African Journal of Basic & Applied Sciences 8 (4): 220-231, 2016
ISSN 2079-2034

DOI: 10.5829/idosi.ajbas.2016.220.231

Condition, Species Composition and Productivity of Natural Pastures of Benishangul-Gumuz Regional State, Western Ethiopia

[1]*Alemayehu Abebe* and [2]*Woldegebriel Tesfamariam*

[1]Ethiopian Institute of Agricultural Research,
Assosa Agricultural Research Center, P.O.Box 265, Assosa, Ethiopia
[2]Ethioipian Institute of Agricultural Research, Pastoral, Agro-pastoral and Emerging Regions,
Research and Capacity Building, P.O. Box 2003, Addis Ababa, Ethiopia

Abstract: This study was conducted in Assosa, Maokomo and Kamash districts located in Benishangul- Gumuz region to assess natural pastures condition, to determine dry matter biomass yields of herbaceous species and factors causing natural pastures deterioration thereby recommending possible improvement options. The study districts were chosen primarily based on their altitude and in each district main sampling sites were selected randomly as study sites. Then each sampling sites were further stratified as communal grazing lands and enclosed areas. Dry matter biomass, density of woody plants and bare ground cover were determined in 45 plots of 500m^2, whereas condition assessment and frequency of herbaceous species were done in 225 subplots of 0.25m^2. Data collected were analyzed in descriptive statistics, correlation and General Linear Model procedures using SPSS computer software. A total of 52 herbaceous species were recorded in the study areas. Out of these, 25 (48.1%) were grasses, 6 (11.5%) were legumes, 21 (40.4%) were sedges and forbs. Based on their forage value, 9 (17.3%) were highly desirable, 10 (19.2%) were desirable, 24 (46.2%) were less desirable and 9 (17.3%) were undesirable. The mean dry matter biomass yield of the natural pastures was 2219 kgha^{-1}and it was significantly affected by locations and grazing types. In overall, natural pastures of the region were under fair condition indicating that it's in transitional state from desirable to less desirable. Thus, it was recommended to apply some rehabilitation techniques, especially for communal grazing lands, like over sowing of desirable grass species and proper stocking techniques.

Key words: Frequency · Grazing capacity · Pasture condition · Rehabilitation techniques

INTRODUCTION

Natural pasture and crop residues are the main feed resources of livestock production in Ethiopia. It was estimated that 80-85% of livestock feed in Ethiopia comes from natural pastures [1]. Besides, trees and shrubs play a significant role in arid areas with moisture constraint. Livestock production using natural pastures has a significant contribution to the overall national gross domestic product (GDP) in developing countries [2]. In Ethiopia, majority of livestock and grazing lands exist in lowland areas. The areas comprise about 62% of the country's land area in which most of them are below 1500 meters above sea level [3]. They comprise 12% of human and 26% of the livestock population [4]. In these areas, grazing is the predominant feeding system where communal grazing is normal and managed as a common property resource [5, 6].

However, the availability and quality of forages from natural pastures are not favorable year round. Thus, the gains made in the wet season are totally or partially lost in dry season [7]. As a result, feed shortage during dry season leads to decline in livestock productivity and sometimes it can end up in livestock mortality. Moreover, studies show that the natural grazing lands of the country are being deteriorated from time to time both in quantity and in quality [8, 9]. The major factors that are causing deterioration include; low and erratic rainfall, wind, soil erosion, bush encroachment, invasive weeds, overstocking and lack/inadequacy of some other proper

Corresponding Author: Alemayehu Abebe, Ethiopian Institute of Agricultural Research, Assosa Agricultural Research Center, P.O.Box 265, Assosa, Ethiopia.

grazing land management practices. Besides, climate change, increasing population and associated changes in land use/land cover are among the critical challenges facing natural pastures.

Range condition is "the state of health and vigor of a range in relation to its full productive potential." It measures degree of range deterioration and improvement [10]. It also used as a guide to ensure sustainable land use, to determine carrying capacity and adjust stocking rates, to identify potential responses to range management programs such as bush control or re-seeding and to evaluate the best locations of fences and water facilities to improve utilization within pasture. Range condition can be excellent, good, fair or poor evaluating the state of range against a certain standard. Excellent and good conditions are desirable, whereas the fair condition is transitional between the desirable and the undesirable states [11].

Optimum productivity and sustainable use of natural pastures are maintained in the future if and only if there is knowledge about the current condition, but base-line information is inadequate in Ethiopia and it is hindering the development of natural pastures [12, 13]. In Benishangul-Gumuz Regional State where this study was conducted, natural pasture is important source of livestock feed. However, there is no information regarding natural pasture condition, productivity, trends and management practices. Therefore, this study was done to assess natural pastures condition, determine dry matter biomass yields of herbaceous species and determine factors causing natural pastures deterioration and thereby recommending possible improvement options.

MATERIALS AND METHODS

Study Area and Sampling Sites Selection: Benshangu-Gumuz Regional State is located in the western end of the country located between geographical coordinates of 9°30'N to 11° 39'N latitude and 34°20'E to 36° 30'E longitude with a total land area of 50 thousand square kilometer. The region is composed of different land features, dominantly of plain lowlands. Rainfall is uni-modal and occurs for 6 to 7 months of the year usually between April and October. The mean annual rainfall is about 1275mm. The region exhibits both mild and hot temperatures. Minimum and maximum temperature of the region varies between 14°C and 20°C and 25°C to 39°C, respectively. Major soil types include: dystric nitsol, orthic acrisols, chromic and orthic luvisols and chromic and eutric fluvisols. Woodlands and shrubs are dominant forest resources covering 77% of the region. Grasslands cover 3% of the total area of the region and the cultivated area occupies 5% of the region's area [14].

Table 1: Abbreviations, locations and descriptions of land use units.

Land use unit (abbreviation)	Meaning	District
AC	Assosa communal grazing land	Assosa
AE	Assosa enclosed area	Assosa
MC	Maokomo communal grazing land	Maokomo
ME	Maokomo enclosed area	Maokomo
KC	Kamash communal grazing land	Kamash
KE	Kamash enclosed area	Kamash

The study was conducted in Assosa, Maokomo and Kamash districts of the region. Assosa town is 670 km west of Addis Ababa, the capital city of the country. Maokomo is located about 105km south of Assosa town, whereas Kamash is 255km north east of Assosa town. Study districts were selected primarily based on their altitude; Maokomo district to represent highland, Assosa to represent mid-altitude and kamash to represent lowland. In each district the main sampling sites were selected randomly as a study sites. Then each sampling sites were further stratified as communal grazing lands and enclosed areas (Table 1).

Data Collection: The number of sampling plots in each land use unit is indicated in Table 2. In each districts, sampling sites were stratified based on grazing types. In the districts 3-4 main sampling sites for communal grazing lands and 1-2 main sampling sites for enclosed areas were randomly selected. The main sampling sites were 15-20 km apart. In each main sampling site, there were 3-4 main sampling plots (50m x 10m) and the first sampling plot established randomly and the subsequent plots were established at 200m intervals on linear transect. Five sub sampling plots were considered per each main sampling plot for the pasture condition assessment and frequency of herbaceous species and one sub sampling plot for herbaceous biomass. Woody plants density and bare ground determination was done from the main plot (Fig. 2). From the three districts a total of 45 main sampling plots and 225 sub sampling plots were considered. For each main sampling plot, location and altitude were recorded using GPS and altimeter. Nomenclature of herbaceous species was done by botanist by using the reference on the Flora of Ethiopia and Eritrea [15]. All data were collected from October to November 2015.

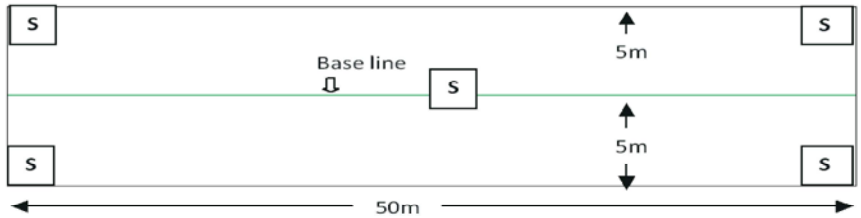


Fig. 1: Sampling design for the pasture condition assessment, herbaceous biomass and woody plants density determination in Benishangul-Gumuz natural pastures. S= subplot for sampling herbaceous data and pasture condition assessment.

Table 2: Assessment types and number of sampling plots per land use unit in natural pastures of Benishangul-Gumuz, western Ethiopia.

	Condition assessment					
Land use unit	Main plots	Sub plots	Herbaceous biomass $1m^2$	Frequency	Percent bare ground	Woody plants density
AC	9	45	9	45	9	9
AE	4	20	4	20	4	4
MC	9	45	9	45	9	9
ME	7	35	7	35	7	7
KC	8	40	8	40	8	8
KE	8	40	8	40	8	8
Total	45	225	45	225	45	45

Biomass, Percent Species Composition and Frequency of Herbaceous Species: Biomass of herbaceous species was sampled from 1 representative sub-plot ($1m^2$) of each main plot ($500m^2$). The herbaceous species were cut to the ground level and weighed immediately using spring balance and transferred to labeled paper bags. Then, each of the samples in the paper bags was hand separated into different species and then weighed. Finally, the dry matter of each species was determined after drying in an oven (65°C for 72 hours) at Assosa Agricultural Research Center.

Frequency is the proportion of plots in which a species occurs and it was calculated based on absence/presence of particular species in the sampling plots. The whole sub plots per land use unit in the districts were considered while calculating frequency. Percent species composition was calculated as contribution (percent by weight) that each species makes to the total biomass.

Grazing Capacity Determination: Determination of the grazing capacity was made from the grass DM yields, using methods described by Minson and McDonald [16] and the formula proposed by Moore *et al*. [17]:

$$Y=d/[DM*f/r]$$

where Y is the grazing capacity (ha /TLU), d is the number of days in a year (365), DM is the total grass DM yield (kg/ha), f is the utilization factor and r is the daily grass DM required per TLU. The grazing capacity was expressed using hectare per Tropical Livestock Unit (ha/TLU). In calculating grazing capacity based upon TLU, the assumption was that an animal will consume 2.5% of its body weight [16], thus each TLU will consume 6.25 kg of forage DM daily. The utilization factor used was 0.35.

Natural Pasture Condition Score: The procedure followed by Dalle *et al*. [11] was applied. Data was collected from forty-five $500m^2$ plots. A 50m tape was used as a baseline. At 5m distance on both sides plastic ropes were used to mark the plot. In each $500m^2$ plots, five subplots of $0.25m^2$ were established (four at the corners and one in the center) for pasture condition assessment (Fig. 1). The natural pasture condition assessment included grass species botanical composition, basal cover, litter cover, number of seedlings, age distribution, soil erosion and soil compaction. The range of 0-10 was used to rate grass composition, basal cover and litter cover, whereas 1-5 was used to rate age distribution; and 0-5 was used to rate number of seedlings, soil erosion and compaction [18].

Herbaceous Plant Species Composition: At each sampling site, herbaceous plant species composition was assessed from five sub-plots of each main sampling plot and then rated 1 to 10 points based on criteria adapted by Baars *et al*. [18]. In each quadrat of $0.25m^2$, the grass species was categorized as highly desirable and desirable species (decreasers), intermediate species likely to increase with heavy grazing pressure (increasers) and undesirable species likely to invade with heavy grazing pressure (invaders) according to succession theory [19]. This classification was done with local community herders.

Basal and Litter Cover: Basal cover (the percentage of soil covered by base of plants) and litter cover were sampled from representative 1m^2 area in each main sampling plot. To make visual estimations the 1 m^2 was divided into eight parts. Then all plants in the selected 1m^2 were removed and transferred to the eighth to facilitate visual estimation. Scores were given according to procedure adapted by Baars *et al*. [18]. The rating of basal cover for tufted species was considered excellent if the eighth was completely filling (12.5%) or very poor if the cover becomes less than 3%.

Number of Seedlings and Age Distribution: Number of grass seedlings was determined in three smaller subplots of A4 paper size (21 cm x 29.7cm) and the mean of the three subplots were recorded for each main plot. The sheet was dropped from an approximate height of 2 meter above the ground. The rating was according to Baars *et al*. [18]. The category 'no seedlings', was given 0 points and more than 4 seedlings was given the maximum score of 5 points. The same procedure was applied to determine age distribution. For all age categories (young, medium and old) of dominant species, the maximum score (5) was given and if only young was found, minimum score that's 1 was given.

Soil Erosion and Compaction: The amount of soil erosion and compaction in each of the quadrats of 0.25m^2 was evaluated by visual observation. Soil erosion assessment was done by considering pedestals and pavements. The scores were given as 5 points for no sign of erosion, 4 points for slight sand mulch, 3 points for weak pedestals, 2 points for steep-sided pedestals, 1 point for pavements and 0 point for gullies. Soil compaction assessment was done based on the level of capping or crust formation of the soil surfaces. The score of 5 points was given for the soil surface with no capping, 4 points for isolated capping, 3 points for greater than 50% capping, 2 points for greater than 75% capping and 1 point for almost 100% capping [18].

In overall, the rating was interpreted as excellent (41-50 points); good (31-40); fair (21-30); poor (11-20); and very poor (3-10).

Woody plants: Density which describes the number of individual woody plants was collected from 45 main plots of 500m^2 size. Then the woody plants were categorized as 'trees', 'saplings' and 'seedlings' following the procedures of Dalle *et al*. [11].

Data Analysis: SPSS computer software was used for data analysis. Data collected was managed in such a way that the qualitative as well as quantitative variables can be analyzed. Descriptive, inferential statistics and correlations were used in the analysis. Locations (Assosa, Maokomo and Kamash) and grazing types (communal and enclosures) and their interaction were used as fixed factors for most dependent variables like biomass yield and variables for pasture condition assessment. These data were analyzed using Analysis of Variance using General Linear Model procedures. The model was

$Y_{ijk}=\mu + L_i + G_j + LG_{ij} + \square_{ijk,}$ where,

Y_{ijk} is dependent variable, μ is the overall mean, L_i is the fixed effect of location i, i= Assosa, Maokomo, Kamash; G_j is the fixed effect of grazing type j, j= communal, enclosure; LG_{ij} is the interaction of location and grazing types and $\square_{ijk}$ is the random error.

Correlation analysis was done to determine the degree of relationship of variables used in pasture condition assessment, bare ground cover and woody vegetation density. For all analysis, the level of significance was set at α of $P<0.05$.

RESULTS

Frequency and Composition of Herbaceous Species: A total of 52 herbaceous species were recorded in the study areas. Out of these, 25 (48.1%) were grasses, 6 (11.5%) were legumes, 21 (40.4%) were sedges and forbs. Based on their forage value, 9 (17.3%) were highly desirable, 10 (19.2%) were desirable, 24 (46.2%) were less desirable and 9 (17.3%) were undesirable (Table 3).

Hypernia rufa, *Sporobulos pyramidalis* and *Eragrostis tenuifolia* were the most frequent grass species in Assosa communal grazing lands, whereas *Hypernia rufa*, *Sporobulos pyramidalis*, *Stylosanthes fruticosa* and *Digitaria abyssinica* were the most frequent in Assosa enclosed areas. In Maokomo district, *Digitaria abyssinica*, *Cynodon dactlon*, *Haplocoelum foliolosum* and *Trifolium rueppellianum* were the most frequently occurring herbaceous species in communal

Table 3: Frequency of herbaceous species (%), their forage value (as perceived by local community) and life form in the study districts

				Land use units						
S.N	Botanical name	Forage value	Life form	AC	AE	MC	ME	KC	KE	Overall
1	*Hypernia rufa*	LD	P	62.2	70.0	0.0	0.0	10	5.0	24.5
2	*Hypernia anthistirioides*	LD	A	0.0	0.0	2.2	2.9	0.0	0.0	0.9
3	*Hypernia collineae*	LD	P	2.2	0.0	0.0	5.7	12.5	0.0	3.4
4	*Hypernia hirta*	LD	P	11.1	30.0	6.7	0.0	32.5	7.5	14.6
5	*Sporobulos pyramidalis*	UnD	P	42.2	60.0	4.4	11.4	27.5	17.5	27.2
6	*Sporobulos africanus*	LD	P	0.0	0.0	53.3	11.4	0.0	0.0	10.8
7	*Pennisetum atrichum*	LD	P	13.3	20.0	0.0	0.0	5.0	12.5	8.5
8	*Eragrostis tenuifolia*	D	A	31.1	0.0	33.3	48.6	7.5	0.0	20.1
9	*Eragrostis tenella*	D	A	0.0	0.0	4.4	17.1	2.5	2.5	4.4
10	*Cyperus rotundus*	LD	P	0.0	5.0	0.0	0.0	0.0	57.5	10.4
11	*Setaria acromelaena*	LD	P	0.0	0.0	13.3	5.7	7.5	0.0	4.4
12	*Setaria verticillata*	LD	A	0.0	0.0	2.2	8.6	20.0	37.5	11.4
13	*Rhynchelytrum repens*	LD	A	0.0	5.0	0.0	14.3	0.0	20.0	6.6
14	*Snowdenia polystachya*	HD	A	0.0	5.0	0.0	0.0	32.5	40.0	12.9
15	*Eleusine indica*	UnD	A	6.7	0.0	37.8	20.0	32.5	15.0	18.7
16	*Andropogon abyssinicus*	HD	A	0.0	0.0	2.2	0.0	0.0	0.0	0.4
17	*Digitaria abyssinica*	HD	A	8	45	71.1	37.1	2.5	0.0	27.3
18	*Digitaria ternate*	HD	A	2.2	0.0	28.9	5.7	0.0	0.0	6.1
19	*Digitaria velutina*	HD	A	0.0	0.0	2.2	0.0	0.0	0.0	0.4
20	*Brachiaria humidicola*	HD	A	6.7	0.0	37.8	42.9	40.0	62.5	31.7
21	*Brachiaria solute*	HD	A	0.0	0.0	17.8	0.0	5.0	0.0	3.8
22	*Chloris pycnothrix*	LD	A	8.9	0.0	31.1	34.3	10.0	12.5	16.1
23	*Bromus pectinatus*	UnD	P	11.1	0.0	0.0	0.0	0.0	0.0	1.9
24	*Cynodon plectostachyus*	HD	P	0.0	0.0	11.1	0.0	0.0	12.5	3.9
25	*Cynodon dactlon*	HD	P	8.9	5.0	64.4	54.3	7.5	0.0	23.4
26	*Leucas martinicensis*	LD	A	2.2	0.0	4.4	17.1	5	15.0	7.3
27	*Leonotis mollissima*	LD	P	24.4	5.0	0.0	0.0	0.0	0.0	4.9
28	*Commelina benghalensis*	D	P	0.0	0.0	6.7	11.4	0.0	0.0	3.0
29	*Tarchonanthus camphoratus*	LD	P	2.2.	15.0	0.0	0.0	0.0	0.0	3.0
30	*Acalypha crenata*	LD	A	2.2	5.0	2.2	2.9	0.0	5.0	2.9
31	*Achyranthes aspera*	LD	P	0.0	10.0	37.8	37.1	45.0	20.0	25.0
32	*Ageratum conyzoides*	UnD	A	2.2	10.0	13.3	65.7	12.5	5.0	18.1
33	*Conyza bonariensis*	UnD	A	2.2	0.0	0.0	0.0	0.0	2.5	0.8
34	*Bidens pilosa*	UnD	A	17.8	20.0	31.1	22.9	12.5	0.0	17.4
35	*Bidens pachylema*	UnD	A	0.0	5.0	2.2	2.9	0.0	0.0	1.7
36	*Trifolium rueppellianum*	D	A	11.1	0.0	53.3	62.9	2.5	0.0	21.6
37	*Crotalaria laburnifolia*	LD	P	15.6	20.0	0.0	0.0	0.0	0.0	5.9
38	*Crotalaria spinosa*	D	P	11.1	5.0	0.0	2.9	0.0	0.0	3.2
39	*Indigofera spinosa*	D	P	8.9	0.0	2.2	0.0	0.0	0.0	1.9
40	*carduus ellenbeckii*	LD	P	0.0	10.0	24.4	28.6	2.5	2.5	11.3
41	*Abutilon mauritianum*	LD	P	2.2	10.0	4.4	0.0	0.0	0.0	2.8
42	*Cladostigma hildebrandtioides*	D	P	6.7	5.0	0.0	0.0	12.5	0.0	4.0
43	*Haplocoelum foliolosum*	D	P	0.0	10.0	57.8	54.3	0.0	0.0	20.4
44	*Sida rhombifolia*	UnD	P	13.3	15.0	11.1	40.0	0.0	45.0	20.7
45	*Tephrosia vogelii*	UnD	P	2.2	5.0	2.2	0.0	0.0	0.0	1.6
46	*Ceropegia abyssinica*	UnD	P	0.0	0.0	13.3	5.7	0.0	0.0	3.2
47	*Guizotia scabra*	LD	P	0.0	0.0	6.7	2.9	10.0	0.0	3.3
48	*Sonchus asper*	LD	A	0.0	0.0	0.0	5.7	0.0	0.0	1.0
49	*Oxalis corniculata*	D	P	0.0	15.0	0.0	0.0	0.0	0.0	2.5
50	*Ocimum basilicum*	LD	A	0.0	0.0	15.6	11.4	0.0	0.0	4.5
51	*Stylosanthes fruticosa*	D	P	0.0	50.0	0.0	0.0	0.0	22.5	12.1
52	*Euphorbia maculata*	LD	A	0.0	0.0	0.0	8.6	47.5	17.5	12.3

[P]=perennial, [A]=annual, [HD]=highly desirable, [D]=desirable, [LD]=less desirable, [UnD]=undesirable

grazing lands, whereas *Ageratum conyzoides*, *Trifolium rueppellianum* and *Haplocoelum foliolosum* in enclosed areas. In Kamash communal grazing lands, *Brachiaria humidicola*, *Cyperus rotundus* and *Sida rhombifolia* occurred most frequently, whereas in enclosed areas *Euphorbia maculata*, *Achyranthes aspera* and *Brachiaria humidicola* were the frequent species. In overall, the frequently occurring species in the study areas in decreasing order were *Brachiaria humidicola*, *Digitaria abyssinica*, *Sporobulos pyramidalis* and *Hypernia rufa* (Table 3).

Biomass, Percent Species Composition and Grazing Capacity: Dry matter biomass production and grazing capacity of the study districts are indicated in Table 4. The mean dry matter biomass yields (Kgha^{-1}) in Assosa,

Table 4: Dry matter biomass yield and grazing capacity of different land use units in the study areas.

Land use unit	Yield ($Kgha^{-1}$) Mean (SE) Total	HD	D	LD	UnD	Grazing capacity ($HaTLU^{-1}$)
AC	2537.6 (350.0)	136.5 (269.9)	1671.6(240.0)	278.8 (172.0)	450.7 (165.8)	2.57
AE	3820.5 (525.1)	724.2 (404.6)	2145.9 (359.5)	561.9 (258.0)	388.8 (248.7)	1.71
MC	1122.3 (332.1)	431.1 (255.9)	18.1 (227.4)	62.3 (163.2)	7.8 (157.3)	5.81
ME	1879.7 (396.9)	428.6 (305.9)	35.6(171.8)	28.4 (195.1)	12.3 (187.9)	3.47
KC	2022.7 (371.3)	667.6 (286.9)	961.8 (254.2)	124.8 (182.5)	168.9 (175.8)	3.22
KE	2924.2 (371.3)	1312.1 (286.1)	0.0 (0.0)	1120.2 (182.5)	491.9 (175.8)	2.23
Loc	***	*	***	*	*	
GT	***	ns	ns	*	ns	
Loc*GT	ns	ns	*	*	ns	

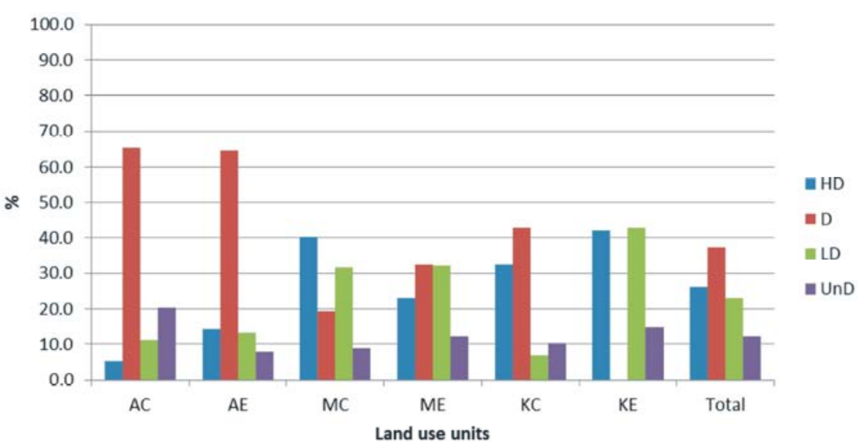
[HD]=highly desirable, [D]=desirable, [LD]=less desirable, [UnD]=undesirabl, [Loc]=Location, [GT]=Grazing type

Maokomo and Kamash were 3179, 1501 and 2473, respectively. In the same manner, the mean dry matter biomass yields ($Kgha^{-1}$) in communal grazing lands and enclosed areas were 1894.2 and 2874.8, respectively. The overall mean was 2219.0 $Kgha^{-1}$. There was a significant difference (P<0.001) in biomass yield among locations and between grazing types. Dry matter biomass yields of natural pastures of Assosa and Kamash were significantly higher (P<0.001) than that of Maokomo. In the same manner, enclosed areas yielded significantly higher (P<0.001) biomass than communal grazing lands.

Local community members classified herbaceous species of the study areas into four categories from highly desirable to undesirable. On biomass basis, highly desirable species were not significantly different (P>0.05) between grazing types, but different among the locations. The biomass yield of highly desirable herbaceous was significantly higher (P<0.05) in Kamash than Assosa and Maokomo. The yield of desirable species was significantly (P<0.001) affected by location rather than grazing type. Natural pastures in Assosa had a significantly higher (P<0.001) biomass yield of desirable species than that of Maokomo and Kamash. But, there was an interaction effect of location and grazing types in this regard. Concerning less desirable species, both location and grazing type had a significant effect (P<0.05) on biomass yield. The interaction effect was also significant (P<0.05).

Grazing capacity is the area of land that is being used by livestock based on the current level of management and livestock distribution. As indicated in Table 4, enclosed areas have better grazing capacity than communal grazing lands.

The percent composition of the four categories of herbaceous species of the study areas is indicated in Fig. 2. Regardless of grazing types, about 65% of natural pastures of Assosa were constituted of desirable species. In Maokomo, communal grazing lands were majorly constituted of highly desirable species (40%) followed by less desirable ones (32%), whereas enclosed areas were



[HD]= highly desirable, [D]= desirable, [LD]= less desirable, [UnD]= undesirable

Fig. 2: Contribution of herbaceous grasses based on desirability to total dry matter biomass in different land use units in the study areas

Table 5: Mean score of natural pasture condition assessment (Standard error in paranthesis) in Benishangul-Gumuz, Ethiopia

Land use unit	n	GC	BC	LC	NS	GAD	SE	SC	TSC	Condition
AC	45	3.8 (0.3)	5.1 (0.3)	4.6 (0.3)	0.0 (0.0)	3.9 (0.1)	4.5 (0.1)	4.5 (0.1)	26.4	Fair
AE	20	7.0 (0.5)	5.9 (0.4)	7.6 (0.4)	2.2 (0.4)	4.4 (0.1)	4.9 (0.1)	4.8 (0.2)	36.8	Good
MC	45	7.3 (0.3)	6.9 (0.3)	2.9 (0.3)	0.6 (0.3)	3.9 (0.1)	4.6 (0.1)	4.7 (0.1)	31.0	Good
ME	35	8.8 (0.4)	6.9 (0.3)	3.8 (0.3)	1.2 (0.3)	4.1 (0.1)	4.9 (0.1)	4.9 (0.1)	34.6	Good
KC	40	3.5 (0.3)	5.7 (0.3)	3.5 (0.3)	0.3 (0.3)	3.7 (0.1)	4.8 (0.1)	4.1 (0.1)	25.6	Fair
KE	40	4.9 (0.3)	5.5 (0.3)	4.6 (0.3)	0.0 (0.0)	3.7 (0.1)	4.6 (0.1)	4.4 (0.1)	27.7	Fair
Loc		***	***	***	**	***	ns	***		
GT		***	ns	***	***	**	ns	**		
Loc*GT		*	ns	**	***	*	**	ns		

[GC]= Grass composition, [BC]=Basal cover, [LC]= Litter cover, [NS]=Number of seedlings, [GAD]=Grass age distribution, [SE]= Soil erosion, [SC]=Soil compaction, [TSC]=Total Score, [Loc]=Location, [GT]=Grazing type

mainly constituted of desirable and less desirable species (32% each). Communal grazing lands of Kamash were constituted of mainly desirable (43%) and highly desirable (32%) herbaceous species, whereas enclosed areas of the same location were dominated by highly desirable and less desirable species (43% each).

In overall, the natural pastures of the study areas were constituted of desirable (38%), highly desirable (26%), less desirable (23%) and undesirable (13%) herbaceous species.

Natural Pasture Condition: The mean score of the condition assessment factors of natural pastures of the study districts is indicated in Table 5. The seven assessment factors were summed up and interpreted as ≤ 10 very poor; 11-10 poor, 21-30 fair; 31-40 good; 41-50 Excellent. The status of the natural pastures of the study districts was found to be in good and fair condition. Communal grazing lands, except Maokomo, were in fair condition while enclosed areas were in good condition, except Kamash. The overall natural pasture condition of the study areas is 30.3 which is fair. Good condition is a desirable state, whereas the fair condition is transitional between desirable and undesirable states.

Grass Composition: The scoring of grass composition was based on the perception of local herders on the palatability of the herbaceous species. Local herders classified the species as highly desirable, desirable, less desirable and undesirable. Based on these scores, the species composition was significantly different (P<0.001) among the locations and between grazing types. The interaction of locations and grazing types was also significant (P<0.05). Location wise, Maokomo had higher mean score of desirable species than Assosa and Kamash, while Assosa was better than Kamash. Natural pastures of Maokomo areas were mainly constituted of desirable species like *Cynodon dactlon, Digitaria abyssinica and Brachiaria humidicola*. Concerning grazing types, enclosed areas were better in desirable species composition compared to communal grazing lands.

Basal and Litter Cover: Basal cover was affected by location of the study sites, but not grazing type. It was significantly (P<0.001) higher in Maokomo than Assosa and Kamash. The mean basal cover scores in Assosa, Maokomo and Kamash were 5.3, 6.9 and 5.9, respectively. The overall mean score of the study locations was 6.0 indicating good basal cover.

Both study location and grazing type affected litter cover. The interaction effect was also significant (P<0.01). Litter cover in Assosa natural pastures was significantly (P<0.001) higher than Kamash and Maokomo; it was also significantly (P<0.05) higher in Kamash than Maokomo. The mean litter covers scored in Assosa, Maokomo and Kamash were 6.1, 3.3 and 4.1, respectively. The overall mean score of litter cover of the study locations was 4.2. Enclosed areas had significantly (P<0.001) higher litter cover than communal grazing areas. The mean litter cover scores in enclosed and communal grazing areas were 4.9 and 3.7, respectively.

Number of Seedlings and Grass Age Distribution: The number of grass seedlings was affected by both study locations and grazing types with a significant (P<0.001) interaction effect. The mean number of grass seedlings in Assosa and Maokomo were significantly (P<0.01) higher than that of Kamash. The mean number of seedlings recorded in Assosa, Maokomo and Kamash were 1.1, 0.9 and 0.1, respectively. Significantly (P<0.001) higher number of grass seedlings were recorded in enclosed areas than communal grazing lands. The mean scores of grass seedlings in enclosed and communal areas were 1.1 and 0.3, respectively. In overall, mean score of number of seedlings in the natural pastures of the study areas (0.7) was poor.

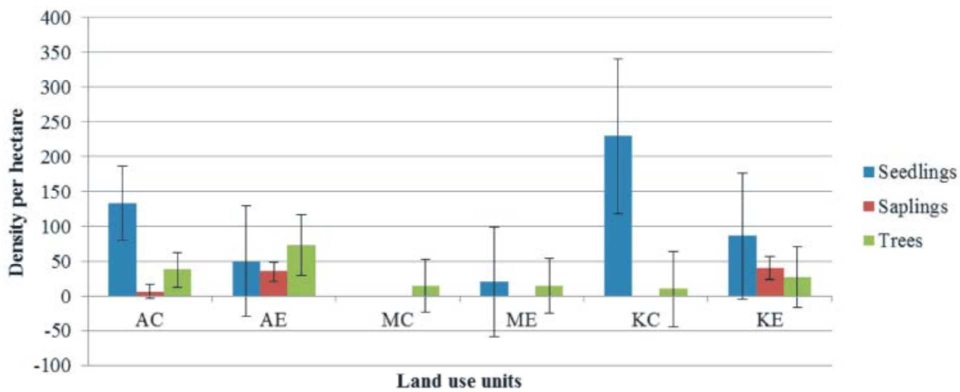


Fig. 3: Density of woody plants per hectare in natural pastures of the study areas.

Table 6: Correlation matrix among the variables studied among land use units of the study areas.

	Biomass	GC	BC	LC	NS	GAD	SE	SC	BG	TS	Sap	Tree
Biomass												
GC	0.110											
BC	0.102	0.390**										
LC	0.631**	-0.01	0.101									
NS	0.021	0.177*	0.136	0.127								
GAD	0.056	0.320*	0.114	0.182**	0.284**							
SE	0.300*	0.077	0.404**	0.327**	0.100	0.162*						
SC	0.336*	0.196**	0.321**	0.360**	0.091	0.181*	0.655**					
BG	-0.451	-0.662**	-0.142	0.279	-0.051	-0.001	0.162	-0.088				
TS	-0.227	-0.288	-0.057	-0.034	-0.168	-0.005	0.191	0.126	-0.214			
Sap	0.404	0.150	-0.452*	0.081	0.270	0.276	-0.292	-0.251	0.288	-0.164		
Tree	-0.079	-0.044	-0.064	0.079	0.143	0.124	0.240	0.271	-0.079	0.728**	-0.016	

Age distribution of grasses in the natural pastures was affected by study locations and grazing types. There was also a significant ($P<0.05$) interaction effect between location and grazing type. Better grass age distribution was recorded in Assosa and Maokomo than Kamash. Enclosed areas were better than communal grazing lands.

Soil Erosion and Soil Compaction: Mean scores for assessment of soil erosion were not different ($P>0.05$) among locations and between grazing types. But, the interaction of location and grazing type was significant ($P<0.01$). The mean scores of soil erosion in Assosa, Maokomo and Kamash were, 4.7, 4.8 and 4.7, respectively. In the same manner, the mean scores for enclosed areas and communal grazing lands were 4.8 and 4.6, respectively. The scores of soil erosion of almost all sampled sites were good with mean score of 4.7 out of 5.0.

Mean score of soil compaction of the study areas was significantly affected by study location and grazing type. Mean scores of soil compaction in Assosa and Maokomo were significantly ($P<0.001$) higher than that of Kamash. In the same manner, mean score for soil compaction was significantly ($P<0.05$) higher in enclosed areas than communal grazing lands. The soil compaction of natural pastures of the study areas was good with mean score of 4.5 out of 5.0

Density of woody plants in the natural pastures of the study areas is indicated in Fig. 3. The density of seedlings, saplings and trees were not different ($P>0.05$) among the land use units. High variations were observed in woody plants density among land use units.

Correlation among Variables: The correlation matrix among the variables is indicated in Table 6. Correlation analysis showed that dry matter biomass yield was positively and significantly correlated with litter cover, good soil erosion and good soil compaction. But, it was negatively correlated with bare ground cover and density of woody plants though it was not significant ($P>0.05$). In the same manner, grass composition was significantly correlated ($P<0.01$) negatively with bare ground, but it was positively and significantly correlated with basal cover, number of grass seedlings and good soil erosion. There was significant ($P<0.01$), but negative correlation between grass composition and bare ground.

Basal cover was positively and significantly ($P<0.01$) correlated with grass composition, good soil erosion and good soil compaction. But, it was negatively correlated ($P<0.05$) with density of saplings. Positive and significant ($P<0.01$) correlation was recorded between litter cover and dry matter biomass yield, grass age distribution, good soil erosion and good soil compaction. Number of grass seedlings was positively and significantly correlated with grass composition and grass age distribution. Similarly, grass age distribution had a positive and significant ($P<0.05$) correlation with good soil erosion and good soil compaction. The correlation between good soil erosion and good soil compaction was also positive and significant ($P<0.01$). Furthermore, tree seedlings and trees were correlated positively and significantly ($P<0.01$).

DISCUSSION

The difference in the distribution of herbaceous species among the study locations is attributed to difference in altitude of the study locations. Maokomo, Assosa and Kamash represent the highland, mid-altitude and lowland of the region, respectively. Getachew *et al*. [20] also reported that altitude has an important influence on distribution, growth and diversity of rangeland plants. The frequent presence of desirable and highly desirable herbaceous species in enclosed areas than communal grazing lands indicates the gradual disappearance of these species in communal grazing lands due to disturbance of livestock and human beings.

The significant difference in dry matter biomass yield in natural pastures among locations and between grazing types could be related with desirability of species, morphological characteristics of herbaceous species, pasture condition and grazing pressure. Maokomo yielded lower biomass because its natural pastures were majorly constituted of palatable species such as *Cynadon dactlon*, *Digitaria abyssinica* and *Trifolium rueppellianum* and, thus, it can be easily utilized by livestock and wildlife. There was also higher livestock population in Maokomo than Assosa and Kamash due to low prevalence of trypanosomiasis which is the rampant disease of livestock in the region. Besides, due to encroaching crop agriculture and increasing human population, lands allocated for natural pastures in Maokomo are narrower than that of Assosa and Kamash. The lower biomass yield in communal grazing lands than enclosed areas is associated with better pasture condition of the latter as biomass yield positively correlates with pasture condition. This result is in agreement with Dalle *et al*. [11] in rangelands of Borana areas.

The dry matter biomass yield in communal grazing lands of the study areas (1894.2 kgha^{-1}) is higher than those reported of the same grazing type in permanent farming system of Assosa zone by Teklu *et al*. [21] (1684 kgha^{-1}), in South Omo Zone by Terefe [22] (244 kgha^{-1}) and in North Shoa Zone by Ahmed (2006)[23] (1264 kgha^{-1}); whereas it was lower than those reported by Teklu *et al*. [21] in shifting cultivation of Assosa zone (2495 kgha^{-1}) and by Mengistie [13] in cotton based farming system (3584 kgha^{-1}) and sesame based farming system (5008kgha^{-1}) in Matema district of North Gonder Zone.

The dry matter biomass yield from enclosure areas in this study is higher than those reported by Amsalu [12], Amaha [24]and Lishan [25] for arid and semi-arid rangelands of Ethiopia; but it is lower than those reported by Mengistie [13]in cotton based farming system and sesame based farming system in Matema district of North Gonder Zone.

Though the dry matter biomass yield of natural pasture of the study areas is better than most rangelands of the country, there is inefficient utilization of forage resources which might be in connection with low cattle population in the region, lack of awareness of forage conservation techniques and un-marketability of forage resources in the area. Usually, these huge resources are left to be lignified and prone to wild fire in dry season. As Alemayehu [10] indicated, optimum utilization of forage resources is obtained by proper grazing management which include proper stocking, proper season of grazing, proper distribution of grazing and proper kind and class of livestock or wildlife.

Lack of interaction effect of location and grazing type in total dry matter biomass yield indicates that there is no difference among enclosed areas across the locations regardless of difference in altitude and management practices. This result is in agreement with findings of Amsalu and Baars [26], Dalle *et al*. [11], Teshome *et al*. [27] and Terefe *et al*. [28]. The better grazing capacity of enclosed areas than communal grazing lands of the study areas has to be connected with better dry matter biomass yield of enclosed areas.

The condition of natural pastures of the study areas was assessed considering vegetation and soil attributes according to Baars *et al*. [18]. The significant difference in mean scores of grass composition among the locations could possibly be due to differences of the locations in altitude. From this result, it can be drawn that grass composition increases with increasing altitude in the study areas. This result is in agreement with findings of Dalle [29] in the vegetation of Borana lowlands and

Teshome *et al*. [27] in rangelands of South-Eastern Ethiopia. The reason for the better species composition of enclosed areas than communal grazing lands in the study areas can be less disturbance of enclosed areas by livestock and human beings. Species composition has primary importance to determine pasture condition in the belief that ideal combination of plant species will give rise to the highest density of plants, stable soil and high production of both forage and animals [10]. The desirability of particular plant species is relative and it seems to be depend on species diversity, biomass availability and stocking rate of particular area; for instance, Hypernia species are reported to be desirable in the rangelands of other parts of the country, but they are less desirable in this study area.

The significant difference in basal cover across the locations is associated with variations in grass species. Maokomo was better in basal cover than Assosa and Kamash as it possessed some tufted and creeping grass species like Cynodon dactylon. The overall mean score of basal cover (6.0) is good and comparable to 5.8 reported in Borana rangelands by Dalle *et al*. [11]. The difference in litter cover among locations and grazing types can be associated with frequency and intensity of grazing. As indicated previously in this report, Maokomo possesses larger livestock population compared to Assosa and Kamash due to lower trypanosomiasis prevalence. Previous studies also indicated that grazing frequency and intensity affects litter cover with important indirect effect on patterns of germination and seedling establishment [8]; Mengistie, [13]; Teshome *et al*., [27]). The availability of giant grasses such as hypernia species in Assosa and Kamash might also contributed to recorded higher litter cover in the mentioned areas. The significant interaction between location and grazing type in litter cover could be as a result of variations in species composition in the locations so that they respond differently to similar grazing or other management practices.

The number of grass seedlings and age distribution in the study areas were poor and lower than Borena rangelands [11]; rangelands of Matema district of North Gonder Zone [13] and rangelands of Rayitu district of South-Eastern Ethiopia [27]. Poor number of seedlings and poor age distribution indicates the downward trend of natural pastures of the study areas. Young, medium-sized and large herbaceous plants indicate that the species is regenerating and that the stand is maintaining itself [10]. The better number of grass seedlings and age distribution in enclosed areas than communal grazing lands could be related with less disturbance and better litter cover in enclosed areas. In the natural pastures of study areas usually the soil losses were low and soils were less compacted that can be related with basal cover, litter cover, soil type and topography of pasturelands.

The overall natural pasture of the study areas is in fair condition and this implies that it is in transitional state from desirable to less desirable. The main constraint of natural pastures of the study areas is the dominance of less desirable species like *Hypernia rufa*, *Sporobulos pyramidalis*; and the dominance of these species could be related with selective grazing. Hence, measures must be taken to improve the situation, especially for communal grazing lands. This study indicated that enclosed areas were in good condition, but the numbers of enclosures were few. Thus, establishing large number of enclosures can be an entry point to improve the natural pastures. Managing stocking, seasonal spelling to allow seeding and regeneration of desirable species and prescribed fire can also help to maintain desirable species and productivity. Wild fire has been a common practice in the study areas, but now a day it's banned due to its devastating effect on natural resources of the areas.

Correlations among the variables have an implication that improving one or more of variables results in improvement of the other and hence helps to improve pasture condition. For instance, improving basal cover leads to improvement in soil attributes like soil erosion and soil compaction and this leads to better dry matter biomass yield and so on.

CONCLUSION

This study was dealt with condition assessment and determination of biomass yield, species composition and carrying capacity of natural pastures of Benishangul-Gumuz. The study indicated that majority of communal grazing lands of the region were in fair condition while enclosed areas were in good condition. The implication is that the trend of communal grazing lands of the region is downwards. Dominance of hypernia species in communal grazing lands is main cause for decreasing trend of pasture condition. This infers that this trend needs to be reversed; otherwise this condition will be worsened and can result in loss of biodiversity and low animals productivity. This in turn might lead to food insecurity in the region. So, some rehabilitation techniques such as prescribed fire, over sowing of desirable grass species and proper stocking techniques should be implemented.

Besides, increasing the size of enclosure areas could also help to maintain the biodiversity. On the other side, inefficient utilization of natural pastures in the study areas should be improved by feed conservation techniques like hay and silage making practices. The higher biomass yield of forages in natural pastures of the study areas seems to be surplus and thus, it's recommended to make hay and avail it to markets for other parts of the country with critical feed shortage.

ACKNOWLEDGMENTS

This study was funded by Ethiopian Institute of Agricultural Research Center. We would like to thank Mr Bedru Roba for his help in identification of botanical names of herbaceous species. We are also grateful to technical assistantes of Livestock research process in Assosa Agricultural Research for their active participation during data collection process. The participation of local community members of the study areas is highly appreciated.

REFERENCES

1. Alemayehu, M., 1998. The Borana and the 1991-92 drought: A rangeland and livestock resource study. Institute of Sustainable Development, Addis Ababa, Ethiopia, pp: 102.
2. Amsalu, T. and S. Addisu, 2014. Assessment of Grazing Land and Livestock Feed Balance in Gummara-Rib Watershed, Ethiopia. Current Agriculture Research 2(2).: http:// dx.doi.org/ 10.12944/CARJ.2.2.08
3. Kidane, G., 1993. Effects of Cutting date on Botanical Composition and Nutritive of value of Native pasture in the Central Ethiopian high lands. MSc. Thesis. Alemaya University of Agriculture. Alemaya, Ethiopia.
4. Beruk, Y. and M. Tafesse, 2000. Pastoralism and agropastoralism: Past and present. In: Proceeding of 8th annual conference of the Ethiopia Society of Animal Production (ESAP). Addis Ababa, Ethiopia, 24-26 August 2000
5. Wolmer, W., 1997. Crop-livestock integration: The dynamics of intensification in contrasting agro ecological zones: A review. Institute of Development Studies, University of Sussex, UK, pp: 30.
6. Eshete, G., 2002. An assessment of feed resources, their management and impact on livestock productivity in the Ginchi watershed area. MSc Thesis, Alemaya University, pp: 171.
7. Alemayehu, M., 2004. Rangelands Biodiversity: Concepts, Approaches and the Way Forward. Addis Ababa, Ethiopia.
8. Belaynesh, D., 2006. Floristic composition and diversity of the vegetation, soil seed bank flora and condition of the rangelands of the Jijiga zone, Somali Regional State, Ethiopia. MSc Thesis. School of Graduate Studies, Alemaya University, pp: 144.
9. Alemayehu, M., 2005. Rangelands: Biodiversity Conservation and Management and Inventory and Monitoring. Addis Ababa University Press. Addis Ababa Ethiopia.
10. Alemayehu, M., 2006. Range Management for East Africa: Concepts and Practices, Sponsored by RPSUD and Printed by A.A.U Printed Press. Addis Ababa, Ethiopia.
11. Dalle G., B.L. Maass and J. Isselstein, 2006. Rangeland condition and trend in the semi-arid Borana lowlands, Ethiopia. African Journal of Range and Forage Science, 23: 49-58.
12. Amsalu, S., 2000. Herbaceous species composition, dry matter and condition of the major grazing areas in the middle rift valley, Ethiopia. MSc. Thesis, School of Graduate Studies, Alemaya University, Dire Dewa, Ethiopia.
13. Mengistie, T., 2008. Characterization of cattle milk and meat production, processing and marketing system in Metema District. MSc Thesis. School of Graduate Studies, Hawasa University, Ethiopia.
14. AsARC (Assosa Agricultural Research Center), 2006. Results of farming system survey Benishangul Gumuz Regional state. Ethiopian Institute of Agricultural Research, Assosa Agricultural Research Center, Assosa. (unpublished).
15. Edwards, S., D. Sebsebe and I. Hedberg, 1997. Flora of Ethiopia and Eritrea. Vol. 6. National Herbovium, Biology Department, Science Faculty, Addis Ababa University, Addis Ababa, Ethiopia; and Department of Systematic Botany, Uppsala University, Uppsala, Sweden.
16. Minson, D. and C. McDonald, 1987. Estimating forage intake from the growth of beef cattle. Tropical Grasslands, 21: 116-122.
17. Moore, C. and J. Cock, 1985. Cassava forage silage as a feed source for zebu calves in the tropics. Tropical Agriculture (Trinidad), 62(2): 142-144.
18. Baars, R., E. Chileshe and D. Kalokoni, 1997. Technical notes: Range condition in high cattle density areas in the Western province of Zambia. Tropical grasslands, 31: 569-573.

19. Dyksterhuis, E., 1949. Condition and management of rangelands based on quantitative ecology. Journal of Range Management, 2(3): 104-115.
20. Getachew, T., B. Tamrat and D. Sebsebe, 2008. Dry land woody vegetation along an altitudinal gradient on the eastern escarpment of Welo, Ethiopia Sinet: Ethiopia.Journal of Science, 31(1): 43-54.
21. Teklu, B., N. Tegene and A. Angassa, 2010. Effect of farming systems on livestock feeding systems in Benishangul-Gumuz region, western Ethiopia. International Journal of Agricultural Science and soil Science, 1(1): 020-028.
22. Terefe, A., 2006. Pastoralists perceptions on range-livestock management practices and rangeland assessment in Hamer and Benna-Tsemay districts of South Omo Zone. MSc Thesis. School of Graduate Studies, Haramaya University, Ethiopia, pp: 159.
23. Ahmed, H., 2006. Assessment and evaluation of utilization practices of natural pastures and other forages in Basona Worana wereda of North Shoa Zone. MSc Thesis. School of Graduate Studies, Haramaya University, Ethiopia, pp: 174.
24. Amaha, K., 2006. Characterization of rangeland resources and dynamics of the pastoral production system in the Somali region of Eastern Ethiopia. PhD Thesis. University of the Free State, Bloemfontein, South Africa, pp: 232.
25. Lishan, T., 2007. Woody and herbaceous species composition and the condition of the rangelands in Shinile zone of condition of the rangelands in Shinile zone of Somali regional state, Ethiopia. MSc Thesis. School of Graduate Studies, Haramaya University, Ethiopia, pp: 136.
26. Amsalu, S. and R. Baars, 2002. Grass composition and rangeland condition of the major grazing areas in the mid rift valley of Ethiopia. Africa Journal of Range and Forage Science, 9: 161-166.
27. Teshome, A., E. Abule and N. Lisanworke, 2009. Pastoralists perceptions and rangeland evaluation for livestock production in South Eastern Ethiopia. Livestock Research for Rural Development 21(7):http://www.lrrd.org/lrrd21/7/abat21101.htm
28. Terefe, A., E. Abule and Z. Tessema, 2010. Rangeland dynamics in South Omo zone of southern Ethiopia:Assessment of rangeland condition in relation to altitude and grazing types, Livestock Research for rural development, 22(10):http:// www.irrd.org// irrd22/10/tref22187.htm
29. Dalle, G., 2004. Vegetation Ecology, Rangeland Condition and Forage Resources Evaluation in the Borana Lowlands, Southern Oromia, Ethiopia. PhD Thesis,Georg-August Universität Göttingen, Germany. Cuvillier Verlag Göttingen.