The Effect of Variations in Rainfall Patterns on Vegetation Dynamics in the Southern Part of White Nile State- Sudan

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Abstract:

This study was carried out at the southern part of White Nile State in 2016. The area under study classified into three sites (site1, 2 and 3) according to the variation in rainfall (350, 450, 550 mm/annum respectively). The results revealed that the variation of rainfall across the three sites resulted in five tree species in site1, two tree species in site2, and seven tree species in site3. *Acacia seyal* (Talh) and *Acacia Senegal* (Hashab) occurred in site1 and site3 with higher ranking from 2 – 1 and from 5-3 respectively, while *Acacia mellifera* (Kitr) occurred in site 2 and site 3 with lower ranking from 1-5. From natural regeneration table *Acacia seyal* (Talh) and *Acacia Senegal* (Hashab) still restricted to site 1 and 3 with lower ranking which may indicates their inadaptability to site 2 according to the site rainfall either in quantity or distribution. *Acacia mellifera* (Kitr) is also restricted to site2 and 3 with the same ranking in natural regeneration. *Acacia nubica* (La'ot) which occurred only in site 2, it starts to occur in site 2 and 3 at regeneration level. *Cadab roupundfolia (*Kurm) followed the same trend as *Acacia nubica* (La'ot) from site 2 to site 2 and 3. *Boscia senegalensis* (Mukh) occurred as a new species at site 2 and 3 in natural regeneration which was not found in tree cover in all sites. This dynamics of tree species at different levels of growth indicates the effect of rainfall in the occurrence and density of tree species.

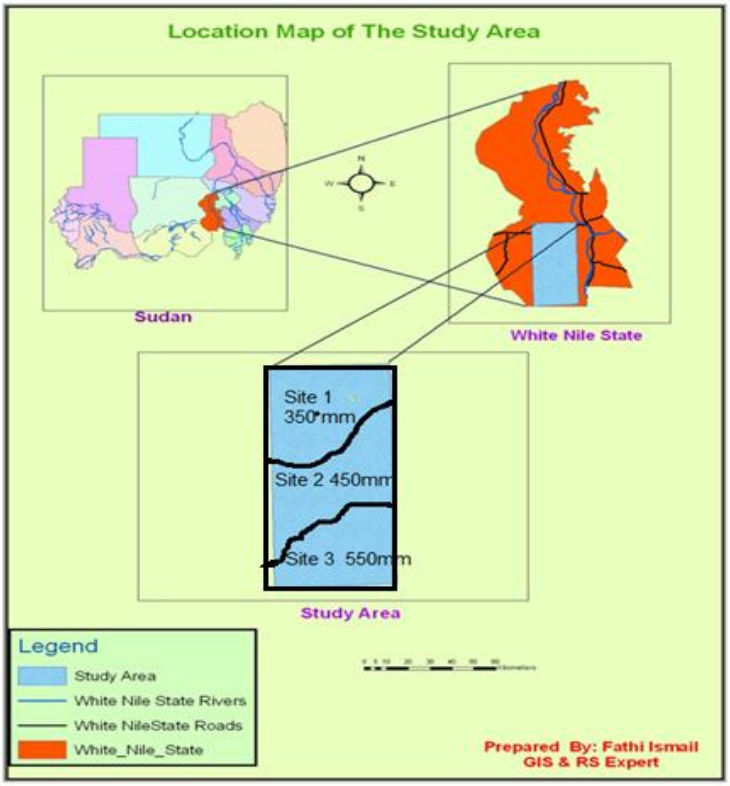
Keywords: Ranking, Relative density, White Nile State, Frequency.

Introduction:

Dry lands, covering nearly 30% of the global land surface, are characterized by high climate variability and sensitivity to land management (N.Andela 2013). Sudan exhibits a wide range of variation in its topography, climate, soil and hydrology. This variation resulted in different ecological habitats that lead to different vegetation constitutions in term of structure, shape and

composition. The distribution of tree cover in the study area varies according to different factors such as rainfall which cause tree cover changing in their frequencies, densities and structure in a pattern that depending on their adaptability to the site characteristics. Studying and understanding of changing patterns of the cover may help in developing the natural stands and further lead to appropriate management. Expansion of agricultural production, felling of selected trees for fuel wood energy and other purposes of land use types, in addition to the climatic factors may be considered as one of the main factors affecting the vegetation cover dynamics, such changes have accelerated during the past 50 years which has had a significant impact on biodiversity (Alberti, 2008). Vegetation dynamics is the change in vegetation with time according to an appropriate scale of abundance (Austin, 1981), while changes caused by external factors such as variation in density and composition are considered as secondary factors (Miles, 1979). The study area is located in the southern part of the White Nile State in the rainfall zone characterized by three isohyets 350 –450 - 550 mm/annum (Fig.1).

Figure 1. Location of the study area



White Nile State could be considered as highly potential State in natural resources that vary in their types and composition according to the variation in soil type and rainfall patterns from northern parts to the southern parts of the State. The stresses and continuous pressure to natural resources, both from climate and human intervention, appeared clearly in changing vegetation cover. Studying the dynamics of vegetation cover under different climatic and social condition will clarify the process and further leads to sustainable environmental condition. Research of the vegetation dynamics in the study area focused on specific tree species, while the whole ecosystem is not yet highlighted by research and studies. This reflects the importance of this study. The main objectives of this study is to investigate the change in vegetation composition and structure in terms of density, frequency and the distribution of diameters and heights classes according to the three soil zones.

Materials and methods:

The area under study was selected to cover the different climatic (Rainfall) and soil variations in the area. It lies in the southern part of the state. Three categories (sites) were identified in the area that constitutes different vegetation compositions resulted from different rainfall patterns, and soil types. The three sites selected follow these trends from north to south.(Site1, Site2, and Site3). A sample plot of approximately 1.5 hectare (120m X 120m) was selected randomly along each site. Nine systematic sub-sample plots were laid out along three parallel lines within each sample, each cover an area of 0.1 ha in a circular shape. The distance between sub-samples was 40m apart, and 40m between lines. While the marginal distance to avoid marginal effect was 20m. The tree species were assessed in terms of frequency, density, and composition. In each sub-sample trees inside the sample area were identified and counted by their local names, dbh, height, were measured in separate forms. Data was further sorted and analyzed into diameter classes and height classes along sites and the whole area. In each sub-sample, natural regeneration were counted and identified by their local names in the same form of tree assessment. Scientific names of species were used together with their local name's codes. The codes were derived from local names.

Results and Discussion:

Frequency:

Table 1. Frequency, relative frequency, and ranking of spp. in the three sites.

Scientific name	Spp.code	Frequency			Relative Frequency %			Ranking		
		Site1	Site2	Site3	Site1	Site2	Site3	Site1	Site2	Site3
Capparis deciduas	Tund	0.8			57.14			1		
Prosopis chilensis	Misk	0.2			14.29			2		
Acacia seyal	Talh	0.2		0.9	14.29		26.47	2		1
Ziziphus spina-christi	Sidr	0.1			7.14			3		
Acacia Senegal	Hash	0.1		0.2	7.14		5.88	3		3
Acacia mellifera	Kitr		0.1	0.6		58.82	17.65		1	2
Acacia nubica	Laot		0.7			41.18			2	
Dichrostachys cinerea	Kadd			0.9			26.47			1
Acacia nilotica	Sunt			0.6			17.65			2
Gerwia tenax	Godm			0.1			2.94			4
Cadab roupundfolia	Kurm			0.1			2.94			4
Total		1.2	0.8	3.4	100	100	100			

Table (1) shows the frequency and relative frequency and ranking of tree species dominating site 1,2,3. *Capparis decidua* (Tundub) shows a high frequency and also has got the highest relative frequency among all other spp. In site 1, which is 0.8 and 57.14% respectively; this may indicate that the species has a high occurrence that shows its wide spread over the area. Other tree species show very low values for both frequency and relative frequency not exceeding (0.2, 14.28%) respectively. While in site 2, *Acacia mellifera* (Kitir) is the species of wide distribution with a frequency of 1 (100% distribution) which indicates its higher ability to occur in site 2. *Acacia seyal* (Talih) and *Dichrostachys cinerea* (Kadad) are distributing over site 3 better than other species occupying the same site with similar frequency of 0.9 for both species. As stated by Sid Amed (2004), amount and distribution of rain fall could also control the species frequency in the different sites. The site potentiality for each species depends, amongst other things, on the population dynamics and the growing conditions prevailing.

Table 2. Species density/ha and ranking across the three sites.

Scientific name	Spp. code	Density/ha			Ranking		
		Site1	Site2	Site3	Site1	Site2	Site3
Capparis deciduas	Tund	10			1		
Prosopis chilensis	Misk	6.7			3		
Acacia seyal	Talh	8.9		63.3	2		1
Ziziphus spina-christi	Sidr	3.3			4		
Acacia Senegal	Hash	1.1		16.7	5		3
Acacia mellifera	Kitr		67.8	11.1		1	5
Acacia nubica	Laot		21.1			2	
Dichrostachys cinerea	Kadd			27.8			2
Acacia nilotica	Sunt			14.4			4
Gerwia tenax	Godm			1.1			6
Cadab roupundfolia	Kurm			1.1			6
Total		30.0	88.9	135.5			

Density:

Table (1) shows the density per ha and ranking for tree species in the three sites. *Capparis deciduas* (Tundub) showed the highest density while *Acacia Senegal* (Hashab) the lowest among all tree species in site 1. This followed the same pattern of species frequency as in table (1) to indicate that Tundub is the species of higher adaptability to the area and *Acacia Senegal* (Hashab) is the species of lower adaptability. As stated by Mohamadain, (2016) that *Acacia Senegal* (Hashab) is dominating the area of the eastern part of southern White Nile State, but according to this study it is the species of lowest adaptability with density ranking of 5 and 3 in site 1 and 3 respectively.

The table shows that site 2 is dominated by two species, *Acacia mellifera* (Kitir) and *Acacia nubica* (La'ot). The trend of density in site 2 is also following the same trend of species frequency as shown in table (1). This also indicates the higher adaptability of *Acacia mellifera* (Kitir) and *Acacia nubica* (La'ot) came next. The species composition is completely varied from that in site1, which may reflects the effect of soil characteristics, rainfall, and other environmental factors in species composition.

Site 3 showed different species composition compared to site 1, and 2. *Acacia seyal* (Talh) and *Acacia Senegal* (Hashab) from site 1 and *Acacia mellifera* (Kitir) from site 2. The other species which were not occurred in site 1, and 2 are Kadad, *Gerwia tenax* (Godm), *Cadab roupundfolia* (Kurm), and *Acacia nilotica* (Sunt). This may indicate their high adaptability to the site characteristics. *Acacia mellifera* (Kitir), and *Acacia seyal* (Talh) from other sites were able to tolerate the high rainfall and different soil characteristics. For *Acacia seyal* (Talh) this site may be the site showing its highest adaptability compared to site1. The trend of density in site3 followed the same trend as other sites to the frequency trend as shown in table (1). Although *Gerwia tenax* (Godm), and *Cadab roupundfolia* (Kurm) occurred only in site 3, but showed low values of frequency and density compared to other tree species in site 3. Eingereicht von (2005) stated that individual density was found to be positively correlated with increase of slope inclination, and negatively correlated with soil fertility. In this study it is clear that individual-density is positively correlated with increase in rainfall. This may agreed with Sid Ahmed (2004) is that water is the main factor to determine spp. density, frequency, and dominance.

Natural Regeneration:

Natural regeneration represents the future of the standing tree cover both in terms of density and frequency. It shows the process of replacement expected to take over depending on the environmental factors and human intervention.

Table (3) shows the natural regeneration in the three sites which follow the same species composition of the standing cover in the same site with little variation. In site1, *Balanites aegyptiaca* (Higl) occurs in natural regeneration but not in the standing cover which may indicate the suitability of environmental factors and soil characteristics for its occurrence. On the other hand *Acacia Senegal* (Hashab) occurs in the standing cover but not in natural regeneration of site 1, which may threaten its sustainability in the site if not restored.

The dynamics of species composition in site 1 shows limited variation between standing tree cover and natural regeneration in term of ranking, this made some kind of species composition stability in the site. Ranking and density/ha for species natural regeneration in site 2 shows that *Acacia mellifera* (Kitir) and *Acacia nubica* (La'ot) which dominate the standing tree cover of site

2, followed the same trend in natural regeneration with occurrence of two new species (Kurm, Mukh). The disappearance of the two newly species in the standing tree cover may indicates either their early utilization as preferred species, or change in environmental condition suited their occurrence and high ranking for both species as 1 and 2 respectively. Similar composition dynamics took place in site 3 with occurrence of three new species in natural regeneration (*Acacia mellifera*, *Acacia nubica*, *Cordia africana*). The ranking of *Acacia nubica* (La'ot) and *Acacia mellifera* (Kitir) as 2, and 3 respectively may indicate their good distribution among other species regeneration that dominate the standing tree cover. In General, agriculture expansion practices (land clearing) and/or climatic changes may cause such changes in ecological components. This may indicate that the lesser species might have appeared in the area recently as a result of the changing conditions of rain distribution or may be more subjected to pressure of grazing, preference by locals and agricultural expansion.

Table 3. Natural regeneration of tree spp. across the three sites:

Scientific name	Spp. Code	Density/ha			Ranking		
		Site1	Site2	Site3	Site1	Site2	Site3
Capparis decidua	Tund	3.3			3		
Prosopis chilensis	Misk	1.1			5		
Acacia seyal	Talh	4.4		30.0	2		5
Ziziphus spina-christi	Sidr	11.1			1		
Acacia senegal	Hash	1.1		4.4	5		8
Balanites aegyptiaca	Higl	2.2			4		
Acacia mellifera	Kitr		32.2	48.9		3	3
Acacia nubica	Laot		14.4	97.8		4	2
Dichrostachys cinerea	Kadd			135.6			1
Acacia nilotica	Sunt			4.4			8
Gerwia mollis Juss.	Godm			5.6			7
Cadab roupundfolia	Kurm		166.7	32.2		1	4
Boscia senegalensis	Mukh		42.2	2.2		2	9
Cordia africana	Andr			6.7			6
Total							

Conclusion and Recommendations

The study concluded that tree species with their density, frequency and natural regeneration across different climatic sites showed changes in their composition from site to another according to rain fall variations. Species with higher ranking in density and frequency indicate their suitability and adaptability to that site. *Acacia seyal* (Talh), *Acacia senegal* (Hashab), *Acacia nubica* (Laot), and Acacia *mellifera* (Kitir) are the species of higher adaptability to the study area and could be introduced in restoration process in the area. Natural regeneration could enhance occurrence of species not found in the tree cover, but their continuing in growth depend on the adequacy of rain fall and other climatic and land use systems in the area. Generally, the study highlighted the effect of rain fall on vegetation dynamics, but other factors need to be handled and investigated.

The study recommends that a soil seed bank investigation is highly required to complete the whole dynamic process in the future. Also an index classes could be developed to indicate the proper adaptability of specific species to site characteristics.

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