The Journal of Agriculture and Natural Resources Sciences

Journal homepage: http://www.journals.wsrpublishing.com/index.php/tjanrs

Online ISSN: 2383-238X Print ISSN: 2423-4397

Original Article

Effect of Climate Change on Rangeland Biodiversity at Selected Sites of Khartoum State

A.A. Balola[1], Muna M.M. Ahmed [2], I. Bushara[3,*] and Dafalla M. Mekki[3]

[1] Islamic University, Sudan
[2] Institute of Environmental Studies, University of Khartoum, Sudan
[3] Department of Animal Production, Faculty of Natural Resources and Environmental Studies, University of Kordofan, Sudan

ARTICLE INFO

Corresponding Author:
I. Bushara
bushara3030@yahoo.com

How to Cite this Article:
Balola, A.A., Ahmed M.M.M., Bushara, I., & Mekki, D.M. (2015). Effect of Climate Change on Rangeland Biodiversity at Selected Sites of Khartoum State. *The Journal of Agriculture and Natural Resources Sciences*, 2(2), 444-454.

Article History:
Received: 6 March 2015
Revised: 14 April 2015
Accepted: 15 April 2015

ABSTRACT

Climate change on the biodiversity of natural resources in Eastern Nile and Northwestern Omdurman has been assessed during two successive years (2011 and 2012). Three sites were selected in Eastern Nile (Wadi Tundub, Wadi El Farish and Wadi Abuseweid) and four Northwestern Omdurman (Wadi Medaisees, Wadi Buhat, Goz Abu Dolou'a Km72, and Goz Abu Dolou'a Km 42, 'G42'. The seven sites selected were within Khartoum state. Random sampling design was used to measure vegetation quantities. For browse production, the Twig Count Method was used. Parker Loop Method was employed to identify plant density index, forage density index. Acetolysis Method was used for recent sheep, goats and camels' feces pollen count to identify their diet. The Range Evaluation Site Method and the Pasture Condition Scoring were used to assess range condition at the study sites. Plant samples were assessed for their nutritional value and mineral contents and to test seasonal change in nutritive value. Results showed that different sites had different type of woody browse species, where *A. ehrenbergiana* showed the highest ($P < 0.05$) twig production at Tundub which was also dominant at this site, *A .radiana* showed the highest ($P < 0.05$) production and dominant at Buhat, while *A. nubica* was the highest ($P < 0.05$) and dominant at Medaisees. For the effect of site, *A. ehrenbergiana* still showed the highest ($P < 0.05$) production at Tundub compared to the other species, while both *A. ehrenbergiana* and *A .radiana* were dominant ($P < 0.05$) at Farish. Within both years, mid rainy season production was better ($P < 0.01$) than end season. Year 2012 browse production was better than year ($P < 0.01$) than year 2011. Abseweid followed by Medaisees showed the highest ($P < 0.05$) diversity for both seasons and within year 2011, within the year 2012, Medaisees followed by Farish showed better diversity of woody species. Dominance of *Aacia radiana* was observed at Abuseweid while *Leptadenia pyrotechnica* was abundant at Medaisees. Total percent woody cover was best at Tundub (49.61%) with best species (6) diversity; however, highest total percent woody cover (89.41%) was observed at Buhat but poorest species (3) diversity. Year 2012 showed better densities, composition and ground cover for all species and for all sites. Best results were obtained for Abuseweid followed by Farish followed by Medaisees or Buhat. Effect of year on species production showed that *A. mutabilis* showed the highest increase in percent in three sites (Abuseweid, Farish, and Tundub). Next was *A.gracizans* at Medaisees and Buhat.

Keywords: Climate change, range, grasses, density, Sudan**.**

INTRODUCTION

Rangeland environments often experience uneven rainfall distribution and fluctuations in quantity and quality of forage available to animals (Abusuwar and Yahia, 2010), climatic extremes, low and erratic rainfall, severe cold or high temperature resulting in high season to season variability (Friedel *et al*., 2000), frequent draught periods. Sudan has experienced increasing levels of rainfall variability in recent decades which had led to diminishing water availability.

In dry savannah and semi-desert regions, natural rangelands guarantee the feed requirements of livestock for a particular period depending on the amount and duration of rainfall during the rainy season. Even though, browse and shrubs are effective insurance against seasonal feed shortages; they constitute vital components in livestock productivity in arid and semi arid zones as they balance protein deficiency during the long dry summer season (Abusuwar and Yahia, 2010). In addition to providing space and feed to livestock upon which a considerable percentage of the pastorals worldwide are dependant, rangelands provide traditional living areas for non-pastoral people and can support a variety of wildlife in addition to providing areas for tourism and recreation (Friedel *et al*., 2000). Rangelands also supply additional products and values such as minerals, construction materials, medicines, chemicals, fuel, areas for preservation of endangered species and anthropological sites. This study aimed to assess the climate change on the biodiversity of natural resources in Eastern Nile and Northwestern Omdurman, Sudan during years 2011 and 2012.

MATERIALS AND METHODS

Study Area

This study conducted at Khartoum state, to cover area of the rangeland that lies within Khartoum state. Soil type is dark cracking clay plains bisected by depressions and seasonal water courses covered with pale yellowish-white coarse sand and small gravels. The undulations of the area resulted in three main land forms, the first form has relatively high elevation compared to the neighboring land forms and are of varying areas and extensions in all directions, with poor vegetation cover even during the wet seasons owing to their inability to hold rain water; they are covered with loose large black igneous rocks and small gravels. The second land form is the flat plains with soil types ranging from reddish fine sandy soil comprising few centimeters upper layer followed by muddy clay soil up to many meters beneath the upper layer. This characterizes most Eastern part of this area which is a part of Butana region whose soil was classified as vertisols which is dark cracking clays referred to as black cotton soil; mostly alluvial in origin from material transported by the Blue and the White Nile, but some might have been formed in situ from basaltic rocks. The vegetation is not homogeneous because of the erosion dominating the area (Abusuwar, 2007). Perennial woody vegetation is confined to seasonal streams with many annual herbaceous species on the plain, along the khors and around depressions. The third land form of the Eastern Nile is valleys, locally known as (Wadies) which are of low elevations. They form wide and shallow seasonal streams with run-off resulting in large and long lasting humidity in their soils. The Northwestern parts of Khartoum state extends from the main Nile up to the boundaries of Northern Kordofan state in the West, White Nile state in the South and the River Nile state in the North.

A total of seven sites were selected, three in the Eastern part of the Blue Nile they were Wadi Tundub (15˚ 42.330' N, 033˚ 06.278' E), Wadi El Farish (15˚ 42.289' N, 033˚ 06.283'E) and Wadi Abu Seweid (15˚ 37.133' N, 032°55.005'E) and four in the Northwestern part of the White Nile they were Wadi Medaisees (16˚ 12.223' N, 31˚ 41.392' E), Wadi Buhat (16˚ 20.395' N, 31˚ 48.686' E), Qoz Abu Dolou'a 72 Km or Q72 and Qoz Abu Dolou'a 42 Km or farish Hamid (16˚ 09.275' N, 31˚ 49.317' E).

Density and Frequency of Vegetation Cover

Density of herbaceous species was measured within 1m x 1m quadrate; individuals of each species were counted, every individual rooted within the quadrate was considered, and the species present in each quadrate were recorded with their numbers. Density of woody species in addition to *Panicum turgidum* (Tumam) was measured within four 20 m x20 m plots for each study site. Species density, species frequency, relative density, relative frequency and importance value were calculated as follows according to Curtis (1959).

Biomass Production

Herbaceous species individuals were clipped to the ground level from 5 (1m ×1 m) quadrate located randomly along a line transect and herbs of each quadrate was placed in a separate paper bag and labeled. Biomass production of woody species was estimated using the Twig Count Method of Bobeck and Bergstorm (1978). Within each 20 m × 20 m plots (5 m × 20 m belt for wadi Abu Seweid), current growth of leafy twigs was clipped from the trees of various ages up to 2.5 m height, at the same time, their height and diameter at 5-10cm above ground level were measured. Herbaceous species composition was determined using the Parker Loop Method (Parker, 1951). Woody cover was measured using the method described by Husch *et al.*, (1982).

Soil Analysis

Soil samples from three randomly selected points within each site (three depths each), (0-30cm, 30-60cm and 60-90cm) were taken. Soils from similar strata were carefully mixed and analyzed for organic matter and minerals.

Statistical Analysis

Randomized Complete Block design was employed for herbaceous dry matter productivity, browse production, total herbaceous and browse density and woody cover as this design is suitable when environmental conditions are not under control. Analysis of variance (ANOVA) was carried out according to Steel and Torrie, (1980). Means were separated using the Duncan's Multiple Range Test (DMRT). Simple Coefficient of correlation (r) was calculated according to test correlation between different variables from the following formula.

RESULTS

Effect of Year, Site Duration of Rainy Season of Year on Herbaceous Dry Weight (Kg/Ha)

Dry herbaceous weight for the two years at different sites is shown in Table 1. For the year 2011, Tundub, Abseweid, Buhat, and Q72, mid rainy season showed higher (P <0.05) dry weights than end of dry season, other sites showed similar weights. During the mid-rainy season, Abuseweid showed the highest weight (P <0.05) followed by Medaisees, while F. Hamid showed the lowest (P <0.05). During end rainy season, Buhat showed the highest weight (P <0.05) followed Medaisees and Abuseweid other sites showed lower weights (P <0.05) (Table 1).

Table 1: Effect of site, duration mid (D1) and end (D2) of rainy season of year 2011 and their interaction on herbaceous dry weight (Kg/ha)

Site	D1	D2	±SE
Tundub	119.6^{ef}	88.0^{fg}	
Farish	132.2^{ef}	110.0^{efg}	
Abseweid	610.4^{a}	262.0^{d}	
Medaisees	393.0^{bc}	346.2^{c}	8.69
Buhat	169.0^{e}	436.6^{b}	
Q72	169.6^{e}	60.0^{fg}	
F. Hamid	17.0^{g}	24.6^{g}	
±SE	16.27	23.01	

For the year 2012, Abuseweid and Medaisees showed higher (P <0.05) dry weights than end of dry season, other sites showed similar weights. During the mid rainy season, Abuseweid showed the highest weight (P <0.05) followed by Medaisees and Q 72 while Tundub and F. Hamid showed the lowest (P <0.05). During end rainy season, Abuseweid and El Farish showed the highest weight (P <0.05), while F. Hamid showed the lowest (P <0.05) (Table 2).

Table 2: Effect of site, duration mid (D1) and end (D2) of rainy season of year 2012 and their interaction on herbaceous dry weight (Kg/ha)

Site	D1	D2	±SE
Tundub	653.0^{c}	574.0^{cd}	
Farish	1154.6^{b}	1100.0^{b}	
Abseweid	1705.8^{a}	1194.0^{b}	
Medaisees	1118.8^{b}	604.2^{cd}	49.16
Buhat	512.8^{cd}	372.0^{cd}	
Q72	1234.0^{b}	536.0^{cd}	
F. Hamid	230.4^{cd}	214.0^{d}	
±SE	91.96	130.05	

Effect of Year, Site Duration of Rainy Season of Year on Herbaceous Production (Kg/Ha)

Comparing mid to mid rainy season between 2011 and 2012 showed higher (P <0.05) herbaceous dry weight during year 2012 than 2011. Similar observations were obtained when comparing end to end rainy season between to two years. Mid to end rainy seasons for the two years showed higher (P <0.05) for mid than end rainy season (Table 3).

Table 3: Effect of year on herbaceous dry weight (Kg/ha)

Site	Years			
	2011		2012	
	Mid	End	Mid	End
Tundub	119.60^{B}	88.00^{b}	653.00^{A}	574.00^{a}
El Farish	132.20^{B}	110.00^{b}	1154.60^{A}	1100.00^{a}
Abuseweid	610.40^{B}	262.00^{b}	1705.80^{A}	1194.00^{a}
Medaisees	393.00^{B}	346.20^{b}	1118.80^{A}	604.20^{a}
Buhat	169.00^{B}	436.60^{a}	512.80^{A}	372.00^{a}
Q72	169.60^{B}	60.00^{b}	1234.00^{A}	536.00^{a}
F. Hamid	17.00^{B}	24.60^{b}	230.40^{A}	214.00^{a}

^{abcdefg} Values within columns or rows bearing different superscripts vary significantly at 0.05.

Table 4: Plant density, forage density and ground cover indexes, percentage plant and percentage forage compositions of the study sites mid rainy seasons of 2011 and 2012

Sites	Pl. D. index		Fr. D. index		Gr. C. index		% Pl. comp.		% Fr. comp.	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Tundub	12	58	12	58	12	58	12	58	100	100
Farish	23	64	23	64	25	76	23	64	100	100
Abuseweid	51	82	51	82	51	82	51	82	100	100
Medaisees	43	59	43	59	43	59	43	59	100	98.78
Buhat	33	60	33	60	35	60	33	60	100	100
G 72	30	51	30	51	30	51	30	51	100	100
FH	10	29	10	29	10	29	10	29	100	100

Pl. D.= plant density, Fr. D. forage density, Gr. C= ground cover, Pl. comp.= plant composition, Fr. comp.= forage composition/

Table 5: Herbaceous species composition (%) of different sites obtained during 2011 and 2012 seasons

Spp.	Sites													
	T		F		A		M		B		Q72		F. Hamid	
	S1	S2	S2	S1	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
A. mutabilis	8	41	2	11	7	26	3	7					8	20
C. rotundus.	2	11												
P. oleracea	1	4			27	35								
I. ochstetteri	1		14	28	4		3							
B. repens			6	23	13	19		2						
T. terrestris			1											
A.gracizans							31	41	26	50				
D. egyptium							6	3		7				
C.depressus Gash									7	3				
P. uadrifida											21	31	2	6
T. entandrus											9	19		
S. sesaban														
I. sinensis														
Mosp.												1		
Z.pentandra														3
C.oletorius				2										

T= Tundub, F= Farish, A= Abuseweid, M= Medaisees, B= Buhat, Q72= Qoz Abudolou'a Km 72, S1= season 1, S2= season 2

Plant Density, Forage Density, Ground Cover, % Plant Composition and % Forage Composition

Plant density indexes, forage density indexes, ground cover indexes, percentage plant compositions and percentage forage compositions are shown in Table (4). The year effect was very clear for all indices where year 2012 showed better plant and forage densities as well as better plant and forage composition with better ground cover. During both seasons, wadi Abuseweid showed the highest values of all of the above mentioned measurements, whereas Farish Hamid showed the lowest values

Percentage Species Composition

Herbaceous species and their percentage compositions at different sites are shown in

table (5). *Aristida mutabilis* constituted the highest percentage composition at two sites, wadi Tundub and Farish Hamid, and also *Amaranthus gracizans* at wadi Medaisees and wadi Buhat. *Indigofera hochstetteri*, *Portulaca oleracea* and *Portulaca quadrifida* constituted the highest % composition at wadi El Farish, wadi Abuseweid and Q72 respectively. *A. mutabilis* showed higher increases at Tundub (8 – 41) and Abuseweid (7 – 26) in year 2012 compared with year 2011. Effect of year was also observed for A. gracizans at Buhat (26 – 50). Same was observed for *B. repens* at Farish (6 – 23).

Effect of sites on herbaceous total density is shown in (Table 6).Wadi Abuseweid was the most dense site (P<0.05) during 2011 followed by Medaisees, while Farish Hamid showed the lowest (P<0.05) value. During 2012, Abuseweid also showed the highest (P<0.05) followed by El Farish while Farish Hamid showed (P<0.05) the least total density. There was an increase in total density from 2011 to 2012 where year 2012 showed higher (P<0.05) densities in all plant species followed by year 2011.

Frequency and Dominance

Abundance, dominance and rareness of different herbaceous species during the rainy seasons of the years 2011 and 2012 are shown in (Table 7). *Aristida mutabilis* was the most common species in the study area during both years as it was recorded at 5 sites out of 7. *Indigofera hochstetteri* and *Boerhavia repens* were during the year 2012.

Table 6: Effect of site on herbaceous total density (number of individuals/m^2) during 2011 and 2012

Site	Years	
	2011	2012
Tundub	89.2^{Bbcd}	835.4^{Ac}
El Farish	99^{Bbcd}	1355.4^{Aab}
Abuseweid	239.6^{Ba}	1396.6^{Aa}
Medaisees	196.6^{Ba}	887^{Ac}
Buhat	100.4^{Bb}	1278.6^{Aab}
Q72	100.2^{Abc}	128.8^{Ad}
F. Hamid	9^{Be}	41.6^{Ad}
±S.E	18.92	37.94

^{Abcd} Values within columns (for site effect, small letters) or rows (for time of season, capital letters) bearing different superscripts vary significantly at P <0.05

Table 7: Abundance (A), co-dominance (Co), dominant (D), frequent F, occasional (Oc) and rare (R) of herbaceous plant species at different sites

Species	Sites													
	2011							2012						
	Tn	Fr	Abs	Med	Buh	Q72	FH	Tn	Fr	Abs	Med	Buh	Q72	FH
P. oleracea	F	-	D	R	-	-	-	F	-	D	Oc.	-	-	-
A.mutabilis	A	F	Co	F	-	-	D	D	Co	Co	F	-	-	Co
I.hochstetteri	F	Co	A	F	-	-	-	F	D	A	Oc.	-	-	R
C.rotundus	D	-	-	-	-	-	-	A	-	-	-	-	-	-
S.sesaban	-	-	R	-	-	-	-	Oc.	-	Oc.	Oc.	-	-	-
C.oletorius	-	-	Oc.	-	-	-	-	Oc.	A	F	-	A	-	-
B.repens	-	D	A	F	-	-	-	Oc.	F	A	Oc.	-	R	-
I.sinensis	-	-	Oc.	-	-	-	-	R	-	F	Oc.	-	-	-
T.terresrtis	-	R	F	R	-	-	-	Oc.	Oc.	F	Oc.	-	-	-
S.dubium	-	R	R	R	-	-	-	R	Oc.	Oc.	Oc.	-	-	-
A.bracteolata	-	-	-	-	-	-	-	Oc.	-	R	-	-	-	-
E.aegyptiaca	-	-	Oc.	OC	-	-	-	-	Oc.	Oc.	Oc.	-	-	-
A.gracizana	-	-	Oc.	D	D	-	-	-	R	F	D	D	-	-
D.aegyptium	-	-	-	F	-	-	-	-	R	-	Oc.	-	-	-
U.tricopus	-	-	A	-	-	-	-	-	-	F	-	-	-	-
C.argentia	-	-	R	-	-	-	-	-	-	Oc.	Oc.	-	-	-
O.bacilicum	-	-	-	-	-	-	-	-	-	Oc.	-	-	-	-
I.crdofana	-	-	-	-	-	-	-	-	-	Oc.	-	-	-	-
M.tuberosa	-	-	-	-	-	-	-	-	-	Oc.	-	-	-	-
S.arundinacium	-	-	-	-	-	-	-	-	-	R	-	-	-	-
D.muricata	-	-	-	-	-	-	-	-	-	Oc.	-	-	-	-
E.colona	-	-	-	A	-	-	-	-	-	-	A	-	-	-
Z.pentandra	-	-	-	-	-	-	A	-	-	-	Oc.	-	Oc.	D
C.biflorus	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Citrullus sp.	-	-	-	-	-	-	-	-	-	-	Oc.	F	-	-
C.depressus	-	-	-	-	A	-	-	-	-	-	-	A	-	-
M.canescens	-	-	-	-	-	-	-	-	-	-	-	Oc.	-	-
M.nudicaulis	-	-	-	-	-	-	-	-	-	-	-	R	-	-
P.quadrifida	-	-	-	-	-	D	-	-	-	-	-	-	D	F
T.pentandrus	-	-	-	-	-	F	-	-	-	-	-	-	F	-
No. of spp.	**4**	**5**	**13**	**10**	**2**	**2**	**2**	**11**	**9**	**19**	**16**	**6**	**4**	**4**

Tn= Tundub, Fr= El Farish, Abs= Abuseweid, Med, Medaisees, Buh= Buhat, Q72= Qoz Abu Dolou'a Km 72, FH= FArish Hamid.

Cyperus rotundus, *Ocimum bacilicum*, *Echonochloa colona* and *Corchorus depressus* were found at only one site.

Total number of herbaceous species increased from the year 2011to the 2012 however; some species not recorded during 2011 at all sites but appeared during 2012. Abuseweid was the richest in herbaceous species during both years followed by Medaisees, while Q72 and Farish Hamid were the poorest sites. At Tundub, El Farish and Farish Hamid, dominant species varied from year 2011 to year 2012.

Browse production

Twig weight/ha

Effects of site and year on mean browse twigs' weight (kg/ha) during 2011 and 2012 are shown in (Table 8).

Table 8: Effect of site and year on total browse production (kg/ha) during 2011 and 2012 seasons

Sites	**Mean** (Kg/ha)	
	2011	**2012**
Tundub	15.28^{aB}	37.5^{aA}
El Farish	4.56^{Bb}	13.69^{Acd}
Abuseweid	6.38^{Bb}	18.82^{Abc}
Medaisees	15.25^{Aa}	20^{Abc}
Buhat	22.81^{Aa}	28.94^{Aab}
Q72	1.5^{Ab}	2.88^{Ad}
Farish Hamid	0.63^{Ab}	0.75^{Ad}
±SE	2.43^{Ee}	4.93^{Ee}

[abcd,] Values within columns (for site effect, small letters) or rows (for time of season, capital letters) bearing different superscripts vary significantly at P <0.05

Wadi Abuseweid showed the highest (P<0.05) twigs' weight (kg/ha) during both seasons, while Farish Hamid showed the lowest (P<0.05) one. Generally there was an increase (P<0.05) in browse twigs weight (kg/ha) from 2011 to 2012. Significant (P<0.05) increases were observed at sites Tundub El-Farish and Abuseweid. For the year 2011, effects of site on browse species production (kg twig weight/ha) during the year 2011 is shown (Table 9).

A. ehrenbergiana showed highest (P <0.05) production at Tundub, whereas *A .radiana* showed highest (P <0.05) production at Buhat and *A. nubica* showed highest (P <0.05) production at Medaisees. *A. ehrenbergiana* showed the highest (P <0.05) production compared with other species at Tudub only, whereas *A .radiana* showed the highest (P <0.05) production compared with other species at Buhat only and *A. nubica* showed the highest (P <0.05) production at Medaisees. For the year 2012, same trends were observed for the above species at the same sites (10). All species production increased in year 2012. Total dry matter (TDM) produced by the study sites, soil water holding capacity (WHC), soil organic matter (OM), herbaceous dry matter (*h*.DM) and woody cover (WC) at the study sites during 2012 season are shown in (Table 11).

Table 9: Effects of sites on browse species production (kg twig weight/ha) during 2011

Species	Sites						
	Tundub	**Farish**	**Abseweid**	**Medaisees**	**Buhat**	**Q72**	**F. Hamid**
A. ehrenbergiana	13.16^{Aa}	1.75^{Ba}					
A .seyal	0.25^{Bb}	-	1.81^{Aa}				
A .radiana	0.44^{Bb}	0.19^{Ba}	1.5^{Ba}	-	22.31^{Aa}		
Z. spinachristi	0.25^{Ab}	0.63^{Aa}	1.19^{Aa}				
A. nubica	0.5^{Bb}	-	1.88^{Ba}	15.25^{A}			
A. spirocarpa	-	2^{Aa}	-	-	0.5^{Bb}		
M. crassifolia	-	-	-	-	-	1.5	0.63

[AB,] Values within columns (for site effect, small letters) or rows (for time of season, capital letters) bearing different superscripts vary significantly at P <0.05

Table 10: Effects of sites on browse species production (kg twig weight/ha) during 2012

Species	Sites						
	Tundub	**Farish**	**Abseweid**	**Medaisees**	**Buhat**	**Q72**	**F. Hamid**
A. ehrenbergiana	29.88^{Aa}	5.81^{Ba}					
A .seyal	0.87^{Ab}	-	6^{Aa}				
A .radiana	4.13^{Bb}	1.75^{Ba}	4.25^{Ba}	-	27.81^{Aa}		
Z. spinachristi	1.88^{Ab}	0.88^{Aa}	1.94^{Aa}				
A. nubica	1.13^{Cb}	-	6.63^{Ba}	20^{A}			
A. spirocarpa	-	5.25^{Aa}	-	-	1.13^{Ab}		
M. crassifolia	-	-	-	-	-	2.88	0.75

[AB,ab] Values within columns (for site effect, small letters) or rows (for time of season, capital letters) bearing different superscripts vary significantly at P <0.05

Table 11: TDM, Soil WHC, Soil OM, *h*.DM and WC. at different sites.

Site	Soil WHC	TDM	Soil OM	*h*. DM	WC
Tundub	21.67	690.5	0.11	653.00	49.61
Farish	25.33	1171.04	0.12	1154.60	19.48
Abuseweid	44.54	1780.8	0.31	1705.80	48.60
Medaisees	40.13	1138.8	0.23	1118.80	17.92
Buhat	41.73	541.74	0.41	512.80	89.41
Q72	20.13	1236.88	0.13	1234.00	3.76
F. Hamid	18.74	231.15	0.10	230.40	4.44

TDM= total dry matter, WHC= water holding capacity, OM= organic matter, *h*.DM= herbaceous dry matter, WC= woody cover.

Dominance and frequency

Distribution and dominance of woody species among the different sites are shown in (Table 12). It was shown that, Tundub was dominated by *A. ehrenbergiana* with rare occurrence of *A. seyal, A. radiana, A. nubica, Z. spina-christi* and *Balanites aegyptiaca*. El Farish was dominated by *A. spirocarpa;* whereas *A. ehrenbergina* was frequent, and *A. radiana* and *Z. Spina-christi* were occasional. *A. seyal* dominated wadi Abuseweid site, *A. radiana* was abundant and *A. nubica* and *Z. spina-christi* were frequent. Wadi Medaisees was dominated by *A. nubica*; Leptadenia *pyrotechnica* was abundant; *Z. spina-christi* and *Maerua crassifolia* were occasional and *Salvadora persica* was rare. Buhat was dominated by *A. radiana* with *Bascia senegalensis* as an abundant species, *Leptadenia pyrotechnica* was frequent and *Salvadora persica* was rare. Q72 and Farish Hamid were dominated by one by *Maerua crassifolia.* Tundub site was found to be the most diverse in woody species (6 species), followed by Medaisees (5 species). El Farish, Abuseweid and Buhat had 4 woody species each, while Q72 and Farish Hamid were least diverse in woody species.

Table 12: Distribution and dominance of woody species throughout the study area based on their importance values

Species	Sites						
	Tundub	Farish	Abuseweid	Medaisees	Buhat	G72	G42
Aacia ehrenbergiana	D	F	-	-	-	-	-
Aacia seyal	R	-	D	-	-	-	-
Aacia radiana	R	O	A	-	D	-	-
Aacia nubica	R	-	F	D	-	-	-
Ziziphus spina-christi	R	O	F	O	-	-	-
Balanites aegyptiaca	R	-	-	-	-	-	-
Aacia spirocarpa	-	D	-	-	-	-	-
Maerua crassifolia	-	-	-	O	-	D	D
Leptadenia pyrotechnica	-	-	-	A	F	-	-
Salvadora persica	-	-	-	R	R	-	-
Bascia senegalensis	-	-	-	-	A	-	-
No. of spp.	**6**	**4**	**4**	**5**	**4**	**1**	**1**

A= abundant, D= dominant, F= frequent, O= occasional, R= rare.

Table 13: Percentage cover/woody species and the overall woody cover at each of the study sites

Species	Sites						
	T	F	A	M	B	G72	G42
Acacia ehrenbergiana	37.95	3.67	-	-	-	-	-
Acacia seyal	3.26	-	38.04	-	-	-	-
Acacia radiana	2.59	1.57	10.87	-	41.44	-	-
Acacia nubica	0.11	-	10.98	10.67	-	-	-
Acacia spirocarpa	-	13.05	-	-	-	-	-
Ziziphus spina-christi	0.32	1.19	8.71	0.96	-	-	-
Balanites aegyptiaca	3.38	-	-	-	-	-	-
Maerua crassifolia	-	-	-	0.62	-	3.76	4.55
Leptadenia pyrotechnica	-	-	-	4.93	40.90	-	-
Salvadora persica	-	-	-	0.74	0.61	-	-
Bascia senegalensis	-	-	-	-	6.46	-	-
% woody cover	**49.61**	**19.48**	**48.60**	**17.92**	**89.41**	**3.76**	**4.44**

T=Tundub, F=El Farish, A=Abu Seweid, M=Medaisees, B=Buhat, G72=Goz Abu Dolou'a Km 72, G42=Goz Abu Dolou'a Km 42

Percentage Woody Cover / Appearance of Some Species

Percentage woody cover/species and the overall woody cover at each of the study sites are shown in (Table 13). Wadi Buhat showed the highest percentage woody cover compared to other sites, while the two sites Goz Abu Dolou'a Km 72 and Farish Hamid showed the lowest values. Wadi Tundub and wadi Abu Seweid are close to each other's regarding woody cover. At wadi Tundub, *Acacia ehrenbergiana* constituted the main woody cover (37.95%). At wadi El Farish, *Acacia tortilis* subsp. *spirocarpa* constituted the main woody cover (13.05%), at wadi Abu Seweid, woody cover was made mainly by *Acacia seyal* (38.04%), while at wadi Medaisees, *Acacia nubica* made the main woody cover (10.67%) compared to other species. At wadi Buhat, *Acacia tortilis* subsp. *radiana* and *Leptadenia pyrotechnica* together constituted most of woody cover with 41.44% and 40.90% respectively. At Qoz Abu Dolou'a Km 72 and Farish Hamid sites, *Maerua crassifolia* constituted 3.76% and 4.55% respectively.

Appearance and disappearance of some species are shown in (Table 14). For grasses: *Cucumis milo* and *Panicum sp.* were replaced by *Cenchrus biflorus, Euphorbia aegyptiaca.* For forbes, *Digera sp., and Ipomoea sinensis* were replaced by *Dactelochtenium sp* and *Cyprus rotundus* were replaced by *Dactelochtenium sp.* and *Cyprus rotundus.* Other species that appeared were: *Ipomoea cordofana, Cassia sp.* and *Sorghum arundinacium*. *Cymbopogon nervatus* replaced by *Aristolochia sp. Amaranthus sp.* replaced by *Prosopis sp. Zaleya pentandra* replaced by *Acacia nubica* and *Gisekia pharnaceoides* by *Maerua crassifolia*. Woody species that remained dominant were: *Ocimum sp., Acacia seyal, Balanites aegyptiaca, Leptadenia pyrotechnica, Capparis deciduas*.

Table 14: Herbaceous and woody species appeared and those disappeared at the study area during the last decades

Disappeared or declined		Appeared	
Latin name	**Local name**	**Latin name**	**Local name**
Grasses			
Cucumis milo	Battiekh	*Cenchrus biflorus*	Taffa
Panicum sp.	Tumam	*Euphorbia aegyptiaca*	Malbein
	Mahareib		Tagar
	Basal kilab	*Sesabania sp.*	Soreib
Forbes			
Digera sp.	Lablab	*Dactelochtenium sp.*	Difra
	Hummeidh	*Ipomoea cordofana*	Tabar
Ipomoea sinensis	Hantout	*Cyprus rotundus*	Seida
	Handal	*Cassia sp.*	Senna
	Faggous	*Sorghum arundinacium*	Adar
Cymbopogon nervatus	Nal	*Aristolochia sp.*	Umgalagil
Amaranthus sp.	Lisan tair	*Prosopis sp.*	Miskeit
Zaleya pentandra	Rabaa	*Acacia nubica*	Laout
Gisekia pharnaceoides	Safal	*Maerua crassifolia*	Sareh
	Rabul		
	Sungud		
Woody			
Ocimum sp.	Reihan		
Acacia seyal	Talh		
Balanites aegyptiaca	Higlieg		
Leptadenia pyrotechnica	Marikh		
Capparis decidua	Tudub		

DISCUSSION

A total of seven rangeland areas were selected to study their biodiversity, productivity and nutritive value as affected by factors; mainly season, year and site. Three sites lies within the eastern side of the Blue Nile, within the Butana region are classified as low lands or Wadies (Wadi Tundub, Wadi El Farish and Wadi Abu Seweid). Four sites are selected on the northwestern parts of the White Nile with lowlands and sand dunes (GOZ). Two Wadies selected were Wadi Medaisees and Wadi Buhat and two sand dunes Goz Abu Dolou'a and Q72. Wadies are wide shallow seasonal streams with run-off resulting in large and long lasting humidity in their soils. They are of varying widths, lengths and directions of flow, and are characterized by fertile soils; dense perennial woody vegetation and rich in annual herbaceous species during the rainy seasons.

Biodiversity for the different plant cover including grasses, forbs and browse trees was the better in the Wadies than in sand dunes sites. Wadi Tundub showed the best diversity followed by Wadi Medaisees and Wadi Abu Seweid. Variations in biodiversity could be related to land elevation, soil type, runoff and seasonal streams as well as their width and depth. The non-homogeneity in vegetation in the Butana region was related to soil erosion as stated by Abuswar (2007). Rainfall was the main limiting factor in range productivity where mid rainy season showed better productivity than the end of rainy season. Furthermore, year 2012 showed far more yields than year 2011 as the amounts received in the second year was higher than the first year. This is confirmed by the increase in different plant indices (forage density, ground cover, percentage plant compositions and percentage forage compositions) at all sites in response to water availability. Similar trends were observed by Elnour, (2008) for two successive years 2005and 2006, where DM production in the rangelands of Eddein locality was 0.782 and 0.777 t/ha respectively.

Abuseweid had the highest plant indices, followed by Medaisees and Buhat. Farish Hamid. High % forage composition at Abuseweid (100%) which according to Parker Loop Method should indicate no presence of non-forage species. However, in the same site species such as *Momordica tuberosa* and *Solanum dubium* were observed meaning that the Parker Loop Method is not accurate for determining species composition. This was in agreement with Thomas *et al*., (1990).

Herbaceous species that had the highest percentage increase from year 2011 to 2012 were *Aristida mutabilis* at Tundub (8 - 41%), *Indigofera hochstetteri* at El Farish (14 and 28%), *Portulaca oleracea* at Abuseweid (27 and 35%), *Amaranthus gracizans* at Medaisees (31 - 41%) and also at Buhat (26 - 50%), *Portulaca quadrifida* at Q72 (21 -31%) and *Aristida mutabilis* at Farish Hamid (8 - 20%). Herbaceous dry weight was found to be highest at Wadi Abuseweid. This could be related to species diversity (13 types during year 2011 and 19 in year 2012) (Godinez-Alvarez et al ., (2009). The high diversity was linked with such characteristics as: high soil water holding capacity (WHC) (44.54), high soil N (0.87), highest soil organic carbon, high soil organic matter (0.31%) and high clay and sand ratios compared to other sites. Similarly, Zaroug (2000) pointed out that vegetation of Butana area is a result of edaphic rather than climatic factors. The high dry weight of herbaceous species observed at Wadi Buhat and Medaisees could be related to high.

Organic matter received by surface runoff through Wadi El Mugaddam, from Kordofan Mountains. Furthermore these wadies were characterized by high soil WHCs (41.73 and 40.13), organic carbon (0.92% and 0.78%), organic matter (0.41% and 0.23%), $CaCO_3$ (7.83% and 9.67%) compared with other sites. The least herbage production was observed at other sites could be related to low water holding capacity and low carbon contents. Same correlations were obtained by De Leeuw and Tothill, (1990). Herbaceous DW was found to be negatively correlated to woody cover; same results were observed by other authors (De Leeuw and Tothill, 1990; Penning de Vries and Djiteye, 1982., Rains and Kassam, 1979). In this study, Buhat showed the highest percentage woody cover (89.41%). This high % was due to the domination of *A. radiana* which constituted 41.44% of the woody cover with old individuals producing high crown cover. The other species that constituted high cover at this site was *Leptadenia pyr*otechnica (40.90%). This means that Buhat Abuseweid and Tundub would sustain animals' feeds during the dry season in spite of its low crude protein content. Changes in dominance in plant covers were compared between years 1985 – 2000 at Wadi El-Wakeeb on the White Nile were found in species like *Acacia mellifera, Capparis deciduas, Acacia nubica, Acacia tortilis, Ziziphus spina-christi* and *Maerua crassifolia* (Egemi and EL Hasan, 2003).

Herbaceous dry weight decreased from the middle to the end of rainy season by 16.79%, 26.42% and 57.08% at El Fairish, Tundub and Abuseweid (as we move towards the Butana at the eastern part of the Blue Nile). This was due to the movement of grazing animals towards Abuseweid during the rainy season resulting in more grazing pressure at this site compared to El Farish and Tundub. Herbaceous DW also decreased from mid to end of rainy season at Medaisees and Q72 at the Northwestern part of the White Nile which meant that they constituted good grazing areas. Buhat and Farish Hamid exhibited poor herbaceous biomass. During 2012, herbaceous DW decreased at all sites as a result of herders' movement from neighboring states in search of good range condition. The decline in biomass at the end of the dry season was estimated as

30% by Wylie *et al*. (1988) as a natural decomposition rate of 4%/dry month. In line, it was found in Ethiopia, one TLU required 8t DM/annum converts to a utilization rate of 30% (Cossins and Upton, 1987). However, Van Wijngaarden (1985) proposed a proper use factor of 45% of TDM during the dry season. In Mali, Hiernaux, (1982) described a similar method of adjustment for rangeland with mainly annual species. It was recommended that protective cover equivalent to 0.2t DM/ha should be left at the end of the dry season in the arid zones of the Niger (Le Houerou and Hostle, 1970).

Browse production showed same trends as herbaceous biomass as their production was related to rain amounts as well as the other soil characteristics. Dominant of differed browse differed according to sites as *Acacia ehrenbergiana* was the dominant species at Tundub whereas *Aacia seyal* dominanted Abuseweid site At Buhat, *A. radiana* constituted the highest browse species wheras, *Leptadenia pyrotechnica* was the abundant species at Medaisees. This could be related with different soil types and pressure of grazing. In this study, percentage of legumes in the total biomass was 40% in Wadi Farish only. Similarly, it was pointed out that in the Sahel, TDM contained 40% edible forage (Le Houerou and Hostle, 1970).

CONCLUSION

It could be concluded that selected range lands on the Blue Nile and White Nile should differences in biodiversity including, grasses, forbs and woody browse trees. Generally the sites on the Blue Nile exhibited better diversity than on the White Nile. Mid rainy season showed better productivity than end of the rainy season. Year 2012 showed far better yields than year 2013. Such changes in addition of appearance of new species could be related climate change particularly fluctuation in rainfall.

REFERENCES

Abusuwar, A. O. (2007). Range Management. Published by UNESCO Chair on Desertification, University of Khartoum, pp: 60-74.

Abusuwar, A.O., and Yahia, E.O. (2010). Seasonal variability in nutritive value of ruminant diet under open grazing system in the semi-arid rangeland of Sudan (South Darfur State). *Agriculture and Biology Journal of North America*, 3, 243-249.

Bobeck, B., and Bergstorm, R. (1978). A rapid method of browse biomass estimation in a forest habitat. *Journal of Range Management*, 31(6), 458-460.

Cossins, N. J., and Upton, M. (1987). The Borana Pastoral System of Southern Ethiopia. *Agricultural Systems*, 25: 199-218.

Curtis, J. T. (1959). The vegetation of Wisconsin: An ordination of plant communities Madison: University of Wisconsin Press, 388p.

De Leeuw, P. N., and Tothill, J. C. (1990). The concept of rangeland carrying capacity in sub-saharan Africa-myth or reality. *Range Ecology at Disequilibrium*, Chapter 5, pp: 77-88.

Egemi, O. A., and El Hasan, S. E. (2003). Rural economic system transformation in arid lands of central Sudan. *1st Scientific Report*, Desertification Research Institute, National Center for Research, Ministry of Science and Technology, Sudan.

Elnour, I. A. (2008). Competition on Range Resources and its Role on the Conflict in Darfur. A case study (Eddaein Locality), South Darfur State. PH.D thesis, Sudan University of Science and Technology.

Friedel, M. H., Laycock, W. A., and Bastin, G. N. (2000). Assessing range condition and trend. In: L t' Mannetje and R.M. Jones (eds.) *Field and Laboratory Methods for Grassland and Animal Production Research*. CAB international, pp: 227-262.

Hiernaux, P. (1982). Méthode d'evaluation du potential fourrager de parcour sahelien. Miscellaneous Paper No 430 CABO Wageningen, Netherlands.

Le Houerou, H. N., and Hostle, C. H. (1970). Rangeland productivity and annual rainfall relation in the Mediterranean Basin and in the African Sahelo-Sudanian Zone. *J. of Range Mgt*., 30(3), 181-189.

Godinez-Alvarez, H., Herrick, J. E., Mattocks, M., and Van Zee, J. (2009). Comparison of three vegetation monitoring methods: Their relative utility for ecological assessment and monitoring. *Ecological Indicators*, 9: 1001-1008.

Husch, B., Miller, C. I., and Berrs, T. W. (1982). Forest Mensuration, 3rd ed. John Wiley & Sons, Inc., New York, 402p.

Parker, K. W. (1951). A method for measuring trend in range condition on National Forest ranges. U. S. Forest Service, 26 pp., illus.,mimeo., Washington, D. C.

Penning de Vries, F. W.T., and Djiteye, M. A. (1982). La Productivité des Pâturages Saheliens Centre for Agricultural Publishing and Documentation Wageningen, Netherlands.

Rains, A. B., and Kassam, A. H. (1979). Land resources and animal production . Consaltants working paper No. 8, FAO/UNFPA Project INT/75/P13 AGLS, FAO, Rome, 28p.

Steel, R. G., and Torrie, J. H. (1980). Principles and procedures of statistics –A biometrical approach-2nd ed.,Mc Graw-Hill company, Inc, USA.

Thomas, C. D., Vasco, D., Singer, M. C., Ng, D., White, R. R and Hinkley, D. (1990). Diet divergence in two sympatric congeneric butterflies: community or species level phenomenon. *Evol. Ecol*. 4: 62-74.

Van Wijngaarden, W. (1985). Elephants-Trees-Grass-Grazers: Relationships between climate, soils, vegetation and large herbivores in a semi-arid ecosystem (Tsavo, Kenya) ITC Publ No 4 Enschede, Netherlands.

Wylie, B. J., Harrington, R. P., Maman, A and Denda, I. (1988). Pasture Assessment Early Warning System Integrated Livestock Production Project Government of Niger/Tufts University/ USAID/New Mexico State University.

Zaroug, M. G, (2000). The forage resource profile for Sudan. Sudan.Unviersity of Khartoum Press.