanites aegyptiaca, Acacia oerfota, Boswellia papyrifera, Acacia Senegal, Dicrostachy scinerea occupied above 50% of the total stem density and relatively those species had higher seedling and sapling density in the study area. These species are probably due to their resistance to drought and disturbance (Abiyot *et al*., 2017). The absence of seedlings in some of the canopy trees of *Sterculia africana* and *Adansonia digitata* highly attributed to disturbance, seed predation, and habitat unsuitability. Disturbance and seed predation have been played sound role in reducing the seedling population of woody species (Alemayehu *et al*., 2009).

***Frequency*:** contributes to indicate homogeneity and heterogeneity of vegetation of a given species (Haileab *et al*., 2005). The study site has high species heterogeneity; because of higher percentage numbers of species were found in the lower frequency class than higher class.

According to lamprecht (1989) low value in lower frequency and high value in higher frequency class indicate similar species composition. To the reverse low percentage number of species in the higher frequency and low percentage number of species in the higher frequency classes reported a high degree of floristic heterogeneity (Simon and Girma, 2004; Abyot *et al*., 2014; Amanuel and Gemedo, 2018). The variation in density and frequency between species may be attributed to

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habitat differences, habitat preferences among the species, species characteristics for adaptation, degree of exploitation and conditions for regeneration (Haileab *et al*., 2011). In KSNP important portions of the species were rare. Therefore, the study site has existence of high floristic heterogeneity.

***Basal area*:** The basal area of all Kafta-sheraro national park woody vegetation (79.3m^2ha^{-1}) is much higher than dry land areas of Ethiopia forests and other countries. NNP (49.45m^2ha^{-1}, Samson *et al*., 2010); Babile elephant sanctuary (17.8 m^2 ha^{-1}; Anteneh *et al*., 2011);(19.3m^2ha^{-1}, Abyot *et al*., 2014); Grat-Kahsu (8.25 m^2 ha^{-1} ,Tesfay *et al*., 2019); Abebaye forest (49.45m^2ha^{-1}, Haileab *et al*., 2011) (72 m^2 ha^{-1}, Amanuel and Gemedo, 2018); virgin tropical forests in Africa (23-37 m^2 ha^{-1}, Lamprecht, 1989); Katerniaghat Wildlife Sanctuary (35.9 m^2ha^{-1} ,Tripathi & Singh., 2009); Gibbon Wildlife Sanctuary (9.62 m^2ha^{-1}: Sarkar and Devi, 2014); Chilimo Forest (30 m^2ha^{-1} ,Tamrat, 1993), Adelle Forest :26 m^2ha^{-1} and Boditi Forest:23 m^2ha^{-1}) (Haile *et al*., 2008); Jibat (59.79m^2ha^{-1},Tesfaye *et al*., 2013); Komto forest (Fekadu *et al*., 2012); Bhadra Wildlife Sanctuary(18.09 m^2 ha^{-1}, Krishnamurthy *et al*., 2010); Metema (42.54, m^2 ha^{-1} ,Haile *et al*., 2012a). But it was less than moist forests; Wof-Washa Forest (102 m^2ha^{-1},Tamrat, 1993); Berbere forest (87.49 m^2ha^{-1},Tesfaye *et al*., 2017b); Belete forest (103.5 m^2ha^{-1}, Kflay & Kitessa, 2014); Tara Gedam (115.36 m^2 ha^{-1}, Haileab *et al*., 2011) and Kimphe lafa forest (114.4 m^2 ha^{-1} ,Kedir *et al*., 2015).

The highest basal area from individual tree species in the study was contributed by *Adansonia digitata* (35.5 m^2 ha^{-1}) while the highest density was *Acacia mellifera* species (69.7 individuals ha^{-1}). This indicates that species with the highest basal area do not necessarily have the highest density and the vi-versa is also true. This was indicated that size difference between species is common in natural vegetation (Tamrat, 1994; Simon and Girma, 2004).

***Importance Value Index*:** is useful to compare the ecological significance of species (Lamprecht, 1989; Premavani *et al*., 2014). Important value index is the degree of dominancy and abundance of a given species in relation to the other species in the area (Kent & Coker, 1992). The importance value index (IVI) of woody species in the study area was generally comparable to other areas of woody vegetation (Haileab *et al*., 2011; Desalegn *et al*., 2013; Abiyot *et al*., 2017). For example, in Jibat forest *Ilex mitis* species had the highest value (27.7%) (Tesfaye *et al*., 2013); 34.6% (Kflay and Kitessa, 2014). 30% woody species had IVI value of one and lower which categorized rarest

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list. Some of the least IVI record was *Maytenus senegallensis*, *Acacia albida*, *Jasminum abyssinicum*, *Salvadora persica*, *Ziziphus mauritiana*, *Feretia apodanthera*. Moreover, least important species are usually found in open woodlands and savanna (Hedberg & Hedberg, 2003). The IVI values can also be used to prioritize species for conservation, and species with high IVI value need less conservation efforts, whereas, those having low IVI value need high conservation effort. Lower IVI may indicate woody species are threatened and need immediate conservation measure (Anteneh *et al*., 2011; Temesgen *et al*., 2015). Low IVI value and poor regeneration status of species in a forest need to be prioritized for conservation (Haileab *et al*., 2011).

Population structure: DBH and height are important indicators of forest reproduction and health status (Schulz *et al*., 2009). The general pattern DBH of KSNP showed an inverted J-shaped distribution where species frequently had the highest frequency in low diameter classes and a gradual decrease towards the higher class. Inverted J shape pattern is normal population structure and shows the existence of species in healthier condition. Similar results were reported by (Abate *et al*. 2006; Haile *et al*., 2008; Ermias *et al*., 2008; Leul *et al*., 2010; Samson *et al*., 2010; Tesfaye *et al*., 2013; Kflay and Kitessa, 2014; Mligo., 2015; Tesfaye *et al*., 2017b; and Tesfay *et al*., 2019). However, the general pattern does not clearly show trends of population dynamics and recruitment processes of a single species (Abyot *et al*., 2014; Getaneh *et al*., 2019). Other seven discontinuous (there were complete absences of individuals in some class and fairly representative of the individual in other class) patterns showed in KSNP. Irregular distribution pattern were reported by (Mekuria *et al*., 1999, Getachew *et al*., 2002, Haile *et al*., 2008, Ensermu & Teshome, 2008; Haile *et al*., 2012a; Melkamu and Abdella, 2019). Moreover, assessing the population structure has been helped to provide initial idea about the status of regeneration pattern of woody plants (Swamy *et al*., 2000).

4.2 Regeneration status of woody plants

Reports stated that the regeneration status of the given natural vegetation is considered as none regenerating if a species is absent both in sapling and seedling stages but present as mature (Khumbongmayum *et al*., 2006; Dhaulkhandi *et al*., 2008; Tiwari *et al*., 2010). Therefore, the regeneration status of Kafta-sheraro national park was considered as none regenerating since mature (88.76%) > sapling (9.22%) > seedling (2.02%). The regeneration and recruitment condition of woody species is one of the major factors that are useful to assess their conservation status (Bekele *et al*., 2002).The population structure, characterized by the presence of sufficient

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population of seedlings, saplings and adults, indicates successful regeneration of forest species (Saxena and Singh, 1984). However, climatic factors and biotic interference influence the regeneration of species in any vegetation (Henle *et al*., 2004; Dhaulkhandi *et al*., 2008). The tree species, which had no seedlings and saplings exhibited discontinuous population structures (Getaneh *et al*., 2019).

The "poor" and "none" regenerating categories which constitute around 81.25% of the woody plant in KSNP have many important and useful tree species. For example trees / shrub species namely: *Sterculia africana*, *Acacia seyal*, *Adansonia digitata*, *Hyphaene thebaica*, *Burkea Africana* and *Grewia flavescens* are source of feed for African elephant some plants in the study like *Boswellia papyrifera*, have economic value. Poor and none regenerating category of woody species was reported in Berbere forest (32.26%, Tesfaye *et al*., 2017b); Grat-Kahsu (26.56%, Tesfay *et al*., 2019); Gibbon Wildlife Sanctuary (25%, Sarkar & Devi, 2014);Wof-Washa (48%, Gebremicael *et al*., 2013).

The regeneration status of the tree species of KSNP dominantly falls in "poor" and "not regenerating" status. Such situation might have been occurred through the existing disturbance like, over grazing (Emiru *et al*., 2007; Kuijper *et al*., 2010; Norden *et al*., 2011), firewood collection, fire, mining and poor biotic potential of tree species which either affect the fruiting or seed germination or successful conversion of seedling to sapling stage and similarly reported in Ethiopia (Haileab *et al*., 2011; Gebremicael *et al*., 2013; Tesfaye *et al*., 2017b; Getaneh *et al*., 2019; Melkamu and Abdella, 2019) and in other tropical dry forests (Ceccon *et al*., 2006; Anitha *et al*., 2010). Moreover, individuals in young stages of any species are more vulnerable to any kind of environmental stress and anthropogenic disturbance (Nagamatsu *et al*., 2002; Getachew *et al*., 2002). Poor regenerating leads poor reproduction and hampered regeneration either due to the fact that most trees are not producing seeds as a result of their old age or there has been loss of seeds by predators after reproduction (Bhuyan *et al*., 2003; Khumbongmayum *et al*., 2006; Mwavu and Witkowski, 2009). Absence of seedlings and saplings of tree species indicates urgent need for targeted forest management plan to enhance regeneration (Abyot *et al*., 2014; Getaneh *et al*., 2019). High herbaceous cover played a major role in preventing successful seed germination, seedling establishment, growth and survival (Kobe and Vriesendorp, 2011).

5. Conclusion and recommendation

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Surveying on structure, and regeneration status of tree species would be provided baseline information and an instrument for the development of successful conservation strategies in KSNP forest. Population structure of most common species of trees and shrubs revealed different patterns of population structure, addressing a high variation among species population dynamics within the forest and an indication for low regeneration. The additional patterns were indicated the absence of populations in various DBH classes. This clearly shows tree species in different stage of development are abnormal population structure status. The regeneration status of the tree species of the study site dominantly showed "poor" and "none" regeneration status but 18% trees/shrubs species, falls under "fair" regenerating" status. Variation in population structure and regeneration status indicates that long time past disturbance of species and the whole resources of the park. The IVI values reveal the most ecologically important woody species in the forests are in poor regeneration status due to human disturbance, particularly livestock grazing, fire and cultivation. **Therefore,** the regeneration status of the woody plant species in the park generally categorized under poor and none regenerating condition; research development is needed on soil seed bank and propagation method of each tree species to stimulate regeneration specifically on species of *Sterculia Africana*, *Adansonia digitata*, *Tamarindus indica*, *Acacia seyal* and *Burkea Africana*. The park as the habitat for different types of wildlife particularly for the population of African elephant; government and community must give conservation and management priority for species with IVI less than 1%, species with no seedling, and families represented by only one species. Design conservation strategies for those economically important tree species like *Boswellia papyrifera* which are needed for their effective productivity and this contributes to the conservation and development of other related tree species in the park.

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Appendix 1: Natural regeneration status of woody species in KSNP (MD =Mature density, SD=Seedling density (Stem ha^{-1}) and SPD =Sapling density; regeneration status (RS) (G = Good, F = Fair, and P = Poor) and N=None regenerating

Scientific name (Species)	Family	Habit	SD	SPD	MD	RS
Acacia albida Del.	Fabaceace	tree	0	0	0.31	None
Acacia etbaica Schweinf	Fabaceae	tree	0	0	0.78	None
Acacia lahai Steud. & Hochst.ex Benth.	Fabaceae	tree	0	0	0.94	None
Acacia mellifera (Vahl) Benth.	Fabaceae	tree	2.2	3.8	69.7	Fair
Acacia oerforta (Forssk.) Schweinf.	Fabaceae	shrub	0.9	3	26.4	Fair
Acacia polyacantha Willd.	Fabaceae	tree	0.8	1.6	7.19	Fair
Acacia senegal (L.) Willd.	Fabaceae	tree	0.5	3.8	24.8	Fair
Acacia seyal Del.	Fabaceae	tree	0	0.9	5.31	Poor
*Acacia sp.*Mart	Fabaceae	tree	0	0	1.72	None
Acacia tortilis (Forssk.) Hayne.	Fabaceae	tree	0	0	1.25	None
Adansonia digitata (L.)	Bombacaceae	tree	0	0	4.22	None
Anogeissus leiocarpus (DC.) Guill. & Perr.	Combretaceae	tree	0	0	11.1	None
Balanites aegyptiaca (L.) Del.	Balanitaceae	tree	1.1	7.7	29.4	Fair
Boscia angustifolia var. *angustifolia* A. Rich.	Capparaceae	tree/ shrub	0	0	1.09	None
Boswellia papyrifera Hochst. ex A.	Burseraceae	tree	0.6	1.7	27.8	Fair
Brucea antidysentrica J.F.	Simaroubacea	tree	0	0	0.47	None
Buddleja polystachya Fresen.	Loganiaceae	Shrub	0	0	0.31	None
Burkea africana Hook.	Caesalpiniaceae	tree	0	0	3.28	None
Cadaba farinosa Forssk.	Capparaceae	shrub	0	0	0.94	None
Calotropis procera (Aiton) W.T.Aiton.	Asclepiadaceae	tree	0	0	2.19	None
Capparis decidua (Forssk.) Edgew.	Capparaceae	tree	0	0	0.63	None
Carissa edulis (Forssk.) Vahl.	Apocynaceae	shrub	0	0	1.72	None
Casuarina equisetifolia (L.)	Casuarinaceae	tree	1.1	4.2	10.8	Fair

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Scientific name (Species)	Family	Habit	SD	SPD	MD	RS
Combretum glutinosum Perr. ex DC.	Combretaceae	shrub	0	0	4.22	None
Combretum hartmannianum Schweinf.	Combretaceae	tree	0.3	3.3	53.4	Fair
Combretum molle R. Br. ex G. Don.	Combretaceae	tree	0	0.8	18.3	Poor
Combretum sp. Loefl.	Combretaceae	tree	0	0	4.22	None
Commiphora boranensis K. Vollesen.	Burseraceae	tree	0	0	5	None
Dalbergia melanoxylon Guill. & Perr.	Fabaceae	tree	0	0.3	7.19	Poor
Dicrostachys cinerea (L.)Wight and Arn.	Fabaceae	tree	0.3	6.4	22.3	Fair
Diospyros abyssinica (Hiern) F. White	Ebenaceae	tree	0	0	2.19	None
Diospyros mespiliformis Hochst. ex A. DC.	Ebenaceae	tree	0	0	4.69	None
Feretia apodanthera Delile.	Rubiaceae	shrub	0	0	0.47	None
Ficus sycomorus (L.)	Moraceae	tree	0	0	0.31	None
Grewia bicolor Juss.	Tiliaceae	tree/ shrub	0	0	4.84	None
Grewia flavescens Juss.	Tiliaceae	tree / shrub	0	0	2.03	None
Grewia mollis Juss.	Tiliaceae	tree	0	0	0.63	None
Grewia villosa Willd.	Tiliaceae	shrub	0	0.5	1.72	Poor
Hyphaene thebaica (L.) Mart.	Arecaceae	tree	1.4	7.8	15	Fair
Jasminum abyssinicum Hochst. ex DC.	Oleaceae	shrub	0	0	1.25	None
Lannea microcarpa Engl. & K. Krause.	Anacardiaceae	tree	0	0	3.59	None
Leptadenia lanceolata (Poir.) Goyder.	Asclepiadaceae	shrub	0	0	0.47	None
Maytenus senegallensis Forssk.	Celastraceae	tree	0	0	0.94	None
Melia azedarach (L.)	Meliaceae	tree	0	0	0.47	None
Moringa stenopetala (Baker f.) Cufod.	Moringaceae	tree	0	0	0.63	None
Nerium oleander (L.)	Apocynaceae	shrub	0	0	0.47	None
Otostegia ellenbeckii Gurke.	Lamiaceae	shrub	0	0	0.31	None
Parkinsonia aculeata (L.)	Fabaceae	tree	0	0	0.16	None
Pittosporum viridiflorum Sims.	Pittosporaceae	tree	0	0	2.66	None
Plumbago zeylanica (L.)	Plumbaginace	shrub	0	0.2	0.78	Poor
Ricinus communis (L.)	Euphorbiaceae	shrub	0	0	0.63	None
Salvadora persica (L.)	Salvadoraceae	shrub	0	0	0.78	None
Sclerocarya birrea (A. Rich.) Hochst.	Anacardiaceae	tree	0	0	2.34	None
Senna sinqueana (Delile) Lock.	Fabaceae	shrub	0	0	0.16	None
Solanum incanum (L.)	Solanaceae	shrub	0	0	1.09	None
Sterculia africana Del.	Sterculiaceae	tree	0	0	6.56	None
Stereospermum kunthianum Cham.	Bignoniaceae	tree/ shrub	0	0	3.28	None
Tamarindus indica (L.)	Fabaceae	tree	0	0	9.22	None
Terminalia brownii Fresen.	Combretaceae	tree	0.2	0.3	32	Fair
Terminalia laxiflora Engl. & Diels.	Combretaceae	tree	0	0	1.56	None
*Terminalia sp.*L.	Combretaceae	tree	0	0	1.09	None
Ziziphus mucronata Willd.	Rhamnaceae	tree / shrub	0	0	2.66	None
Ziziphus spina-christi (L.) Desf.	Rhamnaceae	tree	1.3	2.3	13.6	Fair
Ziziphus mauritiana Willd.	Rhamnaceae	tree/shrub	0	0	0.63	None
Carica papaya (L.)*	Caricaceae	tree*	-	-	-	-
Citrus aurantifolia (Christm.) Swingle*	Rutaceae	shrub*	-	-	-	-
Mangifera indica (L.)*	Anacardiaceae	tree*	-	-	-	-
Rhamnus prinoides L'Hér.*	Rhamnaceae	shrub*	-	-	-	-
Cordia Africana Lam.*	Boraginaceae	tree*	-	-	-	-
Delonix regia (Boj. ex Hook.) Raf.*	Fabaceae	tree*	-	-	-	-
Total	-	-	**10.7**	**48.6**	**466**	-

Note: * Plant species recorded outside quadrat area