Research article

Assessment of livestock feed supply and demand concerning livestock productivity in Lalo Kile district of Kellem Wollega Zone, Western Ethiopia

Jabesa Ayele [a], Taye Tolemariam [a], Abegaze Beyene [a], Dawit Adisu Tadese [c,d], Metekia Tamiru [a,b,*]

[a] Department of Animal Science, College of Agriculture and Veterinary Medicine, Jimma University, P.O. Box 307, Jimma, Ethiopia
[b] Ghent University, Faculty of Veterinary Medicine, Department of Nutrition, Genetics and Ethology, Heidestraat 19, B-9820, Merelbeke, Belgium
[c] Feed Research Institute, Chinese Academy of Agricultural Sciences, Beijing 100081, PR China
[d] Ethiopian Institute of Agricultural Research, Sebeta Fishery, Other Aquatic Life Research Centre, Post Office Box 64, Sebeta, Ethiopia

ABSTRACT

The purpose of this research was to determine the impact of seasonality on feed balance in the Lalo kile district of the Kellem Wollega Zone of Western Ethiopia. The district was divided into two agro-ecological zones: mid and low altitude. A total of 127 respondents were chosen to be interviewed. To collect the required data in the study areas, a cross-sectional survey was used. To analyses the qualitative data, descriptive statistics were performed, while the General Linear Model (GLM) method was used to assess the impacts of seasonal feed availability and agro-ecology on dry matter yield and production constraints. The result showed that there has been seasonal fluctuation in the feed availability and the feed is generally abundant from June to September. The feed supply in terms of DM, ME, and DCP per household per year was 118.7 kg, 74,781 MJ/kg, and 118.61kg, respectively. The feed balance was negatively associated and substantially different all across the studied areas (P < 0.01). With a year's approach, the annual total feed supply exceeds only 66.13, 25.81, and 87.24 percent of the DM, DCP, and ME demands per household, respectively. As a result, total dry matter production, digestible crude protein, and metabolizable energy supply were only fulfilled for 9, 3.5, and 12 months in the research area's mid-altitude and 7, 3 and 9 months in the study area's low land altitude, respectively. The main limitations in both agro-ecologies of the research area include low production and reproduction, poor use of existing feedstuffs, and poor adoption of improved forage production. As a result, for successful livestock development in the study area, the adoption of better fodder and supplementation of productive animals should be considered.

1. Introduction

The livestock industry contributes significantly to physical and economic growth by providing nutritional and food security for a productive and healthy living on a worldwide scale (Behnke and Metaferia, 2015). More precisely, livestock is an essential asset for economic diversification and rural livelihoods in a smallholding agricultural system, showing that its economic and nutritional value to the general community is not affected by Ethiopia's current enormous potential(Ahuja, 2013). Feeding a diet that is balanced in all nutrients and at a level that fulfils the production goal while taking the animal's physiological condition into account is critical for attaining high and sustained livestock output (Ahuja, 2013).

Feed and fodder are critical components in giving adequate nutrition to animals. However, it seems challenging to supply high-quality fodder in adequate amounts throughout the year in tropical areas such as Ethiopia. Inadequate availability of feed, both amount and quality, was found to be the single most significant issue causing livestock production to be poor (Ulfina et al., 2005). According to Fekede et al. (2011), the national feed balance is 40% deficient in feed. During the dry season and cropping season, there is a severe lack of feed supplies, and its nutritional content is inadequate to sustain essential functions, resulting in decreased livestock production (Tonamo et al., 2015). Drought and climate change have an impact on feed supply and quality (Assefa and Nurfeta, 2013).

Significant attempts have been undertaken in the past to address Ethiopia's feed scarcity through increased feed availability to improve livestock production. However, the effect is so small that animals are still exposed to extended durations of nutritional stress (LDMPS, 2006). As a

* Corresponding author.
E-mail address: metekiatam@gmail.com (M. Tamiru).

consequence, animals are unable to meet their nutritional needs and often lose weight and production. Crop-livestock mixed systems are the main agricultural operation in the southwestern area of Ethiopia, where animals are raised in addition to crop production, providing manure and draught power for crop production while crop leftovers are utilized for animal feed (Talore, 2015). Natural pasture and crop wastes are significant feed supplies in this system, whereas farmed forages have just lately been introduced, and their adoption is restricted due to land scarcity.

One of the primary concerns of livestock keepers in the study area is seasonality in the quality and availability of fodder supplies. Seasonal and inter-year changes in crop residue production may also have a significant impact on residue availability at a particular time of year. The majority of study efforts concentrated on evaluating feed resource availability without measuring the quantity of dry matter (DM), metabolizable energy (ME), and digestible crude protein (DCP) acquired in each feed resource type in various parts of the country. Furthermore, the high cost of concentrates and their fluctuating prices, as well as the shortage of feed concentrates and their adaptability to marginal circumstances, render them non-competitive with food crops and aggravate the livestock feeding scenario. Improving raised variables to increase livestock productivity and output aids the nation in ensuring food security and reaping profits from the industry. As a result, the current study sought to investigate the effects of seasonality on feed availability, as well as to determine the balance of feed resource supply and demand, and to identify the resulting impact on livestock production performance and opportunities with available feed in the study area.

2. Material and methodology

2.1. Description of the study area

The research was carried out in the Lalo kile district in the Kellem Wollega zone of western Ethiopia, which is situated 510 km west of Addis Abeba. The district is located at $8°$ $43′$ $36″$N-$9°$ $3′$ $31″$N latitude and $35°12′52″$E-$35°26′54″$E longitude. It is located at an altitude of 1430–1780 m above sea level. The district has a sub-humid climate with long-term rainfall ranging from 1,000 to 1,500 mm per year, with a bimodal distribution that typically lasts from April to November. The area's lowest and highest daily temperatures are 15 $°$C and 31 $°$C, respectively. The district's geography is characterized by mountains, plateaus, and soil textures of black, white, and red. The district's total household population is projected to be 7,797, with 7,157 male-headed families and 640 female-headed households. The district has a total population of 49,783, with 23,760 men and 26,023 females. Thus, the

population density is 123.28 people per square kilometer. The district's agricultural system is characterized by a mixed farming approach that includes both crops and animal production (see Figure 1).

2.2. Ethics approval and consent to participate

The experiment received approval from the Ethical Committee of Jimma University College of Agriculture and Veterinary Medicine, Jimma, Ethiopia and informed consent was also obtained from authors conducting the experiment.

2.3. Sampling procedure and data collection

The research district was stratified, and the study kebeles and families were chosen using random and purposeful selection methods based on their representative character of mixed crop-livestock production systems. The district was divided into two height zones: low altitude (less than 1500m.a.s.l.) and mid-altitude (from 1500 to 2000m.a.s.l.). Three target kebeles were chosen at random from each altitude (for a total of six kebeles) to represent the research region. The (Cochran, 1977) formula $n = \frac{z^2\ p(1-q)}{d^2}$ was used to determine the representative sample size from the selected area at a 95 percent confidence interval, where n is the sample size, z is static for a level of confidence, p is the expected prevalence or proportion (in the proportion of 10%), and d is the level of precision, which is 5%.Finally, 127 representative sample farmers were purposefully chosen by using a simplified formula ($n_1 = \frac{no}{1+\frac{no}{N}}$) (based on crop and livestock production potential, farmer experience, and accessibility for data collection) from the households involved in the agricultural system mentioned from the selected kebeles

Before being administered, a structured questionnaire was created and pre-tested, and then refining and correction were done based on the respondents' perceptions. The cross-sectional survey was used to collect the data needed for the research. The interviews were conducted at the farmer's residence to allow for cross-checking of the farmer's responses regarding the type of available feed resources and quality in order of importance, what type of crop residues are available in the study area, seasonality effect on feed resource availability and quality, scarcity of feed, identifying livestock production performance and opportunities with available feed. Secondary data or additional information was gathered from the livestock development and health care agency, the district agricultural office, the land and environmental protection district office, kebele leaders, and the development agent.
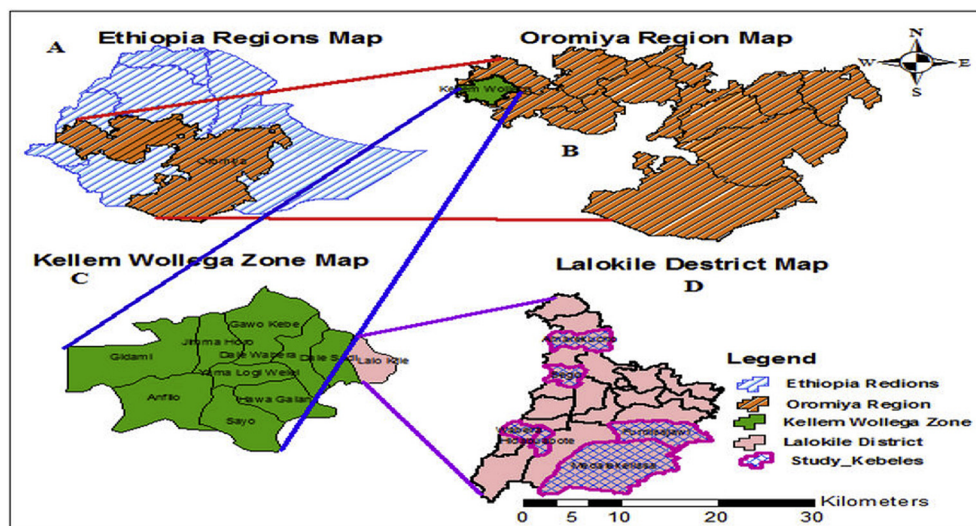

Figure 1. Map of the study area.

2.4. Estimation of the quantity of available feed resource

Using crop production and land area data gathered from respondents, the amount of feed resources in the study area was estimated. Data on annual and perennial crops, as well as the number of grains produced by respondents, were collected, and the number of crop residues and by-products used as a source of animal feed was estimated using conversion factors developed. Grain yields were converted to fibrous residues using multipliers of 1.5 for wheat, barley, oats, and wheat, 1.2 for field pea, fava bean, and linseed, 2.0 for finger millet, 0.3 for sugar cane, sweet potato, and other root & tubers, 4 for noug and linseed, 0.25 for vegetable waste, and 8 for banana (FAO, 1987). Maize stover was estimated using a multiplier of 2 (De Leeuw and Tothill, 1990) while sorghum was estimated using a multiplier of 2.5(Kossila, 1988). Approximately 10% of crop residues were considered waste, either during utilization or when used for other purposes (Tolera and Said, 1994). Moreover, conversion factors of 3.0 t/ha for private grazing land, 1.8 t/ha for fallow land, 2.0 t/ha for communal grazing, 0.50 t/ha for stubble crops, 8 t/ha for improved forages, and 1.2 t/ha for wood, bush, and shrubs were used (Von Carlowitz, 1984). The amount of dry matter basis on non-conventional and concentrates (supplements) feed resources available was estimated by interviewing farm owners about the amount supplied per day, as well as the frequency and quantity purchased per month.

2.5. Estimation of dry matter, crude protein and metabolizable energy contents of feed resources to animal requirements

The feed supply was estimated using major data sets from the supply side, which included the total dry matter yield from the households surveyed. The nutrients supplied by each feed type were estimated based on the total DM output and the nutrient content of that feed on a DM basis (Abdinasir, 2000). The sum of the maintenance energy requirements of livestock was used to calculate the total energy requirements of livestock types. To compare balance, the population of livestock was converted into tropical livestock units (TLU) using the conversion factors of (Kearl, 1982). The total available dry matter, nutrients supplied as metabolizable energy, and digestible crude protein were calculated by adding the nutrients supplied by each major feed resource category.

The maintenance requirements of total DM from major feed resources were calculated at 6.25 kg/DM per day in demand-side estimation. This corresponds to 2.5 percent of the animal's body weight. For one tropical livestock unit, the digestible crude protein requirement for maintenance was 160g digestible protein per day (FAO, 1986) (Body weight: 250 kg). Because there were no exotic breeds available in the study area, the conversion was limited to indigenous tropical livestock units. A standard method developed by (King, 1983) for tropical regions was used to estimate metabolizable energy and livestock maintenance requirements. Maintenance energy requirement was calculated according to the equation $ME = \frac{0.343 X L W^{0.73}}{km}$, Whereby ME is $(MJday^{-1}animal^{-1})$ for maintenance; LW is the live body weight; km $(MJkg^{-1})$ is the efficiency with which ME is used for maintenance and related the average forage metabolizable and always tends to lie 0.64–0.70. Thus, the metabolizable energy (ME) of one tropical livestock unit was 29.84 MJ kg/day/animal.

2.6. Statistical analysis

The questionnaire's validity was ensured using Pearson product-moment correlations, which used SPSS software to connect each questionnaire score with the total values. The item–item questionnaire association demonstrated a significant correlation with the total score, showing that each questionnaire item was valid. After confirming the data's validity, reliability was evaluated using Cronbach's Alpha in SPSS. The dependability statistic produced a score of 0.72, which was more than a cutoff value of 0.600, indicating that the current research instrument was dependable. The data was then analyzed using the Statistical

Package for the Social Sciences (SPSS) (SPSS version 20, 2012). To characterise qualitative variables, descriptive statistics such as frequency means and standard error were used. To compare the impacts of season and agroecology on dry matter yield and production constraints, the General Linear Model (GLM) technique was employed. At a significance level of 0.05, the mean separation was evaluated using the least significant difference (LSD). Yijk = + Ai + Sij + Eijk was the statistical model employed to analyse the data. Where Yijk denotes the response variable, = the overall mean, Ai denotes the influence of the ith agroecology, Sij denotes seasonal variation, and Eijk denotes random error.

3. Result and discussion

3.1. Seasonal availability of feed resources in study area

Figure 2 illustrates the seasonal availability of feed resources in the research region. Three distinct feeding times were found in the research region, each with its own distinct features. During the first phase, from May to November, the major rainy season, feed resources were abundant. Natural pastures and occasional stubble grazing were the primary sources of feed during the seasons, consistent with a study conducted by (Belay and Negesse, 2018). However, it was gradually decreased and then lost entirely during the dry season, which runs from November to April during the early rainy season. To bolster this conclusion, it has been observed that feed availability from natural pasture changed in response to seasonal rainfall dynamics (Mengistu, 1998, 2006; Bogale et al., 2008; Belay and Negesse, 2018). Because forage availability and quality were not consistent throughout the year, gains achieved during the rainy season might be lost entirely or partially during the dry season. This finding was corroborated with Emana et al. (2017) in the Abol and Lare districts of the Gambella area and Hassan et al. (2019)) in the Moyale district of Southern Ethiopia's Boran Zone. This might be explained by the fact that both the amount and quality of feed available from natural pastures vary significantly across time and space (Funte et al., 2009). As a result, the current study concluded that farmers must be aware of feed supply cycles and employ conservation measures. Following the end of the main rain season (November to December) in the study area, grazing stubbles such as haricot bean, maize, and teff were also the predominant feed resources. Throughout this time span, feed quantities and quality were gradually reduced. Simultaneously, Tesfaye (2008) observed that the feed scarcity began in late November and continued until March, during the driest months, when the production of natural pasture and fodder shrubs decreased.

The second phase was a dry time (in most cases from January to early March), during which feed was supplied from crop residues, but was of poor quality, as described by (Funte et al., 2009). Crop wastes such as maize stover, sorghum straw, finger millet, teff straw, wheat straw, nug chuff, haricot bean straw, and barley straw provided the majority of the season's feed supply, as previously recorded in various locations around Ethiopia (Assefa et al., 2014; Lemma et al., 2016; Gashaw and Defar, 2017). During this dry season, grass availability and quality decreased to the point that it may not provide enough nutrition for cattle to maintain their body weight, resulting in a full loss of livestock production. According to (Galmessa et al., 2013), feed shortage led in body weight loss and, as a result, decreased milk production.

The third phase was the late dry season, particularly from late March to May, which was a critical time for cattle because all available feed supplies in the area were depleted. Only browsing trees and non-traditional feeds were available, which was insufficient for this season, as Belay et al. (2012) reported. The feeding calendar was discovered to be a critical component in managing and utilizing available feed supplies in the research region. Additionally, silage production was unknown, as was hay production. However, feed was very plentiful from June to September, owing to increased pasture growth, maize thinning, and weed growth in annual crops. Thus, it was recommended that good collection, conservation, and correct usage of agricultural wastes and
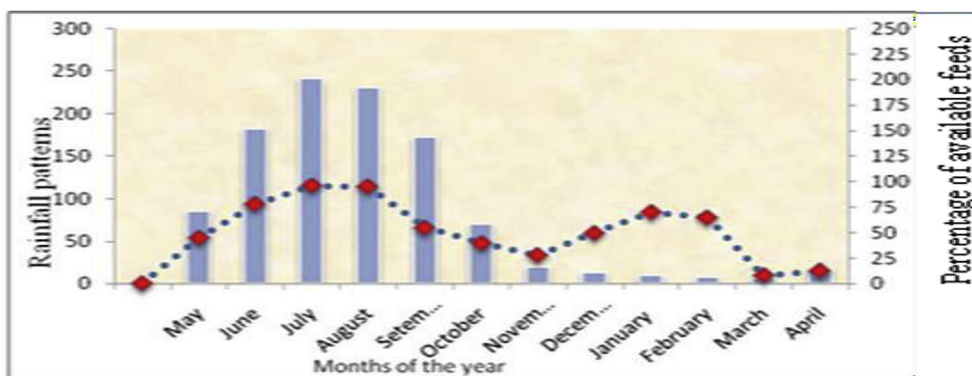
Figure 2. The seasonal availability of feed resources in the Lalo Kite district.

haymaking would enhance the amount of accessible feed. Additionally, other alternative feed quality improvement strategies such as urea treatments, nutrient block and silage production, and participatory scale-up of improved forage species should be used to improve the nutritional quality of available feed during the dry season, as smallholder farmers in the other part of Ethiopia have already done it (Belay et al., 2012; Zewdie and Yoseph, 2014).

3.2. Estimated annual available feed supply in the study area

Table 1 shows the anticipated amount of feed available in each category for the maintenance of the whole livestock population in each household. The available feed resources might be classified according to their value in terms of annual DM production per household as natural pasture, agricultural residues, stubble crops, fodder trees and shrubs, and non-traditional and enhanced forages (see Table 2).

Annual total utilizable DM feed supply was 12.580 ± 22 and 11.170 ± 46 tonnes of DM per family, respectively, at the research area's mid and low altitudes. In comparison to the total tropical livestock unit, the yearly utilizable DM feed supply per family differed across the two agroecologies. Natural pastures (4.300 ± 11 tonnes) were projected to be the largest contributor to the total DM per household per year, followed by crop residues (4.100 ± 11 tonnes) and fodder tree and shrub foliage's (18.83 ± 0.01 tonnes) at both elevations of the research areas. Other less abundant feed resources, such as stubble crops, roadsides, and non-traditional feed, improved forages, and supplementation, contributed a meagre 1.970 ± 07 tonnes of DM per year, which could be attributed in part to the exclusion of weed and supplementary feeds due to a lack of conversion factors. As a result, the study indicates that precise conversion factors must be developed in order to get a valid estimate. The total DM obtained from the major and minor feed supplies accessible in the research region was calculated to be 11.870 ± 62 tonnes TDM per family per year. This result corroborated the findings of (Assefa and Nurfeta,

Table 2. Estimated dry matter, digestible crude protein and metabolizable energy annual maintenance requirements for tropical livestock unit.

Variables	TLU	Daily requirements/ TLU	Annual requirement/ TLU/HH
Mid altitude			
TDM	7.11 ± 0.61	6.25kg	16.22 ± 1.1ton
DCP	7.11 ± 0.61	160g	415.22kg
ME	7.11 ± 0.61	29.84MJ	77439.3MJ
Low altitude			
TDM	8.63 ± 1.08	6.25kg	19.69 ± 1.9ton
DCP	8.63 ± 1.08	160g	503.99kg
ME	8.63 ± 1.08	29.84MJ	93994.5MJ
Overall mean			
TDM	7.87 ± 0.84	6.25kg	17.95 ± 1.5ton
DCP	7.87 ± 0.84	160g	459.61kg
ME	7.87 ± 0.84	29.84MJ	85716.9MJ

TLU = Tropical Livestock Unit; DCP = Digestible Crude protein; ME = Metabolizable Energy; HH = Household.

2013), who found a total available DM of 11.72 tonnes per family in Ethiopia's Adami Tullu Jiddo Kombolcha District.

The average annual supply of digestible crude protein and metabolizable energy per family was calculated to be 120.81kg, or 79254 MJ at low altitude, and 116.41kg, or 70371 MJ at mid altitude. However, the available feeds were found to be of low quality, since they had a significant quantity of fiber and so were unable to provide the animals with the needed amount of protein and calories. In contrast to the current data, Wondatir (2010) found a greater supply of TDM, DCP, and ME per family per year of 21.3tons, 725.4kg, and 146,393MJ, respectively, around

Table 1. Estimated available mean dry matter production (ton), ME (MJ) and DCP (kg) per household per annual feed resources categories according to agroecological differences (N = 127).

Feed resources	Mid altitude (N = 66)			Low altitude (N = 61)			Overall mean (N = 127)		
	TDM	TME	DCP	TDM	TME	DCP	TDM	TME	DCP
Natural pasture	5.08 ± 0.09	32004	59.57	3.53 ± 0.17	22239	36.88	4.30 ± 0.11	27121.5	48.22
Crop residue	4.42 ± 0.10	27846	22.10	3.78 ± 0.19	23814	28.35	4.10 ± 0.11	25830	25.22
Stubble crop	1.01 ± 0.03	6363	8.08	0.92 ± 0.05	5796	7.36	0.96 ± 0.03	6048	7.72
Non-conventional	0.30 ± 0.01	1890	3.15	0.73 ± 0.06	4599	7.30	0.52 ± 0.04	3276	5.23
Tree and shrubs	1.56 ± 0.01	9828	24.34	2.10 ± 0.02	13230	34.65	1.83 ± 0.01	11529	29.50
Improved forages	0.21 ± 0.04	1323	3.57	0.11 ± 0.02	693	1.87	0.16 ± 0.03	1008	2.72
Total	12.58 ± 0.22	79254	120.81	11.17 ± 0.50	70371	116.41	11.875 ± 0.56	74812.5	118.61

TDM = Total Dry matter; TME = Total Metabolizable Energy; DCP = Digestible Crude Protein; N=Number of households.

Ziway, Ethiopia's central rift valley. The discrepancy might be explained by differences in landholding circumstances and feed quality.

3.3. Annual estimated dry matter, digestible crude protein and metabolizable energy requirements

The estimated amount of maintenance requirements of feed nutrients to the total livestock population for the 127 households is presented in Table 3. In the mid and low-altitude areas respectively, the annual total dry matter, digestible crude protein, and metabolizable energy maintenance requirements were estimated to be $16.22 \pm 1.1t$, 415.22kg, 77439.3MJ and $19.69 \pm 1.9t$, 503.99kg, 93994.5MJ with a total of $17.95 \pm 1.5t$, 459.61kg and 85716.9MJ per household per year, respectively. There was a greater need for total dry matter at low altitude than at mid-altitude in the current investigation. This could be because there is a lot of cattle at low altitudes. According to the estimates, the indigenous livestock populations consumed less protein and energy than the recommended daily intakes of 160 g (FAO, 1986) and 29.84 MJ (MJ/TLU). This finding is in agreement with earlier research by (Kassa et al., 2003; Yishak and Janssens, 2014). As a result, the protein and energy needs must be met by the addition of improved forages.

3.4. Estimated annual feed balance between supply and requirements

Table 4 summarizes the total yearly available nutrient supply, nutrient requirements for maintenance, and feed balances. The projected available feed supply in the mid-latitude area met about 77.56 percent of the TDM maintenance requirements of cattle per household each year. Each year, the overall predicted DCP and ME rates per household were 29.10 percent and 102.34 percent, respectively. In the low altitude area, only 56.73 percent of total DM satisfied the overall livestock demand per household per year. Similarly, the total annual availability of DCP and ME met just 23.10 percent and 74.86 percent of the entire livestock demand per household, respectively. As a result, the study area's total dry matter production, digestible crude protein, and metabolizable energy supply were only fulfilled for 9, 3.5, and 12 months in the mid-altitude zone and for 7, 3 and 9 months in the low-altitude zone. Throughout the next months, cattle faced serious feed shortages. The preceding conclusion was consistent with previous research for Ethiopia's agro-ecologically distinct regions (Admassu, 2008; Wondatir et al. 2015; Dawit et al., 2013). The bigger shortfall seen in low altitude areas was attributed to the low nutritional content of the primary feed supplies and the area's higher livestock population. Overall, the yearly feed provided year-round satisfied only 66.13 percent, 25.81 percent, and 87.28 percent of the DM, DCP, and ME total needs per household in the study district, respectively. A negative balance of DM need, total DCP, and ME was seen in the current study, which was comparable to (Wondatir, 2010), who reported 66.4 percent, 36.5 percent, and 67.2 percent, respectively, near Ziway, Ethiopia's central rift valley. However, Sisay (2006) found a surplus DM supply higher than the entire annual livestock requirements in North Gondar, and the nutritional balance in the DM supply of the feed-in Metema area was sufficient to maintain the animals

per household (Tesfaye, 2008). The difference between the current study and the above data might be attributed to high animal population numbers and the sterility of the land to sustain feed production. Thus, as previously stated, both energy and protein are significant constraints on cattle output (McDonald et al., 1988). Animal protein needs are expressed in terms of the amount of protein and its constituent amino acids consumed in a unit of time-typically, the amount provided each day. The declining resistance of livestock to epidemic diseases may be attributed to a deficient supply of dietary proteins, which is reflected in the immunological response. The use of dietary proteins must be considered in relation to the available energy supply (Bakrie et al., 1996). When energy is scarce, food protein is inefficiently utilised as another source of energy rather than being transformed to body protein. However, consistent with earlier findings (Mekasha et al., 2014; Worku et al., 2016; Gashaw and Defar, 2017), the current investigation revealed that protein was the most deficient nutrient in both agro-ecologies, particularly for dry season feed resources. As a result, despite a feed scarcity, there is great opportunity to raise output levels throughout the range of enhancing livestock performance by addressing the issue of nutritional imbalance. Unbalanced nutrition may also result in the overfeeding of some nutrients while leaving others lacking. This not only decreases productivity and raises expenses per kilogram of output, but also has a detrimental effect on a variety of physiological processes, including long-term animal health, reproduction, and productivity.

3.5. Production and reproduction constraints

In the study area, seasonal variations in feed quantity and quality were the main restriction to animal production and caused vacillation in the productivity of livestock throughout the year, particularly in the dry seasons during which feed was scarce and poor in nutritive value. Feed supply shortages were the root causes of the poor performance of livestock. This was corroborated by the report of (Adugna, 2008) who stated that feed shortage in quality and quantity becomes a critical problem leading to a slow growth rate in growing animals and low production and reproduction performance. In this study, Farmers reported that there was a decline in production and productivity and disease problem mainly trypanosomiasis. But the performance parameters like milk yield, age at first calving, calving interval and age at first drought were significantly ($p < 0.05$) different between agro-ecologies. . This might be related to the availability of variable feed quantity and quality in the area. In line with this, it has been confirmed that feed shortage alone could be a major impediment to livestock productivity (Duguma et al., 2012).

Similarly, the production parameters of sheep, goats, donkey, horse and mule were significantly different ($p < 0.05$) between the two agro-ecologies of the study district. This might be reflected in the unambiguous adaptation of livestock to feed shortage in terms of quantity and quality. Given their poor nutritional status, animals tend to be underweight thus producing little meat and achieving low prices when sold as live animals. Moreover, the poor performance of livestock was attributed to the estimated feed value in terms of DM, CP and ME supply which could not yet satisfy the normal maintenance requirements of livestock.

Table 3. Average estimated annual TDM (tons), ME (MJ) and DCP (kg) available, demand and balance per household for maintenances tropical livestock unit in the study area.

Agro-ecologies	N	TLU	Annual nutrient available			Annual nutrient demand			Annual nutrient balance (% fulfilled)		
			TDM	TME	DCP	TDM	TME	DCP	TDM	TME	DCP
Midland	66	7.11 ± 0.61	12.58 ± 0.22	79254	120.81	16.22 ± 1.10	77439.30	415.22	-3.64 ± 0.60 (77.56%)	+1814.70 (102.34%)	-294.41 (29.10%)
Lowland	61	8.63 ± 1.08	11.17 ± 0.50	70371	116.41	19.69 ± 1.90	93994.50	503.99	-8.52 ± 1.10 (56.73%)	-23623.50 (74.86%)	-387.58 (23.10%)
Average	127	7.87 ± 0.84	11.87 ± 0.56	74812.5	118.61	17.95 ± 1.50	85716.90	459.61	-6.08 ± 0.50 66.13%)	-10904.40 (87.28%)	-341.00 (25.81%)

TLU = Tropical Livestock Unit; TDM = Total Dry matter; TME = Total Metabolizable Energy; DCP = Digestible Crude Protein; N=Number of households.

Table 4. Production and reproductive performance of livestock-related to feed in mid-altitude and low altitude areas of the study sites.

Livestock species	Production parameters	Altitude of area		Overall		
		Midland (N = 66)	Lowland (N = 61)	Mean	SEM	p-value
Cattle	Average daily milk yield (lit/day)	1.82	1.47	1.65	0.015	<.0006
	Total lactation milk yield (lit/year)	318.77	257.33	288.05	1.72	<.0001
	Age at first calving (month)	54.11	55.77	54.94	0.63	<.0044
	Calving interval (month)	18.33	21.22	19.77	0.46	<.0016
	Lactation length (month)	5.88	5.55	5.72	0.66	<.8346
	Day open (day)	170.00	188.88	179.44	6.42	<.2593
	Several services per conc.(trial)	1.88	2.44	2.16	0.52	<.1315
	Reproductive life span (year)	9.88	7.88	8.88	0.85	<.0249
	Draught age (year)	3.92	4.24	4.08	0.20	<.0097
	Draught life span (year)	6.11	5.00	5.55	0.79	<.1315
Sheep	Age at first lambing (month)	30.00	32.33	31.16	0.99	<.0011
	Lambing interval (month)	12.11	14.88	13.49	0.85	<.0097
	Age of slaughter (month)	24.11	28.00	26.05	0.89	<.0459
Goats	Age at first kidding (month)	28.88	26.33	27.60	0.72	<.0066
	Kidding interval (month)	13.33	12.11	12.72	0.81	<.5787
	Age of slaughter (month)	28.88	26.00	27.44	1.12	<.0629
Donkey	Age at first foaling (month)	56.00	60.00	58.00	0.00	<.0001
	Age at first working (month)	60.00	62.00	61.00	0.00	<.0001
Horse	Age at first foaling (month)	53.33	59.55	56.44	1.38	<.0065
	Foaling interval (month)	24.22	25.00	24.61	0.81	<.5927
	Age at first working (month)	52.11	58.00	55.05	0.28	<.0001
Mule	Age at first working (month)	52.00	54.00	53.00	0.00	<.0001

The livestock feeding calendar is an essential livestock management practice to use the available feed resources efficiently and to supply the livestock with the required quantity and quality feed and overcome feed shortage. Thus, when there is feed scarcity but the respondents took measurements to alleviate feed shortage in ranked, storing the feed during available, completely reduce livestock numbers and encourage the use of private grazing land in the area (Tadesse et al., 2014). reported that feed scarcity was resolved mostly by storing the feed during available, using browse trees and travelling long distance for search feed, purchasing feed supplement, haymaking and destocking in Lemo and Soro district of southern Ethiopia.

Significant different at (p < 0.1) and non-significant different at (p > 0.1).

3.6. Efficient utilization of feed resources

Utilization efficiency had great problems with the available feed resources in the study area. Especially for crop residues, less attention is given to storage, excessively dumped during the harvest period, excessive sunshine, house construction and way of feeding are some of the problems in both agro-ecologies of the study district. On the other hand, the major uses of crop residues in the district is of course as a feed value but considerable households surveyed alternatively use crop residues for fuel, roof shatter, fences and any of their combinations as the need arises and this puts maximum pressure on the dry matter yield obtained from crop residues besides of failure to collect, store, treat and conserve it properly. This might be attributed to less attention given to post-harvest management of crop residues (Yisehak and Janssens, 2014). reported that shortage of feeds for livestock utilization problem contributes to more than 30% loss in Gilgel Gibe catchment of Ethiopia. Traditionally farmers had to develop not only storage and minor quality improvements but also had to reach a level where they could formulate their ration from mixes of crop residues, indigenous browse and non-conventional feed supplements hence crop residues and stubble could constitute the major feed in the dry season for the area.

In the wet season, grazing lands are overgrazed in a small plot of lands when crops are planted from April to September and indigenous browses are rarely lopped down for animals as feeds (Admassu, 2008). reported that on top of shortages of feeds for livestock utilization problem contributes to more than 20% loss in Alaba district of southern Ethiopia. When feed resources are surplus silage making and haymaking was also not practiced in the area. In another way, the quantity and quality of feed obtainable from natural pastures decline as the dry season progresses. The protein content and digestibility of most grass species decline rapidly with the advancing physiological maturity of the plants and reaches very low levels during the dry season. Low digestibility associated with a low nitrogen content of the feed limits intake and animals on these diets is often in negative energy and nitrogen balance.

Enhance the efficient utilization of feed resources also has to take into account the combined knowledge post-harvest managements, packages of storages, preservation area, processing and improvement in feed quality. There are different techniques by which the quality of a feed could be improved by physical treatments a simple soaking with water, chopping, grinding and pelleting and chemical treatments, especially the latter improves the nutritive value of crop residues. Farmers respond that to alleviate feed shortage, enhance to storing the feed during available in a form of silage and hay preservation as the possible solution in the area.

3.7. Other constraints

Other feeding resource constraints included a scarcity of grazing land, land degradation and low biomass yield, low quality and variable feed across the season, low adoption of improved forage production, a labour shortage, limited access to the feed market, and inadequate extension service in both agro-ecologies of the study district. This result corroborated (Eba, 2012) reports from Ethiopia's Blue Nile Basin highlands. Other variables impacting livestock output include nutritional issues such as bloating and diseases. Increasing farmers' use of intensified feed production (adopting various improved forage development strategies), improving feed quality through ration formulation, increasing available feed resources, and encouraging extension services are all opportunities for farmers to use to alleviate feed shortages in the area.

Ethiopia has an enormous ecological variety and an abundance of biological resources, including cattle producing potential. The varied

terrain, along with environmental variability, provides appropriate habitats for a diverse array of living forms, including a diverse range of pasture species of herbaceous grasses and legumes, shrubs and fodder trees, and various cultivated crops for crop residual supplies.

Integrating pasture and forage into agricultural systems will also optimise farmers' land use efficiency by incorporating pasture and forage into the farming system. The country's seed production methods include farmer-based seed production, ranch-based seed production, specialised plot-based seed production, and opportunistic seed production. This is an excellent opportunity for farmers to start indigenous seed production inside the existing agricultural system.

The research region has a strong irrigation potential. This is an excellent time of year to plant off-season pasture and fodder crops. The irrigation potential in the nation is mostly unexplored, and there is still a significant possibility to create seasonal and long-term irrigated pastures and forages (Mengistu, 2006).

4. Conclusion

From the current study, it was concluded that the dietary needs for cattle in the study area were not met by feed availability in terms of DM, ME, and DCP. Total dry matter production, digestible crude protein, and metabolizable energy supply were only reached at 9, 3.5, and 12 months in the research area's medium and low altitudes. Livestock experience feed shortages the remainder of the year. Almost all accessible feed supplies are chemically and nutritionally deficient, especially during the dry season. The observed feed deficiency in the study area may be impacting livestock productivity in the area. Moreover, the research area's feed resources hampered utilization efficiency. Thus, post-harvest management expertise must be paired with improving feed resource use efficiency. All stakeholders and development actors should work together to create alternative dry season feed production and supply methods that employ irrigation.

Declarations

Author contribution statement

Jabesa Ayele: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Taye Tolemariam: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Abegaze Beyene; Dawit Adisu Tadese: Conceived and designed the experiments; Wrote the paper.

Metekia Tamiru: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Funding statement

This work was supported by Jimma University College of Agriculture and Veterinary Medicine, Ethiopia.

Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

References

Yisehak, K., Janssens, G.P.J., 2014. The impacts of imbalances of feed supply and requirement on productivity of free-ranging tropical livestock units: links of multiple factors. Afr. J. Basic Appl. Sci. 6, 187–197.

Abdinasir, I., 2000. Smallholder Dairy Production and Dairy Technology Adoption in the Mixed Farming System in Arsi highland, Ethiopia. PhD Thesis. presented to Humboldt University, Berlin, Germany.

Admassu, Y.M., 2008. Assessment of Livestock Feed Resources Utilization in Alaba Woreda, Southern Ethiopia. PhD Thesis. Haramaya University.

Adugna, T., 2008. Feed Resources and Feeding Management: a Manual for Feedlot Operators and Development Workers. Ethiopian Sanitary & Phytosanitary Standards and Livestock & Meat Marketing Program (SPS-LMM) Texa Agricultural Experiment Station. (TAES)/Texas A&M University System, Addis Ababa.

Ahuja, V., 2013. Asian Livestock: Challenges, Opportunities and the Response.

Assefa, D., Nurfeta, A., 2013. Assessment of feed resource availability and livestock production constraints in selected Kebeles of Adami Tullu Jiddo Kombolcha District, Ethiopia. Afr. J. Agric. Res. 8, 4067–4073.

Assefa, Malede Birhan, Demoz, Yalew, Birhan, Malede, Addisu, Shewangzaw, 2014. Non conventional feed resources assessment, constraints and resources and their utilization practice in North improvement strategies in Ethiopia. Middle-east gondar, North west Ethiopia. Acad. J. Scient. Res. 21 (4), 616–622, 43. Nutrition, 3(3): 26-2941.

Bakrie, B., Hogan, J., Liang, J.B., Tareque, A.M.M., Upadhyay, R.C., 1996. Ruminant Nutrition and Production in the Tropics and Subtropics.

Behnke, R, Metaferia, F, 2015. The contribution of livestock to the Ethiopian economy– Part II. IGAD Livestock Policy Initiative Working Paper No. 02 – 11.

Belay, Getahun, Negesse, Tegene, 2018. Feed resource availability and their nutrient contribution for livestock evaluated using feed assessment Tool (FEAST) in Burie Zuria District, North Western Ethiopia. Agri. Res. Tech. 17 (3).

Belay, Duguma., Tegegne, Azage, Hegde, B.P., 2012. Smallholder livestock production system in dendi district, oromia regional state, Central Ethiopia. Global Vet. 8 (5), 472–479.

Bogale, S., Melaku, S., Yami, A., 2008. Influence of Rainfall Pattern on Grass/legume Composition and Nutritive Value of Natural Pasture in Bale Highlands of Ethiopia. Livestock Research for Rural Development, 20, 2008.

Cochran G, W, 1977. Sampling technique, 3rd. John Wiley & Sons, New York.

Dawit, A., Ajebu, N., Banereje, S., 2013. Assessment of feed resource availability and livestock production constraints in selected Kebeles of Adami Tullu Jiddo Kombolcha district, Ethiopia. Afr. J. Agric. Res. 8 (29), 4067–4073.

De Leeuw, P.N., Tothill, J.C., 1990. The Concept of Rangeland Carrying Capacity in Sub-saharan Africa: Myth or Reality. Overseas Development Institute, Pastoral Development Network, London.

Duguma, B., Tegegne, A., Hegde, B., 2012. Smallholder livestock production system in dandi district, oromia regional state, central Ethiopia. Read and write 20, 25–26.

Eba, B., 2012. Study of Smallholder Farms Livestock Feed Sourcing and Feeding Strategies and Their Implication on Livestock Water Productivity in Mixed Crop-Livestock Systems in the highlands of the Blue Nile Basin, Ethiopia. PhD Thesis. Haramaya University.

Emana, M., Ashenafi, M., Getahun, A., 2017. Nutritional characterization of selected fodder species in Abol and Lare districts of Gambella Region, Ethiopia. J. Nutr. Food Sci. 7 (2), 581.

FAO, 1986. The state of food and agriculture. FAO Agriculture Series, Rome.

FAO, 1987. THE STATE OF FOOD AND AGRICULTURE. FAO Agriculture Series, no. 21, Rome.

Fekede, F., Agajie, T., Argaw, T., 2011. Producing and Using Alternative Feeds to Crop Residues. Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia.

Funte, S., Negesse, T., Legesse, G., 2009. Feed resources and their management systems in Ethiopian highlands: the case of Umbulo Whaco watershed in Southern Ethiopia. Trop. Subtrop. Agroecosyst. 12, 47–56.

Galmessa, U., Dessalegn, J., Tola, A., Prasad, S., Kebede, L.M., 2013. Dairy production potential and challenges in western Oromia milk value chain, Oromia, Ethiopia. J. Agricult. Sustainab. 2.

Gashaw, M., Defar, G., 2017. Livestock feed resources, nutritional value and their implication on animal productivity in mixed farming system in Gasera and Ginnir Districts, Bale Zone, Ethiopia. Int. J. Livest. Prod. 8 (2), 12–23.

Hassan, Hassanuur, Beyero, Netsanet, Bayssa, Merga, 2019. Estimation of major livestock feed resources and feed balance in Moyale district of Boran Zone, Southern Ethiopia. Int.J. Livestock Roduct. 11 (1), 43–51.

Kassa, H., Gibbon, D., Tamir, B., 2003. Use of livestock feed balance as a potential indicator of the sustainability of tropical smallholder mixed farms—prevailing knowledge gaps: a case study from the Harar highlands of eastern Ethiopia. J. Sustain. Agric. Lond 22, 37–41.

Kearl, L.C., 1982. Nutrition Requirements of Ruminants in Developing Countries. Utah State University.

King, J.M., 1983. Livestock Water Needs in Pastoral Africa with Climate and Forage. ILCA.

Kossila, V., 1988. The AV of Crop Residues in Developing Countries with Livestock Populations.

LDMPS, 2006. Livestock Development Master Plan Study. Phase I. Addis Ababa, Ethiopia.

Lemma, M., Negesse, T., Nurfet, A., 2016. Assessment of feed resource availability and quality in Kedida Gamela district, southern Ethiopia. Int. J. Environ. Agricult. Biotechnol. 1 (1), 31–39.

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D., Morgan, C.A., 1988. Animal Nutrition, fourth ed. Longman Scientific and Technical, Essex.

Mekasha, A., Gerardd, Tesfaye, K., Kigatub, L., Duncan, J.A., 2014. Inter-connection between land use/land cover changes and herders'/farmers' livestock feed resource management strategies: a case study from three Ethiopian eco-environments. Agric. Ecosyst. Environ. 188, 150–162.

Mengistu, A., 1998. The Borana and the 1991-92 Drought: A Rangeland and Livestock Resource Study.

Mengistu, A., 2006. Forage Resource Profile of Ethiopia. FAO forage resources profile. FAO, Rome Italy.

Sisay, Amare, 2006. Livestock Production Systems and Available Feed Resources in Different Agro-Ecologies of North Gondar Zone, Ethiopia. MSc Thesis. Presented to School of Graduate Studies of Haramaya University, Dire Dawa, Ethiopia, p. 95.

Tadesse, G., Kebede, H., Salo, S., 2014. Feed resources and constraints for cattle fattening in Lemo and Soro woredas, Hadya zone, Southern Ethiopia. Glob. J. Anim. Sci. Livest. Product. Anim. Breed. 2, 119–125.

Talore, D.G., 2015. Evaluation of major feed resources in crop-livestock mixed farming systems, southern Ethiopia: indigenous knowledge versus laboratory analysis results. J. Agric. Rural Dev. Tropics Subtropics 116, 157–166.

Tesfaye, Desalew, 2008. Assessment of Feed Resources and Rangeland Condition in Metema District of north Gondar Zone, Ethiopia. MSc Thesis. submitted to the department of Animal sciences, school of graduate studies Haramaya University, p. 161p.

Tolera, A., Said, A.N., 1994. Assessment of feed resources in Welayta Sodo. Ethiop. J. Agricult. Sci.

Tonamo, A., Tamir, B., Goshu, G., 2015. Assessment of cattle feed resources; chemical composition and digestibility of major feeds in Essera district, southern Ethiopia. Sci. Technol. Arts Res. J. 4, 79–88.

Ulfina, G., Zelalem, B., Jemal, D., Gemeda, D., Chala, M., Jiregna, D., Diriba, G., Lemma, G., Workneh, A., Adam, D., 2005. Survey of Cattle Production and Marketing Practices in Danno District, Western Ethiopia, Using PRA Tools. PRA Report.

Von Carlowitz, P.G., 1984. Multipurpose trees and shrubs, opportunities and limitations. In: ICRAF Working Papers (ICRAF).

Wondatir, Z., 2010. Livestock Production Systems in Relation with Feed Availability in the highlands and central Rift valley of Ethiopia.

Worku, Z., Tilahun, S., Tolemariam, T., Jimma, W., 2016. Assessment of prevailing cattle fattening practice in Jimma zone, South western Ethiopia. Global Vet. 17 (2), 105–113.

Zewdie, W., Yoseph, M., 2014. Feed resources availability and livestock production in the central rift valley of Ethiopia. Int. J. Livest. Prod. 5, 30–35.