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Impact of Land Use Pattern on Rangeland Vegetation in Blue Nile State, Sudan

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Abstract: The study was conducted in'Elrosieris'area, Blue Nile State, Sudan, at the end of autumn season on Novermber, 2018 to investigate the impact of land use type on natural rangelands vegetation. Two sites were selected; namely rangelands and abandoned croplands. Three transects of 100 m length were placed randomly in each of these sites. Species composition, plants cover and ground cover were determined using Parker loop method along these transects. Plant density (Plant/m^2), frequency, biomass productivity (ton/ha) and carrying capacity, Tropical Livestock Unit (TLU/ha/yr) were determined using quadrate method applied along these transects. The data were analyzed using descriptive statistic and T- test. The results revealed that plant cover was higher in rangeland (87%) compared to abandoned cropland (79%). Bare soil was lower in rangeland (4%) than in abandoned cropland (8%). *Pennisetum ramsum* was dominant species in rangeland (70.67%) and less so in abandoned cropland (25.33%). Plant density was higher in rangeland (34.67 plant/m^2) compared to abandoned cropland (11.58 plant/m^2). The difference in productivity and carrying capacity were very slight. The study concluded that *Pennisetum ramsum* was dominant in terms of cover and composition regardless of land use type. Plant density was better in rangeland. The differences in yield and carrying capacity were close regarding land use pattern.

Key words: Land use; pattern; abandoned cropland; carrying capacity

INTRODUCTION

Agriculture and raising livestock play a prominent role in the livelihood of the population in the Sudan. Rangelands in the Sudan is estimated to be 97 million hectares (FAO 2015) and varied from poor to rich according to the ecological zones (Harrison and Jackson 1958). It is a main source of feeding livestock with very low cost and play an important role in combating desertification and conserving biodiversity (FAO 2017). The majority of Rangelands in the Sudan are confined in arid and semi-arid regions and are subjected to various natural environomental factors coupled with intensive human activities. Recently, in Sudan, there is continuous pressure on rangelands due to competition as a result of expansion of agricultural area for securing food as well as other land use patterns *e.g* fire wood. Increasing human activities such as expansion of cultivation and cutting down rangeland vegetation cover altered other land use types and their vegetation. Settlement of population and movement of livestock create tremendous pressure on natural rangelands by destroying vegetation, removing palatable grass species, increase invader species and reduction in plants' composition and density (Ibrahim *et al*. 2016). Consequently deterioration of rangelands resources and signs of environmental degradation have occurred. These land use activities have negative impact on the sustainability of rangeland biodiversity and environment. In addition, Sudan has been exposed to the incidence of environmental and social hazards and disasters including drought, desertification, and loss of biodiversity (Gbenga 2008; Kehoe 2016). Institutional and social factors such as collective land tenure system and inadequate policies, as well as human intervention on rangelands have great contribution in rangeland deterioration.

Rangelands in Blue Nile State contribute to conservation, provide feed and habitat for livestock and wildlife, food for pastoral and local communities. However, it had increasingly become weakened by the various pressures induced by human activities, growing of livestock population, overgrazing, and climate vulnerability with their negative effect on biodiversity.

Increasing human activities, such as, expansion of agriculture and cutting down rangeland vegetation cover increased invader species. The palatable species had been subjected to selective grazing by huge number of animals and hence rangeland conditions became more subjected to degradation (Almontasir *et al.* 2015; FAO 2017). Finally, the availability of the plant cover tends to be seasonal and increasingly vulnerable. Sustainable rangeland management systems reduce rangeland biodiversity degradation and insure proper use of the available resources. Proper management of rangeland resources requires long term monitoring and planning of animals grazing with the fundamentals to increase the vegetation cover and decrease the overgrazing, as well as application of the land use map to reduce the irrational expansion of agricultural area. The objective of this study was to investigate the impact of land use pattern on the performance of natural rangeland .

MATERIALS AND METHODS

The study was conducted in 'Elrosieris' locality (11°46′ N, 34°32′ E, 467 m ASL), at a distance of 12 km south eastern of the State capital (Eldamzin) Blue Nile State, at end of autumn season in November 2018 to investigate the impact of land use pattern on the performance of natural rangeland vegetation. Rangeland and abandoned cropland sites were selected. The actual locations of these sites were determined using Global Positioning System (GPS) as follows:

(1) Rangeland site (latitude 11°46′11″, longitude 34°32′36″ E)

(2) Abandoned cropland site latitude 11 ° 57′18″ N and longitude 34°23′23″ E)

The study area

The climate of the study area is tropical sub-humid zone with annual rainfall ranging from 300-800 mm and the climate factors exhibit variation. The rainy season always starts in April to November with a peak in July and August (Gibreel *et al* 2013). The soil of the study area is clay soil which is a part of the central clay plain. In rangeland site, the most dominant tree species were *Acacia seyal* 'Talih*', Ziziphus spinachristi* 'Sidir' and *Balanites egyptiaca* 'Hegleig' and land use was rangeland while in cropland site, the most abundant trees were *Acacia nubica* 'laout', *Acacia seyal* 'Talih' and

Balanites egyptiaca 'Hegleig' and the land was cultivated by sesame crop for previous year, but currently is a fallow area (uncultivated area).

3.2 Data collection

Field data were collected on November 2018. The measurement starting point was selected randomly and then three 100 m transects were stretched in each of these sites. The species composition, plants cover and ground cover were computed using Parker loop method as described by Abusuwar (2007).

Cover and species composition

The $\frac{3}{4}$ inch Loop was placed at ground level at 2 m interval along the transect and whatever inside the loop (plant species, litters, rock and bare soil) was recorded for each of these sites. The plant composition, bare soil and litters were computed according to Abdelrahim and Abdallah (2015) as:

$$\text{Factor} = \frac{\text{Total hits of factor}}{\text{Total number of hits}} * 100$$

where

Factor represents the plant species or bare soil ore litters.

Plant species composition was obtained using the following equation (Abusuwar and Mohamed 2011).

$$\text{Plant species composition} = \frac{\text{Number of hits on the specific species}}{\text{Number of hits on all vegetation}} * 100$$

Plant Density and Frequency

Four quadrates were placed at 25 m regular intervals along the transect of 100 m length to determine plant density, frequency, range productivity and range carrying capacity.

Plant density (plant/m^2) was determined by counting all plants rooted in the quadrate and calculated using this equation:

$$\text{Plant density} = \frac{\text{Total number of plants in the quadrat}}{\text{quadrat area } (m^2)}$$

The frequency was determined by counting all species appeared in the quadrates and calculated using the following equation:

$$\text{Frequency} = \frac{\text{Number of quadrats with species occured}}{\text{Total number of quadrats}} * 100$$

Range productivity (ton/ha)

All plants inside the quadrate were clipped at 3 cm above ground level using scissor, partially dried under sunlight and placed in paper bag. Then they were oven dried at 75 °C for 48 hr and weighed to get the dry matter per quadrate. Range productivity (ton/ha) was determined as follows:

$$\text{Range productivity (ton/ha)} = \frac{\text{Total weight of all plants in the quadrat (g)}}{\text{quatrate area (m}^2) * 100}$$

Carrying capacity (Animal Unit/hectare/year) (AU/ha/yr)

Carrying capacity was determined using the data obtained from range productivity. The carrying capacity was calculated as Tropical Livestock Unit (TLU) base which is expressed as an animal of 250 kg live weight wich consumes about 2.5% of its live weight per day. The carrying capacity was determined using the following formula (Muir and McClaran 1997):

$$\text{Carrying capacity (animal units/ha/yr)} = \frac{\text{Forage requirement yr (animal unit kg)}}{\text{Forage productivity (kg/ha)}}$$

Data were finally organized and analyzed using descriptive statistic and t-test (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Ground cover

The effect of the land pattern on ground cover is presented in Fig. 1. Statistical analysis of ground cover indicated a significant difference between the sites. The plant cover was higher in the rangeland site (87%) compared to the abandoned cropland site (77%). The bare soil was higher in abandoned cropland site (8%) than that in rangeland site (4%) because the plants and litter made good cover and relatively reduced the bare ground in the rangland site. The higher bare soil in abandoned cropland might be caused by agricultural practices *e.g*. intensive ploughing and/or application of herbicides). This result indicated that the human activities had a negative impact on the ground cover of the abandoned cropland site. This result agreed with Fashir *et al.* (2015a) who stated that expansion and intensification of

crop cultivation had increased barren soil and the rangelands were subjected to some environmental hazards *e.g.* wind erosion). Similar observations were reported by Azarnivand *et al*. (2011) and Fashir *et al*. (2015b) who showed that expansion of crop cultivation land to rangeland increased the pressure on remaining areas which exposed them to harmful degradation. The litter percentage was lower in rangeland (9%) compared to abandoned cropland site (15%) as presented in Fig. 1. The very low litter percentage in rangeland site might be due to intensive grazing. This result is confirmed by the findings of Jensen and Gutekunst (2003) who reported that the litters mass generally decrease with increased grazing intensity.

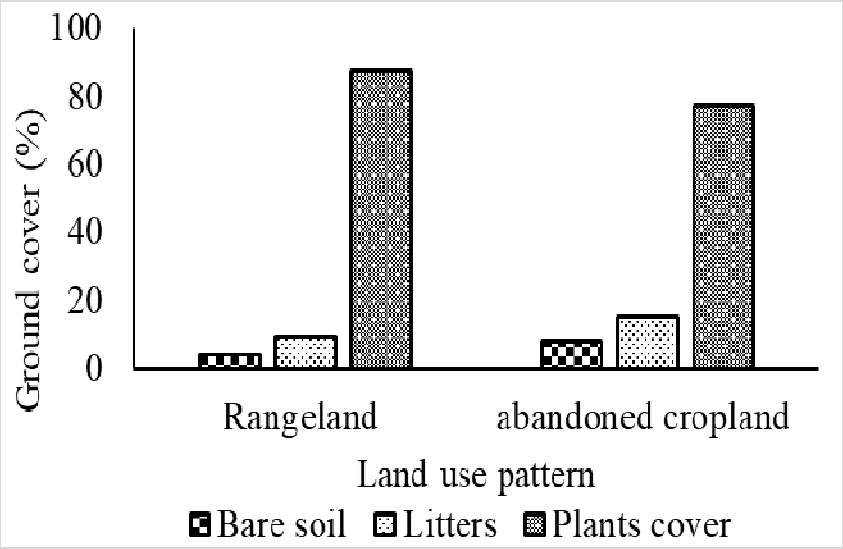

Fig. 1. Impact of landuse pattern on ground cover (%) in Blue Nile State

Plant species composition and frequency

A total of 12 and 11 plant species were identified in rangeland and abandoned cropland sites, respectively. According to the results presented in Table 1, there were spatial variations in species' composition in both sites.

The low plant composition might be due to variable soil properties, rainfall variation and grazing intensity. Abdelrahim and Abdallah (2015) reported that plant composition was changing continuously due to grazing, fire, and rainfall variation. The vegetation of the study area was dominated by the species *Pennisetum ramsum* which constituted about 81.71 % and 32.28 % of total plants in rangeland and abandoned cropland, respectively. This finding might be due to the fact that *Pennisetum ramsum* is less palatable plant species especially after flowering, and highly competitive to soil moisture absorbtion in arid environment . The dominance of such species was considered as an indicator of degradation of both study sites. Human activities like rainfed agriculture , over grazing caused the decreased diversity of such species. Similar results were reported by Abdelsalam *et al*. (2017) who considered the dominance of the single species as an indicator of rangeland deterioration. Moreover, the result showed that other species compositions were very low in both sites. Plant composition diversity was affected by land use pattern. This result might be a reflection of grazing pressure, misuse of land management. This result is supported by Fashir *et al*. (2015a) and Abdelsalam *et al*. (2017) who stated that animals' pressure, continuous open grazing and early grazing lead to selective grazing and change in the vegetation composition of the rangeland. Findings in Table 1, show frequencies of the dominant species in the study area; *Pennisetum ramsum* scored the highest frequency in both sites. The frequencies of species, *Merremia emarginata* and *Barchiaria eruciform,* were 75 % and 50 % respectively, in the rangeland site. The most higher frequencies species were *Kohautia aspera* (50%)*, Barchiaria eruciformis* (41%) and *Cratolaria spp* in the abandoned cropland site. The distribution of plant species was negatively affected in abandoned cropland site. This finding reflected the effect of land use on natural distribution of plants species. Similar result was found by Abdelsalam *et al*. (2017) who concluded that the grazing pattern affected the distribution of species on rangeland and human behavior change the plant diversity.

Table 1. Impact of landuse pattern on plant species composition and frequency of the study area

Scientific Name	Rangeland		Abundant cropland	
	Sp. Composition (%)	Frequency	Sp. Composition (%)	Frequency
Pennisetum ramsum	81.71	100	32.28	100
Aristolochia bracteata	0.74	42	0.83	17
Barchiaria eruciformis	3.00	50	5.13	41
Ocimum americanum	0.70	00	5.04	16
Cratolaria spp	0.00	00	10.13	41
Merremia emarginata	3.04	75	0.00	00
Ipomoea cordofana	1.67	25	4.25	33
Rhynchosia minima	3.02	25	17.72	33
Kohautia aspera	0.00	00	10.96	50
Xanthium brasilicum	0.70	08	5.13	17
Desmodium dichotamum	0.00	17	0.00	00
Vigna trilobata	2.31	17	0.00	00
Sesbania sesban	0.00	00	0.00	25
Rhynchosia memnonia	0.00	00	1.67	00
Cassia tora	0.83	33	1.67	33
Corchorus fasicularis	0.00	17	0.00	00
Pennisetum pedicellatum	0.00	00	0.00	08

Plant density (Plant/m^2)

The results in Table 2 illustrate that the total plant density of the rangeland and abandoned cropland sites were 34.67 plant/m^2 and 11.58 plant/m^2, respectively. Very low plant density in abandoned cropland site might be due to expansion of crop cultivation, clearance of land and that some annual plants could not be able to survive. The limited density in rangeland site may be a result of rainfall variation and overgrazing. Statistical anaylysis of plant density showed significant differences for many plants such as *Pennisetum ramsum, Kohautia aspera, Merremia emarginata, Cratolaria spp,*

Rhynchosia memnonia, Aristolochia bracteata and *Sesbania sesban* between rangeland and abandoned cropland sites. The remaining plant especies densities were not significantly different as presented in Table 2. Fashir *et al*. (2015a) who reported that the expansion of crop cultivation and clearance of land reduced species density. Some annual plants could not be able to survive due to the cultural practices and misuse of available land resources. Moreover, Gbenga (2008) indicated that development of new agricultural areas on lands for irrigation schemes and removal of the existing vegetation had exposed the ecosystem to degradation .

Table 2. Impact of landuse pattern on plant density (plant/m^2) of the study area

Scientific name	Range land	Abandoned cropland	t value	0.05
Pennisetum ramsum	28.75	2.92	9.092	1.71
Rhynchosia minima	0.42	0.83	0.75	
Kohautia aspera	0.00	1.75	2.30	
Barchiaria eruciformis	1.58	1.58	0.18	
Merremia emarginata	1.25	00	4.10	
Cratolaria spp	00	1.25	1.88	
Rhynchosia memnonia	00	1.17	2.03	
Pennisetum pedicellatum	00	0.08	1.00	
Cassia tora	0.50	0.42	0.32	
Ipomoea cordofana	0.33	0.42	0.32	
Aristolochia bracteata	0.67	0.17	1.73	
Sesbania sesban	00	0.33	1.77	
Xanthium brasilicum	0.17	0.08	0.43	
Ocimum americanum	00	0.4	1.8	
Desmodium dicchotomum	0.25	00	1.39	
Corchorus fasicularis	0.42	00	1.45	
Vigna trilobata	0.25	00	1.39	
Total density	34.67	11.58	9.88	

Range biomass productivity (ton/ha) and carrying capacity (TLU/ha/yr)

According to the results in Table 3, there was slight significant increase in biomass production in the abandoned cropland site compared to rangeland site. These results might be due to grazing type of forage plants and species composition in rangeland.. This result agreed with Abdelsalam *et al.* (2017) who stated that some activities such as open grazing reduced rangeland productivity. Animal carrying capacity was not much affected by land use patterns. Following the trend of forage productivity, this could be due to the fact that the difference in forage productivity was not that much to be reflected in the carrying capacity. This result agreed with Abusuwar and Yahia, (2010) who showed that low carrying capacity indicate general land degradation, over grazing, over cultivation and cultivation of marginal lands of low potentiality. However, the result was not in line with Rabeeh *et al.* (2015) who stated that human activities decreased range condition and carrying capacity.

Table 3.Impact of land use pattern on forage productivity (ton/ha) and carrying capacity (TLU/ha/yr) of study area

	Rangeland site	abandoned cropland site	t value	0.05
Forage productivity (ton/ha)	1.29	1.36	0.19	1.71
Carrying capacity (TLU/ha/yr)	5.77	6.83	0.69	

CONCLUSIONS

- The most dominant and abundant species in the study area is *Pennisetum ramsum*,
- Rangeland site is very high in terms of species cover, whereas the abandoned cropland site is high in terms of species diversity.
- Plant density is negatively affected by land use pattern.
- Less plant density with high species diversity is obtained in abandoned cropland site.
- The difference in range productivity and carrying capacity between the sites is very negligible.

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أثر نمط إستخدام الأرض علي معايير الغطاء النباتي في المراعي الطبيعية في محلية الرصيرص النيل الازرق

أبراهيم موسى عثمان، التوم الصادق على والطيب سليمان نايل بابكر

قسم المحاصيل الحقلية ، كلية الزراعة جامعة الخرطوم السودان

المستخلص: أُقيمت دراسة ميدانية بمنطقة الرصيرص، ولاية النيل الأزرق، السودان في نهاية الخريف، خلال شهر نوفمبر 2018 لمعرفة أثر نمط إستخدام الأرض علي معايير الغطاء النباتي في المراعي الطبيعية. أُختير موقعين ؛ مرعي طبيعي و أرض زراعية متروكه. وُضعت ثلاثة قطاعات خطية في شكل شريط قياسي طوله 100م عشوائياً في كل من الموقعين. علي طول هذا الشريط ، أُستخدمت طريقة حلقة باركر لتحديد التركيب النوعي للنباتات، والتغطية النباتية والتغطية الأرضية. كما أُستخدمت اربعة إطارات بمساحة م^2 علي طول الشريط لتحديد الكثافة النباتية (نبات/م^2)، والتردد النوعي، وإنتاجية المرعي العلفية (طن/هكتار) والحمولة الرعوية (وحدة حيوانية مدارية/هكتار/السنة). رُتبت البيانات المتحصل عليها وحللت باستخدام الإحصاء الوصفي وإختبار (t) للمقارنة بين المواقع. أوضحت النتائج ان التغطية النباتية كانت أعلي في أرض المرعي (87.33%) مقارنة بالأرض الزراعية المتروكة (77%). التربة العارية كانت أقل في المرعي (4%) من تلك في الأرض الزراعية المتروكة (8%).النبات كرتشا (*Pennisetum ramsum)* من أكثر الأنوع سيادةً في المرعي (70.67%) وكذلك في الأرض الزراعية المتروكة (25.33%).النباتات كرتشا وأم كويعات *(Barchiaria eruciformis)* سجلا أعلي تكرار في الموقعين . فيما يتعلق بالتركيب النوعي ؛ النبات كرتشا كان سائداً في كِلا الموقعين. الكثافة النباتية كانت أعلي في المرعي (34.67 نبات/ م^2) مقارنة بالأرض الزراعية المتروكة (11.58 نبات/م^2). الإختلاف في الإنتاجية والحمولة الرعوية كان طفيفاً. خلصت الدراسة إلى أن النبات كرتشا أكثر الأنواع سيادةً من حيث التغطية الأرضية والتركيب النباتي بغض النظر عن نوع إستخدام الأرض. الكثافة النباتية كانت أفضل في المرعي.الإختلافات في الإنتاجية والحمولة الرعوية كانتا متقاربة جداً.