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Research Article

Availability, nutritional balance, and needs for dairy cattle feed resources in Derashe special district, Southern Ethiopia

Esatu Bekele[1]*, Tezera Bogale[2]

[1]College of Agricultural Sciences, Arba Minch University, Arba Minch, Ethiopia
[2]College of Agricultural Sciences, Wolayta Sodo University, Tarcha, Ethiopia

Abstract

The research was carried out in the Derashe District of Southern Ethiopia to assess livestock feed availability, utilisation practises, and nutrient balance. Data were gathered by field observations, key informant interviews, and a standardized questionnaire. With 149 responses, the district was divided into three agro-ecologies. Using a technique called probability proportional to size-sampling, the number of responders was calculated. Lowland, mid-altitude, and highland regions all had average land sizes of 1.67, 0.27, and 1.38 ha, respectively. The research district's entire livestock population was calculated to be 134,948.84 TLU. Cattle made up 83.23% of this, followed by goats 6.19%, donkeys 5.09%, sheep 3.51%, chickens 1.19%, mules 0.53%, horses 0.18%, and camels 0.002% of the district's total TLU of the animal population. There were 9.5 heads of local and crossbred cows in each household's average herd. Dairy cattle in the study locations primarily ate natural pasture, crop residues, crop aftershock grazing, standing hay, maize that had been thinned, and unconventional feeds (Cheka atella and Areke atella). Grazing land produced 97.75 tons of dry matter per year, crop leftovers 827.21 tons, conventional feeds 264.78 tons, fodder trees and shrubs 1.29 tons, crop aftermath grazing 110 tons, concentrates 0.5 tons, and forest land 30.54 tons. A total TLU value of 1693.5 was obtained by analyzing the overall feed balance in terms of DM yield annually. The present TLU units with a negative balance of 2513.16 tons demand about 3861.85 tons of DM annually. There was a deficit of 140 tons in the total CP produced and needed for the TLU, which came to 477.18 and 617.72 CP tons, respectively. Overall metabolizable energy (ME) produced and needed for the TLU were 25,739.3- and 73683.72-tons MJ, respectively, with a negative balance of 47,944.42 tons MJ of ME. Free grazing, stall feeding, and tethering were the three main feeding methods used in the research locations. Lack of feed, a lack of grazing pasture, subpar extension services, and a lack of water were the main obstacles and issues for the development of dairy cattle. Possibilities for increasing dairy feed output include favorable meteorological conditions, cereal crop productivity, and road access. The growth of forage, the collecting and storage of crop leftovers under sheds, the conservation of forage, particularly hay and silage, and the facilitation of feed selling mechanisms in local market areas could all help ease feed scarcity issues.

Keywords: Agroecologies; Dairy cattle; Derashe district; Feed; Feeding systems

*Corresponding author: esatubb7@gmail.com

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1. Introduction

The majority of animals in Africa are kept in Ethiopia (CSA, 2020). Although it is the second-largest contributor to the nation's foreign exchange, Alazar estimates that the livestock subsector in Ethiopia generates over 30% of the agricultural GDP and 16% of the entire GDP (2015). About 65 million cattle are thought to be in the nation's total cow population. Male cattle make up 44.10 percent of this total, while female cattle make up 55.9%. According to estimates, native breeds make up 97.79% of the nation's cattle. The other breeds are hybrids and exotics, which make up roughly 1.91% and 0.32% of the CSA%, respectively (CSA, 2020).

Diverse criteria are used to identify various dairy production systems in Ethiopia. Based on location, it can be broadly divided into systems for producing milk in metropolitan areas, peri-urban areas, and rural areas. The production system for dairy cattle can be divided into three categories: traditional small holders, privatized state farms, and urban and peri-urban systems Ketema (2008).

Ethiopia's primary sources of livestock feed are uncultivated pastures and grasslands, crop byproducts, improved pastures, forage crops, agro-industrial byproducts, and unconventional feeds (CSA 2020). Dairy farmers frequently use grazing land, hay, purchased succulent grass, maize stover, pseudo stems of enset and banana, mixed/balanced homemade concentrate feeds, plant weeds, and unconventional feeds like attella (a brewery by-product from locally produced beer and other alcoholic drinks), kitchen and fruit scraps, and leaves of other delectable agro-forest plants Sintayehu et al. (2008). Due to decreasing grazing field sizes, the importance of natural pasture grazing and stall feeding as important cattle feed resources and feeding systems occasionally declines (Yayneshet, 2010). Native hay has a restricted range of applications, but when used properly—that is, when it is cut in a timely manner and handled and stored properly—it has a higher feeding value than agricultural wastes. Because of the Highlands' limited grazing territory and inadequate management, fodder is insufficient to feed animals even during years with a favorable rainy season.

The Derashe district has not yet been described with regard to dairy cattle productivity and feed balance. Inferences for any type of management intervention must be based on research of the production system and feed balance. The first steps in creating a policy briefing and/or further development plan are to identify and prioritize the current management practices, breed identification, marketing milk and its products, performance parameters, opportunities, and restrictions. As a result, the current study is intended to examine the availability of feed resources and establish the balance between the nutritional needs of dairy cattle.

2. Materials and Methods

2.1. Description of the Study Area

The study was carried out in the district of Derashe in the Segen Area Peoples Zone, Southern Nations and Nationalities People's Region (SNNPR) (Figure 1). Derashe district is 500 kilometers (km) from Addis Abeba, 318 km from Hawassa, the regional seat, and 43 km from Segen, the zonal town. There are 18 kebeles in the Derashe district, one of the five districts in the Segen Area Peoples Zone (16 farmer administrations and 2 town administrations). The Derashe district's (AWANRO) office claimed that the district has 174 293 residents overall in 2016. (males: 85,034 and females: 89,259). About 25,202 households (24,062 men and 1140 women) are present (DWFEDO, 2016). The district is generally between 1500 and 2622 meters above sea level. The yearly temperature fluctuates between 15.10°C and 27.50°C, while the annual rainfall is between 600 and 1600 mm. The district's agro-ecologies are divided into three categories: highland (17.27%), midland (35%), and lowland (46.61%) (between 1500 and 2622 m.a.s.l).

A mixed-crop and animal production system is the most popular agricultural technique in the region. Wheat, sorghum, teff, and maize are the main crops that are grown in the study region. The majority of livestock production systems is traditional and geared toward subsistence and is characterized by modest management inputs in terms of production and breeding management, disease control, and nutrition. There are 134,056 cattle in the districts (61,868 males and 72,188 females), 47,404 sheep, 83,660 goats, 3 camels, 13740 donkeys, 297 horses, 1024 mules, and 544 chickens.

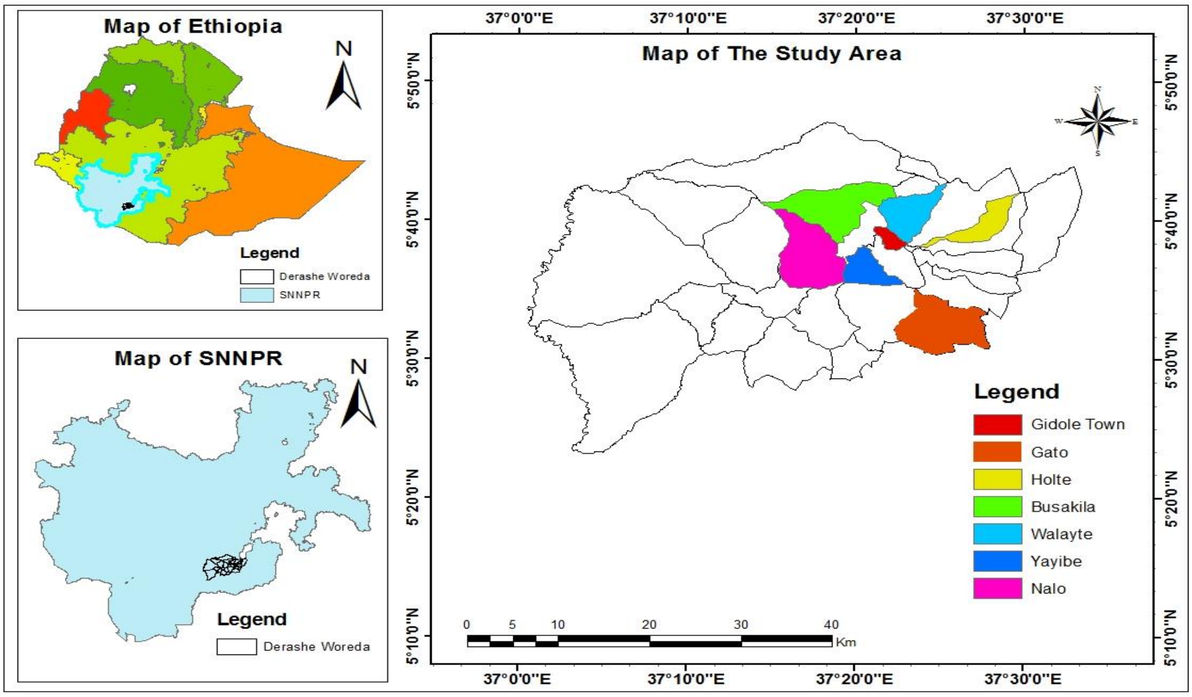

Figure 1. Map of the study area

2.2. Sample size and sampling techniques

Based on the potential for both local and crossbred dairy cattle, farmers' motivation and preferences to crossbreed local cows, and farmers' extensive experience keeping both local and crossbred dairy cattle among the five districts of the Segen area people's zone, the study site was chosen from the district. Agro-ecologies were chosen using a stratified sample technique, whereas the study's farmer associations were chosen using a basic random sampling technique. Using a systematic random sample technique, households with Jersey and HF crossbred cows as well as local cows were chosen for the study. Out all the districts, 149 households total were chosen. The agro-ecological of the districts is made up of 48.0% lowlands (below 1500 m.a.s.l.) and 17.27% highlands (between 230 and 2622 m.a.s.l.). Using a probability-proportional-to-sample-size determinant formula, the proportion of responses within each agro-ecology was determined. Five farmers from each agro-ecology participated in a pre-test of a standardized questionnaire that was used to interview the chosen farmers. Utilizing Cochran's probability proportional to sample size-sampling method, the total sample size for the household interview was calculated based on Eq. 1 (Cochran, 1977).

$$n = \frac{Z^2 * (p)(q)}{d^2} \rightarrow n1 = \frac{n0}{(1 + no/N)} \quad (1)$$

Where n_o= desired sample size according when population greater than 10,000; n_1 = finite population correction factors population less than10, 000; Z = standard normal deviation (1.96 for 95% confidence level); P = 0.11 (proportion of population to be included in sample i.e., 11%); q= 1-0.11 i.e. (0.89); and d = is degree of accuracy desired (0.05), 5% error term.

Based on the first formula, the total number of households were 149 from three agro-ecologies of the district i.e. (26 household highland (17.27%), 52 household mid-altitude (35%) and 71 household lowland (48.0%).

2.3. Quantity estimation of available feed resource

2.3.1. Dry matter yield of natural pasture

The average value of grazing land holdings and the per-hectare DM output of the natural pastures were multiplied to obtain the total quantity of DM available in natural pastures in the research area (FAO, 1987). For each total household and their associated TLU qualified to graze on this land unit, the total community grazing areas were multiplied by the quantity of DM acquired from communal grazing land.

2.3.2 Available crop residues and aftermath grazing

According to the FAO (1987) conversion factor for the Ethiopian condition, the amount of accessible crop leftovers (DM basis) was calculated from the overall crop yields of the households. For barley, wheat, teff, and oats, conversion factors are 1.5; for maize, they are 2; for pulse and oil crop straws, 1.2; and for sorghum, 2.5. Tolera & Said (1994), evaluated the amount of crop residue on the basis of DM available and those actually available for cattle consumption by subtracting 10% for loss. By dividing the amount of land available by the conversion factors of 1.8 for fallow land and 0.5 for aftermath grazing, calculated the quantities of DM available in fallow land and aftermath grazing (FAO, 1987).

2.3.3. Estimation of biomass yield of browses

The stem circumference was measuried in a tape applying the potential fodder yield of the selected shrubs and trees was calculated using Petmak (1983)equation. Thus, using the algometric equation log W = 2.24 log DT – 1.50, the leaf yield of fodder trees was calculated. W is the leaf yield expressed in kilograms of dry weight, and DT is the trunk diameter measured at a height of 130 cm. Likewise, trunk diameter (DT) can be calculated using the formula: DT = 0.636C, where C is the circumference in centimetres (cm). The algometric formula is log W = 2.62log DS -2.46 for a shrub's leaf yield. Where, DS represents the stem diameter at a height of 30 cm in centimeters.

2.3.4. Estimation of the balance between dry matter supply and requirement for dairy cattle

The yearly DM needs of the cattle population in the tested households were compared to the total amount of DM that was available throughout the main rainy season from natural pasture, crop residues, crop aftermath, tree legumes, and concentrates. During the study, interviews with household heads were performed to gather information on the livestock population in the sample houses. Using the ILCA's conversion factors, the quantity of livestock populations was transformed into tropical livestock units (TLU) for comparison (ILCA, 1990).

The daily DM requirements for maintaining 1 TLU were used to calculate the DM requirements for the livestock population. Kearl (1982), employed an 8.368 MJ ME/kg DM diet with a crude protein (CP) composition of 70 g/kg DM. Due to a lack of resources (time, money, and TLU conversion variables), as well as the researcher's and data enumerators' demands, neither the assessment of poultry feed availability or the requirement for poultry feed were included in this study.

2.4. Data and collection tools

Data on the socioeconomic traits of the respondents, household dairy cow holdings, dairy cattle feeds and feeding, health care and common diseases, breeding procedures and farmer's preferred trait combinations, housing, and routine farm management activities were gathered. Lactation length, lactation milk yield, and average daily milk yield were all gathered as milk production traits. The reproductive performances of cows were assessed using economically significant reproductive variables as age at first calving, calving interval, gestation duration, number of services per conception, and days open. A standardized questionnaire was also used to evaluate the benefits and drawbacks of dairy cattle rearing.

Data collection methods included the researchers' own observation, structured questionnaire interviews, focus group talks, and recording performance metrics. Along with performance records, recalled indicative data was also included. The researcher's own observations, a questionnaire survey that was administered, records on reproductive and productive performances, a focus group discussion with model or experienced farmers, and communication with livestock production experts at various levels were all used as data collection tools.

2.5. Data analysis

All of the survey data was examined using Statistical Package for Special Sciences (SPSS version 20). Significant differences were taken into account at P = 0.05 when testing statistical variations for categorical data using cross tabulations and chi-square tests, whereas one-way analysis of variance was used to analyze statistical variations for numerical data (one-way ANOVA). Turkey's honestly significant difference test was used to compare means, and levels of significance were also taken into account at P< 0.05. A table, numbers, percentages, means, and standard error of the means were used to present the analyzed data. The appropriate statistical model used for characterization of the dairy cattle production and feeding system is as follows (Eq. 2):

$$Y_{ijk} = \mu + \alpha_i + \Sigma_{ijk} \quad (2)$$

Where: *yijk* = total observation due to i^{th}, agro ecology effect; μ = is overall mean; α_i = location (agro-ecology); and e_{ijk} = random error.

3. Results and Discussion

3.1. Farm land size of dairy producers in the study area

The average size of the land in the study region was 1.10 hectares per household (Table 1). In the highland, mid-altitude, and lowland regions, the average land size was significantly different amongst the agro-ecologies (P< 0.001) and was 1.38, 0.27, and 1.67 ha, respectively. The research area's lowland region had the largest ownership, followed by the highland region.

The shrinking amount of land required in the study region, particularly in mid-altitude (urban) areas, to efficiently produce and improve forage crops or has access to communal grazing space, is one of the major issues. Similar findings were made by Sintayehu et al. (2008) for the southern Ethiopian regions of Shashemene and Dilla, where rural areas have 1.14 hectares per household. Due to relatively large average land sizes per household among farmers in highland and mid-altitude regions, the overall average values of the current study are greater than the finding of Yayeh et al. (2017) for rural areas of the Debremarkos district (0.98 ha per household). The research area's total average amount of community pastureland or grazing land was 0.32 hectares. In highland, mid-altitude, and lowland regions, the average community grazing was 0.20, 0.058, and 0.68 ha, respectively. This difference amongst agro-ecologies was significant (P< 0.001).

Table 1. Farm land size hectare (ha) of dairy producers in the study area

Land type	Agroecology			Overall (n=149)	*P*-value
	Highland (n=26)	Midland (n=52)	Lowland (n=71)		
Average farm land (ha)	1.38	0.27	1.67	1.10	**
Average communal grazing land (ha)	0.20	0.058	0.68	0.32	**

N= number of respondents; **= P <0.001.

3.2. Livestock population

As indicated in Table 2, the estimated total livestock population in Tropical Livestock Unit (TLU) in the Derashe distric was 134,948,84, which composed of 83.28% cattle, 6.19% goats, 5.09% donkeys, 3.51% sheep, 1.19% poultry, 0.53% mules, 0.18% horses, and 0.0022% camels. Cows made up 37.44% of the livestock, with oxen making up about 45.84%. The reason for the disparity in the number of male and female animals was that farmers in highland regions produced more dairy cattle for plowing purposes than those in mid-altitude and lowland regions.

Table 2. Livestock population in tropical livestock unit (TLU) in the Derashe district

Animals species	Population	TLU equivalent *	Total TLU
Cow	72,188	0.7	50,531.6
Oxen	61,868	1	61,868
Sheep	47,404	0.1	4,740.4
Goat	83,660	0.1	8,366
Donkey	13,740	0.5	6870
Horse	297	0.8	237.6
Mule	1024	0.7	716.8
Camel	3	1	3
Poultry	161,544	0.01	1615.44
Total			134,948.84

Endale s (2015)' findings for the Meta Robi district, West Shewa Zone, and Oromia regional state are supported by the current study. Although this is in line with the current study, under the country's highland production system, cattle made up 92% of the total TLU and approximately 37% of the cattle herd. Funte et al. (2010) In the research district, the average

TLU for cattle, goats, donkeys, sheep, poultry, mules, horses, and camels was 5.35, 0.33, 0.27, 0.19, 0.06, 0.02, 0.01, and 0.0001 correspondingly. Endale noted that, in contrast to the current study, the average TLU for cattle, sheep, goats, donkeys, horses, mules, and poultry in the Meta Robi district was 7.97, 0.74, 0.46, 0.78, 1.44, 0.8, and 0.07, respectively (2015). The sampled households' total number of tropical livestock units (TLU) varied between the three agro-ecologies (highland, mid-altitude, and lowland) and was roughly 182.65, 255.55, and 1254.55 TLU, respectively. When we compare agro-ecologies, lowland regions have more cattle populations than highland and mid-altitude regions.

3.3. Labor division and role of gender in the study area

Different agro-ecologies had different general labor divisions for dairy farming operations in the study locations. Husband, wife, both husband and wife, and the entire family (16.1, 19.5, 39.6, and 24.8%, respectively) were responsible for the feed collection and feeding methods (Table 3). The husband, wife, both of them, and the entire family (13, 4, 3, 1.5, and 51%) were responsible for watering practices, correspondingly. Despite the fact that husband and wife cleaned the dairy home, their combined contributions were 14.8, 7.4, 28.2, and 49.7%. Husbands, wives, and husband and wife worked together to care for dairy cattle 84.6, 1.3, and 14.1% of the time, respectively. Ultimately, 89.9, 9.4 and 0.7% of the practice milking was performed by the husband, the wife, and both the husband and wife. The current study differs from Azage et al. (2013) for the rural highland dairy systems of Fogera and Bure where husbands milk their wives 89.9% of the time, compared to 97.3% in Azage et al. (2013).

Table 3. The overall labor division in the study area as presented in percentage**;**

Types of activities	Husband	Wife	Both	Whole family	*P*-value
Feed collection and feeding	16.0	19.5	36.6	24.8	**
Watering practices	13.4	4.0	31.5	49.7	**
House cleaning	14.8	7.4	28.2	51.0	NS
Milking practices	89.9	9.4	0.7	0	**
Health care	84.6	1.3	14.1	0	**

**= P <0.001; NS=Not-significant

3.4. Feed resources availability in the study area

As shown in Table 14, the primary sources of feed for dairy cattle in the study area varied significantly across agro-ecologies (P< 0.001) and included natural pasture, crop residues (from teff, maize, sorghum, barley, and wheat), standing hay, enset, trees/shrubs, and most households also used non-conventional feed like liquid residues (from local areke, Tella, and Cheka) and common salt. The availability of feed resources varied across agro-ecologies, though; in lowland, more farmers use natural pasture and crop residues; in the mid-altitude region, 32 (61%) households feed their cattle purchased green grass, dry grass/standing hay, crop residues, and non-conventional feeds because there is a lack of grazing land; and 20 (39%) households use natural pastures, crop residues, and non-conventional feeds. In addition to using a little amount of modified forage (elephant grass), Highland farmers also employed natural pasture, crop wastes, enset, palatable fodder trees, and shrubs.

Table 3. Common dairy cow feed type in the study area according to utilization percentage

Feed type	Agro-ecology (%)			Total (n=149)	P-value
	Highland (n=26)	Mid-altitude (n=52)	Lowland (n=71)		
Natural pasture	100	40.4	100	79.2	**
Maize Stover	0	100	100	82.6	**
Sorghum Stover	100	100	0	52.3	**
Wheat straw	100	0	0	17.4	**
Barley straw	100	0	0	17.4	**
Standing hay/dry grass	100	100	0	52.3	**
Industrial by-product (wheat bran)	0	9.6	0	3.4	**
Non-conventional feeds					
Cheka atela/michicha	84.6	100	53.5	75.2	**
Areke atella	0	100	0	34.89	**

N=Number of the respondents, NS=Not-significant; **= p<0.01, *Cheka* is common local drink in study area, *michicha* is the residue of *cheka*

The current study, similar to Ketema (2014) for Kersa Malima woreda, Oromiya regional state, Abebe et al (2014).'s for Ezha district of the Gurage zone, southern Ethiopia, and Asrat et al. (2016) in and around Wolita town, reported that the major feed resources of dairy cattle were natural pastures, crop residues, standing hay, and non-conventional feeds. Natural pastures, crop remnants, and standing hay are the main sources of nutrition for dairy cattle, according to a study conducted by Abdirahin & Kefalew (2015) in Fafa, Eastern Ethiopia.

Dairy cattle feed sources included purchased grass, natural pasture, crop residues, agro-industrial byproducts, conserved hay, and non-conventional feeds, though the current study is in agreement with reports by Sintayehu et al. (2008) in the southern Ethiopian towns of Awassa, Yirgalem, and Dilla that the main sources of dairy cattle feed were enset, natural pasture, and crop residues. Asrat et al. (2013) discovered that the main dairy cattle feed resources in and around Boditti Wolaita, South Ethiopia, were natural pasture, crop leftovers, and non-conventional feeds; Haftu et al. (2014) discovered that the same sources were present in Ganta Afeshum woreda, Eastern Zone of Tigray.

According to Yayeh et al. (2017) in the Debremarkos District of the Amhara Regional State of Ethiopia, the main sources of feed for dairy cattle included natural pasture, crop residues, hay, concentrate, and alternative feeds. According to research by Belay & Janssens (2016), the primary sources of feed for dairy cattle in Jimma Town, Ethiopia, including hay, green feed, cereal grain, wheat bran, commercial concentrate, molasses, noug cake, brewery leftover grains, cotton seed cake, maize powder, and non-conventional feeds. Asrat et al. (2016) discovered that pasture, saved feed, purchased feed, and unconventional feed were the main sources of dairy cattle feed in and around Wolaita Sodo town, Southern Ethiopia.

The study also discovered that the primary sources of feed for cattle are mostly crops like maize that have been thinned. Most responders acknowledged that there was a noticeable lack of feed resources throughout both the dry and wet seasons. A paucity of feed supplies was noted in both highland and lowland regions during the dry season, whereas in mid-altitude regions, a shortfall was noted in both seasons due to a lack of grazing land. Teff, sorghum, and maize were the most common crop residues in highland, mid-altitude, and lowland regions, respectively. The close to towns, mid-altitude dairy producers were buying feed supplies from regional markets as well as highland and lowland farms. The study indicated that industrial by-products were not easily accessible.

3.5, Estimation of annual feed availability in study area

3.5.1. Crop residues dry matter production

Most of Ethiopia uses crop waste as a major source of animal feed, particularly in the dry months of the year. Based on the household total crop yields that were discovered through the questionnaire survey and used to estimate the amount of crop residues (DM) that were readily available. The total biomass of crop residues produced annually in the highland, mid-altitude, and lowland regions was, in accordance with the FAO conversion factor, 64.2, 165.16, and 780.44 tons, respectively.

This equates to 909.93 tons of dry matter annually. 10% of the crop residue loss is anticipated, according to Tolera & Said (1994), for a variety of reasons. Thus, the annual production of crop residues in the highland, mid-altitude, and lowland regions was 58.48, 150.15, and 618.58 tons, respectively (Table 4). This equates to an annual production of dry matter of 827.21 tons. In contrast, lowland farmers tend to have larger plots of land than farmers in highland and mid-altitude regions because they grow more cereal crops, which increases the bio-mass output of agricultural leftovers in these regions.

3.5.2. Natural pasture/grazing land dry matter production

It was determined that the annual production of dry matter from natural pasture was 22,564 (12,282 ha2 tons per ha). The respondents' pasture land holdings were used to determine how much natural pasture they generated.

The total number of respondents owned 5.25, 3.0625, and 48.875 ha of pasture land in highland, mid-altitude, and lowland regions, respectively. As a result, the annual production of pasture in the highlands, mid-altitudes, and lowlands was 10.5, 6.125, and 97.75 tons, respectively, for a total of 114.375 tons of dry matter. In contrast, lowland regions produced higher biomass yields than highland and mid-altitude regions.

Table 4. Dry matter feed resources category and their supply according to DM, CP and ME in three agro-ecologies of study area

Feed supply sources in tonne	Agro-ecology			Overall
	Highland	Mid-altitude	Lowland	
Natural pastures/grazing land	10.5	6.125	97.75	114.375
Crop residues	58.48	150.15	618.58	827.21
Non-conventional feed	48.6	156.6	59.58	264.78
Fodder trees and shrubs	0.42	0.34	0.53	1.29
Crop aftermath grazing	19.75	8.25	82	110
Concentrates	0	0.5	0	0.5
Forest land	6.58	1.62	22.34	30.54
Total	144.33	323.58	880.78	1348.69

3.5.3. Crop aftermath dry matter production

A total of 65,878.25 hectares of land were used for various annual crop kinds in the district's three agro-ecologies. Stubble grazing has a conversion factor of 0.5 FAO in terms of total dry matter production (1987). As a result, the district's annual feed production is 32,939.125 tons (65,878.25 ha * 0.5).

Although the amount of crop aftermath produced by the sampled households in the three agro-ecologies in the highland, mid-altitude, and lowland areas was 19.75 tons, 8.25 tons, and 82 tons, respectively, adding up to a total of 110 tons of feed obtained, a higher yield of crop aftermath (DM) was observed in the lowland areas than in the highland or mid-altitude areas due to the averagely large crop land size as compared to both.

3.5.4. Forest land dry matter production

About 5,455 acres of land were covered in forest throughout the district. To calculate the total dry matter production from forest land, a conversion factor of 0.7 FAO is employed (1987). Thus, 3,818.5 tons of dry matter in total were produced in the district. A total of 30.54 tons of dry matter were produced from forest land, with 6.58 tons occurring in highland areas, 1.62 tons in mid-altitude areas, and 22.34 tons occurring in lowland areas. This suggests that compared to the Highland and Mid-Altitude, the Lowland had a higher availability of forest land, which may serve as a source of feed for dairy cattle. This is because the study area's lowland was relatively wider than the rest.

3.5.5. Estimation of biomass yield of browses in the study area

The estimated total biomass yield of trees and bushes was 1.29 tons (1292 kg), which varied amongst agro-ecologies. They were around 0.42 tons (421 kg), 0.34 tons (344 lb), and 0.53 tons (527 kg), respectively, in highland, mid-altitude, and lowland regions. The pleasant and perennial Dashille, Grawa, shola, Nabinaba, shomboko, and kerkeha trees and bushes were found in highland and mid-altitude regions. In the end, animals in lowland areas were fed on wanza (*Cordia abyssinica*), woybeta (*Terminalia* spp.), and shifara (*Moringa* spp.) throughout the dry season. According to the responders, dashille trees are perennial and edible tree species that are used as a year-round feed source for cattle or dairy animals in highland and mid-altitude regions. In addition to the leaf portion, the young stem portion also serves as a source of food for livestock. Compared to mid-altitude areas, lowland areas had the highest biomass yield of trees and shrubs. Highland areas came in second.

3.5.6. Dry matter, protein and metabolizable energy availability

Grazing land, crop residues, non-traditional feeds, fodder trees and shrubs, crop aftermath grazing, concentrates, and forestland together produced 1,348.69 tons of dry matter (DM) in total. 3861.85 tons of DM per year were needed for the current TLU units based on the overall feed balance in terms of DM yield per annum to a total TLU value of 1693.05 (with the negative balance of 2513.16 tons). In comparison to the total dry matter (DM) needed annually, the number of total tropical livestock units (TLU) in highland, mid-altitude, and lowland environments was 182.65, 255.55, and 1254.85, respectively.

According to this finding, lowland areas require more total dry matter than mid- and highland regions do. This is because there are a lot of animals in lowland areas. In the highland, mid-altitude, and lowland regions, respectively, 144.33, 323.58, and 880.78 tons of dry matter (DM) were generated. The annual total feed balance in tons of DM for highland, mid-altitude, and lowland regions is negative in each case, at 272-, 259.21-, and 1981.53-tons DM. This outcome demonstrated that the annual dry matter production fell short of the annual requirements for animals. The results of the current study are in agreement with those from Endale (2015) in the Meta Robi district, West Shew Zone, Oromia regional state, Ethiopia, and Eba (2012) in the highlands of the Blue Nile basin, who both reported that the annual dry matter production was less than what was needed for annual livestock needs. With a negative balance of 140 CP tons, the total amount of CP generated and needed for the TLU were 477.18 and 617.72 tons, respectively.

Highland, mid-altitude, and lowland areas of the study area's three agro-ecologies produced and needed different amounts of crude protein (CP): 23.11, 51.79, and 140.92 tons of CP, respectively; 66.5, 93.26, and 457.97 tons of CP, respectively; and there was a negative balance of 43.39, 41.47, and 317.05 tons of CP, respectively. Lowland regions produce and use more CP than highland and mid-altitude regions do, in contrast. The total amount of metabolizable energy (ME) generated and used for the TLU was 25,739.3 tons of MJ and 73,683.72 tons of MJ, respectively. The significantly lower balance was 47,944.42 tons metabolizable energy. The amount of metabolizable energy (ME) produced and needed varied among the three agro-ecologies in highland, mid-altitude, and lowland regions. These amounts were 2756.29, 6176-, and 16807-tons MJ ME, respectively; 7949.12, 11121.73-, and 54612.87-tons MJ ME, respectively; and a negative balance was found in each case of 5,192.83, 4,945.73, and 37,805.

The amount of feed generated in the research area affected the differences in agroecology. In comparison to highland and mid-altitude regions, the production of dry matter (DM) from crop residue (618.58 tons year) and natural pastures and grazing land (97.75 tons annually) was greatest in lowland regions. Compared to the highlands and mid-altitude regions, the output of dry matter (880.78 tons), CP (140.92 tons), and ME (16807.8 tons) is often higher in the lowlands.

Table 5. Estimated yearly differences in feed resources availability required and balance in three agro-ecologies of the study area

Nutrients	Feed supply in tonne	Agro-ecology			Total
		Highland	Mid-altitude	Lowland	
Dry matter	Available, tons	144.33	323.58	880.78	1348.69
	Required, tons	416.62	582.9	2862.31	3861.85
	Balance, tons	-272	-259.21	-1981.53	-2513.16
Metabolizable energy	Available, MJ/t	2756.29	6176	16807	25739.3
	Required, MJ/t	7949.12	11121.73	54612.87	73683.72
	Balance, MJ/t	-5192.83	-4945.73	-37805.87	-47944.42
Crud protein	Available, tons	23.11	51.79	140.92	477.18
	Required, tons	66.5	93.26	457.97	617.72
	Balance, tons	-43.39	-41.47	-317.05	-140

The total amount of DM required for the socks annually in three agro-ecologies was 3861.85 tons DM (Table 5). However, only 1348.9 tons DM of feed were actually produced, leaving a negative balance of 2513.16 tons DM per year, or 34.92% of the annual requirement, which is only enough to sustain the current stocks for 4.19 months at the most. Although highland farmers required approximately 416.62 tons of DM annually, only 144.33 tons were actually produced, leaving a negative balance of 272.29 tons each year—just 34.64% of what was needed annually and enough to last the existing supplies for no more than 4.15 months. In the mid-altitude region, the required dry matter per year was 582.9 tons DM/year, but only 323.58 tons DM/year of feed was actually generated, leaving a negative balance of 259.32 tons DM/year, or only 55.5% of what is required to maintain the current reserves for no longer than 6.7 months. There for the overall estimated values for ME and CP availability can only support for 34.9% and 77.2% of energy and protein requirements for the total TLU units in three agro-ecologies of study area.

The shortage of feed supply was the major problems for dairy cattle production between agro-ecologies of study area. In three agro-ecologies, more farmers and dairy producers reported that a reduction in milk yield, lactation length, body condition/growth and reproductive performance of their dairy cattle was due to feed shortage.

As shown in Figure 2, dairy farmers in three agro-ecologies in the area buy feeds from outside suppliers to ease feed shortfalls from their own production. However, informal marketing is the dominating system across all of the study sites, and feed marketing is poorly structured. Green grass, standing hay, and crop residues from teff, maize, and sorghum are among the roughages that are sold informally in small quantities. Concentrates and industrial by-product feed sources weren't utilized at all research locations. Where dairy farmers lack access to land for the production of feed, feed marketing by 32 (61%) dairy producers is frequent in mid-altitude (town) areas.

The remaining 20 (39%) dairy producers used their own land and sold in small quantities at local markets. Therefore, the primary source of feed in communities at a medium height is commercial feed. During drought years, 35 (49% of farmers) in lowland areas buy crop remnants, whereas 36 (51% of farmers) use crop residues from their own cropland. 26 (100%) of the farmers in the highland region used grazing and crop land that they owned for feeding purposes. But in three agro-ecologies, alternative feeds and minerals were being sold clandestinely in the research sites. In the lowland and mid-highland agro-ecologies of the Borana Zone, Ethiopia, Takele et al. (2014) revealed findings that are consistent with the current findings.

Figure 2. Standing hay marketing system in mid-altitude(town) of the study area

3.5.7. Feed resources transporting systems in the study area

The agro-ecologies in the research area used various feed transport techniques. All of the respondents who lived in highland areas transported crop residues and other feed sources using people, particularly women, while dairy farmers in mid- and lowland areas transported feed sources using donkeys, women, and trucks. Depending on the distance to the sources of the crop residues, the truck's transportation cost averaged 720.00 ETB.

The current finding is consistent with research by Azage et al. (2013) from the International Livestock Research Institute (ILRI), Addis Abeba, Ethiopia.

3.5.8. Feed conservation/storage practices in the study area

One of the most crucial methods of managing feed to ensure feed availability is feed conservation. Conservation of agricultural leftovers for dairy cattle and animal feeds was a prevalent practice throughout the three agro-ecologies of the study areas (Figure 3). 61% of the crop residues at mid-altitude were stored in shade, while 39% were stacked in open areas. Farmers from both the highlands and the lowlands stack crop residues (100%) in a clear area.

(a) (b) (c)

Figure 3. Methods of storing different crop residues (a) Maize stover, (b) teff straw, (c) sorghum stover in the study areas

3.5.9. Feeding systems of dairy cattle in the study area

Dairy cattle were fed via stall feeding, free grazing on open pastures, and tethering at backyard and roadside locations. As indicated in Table 6, the overall feeding methods in the research regions were 56.41% free grazing, 20.51% stall feeding, and 23.07% tethering and limited stall feeding. The majority of the cattle that lowland dairy farmers feed graze freely on natural grass all year long in the same location. Participants in focus groups who discussed this issue noted that this type of feeding arrangement reduced the quantity and quality of natural pasture. In mid-altitude, 38.47% of stall feeding and tethering at backyard/roadside and 61.53% of stall feeding were observed.

Most highland farmers (around 69.24%) engage in free grazing, with the remaining farmers (30.76%) tethered on their own crop and grazing property. Lowland farmers supplemented their livestock with crop remains in the morning before letting them graze freely at home, but highland farmers supplemented their livestock with crop residues, enset, trees and shrubs, and non-traditional feeds in the morning and afternoon. Nearly all cattle owners in the study area were supplementing their herds with dry-season crop residues, trees and bushes, and non-traditional diets. Normal weight increase and milk production occur during the wet season, followed by fluctuating losses during the dry season depending on the demand placed on grazing land and the kind and amount of vegetation.

The current study is in agreement with research reports from Derese (2008) in the West Shewa Zone of the Oromia Region, Ethiopia, where the main dairy cattle feeding systems were free grazing, semi-grazing, and fulltime free grazing, and Yayeh et al. (2014) in the Debremarkos district of the Amhara regional state. Similar findings were made by Asrat et al. (2015) that dairy cattle feeding systems in Humbo woreda of Wolaita Zone, Southern Ethiopia, were free grazing, rotational grazing, and zero-grazing.

Table 6. Feeding systems in the study area

Types of feeding systems	Agro-ecology (%)			Overall (n=149)	P-value
	Highland (n=26)	Midland (n=52)	Lowland (n=71)		
Free grazing	69.24	0	100	56.41	**
Stall feeding	0	61.53	0	20.51	**
Tethering and limited stall feeding	30.76	38.47	0	23.07	**

**=P <0.001

According to Lijalem et al. (2015), the three main dairy cattle feeding techniques in southern Ethiopia's Sidama Zone were free grazing, rotational grazing, and zero-grazing. In and around Wolaita Sodo town, Southern Ethiopia, Asrat et al. (2016) discovered that the three main dairy cattle feeding strategies were free grazing, tethering, and cut-and-carry systems and Belay and Janssens (2016) in Jimma town, Ethiopia dairy cattle feeding systems were zero-grazing/stall feeding, Zero and partial grazing and fulltime grazing.

3.5.10. Form of feeding of crop residues in the study area

Asrat et al. (2015) reported similar results, stating that the free grazing, rotational grazing, and zero-grazing dairy cattle feeding regimes in Humbo woreda of Wolaita Zone, Southern Ethiopia. In the Aleta Chukka district of the Sidama Zone, southern Ethiopia, the availability of

Table 7. Form of feeding of crop residues in the study area

Parameters	Agroecology (%)			Overall (n=149)	P-value
	Highland (n=26)	Mid-altitude (n=52)	Lowland (n=71)		
Whole provided	84.65	5.3	97.2	68.9	**
Chopped provided	15.4	92.1	2.8	30.4	**
Mixed with other feeds	0.0	2.6	0.0	0.7	**
Total	100.0	100.0	100.0	100.0	

N=Number of respondents, **= P<0.001

communal grazing, private grazing, and stall feeding was evidenced. In the Sidama Zone of southern Ethiopia, free grazing, rotational grazing, and zero-grazing were the three main dairy cattle feeding methods, according to Lijalem et al. (2015). Asrat et al. (2016) identified three primary dairy cattle feeding practices in and around Wolaita Sodo town, Southern Ethiopia: free grazing, tethering, and cut-and-carry systems.

4. Conclusions

The majority of the dairy cattle feeding and availability systems in the Derashe district are subsistence production systems, with the exception of the mid-altitude (town) area. In the study areas, natural pastures, crop residues, after-harvest grazing, standing hay, maize that has been thinned, ensets, trees, shrubs, and unconventional feeds were the main sources of food for livestock. Grazing land, crop residues, conventional feeds, fodder trees and shrubs, crop aftermath grazing, concentrates, and forested lands were used to produce the majority of the dry matter. The negative balance was used to estimate the total DM yield per year that was produced and needed for the existing TLU units, as well as the amounts of CP and ME that were generated and needed. Stall feeding, free grazing on open pasture, tethering, and limited stall feeding were the feeding practices used in the research regions. The production of dairy cattle is restricted in the research region by a lack of grazing land, feed, and extension services. Despite the numerous issues and limitations that can hinder or slow down the growth of the production of dairy cattle feed in the research area, there were also favorable variables that could enhance feed production, such as climatic factors, agroecology, cereal crop production, and road access.

Based on the finding of the current study, the following recommendations are forwarded:

- All three agro-ecologies face dairy cattle feed shortages. Farmers should adopt conservation practices, such as hay and silage production during surplus periods, cultivate forages on cropland, collect and store crop residues under sheds, and build skills for sourcing feeds from local markets.
- The district lacks grazing land improvement, crop residue treatment, and water management. Stakeholders should deliver targeted extension services and training to innovative farmers to raise awareness and adoption.
- Improved forages contribute minimally due to limited access. Establish nursery sites in high-potential kebeles to promote dissemination and uptake.
- Dairy product marketing is underdeveloped, with highland/lowland farmers selling only butter and buttermilk due to cultural taboos on fresh milk, while mid-altitude producers sell milk informally. Form cooperatives for milk collection centers and market linkages to local/international buyers; extension staff should educate farmers to overcome taboos and expand fresh milk sales.

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