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The Impacts of Oil Exploration and Production on Rangeland Plants Attributes of Balila Area of West Kordofan State, Sudan

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***Abstract*—** *This study was conducted at Balila area, West Kordofan State, Sudan in September 2018. The aim of this study was to examine the impacts of oil exploration and production operations on rangeland plants attributes at Balila area. Three sites being, Balila, Elshag and Elfrdus were selected for the study. The methodology used in the study included botanical measurements for the assessment of rangeland plants attributes which includes range vegetation composition, relative frequency, plant cover, plant productivity and range carrying capacity. This information was used to identify the impacts of oil exploration and production on rangeland plants attributes of the area. The study showed that the current condition of the rangeland plants attributes of the area is largely affected by the current activities of oil exploration and production. The rangeland plants attributes at Balila area indicated that, plant species percentages were 53.3% in season 2017 and reduced to 25.8% in season 2018. Litter recorded 3.2% in season 2017 and increased to record 18% in season 2018.While bare soil showed 5% in season 2017 and decreed to 0% in season 2018. Fourteen species appeared in the rainy seasons of the two seasons 2017 and 2018 respectively (10 annuals and 4 perennials). In 2017 the average vegetation cover was 30%, while it was 25% in 2018. The biomass productivity showed 2.045 Ton/ha in 2017.Then it reduced to show 0.7034 Ton/ha in 2018. In 2017 the carrying capacity was 3.03 Ha/Au/Yr. while it was 1.5 Ha/Au/Yr in 2018. The study concluded that, the oil exploration and production is bound to bring about the suppression of certain plant species in favor of others. This practice was resulted in the decrease of rangeland plants attributes of the area*.

***Keywords*—** *Plants attribute oil, exploration, production, West Kordofan*.

I. INTRODUCTION

Rangelands comprise about 50% of the worlds land area and include natural grassland, scrublands, savannas and deserts. They are the "Wild Open Spaces" that cover about half of the earth's land surface. In most Africa countries, rangeland livestock production is a form of extensive grazing systems practiced by nomads of the arid and semi- arid regions, considering the demand for foodstuffs due to the growing human population, increasing livestock productivity gains importance particularly under harsh environmental condition in arid and semi – arid areas [1]. Rangelands play a major role in supplying human population with animal products in the entire land region in the world. Rangelands account for 16% of world food production compared to 77% for cropland [2]. The rangeland all over the world is subjected to be intensive use due to increasing animals and human population, ecological change and increase in human demands and over economical activities [3]. Range lands in Sudan are facing many problems that hinder their use and development. Some are user oriented whereas others are resource oriented. Most rangelands lie in fragile environments and facing frequent drought periods, seasonal bush fires, changing in species composition, increasing pressure on the range resource especially around water points, expanding cultivation, and destruction of the local institutions and the gradual loss of the traditional knowledge, increase in animal population and low off-take, blockage of the livestock migration routes and lack of local community participation in the planning and execution of range programs [4].

Rangelands form an immense natural resource and the major of feed for national herd in Sudan. The various types of grazing land vary from open grasslands to seasonal water sources, flood plains, river banks, woodlands, hills and mountain slopes [5]. Rangelands in many developing countries are under stress due to, increase in animal numbers, land tenure disputes, dry season grazing problems, and drought, [6].

Pastoralism occurs in more than 100 countries on about 25 % of Earth's land area and supports about 200 million households and herds of nearly a billion animals, including camels, cattle, and smaller livestock that account for about 10 % of the world's meat production [7]. It can be interpreted that nomadism or the movement of stock according to season is a form of grazing management system which is still being carried out in many settled communities such as the Turkaman of the old Soviet Union, and among most of the Middle East countries. The only difference from Sudan and may be the Sudanese Sahelian countries is the fact that in these countries, these seasonal movements are controlled and the grazing utilization is conditioned by the availability, the condition, and the readiness of grazing for livestock use. Pastoralism

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provides very important ecological services, such as primary production, biodiversity conservation, and erosion control [8].

Pastoral nomads depend on range lands and move with stock to where feed and water are available but within specific geographical zones. In Kordofan, Darfor, Central and Eastern regions of Sudan this system is considered as the main livestock production for meat for real demand and for export. In Kordofan pastoralist was the traditional mode of rangeland resources utilization, but the society is experiencing profound change throughout the last decades. These changes are visible through the regression of animal mobility and sedentrisation of the population, rangelands are subject to increasing pressure leading to their degradation. [9]. There are many types of plants that are exist in these rangelands; some of these plants that grow in natural rangeland have grazing importance, thus contributing significantly to the range animal feeding [10]. The rise of oil production in Western Kordofan State has disrupted pastoral livelihoods in oil producing areas and diminished the importance of livestock production for the Sudanese economic [11].

There is no doubt that the exploitation of oil has many benefits to the national economy, but we cannot lose sight of the effects it has on the environment and change the components of the natural resources of the area as well as its social and economic impact. Some changes in the soil appeared with a clear decrease in the number and quality of plants [12]. The flow of oil over large areas of rangeland has had the effect of reducing and changing its compsition. The above features are very much influenced by anthropogenic factors, which include the contamination of soil with petroleum-derived products. Changes in some soil properties resulting from contamination with petroleum-derived substances, and particularly those related to physio-chemical composition, brings about some changes in the biological composition of soil which, inconsequence, can lead to water and oxygen deficits, as well as to a shortage of available forms of nitrogen and phosphorus [13]. Soil constitutes the living environment not only for people, but also for plants and animals and through its functions provides for the needs of the natural environment [14]. The contamination of the natural environment by petroleum substances contributes to the degradation of land, and the occurrence of many spot and area sources of contamination overtime results in the creation of various integrated underground environments contaminated with these substances [15]. Particularly dangerous soil contaminations include pollution with petroleum, which is very often observed in municipal soils, around industrial plants and in areas where petroleum and natural gas are obtained [16] & [17]. Recently oil exploration and production took place in the area. So the current study aims to study the impacts of oil exploration and production on the plants attributes of Balila area of West Kordofan State, Sudan.

II. Materials and Methods

A. The Study Area:

Balila area is located at West Kordofan State in the central part of Sudan extending from 11.25^0 N to 16.67^0 N latitudes and from 27.50^0 E to 32.42^0 E longitudes. The State covers an area of approximately 114,000 Km^2 [18]. The area is a forested land scattered with some plains, valleys and sand dunes which is considered as one of the poor savanna belts. The two main livelihood systems have traditionally been pastoralism and subsistence farming. Pastoralist communities in the area include both nomadic and semi-nomadic (transhumant) cattle, sheep and goat herders.

B. Vegetation Measurements:

1) Methods used in range vegetation measurements:

The current method which was adopted by the Range Management and Pasture Administration (RPA) is the 100 M transect tape and $\frac{3''}{4}$ loop method. This method is used for the measurements of the range vegetation for the assessment and monitoring of the following parameters:

- Percentage species composition.
- Total vegetation cover.

Equipment used:

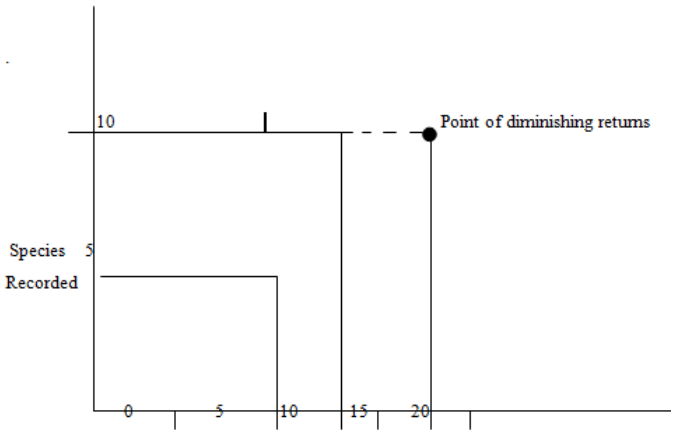
- One meter tape (100M).
- $\frac{3''}{4}$ Loop.
- Recording sheet.

2) Number of measuring sample to be recorded:

Ecologically speaking it is rather difficult to measure or count the entire population, therefore the species area curve method is normally used for the determination of the number of samples to be taken (Fig. 1). As shown in figure (1) the number of species determined in each sample is usually recorded in the vertical axis. The numbers of samples taken are recorded in the horizontal axis of the curve. The measurements will encounter the following:

- Plant species (sp/1, sp/2 … etc).
- Rock (R).
- Dry matter (L).
- Bare soil (BS).

Figure (1) the sampling curve



Number of samples determination curve

When the number of samples increased up to 20 samples no additional plant species was recorded. This point is called the "point of diminishing returns" after which no new species will be recorded with increase of sampling number. This is an

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indication that up to 20 samples is quite enough to encounter the whole population, and after which no new species will be expected to be recorded.

Using the $\frac{3\prime\prime}{4}$ loop, vegetation measured every one meter along the 100 meter transects tape. Resulting information listed in the recording sheet.

The measurements encountered the following:

- Plant species (sp/1, sp/2 … etc).
- Rock (R).
- Dry matter (L).
- Bare soil (BS).

The above parameters were calculated as follows:

Plant species % =

$$\frac{\text{the total number of the plant appearance}}{\text{the total number of all readings}} \; x\ 100$$

Litter % =

$$\frac{\text{the total number of the litter appearance}}{\text{the total number of all readings}} \; x\ 100$$

Bare soil % =

$$\frac{\text{the total number of the bare soil appearance}}{\text{the total number of all reading}} \; x\ 100$$

Relative species frequency =

$$\frac{\text{the total number of the species readings}}{\text{the total number of the all plant readings}} \; x\ 100$$

$$\text{Plants cover} = \frac{\text{total hits of all plants spescieces}}{\text{total hits}} \times \%100$$

$$\text{Range productivity per /m} = \frac{\text{average biomass}/m^2 \times 10000 \times 0.5}{100000} = ton/ha/\text{years}$$

The carrying capacity was calculated according to tropical livestock requirement (7.5 kg per day) [19]. It was determined as hectare/ animal unit / year (ha/Au/yr).

III. Results and Discussions

A. Rangeland Attributes:

Results in table (1) show the rangeland attributes at Balila area. Plant species percentages were 53.3% in season 2017 and reduced to 25.8% in season 2018.Litter recorded 3.2% in season 2017 and increased to record 18% in season 2018.While bare soil showed 5% in season 2017 and decreed to 0% in season 2018.

Table 1. RrangeLand Attributed at Balila Area, West Kordofan State in the Late Rainy Seasons 2017 and 2018.

Parameter measured	No.	Indicators%	
		2017	2018
Plant species	1	53.3	25.8
Litter	2	3.2	18
Bare soil	3	43.5	55.7
Animal manure	4	0	0
Rocks	5	0	0.5

The reduction of plant species from 53.3% in season 2017 to 25.8% in season 2018 may be due to the impacts of oil exploration and production on plants attributes in the area especially the oil spills. This agreed with lot of observant. [20] Stated that**,** pollution of grasslands and farms is a well-known phenomenon. The flow of oil over large areas of rangeland has had the effect of reducing and changing its flora [12]. The obtained results could be explained by the fact that oil reduces the soil fertility such that most of the essential nutrients are no longer available for plant and crop production. Oil spills has adverse effects on nutrient level and fertility status of the soil [21]. [22] Reported that oil pollution might affect soil physical properties. Pore space might be blocked which could reduce soil aeration and water infiltration and subsequently affect plant growth. Oil spills render the soil toxic and unproductive. Spilled oil which is denser than water reduces and restricts permeability: organic hydrocarbons which fill the soil pores expel water and air, thus depriving the plant roots the much-needed water and air [23]. [16] & [17] confirmed the adverse effects of oil on soil characteristic and vegetation cover. Accordingly, a necessity arises for the adoption of remediation technique to restore contaminated soil. The company (Petro energy) involved in oil production at Balila area treats the contaminated soil with cow droppings to break down pollutants. [24] Reported that the addition of cow dung to oil contaminated soil make such contaminated soils useful for agricultural activities and improve growth performance of the plants.

The increase of litter percentage from 3.2% in season 2017 to 18% in season 2018 may indicate that, the area of rangeland reduced as a result of oil activities in the area. Therefore the livestock of the area force to practice intensive grazing causing range degradation. This agreed with [25] who mentioned that, overgrazing occurs when the grazing pressure exceeds the carrying capacity of the range plants. This condition is not really a function of how many animals are on a rangeland, but how long they remain there. In grazing management, time is the most important factor to consider in establishing a grazing system for sustained forage production. Continuous grazing allows livestock to selectively graze the most palatable plants over and over. The problem with this isn't necessarily in the selective grazing activity, but in the fact that the grazed plant does not get the time to re-growth before it is grazed again. Overgrazing has a negative effect on plant diversity. Although several individual plant species are adapted to intensive grazing or seem to be favored due to the reduction of competition [26]; the overall impact of overgrazing is negative, particularly in grasslands [27].

Grazing has a beneficial effect on plant diversity, but under grazing or no grazing at all may also produce negative effects [28]. Under grazed or ungraded rangelands present the problems of abandoned lands being invaded by woody species, which increase the fire risk and result in devastating wildfires. Overgrazing is caused when the numbers of animals carried in a rangeland are more than its grazing capacity, suggesting these extra animals could be from a few to too many. The number of animals grazing in a rangeland or the grazing intensity, expressed as stocking rate, is a very important indicator of rangeland degradation [1] and [27]. Due to the different way that the various grazing animals collect the forage, their impact on vegetation is different [29].The increase of bare soil percentage from 43.5% in season 2017 to 55.7% in season 2018 reflects the most indicative parameter of the degree of disturbance and the degradation of the area.

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According to [30] Soil degradation, primarily through accelerated erosion by wind and water, causes a direct and often irreversible loss of rangeland health. Soil degradation not only damages the soil itself but also disrupts nutrient cycling, water infiltration, seed germination, seedling development, and other ecological processes that are important components of rangeland ecosystems. In addition, soil degradation damages watersheds, which leads to further degradation of rangeland ecosystems as well as water pollution. Indicators of soil stability and watershed function should be central to the evaluation of rangeland health.

B. Plant Occurrence in the Area:

Table (2) shows the high number of annuals in comparison with perennials. This is may be due to the fact that annuals are able to survive under harsh condition which resulted from oil operation in the area.

Table 2. Species Appeared at Balila Area, West Kordofan State in the Late Rainy Seasons 2017 and 2018.

No.	Local name	Habit	Scientific name
1	Um aag	Annual	*Digitaria adscendens*
2	Bano	Annual	*Eragrostis tremula*
3	Gaw	Perennial	*Aristida adscensionis*
4	Defra	Annual	*Echinocloa colonum*
5	Hasskaneet naeem	Perennial	*Cenchrus biflorus*
6	Sheleny	Annual	*Zornia glochidiata*
7	Danab Elkaleb	Annual	*Cynosurus echinatus*
8	Areg Elnar	Annual	*Tormentilla officinalis*
9	Umhemaro	Perennial	*Aristida mutabilis*
10	Um Dfufu	Annual	*Pennisetum pedicellatum*
11	Um Fesifesa	Annual	*Fimbrirtlis dychotoma*
12	Abu Asabea	Annual	*Dacteloctenium aegeptium*
13	Dresa	Annual	*Tribulus terrestris*
14	Lasag	Perennial	*Forsskaolea tenacissima*

[31] Stated that, annuals are able to survive under harsh condition because of their efficient utilization of moisture and the fact that they usually mature and shed their seeds well ahead of the incidence of soil moisture. [32] Stated that, occurrence of high number of annuals and short living species is often an indicator of site disturbance. [33] Following the assessment of Range Vegetation Composition within Kordofan special fund area concluded that the major factors causing eradication of perennial species are over-grazing, fire, and the seasonal short-run fluctuation in soil moisture. He concluded that causes of denudation of natural vegetation include drought, wind, flood, bush, fire and over-grazing. It was concluded that under the stress of harsh environmental sequences, annual herbs are the only species that are able to survive because of their efficient utilization of the available soil surface water moisture, and the fact that annuals usually mature and shed their seeds well ahead before the incidence of soil moisture stress and seasonal fires out-break.

C. Plant Frequency:

Results presented in table (3) show that in 2017 and 2018 *Aristida adscensionis* showed the highest relative frequency 72% and78% respectively, while Digitaria adscendens showed the second highest relative frequency in season 2017 with 64% and declined to record the third highest in season 2018 with 50%. *Eragrostis tremulla* stands as the third percentage in the relative frequency 63.5% in season 2017 and increase to be the second highest relative frequency percentage 77% in 2018. While the fourth highest relative frequency in 2017 was *Pennisetum pedicellatum 28.5%* and increased in 2018 to be 44%., (tables 3 and 4).

Table 3. Relative Species Frequency at Balila Area, West Kordofan State for the two Seasons 2017 and 2018

No.	Local name	Habit	Scientific name	2017	2018
1	Um aag	Annual	*Digitaria adscendens*	64.0	50.0
2	Bano	Annual	*Eragrostis tremula*	63.5	77
3	Gaw	perennial	*Aristida adscensionis*	72	78
4	Defra	annual	*Echinocloa colonum*	9	0
5	Hasskaneet naeem	perennial	*Cenchrus biflorus*	0.5	4
6	Sheleny	annual	*Zornia glochidiata*	20.8	2
7	Danab Elkaleb	annual	*Cynosurus echinatus*	4.5	0
8	Areg Elnar	annual	*Tormentilla officinalis*	17	0
9	Umhemaro	perennial	*Aristida mutabilis*	15.5	54
10	Um Dfufu	annual	*Pennisetum pedicellatum*	28.5	44
11	Um Fesifesa	annual	*Fimbrirtlis dychotoma*	15.5	0
12	Abu Asabea	annual	*Dacteloctenium aegeptium*	7.5	0
13	Dresa	annual	*Tribulus terrestris*	3	0
14	Lasag	perennial	*Forsskaolea tenacissima*	0	13

Table 4. The Four Dominant Species for the Two Seasons (2017, 2018).

Order	2017	2018
1	*Aristida adscensionis*	*Aristida adscensionis*
2	*Digitaria adscendens*	*Eragrostis tremulla*
3	*Eragrostis tremula*	*Aristida mutabilis*
4	*Pennisetum pedicellatum*	*Digitaria adscendens*

The fluctuations of the relative frequency of the different species may reflect the changes of species compositions that took place as a result of the intensive grazing which happened in the area as a result of oil operations.

[34] Stated that livestock grazing negatively affects the plants communities' then it's not grazed in right time. He also mentioned that early livestock grazing consumes the plants in earlier stages before seed setting and tends to reduce the forage production. Grazing removes the biomass aboveground production if maintained at high intensity for sufficiently long period grazing can lead to, shifts in species composition or volatilization loss of soil nutrients [35]. It also may be due to trees cutting that happened to the area as a result of oil explorations. This agreed with [36] Stated that, overgrazing and wood cutting by all measures in the principle cause of range degradation.

In 2017 the average vegetation cover was 30%, while it was 25% in 2018 (table 5). The reduction of vegetation cover from 30% in 2017 to 25% in 2018 may be due to man and animal activities.

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Table 5. Average Vegetation Cover/m^2 in Balila Area, West Kordofan State in the Late
Rainy Seasons 2017 and 2018

Season	%
2017	30
2018	25

[36] Stated that, over grazing is responsible for most of the desertification of rangelands. Cutting woody species for forage, fuel, charcoal production, or construction materials is the other major cause of rangeland deterioration.

D. Biomass Productivity:

In 2017 the biomass productivity showed 2.045 Ton/ha. Then it reduced to show 0.7034 Ton/ha in 2018.The reduction of biomass productivity from 2.045 in 2017 to 0.7034 in 2018 may attributed to overused of range resources and the environmental stress that took place as a result of oil operations in the area (table 6).

Table 6. Average Biomass Productively ton/ha at Balila Area
West Kordofan State in the Late Rainy Seasons 2017 and 2018.

Season	Ton/ha
2017	2.045
2018	0.7034

Similar observations were reported by [37] Mentioned that, in the base line survey of Kordofan and Darfur, the production and long term productivity of the herbaceous biomass have been consciously and constantly decreasing due to over used and environmental stress. The extent of yield depression varies considerably according to the environment and characteristics of the vegetation. For example in Xinjiang (northwest China) the grazing considered in balance with livestock population until the mid – 1970s, during the 1980s productivity was reported to have decreased by about 3% as livestock population become high, with the decline in grass yield in some areas reported to 50% to 60% [7]. Similarly in Balochitan (Pakistan), yield under excessive animal grazing have been estimated to be less than 30% of their botanical [38].

E. Carrying Capacity:

Research result show that in 2017 the carrying capacity was3.03 ha/AU/YR, while it was 1.5ha/AU/YR in 2018 (Table 7).

Table 7. Average Carrying Capacity Ha/Au/Yr

Year	Carrying capacity Ha/AU/YR
2017	3.03
2018	1.5

The variation in carrying capacity in the two seasons may be attributed to the intensive grazing practiced by the herders as a result of the decreasing of the wet season grazing sites which decreased as a result of oil exploration and production that leads to decreasing the vegetation cover in the wet season area. So, nomads enter the area with their animals before plants reach the full maturity stage, and this leads to the reduction of the growth in the coming years causing the degradation of the area, because the animals eat the plants before it produces the seeds. The same results were mentioned by [39] who stated that seed production is especially important to annuals, since it is the only way they reproduce. It has been shown that seed production in annual grasses can be greatly reduced by clipping, especially late in the growth season.

It is unlikely though that grazing can reduce seed production below the amount needed for production. The reduction of carrying capacity also may reflect multiple factors that can affect the carrying capacity. This agreed with [40] who mentioned that the carrying capacity in Gerih Elsarha scheme (western Sudan) in the year 76/77 increased for the reason of high rainfall and better rainfall distribution that led to better and more vigorous plant growth which increased the weight of plants and the scheme's carrying capacity. He also reported that in the period (77-84), although rainfall increased until it reached a maximum in season (79/80) yet the carrying capacity was decreasing. He attributed this phenomenon to overgrazing, uneven distribution of intensity of grazing due to the water points and the improper time of grazing that may occur in the wet season.

IV. Conclusions

The study has revealed that activities associated with oil exploration and production operation in Balila area have local impacts on the plants attributes. Most of the results indicated that, there is reduction in the available pastures, as a result of the reduction in the vegetation cover, biomass production and the range carrying capacity of the area. The study recommended that, further studies regarding the impacts of oil exploration and production on socio and environmental aspects should be done to identify the impacts of oil activities on the flora of the area.

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