Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.12, No.5, 2022 www.iiste.org

Impacts of Climatic Factors on Vegetation Species Diversity, Herbaceous Biomass in Borana, Southern Ethiopia

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Abstract
The study was conducted in three districts of Borana Zone, with the objective to determining the impacts of climatic factors on vegetation species diversity, herbaceous biomass yield of Borana rangelands under commonial grazing rangeland types during end of growing season. The most types rangeland of communial properties are traditional enclosure and continuous grazing rangeland from in where our different data were collected. Within both rangeland types of each districts 20 m x 20 m plots that placed at 200 m distances intervals with three replication was used to collect woody vegetation. The data of herbaceous plant community was collected from seventeen quadrants (1 m x1 m) that layout in the main plot. The collected data was analyzed by linear regression to determine the impact of climate factors. The herbaceous species richness, diversity and biomass study sites had highly significantly difference ($P < 0.001$) and positive linear with mean annual precipitation. There is significantly difference ($P < 0.05$) and negative linear in woody species richness and diversity. Both herbaceous and woody plant species richness and diversity of study areas had a negative linear with mean annual temperature. Climate factors specieally rianfall have a great impact on rangeland ecosystems of study areas. Therefore, rangeland user should be considering climatic factors to improve productivity of rangeland.
Keywords: Rangeland types, Species diversity and richness, herbaceous biomass and rainfall
DOI: 10.7176/JEES/12-5-01
Publication date: May 31st 2022

1. INTRODUCTION

In the world, rangeland is taking place the largest total land mass as compared to other types of terrestrial (Holechek, *et al*., 2001) while in threat due to impacts of climatic factors. Since climatic change encourage reduction of rangeland productivity through increasing frequency and intensity of floods and droughts, and loss of many biodiversity. In arid zone, climate event especially rainfall have a greater impact on rangeland productivity than grazing (Oba *et al*., 2000a, b).

In Ethiopia nation of Oromia regional rangeland, Borana rangeland is the largest and have many renewable natural resources/ecosystem while they were vernaruble to climate variability. Bassi and Tache (2008) stated that pastoral production system in Borana rangeland depends on the availability of range resources that depend on seasonal variability. Now days rate of rangeland resource degradation increase even many research institutions and development organizations and idividuals had been involved to solve several problems. Environmental circumstances and management practices are playing a crucial role in describing the function and distribution of rangeland vegetation species because they are governed the nature and productivity of rangeland ecosystems (Dadamouny, 2015). Hoffman and Vogel (2008) reported that climate factors such as rainfall, temperature, and atmospheric carbon dioxide concentration are the main factors to alter rangeland resource productivity in terms of qualitative and quantitative outputs. So understanding of vegetation response to climatic factors is crucial to facilitate the manipulation of arid and semi-arid regions of natural resource conservation for sustainable use (Hoshino, *et al*., 2009).

Nevertheless, the effort made so far was not satisfactory and the community who intensively depend on Borana rangelands have been vulnerable to a serious livestock feed shortage which resulted due to gradual replacement of highly desirable species by less desirables species. Thus studies are necessary to investigate the response of rangeland vegetation to climatic factors, especially in arid and semi-arid regions of ecosystem. As a result, further study and understanding of the interrelationships of rangeland ecosystems related to climatic factors are the most important tools to approve appropriate management measures in rangeland areas. While, its had less consideration in study areas during rangeland administration and utilization of rangeland resources. Hence, this study designed to generate information with the general objective of evaluating the current species diversity and herbaceous biomass under traditional enclosures and continuously grazed rangelands in relation to climatic factors to develop mitigation and adaptation strategies in Borana rangelands, southern Ethiopia.

Specific objectives

- To assess the effect of climatic factors on species diversity and herbaceous biomass of the rangelands in selected districts of Borana zone.

2. MATERIAL and METHODS

2.1. Description of the Study Area

The study was conducted at Yabello, Arero and Teltele districts of Borana zone, Southern Ethiopia. Yabello is located at a distance of 563 km from Addis Ababa in the southern part of Ethiopia. Arero and Teltele are located at equidistant (100 km), each to east and west of Yabello town respectively.

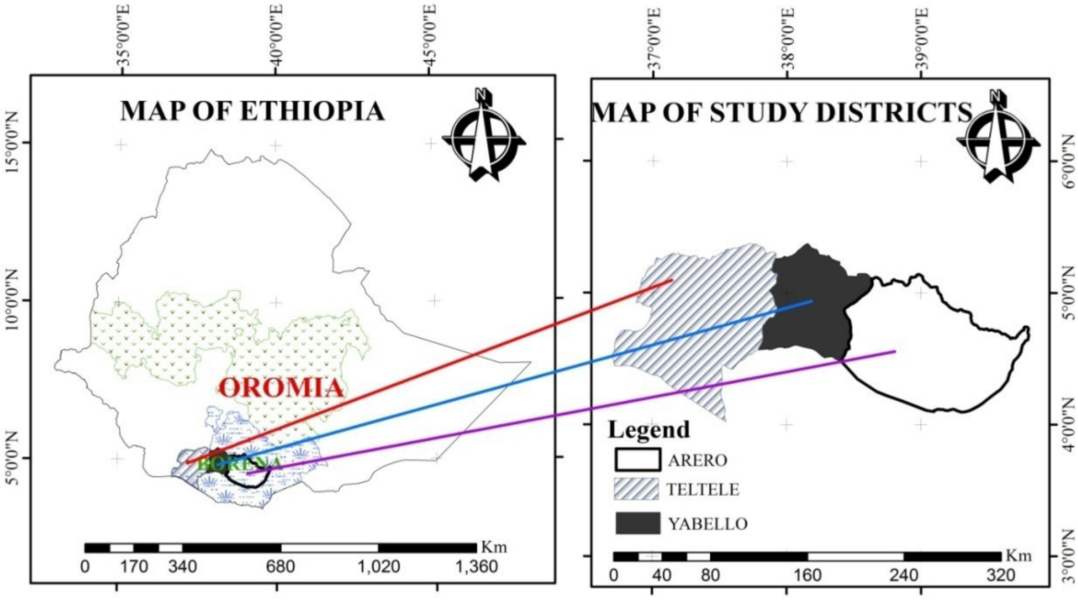

Figure 1: Map descriptions of Study Areas

2.2. Climate features

2.2.1. Rainfall

The climate of study areas has bimodal nature of rainfall namely long (60 %) and short (27 %) intensity rain season which falling between March and May and falling between September and November respectively with 16.80 °C of the minimum and 29.08 °C of the maximum annual mean temperature . The current 17 years (2001 to 2017) rainfall of study areas of growing season (main and short rainy season) that collected by the National Meteorological Services Agency of Ethiopia were highlighted in Table 1. At all study sites, the growing season rainfall of 2016 was lower than the mean growing season rainfall of 2001-2017, but in 2017 it was approximately the same as total average growing season rainfall (2001-2017). This result reflected that there was variability in mean growing season of rainfall between 2016 and 2017 because of drought outbreak in Borana Zone in 2016 that had a nagegetive impact on rangeland ecosystem.

Table 1: Monthly rainfall (mm) during the growing season (main and short rain season) at Arero, Teltele and Yabello site

Element	Year	Long rainy season			Short rainy season			Sum of two rainy season
		Mar.	Apr.	May	Sep.	Oct.	Nov.	
Arero	**2001-17**	**47.51**	**175.74**	**109.91**	**25.48**	**113.13**	**74.22**	**545.98**
	2016	56.20	103.20	56.60	5.00	0.00	0.00	221.00
	2017	15.00	142.30	312.60	40.50	63.20	5.60	579.20
Teltele	**2001-17**	**85.47**	**165.34**	**113.46**	**41.04**	**92.88**	**62.22**	**560.40**
	2016	40.90	84.80	55.50	4.00	0.00	0.00	185.20
	2017	91.80	214.60	59.00	33.30	119.20	0.80	518.70
Yabello	**2001-17**	**53.25**	**158.71**	**98.05**	**20.32**	**102.92**	**63.57**	**496.83**
	2016	50.90	97.50	69.30	0.00	0.00	0.00	217.70
	2017	20.00	304.50	57.30	22.20	124.60	0.00	528.60

Source: National Meteorological Agency of Ethiopia (NMAE)

2.2.2. Temperature

Temperature is other climatic factor that affects the productivity of rangeland biodiversity. The maximum and minimum mean temperatures of 17 years (2001-2017) were taken from the nearest station at Yabello and Teltele sites while temperature data was not registered at Arero site. The monthly mean temperature of growing season that showed in table 2 was not significant differences between study years and sites and as well as the total means of 2001-2017 years while higher mean temperature value was recored in Teltele site.

Table 2: Monthly mean temperature during the growing season (main and short rain season) at Arero, Teltele and Yabello site

Disrict		Mar	Apr	May	Sep	Oct	Nov	Average
Teltele	**2001-17**	**25.02**	**22.90**	**22.42**	**22.53**	**22.83**	**22.63**	**22.93**
	2016	26.00	23.25	22.85	23.55	23.25	24.00	23.70
	2017	22.60	21.95	23.00	21.90	22.15	19.55	21.83
Yabello	**2001-17**	**22.24**	**21.18**	**20.23**	**20.72**	**20.52**	**20.29**	**20.30**
	2016	21.60	21.60	19.70	20.55	21.00	22.00	20.81
	2017	21.50	20.40	19.60	20.20	20.50	19.70	19.90

Source: National Meteorological Agency of Ethiopia (NMAE)

2.3. Sampling Techniques

After discussion held with elders and pastoralists leader of peasant association, traditional enclosure rangeland type that has the same age of enclosing period was selected side by side with continuous grazing rangeland types. Then three main plots each measuring 20 m x 20 m at every 200 m interval on a leaner transect was used for each rangeland types (Gemedo, 2004). Woody vegetation density, richness, and diversity of the rangelands types were determined from this all main plots. The attributes samples of grass and forbs species samples were collected from seventeen subplots of 1 m x 1 m, placed in diagonal and central line at equal interval within the main plots. Samples of the 17 subplots pooled to represent the herbaceous species of a main plot inoder to determine herbaceous species biomass, diversity, and richness. The total standing herbaceous species (grass and non-grass) biomass was clipped at 2 cm above ground of subplots, oven dried at 105 ^{o}c for 24 hours and weighed by sensitive balance in Yabello Pastoral and Dry land Agriculture Research Center of soil laboratory to determine the dry matter yield of herbages (Whelly and Hardy, 2000). Overall, 18 main sampling plot (20 m x 20 m) and 306 sub-quadrants (1 m x 1 m) were established to collect the required data in study districts. To recognize the appropriate location of sampling, GPS (Global Positioning System) was used to locate the right altitude, latitude, and longitude of each sample sites.

2.4. Data Analyses

Plant diversity and richness, of the rangeland types analyzed using PAST version 3.10, Paleontological Statistical software (Hammer *et. Al*, 2001). To examine the impacts of climatic factors on plant species, we accomplished the relationship between annual rainfall and mean annual temperature of studay site with plant species attributes by using linear regression. All statistical analysis were performed within SAS software (version 9.1; SAS Institute, 2002). LSD (least significant differences) test with $P<0.05$ was used for means comparison.

3. RESULTS and DISCUSSION

3.1. Effect of Climate Factors on Rangeland

3.1.1. Effect of rainfall on plant species richness

The result revealed that mean annual rainfall was an important factor that was altering the plant species richness. On present study, the variation in herbaceous species richness of study sites was highly significant difference ($r^2 = 0.56$, P = *0.0003)* with positive linear relationship to mean annual rainfall and woody species richness was significant different ($r^2 = 0.31$, P = *0.02)* with negative linear relationship (Figure 2). The retention of soil moisture that available for plant growth is higher in where receiving high amount of rainfall than low amount of rainfall. This

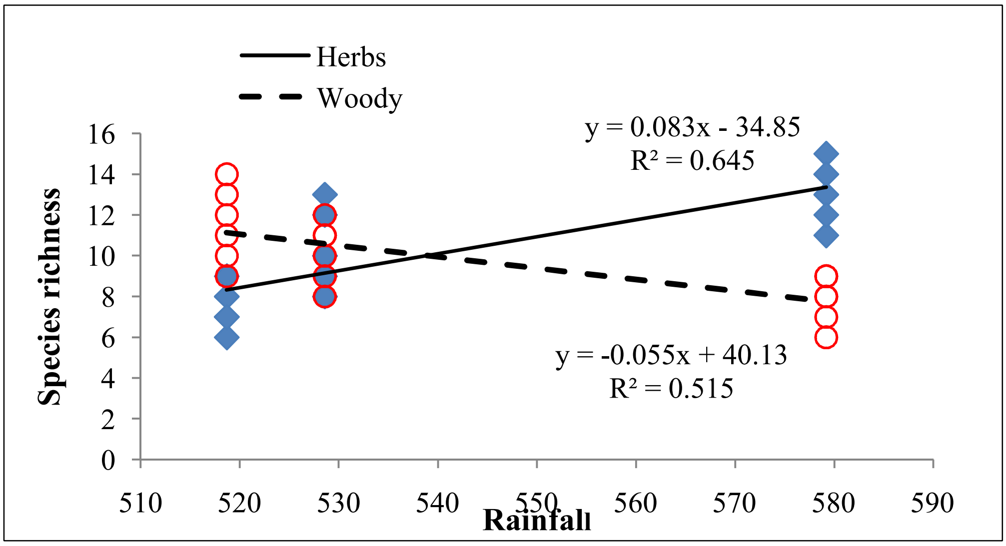

Figure 2: The relationship between plant species richness and mean rainfall of study areas.

indicates that the herbaceous species richness was increased as increased rainfall while woody species richness was less sensitive to short periods of moisture stress. Therefore, the propagation of dormant perennial stems and germination seed of perennial and annual species can increase herbaceous richness during available rainy season than shortage rainy season.

The reduction rainfall in amount and the increment of erratic nature of rainfall in the study areas has a great impact on herbaceous richness. This result agree with Stokes *et al.* (2008) who found that changes in the temporal distribution of rainfall may reduce the effectiveness of rainfall through increased variation within season (fewer, more intense rainfall events) and from year to year (more frequent drought). Zaman (1997) and Habtamu *et al.*, (2013) also reported that the drought increase the rate of natural died of plant root, while only health vigorous perennial grass less damage and maintain production and recover quickly on rainfall occurs.

3.1.2. Effect of rainfall on plant species diversity

In semiarid environment, water availability is the main factor on dynamics species diversity of rangeland. As result indicated, the herbaceous species diversity study area was highly significant difference *(r= 0.62, P = 0.0001)* with positive linear relationship to mean annual rainfall while woody species diversity was significant difference *(r= 0.39, P = 0.005)* with negative linear relationship in Figure 3. The herbaceous species diversity was increased as rainfall amount increased due to reduce in soil moisture stress at soil surface areas that was able to use by herbaceous species root for synthesis their food. Woody species diversity was increased, as rainfall amount decreased due to it is able to utilize ground water from deep soil by their root tapes. This specifies that herbaceous species diversity be highly affected by mean annual rainfall than woody species diversity.

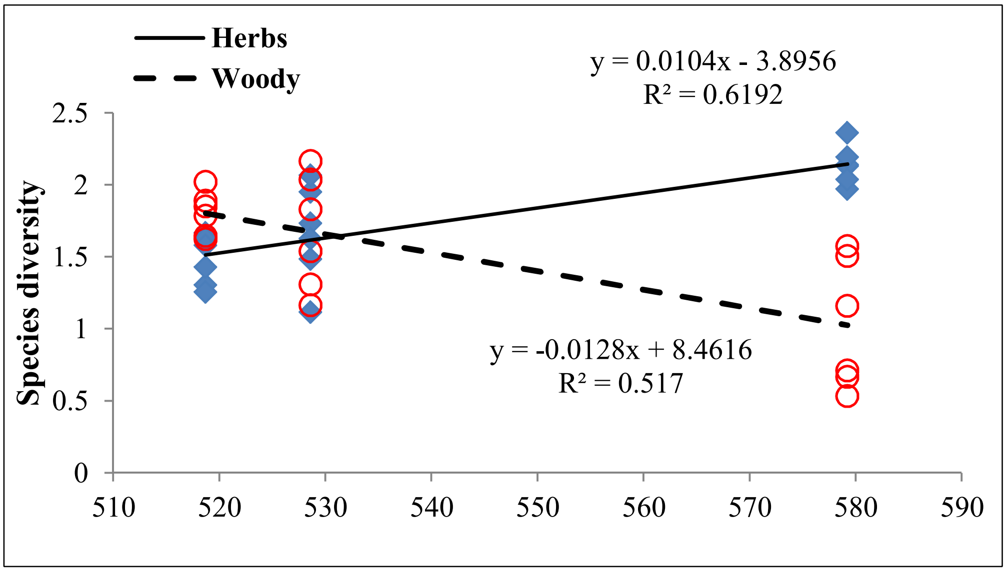

Figure 3: The relationship between plant species diversity and annual rainfall of study area

From this study, the most effective of climatic factor that threatened production of herbaceous species of the study sites were the mean annual rainfall of growing season. Because the time, frequency and amount of mean annual rainfall of study areas is determine the achievement of herbaceous species production. During study, the late onset and uneven distributed of rainfall pattern during growing season may reduce herbaceous species regeneration than woody species. However, the herbaceous species diversity of both rangeland types were lower due to prolonged of dry periods in 2016 that affect the photosynthetic process of herbaceous species in both active and passive of growing season of the plants.

3.1.3. Effect of rainfall on dry matter of herbaceous species

The relationship between herbaceous species productivity with water availability is highly sensitive in semi-arid environments. The result shown that the variation in herbaceous species biomass at each site was significantly difference *(r^2 = 0.79, p =0.017)* with positive linear relationship to mean annual precipitation. This positive linear relationship reflect that a higher biomass in higher amount of mean rainfall of growing season (Figure 4). Since the herbaceous species biomass yield per hector increased from as increased mean annual rainfall. Similarly, Dingaan *et al*. (2016) reported that trend of aboveground biomass increase with increase rainfall. In study site, the herbaceous species biomass production of rangeland type was lower than pervious find due to growth preformances of herbaceous species were influenced during and after drought outbreak. Because during drought year, the annual herbaceous species was disappeared and some perennial herbaceous species was overgrazed and even dried that weakly recovery after drought was observed. This agreement with Cheng *et al*. (2011) reported that annual species was disappeared during drought year and Stokes *et al*. (2008) confirmed that after drought breaks, total forage production might be lower than normal due to less plant per unit areas.

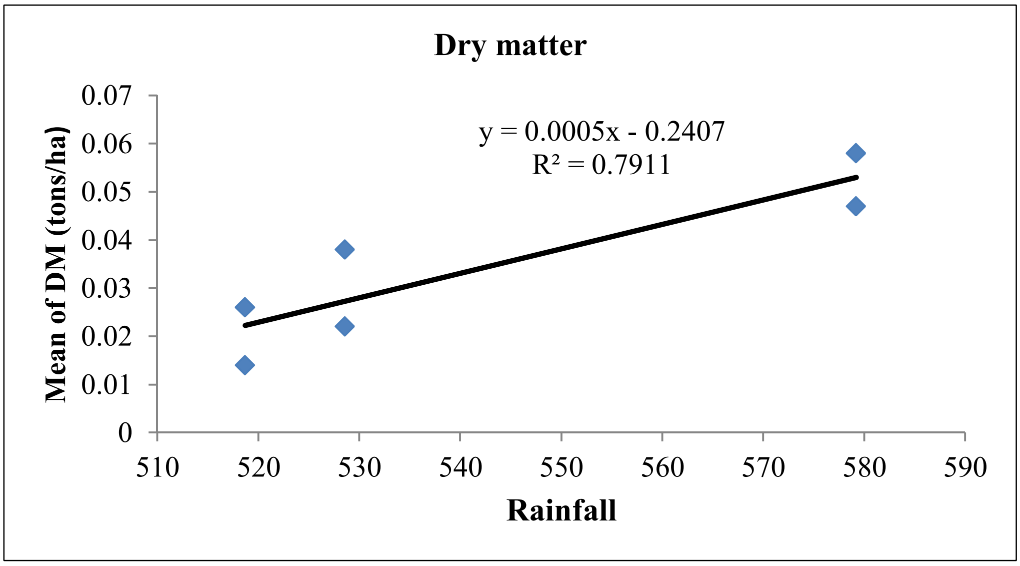

Figure 4: The relationship between herbaceous biomass and annual rainfall of study areas

3.1.4. Effect of temperature on species richness and diversity

The result showed that the mean annual temperature is other climatic factor that was important on dynamics of botanical composition of rangeland. On present study, the variation in herbaceous species richness of study sites was high significantly difference (r2 = 0.67, P = 0.001) with negative linear relationship to mean annual temperature and woody species richness was significant difference (*r2 = 0.44, P = 0.02*) with negative linear relationship due seldom species regeneration in dry season. Herbaceous species diversity was significantly difference (*r2 = 0.65, P = 0.001*) with negative linear relationship to mean annual temperature and woody species diversity was no significant difference (*r2 = 0.50, P = 0.55)* with negative linear relationship because woody species of study area had root tap system that encouraging less sensitive to temperature (Figure 5).

In addition, the biomass yield of herbaceous plant species of study areas was not significant difference (r2 = *0.34*, P = *0.41*) with negative linear relationship with mean annual temperature. This indicates that herbaceous species dry matter was decreased as raised mean annual temperature due to wilting and dried occurs while the mean annual temperature was equally affect the biomass yield of study site because no variation in mean annual temperature between

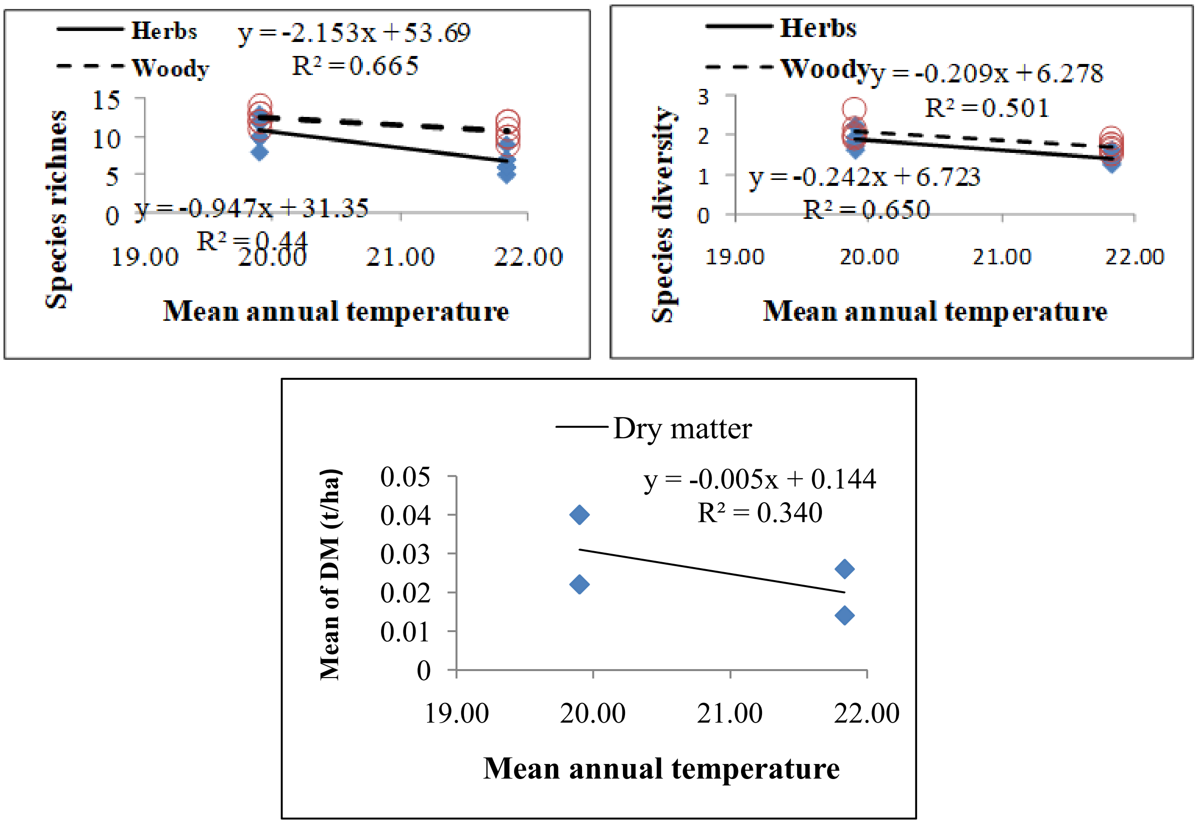

Figure 5: The relationship between plant species richness and diversity and mean annual temperature.

sites and years. This result agree with Stokes *et al*., (2008) who reported that in warmer climates, increase heat stress and increase evaporation demand would likely have negative effect on pasture. Similarly, Neil *et al.* (2009) reported that evaporation raises the rate of soil salinity and reduces volatile soil nutrient and wilting and dried less drought tolerant of vegetation, which enhances the reduction rangeland production. The air temperature of Teltele site is warmer than Yabello study areas, which lead to high evaporation rate on available water that might have higher impact on plant species diversity, richness and biomass yield. Similarly, Coppock (1994) reported that compared to rainfall, air temperatures vary much less throughout the year in most of sub-Saharan Africa, while warmer climates increases evaporation that effects on production and distribution of plant species. In other hand, Stokes *et al*. (2008) also reported that the condition of climate become hotter and drier, pasture composition is shift to more xeric species that may be less suitable to grazing.

4. CONCLUSIONS and RECOMMENDATIONS

Climatic factors special rainfall is the main factor, which was altering botanical composition of Borana rangeland. As recent study, the annual rainfall was positive relationships with plant species diversity, richness and groundcover of rangeland types. However, mean annual temperature of study sites was negatively relationships with plant species diversity, richness and groundcover of rangeland types. The increasing year-to-year variability of rainfall at the study site was altering the production of rangeland. Additionally, rangeland of study sites had been degraded in terms of botanical composition as the result of decreased in palatable herbaceous species due to increase recurrent drought rangeland exposure for heavy grazing. Therfore, pastoralist and agropastolist should be considered and identified avialibility of rainfall ethier for management of rangeland or conservation of excess feed resources for dry period. However, further study across socio-economic factors should be investigated to capture the whole impact of rangeland ecosystem dynamics for sustainable management. Hence, loose of respective culture value, pastoralist knowelage and pattren of livehoods may be educe dagradation of rangeland ecosystems through exposuring rangeland for improper settlement, grazing and cultivation.

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