TRADITIONAL MICROPATCHES, PLANT DIVERSITY, AND LOCAL PERCEPTIONS OF RANGELAND DEGRADATION IN NORTHEASTERN ETHIOPIA

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ABSTRACT

In East Africa, Ethiopia's rangelands constitute about 64 % of lowland areas, serving as primary feed resources for pastoral communities. However, these rangelands face severe degradation due to overgrazing, climate variability, human disturbance, and invasive species, threatening both productivity and biodiversity. This study assessed the impact of grazing and rangeland exclosures on vegetation dynamics, species diversity, biomass, and pastoral livelihoods in Chifra district, Afar Region, Ethiopia. Stratified random sampling compared enclosed and communally grazed areas through vegetation surveys and household interviews (n=195). Results revealed significantly higher species richness, diversity (H'=2.59 vs 1.46), and herbaceous biomass in enclosed areas compared to open communal grazing lands. Exclosures promoted the regeneration of highly desirable grasses and woody species while reducing invasive and less palatable plants. Pastoralists identified low rainfall and overgrazing as major causes of rangeland decline, impacting livestock productivity and food security. Indigenous management practices such as stock mobility, exclosures establishment, and de-stocking ranked highest for restoring rangeland health. The study highlights the effectiveness of grazing exclusion in rehabilitating degraded rangelands and sustaining pastoral livelihoods. Integrating traditional knowledge with scientific approaches and supporting exclosures management can improve vegetation recovery, biomass production, and resilience against environmental stressors. These findings provide key insights for sustainable rangeland management and conservation strategies in arid and semi-arid pastoral systems.

Keywords: Land degradation; Micropatches; Pastoralism; Rangeland; Exclosure

INTRODUCTION

Rangelands make up over a quarter of Earth's land surface and are vital components of the global ecosystem(Pulungan *et al.,* 2019). The diversity, density, and dominance of rangeland species are shaped by spatial and temporal variation (Bennie *et al.,* 2011). Environmental factors and biological processes, including human disturbance, species interactions, and seed dispersal, play key roles in determining species composition, diversity, biomass production, and the land's carrying capacity (Shao *et al.,* 2016). Preserving species diversity in rangelands is essential for sustaining productivity and supporting other ecosystem services (Fenetahun *et al.,* 2021). Among the primary land uses, grazing significantly influences vegetation diversity, biomass, and structure (Wang *et al.,* 2019). Grazing animals affect the formation of plant communities, leading to changes in species richness, diversity, productivity, and carbon storage across rangeland ecosystems (Peper *et al.,* 2011).

Many communal rangelands in Africa are considered overstocked, degraded and unproductive (Vetter, 2005; Tefera *et al.,* 2007). Causes of these degradations are generally attributed to a combination of factors of which most of them are associated with anthropogenic activities. The consequences of human based activities lead to climate change; which subsequently affects rangeland conditions (Harris, 2010). East African countries have a vast area of rangeland, among which Ethiopian rangelands cover about 64 % of the total area below 1,500 m.a.s.l mainly including the Eastern, South, South Western and Western peripheries (Hailu, 2016). The rangeland biomes of Ethiopia are major feed resources for livestock and wild animals. In the arid to semi-arid environments of the country, more than 62 % of the land is used for livestock grazing (Kassahun *et al.,* 2008). However, the majority of these biomes have been subjected to loss of nutrients and biodiversity changes, soil organic matter and land deterioration due to vegetation removal by livestock and/or burning, and climate variability (du Preez *et al.,* 2011) . In response to different kinds of land deterioration and the scarcity of feed for vulnerable herd classes, pastoralists conducted land restoration through livestock grazing management practices (Abate & Angassa, 2016).

Pastoral communities residing in the Ethiopian rangelands make up approximately 10-12 % of the country's population (Hogg, 1995). The main pastoral communities are the Somali (53 %), Afar (29 %) and Borana (10 %) living in the Southeast, North Eastern and Southern parts of Ethiopia respectively and the balance (8 %) are found in Southern, Gambella and Benshangul (Hogg, 1995). Due to low and unpredictable rainfall, their survival relies on surface and groundwater sources. Access to water during the dry season ultimately governs their access to and control over grazing areas. Additionally, rangeland resources are at risk from growing human and livestock populations, leading to soil erosion, deforestation, bush encroachment, and a decline in biodiversity (Blench, 2001).

The effects of grazing on forage nutritional value, forage quality, soil physicochemical properties, and biodiversity have been examined in various studies (Graff *et al.,* 2007). Due to their diverse nutritional demands, jaw anatomy, and grazing habit, different grazing animals have different effects on grassland vegetation (Wang *et al.,* 2019). Restoring natural vegetation by removing grazers is the simplest and most successful way to improve deteriorated rangeland conditions (Song *et al.,* 2020). In dry and semi-arid rangelands, rangeland exclosures is a widely employed technique for regenerating degraded rangelands (Wang *et al.,* 2019). Through the application of rangeland exclosures, the productivity of degraded rangeland biomass and species cover can be restored (Zhao *et al.,* 2019). As a result, grazing exclosures has a substantial impact on the phenological development of plants. Greening, seeding, and flowering are all important features of plant phenology that have a big impact on grassland restoration (Guo *et al.,* 2020).

Rangeland restoration focuses on the structure, abundance, diversity, biomass, and carbon content of grass species (Angassa & Oba, 2008, 2010). Various studies have demonstrated that rangeland exclosures increases species richness and improves plant phenology, but this trend may be reversed as exclosures age increases (Xiong *et al.,* 2016). Internal changes in the exclosures area (grazing disturbance state and colonization process) have a key role in determining species diversity, biomass output, and carrying capacity of grasslands during long-term grazing exclosures, especially in connection to external influencing factors (Wang *et al.,* 2018).

The Afar pastoral communities rely on multi-species livestock production, with camels, sheep, goats, cattle, and donkeys serving as the primary productive assets of the local population (Tsegaye *et al.,* 2013). The main feed sources for this vast livestock population are rangelands made up of native grasses, shrubs, and fodder trees. However, many grass species face ongoing threats of genetic erosion and extinction caused by overgrazing, rangeland degradation, and the encroachment of undesirable plants such as *Prosopis juliflora, Parthenium hysterophorus, Calotropis procera, Tribulis terrestris, Sida ovata, Cryptostegia grandiflora* and *Vachellia nubica,* which are invading the rangeland areas in Chifra district (Abdulatife, 2009).

Significant changes in the composition, biomass, carrying capacity, phenology, and diversity of plant species in rangelands have been observed as a result of animal overgrazing (Raiesi & Riahi, 2014). Currently, the local community and government officials in Chifra district are using the rangeland exclosures approach to restore degraded areas by restricting grazing for extended or short periods (Tefera *et al.,* 2007). In overgrazed and degraded rangelands, this management method is predicted to restore vegetation and improve rangeland health (Song *et al.,* 2020).

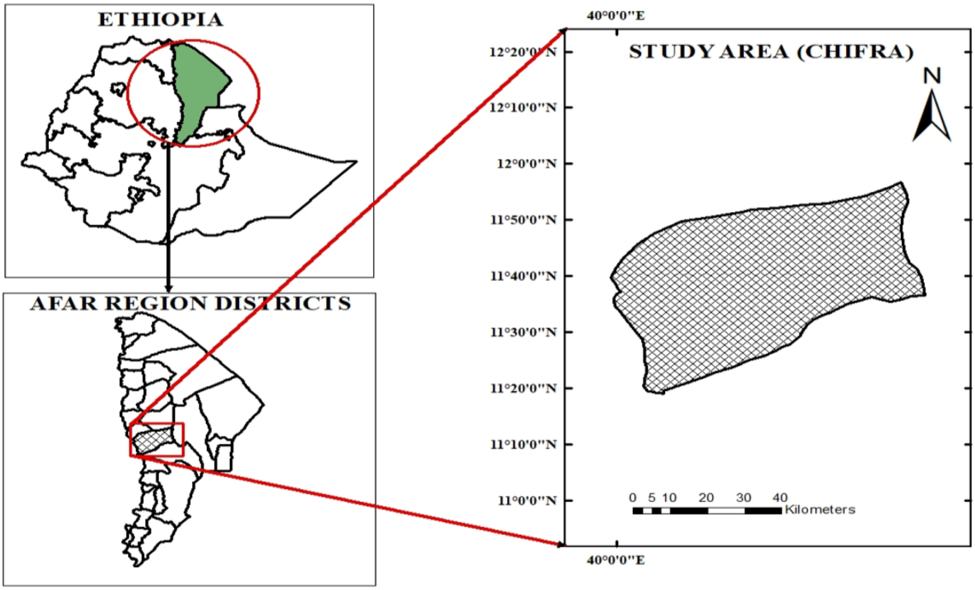
To effectively manage rangelands and achieve conservation objectives, targeted studies are essential. Assessing the overall ecological impact of exclosures on rangelands is crucial for updating knowledge to support sustainable grassland management in the Chifra rangeland. Additionally, evaluating the effects of rangeland exclosures helps to better understand differences in plant species diversity between open grazing areas and enclosed grasslands. The establishment of area exclosures has been promoted as a strategy for restoring degraded land. Consequently, rangeland restoration using exclosures methods requires the collection of clear, quantifiable data on all species within the study area, employing consistent spatial techniques. This study aimed to examine how traditional micropatches contribute to the health and functioning of rangeland ecosystems.

MATERIALS AND METHODS

Study area description

Chifra district is situated approximately 160 km west of Semera, the capital of the Afar Regional State, and about 650 km east of Addis Ababa. Geographically, it lies between 11 °05’48” and 11 °46’06” N, and 39 °53’49” and 40 °30’39” E (Fig. 1). The Mille River, which is fed by more than 11 seasonal tributaries and one perennial tributary (Woama Stream), flows into the Awash River. The majority of the district's population (78 %) are pastoralists, while the rest consist of town dwellers (13 %) and agropastoralists (9 %).

Fig. 1: Map of the study area



Vegetation and climate

The study area is dominated by desert and semidesert scrub as well as Vachellia-Commiphora ecosystems. Some of the characteristic species found in the area include *Vachellia abyssinica* Hochst., *Vachellia mellifera* (Vahl) Benth., *Vachellia drepanolobium* Harms ex Sjostedt., *Balanites aegyptiaca* (L.) Del., *Dobera glabra* (Forssk.) Poir., and *Ziziphus spina-christi* L.(Gebrehiwot & Zeynu, 2022). Trees are found along stream banks, grasses in the mid plains while shrubs and bushes are dominant on the undulating and rolling lands. But the vegetation density is generally low.

The district receives an average annual rainfall of about 312 mm. July, August and September are the rainy months, where the pick is in August that amounts 73.4 mm. November, December and January are the driest months and June is the hottest month, where the maximum temperature approaches 40 °C. There is a small rainfall in the month of February and May, which can contribute to grass and shrubs regeneration.

Slope, Landforms and Soils

Five slope classes are recognized in the district. These are 0-3 %, 3-8 %, 8-15 %, 15-30 % and >30 %. The landform of the district is characterized by flat and almost flat plain, which accounts for about 67 % of the land area, while gently sloping land covers about 26 %. Thus, plains cover a significant area of the Woreda accounting to about 94 % of the Woreda landmass, while Steep slope lands account for 2 % of the landmass of the Woreda.

Folk soil taxonomy in the district recognized two distinct soil types namely red soil (Assa soil) and Black soil (Deta Soil). Based on the FAO soil classification, nine soil types are found in Chifra district (Table 1).

Table 1: Soil color and texture of Chifra district (Rural Land Administration and Use Directorate 2016)

No	Color	Texture	FAO Classification
1	Brown	Alluvial deposit very deep loam soil	Calcaric Fluvsols
2	Black	Deep clay soil	Eutric Regosols
3	Black	Very deep clay soil	Vertic Andosol
4	Grey	Moderately deep sandy soil	Haplic Xerosols
5	Grey	Moderately deep sandy Soil	Orthic Solonchacks
6	Black	Moderately deep Sandy Clay Loam	Chromic Luvisols
7	Black	Moderately deep Loam	Eutric Cambisols
8	Red	Deep Clay Loam	Eutric Nitosols
9	Grey	Shallow depth gravel	Litic Liptosols

Livestock Population

Livestock production is the primary livelihood for both pastoralists and agropastoralists. Livestock play a crucial role by providing a variety of products and benefits essential for survival. Although reliable statistics are lacking, the total livestock population in the district is estimated to be around 1,011,433 (Chifra Woreda Pastoral Office, pers. Comm.).

Rangeland Tenure

Rangeland tenure in the area is governed by local customs and traditional land rights, overseen by Clan Leaders (Kidi-Haba) and youth groups (Ama-Haba), who are responsible for allocating land for communal use and managing grazing mobility, respectively. In Chifra district, customary grazing land tenure follows a system where specific clans are granted rights over particular rangeland estates, locally known as “Kidi Haba.” The Mille River serves as a natural boundary dividing the rangelands between the two main clans, Arbeta and Dodo, while informal (bestride) boundaries further subdivide each clan’s territory into sub-clan rangeland regimes.

These communal rangelands are widely viewed as degraded and unproductive, raising concerns about sustainability and potential conflicts. Despite this, communal land rights are deeply ingrained in the pastoralists' culture and daily life, with land disputes traditionally being resolved within the community. However, restoring these rangelands to their former productivity exceeds the financial and technical capacity of the pastoralists.

Beyond supporting livestock, these customary rangeland regimes are habitats for various wildlife species such as gazelles (Yemeda fiyel), dikdik (Enshu), lesser kudu (Ambarayle), dortas, greater kudu, and jackals. For decades, there has been no competition between livestock and wildlife for grass or water. Nevertheless, recurrent droughts combined with inadequate rangeland management have led to severe degradation of the natural resource base, resulting in significant livestock losses—one of the main challenges faced by pastoral and agropastoral communities.

Research methods

Site selection

To choose the rangeland sites for the study, a group discussion was conducted with various stakeholders, including community members, elders, and experts from the district agricultural office. Using the information gathered, exclosures and open communal rangelands were selected based on similarities in terrain, soil, and land use to reduce variability in the abiotic factors influencing rangeland vegetation composition and function.

Additionally, site selection prioritized minimizing geographic differences such as slope and aspect, as well as ensuring accessibility.

Sample size determination

To determine the sample size (n) of the households; the sampling formula which was developed by Cochran (Cochran, 1977), was used with a desired degree of precision for general population. In this case, population variable (p) is a household unit variable which is given as:

$$S = [\frac{Z^2 P(1-P)}{M^2}] \quad \text{Eq. 1}$$

Where; S is sample size for infinite population; Z is z score 95 %; and P is population proportion

M is margin of error

$$n = \frac{S}{1 + \frac{(S-1)}{P}} \quad \text{Eq. 2}$$

Where; n is adjusted sample size; S is sample size for infinite population; Z is z score 95 %; P is population proportion; and M is margin of error

Using the formula mentioned earlier, this study interviewed 195 households out of a total of 3,044. This included 65 households from each of the three kebeles: Anderkelo, Teabay, and Woama. To gather comprehensive and relevant information from individual households, both structured and semi-structured questionnaires were developed. The questionnaires covered topics such as household size, sources of income, grazing management practices, animal feed resources, natural resource utilization, and pastoralist perceptions of rangeland management. Additionally, questions addressed conservation practices, coping strategies for feed shortages, and other related information. Prior to the main survey, the questionnaires were pre-tested by interviewing a few households, and necessary adjustments were made to ensure clear and effective communication of the required information.

Vegetation species sampling design

To collect data on herbaceous and woody species, the grazing areas were stratified into communal grazing and exclosures, representing the primary grazing zones of the pastoral community. Therefore, a stratified random sampling technique was employed. Four sampling sites were selected from communal grazing areas and four from exclosures areas, with site allocation based on grazing potential and rangeland availability.

At each site, a sampling block measuring 600 m by 100 m was established and further divided into three equal-sized sample plots. In exclosures areas, the sample blocks were set up either contiguously or separately, depending on the available rangeland area. Vegetation composition assessments were conducted during the main rainy season of 2021, when most plants were in their flowering stage.

Sample plots, sized 200 m by 100 m, were laid out in relatively homogeneous vegetation and replicated three times within both enclosed and communal grazing areas. In total, 120 plots measuring 1 m by 1 m were established across the enclosed and communal open grazing sites for herbaceous vegetation data collection.

The woody vegetation survey was carried out from mid-August to September, coinciding with peak flowering periods. In each exclosures and communal grazing area, fifteen 20 m by 20 m plots were laid out randomly to assess woody vegetation.

The identified herbaceous species were classified into four groups using desirability grouping methods i.e., highly desirable, desirable, less desirable and undesirable based on the opinion of informants about the herbaceous species, vigor and palatability. This group includes both perennial and annual species that have low palatability as perceived by the pastoralists. The undesirable group included invader grasses, unpalatable forbs and bare-ground. The above classification procedure was followed as described by (Jerry *et al.*, 1989). The palatability of the identified woody vegetation species was also classified into highly palatable, palatable, less palatable and unpalatable based on the opinion of pastoralist in relation to grazing intensity (Tainton, 1981).

Species diversity analysis

Biological diversity can be measured using different indices. The diversity indices of different community types were calculated using the Shannon–Wiener diversity index (H′) because it accounts both for species richness and evenness, and it is not affected by the sample size (Kent, 2012).

Statistical analysis for household and vegetation

The data collected for the household survey was analyzed using descriptive statistics such as percentages, means, frequency and standard deviations using SAS Enterprise Guide 7.1. Data obtained from the household survey for impact of rangeland degradation, rangeland management techniques and causes of rangeland degradation were analyzed using Relative Important ranking index method (Musa *et al.* 2006). The index was computed as:

Relative Important ranking index value

$$= \frac{5_{n5} + 4_{n4} + 3_{n3} + 2_{n2} + 1_{n1}}{A \times N} \quad \text{Eq. 3}$$

Where:

n_5 = number of respondents for ranked 5th
n_4 = number of respondents for ranked 4th
n_3 = number of respondents for ranked 3rd
n_2 = number of respondents for ranked 2nd
n_1= number of respondents for ranked 1st
A= highest weight/number of ranks

N= Total number of respondents

The effects of grazing (exclosures vs. open grazed) was analyzed using SAS. A one-way analysis of variance (ANOVA) and mean comparison test were used in order to test for differences between study sites. Whereas, to test Herbaceous and woody species Shannon diversity index, and species richness significant differences between exclosures and open grazing land, analysis of variances (ANOVA) was performed. Descriptive statistics were used for species composition, density, Basal area and IVI of tree species.

RESULTS

Socio-demographic information of the informants

Approximately 84.62 % of respondents were male, while females made up the remaining 15.38 % (Table 2). The higher participation of males is attributed to their greater willingness to engage, their availability in the field, and the heavier household workload typically carried by females in the study area. The results also indicated that pastoralism is the primary livelihood for about 72.31 % of the sampled households, with agro-pastoralism accounting for the remaining 27.69 %.

The way that societies interact with their surroundings is influenced by their livelihood features in one way or another. As a result, it was determined that gathering information on the livelihood characteristics of each sampled respondents under the study was critical. As a result, Pastoralism is the most widely practiced economic system, as the district's natural surroundings are more suited to animal rearing than crop cultivation.

Table 2: Socio-demographic information of the informants

	Study Kebeles			**Overall**
Variable	Ander kelo n= 65 N (%)	Teaby n= 65 N (%)	Woama n= 65 N (%)	N=195 N (%)
		Sex of household		
Male	52(80.0)	57(87.69)	56(86.15)	165(84.62)
Female	13(20.0)	8(12.31)	9(13.85)	30(15.38)
X^2	23.40	36.94	33.98	93.46
		Marital status		
Married	54(83.08)	46(70.77)	50(76.92)	150(76.92)
Widowed	8(12.31)	12(18.46)	10(15.38)	30(15.38)
Divorced	3(4.62)	7(10.77)	5(7.69)	15(7.69)
χ^2	72.95	41.56	56.154	168.46
		Main source of livelihood		
Pastoralist	37(56.92)	57(87.69)	47(72.31)	141(72.31)
Agro-pastoralist	28(43.08)	8(12.31)	18(27.69)	54(27.69)
χ^2	1.25	36.94	12.94	38.82
		mean ±SD		
Age (years)	43.23±14.66[a]	42±13.23[a]	42.69±14.01[a]	42.64±13.91
Total family size (N)	4.57±2.66[a]	3.85±2.19[a]	3.94±2.19[a]	4.12±2.37

$p > \chi^2$ at ($p<0.0001$); N = number of households

Livestock Holding and Composition

Pastoralists in the study area rely heavily on livestock as their primary source of income. Keeping a diversified portfolio of livestock species, according to pastoralists, would provide communities an advantage in dealing with difficult climatic conditions, feed and water shortages, and efficient use of currently available feed sources in the rangelands. The type and quantity of available feed (proportion of browse to grass), water availability, and animal sensitivity to drought and illness are the main factors that determine the type of livestock raised in the area. Pastoralists in Chifra keep a variety of livestock, including cattle, goats, sheep, camels, and equines (6.9±4.8). Small ruminants keeping is the most popular because it is the main source of income. The proportion of small ruminants in the herd was often larger than that of large ruminants, and the number of goats was higher than that of sheep.

Pattern of range lands in supporting pastoral livelihood

About 48.72 % of household respondents explained that rangelands have less role in improving the livelihood of the pastoral and agropastoral community whereas about 34.87 % of the respondents reported that rangelands have a moderate role in supporting pastoral livelihood in the research area. On the other hand, the remaining argued rangelands poorly improved their livelihood. According to the respondent's, rangeland deterioration in the district is considerably faster now than in the past. All respondents agreed that rangelands in the study area are declining or shrinking.

Feed Resources and drought coping strategies

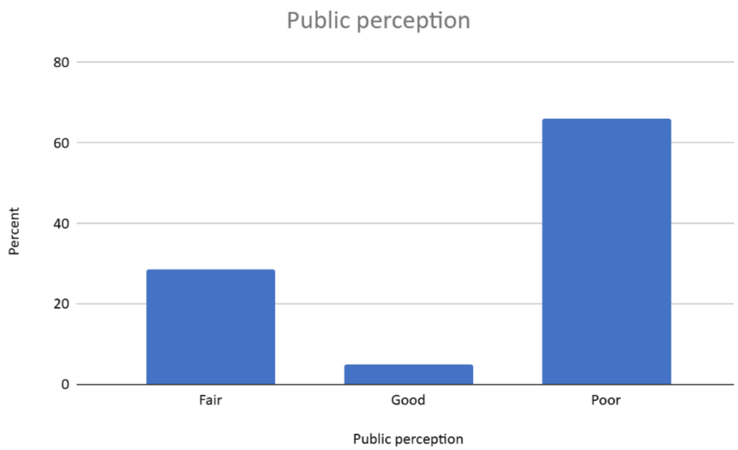
Throughout the year, rangelands have been the primary source of feed for animals in the research area. The alarming decline in grass cover, on the other hand, may place major limits on animal feed and output. During the dry season, the information received from the selected respondents revealed that pastoralists' cattle rely on natural pasture (grass, legumes, and woody plants) (89.23 %), hay (4.62 %), and standing hay (6.15 %). During the wet season, approximately 100 % of respondents rely on natural grazing. As a result, substantial grazing has been the only means to produce animals in the study area pastoral production system.

According to the informants, communal grazing was the main source of feed (84.10 %) and privately fenced areas/exclosures was the alternative source of feed (15.90 %) for animals in dry season. During the dry season, communities with exclosure areas have positive experiences in sharing their feed resources with the elderly and people with disabilities, allowing them to use these resources. Meanwhile, the youth and other community members often migrate to other areas. The coping strategies during drought time were mobility (146, 74.87 %) followed by using a preserved hay (33, 16.92 %). The last resort was livestock sale (16, 8.21 %).

Rangeland degradation

According to both focus group discussions and individual household surveys, rangeland in the communal grazing areas is in a bad condition (Fig. 2).

Fig. 2: Public perception on rangeland conditions in the study area



The perceived causes of land degradations were low rainfall and overgrazing, ranked as 1st and 2nd by the respondents in the study area (Table 3).

Rangeland degradation in pastoral areas has become a severe challenge to pastoral livelihoods, leaving many poor pastoralists trapped in chronic food insecurity. The situation worsens when arid conditions are compounded by human-induced disasters. Despite these difficulties, pastoralists continue to strive for sustainable livelihoods.

Table 3: Respondent's information about the causes of rangeland degradation

Causes of rangeland degradation	N	A(ranks)	Total	A*N	Index(total/A*N)	Ranking
Lack of rainfall	195	4	727	780	0.93	1
Deforestation	195	4	195	780	0.25	4
Overgrazing	195	4	597	780	0.77	2
Population pressure	195	4	433	780	0.56	3

The survey revealed that nearly all respondents understand the causes of rangeland degradation and acknowledge the importance of rehabilitation programs. Natural causes were identified as the primary driver of land degradation across all kebeles than human activities ($P < 0.001$). Additionally, the kebeles of Woama and Teabay were more severely affected by natural factors compared to Anderkelo. The comparatively lower impact in Anderkelo may be attributed to greater community awareness and active participation in conservation efforts.

Impacts of rangeland degradation in the study area

Although there were slight variations in responses (Table 4), the main impacts of rangeland degradation were clearly identified and prioritized according to their effects on the social, economic, environmental, and institutional aspects of pastoralists' lives in the study area. Interviewed pastoralists ranked the decline in both the quantity and quality of rangeland products as the most significant impact, followed by food shortages as the second most important consequence.

Table 4: Respondent's perception towards main impacts of rangeland degradation

Impacts	Total number(N)	A*N	Index	Ranking
Decline rangeland product	195	975	1	1
Death of livestock	195	975	0.2	5
Food shortage	195	975	0.8	2
Reducing price of livestock	195	975	0.6	3
Increase distance to travel to feed	195	975	0.4	4

Rangeland management practices identified in the study area

Traditional rangeland resource management practices have long been established by district rural pastoralists. As a result, this study evaluated indigenous rangeland resource management practices. The most important rangeland management techniques practiced in the study area to improve the current status of rangelands were identified and ranked by sample respondents during the survey, as shown in the table below (Table 5).

Table 5: Rangeland management practices ranked by respondents from the most effective to less effective

Rangeland management practices	N	Mean	Std. Deviation
Moving stock	195	1.00	0
Exclosures	195	2.28	0.449
Destalking	195	2.72	0.449
Supplementary feed	195	4.00	0
Fire	195	5.00	0
Planting tree	195	6.00	0

In general, the study area needs to implement different type of rangeland management approaches. However, according to the respondents of the sample survey, the top rangeland management techniques favored by respondents in the study area were moving stock, exclosures, destalking, supplementary feeding, planting trees and wild fire.

The effect of exclosures on species richness, diversity and biomass

Species composition

In the study area, a total of 21 herbaceous species distributed in four families were identified (Table 6). Nearly 52 % of the grass species were highly desirable, 16 % were desirable, 16 % that were less desirable and 8 % unidentified for desirability. The highly desirable grasses were abundant in the exclosures area than in the open communal grazing areas. The abundance of the herbaceous species with respect to grazing gradients revealed a distinct pattern. *Chrysopogon plumulosus* Hochst*, Sehima nervosum* and *Cynodon plectostachyus Pilger* were the most common grass species in the exclosures. In the open grazed sites, *Tribulus terrestris L., Parthenium hysterophorus, and Dactyloctenium aegyptium* Beauv were the most common.

The effect of exclosures on woody species

A total of 21woody species were identified (Table 6), which were from 11 families. The exclosures and neighboring communal open grazing areas contained 15.79 %, 47.37 %, 21.05 % and 15.79 % of the identified woody species are highly desirable, desirable, less desirable, and undesirable respectively. The absence of a species in the exclosures and its occurrence in open access community grazing areas was owing to pastoralists' woody management influence, which included erecting fences around their exclosures areas and eliminating the majority of the unpalatable shrubs and trees.

Table 6: Species composition (HP = highly palatable; P = palatable; LP = less palatable; UP = Un palatable, HD = highly desirable; D = desirable; LD = less desirable; UD = Undesirable; UI = unidentified)

Scientific Name	Local Name	Family	Growth Habit	Desirability
Aerva javanica (Burm. fil)	Oila	Amaranthaceae	Herb	UI
Andropogon sp.	Gorob	Poaceae	Herb	HD
Aristida funiculata	Baekeli-Aiso	Poaceae	Herb	HD
Balanites aegyptiaca (L.) De.	Uddaito	Balanitaceae	Tree	HP
Blepharis edulis (Forssk.)	Yamarukta	Acanthaceae	Shrub	P
Brachiaria eruciformis (J.E.sm.)	Aiso	Poaceae	Herb	HD
Cadaba rotundifolia Forssk.	Adangalita	Capparidaceae	Shrub	LP
Calotropis procera (Ait.) Ait. f.	Geleato	Asclepiadaceae	Shrub	UP
Cenchrus ciliaris L.	Hantadi	Poaceae	Herb	D
Chloris pycnothrix Trin.	Surukto	Poaceae	Herb	D
Chrysopogon plumulosus Hochst.	Durfu	Poaceae	Herb	HD
Combretum collinum Fres.	Andalito	Combretaceae	Tree	LP
Commiphora africana (A. Rich)	Adohaidi/Mukkal	Burseraceae	Tree	P
Cynodon plectostachyus Pilger	Sardoita	Poaceae	Herb	HD
Cyperus rotundus L.	Godeyta	Cyperaceae	Herb	LD
Dactyloctenium aegyptium Beauv.	Afar-amule	Poaceae	Herb	HD
Digitaria milanjiana (Rendle) Stapf	Aiso	Poaceae	Herb	HD
Eragrostis cylindriflora Hochst	Donhito	Poaceae	Herb	LD
Eriochloa sp.	Burule	Poaceae	Herb	LD
Ficus sycomorus L.	Subula	Moraceae	Tree	LP
Grewia ferruginea Hochst.	Hidaito	Tiliaceae	Shrub	HD
Hyparrhenia hirta (L.) Stapf	Denbenu	Poaceae	Herb	D
Nuxia congesta R.Br. ex Fres.	Atkahara	Loganiaceae	Shrub	HP
Panicum coloratum L.	Randa	Poaceae	Herb	HD
Parthenium hysterophorus L.	Democracy	Zygophyllaceae	Herb	UD

Pennisetum stramineum Peter	Aiso	Poaceae	Herb	HD
Prosopis juliflora L.	Weyane zaf (Dergi hara)	Fabaceae	Shrub	UP
Sehima nervosum (Rottler) Stapf	Melif	Poaceae	Herb	HD
Senna alexanderina Vahl.	Sanu	Fabaceae	Shrub	UD
Setaria verticillate (L.) P. Beauv.	Birro	Poaceae	Herb	UI
Sporobolus ioclados Trin.	Hamilto	Poaceae	Herb	HD
Tephrosia sp.	Olea-yto	Fabaceae	Shrub	LD
Tribulus terrestris L.	Bunketo/Bunket	Zygophyllaceae	Herb	HD
Vachellia abyssinica Hochst.	Keselto	Fabaceae	Tree	P
Vachellia asak Hayne	Eibeto	Fabaceae	Tree	P
Vachellia mellifera (vahl)	Merkato	Fabaceae	Shrub	P
Vachellia nilotica (L.) Del.	Keselto	Fabaceae	Tree	P
Vachellia nubica Benth.	Gerento	Fabaceae	Shrub	P
Vachellia oliveri Vatke	Tikibleita	Fabaceae	Shrub	LP
Vachellia senegal (L.) willd	Adado	Fabaceae	Tree	P
Vachellia seyal Del.	Hadgento/mekani	Fabaceae	Tree	P
Ziziphus spina-christi (L.)	Kurta/Kusraito	Rhamnaceae	Tree	HP

In the grazed areas, highly desirable grass species have been replaced by less desirable herbaceous species such as *T. racemosus*, *S. verticillata*, and *S. marginatus*, as well as undesirable non-grass such as *Parthenium hysterophorus, Abutilon fruticasum*, and *Leucas microphylla*.

Herbaceous Species Diversity and Richness

According to the results the diversity of herbaceous plants differed significantly between the two grazing regimes (P<0.05). The enclosed area has more species diversity than the surrounding communal grazing fields (Table 7). There were also significant differences in species richness (the number of species per unit area) between the grazing regimes (P < 0.05) as well there was significant difference in herbaceous species evenness between the exclosures and neighboring communal grazing areas (P < 0.05). The exclosures had also three times higher herbaceous biomass than the surrounding communal grazing areas.

Table 7: Herbaceous species diversity, evenness and richness in exclosures and openly grazed communal areas (Mean + SE)

Species parameters	Exclosures (Mean + SE)	Communal grazing (Mean + SE)	P-value
Diversity	2.59[a]±0.02	1.46 [b] ±0.06	0.0001
Evenness	0.99 [a] ±0.01	0.86 [b] ±0.02	0.0001
Richness	13.69 [a] ±0.001	5.54 [b] ±0.001	0.0001
Biomass (kg DM/ha)	2533.44 [a]±89.96	757.19 [b]±31.66	0.0001

Means with the different letter in a row are significantly different (P<0.05)

DISCUSSION

Livestock Holding and Composition

Pastoralists and agropastoralists have several reasons to preserve their livestock. Preserving herd variability is often associated to water availability, and animal sensitivity to drought and illness in most dry areas of east Africa (Herlocker, 1999; Alemayehu *et al*., 2004), and has also been previously reported by research conducted in several pastoral areas elsewhere in the world (Abule *et al*., 2005; Belaynesh, 2006). Livestock were primarily maintained for milk and meat production, generating cash income, serving as a form of savings, providing manure, and offering traction and transportation (Assefa *et al*., 2024) since they were more resistant to feed shortages, sheep and goats are primarily kept for income generating. The livestock size in the present study were found higher than studies reported elsewhere (Assefa *et al*., 2024).

Pattern of rangelands in supporting pastoral livelihood

Although the majority of the informants argued the role of rangelands in supporting their livelihood is moderate or poor, they on the other hand, claim rangelands are the main source of feed for their livestock. Studies also acknowledged the invaluable role of rangelands in supporting billions of pastoral and agropastoral livelihood (Niamir-Fuller & Huber-Sannwald, 2020; Ghazali *et al*., 2023). Hence, their perception may be influenced by their overall livelihood strategies, or they could be using the rangeland's poor condition as a scapegoat for broader challenges.

Feed Resources and drought coping strategies

Sharing feed from the private exclosure areas to the people who are unable to migrate to other places shows generosity and sharing of resources equitably. This also shows the value of traditional ecological knowledge and customs (Gómez-Baggethun *et al*., 2013). Recognizing such practices could also invaluable roles in strengthening the societial interactions, conserving biodiversity and improving peoples' livelihood.

In the event of a prolonged drought, livestock can be transported out of the drought-prone area by mobility or de-stocking (sale), or cattle can be kept in the area by providing fodder (Alemayehu *et al*., 2004). The type of migration followed a transhumant style of life, in which they had permanent settlement areas but, during dry periods, their livestock and herders moved seasonally to nearby Afar region in search of feed and water.

Rangeland degradation

The pattern of rangeland degradation is more or less similar in pastoral and agropastoral areas. Similar community perceptions of the reduction in rangeland condition were reported elsewhere in Ethiopia (Abule *et al*., 2005; Ameha *et al*., 2014) and the world (Faramarzi *et al*., 2010; Safaei *et al*., 2018; Sahnouni & Abdesselam, 2023; Monegi *et al*., 2024). The main causes of rangeland degradations reported in the study area are congruent with Alemayehu (2004), who found that overgrazing and climatic variability were linked to rangeland degradation and vegetation change. Population pressure could also be the main driver of land degradation (Gebrehiwot *et al*., 2021). When population density rises, trees and shrubs are cleared to create space for new homesteads, and the increased pressure on remaining range resources has grown.

The main impacts of rangeland degradation

The key impacts identified in the study area included reduced rangeland productivity, livestock mortality, food shortages, decreased livestock prices, and increased distances traveled to find feed. The assessment of pastoralists' perceptions aligned with research findings, highlighting the detailed and multifaceted repercussions of rangeland degradation from various pastoralist viewpoints (Slayi *et al*., 2024).

Rangeland management practices

Globally, rangeland management practices have evolved to address degradation, sustain livestock productivity, and enhance ecosystem services. Similar to the practices observed in the current study area such as moving livestock, establishing exclosures, destocking, supplying feed, tree planting, and the use of wildfire, integrated approaches are implemented to manage rangelands sustainably.

Seasonal livestock movement (transhumance) is a widely adopted strategy, particularly in East Africa and Central Asia, to prevent overgrazing and allow pastures to regenerate (Motta *et al*., 2018). Exclosures, or protected areas closed off from grazing to promote vegetation recovery, are commonly practiced in Ethiopia and Niger, significantly improving biomass and soil fertility (Mekuria & Aynekulu, 2013). Destocking, or reducing herd size, is used in drought-prone areas like Australia and Kenya to match carrying capacity and avoid pasture depletion (Amwata *et al*., 2016; Bowen & Chudleigh, 2021).

Supplemental feeding during the dry season is widely used in different parts of the world, buffering livestock from forage shortages (Cooke *et al*., 2025). Tree planting (agroforestry) enhances soil cover and feed availability, and is promoted in globally. Controlled burning (fire use) is also applied in several parts of the world to control undesirable species and improve forage regeneration in rangelands (Toledo *et al*., 2012). These global parallels validate the appropriateness of practices in Chifra and highlight their effectiveness in building rangeland resilience.

The effect of exclosures on species richness, diversity and biomass

Due to their creeping habit of development, highly desirable species like Chrysopogon plumulosus could be found in areas where grazing pressure is considerable (Sisay & Baars 2002; Gebremeskel, 2006). On the other hand, less desirable grass species like *Cyperus rotundus* L., *Eriochloa nubica*, *Eragrostis cylindriflora* were only found in communal grazing areas and river side grazing areas with heavy grazing pressure. According to Dalle Tussie (2004), the limited spatial distribution of highly valued forage grasses could be a probable signal of deteriorating rangeland conditions. Grazing intensity, according to (Mligo, 2006), is the most important element influencing vegetation distribution in the semi-arid ecosystem. Unpalatable herbaceous species dominated communal grazing areas in South Africa (Kiguli *et al*., 1999).

Due to the overgrazing, highly desirable species are being replaced by undesirable species. This finding is substantiated by other studies (Sisay & Baars, 2002; Admasu, 2006). Both the communal grazing land and exclosures had *D. aegyptium* and *Brachiaria eruciformis* despite their abundance was higher in the exclosures than in the communal grazing areas. Because of its quick growth with even a small quantity of rainfall, *D. aegyptium* is extremely attractive and one of the most drought tolerant grass species; similar result was reported by Tegegn (2009).

Heavy grazing has been shown to alter community structure by reducing diversity—eliminating less grazing-resistant species while promoting those that are more tolerant. This finding is congruent to previous research conducted in Ethiopia (Yayneshet *et al*., 2009; Angassa & Oba, 2010), which found that herbaceous species diversity and richness were higher in the exclosures than in communal grazing areas.

The exclosures had significantly higher herbaceous biomass than the surrounding communal grazing areas. This finding is consistent with other research that have found increased biomass yield in exclosure areas (Yayneshet *et al*., 2009; Angassa & Oba, 2010; Manaye *et al*., 2019; Eshetie *et al*., 2024).

CONCLUSIONS

The present study findings demonstrate that traditional rangeland management practices, particularly the implementation of grazing exclosures, positively and significantly influenced herbaceous and woody plant richness and diversity as well as biomass than the communal grazing lands. These practices contribute to the restoration of some plant species and biomass productivity.

Despite the deep-rooted communal tenure systems and existing customary management structures, challenges remain in sustaining productive rangelands. The pastoral communities' adaptive strategies, including mobility and supplementary feeding, provide important coping mechanisms but are insufficient to reverse the rangeland degradation.

Therefore, sustainable rangeland management in Chifra district should prioritize the scaling-up of exclosures practices integrated with participatory community-based approaches, enhanced grazing regulation, and ecological restoration efforts. This multi-faceted strategy will help restore ecosystem functions, improve forage resilience, and secure pastoral livelihoods in the face of ongoing climatic and anthropogenic pressures.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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