Dynamics of woody Species Composition and diversity as a Result of Conversion of open grazing land to an exclosure in Northern Ethiopia: The case of Tigray lowlands

Abstract

Exclosures have been establishedon open grazing lands to tackle environmental degradation in Ethiopia, particularly in Tigray region. However, little has been know with regard to the effect of establishing exclosures on open grazing lands especially in Lowlands of Tigray region, northern Ethiopia. Hence, this study was conducted to explore the effect of conversion of grazing lands to an exclosure on woody species composition and diversity at Tselemti district, which was taken as testing site to represent the lowlands of Tigray. To collect data on vegetation, three line transects, parallel to each other and across the slope were laid in the exclosure and open grazing lands systematically at 150 meters interval. Along each transect line, six sample plots measuring 20m×20m were laid down at 100 meters intervals from each other. So, a total of 36 plots (18 from grazing land and 18 from exclosure), measuring 20m*20m, were established along 6 transe cts for vegetation sampling. 41 and woody species were recorded in the exclosureand grazing land respectively. Shannon diversity, richness, evenness and density were found to be significant ly higher (*P<0.05*) in exclosure than grazing land. It can be concluded that conversion of open gr azing lands to exclosures is a viable option to restore degraded vegetation. For this reason, additi onal exclosures have to be established on previously degraded open grazing lands in the area and areas with similar biophysical setup.

Keywords: Exclosure, grazing land, dynamics, conversion,lowlands,natural regeneration

1. Introduction

"In response to environmental problems, communities in the Northern highlands of Ethiopia started to establish exclosures about three decade ago" (Mekuria and Aynekulu, 2011). "Exclosures are areas closed off from the interference of human and domestic animals with the goal of promoting natural regeneration of plants and reducing land degradation of formerly degraded communal grazing lands. Exclosures are usually established in steep, eroded and areas that have been used for grazing in the past" (Descheemaeker et al., 2006). "Tigray, northern Ethiopia, is one of the most environmentally degraded regions in Ethiopia, characterized by erratic rainfall, overgrazing, deforestation, soil erosion, soil moisture stress, loss of biodiversity and soil fertility decline" (Tadesse, 2014;Abay et al., 2020).

"To overcome the challenges of land degradation exclosureswereestablished in Tigray region the region in the last 30 and more years" (Nedessa et al., 2005). Exclosures are areas exempted from the interference of human and domestic animals with the goal of reducing land degradation and promoting natural regeneration of plants of formerly degraded grazing lands.

Studies conducted by authors (Birhane et al., 2006; Mamo, 2008; Mekuria et al., 2011; Getseselassie, 2012; Mekuria and Yami, 2013; Mebrat et al. 2014; Mulugeta 2014; Manaye et al., 2019)have shown "the positive role of exclosures on biodiversity enhancement and degraded soil restorations in the region. However, most of these studies focused in the mid (1500 – 2300 meter above sea level) and highlands (> 2300 meter above sea level) with limited intention to the lowlands (< 1500 meter above sea level) such as the study area, Tselemti district". "The effectiveness of restoration options can be affected by the differences in ecological and socio-economic conditions, political and historical contexts and level of management" (Munie, 2013). "The effect of land use conversion on environmental restoration is variable and it depends on soil type, land use history, vegetation type, climate, topography and current land use and land cover" (Marland, 2004) and according to Mekuria et al. (2017), "the effectiveness of establishing exclosures to restore degraded open grazing lands varies across different localities due to heterogeneity of exclosure management, soil, slopes, climate and topography. Therefore, studies which investigate the role of exclosures under different agro-ecologies, socio-economic conditions, soil types and level of management are crucial".Hence, this study was conducted to explore the effect of establishing exclosures in previously degraded communal grazing lands on woody species composition diversity in Tselemti district, Northern Ethiopia representing the lowlands of Tigray region.

2. Materials and Methods

2.1. Study area

The study was conducted at Mai-Saba exclosure and its adjacent grazing land, Sekota-Mariam Kebelle (the smallest political administration units in Ethiopia) in Tselemti district,Tigray, North ern Ethiopia (Figure 1), which is 380 km far from Mekelle, capital city of Tigray region, towards North West. The district has a total area of 19,615 km^2,of which 4066 km^2 is cultivated land, 3500km^2 is forest area and the remaining is other land use types.The study site is located at $13^0$05' latitude and $38^0$18'longitude at an altitude of 1350 meter above sea level (m a.s.l)(Darcha et al., 2018). Areas characterized at an elevation of <1500, but >500 m a.s.l. are classified as lowland or locally called 'Kolla' (Hurni et al., 2016).

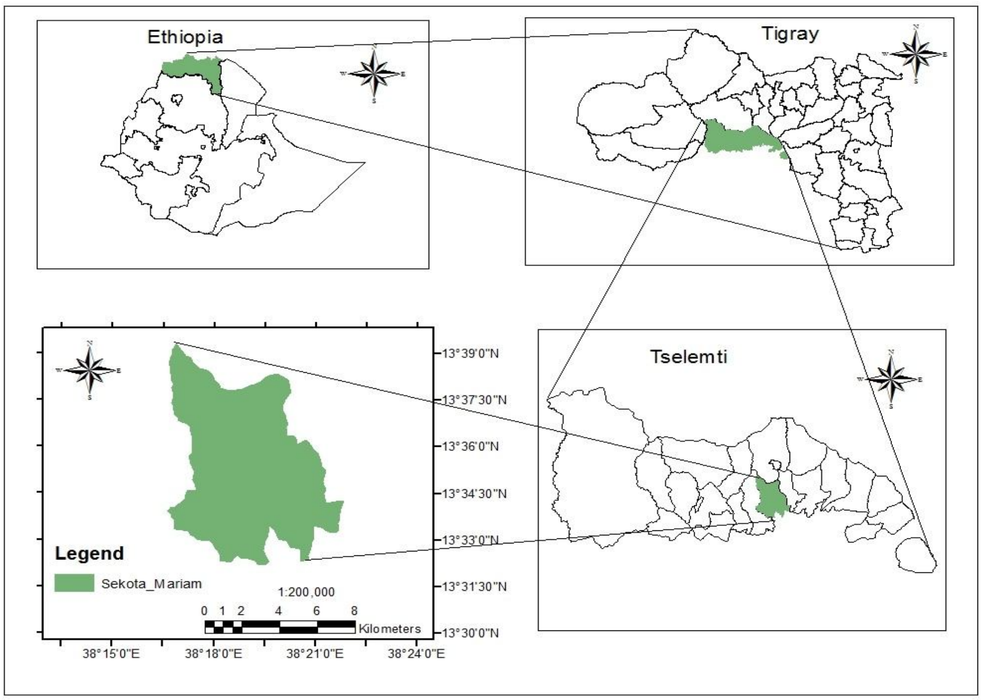

Figure1. Location map of the study area

The study area is characterized by hot to dry semi-arid lowland plain with a very hot temperature. Five years (2012-2016) temperature data show that the temperature in the study are a varies from 15.6°C in January to 38.6°C in April. The dry season occurs between November and April while the rainy season occurs between June and September (Figure 2).

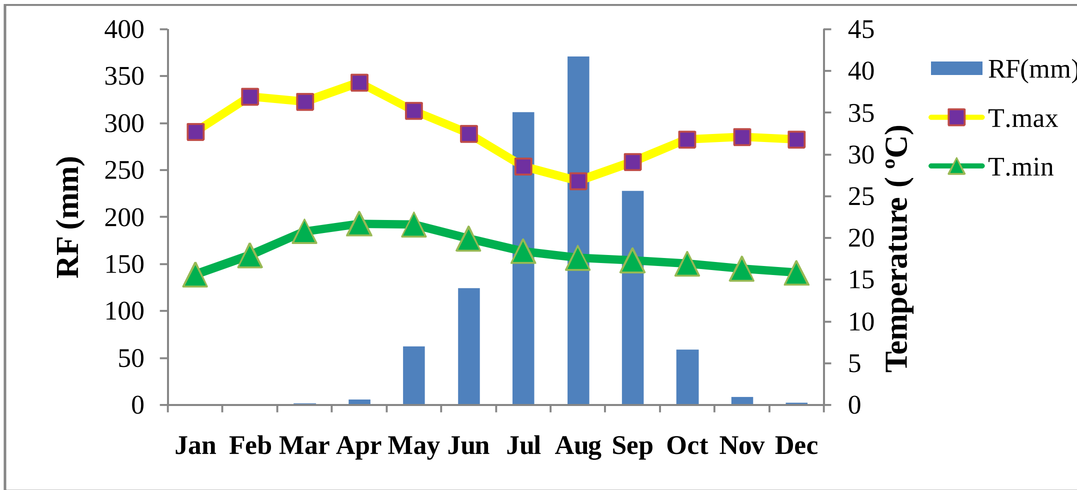

Figure 2. Five years (2012–2016) mean monthly rainfall (mm) and maximum and minimum mean monthly temperatures of the study area (Source: Tigray meteorological services center).

"Nitosols, cambisols and Vertisols are the most dominant soil types of the study area. *Anogeisus leiocarpus, Balanites aegyptica, Cordia africana, Croton macrostachyus, Ficus sycomorus, Ficus thonningii, Ficus vasta, Stereospermum kunthianum, Ziziphus spinachristi, Boswellia papyrifera,Vanguriaedulis,Dodonea angustifolia and Acacia abysinica* are some of the dominant plant species in the district. The community mainly depends on mixed agriculture (both crop and animal husbandry) for livelihood. The dominant crops grown are *Sorghum bicolour* L., *Zea mays* L. and *Eleusinecoracana*L" (Darcha et al., 2018) and the major livestock herds are donkeys, cattle, chicken and goats.

2.2. Experimental design, Data collections and Analysis

2.2.1. Experimental design and vegetation data collection

"Space for time substitution approach was used for data collection. The assumption of this approach is that exclosures and adjacent grazing lands had similar initial conditions before the establishment of exclosures" (Mekuria et al., 2009). "To collect data on vegetation, three line transects, parallel to each other and across the slope were laid in the exclosure and open grazing lands systematically at 150 meters interval. Along each transect line, six sample plots measuring 20m×20m" (Mekuria and Yami, 2013)were laid down at 100 meters intervals from each other (Figure 3). The first plot was laid down randomly and the other plots systematically at equal interval in each of the transects.To avoid the effect of disturbances, the first and the last line transects and plots were laid at a distance of at least 30m from the edges.

Figure 3. Field Layout for exclosures (left) and its adjacent open grazing land (right)

Thus, a total of 36 plots (18 plots from each land use type) were used to collect data on vegetation. All woody species with diameter > 2.5cm(Worku 2006)were identified, counted and recorded by their local name and measured in each plot in both land uses. "The plots were marked using strings and wooden pegs and the counted and recorded woody species were marked using a chalk not to miss or count an individual twice. The woody species encountered in the plots were identified supported by the local residents. The scientific name of the species was identified from: The scientific name of the species were identified from: species list Tigrigna-scientific" (Aerts et al., 2002),and useful trees and shrubs for Ethiopia (Bekelle-Tesemma,2007).

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2.2.2. Vegetation Data analysis

The vegetation data were analyzed by computing the density, frequency, dominance, diversity indices, importance value index (IVI) and coefficient of floristic similarityusing excel.

Density: was computed by summing up all the individuals from all sample plots and translated to hectare base for all the species. Two sets of density were calculated: density/ha of each species and relative density, which was calculated as the ratio of the density of a given species to the sum total of the density of all species:

$$\textbf{Relativedensity} = \frac{\text{Density of species A in hectare base}}{\text{Density of all species in hectare base}} * 100 \ldots\ldots \text{ Eq (1)}$$

Frequency: It shows the presence or absence of a given species in each sample quadrant. Two sets of frequency were calculated, absolute frequency, which refers to the number of plots in which the woody species encountered and relative frequency, calculated as the ratio of the absolute frequency of a given species to the sum total of the frequency of all species:

$$\textbf{Relativefrequency} = \frac{\text{Freqency of species A}}{\text{Frequency of all species}} * 100 \ldots\ldots\ldots\ldots \text{Eq (2)}$$

Dominance: It refers to the degree of coverage of a given species expressed by a space it occupied in a given area. Two sets of dominance were calculated: absolute dominan ce (the sum of basal areas of the stems in m^2/ha), and relative dominance: ratio of the total basal area of a given species to the sum of total stem basal areas of all species. Dominance was calculated for individual stems with diameter > 2.5cm (Worku, 2006):

$$\textbf{Relativedominance} = \frac{Dominance of species A}{Dominance of all species} * 100 \ldots\ldots \text{ Eq (3)}$$

Basal area (BA) was computed using the formula:-

$$BA = \frac{\pi d^2}{4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq (4)}$$

Where BA= basal area in m^2; π=3.14; D=diameter

Importance Value Index (IVI):

It refers to the relative ecological importance of each species in a given area. It was calculated by summing up the relative dominance, relative density and relative frequency of the species as follows:

IVI=Rd+ RD+ RF…………………………… (Eq 5) (Mata et al., 2011)

Where Rd is relative density, RD is relative dominance and RF is relative frequency.

Diversity indices

Species diversity was estimated using Shannon Wiener Diversity Index and evenness (Kent & Coker 1992):

$$H' = -\sum_{i=1}^{s} pi \ln pi \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (eq. 6)}$$

Where:

H'= Shannon diversity index

s = number of species

Pi=the proportion of individuals or the abundance of the ith species expressed as a proportion of the total

ln= natural logarithm

Evenness: was calculated using the formula:

Evenness (J') = $-\sum_{i=1}^{s} \text{pi} \ln \text{pi} / \ln s$……………….. (Eq 7).

Where: S = number of species and ln is a natural log.

Coefficient of floristic similarity

Sorensen's similarity index (Ks) (Sorensen, 1948) was used to determine the similarity of woody species between exclosure and grazing land using the following formula:

$\text{Similarity(Ks)} = \frac{2c}{(a+b)} * 100$………………………Eq (8)

Where, Ks=Sorensen's similarity coefficient

a= number of species in exclosure

b= number of species in grazing land

c= number of species common to both land use systems

2.2.2. Statistical analysis

Data were first checked for normality. Those data which were not normally distributed were log transformed. All variables were subjected to paired samples t-test statistics at 5% level of significance using SPSS version 20 to compare the land uses.

3. Result and Discussions

3.1. Woody species composition

A total of 41 woody plant species which belong to 22 families were recorded at the exclosure (Table 2), while 16 species which belong to 12 families (Table 3) were encounteredat the grazing land. This shows that the exclosure had 25 more species and 10 more families as compared to the grazing area. This could be related to the high chance for emergence and survival of new seedlings from the seed bank in exclosures while the continuous removal of seedlings by livestock grazing, browsing and trampling at the open grazing land (Tesfay et al., 20 09; Mebrat etal., 2014). The soil fertility enhancement due to litter fall in exclosures could also b e another reason for the increment of species and families in the exclosures as it provides suitable media for plant growth and re-growth (Mekuria et al., 2007). "The finding of this study concurs to a finding of Manaye (2019), who reported that the number of species in closed areas was almost twice that of adjacent grazing land in Endamekoni district, Southern Tigray. Similar results were also reported by other authors from different parts of Ethiopia" (Getseselassie, 2012; Mekuria and Yami, 2013; Gebremedihin et al., 2018; Shimelse et al., 2017).

"Fabaceae and Moracea were families with relatively higher number of species in the exclosure, represented by five and four species respectively. These two families contributed to 22% of the species composition. The dominance of Fabaceae was reported from similar prior studies"

*(*Mebrat et al., 2014; Asmare and Gure, 2019; Fikadu and Argaw, 2021). This could be attributed to successful seed dispersal mechanism of the family (Kelbessa and Soromessa, 2008). Combret aceae, Celastraceae, Moraceae and Rhamnaceae were relatively the four most diverse families in gra-zing land each represented by 2 species and constituting 50% of the species composition.

Table 1. Comparison of Shannon diversity index, richness, evenness and density between exclosure and grazing land (Mean ± SEM).

Land use	Density(stems/ha)	Shannon diversity index	Evenness	Richness
EX (n=18)	1301.4 ±180.83 [a]	1.24±0.13 [a]	0.69±0.05 [b]	6.89±0.87 [a]
GL (n=18)	152.8 ±9.01 [b]	0.91±0.08 [b]	0.84±0.03 [a]	3±0.21 [b]
P-values	0.000	0.027	0.004	0.001

Means followed by the same letter across each column do not differ significantly at $p<0.05$. n indicates number of plots. EX= exclosur e, GL Grazing land.

Table 2. Abundance (Ab), relative abundance (RA %), density per hectare (den./ha), relative density (R.den(%), dominance per hectare (Dom(m^2/ha), relative dominance (R.Dom(%), frequency (Fre.), relative frequency (R. Fre (%), importance value index (IVI%) of woody species sampled in exclosure

Species scientific name	Local name	Ab.	RA %	den./ha	R. den (%)	Dom(m^2/ha)	R. Dom(%)	Fre.	R. Fre (%)	IVI %
Anogeisusleiocarpus	Hanse	196	20.9	272.2	20.9	5.9	36.2	12	9.7	66.8
Cassia singueanea	HamboHambo	10	1.1	13.9	1.1	0.0	0.1	8	6.5	7.7
Vangueria edulis	Guramayle	118	12.6	163.9	12.6	4.0	25	15	12.1	49.7
Ficussycomorus	Sagla	1	0.1	1.4	0.1	0.1	0.7	1	0.8	1.6
Ziziphus jujube	Abetere	3	0.3	4.2	0.3	0.1	0.5	2	1.6	2.4
Dovyalis abyssinica	Ayahada	41	4.4	56.9	4.4	0.6	3.6	7	5.6	13.6
Dichrostachys cineare a	Gonoq	6	0.6	8.3	0.6	0.2	1.3	3	2.4	4.3
Lanneafruticosa	Dugdugugni	1	0.1	1.4	0.1	0.0	0.1	1	0.8	1
Ziziphus spina-christi	Gaba	2	0.2	2.8	0.2	0.2	1.1	2	1.6	3
Ficus hochstettelri	Afekemo	1	0.1	1.4	0.1	0.00	0.0	1	0.8	0.9
Gardenia lutea	Hatsinay	1	0.1	1.4	0.1	0.00	0.0	1	0.8	0.9
Acacia polyacantha	Gomoro	1	0.1	1.4	0.1	0.00	0.0	1	0.8	0.9
Cordia africana	Awhi	1	0.1	1.4	0.1	0.0	0.2	1	0.8	1.2
Maytenusarbutifolia	Atat	21	2.2	29.2	2.2	0.6	3.4	8	6.5	12.1
Diospyros mespiliformis	Aye	5	0.5	6.9	0.5	0.2	0.9	2	1.6	3.1
Acokanthera schimperi	Mebtie	6	0.6	8.3	0.6	0.3	1.8	4	3.2	5.6
Rhus natalensis	Tetialo	24	2.6	33.3	2.6	0.6	3.9	7	5.6	12.1
Dodonaea angustifolia	Tahses	460	49.1	638.9	49.1	2.4	14.9	16	12.9	76.9
Acacia persiciflora	Trmi	6	0.6	8.3	0.6	0.0	0.0	2	1.6	2.3

Species scientific name	Local name	Ab.	RA %	den./ha	R. den (%)	Dom(m^2/ha)	R. Dom(%)	Fre.	R. Fre (%)	IVI %
Carissa edulis	Agam	2	0.2	2.8	0.2	0.0	0.2	2	1.6	2
Boswellia papyrifera	Meker	1	0.1	1.4	0.1	0.0	0.3	1	0.8	1.2
Ficusvasta	Daero	1	0.1	1.4	0.1	0.2	1.1	1	0.8	2
Acacia albida	Momona	1	0.1	1.4	0.1	0.1	0.3	1	0.8	1.2
Maytenussenegalensis	Argudi	5	0.5	6.9	0.5	0.0	0.2	3	2.4	3.1
Diospyros abyssinica	Tselimo	1	0.1	1.4	0.1	0.0	0.3	1	0.8	1.2
Ficusingens	Tsekente	1	0.1	1.4	0.1	0.1	0.5	1	0.8	1.4

Table 2. Cont.

Species scientific name	Local name	Ab.	RA %	den./ha	R. den (%)	Dom(m^2/ha)	R. Dom (%)	Fre.	R. Fre (%)	IVI %
Acacia seyal	Chea	1	0.1	1.4	0.1	0.0	0.0	1	0.8	0.9
Trichiliaemetica	Gume	1	0.1	1.4	0.1	0.0	0.3	1	0.8	1.2
Capparismicrantha	Andel	3	0.3	4.2	0.3	0.1	0.3	3	2.4	3
Jacaranda mimosifilia	Bus	2	0.2	2.8	0.2	0.0	0.3	2	1.6	2.1
Sterospermumkunthianum	Adgizana	1	0.1	1.4	0.1	0.1	0.4	1	0.8	1.3
Grewiaferruginea	Tsnquya	1	0.1	1.4	0.1	0.0	0.1	1	0.8	1
Eucleaschimperi	Kilio	1	0.1	1.4	0.1	0.0	0.0	1	0.8	0.9
Otostegiaintegrifolia	Chindog	1	0.1	1.4	0.1	0.0	0.0	1	0.8	0.9
Grewiaflavescens	Mesoqua	1	0.1	1.4	0.1	0.0	0.0	1	0.8	0.9
Calpurnia aurea	Hitsawts	2	0.2	2.8	0.2	0.0	0.0	2	1.6	1.8
Ximeniaamericana	Milio	2	0.2	2.8	0.2	0.0	0.0	1	0.8	1
Ehretiacymosa	Kirah	2	0.2	2.8	0.2	0.1	0.6	2	1.6	2.4
Bosciaangustifolia	Kermed	1	0.1	1.4	0.1	0.1	0.7	1	0.8	1.7
Croton macrostachyus	Tambook	1	0.1	1.4	0.1	0.1	0.7	1	0.8	1.6
Terminalia brownii	Weiba	1	0.1	1.4	0.1	0.0	0.1	1	0.8	1

Total		**937**		**1301.4**		**16.3**		**124**		

Table3. Abundance (Ab), relative abundance (RA %), density per hectare (den./ha), relative density (R.den (%), dominance per hectare (Dom (m^2/ha), relative dominance (R.Dom(%), frequency (Fre.), relative frequency (R.Fre(%), importance value index (IVI%) of woody species sampled in grazing land

Species scientific name	**Local name**	**Ab.**	**RA%**	**den./ha**	**R. den (%)**	**Dom(m^2/ha)**	**R.Dom (%)**	**Fre.**	**R.Fre (%)**	**IVI %**
Anogeisusleiocarpus	Hanse	60	54.5	83.3	54.5	3.5	52.8	16	30.2	137.5
Maytenussenegalensis	Argudi	1	0.9	1.4	0.9	0.1	1.3	1	1.9	4.1
Vangueria edulis	Guramayle	3	2.7	4.2	2.7	0.1	1.6	2	3.8	8.1
Ficussycomorus	Sagla	3	2.7	4.2	2.7	0.4	6.1	2	3.8	12.6
Boswellia papyrifera	Meker	5	4.5	6.9	4.5	0.4	5.8	4	7.5	17.9
Terminalia brownii	Weiba	5	4.5	6.9	4.5	0.1	2.3	4	7.5	14.3
Dodonaea angustifolia	Tahses	1	0.9	1.4	0.9	0.0	0.2	1	1.9	3
Acacia polyacantha	Gomoro	5	4.5	6.9	4.5	0.4	5.6	4	7.5	17.7
Diospyros mespiliformis	Aye	6	5.5	8.3	5.5	0.6	9.1	3	5.7	20.2
Ficusvasta	Daero	3	2.7	4.2	2.7	0.5	6.9	2	3.8	13.4

Ziziphus spina-christi	Gaba	5	4.5	6.9	4.5	0.1	1.1	5	9.4	15.1
Maytenusarbutifolia	Atat	1	0.9	1.4	0.9	0.1	1.2	1	1.9	4
Cassia singueanea	HamboHambo	7	6.4	9.7	6.4	0.0	0.7	4	7.5	14.6
Cordia africana	Awhi	2	1.8	2.8	1.8	0.2	2.5	2	3.8	8.1
Ziziphus jujube	Abetere	1	0.9	1.4	0.9	0.1	1.2	1	1.9	4
Lanneafruticosa	Dugudugugni	2	1.8	2.8	1.8	0.1	1.7	1	1.9	5.4
Total		**110**		**152.8**		**6.6**		**53**		

3.2. Density, Diversity indices and Similarity of woody species

The woody species density was significantly($p<0.001$) higher at the exclosure(1301.4 trees ha^{-1}) than the grazing land (152.8 trees ha^{-1}), indicating more than eightfold higher in the exclosurethan the grazing land (Table1), which is related to continuous disturbances by human and livestock in the grazing land. This finding is in line with the findings of Tekalign (2010); Mekuria et al. (2017); and Asmare and Gure (2019). The study also revealed the existence of variation in density among the woody species. Few species such as *Dodonaeaangustifolia*(638.9 stems ha^{-1}), *Anogeisusleiocarpus*(272.2 stems ha^{-1}) and *Vanguria edulis* (163.9 stems ha^{-1}) were dominant attheexclosure (Table 2). These three species contributed to 83% of the total density. Likewise, *Anogeisusleiocarpus*was found to be the densest species at grazing land with 83.3 stems ha^{-1}contributing to 54.5% of the total plant density (Table 3). In contrast, 21 species in the exclosure and 4 species in the grazing land were found to be the least abundant with 1 stem ha^{-1}each. The dominance of some species could be due to overharvesting of some selective plant species.

The Shannon diversity index was also significantly ($p<0.05$) higher at the exclosure (1.24 ± 0.13) as compared to the grazing land (0.91±0.08) (Table 1). Similarly, the species richness at the exclosure (6.89 ± 0.87) was significantly ($p<0.05$) higher than that of the grazing land (3 ± 0.21). The higher diversity at the exclosures might be due to increased litter accumulation which leads to an increase in organic matter and other nutrients content (Hiernaux, 1998). Similar trend was reported by Mengistu et al. (2005); Bahiru (2008); Asmamaw (2011); and Mekuria et al. (2017) from different locations of Ethiopia. However, the species evenness was significantly ($p<0.05$) higher at the grazing land (0.84 ± 003) as compared to the exclosure (0.69 ± 0.05). This might be due to the uneven distribution of species in the exclosureas a result of high heterogeneity, whereas, even the small numbers of species in grazing land were found to be distributed evenly. The same result was reported by Gebremedihin et al (2018), from four highland districts of Tigray region, who indicated high Shannon diversity and richness, but less evenly distributed species in exclosures, while grazing land had low species richness with high species evenness value.

The Sorenson's similarity of species encountered at the exclosure and grazing land was 56.1%, indicating a difference of 43.9% in woody species composition between the land use types.Worku (2006), indicated that 56.25% similarity index is low, whereas 80% is high. Accordingly, the result in this study revealed that the land uses had low similarity. This is because among the 41 encountered woody species, only 16 were found in common, as a result of protection of woody species in the exclosure which leads to a restoration of species that were lost in the grazing land, while continuous human and livestock disturbance in the grazing land.

3.3. Frequency, Dominance and Importance value index (IVI)

Frequency analyses in the present study showed that most of the woody species had low distribution across the plots and few species in high distribution which revealed that there was an existence of high variation among species. For instance, *Dodonaea angustifolia* and *Vanguria edulis* were the most frequent species in the exclosure recorded in 16 and 15 out of 18 sample plots respectively followed by *Anogeisusleiocarpus*. In contrast, 22 species were encountered only in one plot (Table 2). Likewise, *Anogeisusleiocarpus* and *Ziziphus spina-christi* were the most frequent species in grazing land recorded in 16 and 5 plots respectively out of the 18 plots, while 5 species were recorded only in one plot (Table 3).

A high variation was also observed among species in their dominance. The three top dominant species in the exclosure were *Anogeisusleiocarpus* (36.2%), *Vanguria edulis* (25%) and *Dodonaea angustifolia* (14.9%) with 5.9 m^2/ha, 4 m^2/ha and 2.4 m^2/ha respectively (Table 2). *Anogeisusleiocarpus* was the most dominant species with 3.5 m^2/ha and it alone contributed to more than half (52.8%) of the total basal area in grazing land (Table 3).

Based on the result of the comparison of individual species in terms of their importance value index (IVI),*Dodonaea angustifolia* (76.9%),*Anogeisusleiocarpus* (66.8%), *Vanguria edulis* (49.7%) in the exclosure (Table 2) and*Anogeisusleiocarpus* (137.5%) in the grazing land (Table 3) were the most important woody species, indicating that these species are more ecologically significant and plays a significant role in the restoration of the degraded ecosystem, due to their higher relative abundance, frequency and basal area. The dominance of *Anogeisusleiocarpus* in the grazing land might be due to rapid propagation of the species by wildings and its ability to coppice (personal observation while conducting the study). On the other hand, 33 species in the exclosure and 4 species species in the grazing land had an IVI value of less than 5% (Table 2 and 3), indicating that they must be prioritized for conservation.

4. Conclusion

The present study revealed that establishment of exclosures on degraded communal grazing lands is a viable option to enhance woody species richness, density, Shannon diversity index. The analyses of woody vegetation composition revealed that low woody species similarity was observed between the two land use types. Alternative livestock management systems such as tethering should also be introduced so as to minimize the negative effects of free grazing by livestock. As the present studyonly consider vegetation, further studies on the fauna and micro-organisms, erosion control, hydrology, downstream agricultural production and socio-economic factors analysis that determine the sustainability of the land use systems need to be undertaken. On top of that, the socio-economic implication for local communities has to be studied.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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Details of the AI usage are given below:

1.

2.

3.

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