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The Impacts of Imbalances of Feed Supply and Requirement on Productivity of Free-Ranging Tropical Livestock Units: Links of Multiple Factors

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Abstract: The prospective for livestock production in the tropics depends principally on the availability and quality of feed. Mixed crop-livestock production system within smallholder farms is the dominant form of agricultural production in the humid and semi humid tropical regions. This study aimed to estimate the relationship between feed supply and requirment and live stock productivity vis-a-vis environmental parameters. Results are based on livestock farmers' interview and direct measurements of feed resources at three topographic locations (HAR: high altitude region; MAR: medium altitude region; LAR: low altitude region). The number of tropical livestock units (TLU) and total dry matter (DM) production of feed resources were significantly different between regions (P<0.001). Feed supply was mainly estimated from grazing assets (avg.= 36.30%: 35.30% in LAR, 36.60 % in MAR, 34.32% in HAR) followed by crop residues (avg.=31.83%) (P<0.05). Fodder trees and shrubs accounted for 10.30%, 10.74% and 10.72% of total feed DM contribution in LAR, MAR and HAR, respectively (P<0.05). Maize, sorghum, wheat, barley, beans, peas and tef (*Eragrostis* tef) were the main cultivated crops and their crop residue yield differed between locations (P<0.05). Overall livestock feed balance in terms of DM yield showed that a total of 61,416 tons of DM (tDM) per annum was produced for a total TLU value of 11, 862- meaning 0.23 kg/TLU/d - whereas 270,599 tDM (6.25 kg/TLU/d) is required. Total CP required and produced for the TLU was 30,307 and 5,418 tons, respectively with a negative balance of 24,889 tCP. Total metabolisable energy required for the TLU is 75,536 MJME/t whereas ME available for the total TLU is much lower, 34,938 MJME/kg, with a negative balance of 40,598 MJME/t. The estimation demonstrated that the balance between supply of feed resources and feed requirements differs between regions in the HSH, pointing to the need to identify the underlying causes for this difference and adaptation of livestock to feed insufficiency throughout the year.

Key words: Metabolisable Energy · Feed Requirement · Feed Supply · Feed Resources · Tropical Live stock Unit

INTRODUCTION

Livestock production plays an important role to the economy of smallholder farmers and the national economy of Ethiopia [1] and many other nations in the tropics. In the region livestock is an important asset: it is kept by two-thirds of the rural poor and it plays an integral role in their lives. It contributes to food and nutritional security and income generation. It is also an important, mobile form of wealth storing, it provides transport and on-farm power, contributes towards the maintenance of soil fertility and also fulfills a wide range of socio-cultural roles [2]. However, the level of contribution from the livestock sub-sector in Ethiopia is generally low compared to other African countries due to production constraints grouped under socio-economic and technical limitations [3]. According to Desta *et al.* [4] inadequate feed, spread of diseases, poor breeding stock and inadequate livestock policies with respect to credit, extension, marketing and infrastructure are the major constraints affecting livestock performance in Ethiopia.

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Livestock feed resources are classified as natural pasture, crop residue, improved pasture and forage, agro-industrial by-products, other by-products like food and vegetable refusal, of which the first two contribute the largest feed type [5, 6]. In the highlands, crop residues and agro-industrial by-products augment natural pasture and in the pastoral system, livestock production is almost totally dependent on native pasture and woody plants [7, 8]. According to Yisehak *et al*. [9] the major feed resource bases of humid to semi-humid regions of southwest Ethiopia are natural pasture (Mainly communal), after mass grazing, crop residues, green fodder and non-conventional feeds like *attela,* house left over, grain mill by products, chat (*Catha edulis*) left over, coffee pulp and husk were considered the only source of feed.

For optimum livestock productivity, the available feed resource should match with the production systems practiced and the number of animals in a given area. On the other hand, the availability and relative importance of different feed resources varies from place to place and from time to time depending on agro-ecology, livestock production systems and seasons of the year. Most of research work on the assessment of feed resources in different parts of the country so far conducted only indicated the shortage of feeds without quantifying the amount of dry matter (DM), metabolisable energy (ME) and crude protein (CP) obtained in each feed resource type and whether this is adequate to the total number of livestock available to that particular area. This creates a great problem to recommend a possible solution to livestock producers particularly in the extreme drought seasons in Ethiopia. Therefore, it is very much imperative to assess the already existing feed resources in terms of quantity and quality in relation to the requirements of livestock annual basis so that it would be very easy to suggest either improving the existing feed resources, introduce another feed alternatives or suggest development and policy interventions for each agro-ecology. Further, there is scanty of information regarding the assessment of livestock production systems; livestock feed resources and feeding systems in crop-livestock mixed farming systems of Ethiopia that could represent humid to semi-humid regions of tropical Africa. This study was, therefore, initiated to quantify the livestock feedstuffs and their efficiency of utilization as well as evaluate the impacts of feed supply and demand imbalances on livestock productivity.

MATERIALS AND METHODS

The Study Area: This survey was carried out in 6 districts namely Sekoru, Tiro Afeta, Omo Nada, Kersa, Dedo and Seka Chekorsa which are located in the Gilgel Gibe catchments of Ethiopia (Fig 1). They are characterized as hot semi-humid tropical with bimodal heavy rainfall ranging from 90.0 to 564.0 (mm/month), with short seasons occurring from mid February to May and June to September, respectively. Temperatures range from 7.7 to 28.25°C (http://www.world66.com/africa/ ethiopia/ jimma/ lib/climate). In normal years, the rainy season extends from mid February to early October. Mixed crop-livestock agriculture is the man economic activity. Major crops grown are coffee, maize, tef (*Eragrostis tef*), sorghum, barley, pulses (Beans and peas), root crops (Enset-false banana and potato) and fruits. Ruminants, equine and poultry are the principal livestock species kept in the districts. The major feed resources of livestock [9] are natural pasture, stables and road side grazing, crop by-products, fodder trees and shrubs as well as non-conventional feedstuffs such as residues of local drinks, coffee, *atela, chat* left over, food mill left over, house left over, fruits and vegetables reject and others [10, 11]. Livestock husbandry is entirely free-ranging with no closely confined range in a day.

Sampling Procedure: The study districts were purposively selected for this study based on their representative nature of mixed crop-livestock production systems of semi-humid to humid tropics. The districts were divided into three regions (strata) based on altitude designated as relatively low altitude region (LAR, 1200-1750 meters above sea level, masl), medium altitude region (MAR, 1751-2000 masl) and high altitude region (HAR, 2001-2800 masl), as it has been shown that farming systems, vegetation, soils, climate, mode of life and many other characteristics vary across altitude zones [9, 12, 13]. Measurement of boundaries of each altitude stratum was performed using the geographic positioning system (GPS). A stratified random sampling technique developed by ILCA [12] was used to select farmers within a region, employ the structured questionnaire and collect perception data. The respondents included community leaders, heads of peasant associations, model farmers, laggards and elder farmers of both genders. The selected farmers were interviewed using a structured questionnaire, which was pre-tested on a 50 farmers.

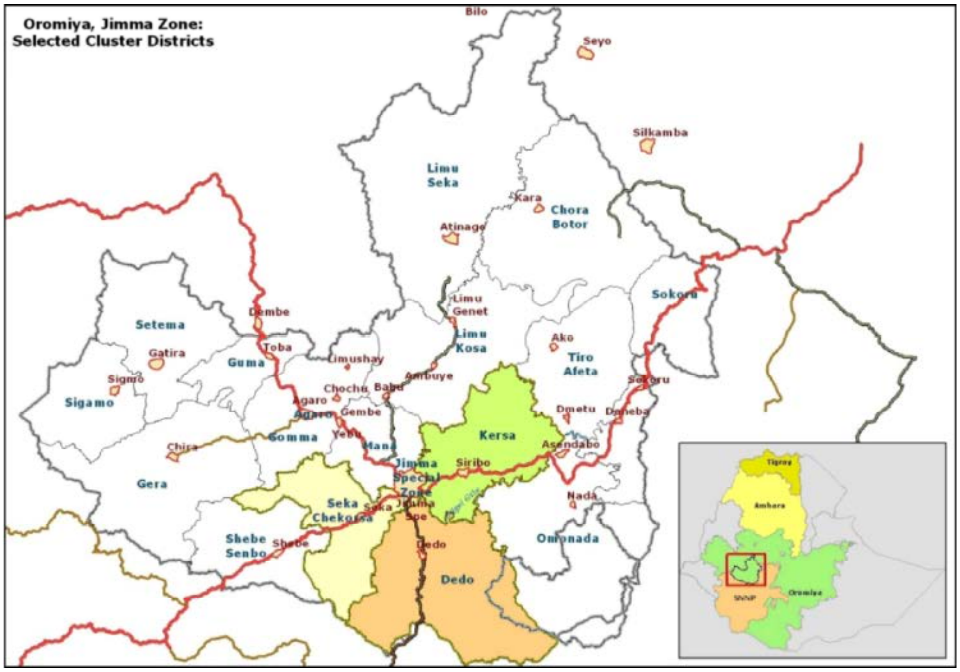

Fig. 1: Selected districts of Gilgel Gibe catchments of Jimma zone

All the pre-tested questions were structured in such a way to provide good quality information that respondents could easily recall. Subsequently, a total of 540 farmers selected from the three study regions (90 farmers from each district) were interviewed. The total number of households sampled for the study was calculated based on the formula given by Cochran [14] and Thrustfield [15]. A precision level of 5% and 95% confidence interval was used to calculate the sample size using the formula $n = (Z^2pq)/d^2$, where, n, desired sample size; Z, abscissa of the normal curve(The acceptable likelihood of error of 5%): 1.96. The value of Z at 95% confidence interval; P, estimated proportion that one is trying to estimate in the population; d, desired absolute precision level at 95% confidence interval, the probability of Type I error (Called alpha). Interview was carried out in a relaxed environment to facilitate collection of the information without being restricted by the questions. For the field survey (Interview), 18 enumerators (Agricultural development agents who have diploma in animal husbandry) were selected and trained to complete the questionnaire. Discussion with key informants were held for triangulation purposes and to assess the trends and the current situation in livestock production systems, livestock feed resources availability - including the types, quality, seasonal availability and feeding systems in the study area, impacts of climate change on the livelihood of resource poor farmers, as well as the expected livestock productivity parameters.

Quantity Estimation of Available Feed Resource

Dry Matter Yield of Natural Pasture: The total amount of dry matter (DM) available in natural pasture was determined by multiplying the average value of grazing land holding with the per hectare DM yield of the natural pastures with conversion factor of 2tDM/ha/year [16, 17]. Amount of DM obtained from communal grazing land is factored into total communal grazing areas for each total households and their associate TLU eligible to graze on this land unit.

Crop Residue, Fallow Land and after Math Grazing: The quantity of available crop residues (DM basis) was estimated from the total crop yields of the households, which was obtained from questionnaire survey, according to FAO [16] conversion factor. The conversion factors were 1.5 for barley, wheat, teff (*Eragrostis tef*); 2 for maize, 1.2 for pulse and oil crop straws and 2.5 for sorghum. The quantities of available DM in fallow land and aftermath grazing are determined by multiplying the available land by the conversion factors of 1.8 for fallow land and 0.5 for grazing aftermath. The quantity of DM obtained from irrigation practices is estimated by multiplying the irrigated land size by 0.3 tDM/ha/seasons [16]. Utilization of crop residues was assumed to be close to 70% (Personal communication) and/or harvesting losses subtracted from total crop residue DM availability.

Quantity of Trees and Shrubs: The potential fodder yield of shrubs and trees are estimated by measuring stem diameter using measuring tape and applying the equation of Petmak[18]. Accordingly, leaf DM yield of fodder trees was predicted using the allometric equation of log W = 2.24logDT-1.50, where W = leaf yield in kilograms of dry weight and DT is trunk diameter (cm) at 130 cm height. Similarly, trunk diameter (DT) can be obtained by DT = 0.636C; where C = circumference in centimeter (cm). For the leaf DM yield of a shrub this allometric equation was used log W = 2.62logDS -2.46, where DS is the stem diameter in cm at 30 cm height. In quantifying tree feed resources from common property resources (e.g. open forest areas) at individual household level similar approaches, as communal grazing area mentioned earlier, was used. Empirical evidence from WBISPP [19], suggests that only about 75% of all available DM is accessible by livestock for use and therefore this study was used the same accessibility factor to quantify total DM utilized by livestock from grazing and browsing areas.

Estimating Available Concentrates: The quantity (DM basis) of non-conventional concentrates (Supplements) available for each household was obtained by interviewing the farmers during the cross-sectional questionnaires survey.

Estimation of Quality of Available Feed Resources: Review of available literature was used to describe the nutritive value of various feed resources. For this purpose, Ethiopian feed resources database (http:// www. vslp. org/ETHFeed/default.asp) and Sub-Saharan Africa feed resources database (http://www.vslp.org/ssafeed/), EIAR handbook [9, 20, 21] and other published or unpublished sources were used to describe the nutritive value of feed resources commonly grown in the study area. The proximate composition of feed samples not obtained from previous records was subjected to laboratory analysis following official procedures [22]. Metabolisable energy (ME) contents of the feedstuffs were predicted from the following equation [23]:

- ME (MJ/kg DM) = 5.34-0.1365CF + 0.6926NFE-0.0152NFE^2 + 0.0001NFE^3; $R^2 = 0.45$, $P < 0.0001$.

Where,
NFE = nitrogen free extract (% NFE = % DM - (% EE + % CP + % ash + % CF, McDonald *et al.* [24]: DM = dry matter; EE = ether extract or crude lipid; CP = crude protein; CF = crude fiber Sodium sulphite (Na_2SO_3) was included in CF determination in order to remove tannins from CF: tannin complexes while acid insoluble ash (AIA) was determined and reduced from total ash.

Estimation of Balance Between Feed Supply and Feed Supply Requirement: Total available DM in the main rainy season from natural pasture, crop residues, crop aftermath, tree legumes and concentrates are compared to the annual DM requirements of the livestock population in the sampled households. Data of livestock population in the sample households will be obtained from the interview of household heads during the survey. To compare, the number of livestock population was converted into tropical livestock units (TLU) using the conversion factors of Varviko *et al.* [25]. The DM requirements of the livestock population are calculated according to the daily DM requirements for maintenance of 1 TLU (250k livestock consumes 2.5% of its BW (6.25 kg DM/d) [26]. A crude protein (CP) content of 70 g/kg DM and 8.368 MJ ME/kg DM diet was used [27]. Data analysis: All data were analyzed using SAS version [28]. Mean comparisons were carried out using Tukey test. Levels of significance were also considered at $P \leq 0.05$. Spearman rho correlation was used to verify the magnitude and direction of relationships between the studied parameters. The statistical model used for data analysis of data was:

$$Y_{ij} = \mu + L_i + e_{ijk}$$

Where, Y_{ijk}, total dry matter yield obtained from grazing, crop residue, green harvests, feed supplements, fodder trees and shrubs; μ, overall mean; A_i is the effect of i^{th} location (altitude region), i = 1… 3; e_{ijk}, random error

RESULTS

Feed Dry Matter, Protein and Energy Supply: A total of 61,416 tons of feed dry matter (DM) were produced from all feed types across the sampled regions (n= 540)

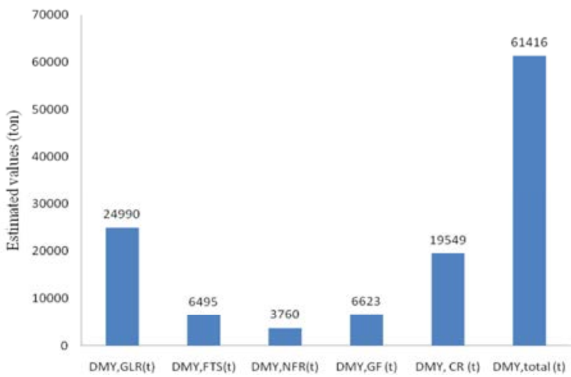

Fig. 1: Total dry matter production shares of different feedstuffs in all districts (DMY, dry matter yield; GLR, grazing resources; FTS, fodder trees and shrubs; NFR, non-conventional feed supplements; GF, green forages; CR, crop residues; t, ton).

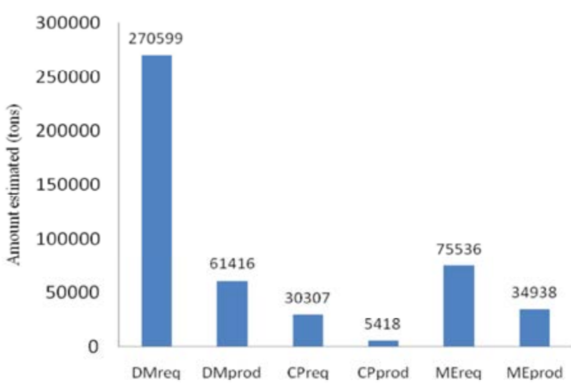

Fig. 2: Estimated balance between nutrient supply and requirement for free-ranging tropical livestock units (DM, dry matter ; CP, crude protein; ME, metabolisable energy; r, requirement; t, supply; b, balance).

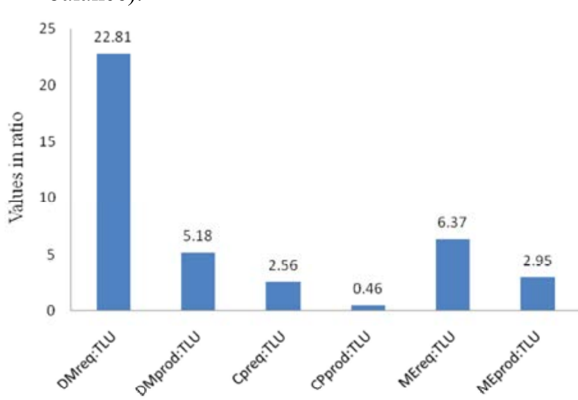

Fig. 3: Ratio of feed supply and requirement to TLU (DM, dry matter ; CP, crude protein; ME, metabolisable energy; req, requirement; prod, supply; TLU, tropical livestock unit)

(Figure 1). Total DM yield shares estimated from grazing assets (pasture, stable, road side and fallow), crop residues, foliages of fodder trees and shrubs, green forages as well as non-conventional feed supplements are also presented in Figure 1. Considerably larger supply of feed DM was estimated from grazing systems (41%) and crop by products (32%), respectively. The contribution of foliages of fodder trees and shrubs to total feed supply was estimated to 11%. Overall feed balance in terms of DM yield per annum to a total TLU value of 11,862 showed ratio of 5.20; yet, 270,599 tones of DM per annum is required for the existing TLU units (With negative balance of 209,183 tDM) regardless of the nutritional content of the DM yield (Figure 2).

Total CP produced and required for the TLU was 5,418 and 30,307 tons, respectively, with the negative balance of 24,889 tCP. Total metabolizable energy required for the TLU is 75,536 tMJ whereas ME available for the total TLU was much lower, 34,938 MJME/kg, with a negative balance of 40,598 tMJ ME.

Feed Availability to TLU Ratio: Ratio of nutrient required to total TLU was ranging from 0.46 to 22.81 (Figure 3) while the implicit ratio between feed supply and TLU was found to be much more lower than requirement values.

Regional Differences of Feed Supply and Demand Imbalances: DM, CP and ME supply by source and their regional differences are presented in Table 1. Regional differences were significant for most of measured parameters (*P*<0.01). Crop by-products and grazing resources were found to be the largest contributors of DM yield per year in LAR and MAR regions compared to HAR (*P*<0.05). Largest DM was produced from crop residue (36.20 t DM/year) as well as grazing resources (41.28 tDM/year) in low altitude region (LAR) compared to other regions (*P*<0.05). Dry matter, ME and CP production was tended to be higher in LAR compared to other regions (*P*<0.01). Filed crop by products had the highest ME yield while greatest CP was estimated for grazing and browsing materials (*P*<0.01).

Results revealed that farmers in LAR needed nearly 468.90 tDM per annum although the actual feed production was only 118 tDM/y (Table 2) - with negative balance of 350.89 tDM/y-which is only 25% of what is required per annum and able to support the existing stocks no more than 4 months. Similar to DM, the highest and lowest ME availability and requirements were recorded for LAR compared to other regions (*P*<0.01). Likewise, CP requirement and supply for LAR and MAR

Table 1: Feed resources category and their supply (DM, ME and CP) according to regional differences (N= 180)

Nutrients	Feed supply by source	Altitude region, Mean LAR (n=180)	MAR (n=180)	HAR (n=180)	Overall Mean	SEM	P
DM	Grazing resource (t)	41.65[a]	40.98[b]	41.20[b]	41.28	0.064	***
	Fodder tree & shrub (t)	12.12	12.13	11.83	12.03	0.082	NS
	Crop residue (t)	39.29[a]	35.70[b]	33.61[b]	36.20	0.738	**
	Green forage (t)	12.65[a]	12.24[ab]	11.91[b]	12.27	0.105	*
	Non-conventional feed stuffs (t)	12.30[a]	11.74[b]	11.85[ab]	11.96	0.097	*
	Total DM supply (t)	118.00[a]	112.79[b]	110.41[b]	113.74	0.797	**
ME	Grazing resource (MJ/t)	17.26[a]	15.49[ab]	14.40[b]	13.72	0.371	**
	Fodder tree & shrub (MJ/t)	9.93[a]	9.01[ab]	8.45[b]	9.13	0.193	**
	Field crop residue(MJ/t)	33.56[a]	29.67[ab]	27.28[b]	30.17	0.817	**
	Non-conventional feedstuff (MJ/t)	4.27[a]	3.78[ab]	3.47[b]	3.840	0.104	**
	Green forage (MJ/t)	6.27[a]	5.78[ab]	5.47[b]	5.84	0.104	**
	Total ME supply (MJ/t)	71.30[a]	63.72[ab]	59.09[b]	64.70	1.590	**
CP	Grazing resource (t)	2.52[a]	2.40[ab]	2.33[b]	2.42	0.025	**
	Fodder tree & shrub (t)	2.30[a]	2.21[ab]	2.15[b]	2.22	0.011	*
	Field crop(t)	2.0[a]	1.95[ab]	1.91[b]	1.95	0.012	**
	Green forage (t)	1.60[a]	1.52[b]	1.52[b]	1.55	0.013	**
	Non-conventional feed stuffs (t)	1.94[a]	1.89[ab]	1.86[b]	1.90	0.011	**
	Total CP supply (t)	10.36[a]	9.97[b]	9.77[b]	10.03	0.073	**

DM, dry matter; ME, metabolisable energy; CP, crude protein;'t', ton; LAR= low altitude region; MAR, medium altitude region; HAR, high altitude region; [a,b,c]Means with different letters in the row are significantly different (P<0.05); SEM, standard error of means; P, probability of obtaining observed result; *P<0.05; ** *P*<0.01; *** *P*<0.001

Table 2: Average yearly differences in the balance between feed resource availability and dietary requirement for free-ranging tropical livestock units (N=180)

Nutrients	Feed supply	Altitude region, Mean LAR	MAR	HAR	Overall Mean	SEM	P
DM	Available, tons	118.00[a]	112.79[b]	110.41[b]	113.74	0.797	***
	Required, tons	468.90[a]	397.74[b]	362.95[c]	409.86	4.380	***
	Balance, tons	-350.89[c]	-284.94[b]	-252.54[a]	-296.13	4.393	***
ME	Available, MJ/t	71.30[a]	63.72[b]	59.09[c]	64.70	1.590	**
	Required, MJ/t	130.90[a]	111.03[b]	101.31[c]	114.41	1.223	***
	Balance, MJ/t	-59.59[b]	-47.30[a]	-42.24[a]	-49.71	1.964	**
CP	Available, tons	10.37[a]	9.96[ab]	9.77[b]	10.03	0.073	**
	Required, tons	52.52[a]	44.55[b]	40.65[c]	45.90	0.491	***
	Balance, tons	-42.15[c]	-34.58[b]	-30.88[a]	-35.87	0.493	***

DM, dry matter; ME, metabolisable energy; CP, crude protein; 't', ton; LAR = low altitude region; MAR, medium altitude region; HAR, high altitude region; [a,b,c]Means with different letters in the row are significantly different (*P*<0.05); SEM, standard error of means; P, probability of observed result; ** *P*<0.01; *** *P*<0.001

was higher than HAR (*P*<0.01). Overall, the estimated values for ME and CP availability can only support for 19.7% and 4.3% of energy and protein requirements for the total TLU units to these respective regions.

Feed supply shortage perceived as major bottleneck for livestock productivity: Overall, farmers reported a decline in productivity and the health condition of their livestock, but all performance parameters showed significant differences between regions (*P*<0.05) (Table 3). In comparison with the other regions, more farmers in the LAR reported a decrease in the body condition, production and reproduction performances of their livestock. However, a higher percentage of farmers perceived increased livestock mortality in the LAR as well as MAR in comparison with the HAR, concomitant with a perception of decreased milk yield, lactation length, time needed to grow to maturity and longer calving intervals (*P*<0.05). The proportions of farmers witness changes in susceptibility to disease were also considerably different between the regions (*P*<0.05). However, more farmers reported higher numbers of days open combined with an increased number of repeated services per conception in the LAR (area with increased nutrient imbalances) compared to the other areas. Finally, the number of TLU per household seemed to remain decreased in all regions (*P*<0.01).

Table 3: Performance of livestock, livestock holding per household and sustainable to diseases at low, medium and high altitude region in humid to sub-humid regions of Ethiopia

		Altitude region			Overall		
Species	Variable	Low (n=180)	Medium (n=180)	High (n=180)	Mean	SEM	*P*
Cattle	Age at first calving (y)	4.9^{a}	4.3^{b}	4.4^{b}	4.53	0.059	**
	BSC (1to 9 score scale)	3.14b	4.11a	4.14a	3.80	0.022	**
	Calving interval (months)	25.0^{b}	25.4^{b}	26.9^{a}	25.70	0.371	*
	Lactation length (months)	6.0^{b}	6.5^{b}	8.3^{a}	6.93	0.151	***
	Days open (d)	249^{a}	241^{ab}	237.6^{b}	242.5	4.92	*
	Milk yield (kg/d)	1.5^{b}	2.0^{a}	2.3^{a}	1.93	0.071	*
	Total lactation milk yield (kg)	178.3^{c}	190.3^{b}	234.2^{a}	200.9	1.270	***
	Number of services per C (y)	3.0^{a}	2.10^{b}	2.12^{b}	2.41	0.105	**
	Reproductive lifespan of cows (y)	6.81^{b}	7.90^{a}	8.1^{a}	7.61	0.170	**
	Draft age (y)	4.1^{b}	4.7^{a}	4.9^{a}	4.58	0.081	*
	Draught lifespan of oxen (y)	5.1^{b}	5.9^{a}	6.42^{a}	5.80	0.090	***
Sheep	Age at first lambing (y)	2.58a	2.41a	2.00b	2.53	0.341	*
	Lambing interval (m)	16.15a	16.01a	15.13c	16.01	0.502	*
	Age at first kidding (y)	2.54a	2.32a	1.90c	2.34	0.055	*
Goats	Kidding interval (m)	15.81b	15.45b	17.00a	16.17	0.36	**
	Age at first calving (y)	5.26a	5.11ab	4.98b	5,2	0.135	*
	Calving interval (m)	29.84c	37.73b	39.65a	35,82	2.329	***
Horse	Age for work (draft)(y)	6.18b	6.58a	6.59a	6,53	0.356	*
	Age at first foaling (y)	6.82a	5.94c	6.39c	6,47	0.331	**
	foaling interval (y)	3.13a	2.73ab	2.33b	2.81	0.165	*
Donkey	Age for work (draft)(y)	7.2a	6.45b	5.98c	6.63	0.132	**
Mule	Age for work (draft) (y)	6.57ab	7.01a	6.72ab	6.85	0.103	*
	Livestock holding per household (%, decrease)	59.2c	79.40a	67.1b	67.37	0.019	***
	Susceptibility to disease (%)	77.41a	68.33b	69.32b	71.02	0.07	**

** P<0.05; ** P<0.01; *** P<0.001; NS=non significant;* Days open (d) as the interval in days between calving and conception; calving interval (Months) was the interval in days between two consecutive calving; Lactation milk yield (Months) was the total lactation milk yield; number of service per conception (y) as the number of services the cow required until she conceived; age at first calving (y) as the number of months from birth date to first calving; C, conception

Table 4: Correlation matrix between feed supply, productivity parameters and soil erosion status

	AGC	CHH	NRSPC	NDO	LCI	LL	MitY	MlY	SCD	BSC	DMY	MEY	CPy	SOE
AGP	1.000													
CHH	0.795**	1.000												
NRSPC	-0.590**	-0.679**	1.000											
NDO	0.532*	0.465*	-0.065	1.000										
LCI	-0.723**	-0.918**	0.722**	-0.512*	1.000									
LL	0.620**	0.471*	-0.068	0.898**	-0.460*	1.000								
MitY	-0.332	-0.213	-0.190	-0.777**	0.227	-0.753**	1.000							
MlY	0.581**	0.556**	-0.188	0.756**	-0.546*	0.861**	-0.710**	1.000						
SCD	0.222	0.442*	-0.621**	-0.477*	-0.405	-0.417	0.577**	-0.219	1.000					
BSC	-0.311	-0.456*	0.622**	0.410	0.401	0.419	-0.582**	0.310	-0.852**	1.000				
DMY	-0.585**	0.435*	-0.264	-0.798**	-0.694*	-0.809**	-0.717**	-0.690**	-0.316	0.381	1.000			
MEY	-0.527*	-0.501*	-0.077	-0.908**	-0.485*	-0.933**	-0.790**	-0.854**	-0.447*	0.481*	0.796**	1.000		
CPy	0.448*	0.440*	-0.116	-0.902**	-0.515*	-0.859**	-0.753**	0.832**	-0.403	0.472*	0.770**	0.900**	1.000	
SOE	-0.541*	-0.392	0.137	-0.925**	0.494*	-0.867**	0.761**	-0.754**	0.425	-0.443*	-0.854**	-0.842**	-0.900**	1.000

**Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed); AGP, Age at first calving (y); Cattle holding per household; NRSPC, Number of services per conception; NDO, Number of days open; LCI, Length of calving interval; LL, Lactation length; MEY, meat yield; MY, milk yield; SCD, Susceptibility to diseases; BCC, Body condition of cattle; DMY, dry matter yield; DMr, Dry matter requirement; MEY, metabolisable energy availability; MEr, metabolisable required; CPy, crude protein yield; CPr, crude protein required; SOE, soil erosion status

The Relationship Between Feed Balance and Animal Performance: The spearman correlation coefficient between nutrient supply and most of livestock productivity parameters as well as soil erosion status were highly significant (*P*<0.05) (Table 4). Strongly negative correlation coefficient was recorded between DM, CP and ME yield and majority of productivity parameters were ($|r \geq 0.50|$, *P*<0.05). Similarly soil erosion status, major deriving force for feed unavailability in the regions, was negatively correlated to most of livestock productivity parameters ($|r \geq 0.50|$, *P*< 0.05). In general, the results of correlation matrix analyses revealed that livestock performance variables were significantly affected by nutrient availability with the extent varied among altitude regions (Table 4).

DISCUSSION

According to the majority of respondents (85%, N= 540), the crucial shortage of feed supply in the region could be attributed to excessive cultivation of grazing areas to put forward food crop production for geometrically growing human population. Yisehak *et al*. [9] in Ethiopia, Ben Phala *et al*. [29] in Nigeria, Indonesia, Ethiopia, Sudan and Brazil indicated shifting of grazing land into crop cultivation has significantly reduced the potential of livestock in the study area and also put enormous pressure on the existing land. The second most important reason could be lack of efficient utilization of crop-residues. Grazing areas are overgrazed during the time when crops are planted from April to December and indigenous browses are infrequently lopped down for animals as feeds. Therefore, on top of shortages of feeds for livestock utilization problem contributes to more than 30% loss in the study areas. Although the greatest proportion of feed supply was obtained from grazing assets followed by crop residues, utilization efficiency of crop residues had great problems (Personal communication). This might be attributed to less attention given to post harvest management of crop residues. They are excessively dumped all through harvest period in addition to competition of alternative uses of crop residues. Traditionally farmers had to developed not only storage and minor quality improvements but also had to reach a level where they could formulate their own ration from mixes of crop residues, indigenous browse and a non-conventional feed supplements hence crop residues and stubble could constitute the major feed for the area. This actually needs a consistent research forward in the long term but it is the way out to feed scarcity along with planting of fodder trees that can conserve the soil and the natural resources.

The second most important factor behinds feed shortage could be low productivity of cereals under stallholder systems. While farmers are not often flexible in dealing with weather and year-to-year variability, there is nevertheless a lower degree of adaptation to the local climate in the form of established infrastructure, local farming practice and individual incident. Gornall *et al.* [30] also confirmed the often debatable possibilities for increasing agricultural productivity in the tropics. In the last few decades relatively low growth rate for cereal grain yield (1%) [31], was reported in the tropics as compared to the annual population growth rate (3%). Low soil fertility [32], which is also a major constraint to increased food crop production in Africa

As majority of farmers perceived feed supply shortage is the main hindrance for productivity of livestock in the study area, animals are producing under their genetic potential. This might indicate unambiguous adaptation of livestock to feed shortage in terms of quantity and quality. It has also known that the estimated values of feed DM, CP and ME supply could not yet satisfy the normal maintenance requirements of livestock.

The average energy requirement of the major feed resource was about 6.3 MJ/kg DM. Yitaye *et al.* [33], using a formula developed by MAFF [34] and the energy requirement for maintenance for one TLU (250 kg body weight) calculated to be 32.1 MJ/day or 5 kgDM/day. This is 2% of body weight of the animal. Hence both energy and protein are the major limiting factors for livestock productivity [35], adequate energy must be supplied by the diet to make efficient use of dietary protein The protein requirements of animals are given in terms of an amount of protein and its constituent amino acids per unit of time - usually the amount to be fed each day. The decreasing status of livestock against epidemic diseases could be referred to low supply of dietary proteins reflected on the immune response. The utilization of dietary proteins [36], must be put in the context of the available energy supply. Energy is the main driving force of metabolism [37]. If energy is limiting dietary protein will be used inefficiently as another source of energy instead of being converted into body protein. However, the present study confirmed that energy and protein are the most lacking nutrients for the all round-striving livestock in the tropical region. Accordingly, feed shortages notwithstanding, considerable potential exists to increase production levels across the range of improving livestock performance might be by addressing the problem of imbalanced nutrition.

The increasing demand for livestock products has far-reaching implications for human well-being, socio-economics, land use, the environment and animal health. To meet the future demand, production of milk and meat, including milk production per lactating cow and daily weight gains for meat animals would need to be increased significantly if the available feed resources are to be sufficient.

Imbalanced feeding could leads to excess feeding of some nutrients whilst others remain deficient. This not only reduces productivity and increases costs per kg product, but also affects various physiological functions including long term animal health, fertility and productivity. To ensure improved productivity it is necessary to augment and secure feed resources through short and long term planning.

The negatively significant correlation between feed DM yield and livestock productivity parameters in the study area might indicate the clear influences of feed shortage on livestock performances. In addition, the lower productive and reproductive performance of free-ranging TLU in the study area is vastly correlated to poor supply in terms of quantity and quality. Alternatively, the negatively significant correlation between feed ME and CP supply botanical and livestock productivity parameters is mainly due to the over utilization of feed by keeping excess TLUs over the carrying capacity of ranging areas as well as low productivity of food crops. Therefore, it may be inferred, that in all regions, it will be difficult to increase animal production without increasing feed resources.

Farmers indicated that livestock holding per household has been decreasing over the last 25 years mainly due to declining of grazing resources. Priority is given to food crops than forage crops in order to feed the increased human population. Also consumption of animal products is showing a decreasing trend due to reduced animal production and productivities. Farmers reported the increasing trends of prices of animal and animal products due to reduced animal productivity and increased human population. Feed shortage, diseases prevalence, low productivity of livestock as the major constraints limiting livestock production in that order of importance in tropical regions of the world [38-42].

CONCLUSION

From this study it can be concluded that, the availability of feed DM, ME and CP did not satisfy the maintenance requirements of livestock units reared in the study area. The study further highlights that the scarcity of feed was more serious in all regions. The feed deficit observed in the study area could be one of the contributing factors affecting livestock productivity. There should be land use policy regulation in the area which can secure area for livestock feed production to make the livestock sector contributes to poverty eradication and encourage smallholder farmer food secured household. The prospect of increasing feed demands raises the serious question of how these additional livestock feed requirements will be provided. Furthermore, the quantification of livestock feeds has proved to be more challenging than the quantification of total crop production for a number of reasons. Data needs and complexities increase with the addition of another trophic level. Various feeding, environment and health management practices must be combined to reduce risk and maximize productivity. However, sustainable development of livestock production in tropical areas cannot be guaranteed without using the adaptation traits of native animal populations or at least without including adaptation traits in selection program for local and exotic breeds. In general, technical and institutional intervention would be very crucial to alleviate the prevailing constraints to livestock production in the study area.

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