Diversity, preference criteria and feeding practice of indigenous browse fodder by livestock farmers in northwest Ethiopia

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Abstract

The study was conducted in South Gondar zone to assess farmers' perception and utilization practice of indigenous browse fodders. Study areas were selected based on agro-ecology representation and availability of fodder species. A total of 245 households were used for data collection. 24 sampling plots of each with a dimension of 20 m × 20 m were used for inventories of the diversity of fodder species. The diversity index was used to determine the species diversity. The collected data was analyzed using SPSS, version 26. A total of 44 indigenous browse fodder were identified in all agro ecologies. Of the identified species *T. brownii*, *A. amara* and *C. Africana* in the lowland; *C. Africana*, *F. vasta*, *A. abyssinica* and *F. thonnigii* in the midlands and *C. abyssinica*, *F. thonnigii* and *V. amygdalina* in the highlands were preferentially opted for livestock feed. The midland showed the highest species diversity of browse fodder. Palatability and multifunctionality were the main preference criteria for selecting browse fodder in the study area. The majority of farmers (42.27%) fed their livestock in partially cut and carry and, browsing. Incorporating locally available resources based on farmers' preference criteria and scientific knowledge is vital to efficiently utilize indigenous browse.

Key Words: Agroecology, Browse, Diversity, Richness and Utilization

Introduction

Ethiopia has a huge livestock resource with an estimated population of 70 million cattle, 42.9 million sheep, 52.5 million goats, 2.15 million horse, 10.8 million donkey, 0.38 million mule, 8.1 million camels, 57 million poultry and 6.99 million beehives (CSA, 2021). The livestock sector has an enormous contribution to the national economy and livelihood of Ethiopians (FAO, 2017). However, the current livestock contribution in the country is below its potential due to a number of factors such as feed shortage, poor genetic makeup of animals, poor veterinary service, underdeveloped marketing system, and less effort in introducing the appropriate package of livestock technologies (Selamawit et al. 2017).

Out of the aforementioned factors, feed is the main factor affecting the success of livestock production. In tropical areas including Ethiopia, poor quality natural pastures and crop residues are the main resources of livestock feed (Belay and Janssens, 2021b). These feeds are low in nutrients, particularly energy and protein. Besides, the fiber in these feedstuffs is usually so high which reduces feed intake and digestibility (Mekuanint and Girma, 2017). In many areas of Ethiopia, livestock farming is increasingly dependent on supplemental feed, particularly during crucial drought intervals. But like most farmers in the tropics and subtropics, small farmers in Ethiopia cannot purchase concentrated feeds, therefore they almost only rely on locally accessible substitute feeds to replenish their herd of ruminants (Avornyo et al. 2018; Barry et al. 2017). The feeding and grazing practices adopted by livestock farmers in developing countries across the globe are dependent on scarcity, seasonal fluctuation (Patel et al. 2016, Montcho et al 2024) and technical knowhow, if available, to upgade the quality of fodder (Mohammed et al 2021).

To increase feed availability and handle issues with feed billing and other feed production concerns for ruminants, underlined the need to use innovative alternative feeds for livestock feeding.

The use of browse fodder as animal feed is the most promising option to combat the existing deficiency of crude protein. Indigenous browse fodder species are good feed resources that remain green year-round and rich in protein, energy, vitamins, and minerals in dry seasons (Takele et al. 2014). Furthermore, including fodder leaves as feed could reduce rumen acidosis and other health-related problems and improve productivity (Revell et al. 2020). In Ethiopia, indigenous browse fodder species are well known to farmers and are better adapted to environments than exotic ones (Mesele et al. 2020; Latamo , 2021). The contribution of browse fodder as livestock feed is documented in Ethiopia (Shenkute et al. 2012: Etefa et al. 2014: Mesele et al. 2020).

In the study area, particularly the south Gondar zone, crop production is the dominant practice, where crop residues and some grazing are the only feed suppliers. However, there are many indigenous species of browse feed that can make a large contribution to livestock feeding during the dry season and alleviate nutritional problem of livestock. Nevertheless, information about the perceptions of farmers on the management and utilization of indigenous fodder is limited. To bridge this gap, it is crucial to assess the perception and utilization practice of the identified indigenous browse-fodder plants to prioritize the beneficial indigenous browse-fodder species. This could help to efficiently utilize the browse fodder in improving livestock productivity. Hence, the objective of this study was to assess farmers' perception and utilization practice of indigenous browse fodder species in the selected districts of south Gondar zone, Ethiopia.

Material and Methods

Study area

The study was conducted in three districts of south Gondar zone of Amhara National Regional State, Northwestern Ethiopia. The three districts were selected based on accessibility and representation of the three different agroecologies. The districts were Ebinat (representing low land), Libo Kemkem (representing mid land) and Farta (representing High land).

Sampling method and sample size determination

A multistage sampling procedure was performed to select respondents' households in the study area. In the first stage, three representative agroecological zones (Ebinat, Libo Kemkem and Farta representing lowland midland and highland, respectively) were selected following a stratified sampling technique. In the second step, six kebeles (two from each agroecology) were chosen based on livestock population and diversity. Kebele is a lower-level administrative name in Ethiopia. The respondents' households were chosen in the third stage based on the results of a preliminary survey that revealed the households feeding practice of indigenous browse species. A total of 245 households (79, 86 and 81 from low, mid and highlands), respectively, were selected based on simple random sampling for individual interview. The sample size of households was determined based on the (Cochran, 1977) formula as follows:

$$no = \frac{Z^2 \times (P \times q)}{d^2}$$

where no = desired sample size according to Cochran when population is greater than 10,000;
Z = standard normal deviation (1.96 for the 95% confidence level);
P = 0.2 (proportion of population to be included in the sample, i.e.20%);

q = 1 – P;
N = total number of populations;
d = degree of accuracy desired (0.05).

Methods of data collection

Data collection was performed after a verbal agreement was made with district agricultural offices and target farmers of the research. In each agroecological zone, an interview was conducted with the individual respondents and key informants (model farmers and development agents) to produce information about indigenous browse fodder species in the study areas. Data on socioeconomic characteristics of households and information related to indigenous browse fodder were collected with a semi structured questionnaire. Focus group discussions with a group of farmers (10 participants in each agro ecology), selected based on their background about browse fodder in each agroecological zone, was organized separately to supplement the data collected using questionnaire.

Identification of indigenous browse species

Indigenous browse fodder species identification was done with the help of key informants and forage experts in each ago-ecological zone. Moreover, identification of the scientific names of species was carried out using books of (Azene , 2007) and by using leaf snap application. During the group discussion, common-agreed criteria were set for evaluating indigenous browse fodder species with farmers. Therefore, after commonly agreed criteria were determined during the group discussion, all farmers scored each species individually.

The diversity of indigenous browse fodder species

The study area is divided into two tiers within each agroecological zone, namely area closure and open grazing area, according to the use of the land for the location of the sample plot. Eight 20 m × 20 m plots were randomly established in each ago-ecological zone and land use with a minimum distance of 100 m between any two plots (Jimoh and Lawal, 2016). The numbers of individual indigenous browse fodder species were counted in the sampled plot and recorded on a species diversity sheet. The species richness index was calculated using the following equation, which is the number of species present in a particular plot.

$$S = \sum n$$

where 'S' is the species richness and 'n' is the number of browse fodder species in a given plot. Species diversity was calculated using the Shannon–Wiener diversity index as follows:

$$(x + a)^n = \sum_{i=1}^{n} Piln(pi)$$

where H′ is Shannon–Wiener diversity index; n is the total number of species in the community; Pi (proportionate) is the proportion of n made up of the i^{th} species; and ln is natural logarithm.

Data analysis

Statistical Package for Social Sciences (SPSS version 26) was used for the analysis of the data collected using semi-structured questionnaire. Descriptive statistics such as percentage and means were used for appropriate parameters to present the results. Data on the species richness and diversity indices of indigenous browse fodder were subjected to one-way analysis of variance (ANOVA) using the GLM procedure of the Statistical Analytical System (SAS, 2002, version 9). The Tukey multiple range test was used for mean comparison. The indigenous browse fodder and farmers evaluation criteria were analyzed and summarized by index method. The index was computed with the principle of weighted average according to the following formula as employed by Musa et al. (2006).

$$Index = Rn*C_1+Rn-1*C_2…R_1*Cn/\sum Rn*C_1+ Rn-1*C_2…R_1$$

Where; Rn: Value given for the least ranked level (example if the least rank is 5^{th} rank, then Rn-5, Rn-1=4 and … R_1= 1) Cn: Counts of the least ranked level (in the above example, the count of the 5^{th} rank = Cn, and the counts of the 1^{st} rank = C_1).

The Model was

$$\mathbf{Y_{ij} = \mu + A_i + e_{ij}}$$

Where, Y_{ij} = response variable
μ = overall mean

A_i = agroecological effect and e_{ij} = random error

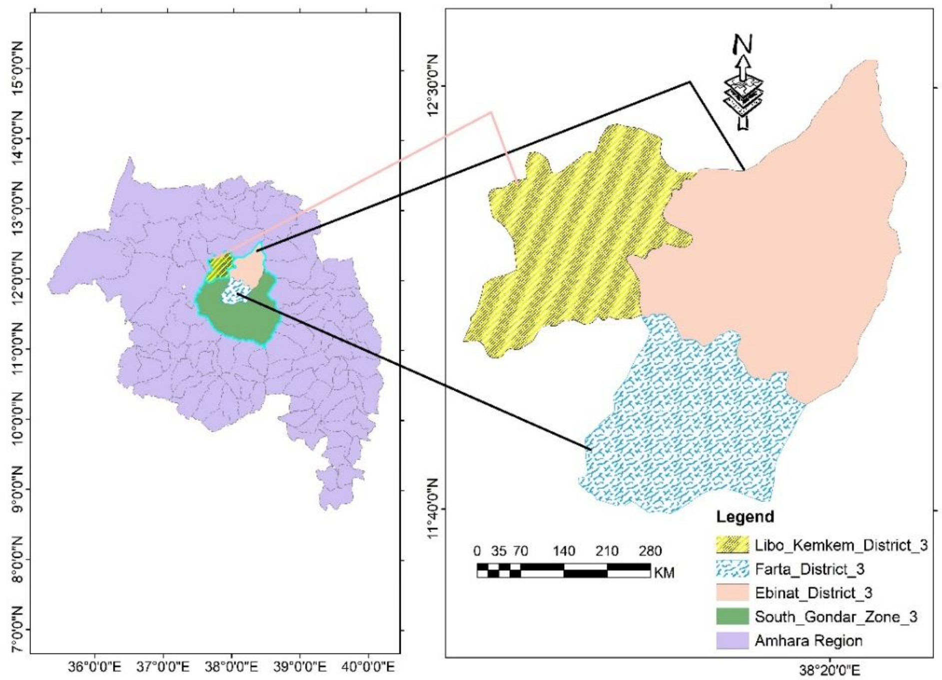

Figure 1. Map of the study area

Result and Discussion

Household characteristics of the respondent

The demographic characteristics of the interviewed respondents are presented in Table 1. Of the total (245) households interviewed, the majority (88.9%) of them were male-headed. This finding is consistent with Ayinadis *et al*. (2021) in the north Shewa zone of the Amhara region showed that the majority of households in mixed crop livestock production system were male headed.

The mean age of the respondents in the study area were 39.5, 44.8 and 46.3 years in low, mid and highland areas, respectively with the overall average age of 43.53±1.5 years. This could mean that there is an active working force that has a progressive effect on the development of livestock production. In line with this, Akililu et al. (2022) demonstrated that age negatively determines the adoption and intensity of agricultural technology. The same author indicated that a one-year increase in the age of the respondents decreases the probability of adoption of improved production technology by 0.031% and the intensity of technology by 0.459%. Consequently, older farmers are less willing to adopt new technology because their mobility and eagerness to gather new information about new technology is limited. Similarly, a study reported by (Dissanayake et al. 2022) found that age negatively determines the adoption of agricultural technology.

The majority of the households (54.6%) were illiterates while the rest were literates. This difference might be due to access to schools and inefficient transfer of knowledge, skills, and technologies from governmental institutions and development agencies to local farming communities (Zerssa et al. 2021). The fact that the majority of the respondents were illiterate would likely affect acceptance, adoption and use of improved feed and livestock production technologies. Therefore, providing basic education to them would be essential for the easy acceptance of improved livestock technologies. Mesele et al. (2022) reported that low education level of farmers can have an influence on transfer of improved agricultural technologies and their participation in agricultural improvement. Likely Abebaw and Girma (2022); Abdela et al. (2021) showed that the educational level of the farmer positively affects the probability of adoption, as farmers with more educational levels allow to acquire, analyze, and evaluate information on agricultural technology and market opportunity.

The mean average family size of households in the study areas was 6.3. The highest average family size was recorded in the highland area (7.23± 0.25). This variation might be due to the difference in family planning program between farmers.

Land ownership and land use pattern

Data on land ownership and land use pattern of the different agro-ecologies is presented in Table 2. The overall average landholding of the respondents was 1.01 ± 0.1 hectare per house hold (ha/hh), which was lower than the average national landholding size (1.4 ha/hh). The landholding in the present finding is slightly higher than the figure (<1ha) reported by Shimelis et al. (2021) in Damote Gale district while lower compared to the result (1.4ha) stated by Hassanuur et al. (2020) in Moyale district. The largest land size (0.84±0.48 ha) was allocated for crop cultivation while the average land allocated for improved forage legumes (0.009 ± 0.003 ha) was the lowest. The average land allocated for private grazing in all agro ecologies was 0.09 ± 0.04 ha. It was significantly smaller in high land (0.169 ± 0.02) as compared to the low (0.05 ± 0.09) and mid (0.05 ± 0.01) lands. In agreement to this finding Solomon et al. (2019) reported that, land allocated for private grazing in Farta was too small (0.23 ± 0.04). The discrepancy in land allocation among agro-ecologies might be due to the difference in farming systems. The average land allocated for crop cultivation is similar with the findings of Solomon et al. (2019) who reported that 1.1 ± 0.04 ha of land allocated for crop production in Farta district, Ethiopia.

Livestock holding of respondents

The average number of livestock holding per household in the study area is presented in Table 3. Except for the number of donkeys, the average number of livestock holding per household significantly varied (p<0.05). Cattle holding were higher in midland 3.15 TLU/hh (tropical livestock unit) as compare to low and highland areas. On the other hand, the average livestock holding for goats in lowland 0.5 TLU/hh was greater than in midland and highland areas. However, sheep holding were higher in mid and highland areas. This indicates that sheep are more adapted and suitable species in highlands compared to goats which are more adapted in lowlands (Henry et al. 2018).

The current result is in agreement with the result of Ahmed et al. (2010) who reported that higher average sheep holding number is observed in the high-altitude zone of Basona Worena district, Amhara region. The total livestock holding of this study is higher than the reports of Addisu et al. (2016) who reported that cattle, sheep and goat holding was 2.48, 0.12 and 0.10, respectively in Enebsie Sar Midr district, Ethiopia. However, the result is lower than 5.8 TLU/hh, reported by Solomon et al. (2019) in Farta district, Ethiopia. On average, cattle are the predominant livestock species reared in the study area. This may be due to the fact that cattle are multipurpose animals; farmers used for traction, provide milk and are means of cash income.

Identified major indigenous browse species

In the study areas, 44 indigenous browse fodder species were identified, of which 32 and 12 were fodder trees and shrubs, respectively. It was observed that farmers had preference for browse species based on the criteria they set. From the total identified 44 indigenous browse fodder species, the top 12 species from each agro-ecology, which were prioritized and frequently used with their scientific and vernacular name are presented in Table 4.

From the current list of available browse fodder species *Albezia amara, Ficus vasta, Terminalia brownii, Acacia abyssinica, Acacia brevispica, Ficus sycomorus, Cordia Africana, Ficus thonnigii,* were found to be commonly grown in the lowlands. *Ficus vasta, Acacia abyssinica, Dodonaea viscosa, Cordia Africana, Ficus thonnigii, Ficus sycomorus, syzygium giuneens and Stereospermum kunthianum* were common in the midland. *Vernonia amygdalina, Ficus thonnigii, Acacia abyssinica, Cordia Africana, Myrica salicifolia, syzygium giuneens, Olea Africana, Ficus vasta* were identified as animal feed resources in the highland areas.

Acacia seyal, Albizia malacophylla, Cordia Africana, Ficus sycomorus, Vernonia amygdalina, Ficus thonningii, Piliostigma thonninigii, Steteospermum kanthianum, Rothmannia urcelliformis were identified in Metekel and Awi zone, north western Ethiopia (Almaze et al. 2021). (Mesele et al. 2020) noticed that *Rhus natalensis, B. aegyptiaca, A. tortilis, A. mellifera, T. brownii, Ziziphus mucronata* and *Tamarindus indica* were present on the grazing areas of selected districts of Gamo Gofa and Wolayta zones, Ethiopia. *Ficus Thonningii, Cordia Africana, Vernonia amygdalina, Grewa bicolar, Dombeya bruceana* and *Ehretia cymosa* were identified in Lay Armacho and Sidama districts whereas, *Acacia mollifiers, Acacia tortilis, Celtis Africana, Cordials Africana, Grewa bicolour* and *Olea europaea* were mentioned by (Shenkut et al. 2012) in Rift Valley of Ethiopia.

Species diversity and evenness of indigenous browse fodders

Species diversity is a function of the number of species present and how evenly the individuals are distributed across these species. Because a greater variety of species allowed for greater species interaction, greater system stability and an indication of good environmental condition. Higher species diversity is typically thought to indicate a more complex and healthier community. Knowing the diversity of native browse fodder offers farmers the chance to choose, propagate, and use browse fodder in the future (Girma et al. 2015).

Table 1. Household characteristics in the study area

Variables	Description	Lowland (79)	Midland (86)	Highland (81)	Over all Mean	P value
Gender	Male	67(85 %)	73(85.24%)	79(96.4%)	88.9%	
	Female	12(15%)	13(14.76%)	2(5.6%)	11.8%	
Education	Illiterate	49(61.67%)	48(55.73%)	38(46.42%)	54.6%	
	Religious education	8(10%)	7(8.12%)	4(5.34%)	7.82%	
	Read and write	4(5%)	-	30(35.71%)	20.36%	
	Elementary	12(15%)	31(36.06%)	10(12.5%)	13.57%	
	Secondary	6(8.33%)	-	-	2.78%	
Age	Mean ± SE	39.5 ± 1.4	44.8 ± 1.9	46.3 ± 1.2	43.53 ± 1.5	0.131
Family size	Mean ± SE	$5.93^b \pm 0.27$	$5.75^b \pm 0.26$	$7.23^a \pm 0.25$	6.30 ± 0.18	0.004

$^{a, b}$ = the different subscripts within the row are significantly different (p<0.05)

Table 2. Land ownership and land use pattern in the study area (*Mean* ± SD)

Variables (ha)	Low Land (79)	Midland (86)	Highland (81)	Overall	P value
Crop cultivation	$1.0^a \pm 0.59$	$0.80^b \pm 0.42$	$0.73^b \pm 0.37$	0.8452 ±0.48	0.0067
Private Grazing	$0.05^b \pm 0.09$	$0.05^b \pm 0.01$	$0.169^a \pm 0.02$	0.09 ± 0.04	0.001
Browse Fodder	$0.01^b \pm 0.003$	0.002^b	$0.04^a \pm 0.008$	0.02 ± 0.004	0.000
Legume forage	0.0^b	0.0^b	$0.028^a \pm 0.01$	0.009 ± 0.003	0.001
Total land	$1.06^a \pm 0.05$	$1.02^a \pm 0.17$	$0.97^b \pm 0.10$	1.01 ± 0.1	0.05

$^{a, b}$, means in a row with the same category that have different supper scripts differ (P<0.05); ha =hectare, N= number of respondents and SD= standard deviation

Table 3. Livestock holding in the study area (Mean ± SD)

Livestock Species	Lowland (79)	Midland (86)	Highland (81)	Overall	P value
Cattle	$2.49^b \pm 1.22$	$3.15^a \pm 1.22$	$2.15^b \pm 1.04$	2.61 ± 1.23	0.004
Sheep	$0.23^b \pm 0.03$	$0.24^a \pm 0.05$	$0.24^a \pm 0.04$	0.23 ± 0.04	0.007
Goat	$0.5^a \pm 0.05$	$0.19^b \pm 0.04$	$0.11^b \pm 0.02$	0.26 ± 0.03	0.00
Equine	0.67 ± 0.13	0.66 ± 0.60	0.52 ± 0.07	0.67 ± 0.26	0.09
Poultry	$0.08^a \pm 0.05$	$0.05^b \pm 0.03$	$0.05^b \pm 0.05$	0.06 ± 0.04	0.004
Bee colony	2.29 ± 0.32	2.63 ± 1.08	3.9 ± 0.69	2.94 ± 0.67	0.308

$^{a, b}$, means in a row with the same category having different supper scripts differ (P<0.05); TLU = tropical livestock unit

Table 4. The most preferred browse species in the study district

Agro ecology	Botanical name	Vernacular name	Family name	Plant habit	Plant part used for livestock feed
Low land	*Albezia amara*	Sibkana	*Fabaceae*	Tree	Leaves & pods
	Terminalia brownii	Ekima	*Combretaceae*	Tree	Leaves & pods
	Acacia brevispica	Gigirkana	*Mimosaceae*	Tree	Leaves
	Ficus sycomorus	Bamba	*Moraceae*	Tree	Leaves
	Rhus glutinosa	Ekimo	*Anacardiaceae*	Tree	Leaves & fruit
	Carissa spinarum *Capparis tomentosa* *Eupharbia spinarum*	Agam Gimero Kinchib	*Apocynaceae* *Capparaceae* *Euphorobiacea*	Shrubs Shrubs Tree	Leaves & fruit Leaves Leaves
Mid land	*Stereospermum kunthianum*	Zana	Bignoniaceae	Tree	Leaves
	Dodonaea viscosa	Kitkita	*Sapindaceae*	Shrubs	Leaves
	Carissa spinarum	Agam	*Apocynaceae*	Shrubs	Leaves & fruit
	Olea Africana	Woyira	*Oleaceae*	Tree	Leaves
	Rhus glutinosa	Qamo	*Anacardiaceae*	Tree	Leaves &seeds
	Acanthusn sennii	Kosheshele	*Acanthaceae*	Shrubs	Leaves & flowers
	Ficus sycomorus	Bamba	*Moraceae*	Tree	Leaves
	syzygium giuneens	Dokima	*Myricaceae*	Tree	Leaves
High land	*Vernonia amygdalina*	Girawa	*Asteraceae*	Tree	Leaves
	Grewia ferruginea	Lenguata	*Tiliaceae*	Shrubs	Leaves
	Buddleia polystachya	Anfar	*Baddlejaceae*	Tree	Leaves
	Syzygium giuneens	Dokima	*Myrtaceae*	Tree	Leaves & fruits
	Rosa abyssinica	Kega	*Rosaceae*	Shrubs	Leaves & fruit
	Myrica salicifolia	Chinet	*Myricaceae*	Tree	Leaves
	Olea Africana	Woyira	*Oleaceae*	Tree	Leaves
Common in all ecology	*Ficus vasta*	Warka	*Moraceae*	Tree	Leaves & fruit
	Acacia abyssinica	Girar (Bazira)	*Mimosaceae*	Tree	Leaves & pods
	Cordia Africana	Wanza	*Boraginaceae*	Tree	Leaves & fruit
	Ficus thonnigii	Chibha	*Moraceae*	Tree	Leaves & pods

The highest species richness (15.75), diversity (2.57) and evenness (0.87) were recorded in mid land than all agro-ecologies which might be associated with environmental differences, such as temperature, moisture, soil characteristics and precipitation of the study area. The result of the current study is contradict with the finding of Abraham et al. (2022) who reported that the highest mean species richness (5.6) and diversity indices (1.59) of indigenous legume fodder tree and shrubs were exhibited in lowland area closure followed by midland area closure which valued 1.2 and 4, respectively in Gamo zone land escapes. Similarly, Fekadu et al. (2018) also reported that the highest diversity indexmeans value of shrubs and trees were recorded at lower altitude than mid and high altitudes.

The mean species richness and diversity indices of area closure revealed significant difference compared with open grazing land in all ago-ecologies explained the level of protection while the lower in grazing lands explained the level of exploitation by human being and livestock. According to Etefa et al. (2014) forest land in the Tigray region has a higher species richness of fodder trees and bushes. In addition, compared to rangelands, Coulibaly et al. (2021) showed that the forest reserve had the highest diversity indices.

Farmers' selection criteria of indigenous browse fodder

Farmers agreed criteria to select a specific plant for animal feed are presented in Table 6. In this study, farmers' criteria for evaluating indigenous browse fodder are important in order to satisfy various farming goals and agronomic requirements they have for trees.

The criteria of the farmers to select the fodder trees and shrubs are not dependent on the specific characteristics of indigenous tree species. The species evaluation was made based on plant characteristics and the perceived animal preference. Among the selection criteria listed by households, palatability (0.213 and 0.186) was the most important criteria to select browse fodder as feed for livestock in low and midland areas respectively. Multifunctionality (0.230) of browse fodder species was mentioned as first important selection criteria in highland. In addition, fast growth and regrowth, adaptability and biomass yield were listed from plant related criteria.

The criteria were also used in previous studies Yohannes et al. (2021) who showed that palatability was the main farmers criteria to characterize browse fodder in their farmlands. Almaze et al. (2021) also reported that biomass yield, availability, feed value and palatability were the most important criteria for ranking the multipurpose browse species. Correspondingly, Begashaw (2018) also reported that farmers' preference to select indigenous browse fodder is mostly based on the availability, palatability and adaptability of plants.

Farmers' ranking of indigenous browse fodder species

Evaluation of indigenous browse fodder species on the stated criteria by the local farmers are shown in Table 7. The purpose of ranking browse species is to determine which species farmers prioritized while choosing and rating native browse fodder species (Almaz et al. 2021). Based on farmers evaluation criteria *Terminalia brownii*, *Albezia amara*, *Cordia Africana*, *Ficus sycomorus*, *Acacia brevispica* and *Ficus thonnigii* were the most preferred species for livestock feed resource in lowland area. *Cordia Africana*, *Ficus vasta*, *Acacia abyssinica*, *Ficus thonnigii*, *Stereospermum kunthianum*, *Ficus sycomorus*, *Dodonaea viscosa* and *Syzygium giuneens* were ranked as the top preferred species in midland. *Cordia abyssinica*, *Ficus thonnigii*, *Vernonia amygdalina*, *Acacia abyssinica*, *Myrica salicifolia*, *Olea Africana*, *Ficus vasta* and *Dodonaea viscosa* were ranked as the top preferred species in the highland.

Mesele et al. (2020) also revealed that, *A. tortilis* was the first favored browse fodder consumed by goats followed by *B. aegypetiaca* in Gamo Gofa and Wolayita zone, Ethiopia. Kindu (2009) likewise reported that in the highlands of central Ethiopia from 29 identified tree fodder and shrub species, farmers prefer four most selected tree fodder and shrub. Among these four trees, *Buddleja polystachya fresen* was preferred as the best based on its ability to improve soil fertility, palatability and fast to intermediate growth.

Planting practice of indigenous browse fodder

About 73.27% of households practiced planting of indigenous browse fodder species for different purposes in land use systems while, the rest 26.73% of households used only naturally grown indigenous browse fodder (Table 10). About 90.2% of the respondents in midland reported planting of browse fodder species followed by 67.9% in highland and 63.3% in lowland areas. This variation could be due to the relatively higher availability of fodders in the lowlands, which aspires the farmers in the lowland to use naturally grown fodder rather than planting. This was supported by the fact that species that have been found to be useful does not necessarily mean that it must be planted. For many species, particularly in lowland areas, protection of natural regrowth may in fact be a more effective and cheaper way to ensure long-term survival (Azene, 2007).

The majority of households in the study areas planted browse fodder in home garden (45.13%), within the home compounds and boundaries of farm land (34.19%), home garden and forest land (9.64%), boundaries of farm land (5.14%). The majority of respondents in lowland and highland areas planted fodder in home compound and soil and water conservation areas and midland area respondents planted on home garden and boundaries of farm land.

Several studies have shown that the niches of trees and shrubs across the landscapes were homesteads, farm boundary, cropland (Mulugeta and Kindu 2013; Dargo and Haftay, 2019), hedge (Dargo and Haftay, 2019), gullies, hill sides and grazing lands (Dargo and Haftay, 2019).

Propagation technique of indigenous browse fodder

The majority of households (31.8%) planted browse fodder using seedling and cutting with higher (51%) proportion from highland area (Table 9.). This result was supported by Begashaw (2018) who reported that the major propagation techniques of browse trees and shrubs were practiced by seedling, direct sowing and using the rhizome. Gezahegn et al. (2017) showed that cutting directly in the field and seedling propagation technique are used for Ficus thongii propagation. Similarly, Getachew et al. (2022) also indicated that seed, seedling, stem cutting and wilding were the prominent propagation methods of indigenous legume tree and shrubs fodder in Gamo landscape. In another study by Meaza and Demssie (2015), it has also noted that natural seedlings from soil seed banks and home nurseries are the main sources of seedlings of fodder trees across the communities in the northern highlands of Ethiopia.

Table 5. Species richness, diversity and evenness of indigenous browse fodder

Agro ecology	**Shannon–Wiener diversity index (H′) Mean ± SD**	**Richness Mean ± SD**	**Evenness Mean ± SD**
Low land	$2.35^b \pm 0.07$	15.00^b	$0.86^b \pm 0.04$
Mid land	$2.57^a \pm 0.03$	17.75^a	$0.88^a \pm 0.02$
High land	$2.31^b \pm 0.10$	14.00^c	$0.87^b \pm 0.06$
P value	0.003	0.00	0.00
Significant level	***	***	***
Land use type			
Area enclosure	2.87 ± 0.05	21.5 ± 4.35	2.05 ± 0.04
Free grazing	2.46 ± 0.23	14.75 ± 2.98	1.89 ± 0.17
P value	0.01	0.0004	0.12
Significant level	***	***	Ns

$^{a,\ b}$, means in a column with the same category having different supper scripts differ ($P<0.05$)

Table 6. Farmers' selection criteria and rank used to evaluate indigenous browse species

Evaluation criteria	**No of farmers**									
	1st	2nd	3rd	4th	5th	6th	7th	8th	Index	Rank
Lowland										
Palatability	33	23	0	0	0	0	0	0	0.213	1
Feeding value	8	14	14	5	12	0	0	3	0.161	3
Improve milk prodn	1	8	9	10	3	0	0	7	0.094	5
Relieve hunger	11	4	16	17	6	4	0	0	0.167	2
Growth and regrowth	0	1	10	10	12	11	4	6	0.106	4
Adaptability	0	5	4	4	11	11	13	3	0.093	6
Multifunctionality	0	1	0	8	6	22	11	4	0.082	8
Biomass yield	5	3	4	2	4	4	19	11	0.086	7
Midland										
Palatability	24	15	7	11	3	1	0	0	0.186	1
Feeding value	3	12	14	9	9	9	3	2	0.140	3
Improve milk prodn	2	6	2	4	1	5	7	30	0.069	8
Relieve hunger	7	1	6	5	1	12	24	6	0.099	7
Growth and regrowth	0	2	10	9	20	7	7	6	0.109	5
Adaptability	3	10	8	14	11	5	7	3	0.131	4
Multifunctionality	17	13	11	5	6	6	3	0	0.166	2
Biomass yield	6	2	3	5	10	16	10	9	0.101	6
Highland										
Palatability	4	12	21	4	3	3	0	0	0.178	2
Feeding value	0	0	4	4	5	10	3	5	0.066	8
Improve milk prodn	1	4	3	8	11	5	3	3	0.102	5
Relieve hunger	0	4	4	6	6	2	11	1	0.085	7
Growth and regrowth	1	11	7	6	3	7	7	3	0.130	3
Adaptability	5	1	5	6	9	2	1	3	0.096	6
Multifunctionality	37	9	1	0	0	0	0	2	0.230	1
Biomass yield	5	7	4	10	0	3	2	7	0.115	4

Table 7. Farmers ranking of indigenous browse fodder species in the study area

Low land	Index	Rank	**Mid Land**	Index	Rank	**High Land**	Index	Rank
Terminalia brownii	0.162	1	*Cordia Africana*	0.144	1	*Cordia abyssinica*	0.211	1
Albezia amara	0.138	2	*Ficus vasta*	0.124	2	*Ficus thonnigii*	0.153	2
Cordia Africana	0.111	3	*Acacia abyssinica*	0.121	3	*Vernonia amygdalina*	0.124	3
Ficus sycomorus	0.09	4	*Ficus thonnigii*	0.119	4	*Acacia abyssinica*	0.119	4
Acacia brevispica	0.084	5	*Stereospermum kunthianum*	0.111	5	*Myrica salicifolia*	0.099	5
Ficus thonnigii	0.083	6	*Ficus sycomorus*	0.092	6	*Olea Africana*	0.065	6
Ficus vasta	0.081	7	*Dodonaea viscosa*	0.069	7	*Ficus vasta*	0.065	7
Acacia abyssinica	0.074	8	*syzygium giuneens*	0.065	8	*Dodonaea viscosa*	0.053	8
Rhus glutinosa	0.065	9	*Carissa spinarum*	0.046	9	*Grewia ferruginea*	0.042	9
Euphorbia spinarum	0.057	10	*Olea Africana*	0.040	10	*Buddleia polystachya*	0.033	10
Carissa spinarum	0.033	11	*Rhus glutinosa*	0.035	11	*Syzygium giuneens*	0.029	11
Capparis tomentosa	0.020	12	*Acanthusn sennii*	0.031	12	*Rosa abyssinica*	0.004	12

Table 8. Planting practice of indigenous browse fodder

Variables	Description of result	Agroecology						
		Lowland (79)		Midland (86)		Highland (81)		Overall Mean
		N	%	N	%	N	%	%
Planting of indigenous browse fodder	Yes	57	71.7	80	93.4	74	91.1	85.4
	No naturally grown	22	28.3	6	6.6	7	8.9	14.6
If yes where you Propagate?	Home garden	40	51.43	28	32.73	41	51.22	45.13
	Boundaries of farm land	5	5.71	6	7.28	2	2.44	5.14
	Soil and water conservation land	5	5.71		-		-	1.9
	Scattered with in grazing land	2	2.86		-		-	0.96
	Home garden and boundaries of farm land	16	20	50	58.18	20	24.4	34.19
	Back yard and conservation land	11	14.29		-	12	14.63	9.64
	Back yard and scattered with in grazing land		-	2	1.81		-	0.6
	Forest land and scattered land		-		-	2	2.44	0.81
	All the above locations		-		-	4	4.88	1.63

Note: N= number of respondents

Table 9. Propagation technique of browse fodder in the study area (Proportion %)

Variables	Description results	Lowland	Midland	Highland	Overall mean
Propagation Technique	Seedling	25.6	33.3	19.7	26.2
	Direct sowing	18.6	5.2	2.0	8.63
	Cutting	27.9	5.2	21.5	18.2
	Seedling and sowing	7.0	8.8	4.0	6.6
	Seedling and cutting	16.3	28.1	51	31.8
	Sowing and cutting	0	14.0	0	4.67
	Seedling, sowing and cutting	4.7	5.4	1.8	3.96

Table 10. Farmers preferred method of feeding in the study district

Variables	Description results	Agroecology						
		Lowland (79)		Midland (86)		Highland (81)		Overall Mean
		N %		N %		N %		%
Preferred method of feeding	Based on farmers' perceived quality of fodder	41	51.7	49	57.4	14	17.9	42.33
	Based on animal preference	37	46.7	36	41	67	82.1	56.6
	Both preferred method	1	1.7	1	1.6		0	1.1
Feeding system	Cut and carry	26	33.3	14	16.4	15	18	22.56
	Browsing	22	28.3	24	27.9	40	49.2	35.13
	Both Cut and carry and, browsing	31	38.3	48	55.7	26	32.8	42.27

Note: N =number of respondents

Table 11. Conservation method and form of feeding of indigenous browse fodder

Variables	Description results	Proportion (%)			Overall mean
		Lowland (79)	Midland (86)	Highland (81)	
Do you conserve browse fodder?	Yes	11.7	6.6	17.9	12.07
	No	88.3	93.4	82.1	87.9
If yes conservation method	Hay making	10	6.6	14.3	10.3
	Silage making	1.7	0	3.6	1.8
Form of feeding	Fresh form	58.3	83.6	28.6	56.8
	Dry form	17.7	4.9	14.3	12.3
	Both fresh & dry form	24	11.5	57.2	30.9

Feeding method of indigenous browse fodder species

From the total respondents, 56.6% of the respondent fed browse fodder species based on animal preference followed by 42.33% based on farmers' perceived quality of fodder, and the rest (1.1%) feed based on both animal and farmers' perceived quality of fodder. About 82.1% respondents in highland area feed livestock based on animal preference, while 46.6% and 41% of the respondents in lowland and midland feed based on animal preference, respectively. Especially during the dry season, when feed scarcity occurs, animals were obliged to consume the available fodder tree and shrub to survive. This was supported by Dargo and Haftay (2019) who reported that the dry season progress less palatable species are also browsed by livestock.

The majority of respondents (42.27%) were feeding livestock by using partially cut and carry and partially browsing. This result agreed with the report of Gaiballa and Lee (2012) and Getachew et al. (2017) who reported that leaves of browse trees were fed to livestock by cut and carry system. In the contrary Mesele et al. (2020) stated that most of the farmers (66%) in Gamo Gofa and Wolayta zones, Ethiopia were directly let their goats to browse in the grazing areas. This may be due to variation in the type of the plant and the type of animals available in the study area.

Conservation method and form of feeding of indigenous browse fodder

About 56.8%, of respondents fed animals with indigenous browse fodder in fresh form and 12.3% fed in dry forms (Table 11). Feed conservation could be one possible solution in areas where feed shortage is severe during the dry seasons (Solomon et al. 2019). Javed et al. (2008) also found that, fodder tree leaves are harvested during summer and fed to livestock and also stored as hay. However, in the current study the practice of conservation system for browse fodder were very low. In the study area only 12.07% of respondents used conservation of browse fodders. This showed that the practice of browse fodder conservation was not practicable more in the study area. In line with the current result, Solomon et al. (2019) showed that 4% and 8% in the highland and midland, respectively use forage conservation for dry period.

In the highlands of northern Ethiopia, farmers harvest green leaves of Chinese banyan *(Ficus macrocarpa*) plant and store it as a hay for use in the dry season (Mulubrhan *et al*. 2015). Fodder harvested from browse trees has also been ensiled, usually in combination with grains (Mbatha and Bakare, 2018). Phiri et al. (2007) also demonstrated that browse fodder from tree legumes *Leucaena leucocephala* and *Vachellia boliviana* ensiled with maize can be used to replace dairy concentrate diets while sustaining intake and body weight gain.

Conclusion

The study revealed that there are different species of indigenous browse fodder feed resources found in the three agro ecologies of the study area. Farmer's preference criteria in selection of browse fodder encompasses palatability, multifunctionality and feeding value were the most important criteria to select browse species in three agro ecologies. The majority of farmers plant indigenous browse fodder planted on their farm boundaries, home compound and soil and water conservation areas. Partially cut and carry and partially browsing systems were the preferred feeding system in the study areas. It is possible to conclude that when incorporating locally available feed resources, farmers indigenous knowledge and experience-based choice of browse fodder species is vital for efficient utilization of available fodder browse species to tackle feed shortage in different agro-ecological zones. Therefore, further research is required to verify the nutritional value of indigenous browse fodder and evaluate the effect of these plants on the production performance of animals.

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Data availability Data are available with the corresponding author upon reasonable request

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