Effects of soil physical and chemical properties on the distribution of trees in some ecological zones of Zalingei-Darfur; Sudan

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Abstract— *This paper is part of a big research work on the analysis of woody vegetation and natural regeneration of some areas, as influenced by topography and distance from major wades at the study area. Inventories of tree species abundance, dominance and natural regeneration were made. Composite soil samples were taken from the seven identified ecological zones, the soil samples were analyzed for their chemical and physical properties. The distribution of tree species based on soil characteristic was analyzed. The soil texture of the study area was found to be sandy loam at lower hill slope (LH), Stony hill slope (SH) and lower terraces (LT). Sandy clay loam at sedentary plain (SP) and upper terraces (UT). Loamy sand at contemporary flood plain (CF). Clay at clay plain (CP) and. The soil pH is generally acidic. Faidherbia albida is the dominant tree species in Loamy sand and Sandy loam of (CF) and (LT). Balanites aegyptiaca dominant at the sandy clay loam of (UT). At sandy clay loam of (SP) and Sandy loam of (LH) the dominant species are Albizia amara and Acacia senegal. But Acacia seyal and Acacia Senegal dominant at the CP. Boswellia papyrifera and Albizia amara dominant at the sandy loam of SH. Result of Simpson diversity index showed that the most diversity site is at sandy loam of LT (0.15) , sandy loam of LH (0.26), SH (0.33), CP (0.34), sandy clay loam of SP (0.35), UT (0.41) and there is no diversity at loamy sand of CF. Generally there is no diversity in (CF). The (LT) have the highest diversity index of (0.15).*

Keywords— distribution, dominant , properties , soil , trees.

I. INTRODUCTION

The study was carried out at Zalingei area of central Darfur state in Sudan, the area lies between latitude 12° 42’ 576’’ N (South point) and 13° 08' 055" N (North point) and between longitude 23° 39' 761" E (East point) and 23° 25' 835" E (West point), with altitude that varies from 890 m to 1121 m above the sea level. The area lies on the semi-arid Savannah zone, which is affected by the elevation of Jebel Marra massif. The soils of the country can be classified as 60% sandy, 30% heavy cracking clays and 10% red soils of different types [1]. This research was conducted to study the Effects of soil physical and chemical properties on the distribution of trees in some ecological zones of Zalingei-Darfur; Sudan with the object of understanding the relationship between dominant tree species in each site and the soil physical and chemical properties. and the effects of soil physical and chemical properties in the woody plant diversity. And Identify, the dominant tree species at the study area.

1.1 Soils of the study area

The combination of rainfall and soil texture determines the distribution of vegetation [2]. The soils of study area are derived from the gneisses and shists and granites of underlining basement complex, the soils include those of drift alluvial and dry plains. These few sedentary soils and when found are generally truncated [3]. The soils of the area are rather shallow and compact derived from the basement complex rock and volcanic material with rock close to the surface or expose mainly along water courses. In many cases transported soil material overlies a weathering zone, becoming a part of depositional layering. The predominant top soil is sandy loam, becoming loam or sandy clay [4]. Other soils range from grey to brown gravely clay of pedi plains to alluvial and colluvial soils (clay loam) in depressions and along the main valley and water courses to volcanic ash and sandy loam pediments plains.

The soil of Zalingei area is mostly neutral or slightly acid with little or no lime content. Soil organic matter and the available phosphorous are low, with relatively highly soluble potassium and the Carbon/ Nitrogen ratio is wide [5].

1.2 Geology

The study area is in the surrounding lowlands of Jebel Marra which is a dormant, late tertiary, volcanic massif resting on a base of Archaean rocks at the summit of an up warping between the Chad and Nile basins. The low land of the basement complex have been formed by the more easily weathered schists and gneisses, while the hill lands such as Tebella massif (1413 m) and the Kongyo hills (1359), lying to the south east and north of Zalingei respectively, are from the more resistant paraschstis and gneiss, and represent the remnant of higher and older land surface [6].

II. MATERIALS AND METHODS

2.1 Sites selection

According to the reconnaissance survey the selected sites for investigation, represented 278 ha of Zalingei woody vegetation area distributed as follows: 96 ha in Zalingei administrative unit, 108 ha in Abata administrative unit and 74 ha in rural Teraje administrative unit. The total size of sample plots was 13.9 ha representing 5 % of the total survey area.

2.1.1 Selection criteria

Sites selection for investigations was primarily based on its geographical position to the Wadi system, i.e. lying perpendicular to the wadies system, and this included Wadi Gallabat Traje, Wadi Aribo Zalingei, Wadi Dahab sharo Zalingei, Wadi Azum Zalingei and Wadi Uyer Abata, other factors dictated site selection were the existence of woody vegetation, the distribution of trees species in the area, and altitude for the stony hill slope sites.

2.1.2 Description of the sites

Eleven sites were selected for this study. Site 1 is a contemporary flood plain on Wadi Gallabat Teraje with altitude of 999 m.a.s.l. Sites 2 and 3 represent lower terraces at Wadi Uyer in Abata with altitude of 960 m.a.s.l and Wadi Aribo in Zalingei with altitude of 902 m.a.s.l. Sites 4 and 5 are upper terraces at Wadi Dahab Sharo in Zalingei with altitude 922.2m.a.s.l and Wadi Gallabat Teraje with altitude of 1002 m.a.s.l. Site 6 is clay plain at Wadi Uyer in Abata with of altitude 973 m.a.s.l. Site 7 is sedentary plain at Wadi Uyer Abata with altitude of 980 m.a.s.l. Sites 8 and 9 are lower hill slope at Wadi Uyer in Abata with altitude of 993m.a.s.l and Wadi Gallabat Teraje with altitude of 1016 m.a.s.l. Sites 10 and 11 are Stony hill slope at Wadi Gallabat Teraje with altitude of 1112 m.a.s.l and Wadi Azum in Zalingei with altitude of 944.4 m.a.s.l.

Soil samples collection and analysis

2.2 Soil samples collection and analysis

According to [7] who reported that random samples are collected in statistically random manner, and the actual depths selected will obviously vary, depending on the soils and crops involved; two possible systems might be follows (depths in cm):

A/ 0-15, 15-30, 30-60, 60-90, 90-120 **B**/ 0-10, 40-50, 90-100, 140-150. [8] indicated that the suitable depth for the fruit trees is 0-30, 30-60, 60-100. Since the topsoil is generally subject to variation over short distances, the Soil samples were taken and collected from subsurface soils 15 - 60 using an auger. From each site four samples were collected randomly accordingly a total of 44 (4×11) soil samples were taken for analysis. Soil physical and chemical analysis was done at the soil department laboratory, faculty of Agriculture University of Khartoum.

2.3 Woody vegetation survey.

The systematic circular line-plot sampling design and systematic strip sampling after [9] was used for this survey. Using the Global Positioning System (GPS), measuring tape. In the sites described above, sample plots were established as follows: Site 4,7,8,9 and 11 consisted of 42 hectare (600 m × 700 m) with 21 sample plots for each one. The sample plots were circular in shape with a radius of 17.84 m (0.1 ha in area). In addition, the survey lines were drawn with seven sample plots per line. The distance between survey lines is 200 m and the distance between successive sample plots is 100 m. The distance from the outer survey lines to the borderlines is 100 m. each sample plot represents 2.1 hectares. In site 2, 3,5and 6 the area occupied by trees was laid on strip and they were relatively smaller, therefore, strip sample plot were used each of them consisted of 12 hectare (200 m × 600 m) with 2 strip (5m× 600m) along the site and the distance between each strip is 100 m, each strip divided in to two sample plots. The size of each sample plot was (5m×300m), the selected strip sample plot in site 1 and 10, because the areas of trees was laid on narrow strip at site 1 and Steep slope at site 10. Also they were relatively smaller, each of them consists of 10 hectare (200 m × 500m) with 2 strip (5m× 500m) along the site and the distance between

each strip is 100 m, each strip divided in to two sample plots, Size of each sample plot (5m× 250 m). In the eleven sites, the tree species were identified and recorded, and all trees per plot with dbh equal to or greater than seven centimeters were enumerated. The number of trees per ha were calculated.

2.4 Species composition

For the analysis of the species composition using the formulas: Abundance (AB) = Stem number of a given species per hectare. Absolute abundance (AAB) = Number of individuals per species. Relative abundance (RAB) = percentage of each species of the total stem number per hectare. Frequency is defined as the probability or chance of finding an individual of a particular species in a given sample area or quadrate. Absolute dominance (BA) = the sum of the individual stem basal areas. Relative dominance (RBA) = percentage of a given species of the total stem basal area measured [10].

2.5 Woody plant Diversity

Simpson Diversity index was used to measure the woody plant Diversity. The value of this index ranges between 0 and 1. Within this index, 0 represents infinite diversity and 1, no diversity. Where: Simpson Diversity index in the following equation:

$$D = \sum n(n-1)/N(N-1)$$

Where:

D = Simpson Diversity index.
N = the total number of individuals.
N= the total number of species [11].

TABLE 1
SOIL TEXTURE AT THE STUDY AREA

Sites	Clay %	Silit %	Sand %	Texture class
CF	8.43	7.58	83.99	Loamy sand
LT	15.31	20.70	63.99	Sandy loam
UT	35.31	21.95	42.27	Sandy clay loam
CP	54.68	26.33	18.99	Clay
SP	25.93	15.08	58.99	Sandy clay loam
LH	16.55	11.33	66.62	Sandy loam
SH	11.56	32.58	55.86	Sandy loam

Were site: **CF=** Contemporary flood plain **LT** = Lower terraces **UT** = Upper terraces **SP=** Sedentary plain
CP = Clay plain **LH** = Lower hill slope **SH** = Stony hill slope

III. RESULTS

3.1 Soil characteristics

3.1.1 Physical properties

Results in table (1) demonstrate the differences in soil texture at the study area. It is generally sandy loam at Lower terraces , Lower hill slope and Stony hill slope, sandy clay loam at Upper terraces and Sedentary plain, loamy sand at Contemporary flood plain and clay at Clay plain

3.1.2. Chemical properties

The pH of the soil in the survey sites was found to range from 5.7 at LH to 7.03 at CP. EC e ranges from 0.24 at CF to 1.35 at SH. SP ranges from 36.8 to 48 for LH, SH respectively. Ho_3 ranging from 3.25 at LH to 7. 5 at CP. Na meg/l ranges from 0.333 to 7.313 for CF, SH respectively. Ca+M meg/lg range from 11 at SH to 3 at CF, LT and CP collectively. K meg/l range from 0.1 at CP to 1.33 at LT. Cl meg/l range from 5.75 at CF to 11.75 at SH see table 2.Fig.1.

TABLE 2
SHOW CHEMICAL PROPERTIES OF THE SOIL IN THE SELECTED SITES

Sites	Ph	ECe Mmhos/cm	SP ds/m	Na meg/l	Ca+Mg meg/l	Ca meg/l	Mg meg/l	K meg/l	Hco_3 meg/l	Cl meg/l
CF	6.50	0.242	44.00	0.333	3.00	2.25	0.75	0.138	3.50	5.75
LT	6.80	0.43	42.7	0.77	3.00	2.25	0.75	1.33	4.25	6.25
UT	6.45	0.45	44.21	1.49	3.26	2.63	0.63	0.36	4.75	7.75
CP	7.03	0.508	47.36	3.043	3.00	2.25	0.75	0.102	7.50	7.75
SP	6.15	0.690	38.95	1.128	4.50	3.75	0.75	0.328	4.00	9.50
LH	5.7	0.54	36.8	2.315	3.50	2.75	0.75	0.31	3.25	7.00
SH	6.42	1.35	48.00	7.313	11.00	8.25	2.75	0.95	5.00	11.75
average	6.44	0.60	43.15	2.34	4.47	3.45	1.02	0.50	4.61	7.96

Soil analysis was carried out at laboratory of soil Department, Faculty of Agriculture, University of Khartoum, E.C. - Electrical conductivity mmho s /c S P -Saturation percentage

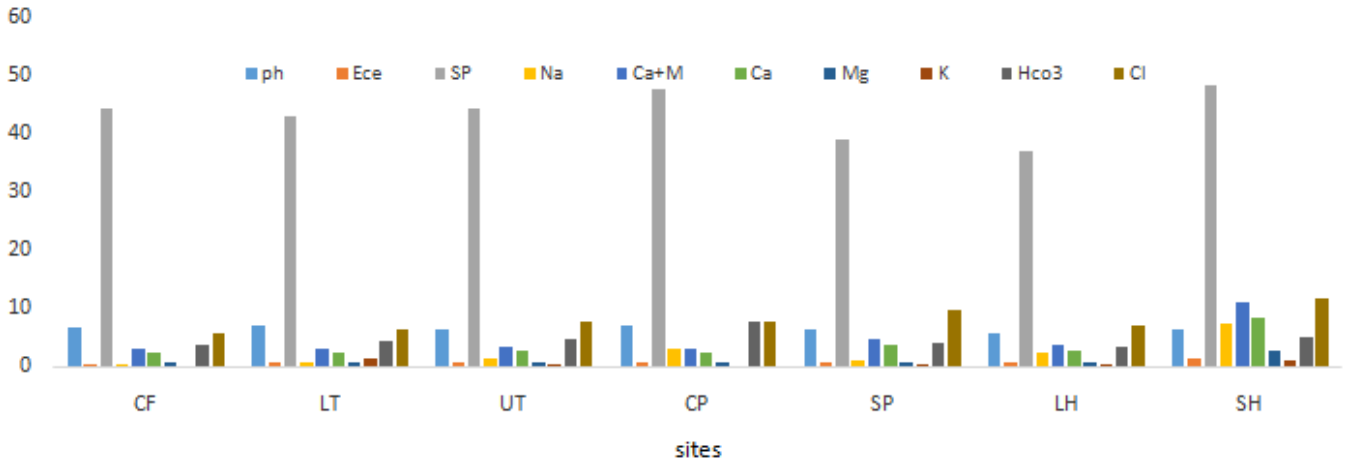

FIG. (1) CHEMICAL PROPERTIES OF THE SOIL IN THE SELECTED SITES.

3.2 Distributions of tree species at the study sites.

In sites, 1, 2 and 3 the tree with the highest density was *Faidherbia albida with* 4 tree/ha, 5 tree/ha and 6.7 tree/ha respectively. In site 4 and 5 it was found that the highest tree density (tree/ha) was for *Acacia seyal* and *Balanites aegyptiaca with* 55.24 tree/ha and 35.24 tree/ha respectively, also the densityof *Balanites aegyptiaca* and *Anogeissus leiocarpus* were 8.3 tree/ha and 3.3 tree/ha respectively. In site 6 the highest tree density was calculated *for Acacia seyal* 106.7 tree/ha, *Acacia senegal* 31.7 tree/ha, *Acacia nilotica* 21.7 tree/ha. In site seven *Albizia amara* scored the highest density 52.4 tree/ha, followed by *Acacia senegal* 29.5 tree/ha. There are only two dominant species in site 8 namely *Albizia amara* 69.05 tree/ha followed by *Acacia senegal* 30.84 tree/ha but, in site 9 the highest tree density (tree/ha) was *Balanites aegyptiaca*, 20 tree/ha followed by *Acacia seyal* 12.4 tree/ha, Anogeissus *leiocarpus* 6.2 tree/ha and *Albizia amara* 5.24 tree/ha. There is only one dominant tree species in site 10 namely *Boswellia papyrifera* 52 tree/ha followed by *Lannea fruticosa* 18 tree/ha, *Dichrostachys cinerea* 12 tree/ha and *Acacia girrardii* 8 tree/ha. The dominant tree species in site 11 was *Albizia amara* 45.25 tree/ha followed by *Balanites aegyptiaca* 7.62 tree/ha and *Acacia senegal* 6.19 tree/ha see table 3.

3.3 Woody plant Diversity

The diversity index for the terraces ranged between 0.15 - 1. The highest diversity for the terraces was for the lower terraces 0.15 followed by Lower hill slope 0.26, stony hill slope 0.33, clay plain 0.34 , sedentary plain 0.35, upper terraces 0.41 and contemporary flood plain (Table 4).

TABLE 4
SHOWS SIMPSON DIVERSITY INDEX FOR THE TERRACES

Site	N	N(n-1)	$\sum n(n-1)$	Simpson's index
Lower terraces	13	156	24	0.15
Clay plain	118	13806	4620	0.34
Sedentary plain	214	45582	15828	0.35
Lower hill slope	351	122850	31470	0.26
Upper terraces	220	48180	19732	0.41
Stony hill slope	177	31152	10124	0.33
Contemporary flood plain	2	2	2	1

3.4 Effects of soil physical properties on the distribution of trees in study areas.

Faidherbia albida is the dominant tree species in Contemporary flood plain and Lower terraces which the soil texture was Loamy sand and sandy loam respectively. *Balanites aegyptiaca* dominant at the Sandy clay loam of Upper terraces. At Sedentary plain and Lower hill slope which the soil texture was Sandy clay loam and Sandy loam respectively the dominant species are *Albizia amara* and *Acacia senegal.* But *Acacia seyal* and *Acacia senegal* dominant at the Clay plain which the soil texture is Clay. *Boswellia papyrifera, Albizia amara* dominant at the sandy loam of stony hill slope.

Result of Simpson diversity index show that the most diversity site is lower terraces (0.15) which the soil texture was sandy loam followed by sandy loam of lower hill slope (0.26) and stony hill slope (0.33), followed by clay plain (0.34) followed by sandy clay loam of sedentary plain (0.35) and upper terraces (0.41) and the is no diversity at loamy sand of contemporary flood plain see table 5.

TABLE 5
SHOW THE EFFECTS OF SOIL PHYSICAL AND CHEMICAL PROPERTIES ON THE DISTRIBUTION OF TREES AT STUDY AREAS

sites	Chemical properties								Soil texture	D value	Dominant tree species
	Ph	ECe Mmhos/cm	SP ds/m	Na meg/l	Ca+Mg meg/l	K meg/l	Hco_3 meg/l	Cl meg/l			
CF	6.50	0.24	44.0	0.33	3.00	0.14	3.50	5.75	Loamy sand	1	*Faidherbia albida*
LT	6.80	0.43	42.7	0.77	3.00	1.33	4.25	6.25	Sandy loam	0.15	*Faidherbia albida*
UT	6.45	0.45	44.2	1.49	3.26	0.36	4.75	7.75	Sandy clay loam	0.41	*Balanites aegyptiaca*
CP	7.03	0.51	47.4	3.04	3.00	0.10	7.50	7.75	Clay	0.34	*Acacia seyal , Acacia senegal*
SP	6.15	0.69	39	1.13	4.50	0.33	4.00	9.50	Sandy clay loam	0.35	*Albizia amara , Acacia senegal*
LH	5.7	0.54	36.8	2.32	3.50	0.31	3.25	7.00	Sandy loam	0.26	*Albizia amara , Acacia senegal*
SH	6.42	1.35	48.0	7.31	11.00	0.95	5.00	11.8	Sandy loam	0.33	*Boswellia papyrifera, Albizia amara*

Were site:
CF= Contemporary flood plain **LT** = Lower terraces **UT** = Upper terraces **SP=** Sedentary plain **CP** = Clay plain **LH** = Lower hill slope **SH** = Stony hill slope **D value** = Simpson Diversity index 0.00 The lowest value 0.00 the heights value

3.5 Effects of soil Chemical properties on the distribution of trees at study areas.

Faidherbia albida is the dominant tree species in Contemporary flood plain and Lower terraces which the soil chemical properties such as Ph ranges from 6.5 - 6.8, ECe Mmhos/cm ranges from 0.24 – 0.43, SP ds/m ranges from 42.7 – 44, Na meg/l ranges from 0.33- 0.77, Ca+Mg meg/l is 0.30, K meg/l ranges from 0.14 – 1.33, Hco_3 meg/l ranges from 3.5 – 4.25 and Cl meg/l ranges from 5.75 – 6.25. *Balanites aegyptiaca* dominant at the Sandy clay loam of Upper terraces . *Albizia amara* dominant at sedentary plain, lower hill slope and stony hill slope which the soil chemical properties such as Ph ranges from 5.7 - 6.42, ECe Mmhos/cm ranges from 0.54 –1.35, SP ds/m ranges from 36.8 – 48, Na meg/l ranges from 1.13- 7.31, Ca+Mg meg/l ranges from 3.50 - 11, K meg/l ranges from 0.31 – 0.95, Hco_3 meg/l ranges from 3.25 – 5 and Cl meg/l ranges from 7 – 11.8. *Acacia senegal* dominant at Sedentary plain, lower hill slope and clay plain which the soil chemical properties such as Ph ranges from 5.7 - 7.03, ECe Mmhos/cm ranges from 0.54 –0.69, SP ds/m ranges from 36.8 – 47.4, Na meg/l ranges from 1.13- 3.04, Ca+Mg meg/l ranges from 3.00 – 4.5, K meg/l ranges from 0. 1 – 0.33, Hco_3 meg/l ranges from 3.25 – 7.50 and Cl meg/l ranges from 7 – 9.5. *Acacia seyal* dominant at the clay plain. *Boswellia papyrifera* dominant at the sandy loam of stony hill slope see table 5.Generally there is no diversity in contemporary flood plain due to the low value of chemical properties and the site receiving clay and sand every rainy season and expose to the gallery erosion yearly. the lower terraces have the highest diversity index of (0.15) due to availability of water and good soil conditions especially K meg/l (1.33) see table 5.

IV. DISCUSSION

4.1.Soil characteristics and tree distribution

4.1.1. Soil Texture

Results in Table (1) agreed with [10] who reported that physical properties of soils of the 134 ha of Jebel Marra area are generally sandy loam to sandy clay loam, these disagreed with Adam 2003 on two site namely CF and CP sites, at these sites soil physical properties were Loamy sand and clay respectively, because the first one was Contemporary flood plain and the second one was clay plain while the survey of [10] was on Jebel Marra hill.

4.1.2. Chemical properties of the soil

Table 2 showed the chemical properties of soils at the survey area. pH ranging from5.7 at to 7.03 the soil at this area ranges from saline soil at stony hill slope to acidic one at lower hill slope and contemporary flood plain to non- saline non-sodic at the rest of the sites and this is to some extent agreed with [15]which reported that the soil of Abata are classified as non-saline non-sodic with pH ranging from 7.1 – 10.2. This disagreed with [10] who reported that the soils of Jebel Marra hill is acidic and pH ranging from 5.2 – 6.4. that is due to increasing of soluble cat ions mg/L such as Na, especially at stony hill slope zalingei (kirrodito) which is famous by salinity soil. The E.Ce ranges between 0.24 at Contemporary flood plain indicating low amounts of soluble salts, this means there are no problems of salinity, to 1.35 at stony hill slope indicating high amounts of soluble salts, this means that there are salinity problems.

4.2 Distributions of tree species in the seven ecological zones

Results in table 3 agreed with [6] who described the *Faidherbia albida* and *Balaniyes aegyptica* association on alluvial soils of Wadi Azum system. Also this result agreed with [12]who reported that they found *Faidherbia albida* at Zalingei area around valleys (Azum, Aribo and uyer), and *Balaniyes aegyptica* covers the majority of Zalingei area. This result agreed [6] who described the *Faidherbia albida* and *Balaniyes aegyptica* association on alluvial soils of the major Wadi Azum system. The lower terraces are dominated by pure stand of *Faidherbia albida*, often forming a closed canopy. The drier soils of the upper terrace carry amore vegetation with *Balaniyes aegyptica* as the dominant species with *Ziziphus spina-christi, Acacia gerrardii, Albizia amara* and *Combretum aculeatum* also present.

Also this agreed and disagreed with [6] who said that "*on the clay plain and red-brown drift soils of the upper basin of wadi Azum system the Acacia seyal- Balaniyes aegyptica forms a mosaic with Anogeissus association, with Acacia seyal dominating".*

Results In table 3 indicates that *Albizia amara* and *Acacia senegal* are positively associated together, and disagreed with [6] who described the *Anogeissus leiocarpus* was dominant on the sedentary plain. That is due to deterioration of *Anogeissus leiocarpus* in Zalingei area as a result of [13] who indicated that *Anogeissus leiocarpus,* which was a dominant species area since a long time ago is disappearing and is being replaced by *Albizia amara* and *Faidherbia albida* in wadies which showed

very low profile especially in Wadi salih area where only 7 and 4 trees per hectare were recorded in Wadi Jiddo and Taringa respectively, but at Zalingei 9 tree/ ha were recorded. Results in (3) disagreed with [16] who mentioned that sites on slopes of low hills of Zalingei showed a more diversified tree cover including, *Sclerocarya birrea, Acacia senegal, Albizia sericocephala, Dalbergia melanoxylon, Lanea fruticosa ,Lanea schimperi* and *Azanza garckeana*. Due to adverse human activities that lead to degradation of the vegetation of Zalingei area. *Boswellia papyrifera* is a dominant tree species in site 10, and the dominant tree species on site 11 was *Albizia amara* and this agreed [6] who described *Boswellia papyrifera* was dominant on the stony hill slope and *Albizia amara* was dominant on the lower hill slope. Results of distributions of tree species in each sites of the study area agreed with [14] who reported that *Albizia amara* and *Balanites aegyptiaca* are dominant. However, these two species together with *Acacia Senegal* dominate the floristic composition of the area. The rest of species occur in varying numbers at Wadi Salih and Azum locality.

TABLE 3
SHOWS SPECIES COMPOSITION, ABUNDANCE (AB), ABSOLUTE ABUNDANCE (AAB), RELATIVE ABUNDANCE (RAB), DOMINANCE (BA), RELATIVE DOMINANCE (RB) ON DIFFERENT SITES.

NO. site	Species	AAB	AB	RAB	BA	RBA
1	*Faidherbia albida*	2	100	4	3.522	100
	Total	2		4	3.522	
2	*Faidherbia albida*	3	60	5	1.251	80.8
	Kigelia africana	1	20	1.7	0.1451	9.4
	Balanites aegyptiaca	1	20	1.7	0.1520	9.8
	Total	5		3.4	1.548	
3	*Faidherbia albida*	4	50	6.7	2	62.5
	Ziziphus abyssinica	3	37.5	5	0.9	28.1
	Ailanthus excelsa	1	12.5	1.7	0.3	9.4
	Total	8		12.4	3.2	
4	*Balanites aegyptiaca*	74	35.24	35.2	4.3	60
	Acacia sieberana	1	0.47	0.48	0.04	0.56
	Acacia nilotica	3	1.43	1.43	0.23	3.21
	Acacia senegal	4	1.88	1.9	0.07	1
	Acacia seyal	116	54.5	55.24	2.07	28.9
	Ziziphus abyssinica	15	7	7.14	0.46	6.42
	Total	213		101.39	7.17	
5	*Anogeissus leiocarpus*	2	29	3.3	0.2	25
	Balanites aegyptiaca	5	71	8.3	0.6	75
	Total	7	100		0.8	
6	*Acacia seyal*	64	54.2	106.7	0.38	46.3
	Acacia nilotica	13	11	21.7	0.11	13.41
	Balanites aegyptiaca	5	4.2	8.3	0.04	4.9
	Acacia senegal	19	16.1	31.7	0.17	20.7
	Acacia girrardii	6	5.1	10	0.06	7.3
	Bauhinia rufescens	5	4.2	8.3	0.02	2.4
	Albizia anthelmintheca	1	0.5	1.7	0.01	1.2
	Ziziphus spina-christi	5	4.2	8.3	0.03	3.7
	Total	118		196.7	0.82	
7	*Balanites aegyptiaca*	7	3.3	3.3	0.36	7.5
	Albizia amara	110	51.1	52.4	3.18	66.4
	Albizia anthelmintheca	4	1.9	1.9	0.12	2.5
	Acacia girrardii	6	2.8	2.9	0.11	2.3
	Acacia laeta	1	0.48	0.48	0.05	1.04
	Anogeissus leiocarpus	4	1.9	1.9	0.28	5.85
	Acacia mellifera	1	0.48	0.48	0.01	0.21
	Acacia nilotica	5	2.3	2.38	0.04	0.84
	Acacia oerfota	6	2.8	2.9	-	-
	Acacia senegal	61	28.5	29.5	0.56	11.7
	Acacia seyal	6	2.8	2.9	0.08	1.7
	Grewia mollis	2	0.9	0.95	-	-

	Xeromphis nilotica	1	0.48	0.48	-	-
8	*Total*	214		62.2	4.79	
	Albizia amara	145	63.3	69.05	3.2	74
	Acacia senegal	64	27.9	30.48	0.7	16
	Acacia girrardii	1	0.43	0.48	0.05	1.2
	Bauhinia rufescens	3	1.31	1.43	0.03	0.6
	Acacia nilotica	5	2.18	3.38	0.07	1.5
	Balanites aegyptiaca	1	0.43	0.48	0.01	0.14
	Acacia seyal	3	1.31	1.43	0.2	4.9
	Dalbergia melanoxylon	2	0.87	0.95	0.03	0.6
	Dichrostachys cinerea	3	1.31	1.43	0.02	0.39
	Acacia oerfota	1	0.43	0.48	-	-
	Acacia tortilis	1	0.43	0.48	0.03	0.58
	Total	229		110.07	4.32	
9	*Ziziphus spina-christi*	4	3.28	1.9	0.04	0.8
	Acacia senegal	2	1.64	0.95	0.01	0.2
	Balanites aegyptiaca	42	34.43	20	1.58	31.4
	Acacia seyal	26	21.31	12.4	0.45	8.95
	Dalbergia melanoxylon	1	0.82	0.48	0.34	6.8
	Anogeissus leiocarpus	13	10.66	6.2	1.13	22.5
	Albizia amara	11	9.01	5.24	0.69	13.7
	Faidherbia albida	1	0.82	0.48	0.01	0.2
	Dichrostachys cinerea	4	3.28	1.9	0.02	0.4
	Acacia girrardii	5	4.1	2.38	0.07	1.39
	Acacia nilotica	6	4.92	2.9	0.16	3.18
	Lannea fruticosa	1	0.82	0.48	0.05	1
	Sclerocarya birrea	5	4.1	2.38	0.38	7.55
	Sterculia setgera	1	0.82	0.48	0.1	2
	Total	122		58.2	5.03	
10	*Boswellia papyrifera*	26	54.2	52	1.37	76.1
	Lannea fruticosa	9	18.8	18	0.17	9.4
	Acacia senegal	1	2.01	2	0.004	0.022
	Acacia seyal	1	2.01	2	0.23	12.8
	Dichrostachys cinerea	6	12.5	12	0.024	1.3
	Dalbergia melanoxylon	1	2.01	2	0.018	1
	Acacia girrardii	4	8.3	8	0.027	1.5
	Total	48		96	1.8	
11	*Albizia amara*	95	73.6	45.24	2.44	47.4
	Balanites aegyptiaca	16	12.4	7.62	2.34	45.4
	Dalbergia melanoxylon	1	0.78	0.48	0.05	1
	Combertum glutinosum	3	2.33	1.43	0.06	1.2
	Terminalia mollis	1	0.78	0.48	0.07	1.4
	Acacia senegal	13	10.1	6.19	0.19	3.7
	Total	129		61.44	5.15	

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