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Assessment of Woody Vegetation Structure in Relation to Different Grazing Areas and Chemical Composition of Major Browse Species in Chifra District, Afar Regional state

Mohammed Abdulatife[1*] Hanfere Mohammed[1] Abule Ebro[2]
1.Dubti Pastoral and Agro-pastoral Research Center P.O.Box 16, Semera (Afar), Ethiopia
2.International Livestock Research Institute, Addis Ababa, Ethiopia

Abstract
The objectives of the study were to assess the woody species composition and chemical composition of major browse species under three grazing areas. The study was undertaken in Chifra district of zone one (Awsi Rasu) of the Afar Regional State. The total tree species recorded in the study district was 14. According to the perceptions of the pastoralists, of the identified woody species, 42.9, 28.6, 21.4 and 7.1% were highly palatable, palatable, less palatable and unpalatable, respectively. Some of the dominant (>20% of the density) and/or common (10% to 20% of the density) woody species in the communal grazing areas of the lower altitude (>550-850m) were *Acalypha fruticosa* and *Solanum incanum.* A long riversides species like *Casuarina equisetifolia* and *Salvadora persiaca* were dominant and/or common. Whereas, *Acacia tortilis*, *C. equisetifolia*, *C. africana* and *G. tembensis* were common and/or dominant in the enclosure areas. A. fruticosa and G. tembensis were common and/or dominant in the communal grazing area of the upper altitude (>850-1100 m) The communal grazing areas had a higher percentage of woody vegetation in two consecutive height classes i.e. >0-0.5 m and >0.5-1m in the lower altitude (>550-850 m) but in the upper altitude (>850-1100 m) a higher percentage of woody vegetation were found in three consecutive height classes, i.e.,>1.5-2m, >2-3m and >3-4m than in the other two grazing areas. The CP content was higher in the composite sample taken from enclosure areas and lowest in riversides grazing areas in both seasons. *Grewia tembensis* was the best tree species with better nutritive value due to higher content of CP, whereas *Balanite aegyptica* was a low quality species relative to the other tree species.
Keywords: Communal, riversides, enclosure, tree species, common and dominant

Introduction

The livelihood of the people depends on livestock husbandry. The livestock sector plays a central role in the economic and social life of the pastoralists and is a corner stone of the economy. Even though there were abundant pasture and water in the region before some years back, the degradation of the natural resources and recurrent drought aggravated the feed shortage. Most of the grass species in the rangeland areas of Afar region is subjected to continuous treat of genetic erosion due to overgrazing, rangeland degradation, invasion and encroachment by undesirable species and the grazing capacity of large area has declined time to time.

Currently, however, the diversity and availability of these resources have diminishing from time to time. Since many of these species provide tree products that are the cornerstone of a family's survival strategy, identifying alternative harvesting/managing and species selection options is an extremely important step towards slowing the deforestation of forests and woodlands, as well as helping to assure supplies of forest products vital to local people. The identification of economically important species is the first step in helping to determine which indigenous species can be managed or cultivated and which other species may be substituted to produce the same end products.

Bush encroachment is an increase in invasive woody plants with a general decline in forage productivity. Bush encroachment leads to reduced grazing potential. It poses a threat to the conservation of biodiversity. Misconceptions of traditional resource management and the impact of fire ban have resulted in bush encroachment. One of the major threats of bush encroachment is reduction of grass production. Exotic and indigenous trees and shrubs are widely spread throughout semi-arid and arid zones of Ethiopia. Out of the exotic tree species *Prosopis juliflora* is currently spreading and encroaching the grazing lands of Afar, Somali and Borana and is causing severe negative impacts on the production and productivity of pastoral areas. This species is spreading at an alarming rate into best grazing areas especially in the Afar rangelands. Other species such as *Acacia drepanolobium, Acacia seyal, Acacia mellifera* and *Acacia nubica* are also causing serious problems by encroaching in dry and wet season grazing areas. Currently, however, the diversity and availability of these resources (mostly indigenous tree species) have diminishing from time to time. Hence, assessing and knowing the status of woody species in the rangeland area will be very important for future development interventions. Therefore, this study is initiated with the aim to identify the major indigenous woody species, to see their diversity and use categories as well as to document the chemical composition of the most important indigenous tree species for conservation and sustainable utilization of trees in Chifra district of Afar region.

Objectives

- ✓ To assess the woody composition in different grazing areas
- ✓ To know the chemical composition of the most important indigenous tree species

Material and methods

Description of the study area

The study was conducted in Chifra district of Afar Region, during the 2009 growing season. Annual rainfall averages 400-600 mm, but is highly variable (APARDB, 2006). The main rainy season is from July to September, inclusive, and the second, shorter rainy season from February to April, inclusive. The average temperature of the area is about 29^{o}C. The number of rainy days per month is the highest in August.

Sampling procedures

Site selection and layout

For the woody vegetation assessment study, the rangeland in the study district was stratified based on altitude and grazing areas. Accordingly, the altitude classifications used were >550-850 m a.s.l and >850-1,100 m a.s.l. Furthermore, the grazing areas were stratified as communal grazing, riversides and enclosure, which represent the major grazing areas of the pastoral community. The sampling procedure was stratified random sampling technique (ILCA, 1990).

The number of sampling range sites from altitudinal range between >550-850m a.s.l were 11 from communal grazing, 6 from riversides and 2 from enclosure areas and from the altitudinal range between >850-1100 m a.s.l., 4 from communal grazing, 2 from riversides and 2 from enclosure areas. The allocation of range site is based on the grazing potential and the availabity of rangeland (proportional sampling method). In each range site, a sampling block of 3 km by 1 km was demarcated and further stratified into three sample plots of equal size based on landscape.

The density and height of the woody plant species were recorded in each sample plot (belt transect) (20m x 20m), only live woody plant species were recorded and identified. To estimate the woody plants density per hectare, the number of individuals of each tree and shrub species was counted. All plant heights were measured using calibrated aluminum poles of 2 and 5 meters and categorized into eight height classes, namely >0 - 0.5 m; >0.5 - 1 m; >1 - 1.5 m; >1.5 - 2.0 m; >2 -3 m; >3 - 4 m; >4 - 5 m and >5 m (Friedel, 1987).

Species Identification

In each study sample plot (belt transect) (20m x 20m), elder pastoralists and knowledgeable people were consulted to identify the local name of each woody plants. Nomenclature of the plant species followed the Flora of Ethiopia (Hedberg and Edwards, 1989; 1995) and the Flora of Tropical East Africa (Cufodontis, 1953-1972).

Chemical analysis of browse species

Chemical analyses were undertaken on three browse species. Samples were stratified by season i.e., rainy season (from Mid-June to Mid-September) and dry season (from November to February) and types in order to know the difference in nutrient composition. Sample from tree species was taken from three different heights (strata); i.e., upper, middle and lower strata of the canopy and a composite sample was taken after thoroughly mixing from at least five trees per species. The sample was collected and air dried, kept in air tight paper bags and moved to Haramaya University Animal Nutrition Laboratory. Samples of each species were milled using a simple laboratory mill to pass through 1mm sieve and oven-dried at 60^{0}C for 72 hours and prepared for further determination of %DM, %Ash, %CP, %NDF, %ADF and %ADL. Dry Matter (DM), ash, nitrogen were determined according to AOAC (1990) procedure. The crude protein was estimated by multiplying the N percentage by 6.25. Neutral Detergent Fiber (NDF), Acid Detergent
Fiber (ADF), and Acid Detergent Lignin (Lignin) were analyzed following the procedures of Van Soest and Robeson (1985).

Statistical analysis

The frequency of each tree species was expressed as a percentage of the total number of tree plant found in the study area. The proportion of the different tree species according to their desirability was calculated using percentage.

For the woody vegetations, each of the belt transact of 20 m x 20 m at each of the sample plot was taken as experimental unit. Accordingly, the altitude range between >550-850 m a.s.l. (Communal = 33 samples, Riversides = 18 samples, and Enclosure = 6 samples) and altitude range between >850-1100 m a.s.l (Communal = 12 samples, Riversides = 6 samples and Enclosure = 6 samples) was used for data analysis.

Result and Discussion

Woody Vegetation Composition and Height class

A total of 14 woody species were identified in upper and lower altitudes of the study district (Table 1) and the percentage abundance of each species is given in Appendix Table 1. According to the perceptions of the pastoralists, of the identified woody species, 42.9, 28.6, 21.4 and 7.1% were highly palatable, palatable, less palatable and unpalatable, respectively. From the highly palatable species, the largest was contributed by different species of *Acacia, Cordia* and *Grewia* which are very important for animals like camels and goats. Of the identified highly palatable category (5) in lower altitude (>550-850m), 4 woody species (80%) were found in enclosure areas and 2 woody species (40%) were found in communal grazing areas. In upper altitude (>850-1100m), 6 woody species (100%) were recorded from enclosure areas, 4 woody species (66.7%) in communal and 2 woody species (33.3%) in riverside grazing areas.

Some of the dominant (>20% of the density) and/or common (10% to 20% of the density) woody species in the communal grazing areas of the lower altitude (>550-850m) were Acalypha fruticosa and Solanum incanum. A long riversides species like Casuarina equisetifolia and Salvadora persiaca were dominant and/or common. Whereas, Acacia tortilis, C. equisetifolia, C. africana and G. tembensis were common and/or

dominant in the enclosure areas. A. fruticosa and G. tembensis were common and/or dominant in the communal grazing area of the upper altitude (>850-1100 m) and along riverside grazing areas only C. equisetifolia was dominantly found Acacia nilotica, C. africana and G. termbensis were commonly and/or dominantly found in the enclosure areas of the upper altitude (>850-1100 m).

G. tembensis and C. africana were the most important woody species that are browsed by livestock but their availability was limited only in the enclosure grazing areas. Acacia species were found in upper and lower altitudes of the study district, which are used as animal feeds and also the pods are eaten by camels, goats, sheep and cattle as protein supplement. Of Acacia species, A. nilotica and A. seyal were very important woody plants but *A. nubica* and *A. mellifera* are invading plants based on pastoral opinion. The latter two *Acacia* species especially *A. nubica* was spreading at alarming rate in lower altitude (>550-850 m a.s.l.) of the study district. Livestock are an important means of seed disposal and propagation in the rangelands (Amaha, 2006). Moreover, consumption of the pods by livestock and the delignification of the seed cover in the animal digesta is believed to contribute to the expansion of encroaching woody plants such as *A. mellifera* and *A. nubica* in the rangelands over a vast area (Amaha, 2006).

Table 1. Woody species composition, use values, relative abundance in different altitudes and grazing areas of the Chifra district in Afar Region

Woody plant species	Cg (Use values)	>550-850 m a.s.l			>850-1100 m a.s.l		
		C	R	E	C	R	E
Acacia mellifera	Lp	P	P	P	-	-	-
Acacia nilotica	Hp	-	-	P	P	P	D
Acacia nubica	Lp	P	P	P	-	-	-
Acacia tortilis	Hp	-	-	C	-	P	P
Acacia seyal	Hp	-	-	-	P	-	P
Balanites aegyptica	Pl	P	P	P	P	P	-
Casuarina equisetifolia	Pl	-	C	C	P	D	-
Acalypha fruticosa	Pl	D	P	P	C	P	P
Cordia Africana	HP	P	-	C	P	-	D
Vernonia natalensis	P	P	-	-	-	P	-
Grewia termbensis	Hp	-	-	D	D	P	C
Salvadora persica	Lp	-	D	-	-	P	-
Ziziphus mucronata	Hp	P	-	-	-	-	P
Solanum incanum	Up	C	P	-	-	-	-

Note: Cg = Categories; C = Communal grazing areas; R = Riverside grazing areas; E = Enclosure; Hp = highly palatable; Pl = Palatable; Lp = Less palatable; Up = Unpalatable; D = Dominant (>20%); C = common (10-20%); P = Present (<10% of the total woody plant) and - = Absent

Acacia nubica and *S. incanum* were commonly found in the communal rangeland areas of the study district in lower altitude (>550-850 m a.s.l.), while they did not occur in the communal grazing areas of the upper altitude (>850-1100 m a.s.l). The possible reason might be the communal grazing areas in the lower altitude accommodates more number of animals than the communal grazing areas in the upper altitude which might have caused overgrazing which favors the invasion of the area by aggressive encroacher species.

However, the increase in the encroacher woody plant is a threat for the productivity of the herbaceous layer, which will result in a decline of grass production for livestock species mainly the grazers. This finding is similar to the report of Amaha (2006), who indicated that *A. nubica* was a highly aggressive encroacher plant and mostly grow in denuded grazing areas.

From the identified *Acacia* species, *A. seyal* was recorded only in upper altitude (>850-1100 m a.s.l.) of the study district and this species has been regarded as a very important feed source for various ruminants. *S. incanum* was commonly found in communal and riverside grazing areas in the lower altitude (>550-850 m a.s.l.) but there were not available in upper altitude (>850-1100 m a.s.l.) of the study district. This might be as result of high grazing pressure on rangelands which favored the growth of unpalatable and poisonous plants. Dale and Greeenway (1961) and Irvine (1961) reported that *Solanum* species are indicators of a change in the condition of the rangeland towards deterioration and are also considered as poisonous plants species in Ethiopia (Mekonnen, 1994). From this result, the lower altitude (>550-850 m a.s.l.) of the grazing areas like communal and along riverside grazing areas were invaded by less palatable and unpalatable woody species.

This shows that, in the lower altitude (>550-850 m a.s.l.), the grazing areas were invaded by encroaching plants and which might affected the productivity of the herbaceous layer. This finding was in line with the report of Barnes (1997).

Woody Vegetation Height class in upper and lower altitude

In both altitudes of the study district, the height classes >1-1.5 m and >1.5-2 m constituted a higher percentage than the other height classes (Figure 1).This showed that the rangeland of the study district was largely invaded by small bushes and shrubs. As indicated in the study of Belaynesh (2006), very high abundance of small bushes and shrubs suggest that the rangeland might have been exposed to increased anthropogenic disturbances. The first three height classes (i.e., >0-0.5 m, >0.5-1 m and >1-1.5 m) were mostly found in the >550-850 m altitude but the rest five height classes (i.e.,>1.5-2 m, 2-3 m,>3-4 m,>4-5 m and >5 m) were found in >850-1100 m altitude category. This showed that most of the small bushes and shrubs are found in lower altitude (>550-850 m a.s.l.) and the dominance of the three height classes in lower altitude (>550-850 m a.s.l.) were due to their inherent physiological growth pattern; as there is frequent moisture stress and high evaporation, the plant grow more in roots than in shoot (White, 1983). In upper altitude (>850-1100 m a.s.l.) the woody plants were relatively taller. This could be due to some forest remains and the less wood cutting practice for fuel wood sale and charcoal making.

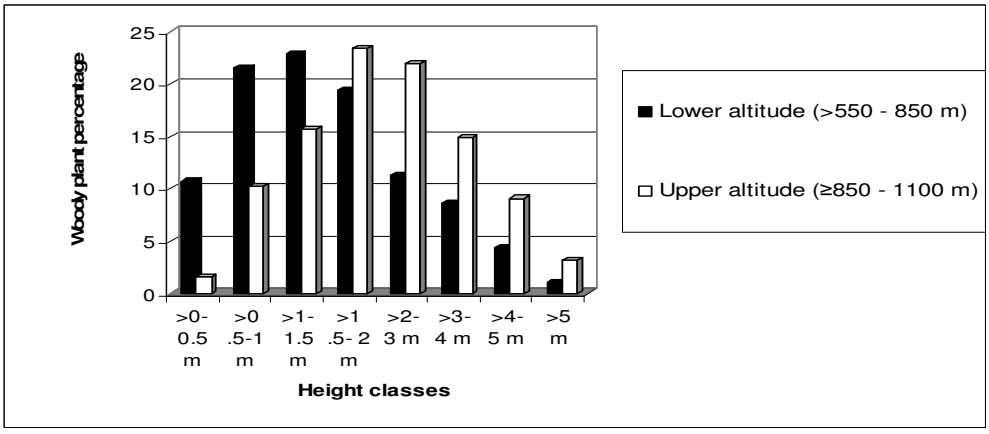

Figure 1. Percentage composition of the different height classes of woody species in upper and lower altitudes of Chifra district in Afar Region

The communal grazing areas had a higher percentage of woody vegetation in two consecutive height classes i.e. >0-0.5 m and >0.5-1m in the lower altitude (>550-850 m) but in the upper altitude (>850-1100 m) a higher percentage of woody vegetation were found in three consecutive height classes, i.e.,>1.5-2m, >2-3m and >3-4m than in the other two grazing areas (Figures 2 and 3). This showed that the woody plants in the upper altitude (>850-1100 m) were taller in their height than the woody plants in the lower altitude (>550-850 m). The possible reasons for this are already discussed above.

The riverside grazing areas of the study district was dominated by four consecutive height classes i.e., >2-3m, >3-4m, >4-5m and >5m (Figures 2 and 3). Looking at the share of each species to these height classes (Appendix Tables 4 and 5), the less palatable and unpalatable species like *A. mellifera* and *S. incanum*, contributed a high share. The enclosure areas in the lower altitude (>550-850 m) were dominated by the height class >1-2m, while in upper altitude (>850-1100 m) it was dominated by >0.5-1m and >3-4m height classes.

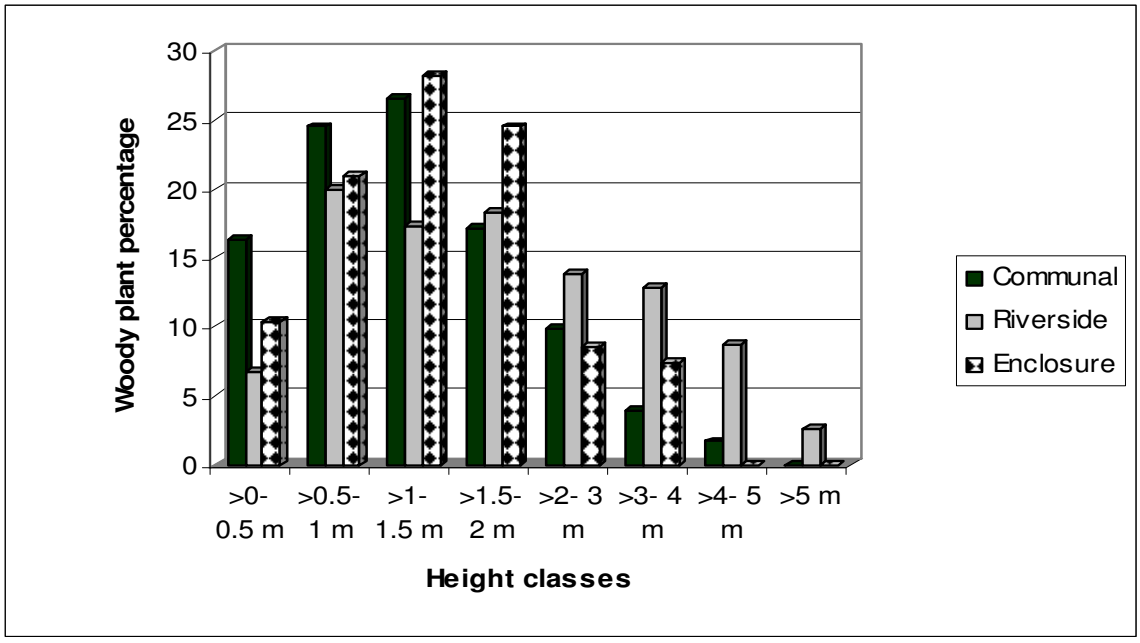

Figure 2. Woody vegetation height classes in lower altitude of Chifra district in Afar Region

The palatable and highly palatable species like *C. equisetifolia* and *A. tortilis* were commonly observed in the enclosures areas of the lower altitude (>550-850 m). This was because of the thinning practices of the pastoralists of the less palatable and unpalatable woody plants from the enclosure areas, whereas, the species *A. nilotica* and *C. africana* dominated the enclosures in the upper altitude (>850-1100 m) (Appendix Tables 29 and 30). This might be due to ecological effect because the grazing areas in the upper altitude (>850-1100 m) received a better amount of rain fall than the areas in the lower altitude (>550-850 m).

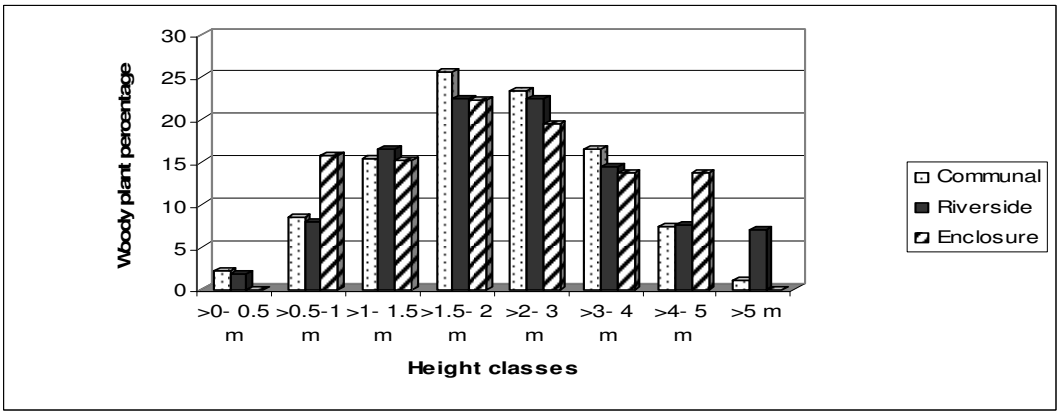

Figure 1. Woody vegetation height classes in upper altitude of Chifra district

In general, it can be concluded that in the lower altitude (>550-850 m), the three lowest consecutive height classes, i.e.,>0-0.5m, >0.5-1m and >1- 1.5m dominated the communal grazing areas. This might be due to over-browsing that resulted from high livestock pressure on the communal grazing areas and it could be due to cutting of the bigger trees and shrubs for use as fuel wood and construction purposes. Whereas the height classes 2-3m, >3-4m, >4-5m and >5m dominated the riverside grazing areas in the lower altitude (>550-850 m). This showed that, some forest remain in the lower altitude of the study district. However, in the enclosure grazing areas of the lower altitude (>550-850 m), a fair distribution of the height classes starting from >0.5-1m to >1.5-2m was observed. Meanwhile, there were a fair distribution of the height classes starting from >1-4m in the three grazing areas i.e. enclosure; riverside & communal in upper altitude (>850-1100 m).

The woody vegetation structure study revealed that in upper altitude (>850-1100 m) four height classes (Figure 3) >1-1.5 m; >1.5 -2m; >2-3 m and >3-4m contributed the highest percentage whereas in lower altitude (>550-850 m) three height classes >0.5 -1 m; >1 -1.5m and >1.5-2m contributed for the highest percentage and this could be associated with the low rainfall (greater aridity experienced) and cutting of bigger trees and shrubs for use as fuel and charcoal making were common in the study area. With decreasing and erratic rainfall, the height of woody vegetation decreased from 15 m to 3 m (Langdale-Brown *et al.*, 1964: cited in Herlocker, 1999). This result is in line with that reported by Blaynesh (2006) for Jijiga rangelands, which exhibited that

most of the woody vegetation fell in the height class of 1-3 m. The height classes up to 1.5 m fell within the mean browsing heights of goats (Aucamp, 1976; Dayton, 1978) while the height categories >2 to 4 m fell within the browsing heights of camels. Therefore, the finding of this study clearly showed that the grazing areas in the >550-850 m altitude of the study district can be used for rearing of browsing animals.

Chemical Composition of Browse species

The highest ash content during wet season was found in *Balanite aegyptica*, while in dry season the lowest ash content was found in *Acacia nilotica.* The higher CP content was found in *Grewia tembensis* and the lowest in *B. aegyptica* in both seasons. The lowest and highest NDF content were found in *G. tembensis* and *B. aegyptica* during the wet and dry seasons, respectively. The lowest ADF content was found in *A. nilotica* during wet season, while *G. tembensis* had the lowest ADF content during the dry season. The ADL content ranged from 5.1% in *A. nilotica* to 5.66% in *B. aegyptica* during the wet season while in the dry season ADL content varied from 4.7% in *G. tembensis* to 8.62% in *B. aegyptica* (Table 2). The CP content of woody plants was negatively correlated with NDF, ADF and ADL (Gemedo, 2004) whereas NDF, ADF and ADL were strongly and positively correlated with each other (Ammar, 2004). In case of woody/browse species, *G.tembensis* had a higher quality followed by *A.nilotica.*

Compared to grasses and composite samples, the chemical composition of browse species is subject to less variation with seasons (Ibrahim, 1981) and this particularly enhances their value as dry season feeds for livestock (Dicko and Sikena, 2004). Heitschmidt *et al*. (1995) concluded from CP and fiber concentrations that the principal factor affecting forage quality values was the age of a tissue. As the stage of harvesting increased, the ADF content also increased which is in agreement with the findings of Kidane (1993) and Yihalem (2004). According to Beever *et al.* (2000), as forage species mature, the concentration of CP declines due to increased stem: leaf ratio and sugars. As the maturity of forage grasses advanced, the concentrations of cellulose, hemi-cellulose and lignin increase and the proportion of forage organic matter digested in the whole digestive tract decreases. The degree of lignification and cell wall content greatly determine the extent of forage digestion and, therefore, most predictions of forage nutritive value are based on estimates of cell wall fractions (Adesogan *et al*., 2000).

Table 2. Chemical composition of browse species collected in the wet and dry seasons at Chifra district in Afar Region

Species	DM (%)	As (%)	ADF (%)	ADL (%)	NDF (%)	CP (%)
			Wet season			
Grewia tembensis	92.5	13.9	28.8	5.4	30	22
Balanite aegyptica	92.7	14.1	28.1	5.6	36.0	17
Acacia nilotica	92.9	6.0	21.5	5.1	34.2	18
Mean ± SD	92.7 ± 0.2	11.3 ± 4.5	26.1 ± 4.0	5.3 ± 0.2	33.4 ± 3.0	19 ± 2.6
			Dry season			
Grewia tembensis	90.0	14.5	18.5	4.7	32.3	17
Balanite aegyptica	90.6	15.2	23.8	8.6	47.3	12
Acacia nilotica	89.2	16.4	24.8	7.2	38.6	14
Mean ± SD	89.9 ± 0.7	15.4 ± 0.9	22.4 ± 3.3	6.8 ± 1.9	39.4 ± 7.5	14.3 ± 2.5

Conclusion

The woody vegetation was affected much by over-utilization and prolonged droughts. Rangeland woody vegetation degradation has been increased time to time due to overgrazing, drought, invasion of new unpalatable species and so on. As a result of these factors, the rangelands in the study district are dominated by less palatable and undesirable drought tolerant species, which in turn might affect the sustainable production of livestock in the area. The level of woody vegetation degradation in lower altitude (>550-850 m) of the study district was higher than that of the upper altitude (>850-1100 m). This might be due to precipitation and livestock number differences. From this finding, it can be concluded that the woody vegetation found in the lower altitude of the study area, is mostly unpalatable and drought tolerant thorny species while in upper altitude the woody vegetation is palatable and most of the species are preferable by pastoralists for camel and goat feeds and also for medicinal purpose. Woody/browse species chemical composition, G. *tembensis* had a higher quality interms of Crude protein in both wet and dry seasons followed by *A.nilotica.* Therefore preservation of promising tree species by collecting and multiplying through seedling in order to planting in degraded areas.

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ANNEX

Appendix Table 1. Woody species density in percentage per hectare on three grazing areas of Chifra district in Afar Region

Woody plant species	Vernacular name	Cg	>550-850 m a.s.l			>850-1100 m a.s.l		
			C	R	E	C	R	E
Acacia mellifera	-	Lp	4.2	8.4	4.2	-	-	-
Acacia nilotica	*Keselto*	Hp	-	-	6.2	8.4	9.4	25.1
Acacia nubica	*Gerento*	Lp	8.7	6.3	8.7	-	-	-
Acacia tortilis	*E'eb*	Hp	-	-	18.3	-	8.0	7.2
Acacia seyal	*Agdento*	Hp	-	-	-	6.31	-	8.4
Balanites aegyptica	*Uda*	Pl	5.6	8.6	5.6	8.0	6.6	-
Casuarina equisetifolia	*Segento*	Pl	-	17.9	11.3	8.9	42.3	-
Acalypha fruticosa	*Subahe*	Pl	41.3	7.9	8.3	17.1	8.7	5.6
Cordia Africana	*Medira*	HP	7.0	-	7.0	7.1	-	31.2
Vernonia natalensis	*Kandeda*	P	8.3	-	-	-	8.3	-
Grewia termbensis	*Hedayto*	Hp	-	-	30.1	44.1	7.2	14.1
Salvadora persica	*Adayto*	Lp	-	42.1	-	-	9.2	-
Ziziphus mucronata	*Kusra*	Hp	6.2	-	-	-	-	8.2
Solanum incanum	-	Up	18.3	8.5	-	-	-	-

Note: Cg = Categories; C = Communal grazing areas; R= Riverside grazing areas; E = Enclosure; Hp = Highly palatable; Pl = palatable; Lp = Less palatable; Up= Unpalatable; D = Dominant (>20%); C = Common (10-20%); P = Present (<10% of the total woody plant) and - = Absent.

Appendix Table 2. Distribution of woody plant on three grazing areas based on palatability

Degree of palatability	Grazing Types							
	Riverside		Communal		Enclosure		Total	
	No	Per	No	Per	No	Per	No	Per
Highly palatable	4	66.7	5	83.3	6	100	6	42.9
Palatable	2	50	3	75	3	75	4	28.6
Less palatable	3	100	2	66.7	2	66.7	3	21.4
Unpalatable	1	100	1	100	0	0	1	7.1
Total							14	100

- N^{o} = Number; Per = Percentage

Appendix Table 3. Woody plant species identified in Chifra district in Afar Region

No	Scientific name	Vernacular name	Categories
	Woody plant species		
1	*Acacia mellifera*	-	Lp
2	*Acacia nilotica*	*Keselto*	Hp
3	*Acacia nubica*	*Gerento*	Lp
4	*Acacia tortilis*	*E'eb*	Hp
5	*Acacia seyal*	*Agdento*	Hp
6	*Casuarina equisetifolia*	*Segento*	Pl
7	*Acalypha fruticosa*	*Subahe*	Pl
8	*Cordia africana*	*Medira*	Hp
9	*Vernonia natalensis*	*Kandeda*	Pl
10	*Grewia termbensis*	*Hedayto*	Hp
11	*Salvadora persiaca*	*Adayto*	Lp
12	*Ziziphus mucronata*	*Kusra*	Hp
13	*Solanum incanum*	-	Up
14	*Balanite egyptica*	*Uda*	Pl

Hd = Highly desirable; D = Desirable; Ld = Less desirable; Ud = Undesirable; Hp = Highly palatable; Pl = Palatable; Lp = Less palatable and Up = Unpalatable

Appendix Table 4. Height classes of woody plant species in three grazing areas of lower altitude

Woody plant species	Grazing types and height classes																							
	Communal								Riversides								Enclosure							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Acacia mellifera	0	0	3	5	6	0	0	0	0	0	0	9	4	2	0	0	0	0	0	3	4	0	0	0
Acacia nilotica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	3	5	0	0	0	0
Acacia nubica	0	6	9	12	4	3	1	0	0	0	5	4	0	0	0	0	0	3	2	0	0	0	0	0
Acacia tortilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	3	3	0	0	0	0
Acacia seyal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Balanite egyptica	0	6	8	6	0	0	0	0	0		7	4	2	0	0	0	0	0	6	3	1	0	0	0
Casuarina equisetifolia	0	0	0	0	0	0	0	0	0	0	0	11	9	12	10	3	0	0	0	0	0	0	0	0
Acalypha fruticosa	0	15	31	24	17	9	4	0	0	0	4	6	2	0	0	0	0	0	4	3	0	0	0	0
Cordia africana	10	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	15	8	5	2	6	0	0
Vernonia natalensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	8	15	21	6	3	0
Grewia termbensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	12	0	0	0	0
Salvadora persiaca	0	0	0	0	0	0	0	0	0	25	16	10	3	5	2	0	0	0	0	0	0	0	0	0
Ziziphus mucronata	5	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solanum incanum	23	19	9	2	0	0	0	0	0	5	3	1	0	0	0	0	0	0	0	0	0	0	0	0
Total	20	35	45	30	19	12	3	0	0	49	57	62	38	27	12	5	9	30	47	41	20	4	1	0
Percentage	12.2	21.3	27.5	18.4	11.7	7.3	1.8	0	0	19.6	22.8	24.8	15.2	10.8	4.8	2	5.9	19.7	30.9	26.9	13.3	2.6	0.7	0

Notice: 1 = (> 0 - 0.5 m); 2 = (>0.5 - 1 m); 3 = (>1 – 1.5 m);4 = (>1.5-2.0m); 5 = (> 2 -3 m); 6 = (>3-4m); 7 = (>4-5m) and 8 = >5m

Appendix Table 5. Height classes of woody plant species in three grazing areas of upper altitude

Woody plant species	Grazing types and height classes																							
	Communal								Riverside								Enclosure							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Acacia mellifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia nilotica	0	10	17	5	0	0	0	0	0	0	5	9	7	0	0	0	0	0	0	0	3	6	0	0
Acacia nubica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia tortilis	0	0	0	0	0	0	2	3	0	0	0	0	0	0	2	6	0	0	0	0	0	13	9	5
Acacia seyal	0	0	0	0	7	11	6	0	0	0	0	4	7	3	0	0	0	0	0	0	0	0	0	0
Balanite egyptica	0	0	2	0	0	0	0	2	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Casuarina equisetifolia	0	0	0	0	8	5	0	0	0	0	0	11	24	7	0	0	0	0	0	0	0	0	0	0
Acalypha fruticosa	0	0	21	14	0	0	0	0	0	16	3	0	0	0	0	0	0	0	5	8	0	0	0	0
Cordia africana	12	14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	24	17	6	0	0	0	0	0
Vernonia natalensis	0	0	0	0	0	0	0	0	4	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gerwia termbensis	0	0	0	23	16	6	0	0	0	0	7	11	0	0	0	0	0	0	6	13	8	0	0	0
Salvadora persiaca	0	0	0	0	0	0	0	0	0	0	0	8	5	0	0	0	0	0	0	0	0	0	0	0
Ziziphus mucronata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	10	0	0	0
Solanum incanum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	7	11	18	28	26	19	10	5	15	19	28	34	34	26	18	13	1	17	16	23	19	14	15	1
Percentage	5.6	8.9	14.5	22.6	21	15.3	8.1	4	8	10.2	15	18.2	18.2	13.9	9.6	6.9	0.9	16	15.5	21.3	17.9	13.2	14.3	0.9

Notice: 1 = (> 0 - 0.5 m); 2 = (>0.5 - 1 m); 3 = (>1 – 1.5 m);4 = (>1.5-2.0m); 5 = (> 2 -3 m); 6 = (>3-4m); 7 = (>4-5m) and 8 = >5m