academicresearchJournals

Vol. 8(1), pp. 24-36, January 2020
DOI: 10.14662/ARJASR2019.175

ISSN: 2360-7874
http://www.academicresearchjournals.org/ARJASR/Index.htm

Academic Research Journal of Agricultural Science and Research

Full Length Research

Vegetation Structure and Diversity of Grazing Lands in Abijata-Shalla Lake National Park, Oromia Regional State, Ethiopia

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Accepted 11 November 2019

This paper aimed to assess the vegetation structures and diversities in grazing land of the Abijata Shalla Lake National Park in Ethiopia. The stratification was done before sampling based on grazing intensity and the random sampling techniques were used. The two grazing intensities* 12 sampling site* five plots per sample site=120 samples were used. The 10m*10m, 5m*5m and 1m*1m plot size were used for trees, shrubs and herbaceous respectively. The indivudal abundance, density and important value index of each plant species were estimated. The height of woody vegetation was estimated by clinometers and the DBH at 1.3m and 0.3m by caliper for tree and shrubs respectively. The proportions of desirable and undesirable species, richness and diversity with the life form of herbaceous were determined. Then, the fresh weight of biomass was clipped and sub-sample were oven dried at 105^{o}C for 24hr to determine the dry matter. A total of 64 species, that belonged into 27 families were identified, whereas 24 were woody and 40 were herbaceous. The height of woody vegetation ranges from 2m to 25m and classified into five classes as (2-5m, 5.1-10m, 10.1-15m,15.1-20m and 20.1-25m). The DBH also classified into six as (<10 cm, 10-20cm, 20-30cm, 30-40cm, 40-50cm and >50cm). The high proportions of (45.35%) woody species found in (10-20cm) DBH classes in the heavy grazed area and (38.78%) in the low grazed area. The densities of woody trees decrease as the height and the DBH increases. Furthermore, the herbaceous species have a significant variation (P<0.05) of species richness, diversity and evenness with grazing intensities. Generally, the high grazing intensity has negative impacts on the vegetation structure, diversity and vegetation biomasses. Therefore, the sustainable management and intervention of community based conservation was suggested to improve the ecosystem and abundances of vegetations.

Keywords: Herbaceous species, Important value index, Shrubs, Species richness, Dry matter, Species diversity, Diameter at breasy height

Cite this article as: Meseret T., Tessema Z (2019). Vegetation Structure And Diversity Of Grazing Lands In Abijata-Shalla Lake National Park, Oromia Regional State, Ethiopia. Acad. Res. J. Agri. Sci. Res. 8(1): 24-36

INTRODUCTION

Ethiopia is one of the tropical countries that is endowed with rich biological resources (Fikadu *et al.,* 2014; Melese and Wendawek, 2016) and encompasses different agro-ecologies. The dry land is one of this Agro-ecology that is estimated to be over 75 million hectares of land (about 66% of the total area of the country), of which about 25 million hectares is covered with woodlands and bush lands (Abera *et al.,* 2016). This implies that the largest vegetation resources of the country are found in the dry land areas that have different structures, diversity and compositions.

The Abijata Shalla Lake National Park is one of the ecosystems and protected area that were established for the conservation of flora and fauna. It exists with the anthropogenic impact and grazing pressures that influences the vegetation structures, diversities and compositions. Currently, there are more than 5,600 households with their family of about 56,000 people are living in the park (Fisseha, 2014) that depends on its wood resources for fuel and charcoal production, livestock rearing and subsistence agriculture to sustain their life.

According to Temesgen *et al.* (2017) on average 191,982 heads of livestock (132,629 cattle, 40,490 sheep and goats and 10153 horses) use the park every day. The land resources are clearly overgrazed by these abundant livestock populations and the habitat of ASLNP has been degraded because of concentrated grazing and trampling by a large number of cattle, to the extent that shallow topsoil is exposed to wind erosion (Tolcha, 2005). Before humans settled within and around the park, the study area was covered by *Vachellia tortolis* dominated woodland (Girma *et al.,* 2011). The grasses and soil exhausted due to overgrazing. This left many Vachellia trees intentionally uprooted and fallen that might have decreased the vegetation structures and diversity. However, the vegetation structure, diversity and status of the Abijata Shalla Lake National Park were not studied with grazing intensity. Therefore, this MSc research was done with the following objectives of assessing the vegetation structure under low and heavy grazing pressure of Abijata Shalla Lake National Park in Oromia region of Ethiopia.

MATERIAL AND METHODS

Description of study area

Abijata Shalla Lake National Park is one of the low and dry land protected habitat and an important wildlife conservation area. It is a critical ecosystem in the Great Rift Valley of the Oromia Regional State, Ethiopia. It was established as a National Park by the Ethiopian Wildlife Conservation Authority in 1970 with the aim of conserving the biodiversity of the magnificent number of aquatic birds (Tewodros and Afework, 2014). It comprises two types of ecosystems, namely, the aquatic parts (482 km^2) and terrestrial (dry land) (405 km^2) together covering a total area of 887 km^2 (Senbeta and Tefera, 2001). Abijata Shalla Lakes National Park is bounded by three districts namely; Adami Tulu Jido Kombolcha, Arsi Negele and Shalla. It lies between 7°15'-7°45'N and 38°30'-38°45'E and found at about 207km south of Addis Ababa. The altitude of the Park ranges from 1,540 to 2,075 meters above sea level (masl), the highest peak being Mount Fike, which is situated between the two lakes (Abijata and Shalla).

The agro-ecology of the area is semi-arid with the climate of two distinct rainy seasons, short rains in March to May and long rain during June to September (Tewodros and Afework, 2014). The ASLNP receives an annual rainfall ranging between 500-700mm, due to its location in a rainfall deficit area of the Rift Valley. Its temperature is normally in the ranges of 16 to 24°C with a mean annual temperature of 21°C (Girma *et al.,* 2011).

The rift floor is occupied by a series of large lakes fed by perennial rivers originating from the nearby highlands both to the east and west directions (Tenalem, 2001). The previous record states that ASLNP has great changes in the sizes of the lakes in the past years and other features of the park such as hot springs, cliffs, and lava cave (Adem, 2008). The water level has declined due to various factors, mainly by the soda ash factory, and increased irrigation upstream (Tolcha, 2005). Furthermore, in case of land settlements and human, increase in livestock populations is a major problem in the conservation area. Its biodiversity has undergone dramatic environmental changes (Tewodros and Afework, 2014).

Abijata-Shalla Lake National Park has immense natural resources, including wetland, aquatic and terrestrial birds. It is dominated by different species of vegetation (woods, shrubs and herbaceous). The vegetation zone of the study site is generally classified as savannah, Vachellia trees and Ficus savannah (Tewodros and Afework, 2013). Among the different type of vegetation, the dominants are Vachellia woodlands, Euphorbia woodland with small areas of reverine vegetation, bush and open shrub on the rocky slopes with herbaceous species and short grasslands comprising of Cynodon and Sporobolus that are important for stabilizing the fragile soils (Gemechu, 2010; G/Michael, 2008). Of the vachellia species, *Vachellia tortilis, Vachellia seyal, Senegalia senegal* and *Vachellia gerardi* were the dominant species (Fisseha, 2014). The Abijata Shalla Lake National park hosts 31 species of mammals such as spotted Hyena, golden and black backed Jackals, Olive Baboon, Grant's gazelle, etc. The countless birds either of endemic or exotic birds that come from Europe and different parts of the world congregate here in at Lake Abijata. There are also vast colonies of scared Ibis, Queela, Stilt, Snap Black Heron, Avocet, Egyptian Geese, Eaglets, Plovers, etc. Generally, a total of 453 bird species has been recorded in the Park and 6 are endemic to Ethiopia (Tefera and Almaw, 2002). Hundreds of thousands of Flamingoes and great white Pelicans, Fish eagles, Kingfishers, the tall Marabou stork, Cormorants, and Darters, etc. roam here in Lake Abijata and on the side-by lake Shalla. Flamingos are the most prominent and important consumer in the lakes (Tewodros and Afework, 2014). Thus, it uses in the eco - tourism region in the rift valley for tourist attraction. However, 191,982 heads of livestock (132,629 cattle, 40,490 sheep and goats and 10,153 horses) uses the Park every day (Temesgen *et al.,* 2017) and degrading the study area.

Site Selection and Sampling Procedures

This study was done during the rainy season completed from September to October for identification of vegetation. The study area was selected due to the presence of having diverse plant species and also exists as a protected area with grazing impacts. The two grazing pressure areas, i.e., heavy and the low grazed area were sought. Prior to the field layout and sampling techniques, a reconnaissance survey was made to assess its present situation with the park scouts. In order to establish permanent plots, the area of interest was set randomly and clearly identified with detail observation as to assure the sample plots did not all fall in the similar vegetation area.

Stratification of the study area

The stratification was done based on the grazing intensity by the livestock and wildlife, which affected the vegetation types, structures and productivity of the grazing land in the Abijata Shalla Lake National Park (Fisseha, 2014) after the reconnaissance survey was done. The study area encompasses grazing lands, settlement, farmland and other sandy source (Fisseha, 2014). The grazing land was preferred for this study if it has a high interaction with livestock production and degrading. Therefore, the grazing land was stratified into two (heavy and the low grazed area) based on the physical observation and consulting with the expert of the national park. Furthermore, in the ASLNP 1.2 km^2 area of the Park was wire-fenced since its establishment, the density of herbivore wildlife species is relatively low (Temesgen *et al.,* 2017). This area is better protected from livestock grazing and logging activities that occur periodically (Tewodros and Afework, 2014). The fenced area was preferred as low grazed area while the outsides considered as a heavy grazed area due to exposures for livestock frequently. The twelve 30m*30m sample sites in the each grazing intensities, were identified randomly and the red ribbons were tied to the feasible place during the stratification of the study area as a demarcation and GPS coordination was taken to identify the selected area of the main plot.

Sampling design and techniques

The simple random sampling techniques were used for vegetation structure and composition sample collection. The total of (2-grazing pressure x 12-sample site x 5-plot=120) were used for measuring and counting of trees, shrubs and herbaceous with (10m*10m, 5m*5m and 1m*1m) plot size respectively. All vegetation types and layer were sampled and measured (Genene, 2013) that were used for morphometric measurement (height, DBH and tree crown), biodiversity assessments (species identification and quantification) species diversity, species richness and similarity with herbaceous life form (annual and perennial).

Tree vegetations sampling

The five 10m*10m plots were sampled in 12 random sample sites in each grazing intensity. The 120 plots were used totally (2 grazing intensity x twelve plot site x five sub plot) for woody vegetation structures assessments. In each quadrant, all the trees have been counted, DBH at 1.3m, crown cover and height were measured by caliper and meter tape, respectively. Diameter at breast height (DBH) is one of the most common dendrometric measurements of trees. An estimating of the vegetation biomass can provide the information about the nutrients stored in the vegetation as a whole, or the amount in specific fractions such as extractable wood (Genene, 2013). Thus, the biomasses of trees were obtained from the measurement of tree parametric and non-destructively using allometric biomass regression equations (Henry *et al.,* 2010; Chave *et al*., 2014).

Shrub vegetation sampling

The four 5m*5m quadrant frames were located at the corner of the main plot and one at the center for shrub sampling. The total shrubs were counted to estimate the abundance of shrub species composition, basal area, canopy cover, and density of vegetation. The height and DBH of the shrub at 0.3m heights were measured by meter tape and caliper as stated by Rau (2009). Shrubs with a basal stem circumference less than 2cm were not sampled, but considered under herbs.

Herbaceous sampling and botanical composition

The herbaceous vegetation biomass and botanical composition of the five 1m*1m (1m^2) quadrants in each 30m*30m (900m^2) plot size, were taken at four corners and the center of the main plots. To estimate the biomass of herbaceous species within each sample, it was clipped close to the ground at (0.5cm). The clipped vegetation was weighed, recorded and separated into botanical compositions based on biomass grass and herbs (non-grass species) to determine the contribution of each component in the total dry matter yield of the pasture (ILCA, 1990). The proportions of desirable and undesirable species, richness and diversity with the life form of herbaceous were determined. Then, the fresh weight of clipped biomass was taken by using a weighing balance for the total weight determination and the sub-sample were taken and placed in a paper bag separately. Then, the samples were oven dried at 105^{o}C for 24hr at Adami Tulu Agriculture Research Center (ATARC) for further dry matter (DM) and organic matter (OM) determinations. The dry weights of the sub-samples were used for calculating the whole biomass of the quadrant dry matter of grass and forbs. Oven-dry weights of sub-samples were used to compute for the total dry weights (Hairiah *et al.,* 2010). After the DM was determined, the organic matter of dried sample was calculated from DM multiplying by 0.5. The total DM and organic matter were computed proportionally from 1m*1m (1m^2) sub-plot to hectare and study area to recognize the biomass of the study area.

Basal cover and bare ground estimation

The basal area is a forest measurement to estimate volumes, understand stand density and competition of the trees. The basal area determined from the radius of trees and shrubs at a DBH height (1.3m) and (0.3m), respectively. Generally, the total basal area was calculated from the sum of the total diameter of emerging stem. The basal area of herbaceous species is an indicator of growing stock and biomass production. It can be measured on the ground level by using calipers. But, due to shortage of time, it was estimated by physical observations visually in percentage before the herbaceous stands were clipped within the quadrants. The bare ground cover also estimated visually (Tessema *et al.,* 2011) from the 1mx1m quadrant coverage of vegetation by categorizing plot into two diagonally.

Identification of vegetation

The plant species identifications were performed on the field by using manual, technical assistant, local elders and expert of the park (scout) who has been living around and in the national park. Finally, vernacular names were cross-checked with their scientific names by using the previous study of (Gemedo *et al.,* 2006; Abule *et al.,* 2007; Azene, 2007; Tesfaye, 2007; Belete *et al.,* 2011 and Naidu, 2012). In all cases, the local names and habitat (life form) of vegetation were recorded during data collection. After identification of vegetation species, the highly palatable (decrease), less palatable (Increaser) and unpalatable (invaders or pioneers) were identified from the literature review and local elders perceptions based upon palatability of species.

Vegetation Structure

The vegetation structure was sampled by measuring of the diameters at breast height at (1.3m and 0.3m) heights and height of tree and shrubs, respectively. The woody vegetation >2cm DBH, in 60 quadrants per grazing intensity were counted and identified. For trees with DBH greater than the caliper size, the circumference was measured and converted to DBH. Generally, the vegetation attributes (species composition, frequency, and density) of trees and understory vegetation were estimated in each plot.

Species Richness, Diversity and Similarity

Species diversity

The Shannon diversity indices were computed for analysis of the diversity and relative abundances of the species. The Alpha diversity (diversity within a given sampling site) was computed for the strata of this grazing land of the ecosystem using the Shannon Weiner diversity index (Kent and Coker, 1992). The indexes of each species were calculated by adding the proportion of each species multiplied by the proportion expressed in natural logarithm.

Species richness

Species richness is the number of species present per sampling unit, while plant density is the total number of individuals of a species per sampling unit in each stratum of grazing land ecosystems.

Species evenness and similarity

Shannon evenness was also determined for each sampling site by dividing the value of the Shannon index to the species richness expressed in natural logarithm. The values for an evenness range from 0-1; while a sample of equal numbers of individuals of the same species has a value of 1 i.e. the closer the value to 1 the more even the populations that form the community. Generally, Shannon diversity index (H) and evenness (E) assess the diversity of flora occupying a given sub-habitat and this is alpha diversity-also “local diversity”, which refers to diversity within a particular sub-habitat.

Important Value Index

This index is used to determine the overall importance of each species in the community structures. It is the summation of three parameters. These were relative frequency, relative density, and relative dominance. The percentage value of each summed together and this value is designated as the Importance Value Index (IVI) of the species (Curtis, 1951). The importance value, index ranges from (0-300). It permits a comparison of species in a given location and reflects the dominance, occurrence and abundance of a given species in relation to other associated species in an area (Kent and Coker, 1992). Therefore, it is a good index for summarizing vegetation characteristics and ranking species for management and conservation practices (Mekbib, 2012).

Statistical data analysis

All the data collected from the field were arranged and incorporated into the Microsoft Excel for further analysis. The Biodiversity professional software pro.2 was used for Shannon Wiener diversity index, evenness, and similarity analysis of trees, shrubs and herbaceous species in grazing land. The SAS, software, version 9.1 was used for statistical analysis and One-way ANOVA procedure were computed for mean comparisons of species diversity, species richness, species similarity by using with Tukey's Studentized Range (HSD) test at P<0.05.

RESULTS AND DISCUSSION

Floristic Composition and Vegetation Structure

The species composition and vegetation structure provides important information to understand and recognize the vegetation and the status of the study area in a given ecosystem. A total of 64 plant species was identified in the study area that belongs to 27 families. Of these, 14 (21.88%), 10 (15.63%) and 40 (62.52%) were trees, shrubs and herbaceous species, respectively.

Trees and shrub species composition

A total of 24 trees and shrubs species that belongs to (16) families were identified and recorded from the study area. Out of overall woody vegetation, 14 (58.33%) covered by trees, whereas 10 (41.67%) species were shrubs. The trees belong to (6) families, whereas the shrubs were (9) families. The species composition of trees and shrub were varied with the grazing intensities in the study area. The Fabaceae families showed high dominant in both heavy and the low grazed area by encompassing more than half of the species counted as indicated on the following table (1 and 2). Of the fabaceae families, the highest dominant species with the highest densities were *Vachellia tortilis* (266.67 ind. ha^{-1}), *Vachellia seyal* (225.00 ind. ha^{-1}) and *Balanites aegyptiaca* (166.67 ind. ha^{-1}) in the heavy grazed area, whereas *Vachellia tortilis* (300.00 ind. ha^{-1}), *Sengalia senegal* (258.33 ind. ha^{-1}) and *Vachellia seyal* (233.33 ind. ha^{-1}) in the low grazed area. The low grazed area had 12.50% and 11.35% relative frequency of *Vachellia tortilis* and *Vachellia seyal* followed similar relative frequency 10.23% of *Balanite aegyptica* and *Senegalia senegal*. However, the higher relative frequent species in the low grazed area were *Vachellia tortilis* (12.22%) and *Vachellia brevispica* (11.11%) followed by *Vachellia senagal* (10.00%) and *Balanites aegyptiaca* (10.00%). The *Vachellia nilotica* and *Ficus sir* had low abundance, relative frequency and relative dominance in the low grazed area, whereas, *Ficus sur* and *Croton macrostachyus* in the heavy grazed area The tables (Table 1 and Table 2) showed a high dominance of Vachellia species in the study area and this result was line with Garuma and Wendawek (2016) on Magada Forest, Bule-Hora District, Borana zone, Oromia region. In addition, a similar result was stated by Getaneh *et al.* (2015) on the dominance of fabaceae families in the the rift valley area.

The species abundance, frequency and relative dominance of trees were higher in the low grazed area than the heavy grazed area. This is due to the exposure of the heavy grazed area for different anthropogenic impacts (farm land expansion, sand and charcoal) and overgrazing impacts than the lower grazed area. The same result was reported by (Garuma and Wendawek, 2016) as to be the vegetation disturbed by many factors, including grazing and browsing by livestock and other human activities. From the physical observation, the grazing land of the study area was used for different land uses (sand mining, farm land and settlement) that have a negative influence on all vegetation abundances. This is increasing from time to time with population number (settlement) (Michael *et al.,* 2015) which resulted in the decline of the natural resource goods and services that the ecosystems was to provide.

The IVI values of all species ranged between 4.32 (*Ficus sir*) and 50.43 (*Vachellia tortilis*) in the heavy grazed area of ASLNP Table 2). In the low grazed area, IVI values ranged from 5.27 (*Vachellia nilotica*) and 53.39 (*Vachellia tortilis*) (Table 1). The IVI value is directly related to abundance, basal area, density and frequency distribution, and is an important parameter indicating the ecological significance of a species in a given ecosystem (Worku *et al.,* 2012; Tsegay *et al*., 2017). The species with high IVI values are considered more important than those with low IVI values for conservation program and managements by the community and other stakeholders before the disappearance (Tsegay *et al.,* 2017).

Table 1. Species composition, abundance (AB), density (D, ind.ha^{-1}), relative density (RD, %), frequency (FR, %), relative frequency (RF, %), basal area (BA, m2 ha^{-1}), relative dominance (RDO, %) and Importance Value Index (IVI) of trees in the low grazed area

No	Scientific name	AB	D	RD	FR	RF	BA	RDO	IVI
1	*Balanites aegyptiaca*	23	191.67	11.44	9	10.00	5.01	12.61	34.05
2	*Cordia Africana*	7	58.33	3.48	4	4.44	1.29	3.24	11.16
3	*Croton macrostachyus*	8	66.67	3.98	6	6.67	1.84	4.63	15.28
4	Dichrostachys cinerea	8	66.67	3.98	5	5.56	1.38	3.48	13.02
5	*Ficus sur*	4	33.33	1.99	4	4.44	0.42	1.05	7.48
6	*Olea europea*	8	66.67	3.98	6	6.67	1.47	3.70	14.35
7	*Sengalia senegal*	31	258.33	15.42	10	11.11	8.65	21.74	48.27
8	*Vachellia albida*	13	108.33	6.47	6	6.67	1.54	3.88	17.02
9	*Vachellia brevispica*	18	150.00	8.96	10	11.11	1.31	3.30	23.37
10	*Vachellia mellifera*	15	125.00	7.46	9	10.00	3.70	9.31	26.77
11	*Vachellia nilotica*	2	16.67	1.00	2	2.22	0.82	2.05	5.27
12	*Vachellia seyal*	28	233.33	13.93	8	8.89	3.08	7.75	30.57
13	*Vachellia tortilis*	36	300.00	17.91	11	12.22	9.25	23.26	53.39
Total		201		100		100		100	300

Table 2. Species composition, abundance (AB), density (D, ind.ha^{-1}), relative density (RD, %), frequency (FR, %), relative frequency (RF, %), basal area (BA, m^2 ha^{-1}), relative dominance (RDO, %) and Importance Value Index (IVI) of trees in the heavy grazed area

No	Scientific name	AB	D	RD	FR	RF	BA	RDO	IVI
1	*Balanites aegyptiaca*	20	166.67	11.30	9	10.23	6.8	14.53	36.06
2	*Cordial Africana*	8	66.67	4.52	5	5.68	0.43	0.98	11.18
3	*Croton macrostachyus*	2	16.67	1.13	2	2.27	2.23	5.08	8.48
4	Dichrostachys cinerea	7	58.33	3.95	6	6.82	1.21	2.76	13.53
5	*Ficus sur*	1	8.33	0.56	1	1.14	1.15	2.62	4.32
6	*Olea europaea*	3	25.00	1.69	3	3.41	3.38	7.70	12.8
7	*Sengalia senegal*	18	150.00	10.17	9	10.23	1.64	3.73	24.13
8	*Vachellia albida*	8	66.67	4.52	7	7.95	4.8	10.93	23.40
9	*Vachellia brevispica*	9	75.00	5.08	8	9.09	4.13	9.40	23.57
10	*Vachellia mellifera*	18	150.00	10.17	9	10.23	1.95	4.44	24.84
11	*Vachellia nilotica*	8	66.67	4.54	4	4.55	1.01	2.30	11.39
12	*Vachellia oerfeta*	16	133.33	9.04	4	4.55	0.99	2.25	15.84
13	*Vachellia seyal*	27	225.00	15.25	10	11.35	5.9	13.43	40.03
14	*Vachellia tortilis*	32	266.67	18.08	11	12.50	8.72	19.85	50.43
Total		177		100		100		100	300

The shrubs also showed high abundance, relative frequency, relative density and relative dominances in the heavy grazed area compared to the low grazed area. This reflects that bush encroaching on the heavy grazed area was due to overgrazing. Of the species, the *Maytenus arbutifolia* (733.33 ind.ha^{-1}) showed a high density followed by *Capparis tomentosa* (666.67ind.ha^{-1}) and *Carissa spinarum* (633.33ind.ha^{-1}) in the low grazed area while *Dodnonaea viscosa* (133.33 ind. ha^{-1}) and *Grewia bicolor* (100 ind.ha^{-1}) have low density.

Table 3. Species composition, abundance (AB), density (D, ind.ha^{-1}), relative density (RD, %), frequency (FR, %), relative frequency (RF, %), basal area (BA, m^2 ha^{-1}), relative dominance (RDO, %) and Importance Value Index (IVI) of shrubs in low grazed area

No	Scientific name	AB	D	RD	FR	RF	BA	RDO	IVI
1	*Capparis tomentosa*	20	666.67	20.20	10	17.24	11.10	20.69	58.15
2	*Carissa spinarum*	19	633.33	19.19	8	13.79	7.91	14.74	47.72
3	*Celtis africana*	6	200	6.06	5	8.62	6.76	12.60	27.28
4	*Dodnonaea viscosa*	3	133.33	3.03	3	5.17	2.57	4.79	12.99
5	*Ephorbia tirucalli*	6	200	6.06	5	8.62	5.22	9.73	24.41
6	*Grewia bicolor*	4	100	4.04	3	5.17	4.67	8.70	17.91
7	*Lantanea camara*	8	183.33	8.08	7	12.07	4	7.46	27.61
8	*Maytenus arbutifolia*	22	733.33	22.22	10	17.24	7.35	13.70	53.16
9	*Maytenus senegalensis*	6	200	6.06	4	6.90	1.86	3.47	16.43
10	*Rhus glutinosa*	5	266.67	5.05	3	5.17	2.21	4.12	14.34
Total		99		100		100		100	300

Table 4. Species composition, abundance (AB), density (D, ind.ha^{-1}), relative density (RD, %), frequency (FR, %), relative frequency (RF, %), basal area (BA, m^2 ha^{-1}), relative dominance (RDO, %) and Importance Value Index (IVI) of shrubs in the heavy grazed area

No	Scientific name	AB	D	RD	FR	RF	BA	RDO	IVI
1	*Capparis tomentosa*	23	766.7	17.8	10	14.92	72.55	10.90	43.66
2	*Carissa spinarum*	15	500.0	11.6	8	11.94	80.00	12.02	35.59
3	*Celtis africana*	15	266.7	11.6	7	10.45	73.75	11.08	33.16
4	*Dodnonaea viscosa*	14	466.7	10.9	6	8.96	66.67	10.02	29.83
5	*Ephorbia tirucalli*	10	333.3	7.8	4	5.97	68.39	10.28	24
6	*Grewia bicolor*	8	266.7	6.2	5	7.46	18.84	2.83	16.49
7	*Lantanea camara*	12	400	9.3	6	8.96	46.08	6.93	25.19
8	*Maytenus arbutifolia*	14	566.7	13.2	8	11.94	92.17	13.85	38.97
9	*Maytenus senegalensis*	7	233.3	5.4	6	8.96	116.75	17.47	31.86
10	*Rhus glutinosa*	8	266.7	6.2	7	10.44	30.75	4.62	21.27
	Total	**126**		**100**		**100**		**100**	**300**

The *Capparis tomentosa* showed highest density and relative density followed by *Maytenus arbutifolia, where as Carissa spinarum and Celtis Africana* had a similar relative density in the heavy grazed area. The *Maytenus arbutifolia* (17.24%) and *Capparis tomentosa* (17.24%) showed higher relative frequency followed by *Carissa spinarum* (13.79%) and *Lantana camara* (12.07%) in the low grazed area, whereas, *Capparis tomentosa* (14.93%) had a higher relative frequency in the heavy grazed area. However, *Dodnonaea viscosa, Grewia bicolor and Rhus glutinosa* showed lower relative frequency and had equal distribution. Furthermore, *Euphorbia tirucalli* had a less relative frequency in the low grazed area. The *Maytenus senegalensis*, *Maytenus arbutifolia* and *Carissa spinarum* had 17.47%, 13.85% and 12.02% relative dominance in the heavy grazed area respectively. However, *Grewian bicolor* (2.83%) had less relative dominance in the heavy grazed area. The percentages of species occurrence, relative dominance and relative frequency had different proportion based upon the grazing intensity.

Vegetation structures

Vegetation refers to an assemblage of plants growing together in a particular location (Jennings *et al*., 2003; Mekbib, 2012). The vegetation structure was characterized using size class distribution (height), tree density, height, diameter at breast height (DBH), basal area (BA) (Tamene, 2016) assess number, width and density of vegetation layer and cover and canopy, leaf index, leaf area size. Trees have a wide variety of sizes, shapes and growth habits.

Trees height distribution

Tree height is the vertical distance between the base of the tree and the highest twig at the top of the tree. The height is the basic character to vegetation structure measurement, biomass estimation and determination of woody vegetation's productivity. The height classes of trees and shrubs ranged from 2 to 25 meters. As indicated in the following figures, it was classified into five and the highest percentage of individual species abundance found in 5.1-10m height classes followed by 10.1-15m in the low grazed area whereas, 2-5m height classes in the heavy grazed area.

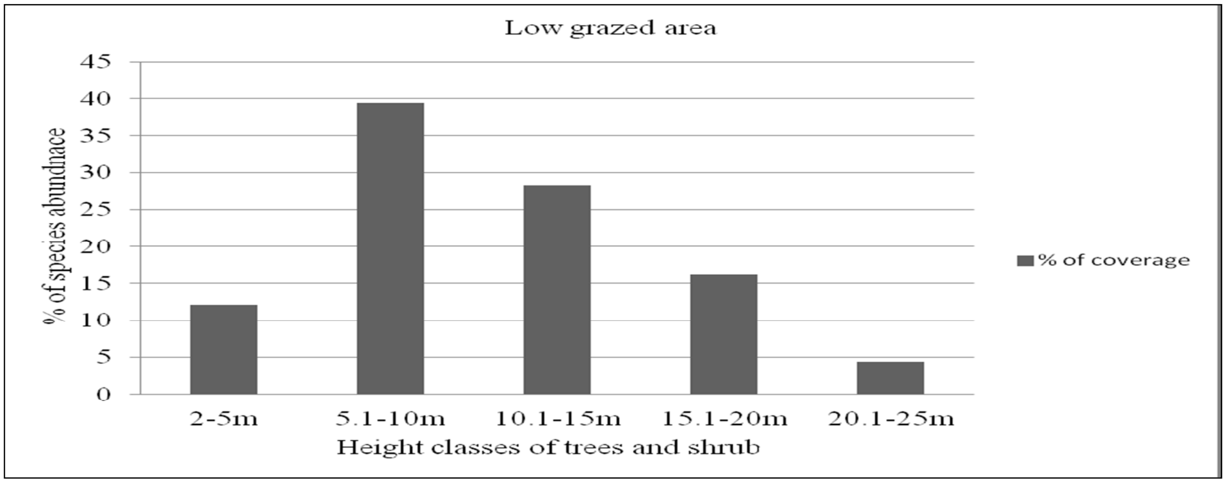

Figure 1. The height classes of trees and shrubs percentage in the low grazed area

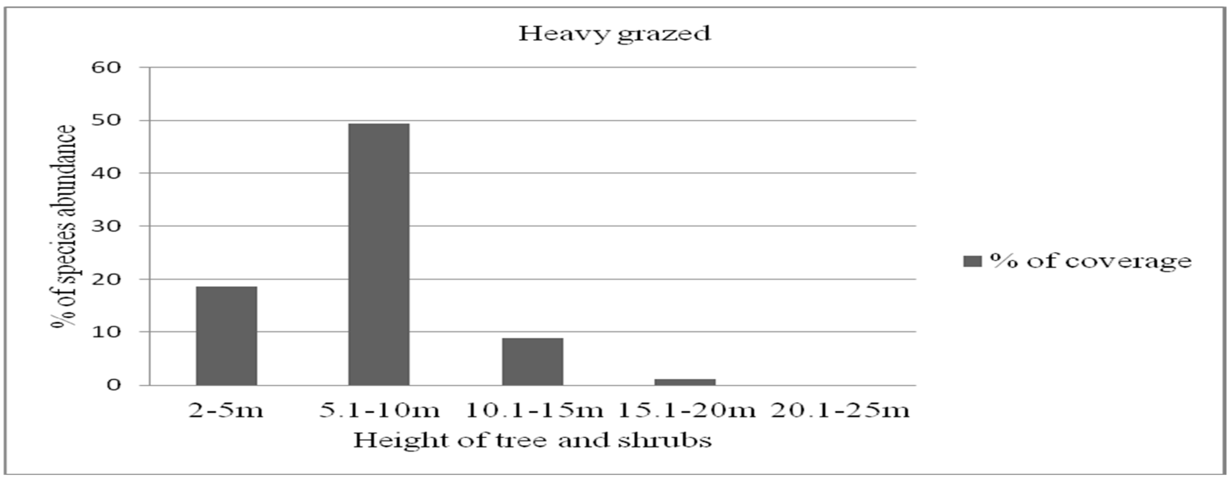

Figure 2. The height classes of tree and shrubs percentage in heavily grazed area

The heavy grazed area showed a high percentage of species abundance in 2-5m height class than the low grazed area. This refers that, the bush encroachment of heavily grazed area than the lower grazed. However, most of the woody vegetation species (49.45%) and (39.39%) in the heavily grazed and low grazed were found in the height class of 5.1-10m, respectively. When the height increased from one class to the other, the density of individual species fell dramatically. The decrease in density with increasing height could be attributed to a high rate of regeneration but irregular recruitment potential. This clearly reveals the dominance of the medium sized individual classes and the presence of high bush encroachment in the grazing lands. It might be due to the presence of competition among the species and the area was disturbed by anthropogenic factors such as deforestation, expansion of agricultural land, overgrazing and unsustainable utilization of species some decades ago (Tolcha, 2005; Mekbib, 2012). Furthermore, Feyera and Demel (2003) revealed that the dominance of small trees and shrubs in the forest suggests that the bigger tree species are selectively removed or exploited. The woody species, particularly, in the low grazed area have longer periods of protection from cutting or logging (Tsegay *et al*. 2017). This indicates that the contribution of the highest height class in the low grazed area.

Diameter at Breast Height.

The diameter at breast height (DBH) is one of the characters of vegetation structure determination. The DBH of woody vegetation was classified into six classes. The highest abundance of woody species percentage found in 10-20cm DBH in both heavy and the low grazed area.

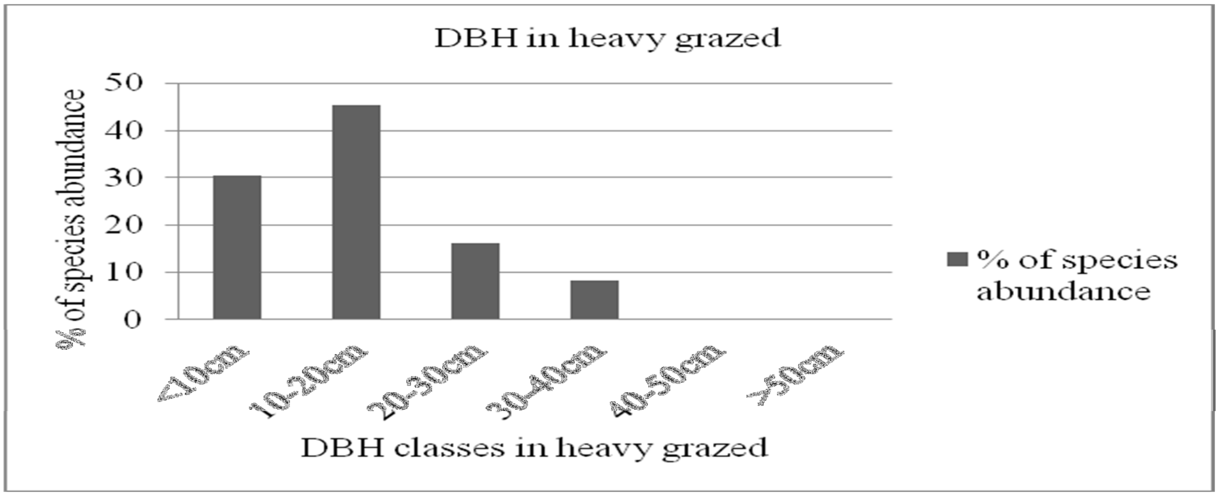

Figure 3. Trees and shrubs DBH classes in the heavy grazed area of ASLNP

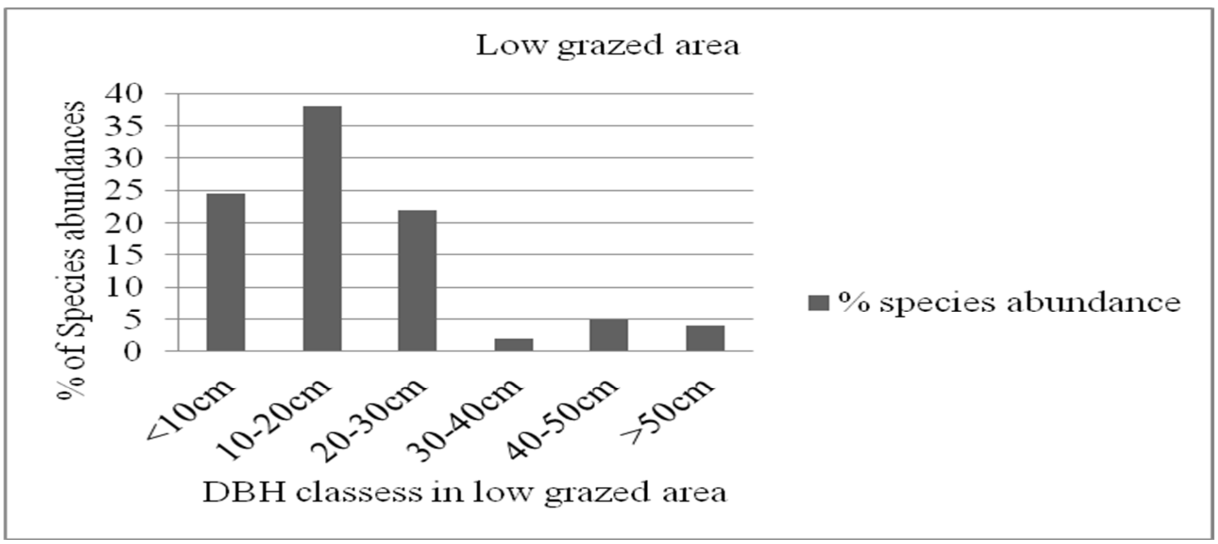

Figure 4. Trees and shrubs DBH classes in the low grazed area of ASLNP

The result in the table shows that the DBH classes of woody trees has the higher proportion (heavy grazed =45.35%; low grazed=38.78%) of woody species in the DBH class of 10-20cm and the lowest in the DBH classes of 40-50cm and >50cm (heavy grazed) and >50cm (low grazed). These results indicate that as DBH increase, the number of individual decrease and a similar result was reported by Tesfaye *et al,* (2013) at Jibat natural forest west Shoa zone. This reflects that the status of grazing land was under serious degradation due to overgrazing, browsing and human activities (Garuma and Wendawek, 2016) such as charcoal and firewood production. According to Garuma and Wendawek, (2016) there are six different sizes of DBH classes that can be defined as follows: <10 cm, 10-20cm, 20-30cm, 30-40cm, 40-50cm and >50cm and a similar report was indicated as (<20cm) DBH were dominating the grazing land/Ecosystem. In general, similar to the DBH, the result indicated that the proportion of trees in each successive class decreased as the height class increase.

Herbaceous Botanical Composition and Related Parameter

A total of 40 herbaceous species, that belonged into (18) families were recorded and identified. Of these, 20 species (60.61%) were forbs and 13 species (39.39%) were grasses in the heavy grazed area and 21 species (52.5%) were forbs and 19 species (47.5 %) were grasses in the lower grazed area. The Poaceae has the largest proportion followed by Euphorbiaceae family. In terms of the life forms of grass species 4 (30.77%) were annuals and 9 (69.23%) were perennials in the heavy grazed area and 6 (31.58%) were perennial and 13 (68.42%) were annual in the low grazed area. Therefore, the perennial species were decreasing due to increasing of grazing intensity. This revealed that the impact of overgrazing on herbaceous species abundance, the species compositions and life forms. In addition, the overgrazing influences the perennial plants and replacement of weeds in the grazing land. Grazing exerts more pressure on the most palatable plant species, which may decrease depending on grazing system and exclusion periods, changing grassland floristic composition (Taboada *et al.,* 2011). Generally, there was a decline in decreasers and an increase in increasers along grazing intensity from low grazed into the heavy grazed area. Furthermore, the proportion of highly desirable species decreased with increasing grazing pressure, while the abundance of herbaceous species with lower forage values tended to increase in the Abijata Shalla lake national park. The biomass of herbaceous species also decreased with species composition.

Trees and shrub species richness, diversity, evenness

The individual abundance of species result showed that there was a significance difference (P<0.05) between the heavy and the low grazed area (Table 5). The Low grazed area has a high species abundance than the heavy grazed area. This states that the heavy grazed area was exploited for anthropogenic impacts. However, the species richness of woody vegetation does not have significant variation (P>0.05) between high and the low grazed area.

Table 5. Woody species richness, diversity and evenness in Abijata Shalla lake national park

	Species richness	Individuals abundnace	Shannon_H	Evenness_e^H/S
Heavy grazed	7.17± 0.49[a]	17.83± 2.10[b]	1.73± 0.07[a]	0.82± 0.02[a]
Low grazed	8.67± 0.56[a]	26.67± 1.71[a]	1.86± 0.08[a]	0.77± 0.03[a]
Mean	7.92± 0.39	22.25± 1.61	1.80± 0.05	0.79± 0.02
CV	22.90	29.82	14.01	10.63
P-value	0.0550	0.0036	0.2196	0.1632

CV=coefficient variation

a* Means with the same letter in the same column are not significantly different at P<0.05.

The heavy grazed area had lower species richness of woody vegetations than the low grazed area with an overall mean of (7.92). The Shannon diversity and evenness also does not indicate a significant difference and had a mean value of 1.8 and 0.79 respectively. This result revealed that the Abijata Shalla Lake National park, grazing land was less diversified of trees and shrub vegetation. It was dominated by fabaceae family, particularly Vachellia species.

Herbaceous species richness, diversity, and evenness

The species richness, diversity and evenness of the herbaceous layer has a significant variation (P<0.05) between the heavy and the low grazed areas.

Table 6. Herbaceous species richness, diversity and evenness in the ASLNP grazing strata

	Species richness	Shannon_H	Evenness_e^H/S
Low Grazed	26.95±0.2[a]	2.32±0.4[b]	0.39±0.12[b]
Heavy grazed	20.32±0.15[b]	2.61±0.5[a]	0.70±0.03[a]
Mean	23.63±0.3	2.47±0.4	0.54±0.02
CV	20.81	11.36	14.10
p-value	<.0001	<.0001	<.0001

CV = *coefficient variation*

a* Means with the same letter in the same column are not significantly different at P<0.05.

Overgrazing influences the species richness, diversity and similarity of the herbaceous vegetation. It resulted in gradual changes in the vegetation species compositions, with a consequent reduction in the diversity and loss of some native species (Wang and Batkuishig, 2014). The species richness was influenced by grazing pressure along grazing strata which was by Asheber *et al*. (2010) also similar results in Allaidege Rangeland. The species diversity index ranges from 1.5 - 3.5 and rarely greater than 4 (Magurran, 2004). The Shannon index increases as both the richness and the evenness of the community increase (Kerkhoff, 2010). The high value of Shannon indices indicates that there is a high diversity of species.

Table 7. Effects of grazing pressure on the herbaceous species composition, coverage and bare land of the study area

	No of species	Forbs abundance	Legumes	Grasses abundance	% Coverage	% Bare
Heavy grazed	16.29±0.63[b]	6.54±0.33[b]	1.89±0.28[a]	7.88± 0.42[b]	35.80±1.67[b]	63.10±2.05[a]
Low grazed	19.59±0.59[a]	8.33±0.36[a]	2.05±0.23[a]	9.21±0.47[a]	50.39±1.92[a]	49.12±1.94[b]
Mean	17.97±0.46	7.45± 0.26	1.98±0.18	8.56±0.32	43.21± 1.44	56. 00±1.55
CV	26.42	36.07	36.07	40.28	32.32	27.62
P-Value	0.0002	0.0004	0.6771	0.0365	<.0001	<.0001

CV = *coefficient variation*

a* Means with the same letter in the same column are not significantly different at P<0.05.

The species composition of herbaceous species has significant variation (p<0.05) with the grazing pressure. The grazing pressure influences the forbs and grasses abundance while the legumes did not show significant change with grazing pressures. The low grazed area showed the high mean value of forbs, grasses and legumes abundance than the heavy grazed area. The other impact of overgrazing is the replacement of productive species with weed species that are increasing with vegetation cover.

The proportion and the percentage of coverage of grasses and forbs were higher in the low grazed area than heavily grazed. The bare land coverage is high in the heavy grazed site (63.10%) than the low grazed area (49.12%) due to overgrazing (P<0.05) and trampling. A similar result was reported by Tessema *et al.,* (2011) where they explained grazing pressure had a highly significant effect on the percentages of bare ground and basal cover of herbaceous species. Similarly, the percentage basal cover of herbaceous species was larger on the low grazed sites. Low grazing sites also had a higher standing biomass of herbaceous species compared with the heavy grazing sites (Tessema *et al.,* 2011). The species composition and palatable plant species decreased by grazing (Taboada *et al.,* 2011) and excessive grazing are detrimental to plant communities. Primary production in overgrazed grasslands can decrease if herbivores decrease plant growth capacity, vegetation density, community biomass, or community composition changes. Additional effects of overgrazing include decreased species diversity, proliferation of unpalatable species, increased soil erosion, and degradation of soil quality (Conant *et al.,* 2002).

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

From the results of the study, it was possible to conclude that the Abijata shalla Lake national Park was dominated by vachellia species of woody vegetation. However, the poaceae has high dominance of herbaceous species. In addition, the vegetation structure and diversity were influenced by grazing intensity and lack of sustainable managements that has negative influence on the grazing lands. Due to this the heavy grazed area was bush encroached and deteriorated than the low grazed area. Hence, the potential of grazing land and vegetation structures was declined.

RECOMMENDATIONS

The total dry matter production, vegetation structure and diversity of the ecosystem were affected by grazing intensity based upon the abundance of livestock and wild life in the park. Therefore,

- ❖ Appropriate and integrated land management options for different land use systems and natural resource conservation should be done in the sustainable way by stakeholder and responsible organization to enhance the vegetation diversity.
- ❖ The government and policy makers should be aware concerning the impacts of sand mining, soda ash factory and upstream irrigation that affect vegetation species compositions, structures and biomass potential by declining the natural resource.

ACKNOWLEDGEMENTS

The authors would like to expres heartfelt thanks to Oromia Agricultural Research Institute, for providing M.sc opportunity, transport and other inputs during the field work. Ethiopian Wildlife Conservation Authority and Abijata Shalla Lake National Park also deserves special acknowledgment for permit study area. Kufa Edao would be duly acknowledged for his effert while the author works this research.

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