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Research Article

Woody Fodder Species Diversity, Their Use, and Preferences in Agropastoral Areas of Gomole District, Borana Zone, Southern Ethiopia

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Livestock production in the semiarid regions of Ethiopia is increasingly challenged by recurrent droughts and seasonal forage shortages, particularly during the dry season. Despite these constraints, certain indigenous woody fodder species serve as critical feed resources, supporting agropastoral livelihoods during periods of scarcity. However, there remains a substantial knowledge gap regarding the diversity, availability, and local preferences for these species among agropastoral communities. Thus, this study aimed to investigate the diversity, species preferences, and utilization of woody fodder plants in the Gomole district of Southern Ethiopia. Data were collected through a combination of household surveys, key informant interviews, and field-based vegetation inventory. A total of 328 households and 12 key informants from two kebeles participated in the interviews. For the vegetation survey, 36 plots were systematically placed using purposive sampling to ensure spatial and ecological representativeness. The collected data were analyzed using frequency, the Shannon Wiener index, and pairwise ranking methods. A total of 35 woody fodder species belonging to 17 plant families were documented in the study area. The study recorded a Shannon diversity index of $H' = 3.2$ and an evenness value of 0.76. Of the documented species, 19 (54%) were available and utilized as livestock feed during both dry and rainy seasons, while 16 species (46%) were available and utilized only during the rainy season. The research indicated that 22 species were utilized as feed for cattle, while camels and goats consumed all species, with leaves being the most commonly used plant part (91%). Preferred species varied by livestock type: *Olea europaea*, *Pappea capensis*, *and Phyllanthus leucanthus* for cattle; *Phyllanthus leucanthus*, *Senegalia brevispica*, and *Dalbergia microphylla* for goats; and *Senegalia brevispica*, *Vachellia tortilis*, and *Indigofera spinosa* for camels. Beyond their primary role as livestock fodder, woody species were used for fuelwood, food, medicine, construction, and cultural ceremonies, making them critical resources. Despite their value, these species have faced growing threats from overexploitation, overgrazing, climate change, bush encroachment, and agricultural expansion. In conclusion, woody fodder species play a crucial role in supporting livestock, livelihoods, and biodiversity, underscoring the urgent need for their conservation. Therefore, effective conservation strategies are urgently needed to address the threats to woody fodder species by promoting alternative fuel sources, sustainable grazing practices, and reducing pressure on these species.

Keywords: fodder composition; Gomole; livestock; preference; threat

1. Introductions

Livestock production is a vital component of agricultural systems worldwide, providing sustenance and food security for million people [1, 2]. In Ethiopia, livestock accounts for over 85% of farm cash revenue and contributes 13%–16% to the national GDP, with approximately 16% of total exports [3]. In the Gomole district, the livestock sector is even more critical, contributing 98% to the livelihoods of pastoral and agropastoral communities [4].

Livestock in this region heavily rely on natural pastures, which include a diverse array of woody fodder species, herbs, and grasses throughout the year [5, 6]. According to Angassa and Beyene [7], Borana's natural pastures were recognized as some of the most productive rangelands in Africa 3 decades ago. However, these natural pastures face increasing challenges due to human activities and natural calamities, such as drought [8–11].

For instance, the Borana Zone, which includes the Gomole district, has experienced two severe droughts in the past decade, significantly limiting forage availability [12]. Drought conditions lead to reduced water availability, which can severely hinder the growth rates of woody fodder species [13, 14]. Insufficient moisture can cause these plants to exhibit stunted growth, limiting their ability to photosynthesize, absorb nutrients, and leaf productions [15]. The reduction in leaf production further decreases the biomass available for grazing, negatively affecting livestock nutrition [16].

Despite these challenges, numerous studies have indicated that certain woody plant species serve as important feed sources for livestock during both the dry season and periods of drought, due to their evergreen nature and palatability [17–19]. Woody fodder species, including trees and shrubs, play a crucial role in maintaining livestock feed availability, particularly in dry conditions [20, 21]. These species are resilient to drought, provide high nutritional value, and can regenerate in harsh environments, making them a sustainable source of forage that enhances livestock health and productivity [22–24].

Furthermore, woody fodder species provide important environmental and cultural benefits, including shade for livestock and people, erosion control, and heritage value [25]. Despite these advantages, many woody fodder species are threatened and declining [26, 27]. Therefore, there is an urgent need to conserve tree and shrub species diversity and other plant species in natural ecosystems [28], given the global concern for the scientific, economic, ecological, and political implications of increasing extinction rates due to human activities [29].

Understanding the existing patterns of woody species, how pastoralists utilize them in rangelands, and the roles these species play in production systems is crucial for managing woody fodder species effectively for conservation and production goals. Additionally, assessing the status and diversity of trees and shrubs in rangelands, including species richness and evenness, is essential [25, 30]. However, there is a lack of comprehensive studies on the diversity, utilization, seasonal availability, preferences, and threats of woody fodder species in the rangelands of the Borana Zone, particularly the Gomole district. This knowledge gap hampers efforts to promote sustainable livestock management practices, potentially leading to overgrazing, resource depletion, and increased vulnerability to drought. Therefore, this study aims to fill this critical knowledge gap by identifying the woody fodder species utilized by pastoralists in the Gomole district, exploring their preferences, and evaluating their local utilization. More specifically, the study aims to: (a) to identify woody fodder species and their diversity, (b) to explore seasonal availability of woody fodder species and their use, (c) to determine the most preferred species for different livestock types and assess threats to woody fodder species in Gomole District, Southern Ethiopia. This investigation is essential for establishing baseline information on woody fodder species diversity, local significance, and pastoralist preferences, all of which are crucial for ensuring sustainable livestock production in the district (third-level administrative unit).

2. Materials and Methods

2.1. Description of the Study Area. The research was conducted within the bounds of Gomole District, which is situated in the Borana Zone of Oromia Regional State in southern Ethiopia. Specifically, the district is located approximately 535 km to the south of Addis Ababa, the capital city of Ethiopia. The geographic coordinates of the district span from 5°0′0″ N to 5°20′0″ N latitudes and 38°0′0″ E to 38°30′0″ E longitudes (Figure 1). Gomole District exhibits a semiarid climate with altitudes ranging from 1100 to 1750 m above sea level [31]. The district covers a total area of 118,134.4 ha and has a population of 67,798, with 29,545 males and 38,253 females [32, 33]. The district's landscape is woodland, predominantly characterized by scattered shrubs and woody vegetation [34]. The livelihoods of the district's inhabitants primarily depend on agropastoralism, which encompasses both crop cultivation and livestock rearing for subsistence [4]. The livestock population in the district as of 2023 was 160,112, consisting of 37,000 cattle, 108,222 goats, and 14,890 camels [35]. The region experiences a distinctly bimodal rainfall pattern: 59% of the annual precipitation falls between March and May during the long rainy season, while 27% occurs from September to November in the short rainy season (Figure 2). The area is marked by erratic and variable rainfall, with annual precipitation levels ranging from 238 to 896 mm [36].

2.2. Study Site Selection. For this study, the researchers purposively selected the Gomole district due to its extensive rangeland resources, which are notably dominated by fodder woody species, making it the largest rangeland area in the Borana zone. Its accessibility further supported its suitability for fieldwork. Within the district, Haro Bake and Bildim kebeles (Ethiopia's smallest administrative units) were chosen from a total of ten, based on their considerable land coverage; together, they account for approximately 30% of the district's area. This selection aimed to ensure a representative sampling of the region's ecological and land use characteristics.

2.3. Woody Inventory and Sampling Design. A reconnaissance survey was conducted through field visits and direct physical observation to gain a general overview of site conditions and to identify appropriate sampling sites in two adjacent and demarcated kebeles: Haro Bake and Bildim. In line with the rangeland utilization guidelines of the Borana Zone, the neighboring kebele lands were utilized for similar purposes along their shared boundary [37]. The road leading to Surupha serves as a natural demarcation between the two

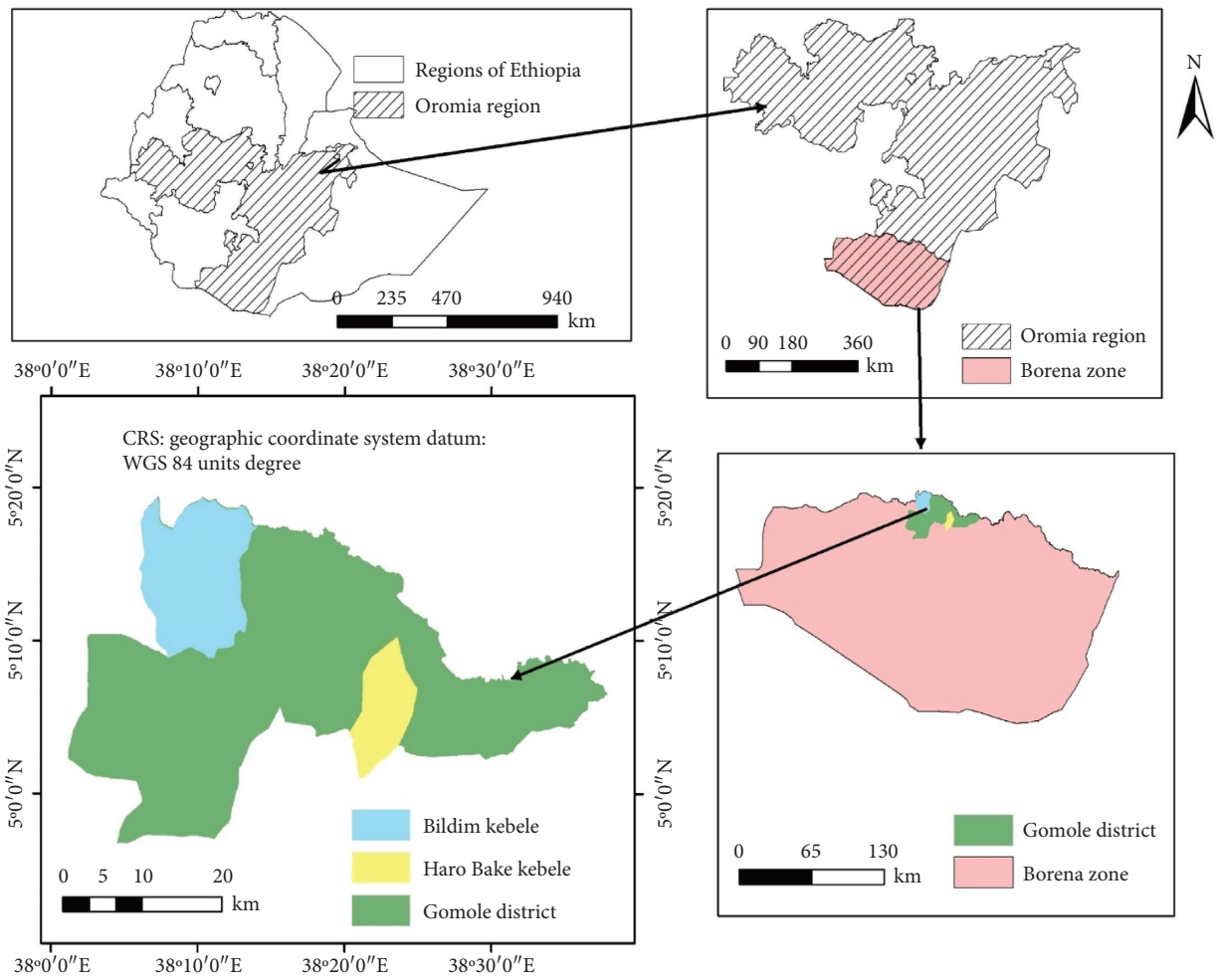


Figure 1: Location map of the study area within Gomole woreda of Borana zone, Oromia regional state, Ethiopia.

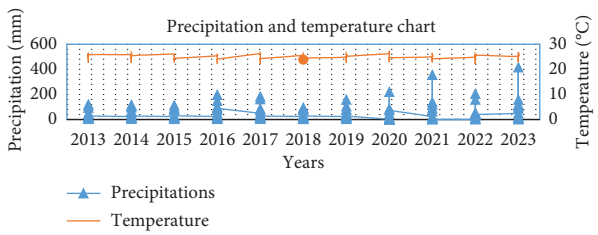


Figure 2: Annual temperature and precipitation of study area sources https://crudata.uea.ac.uk/cru/data/hrg/ (CRUTS = Climatic Research Unit Time series).

kebeles. The study kebeles fall within the same agroecological zone, characterized by similar climate conditions, soil types, vegetation cover, and land use practices. This uniformity is crucial for conducting integrated rangeland assessments, as it ensures consistency in ecological parameters across the study area. To ensure spatial representation and systematic sampling, three transects were established within each kebele. Transects were deliberately oriented from south to north in Bildim and from north to south in Haro Bake to align with kebele-specific access routes and optimize spatial sampling coverage. This bidirectional layout ensures ecological representativeness and logistical feasibility across the study landscape. In each of the kebeles (Haro Bake and Bildim), three parallel transect lines were established, each measuring 1800 m in length and spaced at 500-m intervals [38]. To reduce edge effects and maintain consistency across the study area, the first transect in each kebele was purposively positioned 100 m away from the main road or edge. This purposive placement was intended to avoid boundary disturbances and ensure more representative sampling. The initial plot along each transect was purposefully established at the beginning of the transect to align with its overall length and ensure comprehensive coverage of the study area. This strategic placement was designed to capture the full range of ecological conditions and variations present within the transect, facilitating a more accurate assessment of biodiversity and environmental factors. A total of 36 sample plots, each measuring 50×50 m, were systematically laid along the transect lines at 200-m intervals, resulting in six sample plots per transect and 18 plots per kebele (Figure 3).

The vegetation survey was conducted in early May 2024 (the late wet season) when most plants were in the flowering stage, which is an important tool for species identification. All the woody plant species (tree and shrub species) in each

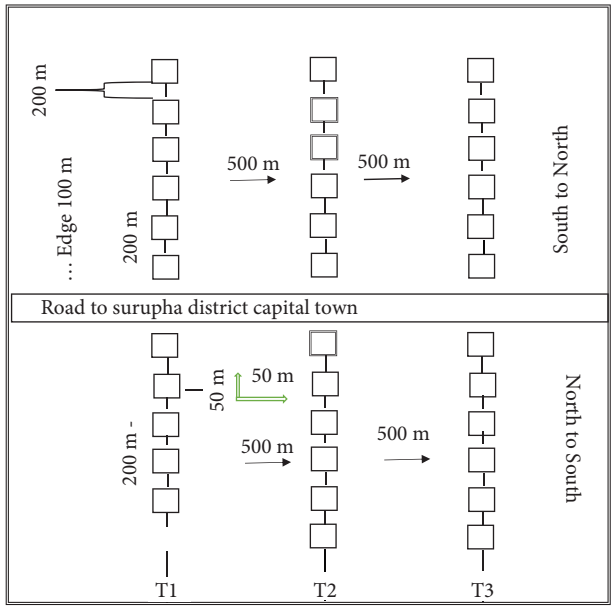


Figure 3: Field plot layout of the experimental site.

plot were recorded for species richness, diversity, density, and frequency assessments. For species density assessments, trees with forks originating below 1.30 m were counted as separate individuals, whereas those with forks above 1.30 m were recorded as a single tree. During the field survey, local participants assisted in the collection of plant samples. The identification of the collected species was carried out with the guidance of community members and the local flora expertise. Botanical keys from published journals on Ethiopian and Eritrean flora were utilized to aid in the identification [39–42]. In cases where species identification proved difficult in the field, specimens were collected, pressed, and dried, then sent to the National Herbarium within the Biology Department at Addis Ababa University for formal identification. Cronquist classification system was adopted to place species with their respective families [43, 44].

2.4. Household and Key Informant (KI) Interview. To determine the representative sample size for household surveys, population records from kebele administrative offices were used. Subsequently, 1810 households in the two kebele registered, 956 were from Haro Bake kebele and 854 were from Bildim kebele. Yamane [45] formula was adopted in order to obtain a representative sample size (equation (1)) Following the prescribed formula, a total of 328 households were identified and randomly selected for the purpose of the study. The selection of household sizes was proportional to the population size of each kebele. Therefore, 173 households were selected from Haro Bake kebele, and 155 households were selected from Bildim kebele:

$$n = \frac{N}{1 + N(e)^2}, \quad (1)$$

where "n" is number of representative samples for the study, "N" is total population, and "e" is the error to be considered, e.g., level of precision (5%).

Furthermore, to rank the most preferred woody fodder species, information was gathered through KI interviews. In this study, KIs were identified as individuals who possess knowledge about woody fodder species, own various types of livestock (such as cattle, goats, and camels), are familiar with local usage and preferences, and have resided in the study area for over ten years. Furthermore, the selection of KIs was done purposively using the snowball method [46]. Initially, five individuals engaged in pastoralist or agropastoralist activities were randomly chosen and asked to nominate seven potential informants who met the defined selection criteria. The names provided were then compiled, and those appearing most frequently were prioritized. The top six recurring nominees in each kebele Bildim and Haro Bake were finalized as the KIs for the study. In total, 12 KIs (six per kebele) participated in semistructured interviews.

To collect information on the local use of fodder woody species and the preferences of agropastoralists, a variety of methods were employed, including KI interviews, household interview, and field observations [47, 48]. The questionnaire was initially prepared in English and then translated into Afan Oromo. A pretest of the questionnaire was conducted with five pastoralists to evaluate its clarity, relevance, and overall effectiveness in capturing the intended information. This initial trial helped identify ambiguous questions, technical terms unfamiliar to respondents, and issues with question sequencing that could hinder comprehension. Based on feedback from these pastoralists, the questionnaire was revised to improve phrasing, simplify complex terms, and reorder sections to enhance logical flow and respondent engagement. These revisions ensured that the final survey instrument was culturally appropriate and contextually accurate. By incorporating lessons from the pretest, the study enhanced data quality, minimized response bias, and improved transparency in both survey design and execution. Following the pretest adjustments, formal surveys were administered to 328 sampled households. Semistructured questionnaires were used to gather insights on the seasonal availability, local use, and threats to woody fodder species. The household survey took place between April and May 2024. The respondents were asked the following key questions: (i) Which woody species are used as fodder? (ii) Which woody species are preferred by different livestock species based on their experience herding? (iii) Which parts of the woody plants do animals consume? (iv) What are the major threats to woody fodder species in the study area? (v) What are the other uses of woody fodder species? To identify and rank woody fodder species preferred by different livestock, criteria were developed and data were gathered through focused discussions with twelve experienced KIs. Each species was rated on a five-point scale based on consumption frequency and enthusiasm: 1 (Not Preferred) never consumed; 2 (Low Preference) rarely browsed, only in absence of alternatives; 3 (Moderately Preferred) occasionally browsed with moderate palatability; 4 (Preferred) regularly browsed, especially during forage scarcity; and 5 (Most Preferred) consistently browsed and highly favored year-round. This classification helped capture the relative importance of each woody species in the diet of different

livestock types. Field observation was employed as a supplementary method in this study to gather additional data that could complement and provide a different perspective compared to other data collection techniques. Its purpose was to enable cross-validation of the gathered data, thereby enhancing the validity of the data by comparing and contrasting information obtained through different methods.

2.5. Data Analysis. The woody plant composition was determined by species diversity, richness, evenness, relative frequency (RF), and relative density (RD). Woody species richness was assessed through direct species counts. Species diversity was quantified using the Shannon Diversity Index (H′), following the methodologies outlined by Magurran [49] and Krebs [50]. The Evenness (Shannon equitability) index (E) was calculated to estimate the homogeneous distribution of woody species on the agroforestry practice, following Magurran [49]. The mean density of the woody plant species was calculated by converting the total number of individuals of each woody species encountered in all the sample plots per hectare. RD was determined by dividing the number of individuals of a particular species by the total number of individuals per hectare, and then multiplying by 100. Absolute frequency is the number of plots in which species occur divided by the total number of plots laid out in the study site. The relative frequency was computed by dividing the frequency of a particular species by the total count of all species at each site and then multiplying by 100.

To determine the priority order of the listed fodder woody plant species, the frequency citation (FC) index was used [51]. The FC is calculated by the number of use-reports of each species divided by the number of all informants. We used direct matrix scoring to determine which woody species preferred by different livestock types based on herders' experience, drawing on methodologies established by earlier researchers [51, 52]. Following data collection through vegetation assessments and household surveys, the information was encoded in Microsoft Excel. The encoded data were then subjected to statistical analysis using SPSS version 20.0 and Excel [53, 54], allowing for both quantitative and qualitative insights. We then employed descriptive analytical tools including tables, pie charts, and graphs through Microsoft Office Excel 2019 and SPSS to present the findings.

3. Results

3.1. Sociodemographic Characteristics of Participants. Table 1 presents the distribution of participants based on their sex, age, educational background, and marital status within the study area. Out of the 328 individuals involved in this study, approximately 212 (64.6%) were male, while 116 (35.4%) were female. The largest age group among the participants, constituting 40%, was between 42 and 52 years old. Among the respondents, 254 (77.5%) were found to be had no formal education, with the remaining participants having completed primary, secondary, college, and university education. Furthermore, 288 (87.8%) of the respondents were married, as illustrated in Table 1.

3.2. Woody Fodder Species Compositions. The study found 35 woody species, classified under 17 families, that are used as fodder for livestock (Table 2). The life-form distribution of these species was 18 (51%) trees, 16 (42.8%) shrubs, and 1 species (3%) was a woody climber. The *Mimosaceae* family was identified as the most diverse, comprising six species (35%), followed by Combretaceae and Anacardiaceae, each represented by three species (17.6%). The study recorded a Shannon diversity index (H′) of 3.2 and an evenness value of 0.76 for woody vegetation in the Gomole rangeland (see Figure 4). The most frequent woody plant species in the study area are presented in Table 2. The top five most frequent woody plant species in the study area were *Combretum collinum* (9.6%), *Vachellia drepanolobium* (7.8%), *Cordia sinensis* (6.2%), *Euclea divinorum* (6.2%), and *Terminalia brownie* (6%). Meanwhile, the highest recorded relative densities were for *Combretum collinum* (8.6%), *Terminalia brownie* (8%), *Euclea divinorum* (8%), *Cordia sinensis* (7%), and *Lannea rivae* (6.2%) (Table 2).

3.3. Seasonal Availability of Woody Fodder Species. The study identified seasonal patterns in the availability of woody fodder species, which varied across species (Table 2). The study revealed that 19 species (54%) were available and utilized as livestock feed resources during both the dry and rainy seasons, whereas 16 species (46%) were available and utilized only during the rainy season.

3.4. Herders' Knowledge and Livestock Preference for Woody Fodder Species. The FC values for woody fodder plants among agropastoralists showed significant variation, ranging from 5 to 98. Notably, 71% of the recorded species had FC values exceeding 50% (0.5), as illustrated in Table 2. These species included *Olea europaea, Vachellia tortilis, Balanites aegyptiaca, Pappea capensis, Lannea rivae, Commiphora schimperi, Senegalia brevispica, Hibiscus ovalifolius, Phyllanthus sepialis,* and *Grewia pennicillata*. In contrast, *Vachellia drepanolobium, Cordia sinensis, Terminalia brownie, Ficus thonningii, and Vachellia seyal* were among the least frequently mentioned woody fodder species by participants.

Table 2 illustrates that different species of livestock exhibited diverse levels of fodder utilization. Of the 35 identified woody fodder species, pastoralists specifically mentioned 22 plant species used for cattle feed. On the other hand, the study found that camels and goats were able to utilize the full range of 35 woody fodder species available in the study area (Table 2). The KIs reported that the most consumed parts of woody fodder species were leaves (91%), twigs (51%), fruits (48%), whole parts (8%), and bark (5%) (Figure 5).

Based on herders' experiential knowledge, the study identified distinct differences in preferences for woody fodder species among livestock types (Figure 6). Cattle exhibited the highest preference for *Olea europaea*, followed by *Pappea capensis*, *Balanites aegyptiaca*, *Phyllanthus leucanthus*, and *Vachellia tortilis*. Goats primarily preferred *Phyllanthus leucanthus*, followed by *Senegalia brevispica, Dalbergia microphylla*, and *Commiphora schimperi*. Camels

Table 1: Sociodemographic characteristics of the households' respondents.

	Categories	Total number of participants	Percentage (%)
Gender	M	212	64.6
	F	116	35.4
Age	20–30	23	7
	31–41	96	29.3
	42–52	131	40
	53–63	58	17.7
	> 64	20	6
Marital status	Single	28	8.5
	Married	288	87.8
	Divorced	12	3.7
Education	Had no formal education	254	77.5
	Primary	50	15.2
	Secondary	6	1.8
	College	8	2.5
	University	10	3

Table 2: Woody fodder species life form (WC: woody clumber, T: tree and S: shrubs); frequency citation (FC), part used (L: leaves; F: fruit; Tw: twigs; B: bark and Wp: whole part); seasonal availability (R: rain season W; whole or entire year); animal species (Ca: cattle; Cm: Camel; G: Goat); and other uses (Fu: fuelwood; M: medicine; Co: construction; Fo: food; Ch: charcoal; Cu: cultural ceremonies and ritual; Fe: fencing; and Gu: gum).

Scientific name	Family	Life form	FC %	Part used	Animal species	Seasonal	Other use	RF	RD
Olea europaea	*Oleaceae*	T	96	L, F, Tw	Ca, G, Cm	W	Co, Fu	1.3	0.5
Vachellia tortilis	*Mimosaceae*	T	92	L, F	Ca, G, Cm	W	Fu, M, Fe, Ch	3.5	3.8
Balanites aegyptiaca	*Zygophyllaceae*	T	90	L, Tw, F	Ca, G, Cm	W	M, Fo, Fu	2.2	2.1
Combretum collinum	*Combretaceae*	T	10	L, Tw	G, Cm	W	Fu	9.6	8.6
Senegalia goetzei	*Mimosaceae*	T	54	L,F	G, Cm	R	FU, CO, Ch	1.5	1.3
Indigofera spinosa	*Fabaceae*	T	87	Wp	G, Cm	R	M	3.5	6.4
Haplocoelum foliolosum	*Sapindaceae*	T	28	L, B	G, Cm	W	Fu, Cu	3.7	2.9
Balanites rotundifolia	*Zygophyllaceae*	T	81	L, F	Ca, G, Cm	W	M, Fu, Fo	1.1	4.3
Boscia mossambicensis	*Capparaceae*	T	77	L, Tw	Ca, G, Cm	W	Fu, Cu, Ch	2.2	1.9
Ficus vasta	*Moraceae*	T	17	L,B	Ca, G, Cm	R	Gu	0.5	0.3
Dalbergia microphylla	*Fabaceae*	S	75	L, F, Tw	Ca, G, Cm	W	Fu, Co, Ch	2.5	0.9
Euclea divinorum	*Ebenaceae*	T	46	L	Ca, G, Cm	W	Cu, M	6.2	6.2
Cordia sinensis	*Boraginaceae*	S	9	L	G, Cm	W	M, Fu	7.8	7
Ficus thonningii	*Moraceae*	T	12	L	G, Cm	R	Fu	2.5	5.3
Phyllanthus sepialis	*Euphorbiaceae*	S	80	L, Tw	Ca, G, Cm	R	Cu	4	0.6
Grewia pennicillata	*Tiliaceae*	T	83	L,F, Tw	Ca, G, Cm	R	Cu, Fo	0.6	0.3
Commiphora schimperi	*Burseraceae*	S	76	L, F, B	G, Cm	R	Fu, Fe	3.2	2.6
Searsia pyroides	*Anacardiaceae*	S	84	L, Tw	Ca, G, Cm	W	Fu, M, Fo	1.9	0.8
Pappea capensis	*Sapindaceae*	T	91	L, Tw, F	Ca, G, Cm	W	M, Fu, Ch	2	0.3
Lannea rivae	*Anacardiaceae*	T	51	L, Tw, F	Ca, G, Cm	R	Fu, Cu, Fo	4.6	8
Senegalia brevispica	*Mimosaceae*	S	68	L, Tw, F	G, Cm	W	M	0.4	0.3
Hibiscus ovalifolius	*Malvaceae*	S	73	L, F, Tw	Ca, G, Cm	R	Fo, M	1.3	1.5
Cordia ellenbeckii	*Boraginaceae*	S	50	L, F, Tw	Ca, G, Cm	R	Fo, Fu	5.2	4.6
Terminalia brownie	*Combretaceae*	T	8	L	G, Cm	R	Fu, M	6	8
Combretum molle	*Combretaceae*	T	14	L	G, Cm	W	Fu, Ch	4	6
Vachellia drepanolobium	*Mimosaceae*	S	5	L	G, Cm	W	Fu	6.2	3.9
Vachellia seyal	*Mimosaceae*	T	39	F, L	G, Cm	R	Fu, M, Fe, Ch	2	4.8
Vepris glomerata	*Rutaceae*	S	50	L, Tw	G, Cm	W	Fu	2	0.2
Dichrostachys cinerea	*Mimosaceae*	S	60	L, F	G, Cm	R	Fu, Co, Fe, Ch	1.7	0.5
Maerua triphylla	*Capparaceae*	S	62	L, Tw	Ca, G, Cm	W	Fu	0.9	0.2
Phyllanthus leucanthus	*Euphorbiaceae*	S	81	L, Tw	Ca, G, Cm	W	Cu	0.9	0.4
Vernonia phillipsiae	*Asteraceae*	S	51	L	Ca, G, Cm	R	Co	1.2	0.7
Kleinia squarrosa	*Asteraceae*	WC	60	Wp	G, Cm	W		0.5	0.1
Searsia longipes	*Anacardiaceae*	S	52	L, Tw, F	Ca, G, Cm	R	Fo, Fu	2.9	4.4
Grewia bicolor	*Tiliaceae*	S	60	L, F, Tw	Ca, G, Cm	R	Fo, Fu, Co	0.4	0.3

Abbreviations: RD, relative density; RF, relative frequency.

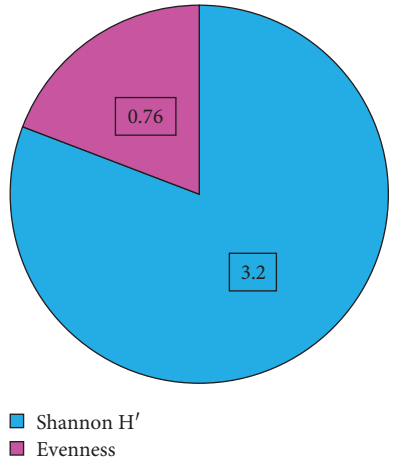


Figure 4: Shannon diversity (H) and evenness for tree and shrubs in communal rangeland of the study area.

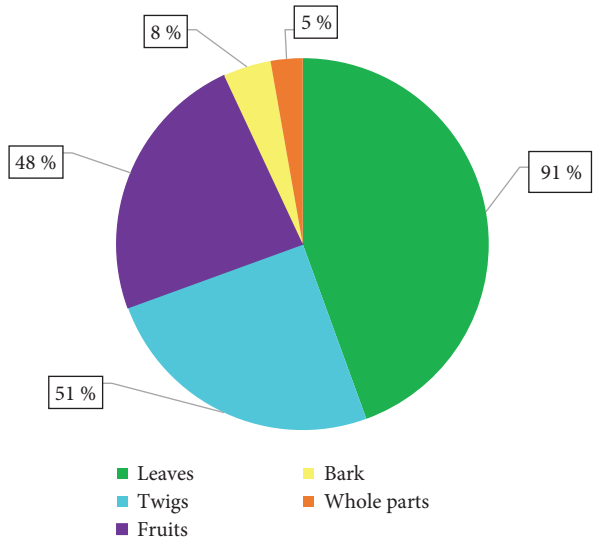


Figure 5: Parts of woody fodder species consumed by different livestock species.

showed the strongest preference for *Senegalia brevispica*, followed by *Vachellia tortilis, Indigofera spinosa, Searsia pyroides*, and *Kleinia squarrosa*.

3.5. Local Uses and Associated Threats to Woody Fodder Species. In addition to their primary role as fodder, the agropastoralists in Gomole were used woody species for various purposes, including fuelwood, medicine, food, cultural ceremonies, construction, and gum production (see Figure 7(a)). Specifically, 23 species were cited for fuelwood, 12 for medicinal use, 9 for edible purposes, 8 for charcoal production, 7 for cultural ceremonies, 6 for construction, 5 for fencing, and 1 for gum production.

Figure 7(b) shows a significant threat to woody fodder species in the study area. Overexploitation (87%) posed the greatest threat to woody fodder species, followed by overgrazing (84%), climate change (78%), bush encroachment (65%), and agricultural expansion (48%).

4. Discussions

4.1. Sociodemographic Characteristics of Participants. The evaluation of the sociodemographic attributes of respondents in social surveys is crucial, as these characteristics provide important context for the analysis and interpretation of survey findings. In this study, a notable majority of the participants (64.5%) were male. This finding is consistent with the research conducted by Bashe [55], which revealed that men represented the majority demographic among survey participants concerning the use of fodder species in the Wolaita Zone of Ethiopia.

4.2. Woody Fodder Species Compositions. The study found 35 woody fodder species in the Gomole rangeland, indicating a moderate level of species richness. This finding is consistent with Gilo [18], who reported comparable richness in woody fodder species. Conversely, Gochera et al. [56] documented a higher number of species in Arba Minch Zuria Woreda. These differences in species richness may be attributed to varying degrees of environmental protection, geographic location, pastoralists' species preferences, cultural practices, and the adaptive potential of species to local ecological conditions [57, 58].

Mimosaceae was a dominant family in the study area. The dominance of *Mimosaceae* as the most abundant family has been widely observed in several ethnobotanical studies in Ethiopia [19, 59], and other African countries such as Chad [60], Benin [61], and Niger [62]. The dominance of certain plant families such as *Mimosaceae* and Combretaceae in the study area indicates the adaptability and resilience of these plant groups to the prevailing environmental conditions and management regimes [19, 59].

The study found a Shannon diversity index of 3.2 and an evenness value of 0.76, indicating a moderate diversity of woody species in the study area. These values suggest a stable ecological structure that contributes positively to biodiversity conservation in dryland rangelands.

This finding aligns with the diversity index reported by Garbole and Tekklu [19] in the Dugda Dawa rangelands of southern Ethiopia, indicating comparable ecological conditions. Conversely, the diversity value was higher than that reported by Shiferaw et al. [63], in Awash Fentale ($H' = 2.23$), indicating lower species richness and more degraded conditions. The variation in woody fodder species diversity was due to variations in land management practices, grazing intensity, and geographical location, which influence species composition and ecological resilience across regions [48].

The highest values of RF and RD were recorded for *Combretum collinum, Vachellia drepanolobium*, and *Terminalia brownie*. This is consistent with the findings of Garbole and Teklu [19] and Assani et al. [62], who reported

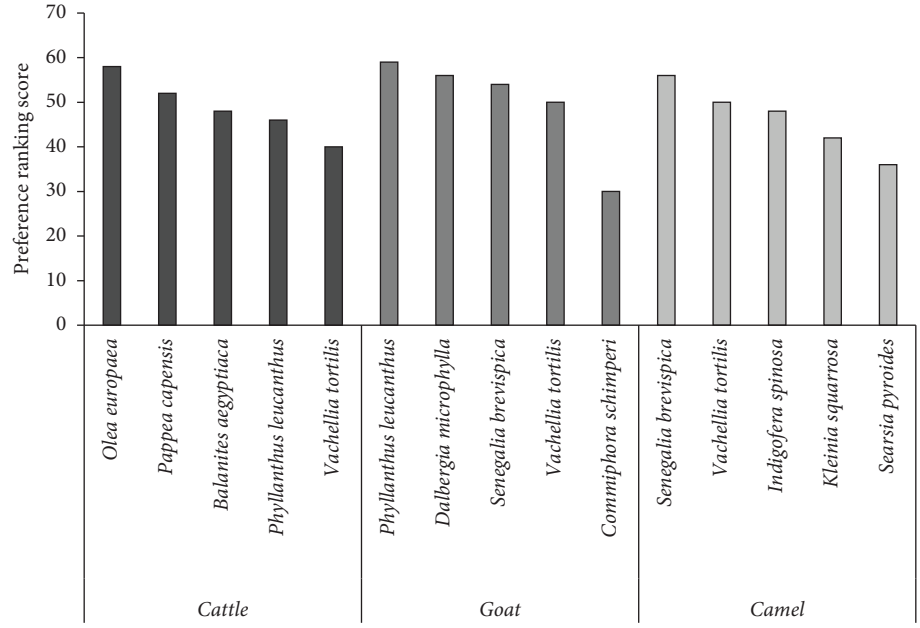


Figure 6: Woody fodder species preference by different livestock species.

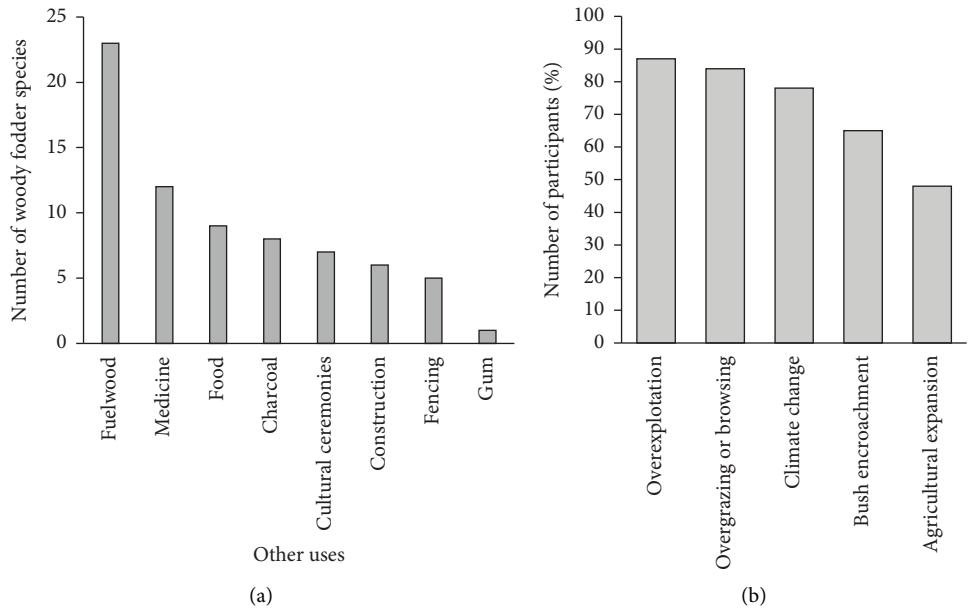


Figure 7: Local uses (a) and associated threats to woody fodder species (b).

higher abundance of these species, which was linked to their lower preference and strong ecological adaptability.

4.3. Seasonal Availability of Woody Fodder Species. The study revealed that 54% of woody fodder was available and utilized during the dry and rainy seasons as livestock feed, whereas 46% was available only in the rainy season. This suggests that woody fodder serves as a dependable feed source across seasons, particularly in dry periods when other forage types decline. These findings are consistent with those reported by Jatani [64], who documented a comparable number of woody fodder species being available and used across both seasons. The unavailability of nearly half of these species during such periods forces livestock managers to seek alternative feed sources, which might be less nutritious or more costly [65, 66]. Such a scenario increases operational costs and potentially affects the health and productivity of livestock [67]. Reliance on a limited number of species productive during the dry season could lead to overexploitation of those species, threatening their sustainability and reducing biodiversity [68, 69]. Understanding these dynamics is crucial for promoting ecosystem stability and ensuring long-term availability of fodder resources [70].

4.4. Herders' Knowledge and Livestock Preference for Woody Fodder Species. More than 71% of woody fodder plants had a FC above 50%. A higher FC indicates frequent mentions by participants, suggesting that these species are well-known within the community and are essential for livestock nutrition and the overall health of community members. Species with higher FC values are generally considered more popular and familiar among local inhabitants [71, 72].

The study findings revealed differences in the dietary habits of various livestock species, highlighting that camels and goats utilize more species than cattle. This suggests that goats and camels have broader dietary preferences, while cattle rely on a more limited selection of plant species. A similar result was reported by Sanon [73]. The ability of camels and goats to consume a wider variety of woody fodder species is particularly advantageous in arid and semiarid environments, where forage options may be scarce [73–75]. This adaptability is essential for maintaining livestock health and productivity under challenging ecological conditions.

The study findings revealed that *Olea europaea, Pappea capensis*, and *Phyllanthus leucanthus* were the most preferred woody fodder species for cattle, based on herders' experiential knowledge. This preference aligns with earlier observations reported by Aregawi [76], who documented the multipurpose value of *Olea europaea* and *Pappea capensis* in East African rangelands. For goats, herders' identified *Phyllanthus leucanthus*, *Senegalia brevispica*, and *Dalbergia microphylla* as key fodder species. These shrubs and small trees are known for their high digestibility, nitrogen-fixing capacity, and adaptability to degraded soils, making them particularly suitable for small ruminants. This finding is consistent with studies by Derara and Bekuma [77], and Raj [78] that highlight their importance in dryland pastoral systems. Camels, on the other hand, showed a strong preference for *Senegalia brevispica*, *Vachellia tortilis*, and *Indigofera spinosa*. These species are well adapted to arid environments, with deep-rooting systems, high biomass production, and drought tolerance. *Vachellia tortilis*, in particular, was widely recognized for its role in camel nutrition and land rehabilitation, as reported by Elfeel [79] and Desalegn et al. [80].

The most consumed parts of woody fodder species were leaves, followed by twigs, fruits, whole parts, and bark. These results align with previous research conducted in Ethiopia [81] and other regions [82–84], which similarly emphasized the predominance of leaves as preferred fodder. The preference for leaves across all livestock aligns with existing literature, which indicates that leaves provide critical nutrients necessary for animal growth and overall health [85–87].

4.5. Local Uses and Associated Threats to Woody Fodder Species. In addition to their primary role as fodder, woody species were used for fuelwood, food, medicine, construction, cultural ceremonies, and gum. This multiple use of woody plant species has been reported by others [88, 89]. In Ethiopia, Mekoya [90] reported that the sale of products such as timber, fuelwood, and fruit from fodder species serves as an important supplemental income source for poor households. Additionally, the use of woody fodder species for food and their wide range of medicinal applications [91] further emphasizes their vital role in the livelihoods and well-being of these communities.

Despite their multipurpose utility, woody fodder species are facing mounting challenges due to overexploitation, overgrazing, climate change, bush encroachment, and agricultural expansion. The study highlights overexploitation as the most critical threat, primarily driven by unsustainable harvesting for charcoal production, construction materials, and fencing. This has resulted in a marked decline in both the availability and natural regeneration of key fodder species. These findings align with previous research conducted in similar agroecological zones, which underscore the adverse effects of excessive wood extraction on rangeland vegetation structure and biodiversity [84, 89].

The second most frequently cited threat, overgrazing (84%), significantly contributes to the degradation of woody fodder resources. Persistent browsing and trampling by livestock impede the regeneration of woody species and shift species composition toward less palatable or invasive plants. This pattern mirrors observations from other regions in Ethiopia and East Africa, where high livestock densities have been closely associated with diminished vegetation cover and accelerated land degradation.

Climate change was reported to complicate the matter by altering temperature and precipitation patterns, which can adversely affect the growth and survival of woody fodder species. This issue is further compounded by the limited availability of other herbaceous fodder species [92–95].

Overgrazing was also found to exacerbate the issue by damaging these species and impeding their ability to regenerate and produce fodder [96, 97]. Large herds of livestock significantly damage the undergrowth by trampling and feeding on young trees and seedlings, which obstructs the natural regeneration process and undermines rehabilitation efforts [98].

Bush encroachment was also identified as a factor affecting the growth of woody species, which was often a result of overgrazing and changes in land use patterns. Additionally, a survey indicated that 48% of participants perceived agricultural expansion as threatening woody fodder species. This problem was linked to the clearing of land [99]. These observed threats have not occurred without adverse effects. The threat to woody fodder species poses a decline in the availability of feed resources, which has resulted in a decrease in animal productivity. This was due to the threat to woody fodder plant species, which led to a reduction in the availability of suitable habitats and food sources for animals [100].

5. Conclusions

The findings of this research demonstrate that woody fodder species play a vital role in sustaining livestock production during the dry seasons in semiarid regions of Ethiopia, underscoring the importance of their conservation. The

results further revealed that the Gomole rangeland possesses moderate richness and diversity of woody fodder species, with a relatively even distribution across the landscape. A total of 35 woody species were recorded, along with a Shannon diversity index of 3.2 and an evenness value of 0.76, which highlight the area's significant contribution to biodiversity conservation. The most frequently encountered woody plant species in the study area were *Combretum collinum, Vachellia drepanolobium, Cordia sinensis, Euclea divinorum,* and *Terminalia brownie*. The study findings highlight that the majority of woody fodder species are available as a livestock feed source throughout both the dry and rainy seasons. Their year-round availability, especially during the dry season, plays a crucial role in ensuring a consistent feed supply and enhancing the stability of pastoral systems. The study revealed clear species-specific preferences for woody fodder among different livestock types, underscoring the importance of tailored forage management. Cattle predominantly favored *Olea europaea, Pappea capensis*, and *Phyllanthus leucanthus*. Goats showed a marked preference for *Phyllanthus leucanthus*, *Senegalia brevispica*, and *Dalbergia microphylla*. In contrast, camels selected *Senegalia brevispica, Vachellia tortilis*, and *Indigofera spinosa* as preferred browse species. Additionally, the study found that woody fodder species are an important resource for the local community, providing a variety of benefits such as fuelwood, medicine, food, and cultural ceremonies, constructions, fencing, charcoal, and gum. Despite their significance, these woody fodder species face numerous threats, including overexploitation, overgrazing, climate change, bush encroachment, and agricultural expansion, which need to be addressed to ensure their conservation and sustainable use. Therefore, the following recommendations are made based on the findings of this study.

- ☞ Promote the development of alternative sources of fuel and construction materials to reduce the pressure on woody fodder species.
- ☞ Develop and implement sustainable grazing management practices to reduce the impact of overgrazing.
- ☞ Conduct further research on the ecology and management of woody fodder to inform conservation and sustainable use strategies.

Data Availability Statement

All datasets that underpin the conclusions of this paper are made available within the manuscript.

Ethics Statement

The study followed the guidelines set by the Declaration of Bule Hora University and received approval from the Institutional Research Ethics Review Committee of Bule Hora University (BHU/IRERC/003/17, March 28, 2024). Data collection was conducted with careful consideration of the cultural perspectives of the local communities involved in the study. Before initiating KIs and household interviews, respondents were provided with an explanation of the study's objectives and their verbal consent was obtained. Subsequently, data collection began with their oral permission. To ensure confidentiality, all participants were anonymized, and their personal information has not been disclosed in this paper.

Disclosure

All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

Author Contributions

J.G.: conceptualization, collection of the data; field visit; formal analysis; investigations; methodology; software; writing–original draft; and writing–review and editing. Z.A.: review and edit of the manuscript.

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