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# Ecological Assessment of the Woody Vegetation, Along Canopy and Regeneration Layers in Al Galabat District, Al Gadarif State, Sudan

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ABSTRACT

This study aimed to determine and compare the composition, diversity and density of canopy and regeneration layers; and to examine how the understory species richness differ from the overstory in the forests in AlGalabat area, AlGadarif State The data were collected from 36 systematic circular sample plots of 0.1 ha., with intervals of 200 m between each plot representing six vegetation sites along different topographical feature. A total of 1163 stems of mature woody vegetation and 962 stems of regeneration, representing 37 species, belonging to 16 families were identified. Number of ecological parameters and indices has been studied for each plant species and vegetation community for both canopy and regeneration layers. The results revealed that canopy layer was most dense and diverse in all sites when compared to regeneration layer. *Cephalocroton cordofanus* was recorded the highest value of importance value index (IVI= 129.48) and relative density (59.94%) in the canopy layer.

## 1. Introduction

Sudan is considered one of the largest African countries with an area of 1882000 square kilometers, which highly exhibit variation in topography, soil types and climate that reflected in diversification of vegetation distribution from north to south. Harrison and Jackson (1958) classified the vegetation of the Sudan into desert, semi-desert, low-rainfall woodland savanna, high-rainfall woodland savanna and mountain vegetation. The study area corresponds to AlGalabat (AlGadarif State, eastern Sudan), which is located in low rainfall woodland savanna. The future composition of forests depends on the potential regenerative power of the woody species within a forest stand in space and time (Henle et al., 2004). Presence of sufficient number of seedlings, saplings, and young trees in a given forest indicate a successful regeneration (Saxena and Singh, 1984). This area was selected to be studied due to its importance as one of the richest and diversified vegetation regions, in addition to the fact that there is no previous detailed study regarding the vegetation of this region.

The objectives of the current study were to determine and compare the composition, diversity and density of the regeneration and canopy layers and to examine how the understory species richness differs from the overstory in the forests.

## 2. Materials and Methods

### 2.1 Study Area

The study area is located in the southeast of AlGadarif State in Sudan, it is bordered by the western Ethiopian boundaries, which lies between 12° 21`and 12° 32` N ; 30° 35` and 30° 35` E (Figure 1).

Regarding the climate of the study region, the area is classified as low rainfall woodland savanna, in clay (Harrison and Jackson, 1958). The average annual precipitation is around 670 mm, it is concentrated in a relatively short summer season, that extends from June to September. As for temperatures, the annual average is about 28.7 °C. The temperature ranged from a minimum average of 21 °C, reached in January to a maximum average of 36.4 °C, attained in April and May (Sulieman, 2008).

### 2.2. Data collection and analysis

#### *2.2.1. Data collection*

The vegetation data were collected from 36 systematic circular sample plots of 0.1 ha. (Radius = 17.84) with a separation distance of 200 m between each plot, representing 6 vegetation sites along different topographical feature using the Global Positioning System (GPS) (Garmin version 12).

Plant species in each plot were counted and recorded at individual level, and then, the plant specimens were collected, numbered, pressed in drying paper, and identified by following the method described by Lawrence (1969) and Froman and Bridson (1992). The plant specimens were deposited in the Soba Forests Herbarium

(Forestry and Gum Arabic Research Centre) after confirmation of the identification. The arrangement and classification of families in this study were done following the Linear Angiosperm Phylogeny Group (LAPG) III (Haston et al., 2009).

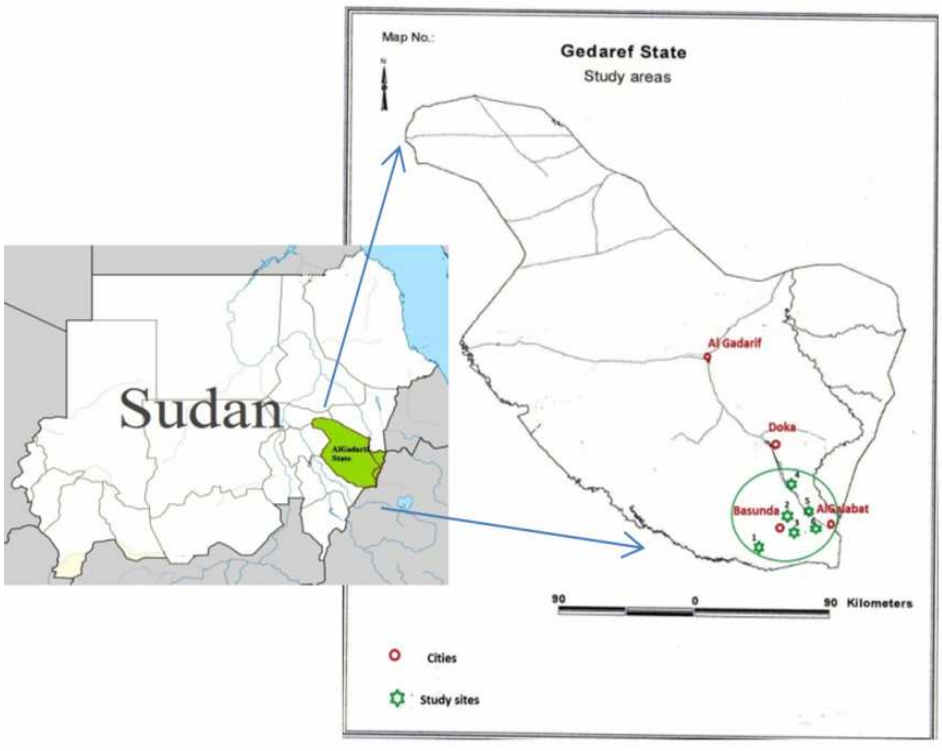



**Figure 1.** Situation of the study area

*2.2.2. Data analysis*

A). Phytosociological analysis

In order to assess the dominance of species in the vegetation communities, density, frequency and abundance were converted to relative values and summed to obtain importance value index (IVI) as reported by Dangoli and Shivakoti (2001) and Chaudhry et al. (2006).

Density (D) = Number of plants of a certain species
Total area sampled
Relative density (RD %) = Density of species x100
Total density of all species
Abundance (A) = Total number of individual x 100
No. of quadrate where species occur
Relative abundance (RA %) = Abundance of species x 100
Total abundance of all species
Frequency (F %) = No. of quadrate where species occur x 100
Total numbers of quadrate
Relative frequency (RF %) = Frequency of species x 100
Total frequency of all species
Importance value index (IVI) = RD% + RA% + RF%

B). Diversity indices

The species richness was determined as the total number of species present in the studied site. The Shannon diversity index was applied to estimate the woody plant species diversity along the study area (Shannon, 1963). This index was calculated by the following equation:

$$Hs = -\sum pi \; In \; pi$$

Where, '*pi*' is the proportion of individuals found in the '*i* ' species and '*In*' denotes the natural logarithm.

Besides, the Pielou index was used for the estimation of species evenness (E) (Pielou, 1966). This index was calculated by the following equation :

$E = H'/lnS$

Where: $H'$ is the Shannon-Wiener diversity measure and $S$ is the number of species.

Species distribution test and comparisons of the woody plant species composition between the different plots were estimated using the single linkage cluster analysis based on Jaccard similarity, using the statistical software named Biodiversity Pro version n° 2 (McAleece, 1998).

## 3. Results and discussion

### 3.1. Floristic composition

Among the 1163 stems of mature woody vegetation and the 962 stems of regeneration measured in 36 sample plots, 37 species belonging to 16 families were identified (Table 1). The family represented by the highest number of species was Fabaceae (12 species), followed by Combretaceae (6 species), Malvaceae (3 species), and the families Rhaminaceae, Euphorbiaceae and Ancardiaceae were represented by 2 species for each, while for the other ten families, they were represented by one species (Table 1).

Information on the species composition of a forest is essential for its wise management in terms of economic value, regeneration potential (Wyatt-Smith, 1987), and ultimately may lead to conserve the biological diversity (Verma et al., 1999).

In terms of species richness AlGalabat area has showed relatively lower number of sampled woody species (37 species) when compared to that of Jebel ElDair (47 species) (Ismail & Mahmoud, 2007), Nuba Mountains (64 species) (Ismail, 2013) and Jebel Al Gerri (44 species) (Ismail & El Sheikh, 2015).

Species from the family of Fabaceae were the most common in the study area. The abundance of Fabaceae could be explained by the fact that most of these species are palatable and grazed by animals, which facilitate the dispersal and distribution of their seeds all over the study area.

### 3.2. Density

The total density of woody plant in canopy layer ranged between 483.35 stem ha$^{-1}$, in Jebel Abgunfa (Site 3) to 165.02 stem ha$^{-1}$., in Jebel Yasin. (Site 2). On the other hand, the total density of the regeneration layer ranged between 506 stem ha$^{-1}$, in Khor Jebel Dolar (site 6) to 78 stem ha$^{-1}$, in Khor Yabis (site 5) (Figure 2). The highest values of relative density in canopy layer were recorded by *Cephalocroton cordofanus* (59.94%) in Jebel Hadad (Site 1), followed by *Boswellia papyrifera* (31.31%), *Ziziphus spina-christi* (33.14 %), in Khor Kunena (Site 4), *Combretum hartmannianum* (27.84%) %*)* in Jebel Hadad (Site 1), *Balanites aegyptiaca* (26.74%) in Khor Kunena (Site 4) and *Maytenus senegalensis* (22.22%) in Jebel Yasin. While the least value was 0.28% which was recorded by *Asparagus flagellaris*, *Dalbergia melnoxylon* and *Combretum collenum* in Jebel Hadad (Site 1).

The regeneration status in El Galabat district expressed that the highest values of relative density were recorded by *Ziziphus spina-christi* (49.17%) in Site 4 (Khor Kunena) followed by *Dichrostachys cinerea* (43.59%) in Site 5 (Khoy Yabis), *Acacia seyal* (39.23%) in Site 1 (Jebel Hadad), *Maytenus senegalensis* (36.49%) in Site 2 (Jebel Yasin). While the least value was 0.37% recorded by *Acacia seyal* and *Ziziphus abyssinica* in Site 3 (Jebel Abganfa) (Table 1).

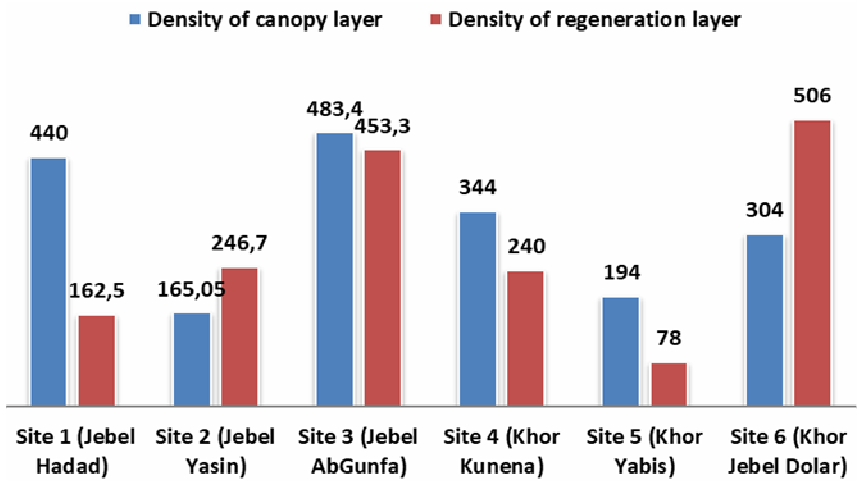



**Figure 2.** The total density (stem ha$^{-1}$) for both canopy and regeneration layers in different sites

### 3.3. Dominance

Dominance was determined as the importance value index (IVI). The results revealed that *Cephalocroton cordofanus* (IVI= 129.48) dominated the canopy layer of Site 1 (Jebel Hadad), followed by *Combretum hartmannianum* (IVI= 74.84). Whereas in the regeneration layer *Ziziphus spina christi* was dominant with IVI value of 96.59 followed by *Acacia seyal* Del. var. *seyal* IVI =91.07. *Boswellia papyrifera* dominated the canopy layer in Site 2 (Jebel Yasin) with IVI value of 76.13, followed by *Maytenus senegalensis*. While *Dichrostachys cinerea* dominated regeneration layer with (IVI=75.6), followed by *Lannea fruticosa* in site 3 (Jebel Abganfa) which dominated in both vegetation layers followed by *Combretum hartmannianum* in canopy layer and *Dichrostachys cinerea* in regeneration layer. in Site 4 (Khor Kunena) *Ziziphus spina-christi* dominated both layers, followed by *Balanitesa aegyptiaca*. the Canopy layer of Site 5 (Khoy Yabis) dominated by *Acacia seyal* and followed by *Ziziphus spina-christi*. While regeneration layer was dominated by *Dichrostachys cinerea*. *Lannea fruticosa* dominated canopy layer and regeneration layer dominated by *Dichrostachys cinerea* followed by *Ziziphus spina-christi* and *Balanites aegyptiaca* (Table 1). Despite the dominance of *Cephalocroton cordofanus* in Site 1 (Jebel Hadad). All the encountered individuals of the species were stunted due to the over grazing since the plant is considered as one of the most palatable species for animals. According to the results, the dominance of *Cephalocroton cordofanus* and *Combretum hartmannianum* in canopy layer could be attributed to the suitability of the environmental factors to requirements of those species especially the precipitation amounts and the type of soil.

The results obtained herein revealed that, most of the woody species fails to regenerate, including some economically important species such as *Acacia nilotica, Adansonia digitata, Tamarindus indica, Acacia hochii, Sterculia setigera, Ximenia americana, Feretia apodanthera, Boscia angustifolia, Combretum mollis, Pterocarpus lucens* and *Bauhinia reticulata*, this Might due to the overgrazing and the lack of seeds soil in the soil bank, Which could be the consequence of the removal of seeds from soil by rainwater during the rainy season, specially that the area is characterized by its high slopes, Moreover, seeds viability could be affected by the biotic factors such as the attack of seed borers beetles or any other pests immediately after the fruits being ripe. Therefore, the density and the dominance of species in regeneration layer in all sites is lower than that of canopy layer, these suggestions were in concordance with the fact, which states that the regeneration is affected by both abiotic (environmental factors) such as climate, fire, soil; and biotic factors such as overstory structure, overgrazing and soil seed bank (Borja, 2014; Bose, 2016).

### 3.4. Species richness and diversity indices

The diversity among the different sites in terms of species richness showed that the highest species diversity was observed in sites 5 of canopy layer with a species number of eighteen; followed by site 6 with 15 species. While the highest number in regeneration layer was recorded by site 3 with 13 species, followed by site 2 with 12 species, whereas sites 1, 4 and 5 in regeneration layer were recorded the least number of species (7 species).
The biodiversity indices of canopy layers varied form 2.47 as the highest value to 1.1 as the lowest value, whereas site 5 recorded the highest values of Shannon diversity index (2.47) and evenness index (0.66); while the highest value of Simpson index was (0.88) recorded by site 1. For the regeneration layer, site 2 showed the highest Shannon diversity index (1.96). The highest value of Pielou evenness index was 0.74 that was showed by site 5. and the highest Simpson index value (0.81) was showed by site 2 (Figures 3 and 4).

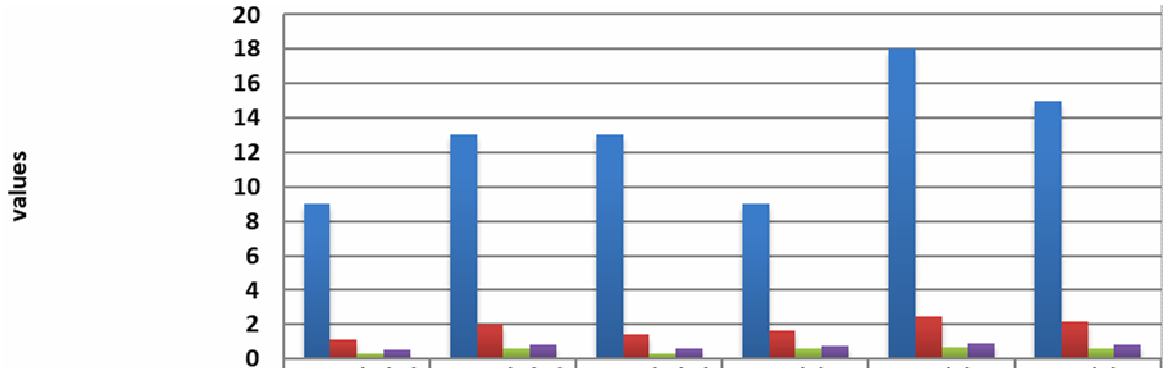
The mentioned above values of Shannon and evenness indices are relatively close to that of Jebel ElDair (Ismail and Mahmoud, 2010) and of Rashad and Alabassia (Ismail and Elawad, 2017), this might be attributed that all these areas are similar in their environmental condition and topography especially most studied sites are mountainous, in addition to that all these areas are classified as low rainfall woodland savanna of Sudan (Harrison and Jachson, 1958). In general view, the values of diversity indices of regeneration layer are relatively low when compared to those of canopy.

**Table 1.** Relative density (Rd%), Importance Value Index (IVI) of canopy and regeneration layers of six studied sites

| *plant species* | *Canopy layer* | | | | | | | | | | | | *Regeneration layer* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Site 1 (Jebel Hadad)* | | *Site 2 (Jebel Yasin)* | | *Site 3 (Jebel abganfa)* | | *Site 4 (Khor Kunena)* | | *Site 5 (Khoy Yabis)* | | *Site 5 (Khor Jebel Dolar)* | | *Site 1 (Jebel Hadad)* | | *Site 2 (Jebel Yasin)* | | *Site 3 (Jebel abganfa)* | | *Site 4 (Khor Kunena)* | | *Site 5 (Khoy Yabis)* | | *Site 5 (Khor Jebel Dolar)* | |
| | *Rd* | *IVI* | *Rd* | *IVI* | *Rd* | *IVI* | *Rd* | *IVI* | *Rd* | *IVI* | *Rd* | *IVI* | *Rd* | *IVI* | *Rd* | *IVI* | *Rd* | *IVI* | *Rd* | *IVI* | *Rd* | *IVI* | *Rd* | *IVI* |
| **Asparagaceae** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Asparagus flagellaris* (Kunth) Baker. | 0.3 | 5.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Zygophyllaceae** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Balanites aegyptiaca* (L.) Delile | 0 | 0 | 3 | 13.2 | 0 | 0 | 26.4 | 66 | 7.2 | 20.8 | 0.7 | 5.4 | 0 | 0 | 1.35 | 8.9 | 0 | 0 | 23 | 60.4 | 7.7 | 34.6 | 23 | 60.4 |
| **Celastraceae** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Maytenus senegalensis* (Lam.) Exdl. | 0 | 0 | 22 | 49.2 | 4.14 | 21.1 | 0 | 0 | 0 | 0 | 3.3 | 14 | 0 | 0 | 36.5 | 76 | 5.9 | 21 | 0 | 0 | 0 | 0 | 0.8 | 7.13 |
| **Fabaceae** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Acacia hockii* De Willd. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acacia nilotica* subsp. *tomentosa* (Schum. & Thonn.) Roberty. | 0 | 0 | 0 | 0 | 0 | 0 | 0.58 | 6.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acacia polyacantha* Willd. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4.1 | 16.8 | 5.9 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.2 | 10.6 |
| *Acacia sieberiana* DC. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.8 | 8.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acacia senegal* (L.) Willd. | 3.69 | 21 | 1 | 6.71 | 0 | 0 | 4.65 | 21 | 0 | 0 | 0 | 0 | 16.2 | 51.6 | 0.68 | 6.2 | 0.4 | 4.2 | 5 | 23.7 | 0 | 0 | 5 | 23.7 |
| *Acacia seyal* Del. var. *Seyal* | 3.98 | 29 | 1 | 6.09 | 2.41 | 12.9 | 0 | 0 | 27 | 53.5 | 8.6 | 26 | 39.2 | 91.1 | 0 | 0 | 5.2 | 21 | 0 | 0 | 10 | 32.3 | 1.6 | 11.6 |
| *Bauhinia reticulata* DC. | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| *Dalbergia melanoxylon* Guill. & Perr. | 0.28 | 5.7 | 0 | 0 | 0.35 | 4.49 | 0 | 0 | 0 | 0 | 7.9 | 24 | 0 | 0 | 0 | 0 | 0.7 | 7.1 | 0 | 0 | 0 | | 0 | 0 |

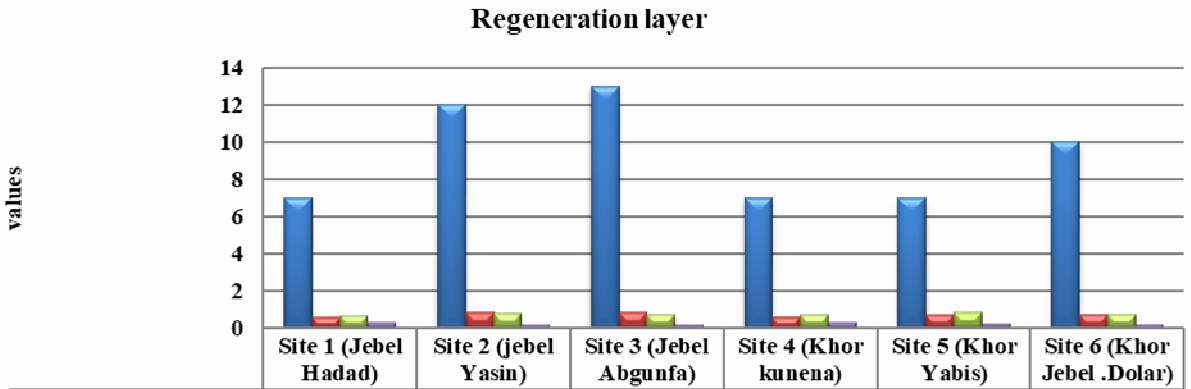
| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Dichrostachys cinerea* (L.) White & Arn. | 0 | 0 | 0 | 0 | 4.14 | 21.1 | 0 | 0 | 3.1 | 12 | 1.3 | 8.3 | 0 | 0 | 0 | 0 | 29 | 60 | 9.2 | 44.4 | 44 | 106.24 | 35 | 78.6 |
| *Entada africana* Guill. & Perr. | 0.57 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocarpus lucens* Lepr. ex Guill. & Perr subsp. *lucens* | 0 | 0 | 1 | 6.09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tamarindus indica* L. | 0 | 0 | 0 | 0 | 0.35 | 4.5 | 0 | 0 | 4.1 | 15.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Rhamnaceae** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Ziziphus abyssinica* Hochst. ex A. Rich. | 0 | 0 | 0 | 0 | 0.35 | 4.5 | 0 | 0 | 0 | 0 | 11 | 29 | 0 | 0 | 0 | 0 | 0.4 | 4.2 | 0 | 0 | 0 | | 4 | 17.9 |
| *Ziziphus spina-christi* (L.) Desf. | 3.13 | 19 | 3 | 13.7 | 3.79 | 20.5 | 33.1 | 76 | 13 | 31.9 | 13 | 34 | 34.6 | 96.6 | 4.05 | 17 | 7 | 24 | 49 | 133 | 10 | 32.3 | 24 | 62 |
| **Euphorbiaceae** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Cephalocroton cordofanus* Hochst. | 59.9 | 129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.85 | 20.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ricinus communis* L. | 0 | 0 | 0 | 0 | 0 | 0 | 17.4 | 53 | 1 | 6.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 38.4 | 0 | 0 | 0 | 0 |
| **Combretaceae** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Anogeissus leiocarpa* (DC.) Guill. & Perr. | 0 | 0 | 6.1 | 25.9 | 0 | 0 | 10.5 | 35 | 5.2 | 16.6 | 4.6 | 18 | 0 | 0 | 1.35 | 10 | 0 | 0 | 0 | 0 | 2.6 | 15.2 | 0 | 0 |
| *Combretum aculeatum* Vent. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9.3 | 25.2 | 0 | 0 | 0 | 0 | 0 | 0 | 3.7 | 19 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Combretum collinum* subsp. *binderianum* (Kotschy) Okafa. | 0.28 | 5.7 | 1 | 6.09 | 1.38 | 5.65 | 0.58 | 6.9 | 0 | 0 | 0 | 0 | 0 | 0 | 8.79 | 29 | 0.7 | 7.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Combretum glutinosum* Perr. ex DC. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7.1 | 26.1 |
| *Combretum hartmannianum* Schwein f. Beitr. | 27.8 | 75 | 5.1 | 18.9 | 20 | 108 | 0 | 0 | 0 | 0 | 1.3 | 8.3 | 17.3 | 37 | 13.5 | 37 | 4.4 | 17 | 0.8 | 8.85 | 0 | 0 | 3.2 | 15.8 |
| *Combretum molle* R.Br. ex G. Don. | 0 | 0 | 0 | 0 | 1.72 | 10.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Burseraceae** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Boswellia papyrifera* (Del.) Hochst. | 0 | 0 | 31 | 76.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.7 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Anacardiaceae** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Lannea fruticosa* (Hochst. ex A. Rich.) Engl. | 0 | 0 | 10 | 29.2 | 58.3 | 115 | 0 | 0 | 3.1 | 13.2 | 35 | 71 | 0 | 0 | 14.2 | 39 | 30 | 64 | 0 | 0 | 0 | 0 | 19 | 50.8 |
| *Rhus natalensis* Bernh. ex Krauss | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1** | **6.12** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Malvaceae** | | | | | | | | | | | | | | | | | | | | | | | |
| *Adansonia digitata* Linn. | **0** | **0** | **0** | **0** | | **0** | **0** | **0** | **1** | **3.7** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| *Grewia villosa* Willd. | 0 | 0 | 0 | 0 | | 0 | 0.58 | 6.9 | 3.9 | 13.3 | 0 | 0 | 0 | 0 | 1.4 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sterculia setigera* Del. | **0** | **0** | **0** | **0** | | **4.49** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **Capparaceae** | | | | | | | | | | | | | | | | | | | | | | | |
| *Boscia angustifolia* A. Rich. | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1** | **6.12** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **Olacaceae** | | | | | | | | | | | | | | | | | | | | | | | |
| *Ximenia americana* L. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.3 | 8.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Ebenaceae** | | | | | | | | | | | | | | | | | | | | | | | |
| *Diospyros mespiliformis* Hochst. ex A. DC. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6.2 | 18.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 39.7 | 0 | 0 |
| **Rubiaceae** | | | | | | | | | | | | | | | | | | | | | | | |
| *Feretia apodanthera* Del. | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **5.2** | **16.6** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **Apocynaceae** | | | | | | | | | | | | | | | | | | | | | | | |
| *Calotropis procera* (Aiton) Dryand. | 0 | 0 | 7.1 | 22.5 | 0 | 0 | 5.81 | 28 | 3.1 | 12 | 0.7 | 5.4 | 0.77 | 8.08 | 7.43 | 26 | 5.5 | 27 | 1.7 | 15.6 | 0 | 0 | 1.7 | 15.6 |
| **Bignoniaceae** | | | | | | | | | | | | | | | | | | | | | | | |
| *Stereospermum kunthianum* Cham. | 0 | 0 | 8.1 | 24.4 | 2.76 | 14.7 | 0 | 0 | 2.1 | 9.71 | 0 | 0 | 0 | 0 | 8.11 | 27 | 7.4 | 23 | 0 | 0 | 13 | 37.3 | 0 | 0 |




| | Site 1 (Jebel Hadad) | Site 2 (jebel Yasin) | Site 3 (Jebel Abgunfa) | Site 4 (Khor kunena) | Site 5 (Khor Yabis) | Site 6 (Khor Jebel .Dolar) |
|---|---|---|---|---|---|---|
| Rishness | 9 | 13 | 13 | 9 | 18 | 15 |
| Shannon index | 1,1 | 2,04 | 1,42 | 1,66 | 2,47 | 2,15 |
| Pielou evenness index | 0,31 | 0,59 | 0,32 | 0,58 | 0,66 | 0,57 |
| Simpson index | 0,56 | 0,82 | 0,61 | 0,77 | 0,88 | 0,83 |

**Figure 3.** Diversity indices of canopy layer in studied sites




| | Site 1 (Jebel Hadad) | Site 2 (jebel Yasin) | Site 3 (Jebel Abgunfa) | Site 4 (Khor kunena) | Site 5 (Khor Yabis) | Site 6 (Khor Jebel .Dolar) |
|---|---|---|---|---|---|---|
| Rishness | 7 | 12 | 13 | 7 | 7 | 10 |
| Shannon index | 0,595 | 0,852 | 0,847 | 0,613 | 0,715 | 0,755 |
| Pielou evenness index | 0,705 | 0,789 | 0,76 | 0,726 | 0,846 | 0,755 |
| Simpson index | 0,298 | 0,189 | 0,193 | 0,311 | 0,231 | 0,223 |

**Figure 4.** Diversity indices of regeneration layer in the studied sites

### 3.5. Similarity

The between-plot taxonomic similarity was assessed using Jacquard's coefficient based on the occurrence of species at the six sites for both canopy and regeneration layers (Figure 5). The findings revealed that the most similar sites in canopy layer were site 6 and site 2 by showing a highest similarity (38%). In canopy layer, site 1 and site 2 showed the least similarity (29.41%). On the other hand, the highest similarity encountered in the regeneration layer was that (53.3%) recorded between site 3 and site 6; while the least similarity was (30.77%) between site 1 and site 5. The percentage of similarity between different sites in both layers is relatively low that could be due to the difference in species composition between the studied sites, which may differ in environmental factors.

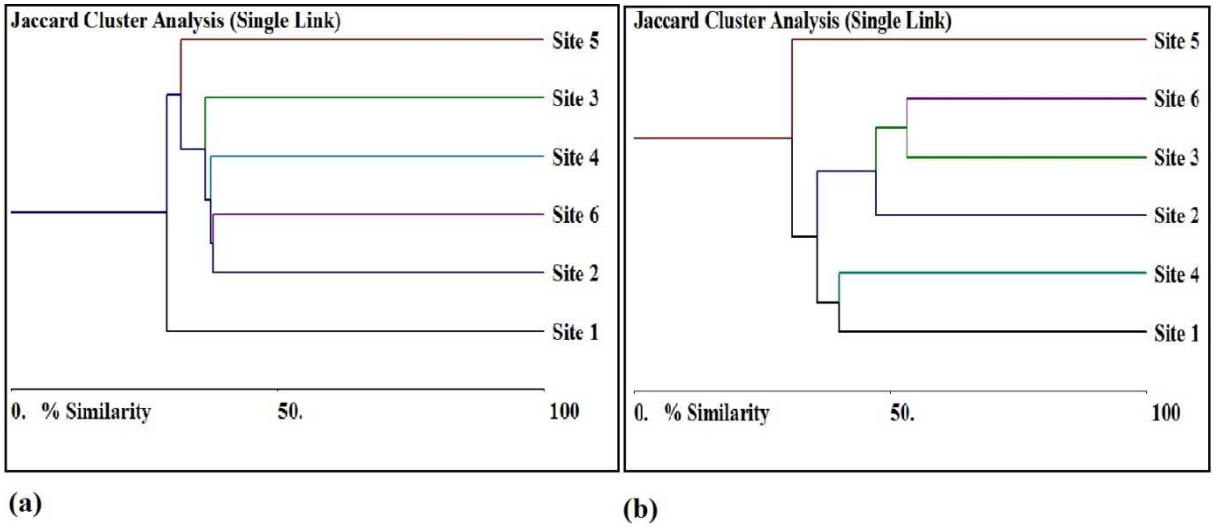



**Figure 5.** Showed the similarity in canopy layer (a) and regeneration layer (b)

## 3. Conclusion

According to the results obtained in the present study, it can be concluded that woody species in canopy layers differ from those of regeneration layers in all the studied sites, which, in the future may lead to major changes in woody species composition along canopy layers of those sites. Several species recorded in canopy layers, were disappeared from regeneration layers, including*: Acacia hochii, Acacia nilotica, Acacia polyacantha, Entada africana, Pterocarpus lucens, Tamarindus indica, Combretum mollis, Adansonia digitata, Sterculia setigera, Boscia angustifolia, Ximenia americana, Feretia apodanthera.*

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