Effects of Application of some Water Harvesting Techniques on Range Attributes in Abuelghor Area, North Kordofan, Sudan

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Abstract: This study was conducted on rangeland of Abuelghor area, Sheikan locality, North Kordofan State, Sudan with the objective of studying the effects of applying some rainwater harvesting techniques on range plants composition, frequency, density, and biomass production. Four plots were set for this purpose. The first one (I) was protected and left without applying any technique. The second one (II) was divided by straight line furrows against surface water runoff while the third plot (III) was covered with alternating crescent shape ditches and the fourth (IV) was divided into plots of 4^2 meters. Line transect method was used for range inventory in randomly selected sites. The experiment was set as a complete randomized design and the data was analyzed using analysis of variance, and the differences among means were detected with least significance test (LSD). The results indicated no significant ($\geq$0.05) differences among treatments in plant composition and frequency. Ground cover showed significant differences ($P \leq 0.05$) among treatment means where plot IV showed the highest ground cover followed by II and III that were similar in ground cover. Treat (I) had the lowest ground cover. The results of density were similar to the results as that were recorded for ground cover. Biomass was higher in treatment III and IV followed by treatment II while treatment I had the lowest biomass production. It was concluded that water harvesting could improve ground cover, density and biomass production with some techniques having greater effects than others. It is recommended that crescent shapes be used since their effects were similar to those in plot IV upon dividing rangeland into plots because it showed being lower cost in establishing it.

Keywords: *Rangeland Improvement, Rainwater Harvesting, Biomass Production.*

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I. INTRODUCTION

Sheikan locality where Abuelghor is situated, is within low rainfall savanna on sand, though the soil on the study site is sandy loam. The area is a main rainy season camping site for cattle owners coming from South Kordofan. Rangelands in this area are heavily and continuously grazed during the rainy season and slightly used during the dry period by the sedentary agro-pastoralists, who own small herds of goats, sheep, and cattle. In Sudan, rangelands face challenges including expansion of agriculture, climate changes, and overgrazing. Climate changes have caused alterations in species composition which has disturbed the ecosystem, while overgrazing has replaced palatable plant species with undesired ones. Human activities such as illicit cutting of trees, burning grasslands and agricultural practices in the area

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have made vegetation patchy and vulnerable leading to degradation of land (ARC, Agricultural Research Corporation,2002 Range and Aministration,2015). There is a need of prudent policies, restoration, and practices for protection of rangelands in Sudan. Due to communal use of the rangelands, it is overstocked and deteriorated being badly in need of rehabilitation and improvement. Methods conventionally used for improvement of degraded rangelands include grazing management, reseeding, fertilizers application, water points distribution, and water harvesting (Salih *et al.,* 2020; Abdelsalam, 2019). However, it has been suggested that the app;ication of water harvesting methods could help in improving the productivity of such undegraded rangelands.

Rangelands are uncultivated lands that are suitable of grazing and browsing animals, and considered the principal source of forage for livestock, (Getabalew and Alemneh, 2019). Rangelands all over the world are subjected to intensive use due to increasing animal and increasing human demands and high economic activities, which led to rangeland resource deterioration, (Salih *et al.,* 2020; Abdelsalam, 2019). The Sudan rangelands provide more than 80% of the total feed requirements of the national herd, in addition, protect the soil and watershed areas against erosion (Abusuwar, 2007). Despite of the importance of rangelands in Sudan, they suffer from several crises, the most significant of which are the fluctuations in rainfall rates, expansion of agriculture, seasonal fire and overgrazing.

➢ *The Objective of the Study*

The overall objective of this study was to examine means for restoring degraded rangelands for sustainable use of the resource. The specific objective is to evaluate effects of some rainwater harvesting in improvement of rangelands.

II. MATERIAL AND METHODS

➢ *The Study Area*

Sheikan locality is located at 13′ 58^0 37 N and 29′ 59^0 31 E) and Abuelghor lies about 15 km on the main tarmac road to Kosti. It is an important rainy season camping area. Determining range condition and recommending rehabilitation methods is vital to livestock producers in this site. The area is also livestock vaccination center and an important livestock seasonal market. The rangelands are continuously grazed that necessitates monitoring and grazing management as well as improvement through different techniques including water harvesting. The rainy season starts in June, reaches its peak in July and August and exends in October. The average rainfall is 250-450mm. During this period, the rangeland of this area provides grazing for pastoralists from South Kordofan who spend the rainy season here. The maximum temperature reaches 34.7^0 in summer and the minimum temperature is 19.9^0 in winter. The temperatures are modified by precipitation. The average daily temperatures reach lowest in January (13^0 C), and highest in April (40^0 C), (Eltahir 2009). The settled inhabitants are traditional farmers keeping small herds of goats, sheep , and cattle.

➢ *Setting Range Areas for the Experiment*

Four sites within the study area were selected and guarded before establishing the suggested three water harvesting techniques. The land preparation was done in May anticipating having rainy season in June. Annual precipitation measuring sets were fixed on each site.

➢ *Range Inventory*

Vegetation attributes samples were distributed systematically across line transects of 100m length distance tape. Parker loop method (Parker,1951) was used to determine ground cover. Quadrat of one square (M^2) was placed along transect at 10 m interval between each other for biomassproduction estimation, density, and frequency determination.

Four line transects (100m long) in each site were established for seasonal inventory. Along the line, range attributes were determined at each meter recording 100 observations. Ten quadrats were placed along each line transect at 10 meters interval for range inventory that was conducted in October for three seasons. Within the quadrat, ground cover was determined and biomass was harvested. The vegetation inventory was carried out in all sides of study area using quadrat and loop for determining range attributes. The range inventory was conducted by sampling in the four directions: northern, southern western, and eastern directions of each site, recording the points by using GPS.

The measurements were done to collect data on range attributes: (Plant% litter% bare soil%, species density and frequency and the biomass yield (g\m2). Carrying capacity plant composition were determined.

➢ *Statistical Analysis*

Data on ground cover, plant composition, density and biomass production as well as carrying capacity were treated as complete randomized design and analyzed via analysis of variance. Differences among treatments means were detected using least significant difference test (LSD).

III. RESULTS AND DISCUSSIONS

➢ *Range Attributes as Affected by Type of Water Harvesting Technique*

The results of plant composition as affected by type of technique is presented in Table (). No significant differences ($P \geq 0.05$) were recorded that could be attributed to techniques applied., the values that were scored in techniques I, II, III and IV were 66.25% and 58.5%, 69.35% and 70.21%, respectively. The similarity in this attribute many be due to protection and deferment of grazing during the study period. According to Khatir and Jadalla, (2014) deferment of grazing by domestic livestock has been considered as a main factor affecting plant composition. Grazing changes vegetation composition as a result, some species increase in abundance and others decrease. The plant composition is changing continuously in space and time due to some factors, such as grazing, fire, and rainfall which differ in intensity, duration, and timing, this agreed with Le Houèrou, and Hoste, (1977) who reported that the mentioned factors affected plant

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composition. Litter % is shown in table (1) and it was also similar since animals were prevented from grazing. The slightly low litter percentage in techniques III and IV may be due to their nature in keeping the soil with high water holding capacity than I and II which resulted in high vegetation cover increasing plant vigor. Shasha, ((2001). reported that litter in a rangeland is a function of forage growth, senescence, harvest and decomposition. It may be also due to both the continuous grazing of the available sparse vegetation and the redistribution of litter by wind and water. O'Connor,(1991) and OCHA, (2013) reported that the standing and fallen litter mass generally decrease with increased absence of grazing. The results of this study are in close agreement with the findings of Parker, (1951) who observed that standing and falling litter mass generally decreased while amount of bare soil increased with increasing grazing intensity.

$$\text{Biomass production kg/hectare} = \frac{\text{biomass/quadrateX10000}}{1000}$$

$$\text{Carrying capacity} = \frac{\text{biomas/hectare}}{10\text{X}30\text{X}8} \quad \text{animal unit per hectare}$$

➢ *Density*

Quadrat frames are used for measuring density of sample plots. Whether you will use the quadrat frame method or the string-and-stakes method to establish sample plots, either choose the sample plots randomly throughout the study area or create a grid over the study area and place a sample plot in one corner of each grid unit.

$$\text{Density} = \frac{\text{Total of plant count}}{\text{Area of quadrat}}$$

Results of plant density of the different techniques are shown in Table (2). The average plant density was 88.63, 89.75, 90.13 and 93.11 plants/m^2 for techniques I.II, III and IV, respectively. The increased vegetation density in some techniques may be attributed to the effects of the technique in increasing soil moisture that improved plants germination and growth. Rebeca, *et al*.,(2011) mentioned that plant vigor and density is the result of several factors most important of which is soil moisture content. The activities such as heavy grazing might affect density, but the treatments were protected from grazing. Results of density of the most dominant species were presented in Table (1), *Eragrostis sp* scored the highest density while *Echinocloa colonum* scored the lowest density at different periods. The variation in species density may be attributed to previous situation of the study site and had nothing to do with the techniques used. RPA, (2011.) reported that species could be changed only upon heavy grazing.

➢ *Biomass production and carrying capacity*

The forage biomass production as affected by type of water harvesting technique is presented in Table (). Biomass was estimated being 75, 81, 88, and 90g/m^2 for techniques I, II, III and IV, respectively as an average for the three seasons. This has been the main objective for this study. Technique III and IV had higher biomass production than techniques I and II. This superiority in dry matter production for two techniques may be attributed to their ability to harvest and catch water efficiently leading to higher soil moisture for optimum growth while techniques I and II had higher surface runoff. The carrying capacity, CC, of the experimental range plots showed that techniques III and IV had better values of carrying capacity that II and the control plot showed the lowest carrying capacity. The values obtained for CC were 3.19, 2.94, 2.78 and 2.67 hectare/animal unit per year. Results of this study are similar to of Stoddart, *et al.,* (1975) who indicated that with adequate protection and controlled surface runoff, the forage yield on the rangeland practically doubled in about 3 to 5 years. So, increased soil moisture on rangeland and protection of some areas, application of fertilizer, reseeding with the adapted and palatable grasses and legumes can be applied to increase plant density and biomass production of the protected areas. The utilization of the appropriate rainwater harvesting technique and utilization of supplementary feeds to decrease the pressure on the over grazed areas proved to have similar effects.

➢ *Vegetation Cover*

Result of ground cover percentages as affected by some rainwater harvesting techniques are presented in Table (4). The ground cover was 51.96%, 55.12% , 65.45% and 67.44% in techniques of I, II, III and IV, respectively. Soil moisture content proved being the most important factor that influenced the rangeland particularly the vegetation cover in areas subjected to overgrazing. The vegetation in the study area suffers from high population of livestock that exceeds the carrying capacity of the area.

➢ *Frequency*

Plant species frequency in the study and affected by type of water harvesting technique is presented in table (1). The results indicated no significant difference($P \geq 0.05$) observed in species frequency. However, grasses like *Cenchrus biflorus, Aristida pallida, Chlorus gayana* and forbs as *Zornia glochidiata, Merrimia emarginata, Cassia occidentales* and *Cassia obutiflolia* had scored nonsignificantly higher frequency on techniques III and IV. Increasing soil moisture via water harvesting has nothing to do with species frequency in short term. Since the area is protected and deferred from grazing no change is expected in composition or frequency. The study area was dominated by different species as indicated before but that made no differences in species frequency

$$\text{Frequency\%} = \frac{\text{The number of quadrats containing the species X 100}}{\text{Total number of quadrats}}$$

IV. CONCLUSIONS

Since the study area is a rainy season camping site for pastoral groups, their pattern of communal grazing initiated degradation of the rangeland. Range improvement is badly needed. There are several methods that are recommended for range improvement. Rainwater harvesting is an important and even sometimes complementary in improving rangelands. From the results of this study it is concluded that rainwater harvesting, irrespective of type of technique used could increase vegetation ground cover, density, and biomass production. This in turn increased carrying capacity. There

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have been differences among types of techniques applied. It was found that building basin shaped and dividing range into ditches had greater effects that establishing furrows against surface water runoff.

V. RECOMMENDATIONS

It is recommended that more studies be carried out to study effects of other rainwater harvesting techniques on range improvement. Using rainwater harvesting techniques under grazing conditions is also needed. Combining water harvesting together with reseeding and fertilization is worth examining**.**

Table (1). Species Frequency as Affected by Type of Water Harvesting Technique

Botanical name	I	**II**	**III**	**IV**	**SE**
Aristida pallida	**76**	78	81	83	+ 2.24
Cassia obtusifolia	**75**	70	74	76	+3.56
Cassia occidentales	70	75	79	80	+1.25
Chloris gayana	43	46	11	13	+2.25
Commicarpus africanus	65	66	78	80	+4.24
Dactyloctenium aegyptium	45	55	65	66	+2.24
Datura stramonium	45	51	35	36	+2.24
Echinocloa colonum	13	16	25	29	+5.31
Eragrostis tremula.	25	34	55	65	+3.27
Merrimia emarginata	11	13	14	15	+2.33
Schoenefeldia gracilis	10	12	23	25	+3.24
Sida cordifolia	41	45	47	49	+1.45
Solanum dubium	35	38	45	51	+2.14

Table (2). Range Attributes as Affected by Type of Water Harvesting Technique

Attributes	**I**	**II**	**III**	**IV**	**SE**
Ground cover	78.45	88.34	93.32	95.56	+2.24
frequency	92.36	95.43	97.47	98.49	+2.24
Density	51.96	55.12	65.45	51.96	+5.31
% Plant	77.33	86.15	92.16	95.36	+3.27
Litter	11.25	13.33	15.25	16.56	+2.24
Biomass production	75.26	81.88	89.88	90.25	+2.24
Carrying capacity	3.19	2.94	2.78	2.67	+5.31

REFERENCES

[1]. Musa, A. Shasha, (2001). African green belt. Republic of Sudan.
[2]. Abdelrahim O Abdelrahim, Nancy I Abdalla(). Assessment of rangelands in semi-arid areas of Sudan - south kordofan state (eldebeibat area), ARPN journal of science and technology. 2015; 5(2): 117-124.
[3]. Abdelsalam, M. I., 2019. Effect of Cultivation Practices on Al-Safari (Crotalaria senegalensis) for Domestication as Forage Plant. SUST Journal of Agricultural and Veterinary Sciences (SJAVS). (20) 2. 101-107
[4]. ARC, (Agricultural Research Corporation). Annual report of range and forage research program, zalingie research station, zalingei, Sudan. Aug 2015.
[5]. Le Houèrou, H.N. and C.H. Hoste, 1977. Rangeland Production and Annual Rainfall Relations in the Mediterranean Basin and In the African Sahelian and Sudanian Zones. Journal Of Range Management, 30: 181-189.
[6]. O'Connor, T.G. 1991. Influence of rainfall and grazing on the compositional change of the herbaceous layer of a sandveld savanna. J. Grassl. Soc. South Africa 8:103–109.
[7]. OCHA, 2013. United Nations Office for the Coordination of Humanitarian Affairs. March 14 2013, 2:21.34 PM. http://www.unocha.org/sudan/mapsgraphics/administrative-maps
[8]. Parker, K. W. (1951). A method for measuring trend range condition on national forest range. Administrative studies, U. S. Department of Agriculture, forest service, Washington, D. C. 26 pp.
[9]. Rebeca, V. M. Eusebio, V. R. Klavdia, O. Luis, H. S. and Miguel, A. D (2011). Soil Erosion Processes in Semi arid Areas: The Importance of Native Vegetation. Soil Erosion Studies. Edited by Dr. Danilo Godone. ISBN 978-953-307-710-9.
[10]. RPA, 2011. Range and Pasture Administration, 2011. The situation of fodder source in Sudan. Range and Pasture P.O Box 2513. Sudan.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr1245

[11]. Salih, E. M, Nimir, O. A, Kobbail, A. A, Elkhalifa, A. A, Abdelsalam, M. I and Lazim, A. M. M., 2020. Performance of Some Selected Forage Plant Species in Sandy Loam Soil at Esunnot Area of Western Kordofan State, Sudan. International Journal of Multidisciplinary Research and Publications (IJMRAP), 3 (5), 1- 4
[12]. Stoddart, L. A., D. Smith, and Box, T. W. Box, (1975). Range Management. 3rd Ed, Mc Graw – Hill Book Company, Inc, NY
[13]. ARC, Agricultural Research (Corporation,2014).Range biodiversity and Rangelands of Sudan, ARC Sudan (presented by Fatima Sadig Almahadi in a workshop)
[14]. Range and Aministration, in Kordofan (2015). Annual range inventory and determination feed banalce of North Kordofan state. Ministry of Production and Economic resources