LIVESTOCK FEED DRY MATTER AVAILABILITY AND UTILIZATION IN BURIE ZURIA DISTRICT, NORTH WESTERN ETHIOPIA†

[DISPONIBILIDAD DE MATERIA SECA DE ALIMENTO PARA GANADO Y SU UTILIZACIÓN EN EL DISTRITO DE ZURIA DE BURIE, ETIOPÍA OCCIDENTAL DEL NORTE]

Getahun Belay[1] and Tegene Negesse[2,*]

[1] Department of Animal Science, Alage ATVET College, Ethiopia. Email: getahunbelay2015pmeas@gmail.com
[2] School of Animal and Range Sciences, Hawassa University, Ethiopia. Email:tegenengss38@gmail.com
**Corresponding author*

SUMMARY

Availability of feed resources, their utilization and balance between supply and demand in Burie Zuria district, north western Ethiopia, were assessedusing focus group discussion, individual interview, key informant interview and secondary data. Data was collected from February to April 2017 on 90, 30 and 30 households (HH)Hs selected from mid, high and low altitudes,respectively, using multi-stage sampling techniques. Data was analysed using FEAST version 2.21 and SPSS version 20.0. Mean land holding, livestock holding and family size were 1.8 ha, 9.03Tropical livestock unit (TLU) and 6.82 persons/HH, respectively. Crop residues, stubble grazing and natural pasture were major feed resources. Maize stover, finger millet and teff straws were the main crop residues produced in all agroecosystems ($p<0.05$). Inappropriate collection, conservation and feed processing practices reduced efficiency of utilization. Utilizable dry matter (DM) supply was 12.87±0.41 t/HH/yr; and 7.2±0.69, 14.6±0.47 and 15.38±0.66 were from high, mid and low altitudes, respectively; crop residues contributed major part (9.76±0.76 t)($p<0.05$). Annual livestock maintenance DM requirement was 20.37±4.14 t/HH/yr with a deficit of 7.5±3.73 t, with DM requirement of 18.25±4.49, 26.78±4.14 and 16.09±3.83t/HH/yr ($p<0.05$) for high, mid and low altitudes, respectively. Available DM satisfies 63.18 % of DM requirements, where 39.45, 54.51 and 95.58 % ($p<0.05$) were for high, mid and low altitudes, respectively ($p<0.05$), indicating more feed shortage at high altitude. In conclusion, the main feed resource is crop residue with low DM contribution. Thus apropriate crop residues management should be used.

Keywords: Agro-ecology; feed availability; feed balance; nutrient utilization.

RESUMEN

La disponibilidad de recursos alimentarios, su utilización y el equilibrio entre la oferta y la demanda en el distrito de Burie Zuria, al norte occidental de Etiopía, fueron evaluados mediante la discusión de grupo, entrevista individual, entrevista del informante clave y datos secundarios. Los datos se recolectaron desde febrero a abril de 2017 en 90, 30 y 30 unidades de producción (HHs) seleccionados de media, alta y baja altitud, respectivamente, utilizando técnicas de muestreo de etapas múltiples. Los datos se analizaron mediante FEAST versión 2.21 y SPSS versión 20.0. Significa tierra tenencia, explotación ganadera y el tamaño de la familia fueron 1,8 ha, 9,03 unidades ganaderas tropicales (UGT) y 6.82 personas/HH, respectivamente. Los residuos de cultivos, pastoreo de rastrojos y pastos naturales fueron los principales recursos alimentarios. Rastrojo de maíz, mijo y paja de teff fueron los residuos de cultivo producidos en los agroecosistemas ($p<0.05$). La recolección inadecuada, conservación y prácticas de procesamiento de los alimentos reducen la eficiencia de utilización. La oferta de materia seca utilizable (MS) fue de 12.87±0.41 t/HH/año; y 7.2±0.69, 14.6±0.47 y 15.38±0.66 para alta, media y baja altitud, respectivamente. Los residuos de cultivos contribuyeron la mayor parte (9.76±0.76 t) ($p<0.05$). Las necesidades anuales para mantenimiento del ganado (MS) fueron de 20.37±4.14 HH/t/año con un déficit de 7.5±3.73 t, con una necesidad de MS de 18.25±4.49, 26.78±4.14 y 16.09±3.83 t/HH/yr ($p<0.05$) para alta, media y baja altitud, respectivamente. La MS disponible satisface el 63.18 % de requerimientos de MS, donde 39.45, 54.51 y 95.58 % ($p<0.05$) fueron para, altitudes medias y bajas, respectivamente ($p<0.05$), indicando un mayor déficit de alimento en altitud alta. En conclusión, el principal recurso de alimentación son los residuos de la cosecha pero con baja contribución de MS. Por lo tanto deben utilizarse una apropiada gestión de residuos de cultivos.

Palabras clave: Agroecología; disponibilidad de alimentos; equilibrio de la alimentación; utilización de nutrientes.

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INTRODUCTION

Ethiopia's got very large livestock population and stands 10th in the world and 1st in Africa (CSA, 2017; FAO, 2015). The livestock sector serves as a major source of currency earnings and delivers important products and services (FAO, 2017) and thus has an enormous contribution to the national economy and livelihood of lots of Ethiopians. The demand for livestock products is globally projected to raise to about 70 % in 2050, to be forced by growing world population, increasing prosperity and urbanization (FAO, 2014). There are opportunities to boost production to meet escalating demand especially in developing countries and enhance farm income (Mayberry *et al*., 2017). However, feed for livestock is often cited as the prime constraint to improved productivity for smallholder farms (ILRI, 2014).

In Ethiopia feed resources are classified as natural pasture, crop residues, hay, agro-industrial by products, improved forage and other feeds (CSA, 2017); which are 54.59, 31.06, 6.81, 1.53, 0.31 and 5.11 % of the total livestock feed supply of the country, respectively (CSA, 2017); natural pasture is the primary feed resource throughout the wet season while crop residues play a substantial role during dry season (Gelayenew *et al*., 2016). The natural pasture accounts about 25 % of total land mass of the country (Ulfina *et al.*, 2013). However, the productivity of grazing lands in most parts of Ethiopia is extremely low (Ulfina *et al.*, 2013), due to seasonal fluctuation of rainfall and poor pasture management and conversion of natural pasture in to crop lands (Kebede *et al*., 2016; Nigus, 2017).

Crop residues possess immense global potential as livestock feed resource (Mahesh and Madhu, 2015) with estimated global level of about 1.14 billion (FAO, 2017) and local 30 million (Tolera *et al*., 2012) t of DM, of which 70% is utilized as livestock feed. Crop residues provide considerable quantity of dry season feed in most farming areas of the country (Gurmessa *et al.*, 2015, 2016; Demeke *et al*., 2017; Gashe *et al*., 2017) and contributes up to 30-80% of the total feed DM available in the highlands of Ethiopia (African RISING, 2014). However, crop residues are fibrous and limited by their low value of voluntary intake, digestibility, nitrogen, energy, mineral and vitamin (Chalchissa *et al*., 2014; Hailemariam *et al*., 2017). There is limited experience in treatment and processing methods for improving the nutritional value of crop residues (Abera *et al*., 2014).

Feed is number one priority and securing year round feed supplies to meet goals set for meat (58 %), milk (83 %) and eggs (240 %) productions in 2020 (ELMP, 2015). However, the available feed satisfies only 63 % of the DM demand at national level (Salo, 2017). The available feeds meets only 60-80 % DM of the annual maintenance requirement of livestock in highlands of Ethiopia (Gizaw *et al*., 2017). Generally there is negative feed balance in the highlands of Ethiopia. Availability and utilization of different feed resources varies depending up on agro-ecology, livestock production system and seasons of the year. Hence, assessment of feed resources helps to guide development of effective intervention strategies to improve quality of nutrition, feed use efficiency and livestock productivity. Thus this study was carried out to investigate spatial and temporal availability and utilization of livestock feeds between January 2017 to February 2018 in Burie zuria District, north western Ethiopia.

MATERIALS AND METHODS

Main features of the study area

The survey was conducted in Burie Zuria district which is located 400 km North West of Addis Ababa and 148 km South West of the Regional State capital, Bahir Dar, North Western Ethiopia at a coordinate of 10˚15′2″N and 10˚42′29″N latitude and 36˚52′1″E and 37˚7′9″E longitude with an altitude range of 700 to 2350 m.a.s.l (IPMS, 2014). The district has 18 kebeles (BZDOA, 2017) with a human population of 104,784 and 13,940 male headed, 1,988 female headed HHs (IPMS, 2014). The district was stratified into high (greater than 2,300 meters above sea level), mid (1,500-2,300 meters above sea level) and low altitudes (less than 1,500 meters above sea level) according to the Ethiopian agro-ecological classification (Dereje and Eshetu, 2011); and mid, low and high altitudes were 82 %, 10 % and 8 %. Minimum, maximum and mean temperatures are 14, 24 and 19^{0}C, respectively. The rainfall pattern is uni-modal (May to September) and the minimum, maximum and mean annual rainfall is 1000, 1500 and 1250 mm, respectively.

Sample size determination and sampling techniques

The number of HHs selected was determined by $N = 0.25/SE^2$, where N = number of sampled HHs, SE = standard error (Arsham, 2007). Considering, standard error of 4.09 % at a precision level of 5 % and 95 % confidence interval. Accordingly, 150 HHs were selected. Multistage purposive sampling technique was used for the survey. A single-visit multi subject formal survey method (ILCA, 1990) was used for the study. In the first step, the district was chosen based on the information of zone agriculture office based on presence of number of animals and accessibility for data collection. Secondary data were obtained from IPMS (2014) of the district. Out of 18 kebeles (the lowest government administrative units below district) 5 kebeles (3 out of 12 kebeles representing mid, 1 out of 3 kebeles representing low and 1 out of 3 kebele representing high altitudes) were selected purposively in consultation with the districts' livestock experts, kebele administrators and development agents based on the size of agro-ecologies, potential of livestock resources and

accessibility. Accordingly, Zalema, Wadera Gendeba and TiyaTiya (from mid altitude), Fetam Sentom (from low altitude) and Jib Gedele (from high altitude) were included in the survey.
Development agents and kebele representatives of the selected kebeles selected respondents purposively based on land holding, wealth category (small, medium and large), HH headship (men and women HH head), age group (youth, middle age and elders), livestock holding and experience of keeping livestock. In each of the 10 villages selected 15 HH heads (10 men and 5 women) were chosen for focus group discussion, giving a total of 150 farmers. After the focus group discussions, according to FEAST's recommendations 60 % (9 out of 15 farmers = total of 90) were selected from each group for semi-structured questionnaire then grouped into three wealth categories through stratified sampling techniques based on the community's existing standards and respondents were interviewed independently. The number of respondents per agro-ecology were designed to be proportional to the overall HHs in each agro-ecology (30, 30 and 90) for focus group discussions and (18, 18 and 54) for individual interviews from high, low and mid altitudes, respectively.

Data collection methods and tools
Qualitative and quantitative investigation was carried out using FEAST developed by International Livestock Research Institute (Duncan *et al*., 2012). FEAST offers a systematic and rapid methodology to assess feed resources availability and utilization at a site level with a view to developing a site-specific intervention approach to improve and optimize feed supply and utilization through technical or organizational interventions. The tool encompasses focused group exercises that provide indications of production systems with particular emphasis on livestock feed resources and simple and succinct quantitative questionnaire intended to be completed by professionals under the direction of FEAST facilitator.

In addition, key informant interview and discussion with district livestock experts to confirm information obtained from group discussions and individual interviews and field observation were made to assess the state of feed utilization. Three key informants were selected from development agents, kebele officials and elderly people who have detailed information about the kebele.

Secondary data accessible in the district, zone and region agricultural offices; and all possible relevant sources (published and unpublished documents) were collected and extensively used.

Estimation of annual feed availability
The quantity of feed DM obtained annually from different land use types calculated by multiplying hectare of land under each land use types by its conversion factors. Appropriate conversion factors were used for natural pastures, aftermath grazing, forest land, improved forages and crop residues (FAO, 1984, 1987; Kossila, 1984, 1988; De Leeuw and Tothill, 1990; Tolera, 2007; Fekede *et al*., 2015; Mekasha *et al*., 2015). The total quantity of potentially available crop residues for animal consumption were estimated by multiplying the yield of crop residues 90 % assuming that 10 % wastage of the feed mostly occurs during feeding and/or utilization (Tolera, 2007).

Estimation of balance between feed supply and requirement
Individual interviews of farmers aimed at collecting quantitative information on feed resource availability and quality. Responses collected from individual interviews were used to estimate average values of key variables per HH such as the composition and availability of dry matter (DM), metabolisable energy (ME) and crude protein (CP) in the diet. Calculation was based on quantities of purchased feed and production of on-farm crop residues and other feed resource. Standard DM, ME and CP value for feed materials was obtained from FEAST Software Version 2.21 (ILRI, 2015).

Total annual DM produced from natural pasture, crop residues, improved forages and concentrates was compared with annual DM requirements of the livestock population in the sampled HHs. The number of livestock was converted into tropical livestock units (TLU) using the conversion factors of Jahnke (1982), ILCA (1990) and Varviko *et al*. (1993). The DM requirement of livestock population was calculated according to Kearl (1982) where the daily DM requirement for maintenance of 1 TLU (equivalent to 250 kg livestock) which consumes 2.5 % of its body weight is 6.25 kg DM/day or 2281 kg DM/year.

Statistical analysis
The collected data was managed and organized with MS-Excel and analyzed using the updated FEAST software version 2.21 (ILRI, 2015) (www.ilri.org/feast) and general linear model procedure of statistical package for social science (SPSS) version 20 (SPSS, 2011). Means were compared using least significant difference (LSD), adopting the probability level of 5 %. In all univariate analyses, p-value<0.05 was declared significant. The statistical model used for the assessment of feed resources availability and utilization:

$$Y_i = \mu + \alpha_i + \varepsilon_i$$

where:
Y_{ij} = the response of the ith agro-ecology; μ = overall mean; α_i= effect of ith agro-ecologies (i = 3); and e_i= random error.

RESULTS

Land holding and land holding category

According to perception of sampled households (HH), farm size of respondents was grouped into small, medium and large. The criteria developed by the focus group were aimed at covering all classes of smallholder farmers in the study agro-ecologies. The average land size per HH and land holding categories are shown in Table 1. The average cultivated land size owned per HH in high, mid and low altitudes was different ($p<0.001$) low altitude having the highest and high altitude the lowest mid altitude found in between. In all three altitudes percentage of farmers owning medium size of land is about the same, while more farmers own small land size and consequently much lower percentage own large farm size in the low altitude than high altitude.

Species of livestock kept

The average livestock holding per HH is summarized in Table 2. Livestock holding of farmers in mid altitude was higher ($p<0.05$) than high and low altitudes. Cattle is the dominant livestock species reared followed by goats, donkeys and horses and in mid altitude there was large number of cattle per HH ($p<0.001$) than those in high and low altitudes. Sheep holding was higher in high and mid altitudes ($p<0.05$) than low altitude and goats holding were higher in low and mid altitudes ($p<0.05$) than high altitude. Donkey holding was higher ($p<0.05$) in high and mid altitudes than low altitude. Number of chicken, horse and mule per HH were higher ($p<0.05$) in high altitude than mid and low altitude.

Assessment of availability of major feed resources

Crop residues, natural pasture, stubble grazing, cut and carry, improved forage, purchased feeds and non-conventional feed resources like local brewery by-products (atella) were the livestock feed resources in the study area. Crop residues, stubble grazing and natural pasture were the major feed resources. Dry matter (DM) contribution to livestock diet come from natural pasture, crop residues, cut and carry, cultivated fodder and purchased feed (Table 3).

Dry matter production and conservation of natural pasture

There were private and communal grazing lands in all agro-ecologies of the district studied. Natural pasture was the major source of feed next to crop residues (Table 3). Agro-ecology had shown no significant ($p>0.05$) effect on the contribution of natural pasture (Table 3).

As shown in Table 4, there were significant ($p<0.001$) differences in private grazing land holding and DM produced from private grazing lands (PGL). The mean DM produced from PGL was higher ($p<0.001$) in high altitude than mid and low altitudes (Table 4). The overall mean DM produced from PGL was lower than that of earlier report (FAO, 1987). For the average livestock holding per HH in the study areas of 9.03±1.825 TLU, the annual DM requirement for maintenance is 20.56±4.16 t (Kearl, 1982). Therefore, the quantity of feed DM obtained from PGL is not sufficient to meet the requirement. Discussion with focus groups and key informants revealed that communal grazing lands (CGL) is successively decreasing from time to time due to increasing human population and allocation of the available grazing land for the newly formed HHs by local leaders.

Small proportion of the respondents conserved natural pasture in the form of hay and silage. However, there are significant ($p<0.05$) differences in conservation practices among agro-ecologies. Significantly ($p<0.001$) higher percentage of respondents made hay in high altitude than low and mid altitudes (Table 4) because they allot on average 0.13 ha of pasture lands for hay production which is much larger than that in low and mid altitudes. Hay is commonly made during September to November and is of poor quality. Part of the pasture could be protected and left for standing hay. Hay is also prepared from natural pasture land, rehabilitated areas and arable lands and is used during the dry season (January-May). More number of farmers ($p<0.05$) produce silage in mid altitude than low altitude, but silage making is not practiced in high altituded.

Table 1. Average cultivated land holding (ha, Mean ± SEM) per HHs and land holding category (% of HHs).

Agro-ecologies	Cultivated land holding	Land holding category			N
		Small	Medium	Large	
High altitude	0.84±0.24[a]	10	65	25	18
Mid altitude	2.03±0.14[b]	20	60	20	54
Low altitude	2.5±0.24[c]	25	65	10	18
Overall	1.8±0.12	18.33	63.34	18.33	90
SL	***	-	-	-	-

[a, b, c] Mean values with different superscripts in a column indicate statistically significant difference between agro-ecologies ($p<0.05$); SEM=standard error of means; N= number of respondents; SL= level of significance

Table 2. Overall livestock herd composition (TLU) per HH (Mean ± SEM).

	Agro-ecology				
Variables	Mid altitude (N=54)	Low altitude (N=18)	High altitude (N=18)	Overall (N=90)	SL
Cattle	8.19±0.95[c]	4.57±0.95[b]	3.76±0.95[a]	5.5±0.95	***
Sheep	0.50±0.30[ab]	0.45±0.21[a]	0.54±0.26[ab]	0.49±0.26	*
Goat	1.00±0.57[ab]	1.34±0.23[ab]	0.94±0.19[a]	1.1±0.33	*
Chicken	0.11±0.10[a]	0.12±0.02[a]	0.13±0.02[ab]	0.12±0.05	*
Donkey	1.00±0.07[ab]	0.75±0.12[a]	1.05±0.14[ab]	0.93±0.11	*
Horse	0.80±0.17[a]	-	0.88±0.08[ab]	0.56±0.125	*
Mule	0.14±0.10[a]	0.14±0.10[a]	0.70±0.04[b]	0.32±0.05	*
Total	11.74±1.82[b]	7.37±1.68[a]	8 ±1.97[a]	9.03±1.825	*

[a, b, c] Mean values with different superscripts in a row indicate statistically significant difference between agro-ecologies ($p<0.05$); N= number of respondents; SEM= standard error of means; SL=significant level

Table 3. Dry matter contribution (%) of major feed resources across agro-ecologies.

	Agro-ecology				
Variables	High altitude (N=18)	Mid altitude (N=54)	Low altitude (N=18)	Overall (N=90)	SL
Natural pasture	23.18	22.31	22.25	22.58	NS
Cultivated fodder	13.86[c]	3.78[b]	1.30[a]	6.3	**
Collected fodder*	14.75[a]	17.25[b]	13.26[a]	15.08	**
Crop residues	32.68[a]	54.39[b]	55.60[b]	47.56	***
Purchased feeds	15.59[c]	2.27[a]	7.59[b]	8.48	***

[a, b, c] Mean values with different superscripts in a row indicate statistically significant difference between agro-ecologies ($p<0.05$); N=number of respondents; SL=significant level; NS=not-significant ($p>0.05$); *Fodder materials from communal areas other than natural pasture and includes crop thinning, weeds from cropping areas, road side weeds and any other naturally occurring green material collected for livestock feed.

Table 4. Mean DM production (tons/yr/HH) from PGL and CGL (Mean ± SEM) ad processing forages (%HH).

	Agro-ecology				
DM production	High altitude (N=18)	Low altitude (N=54)	Mid altitude (N=18)	Overall (N=90)	SL
Private grazing land (ha)	0.13±0.01[c]	0.005±0.01[a]	0.04±0.007[b]	0.06±0.005	***
DM production from PGL	0.26±0.02[c]	0.01±0.02[a]	0.08±0.014[b]	0.12±0.01	***
DM production from CGL	0.2	0.4	0.3	0.3	NS
Processing forage(% HH)					
Hay	65±2.89[c]	24.5±1.67[b]	4±2.89[a]	31.17±1.47	***
Silage	-	3±0.5[b]	1.5±0.86[a]	1.5±0.45	*

[a, b, c] Mean values with different superscripts in a row indicate statistically significant difference between agro-ecologies ($p<0.05$); N= number of respondents; SEM: standard error of means; DM: dry matter; PGL: private grazing lands; CGL: communal grazing lands; SL=level of significance; NS=non-significant at ($p>0.05$)

Crop residues production, conservation, supplementation and processing practices

Crop residues were primary feed resources for livestock in the study area. The principal crop residues come from stover (maize); straws (teff, finger millet, wheat and barley); haulms (fava bean and field pea) and noug or *Guizotia abbyssinica* chaff (Table 5). More crop residues were produced in low altitude followed by mid altitude and the least was from high altitude. Thus total utilizable crop residues were much higher ($p<0.05$) in mid and low altitudes than high altitude. Availability of crop residues varied according to the type of crops grown across agro-ecologies. More maize, finger millet and wheat ($p<0.001$), field pea ($p<0.01$), teff, fava bean and noug ($p<0.05$) are produced in the mid and low than high altitude. However, more ($p<0.001$) barley straw is produced in high altitude than mid and low altitudes. The overall DM produced from utilizable crop residues in the studied agro-ecologies was much lower than the minimum requirement (20.56±4.14 t DM/TLU/yr, Kearl 1982).

Summary of the practices of conserving and techniques of improving nutritive value crop residues is shown in Table 6. Baling under shade was the main crop residues conservation method for dry period use. Conservation practice of crop residues via baling under shade was higher ($p<0.01$) in high altitude than mid and low altitudes and baling in the open air was significantly ($p<0.01$) higher in low altitude than high and mid altitudes. Crop residues were compiled and stored depending on the method of threshing and types of crops. Small seeded crops such as teff, wheat, finger millet and barley are transported to homestead area and threshed. The straw is then stored in the form of a heap around the homestead. The heap was commonly fenced with prickly branches of trees and shrubs for defense

against stray animals. Most of the HHs in all agro-ecologies conserve teff straw for livestock feeding. In case of maize, the majority of the HHs harvests the ears and leave of the stover for on field grazing. Less maize stover is collected and stored for animal feeding because of difficulty in transportation and its direct use as fuel. Wheat and barley straws and haulms of pulses are usually left on the threshing area for in-situ feeding.
Supplements are seldom used to improve the nutritional value of crop residues in all agro-ecologies. The supplements include salt, wheat bran and local brewery by-products (atella). Salt and atella were reported to be used by majority of HHs in all altitudes. Majority of the respondent had no experience of feeding agro-industrial by products in all altitudes (Table 6). Slightly more ($p<0.05$) households used atella and salt as supplement in low altitude than high and mid altitude. However, more of the HHs used wheat bran in high altitude ($p<0.001$) than mid and low altitudes. Hence, in all the agro-ecologies most of the HH efficiently use local brewery by products to sustain livestock during feed deficiency period through improving the palatability of crop residues.

Mixing, treatment with effective microbe (EM) and urea were processing methods used to improve nutritive value of crop residues in the study area (Table 6). Mixing crop residues either with atella and/or with dissolved salts seem more popular in mid altitude and very few respondents treat crop residues using urea and EM in all agro-ecologies. Significant proportions of the respondents mix crop residues with local brewery by products ($p<0.05$) and treat of crop residues with urea ($p<0.001$) in mid altitude than high and low altitudes. However, the practice of treatment of crop residues by EM was highest ($p<0.001$) in high altitude than mid and low altitudes.

Stubble grazing/crop aftermath
Crop aftermath is one of the important feed sources in the studied agro-ecologies for livestock keepers. After harvesting crops, livestock are allowed to graze stubble of different crops (maize, teff, finger millet, etc.) mainly from November to December depending on the type of crop and time of harvest. There was a significant ($p<0.05$) difference in the amount of stubble grazing among agro-ecologies and that produced per HH. The amount of DM produced was higher in low and mid altitudes ($p<0.05$) than in high altitude (Table 5). Farmers in all agro-ecologies use crop aftermath to sustain their livestock from November until February.

Improved forage and pasture
The production of improved cultivated forage crops such as Rhodes grass (*Chloris gayana*), tree lucerne (*Cytisus proliferus*) and desho grass (*Pennisetum pedicellatum*) is practiced in all agro-ecologies (Table 7). The overall DM contribution of improved forage as animal feed sources in the study area was very low (Table 7). The DM contribution of improved forages was higher in high altitude ($p<0.001$) than mid and low altitudes. The production of Rhodes grass and tree lucerne was higher in high altitude ($p<0.001$) than mid and low altitudes.

Purchased feeds
Farmers purchase different feeds including crop residues such as teff, maize, finger millet straws; hay and noug seed cake (Table 7). In the dry season, concentrate feeds are fed mixed with crop residues to animals. However, most of the farmers could not use concentrate feeds because of their rising price. The overall quantity of DM feed purchased annually per HH was 1.12±0.08 t. The amount of purchased feeds was higher ($p<0.01$) in low and high altitudes than mid altitude.

Table 5. Mean DM produced (tons DM/year/HH, Mean ± SEM) from crop residues and stubble natural pasture across agro-ecologies.

	Agro-ecology				
Variables	Mid altitude (N=54)	Low altitude (N=18)	High altitude (N=18)	Overall (N=90)	SL
Maize	$8.16±0.61^{b}$	$8±1.058^{b}$	$2.97±1.35^{a}$	6.376±0.608	***
Wheat	$3.08±0.21^{c}$	$2.35±0.06^{b}$	$1.19±0.39^{a}$	2.11±0.91	***
Finger millet	$1.1±0.06^{b}$	$1.2±0.02^{b}$	$0.87±0.12^{a}$	1.04±0.09	***
Teff	$0.98±0.11^{a}$	$1.45±0.16^{b}$	$0.71±0.23^{a}$	1.04±0.10	*
Barley	$1.40±1.11^{b}$	$0.93±0.12^{a}$	$2.62±0.32^{c}$	1.65±1.11	***
Field pea	$0.39±0.1^{a}$	$0.6±0.069^{b}$	-	0.48±0.06	**
Fava bean	$0.96±0.08^{b}$	-	$0.44±0.076^{a}$	0.69±0.05	*
Total CR	$13.86±0.97^{b}$	$13.76±1.68^{b}$	$4.94±1.68^{a}$	10.85±0.85	*
Utilizable CR	$12.47 ±0.87^{b}$	$12.38 ±1.51^{b}$	$4.44 ±1.51^{a}$	9.76 ±0.76	*
Aftermath	$1.01 ±0.07^{b}$	$1.25±0.12^{b}$	$0.42±0.12^{a}$	0.89±0.06	*
Total	$13.48±0.94^{b}$	$13.63±1.63^{b}$	$4.86± 1.63^{a}$	11.16±0.82	***

[a, b, c] Mean values with different superscripts in a row indicate statistically significant difference between agro-ecologies ($p<0.05$); N=number of respondents; CR= crop residues; Utilizable CR= 90% of total CR; SEM= standard error of means; SL=level of significance

Table 6. Practice of crop residues conservation, HHs providing supplementary feeds and techniques of improving nutritive values of crop residues (% respondents, Mean±SEM).

	Agro-ecology				
Conservation practice	High altitude (N=18)	Mid altitude (N=54)	Low altitude (N=18)	Overall (N=90)	SL
Baling under shade	91.5±1.92^{b}	82.17±1.1^{a}	81.5±1.92^{a}	85.06±0.98	**
Stacked/baled outside	9.5±1.42^{a}	14±0.82^{b}	19±1.42^{c}	14.16±0.72	**
Techniques of improving nutritive value of crop residues					
Supplementing atella and salt	94±2.51^{a}	96.16±1.45^{a}	100±2.52^{b}	96.72±1.28	*
Supplementing wheat bran	10.5±0. 99^{c}	4.66±0.57^{b}	0.17±0.99^{a}	5.11±0.50	***
Mixing	49.5±21.21^{b}	82.33±12.24^{c}	10±21.21^{a}	47.28±10.79	*
Treat crop residues with urea	17.5±1.28^{b}	23±0.74^{c}	9.5±12.82^{a}	16.67±0.65	***
Treat crop residues with EM	20.5±0.59^{c}	2±0.345^{b}	0.5±0.59^{a}	7.67±0.30	***

$^{a, b, c}$ Mean values with different superscripts in a row indicate statistically significant difference between agro-ecologies (p<0.05); N=number of respondents; SEM=standard error of means; SL=significant level

Table 7. Mean DM production (kg/HH, Mean ± SEM) from cultivated forage lands and estimated average quantity of purchased feeds (tons DM/HH/year, Mean ± SEM).

	Agro-ecology				
Variables	High altitude (N=18)	Low altitude (N=41)	Mid altitude (N=12)	Overall (N=71)	SL
Rhodes grass	200±0.05^{c}	34±0.05^{b}	66±0.3^{a}	100±0.02	***
Desho grass	120±0.07	40±0.07	90±0.04	83±0.03	NS
Tree Lucerne	20±0.003^{b}	6±0.003^{a}	4±0.001^{a}	10±0.001	***
Total	340±0.16^{c}	80±0.16^{a}	160±0.09^{b}	193±0.08	***
Purchased feeds					
Finger millet straw	0.44±0.1	0.5±0.1	0.26±0.06	0.4±0.06	NS
Teff straw	0.55±0.17	0.67±0.17	0.21±0.1	0.48±0.09	NS
Maize straw	0.18±0.03^{b}	0.28±0.03^{c}	0.004±0.02^{a}	0.15±0.01	***
Hay	0.16±0.05^{c}	0.001±0.045^{a}	0.08±0.03^{b}	0.08±0.02	*
Noug seed cake	0.01	0.01	0.02	0.013	NS
Total	1.34±0.17^{b}	1.46±0.17^{b}	0.57±0.09^{a}	1.12±0.08	**

$^{a, b, c}$ Mean values with different superscripts in a row indicate statistically significant difference between agro-ecologies (p<0.05); N=number of respondents; SEM= standard error of means; DM=dry matter; SL=significant level; NS=non-significant at (p>0.05)

Table 8. Quantity of feed resources (tons DM/HH/year, Mean±SEM) produced in the three agro-ecologies.

	Agro-ecology				
Variables	High altitude (N=18)	Mid altitude (N=54)	Low altitude (N=18)	Overall (N=90)	SL
Private grazing land	0.26±0.02^{c}	0.09±0.01^{b}	0.01±0.02^{a}	0.12±0.01	***
Communal grazing land	0.40±0.11	0.30±0.10	0.20±0.06	0.30±0.08	*
Utilizable crop residues	4.44 ±1.51^{a}	12.47 ±0.87^{b}	12.38±1.51^{b}	9.76 ±0.76	*
Stubble grazing	0.42±0.12^{a}	1.01 ±0.07^{b}	1.25±0.12^{b}	0.89±0.06	*
Improved forage	0.34±0.16^{c}	0.16±0.09^{b}	0.08±0.16^{a}	0.19±0.08	***
Purchased feeds	1.34±0.17^{b}	0.57±0.09^{a}	1.46±0.17^{b}	1.12±0.08	**
Total supply	7.20±0.69^{a}	14.6±0.47^{b}	15.38±0.66^{b}	12.87±0.4	*

$^{a, b, c}$ Mean values with different superscripts in a row indicate statistically significant difference between agro-ecologies (p<0.05); N = number of respondents; Utilizable crop residues = crop residue (90%); SEM=standard error of means; SL=significant level; NS=non-significant at (P>0.05)

Estimation of annual feed balance

The total annual DM production of available feed resources per HH in the study area is shown in Table 8. The highest amount of available feed DM comes from crop residues followed by purchased feed, stubble grazing, natural pasture and cultivated forage in decreasing order of importance. However, DM production from cropping system varies among agro-ecologies (p<0.05). Accordingly, the highest DM was produced from crop residues in low altitude followed by mid altitude and the least was in high altitude. The contributions of natural pasture from both private and communal grazing lands and of improved forages as feed sources are minimal.

The overall mean annual utilizable feed DM production per HH per annum and the overall mean annual maintenance DM requirement calculated according to Kearl (1982) are displayed in Table 9. Annual utilizable feed DM is quite low and satisfied only part of the livestock maintenance requirement which clearly shows the gap between feed supply and livestock requirement. However, in the current study non-conventional feeds like HHs food leftovers and residue from different local drinks and crop thinning, weeds from cropping areas, road side weeds and any other growing green materials collected and fed were not quantified, due to lack of reliable data and measurement units.

DISCUSSION

There is a significant difference in land holding of the HHs among agro-ecologies. The higher land holding was from low altitudes which might be due to expansion of farm land by clearing of forest and low population density. The average land holding of HHs in the current study is less than those (1.95, 2.18, 2.99, 2.05, 2.14, 4.43, 3.7 ha/HH) earlier reported [for Gozamen district East Gojjam zone (Gashe *et al*., 2017); neighboring districts of North Achefer (Demeke *et al*., 2017); Chire district, south western Ethiopia and Jimma zones (Geremew *et al*., 2017; Biratu and Haile, 2017; Husen *et al*., 2016); Horro and Guduru districts (Gurmessa *et al*., 2015) and Sinana district (Yasar *et al*., 2016) in Amhara, SNNP and Oromia Regional States]. However, the current finding was higher than the national average 1.06 ha/HH (CSA, 2016) and also of those reported by Lemma *et al*. (2016), Endalew *et al*. (2016), Gelayenew *et al*. (2016), Gilo and Berta (2016), Negesse *et al*. (2016), Debela *et al*. (2017) and Emana *et al*. (2017). These differences could possibly be due to variations in population density of the areas. Moreover, the proportion of HHs that falls in different land holding categories (18.33 % small, 63.34 % medium and 18.33 % large) are consistent with the reports of Dejene *et al*. (2014), Duressa *et al*. (2014) and Wondatir *et al*. (2015a).

Cattle are the dominant livestock species in all agro-ecologies due to high demand of oxen for cultivation and other farm activities in the study area. Higher number of cattle was found in mid altitude than low and high altitudes because of better access for veterinary services and feed resources in the mid altitudes. Higher number of sheep per HH was in mid altitude than low altitude and that of goats in low than high altitude, which could be due to the presence of higher area of browsing land in low altitude and grazing land in mid altitude. The number of horses and mules kept per HH were significantly higher in the high and mid altitude than low altitude areas because of more suitability of highlands for horse and mule rearing with lower incidences of disease and presence of large area of grazing land.

The overall cattle holding reported in the present study areas are comparable with previous reports (Gurmessa *et al*., 2015; Gashe *et al*., 2017). The livestock holding of the study area was higher than the one reported for Diga, Jeldu and Fogera districts (Eba *et al*., 2012; Biratu and Haile, 2017; Demeke *et al*., 2017; Geremew *et al*., 2017). However, livestock holding in the study area was lower than those of Pawe (12.05±3.2 TLU), Dibase (14.38±1.86 TLU), Wombara (15.11±1.51 TLU) and Guba (14.59±1.74 TLU) districts of Metekel zone of Benishangul-Gumuz region in western Ethiopia (Altaye *et al*., 2014) and of Borena and Guji zone (16.5 TLU ; Urgesa, 2015). The average livestock holdings per HH were 5.5, 1.1, 0.93 and 0.56 TLU for cattle, goats, donkeys and horse, respectively. Livestock per HH in the current study area is lower compared to other areas of the country (Altaye *et al*., 2014; Urgesa, 2015) mainly due to limited grazing land because the available land is mainly utilized for crop production.

Crop residues and natural pasture were the major feed resources for livestock feeding in the study area which agree with the report of CSA (2017), Gashe *et al*. (2017), Gashaw and Defar (2017), Gizaw *et al*. (2017) and Megersa *et al*. (2017).

Natural pasture is one of the major sources of animal feed in the study area and its contribution is 22 % of overall feed resources which agrees with the report of Wondatir and Mekasha (2014) and Gizaw *et al*. (2017). On the other hand, the contribution of natural pasture is higher than the report of Gurmessa *et al*. (2015) but lower than those of earlier reports (Jimma *et al*., 2016; Kebede *et al*., 2016; Tonamo *et al*., 2016; Biratu and Haile, 2017; Megersa *et al*., 2017). Differences in size and management of natural pasture are main reason for these variations. However, quality of natural pasture is very low to meet the nutrient requirement of animals especially during the dry season due to poor management which agrees with the report of Malede and Takele (2014) and Gizaw *et al*. (2015, 2016, 2017).

Table 9. Maintenance requirement versus utilizable feed supply (tons DM/yr, Mean±SEM).

Variables	Agro-ecology			Overall (N=90)	SL
	High altitude (N=18)	Mid altitude (N=54)	Low altitude (N=18)		
Utilizable feed supply (tons DM/yr)	7.2±0.69^{a}	14.6±0.47^{b}	15.38±0.6^{b}	12.87±0.41	*
Maintenance requirement (tons DM/yr)	18.25±4.49^{a}	26.78±4.1^{b}	16.09± 3.8^{a}	20.37 ±4.1	*
Balance (tons DM/yr)	-11.05±-3.8^{a}	-12.2±-3.67^{a}	-0.71±-3.17^{b}	-7.5±-3.73	*
Supply (% requirement)	39.45^{a}	54.51^{b}	95.58^{c}	63.18	*

$^{a, b, c}$ Mean values with different superscripts in a row indicate statistically significant difference between agro-ecologies (p<0.05); N= number of respondents; SEM= standard error of means; SL=significant level

There were significant differences in the amount of DM produced by private grazing land (natural pasture) among agro-ecologies; it was higher in high than mid and low altitudes; and is comparable with earlier reports (0.1±0.016 and 0.14±0.02 t DM/year) from Aleta Chuko and Gozamen district (Negesse *et al*., 2016; Gashe *et al*., 2017, respectively) but was lower than the findings (2.10 and 2.76 t DM from 0.19±0.34 and 0.57±0.53 ha) of Wondatir and Mekasha (2014) and Geremew *et al*. (2017) for Jimma zone and Chire district, respectively. On the other hand, it was higher than those of earlier findings (Gurmessa *et al*., 2015; Husen *et al*., 2016; Mengistu *et al*., 2016). It was smaller when compared with estimated national average of 0.26 ha (CSA, 2013) and the regional average of 0.3ha/HH (BoA, 2014). These differences might be due to variations in size of lands per HH and human population.

The DM production from communal grazing lands is very low due to over grazing of the natural pasture by large livestock population resulting in land degradation and soil erosion; which is consistent with earlier reports (Husen *et al*., 2016; Demeke *et al*., 2017). The overall mean DM produced from communal grazing land in the study areas is comparable with earlier reports (0.3±0.03, 0.25±0.03, 0.38±0.04, 0.36±0.038, 0.27±0.035 and 0.48±0.039 t DM/year) for Ariba, Azula, Marwenz, Kolama, Guntala and Dokmit watershed, respectively in North Achefer district, north western Ethiopia (Demeke *et al*., 2017) but, higher than earlier finding reported (0.13±0.03 t) for Jimma zone (Husen *et al*., 2016) . Natural pastures are progressively reducing due to conversion of principal natural pasture lands to crop lands to augment the rapidly increasing human population and rising demand for food which is consistent with the report of Gizaw *et al*. (2015, 2016, 2017).

In the high altitude larger percentage of respondents utilize natural pasture for hay making than those in low and mid altitudes possibly because crop residue had small contribution in high altitude which agrees with the report where 32 % HHs conserve natural pasture (Husen *et al*., 2016) but it was higher than those earlier reported (Jimma *et al.,* 2016; Gashe *et al*., 2017) and lower than those earlier reported (72.5 %, 62.5 %, 82.5 %, 85 %, 70 % and 75 % for Ariba, Azula, Marwenz, Dokmit, Kolama and Guntal watershed, North Achefer District, respectively) by Demeke *et al*. (2017). These differences might be related to shortage of land and lack of awareness of farmers about forage conservation.

More of the crop residues were produced in low altitude followed by mid and high altitudes may due to differences in size of crop land, soil fertility and types of crop grown. Maize, finger millet and teff were the main sources of crop residues produced in all agro-ecologies which are in harmony with earlier report of Demeke *et al*. (2017). The overall mean crop residues produced in the study areas is comparable with earlier reports (9.7±0.6, 10.44, 10.29±0.27 and 9.19 t DM) for Adami Tulu Jiddo Kombolcha district, Horro and Guduru districts and Jimma zone (Assefa *et al*., 2013; Gurmessa *et al*., 2015, 2016; and Worku *et al*., 2016, respectively); but it is higher than earlier reports (Demeke *et al*., 2017; Gashe *et al*., 2017; Geremew *et al*., 2017); and it is lower than the reports of Tolera *et al*. (2012) and Gashaw and Defar (2017). These differences may be attributed to size of crop land, soil fertility, types of crops grown and crop management.

Conservation of crop residues under shed is mostly practiced in high altitude and open air in low altitude. This might be related to availability of labour and awareness of farmers. Crop residue is stored and fed to livestock during dry season which is in harmony with earlier reports (Yadessa *et al*., 2016b; Debela *et al*., 2017). Storing crop residues under shed is commonly practiced in the study area which is similar with the reports of Husen *et al*. (2016) and Gizaw *et al*. (2017) but it is higher than earlier reports of Assefa *et al*. (2014) and Gelayenew *et al*. (2016). Crop residues like wheat and barley straws were less conserved and commonly left on the threshing area for in situ feeding. Similar report was presented by Gurmessa *et al*. (2016) where the bulky nature and transportation problems constrain the collection and storage of straws and stovers as feed.

Natural pasture and crop residues do not fulfill the nutrient requirements of animals particularly in the dry season due to low quality and poor management (Malede and Takele, 2014). Supplementing crop residues with salt and atella is reported by majority of HHs in all agro-ecologies which is in line with the report of many authors in different regions (Demeke *et al*., 2017; Gashe *et al*., 2017; Gizaw *et al*., 2017). However, more farmers practice it in low altitude than in other agro-ecologies may be due to lack of commitment and awareness. Majority of respondents had no experience of feeding agro-industrial by-products in all altitudes because of problem of availability and awareness of respondents which is in agreement with earlier findings (Gilo and Berta, 2016; Worku *et al*., 2016; Gashe *et al*., 2017).

Crop residues are mixed with either atella and/or salt solution by majority of the respondents from mid or about half of them from high altitudes which are in harmony with earlier report (Demeke *et al*., 2017). Very few respondents treat crop residues with urea and effective microbes in all agro-ecologies with significant difference among agro-ecologies which is consistent with the reports of Geremew *et al*. (2017) and Gizaw *et al*. (2017). Crop residues processing practice in the study area is consistent with earlier findings (Gurmessa *et al*., 2016; Tesfay *et al*., 2016). These differences in applying the processing methods might be related to lack awareness and commitment of farmers.

The amount of DM produced from crop aftermath was significantly higher in low and mid altitudes than high altitude. In consistent with the findings in this study similar results were reported earlier (Gashaw and Defar, 2017; Gizaw *et al*., 2017; Zeleke and Getachew, 2017). The overall DM production of stubble grazing in the current study agrees with values (1.12, 1.20, 1.35 t DM/ha) for Adami Tullu Jiddo Kombolcha District, Chire District and Jimma zone earlier reported (Assefa *et al*., 2013; Worku *et al*., 2016; Geremew *et al*., 2017, respectively), but it was higher than that reported (0.97±0.06 t DM/ha) by Husen *et al.* (2016), for Jimma zone, south west Ethiopia; and it is lower than those values reported by Gurmessa *et al*. (2015, 2016), Gashaw and Defar (2017) and Gashe *et al*. (2017). The above differences might be due to variation in size of cultivated/crop land.

In the study areas, residues of local beverages like *areke* and *tela* are mainly used as livestock feeds which is consistent with the reports of Demeke *et al*. (2017), Emana *et al*. (2017), Gizaw *et al*. (2017), Megersa *et al*. (2017) and Mengie *et al*. (2017). The percentage of HHs feeding non-conventional feeds is in agreement with earlier report of Tonamo *et al*. (2016) but it is higher than those earlier reported (Duguma and Janssens, 2016; Husen *et al*., 2016; Duguma *et al*., 2017; Gashe *et al*., 2017). This difference might be due to lack of awareness of farmers about the potential of these residues to improve the palatability of crop residues and the quality of the total diet which is supported by earlier report of Tesfay *et al*. (2016).

The level of production of improved and cultivated forage crops in the study area is similar with earlier findings (Wondatir *et al*., 2015a; Demeke *et al*., 2017; Geremew *et al*., 2017) but it is lower than earlier finding of Tesfay *et al*. (2016). The major reasons hindering improved forage production and utilization were lack of awareness, uncontrolled free grazing, shortage of land and forage seeds which are consistent with observations in different parts of the country (Debela *et al*., 2017; Gashe *et al*., 2017; Geremew *et al*., 2017; Gizaw *et al*., 2017).

The contribution of improved forages is higher in high altitude than mid and low altitudes which is in line with earlier reports (Duressa *et al*., 2014; Wondatir *et al*., 2015a; Demeke *et al*., 2017).The contribution of improved forage in the study area was higher than those reported by Mekasha *et al*. (2014), Wondatir and Damtew (2015) and Wondatir *et al*. (2015b). However, it is lower than those reported (13.75, 14 and 25 %) for Shashogo district (Assefa *et al*., 2015), Adama district (Addisu *et al*., 2012) and central and eastern Tigray (Tesfay *et al*., 2016; Gizaw *et al*., 2017), respectively. The above differences might be related to availability of other feeds, the size of farm land, inaccessibility of forage seed and poor adoption rate of the farmers to cultivate improved forage.

The overall contribution of feed DM purchased in the district was 7.04 %. The amount of feed DM purchased was higher in low and high altitudes than in mid altitude. Purchased feed types in the study area are similar with those of Adama and Arsi Negelle districts, Hawassa Zuria and Bahir Dar Zuria districts (Addisu *et al*., 2012; Wondatir and Damtew, 2015; Wondatir *et al*., 2015a). The overall DM contribution of purchased feeds in this study is in line with the findings of Yami *et al*. (2013) and Wondatir and Damtew (2015) but higher than those earlier reported (Mekasha *et al*., 2014; Wondatir *et al*., 2015b; Gizaw *et al*., 2017) and lower than the reports of Addisu *et al*. (2012) and Amole and Ayantunde (2016). Differences might be due to lack of awareness of farmers, high cost and unavailability of the feed resources.

Most of the utilizable DM produced in the study area was contributed by crop residues and stubble grazing because of a shift in land uses from natural pasture to crop production to satisfy the food demand as a result of increasing human population. The total utilizable DM produced from crop residues and stubble grazing is in accord with earlier results reported by researchers (Gurmessa *et al*., 2015; Husen *et al*., 2016; Worku *et al*., 2016) it is higher than earlier findings (Demeke *et al*., 2017; Gashe *et al*., 2017; Geremew *et al*., 2017). This difference may be due to variation in size of crop lands and soil fertility. The DM contribution of private and communal grazing lands is minimal which also agrees with earlier reports for different parts of the country (Worku *et al*., 2016; Demeke *et al*., 2017; Geremew *et al*., 2017) may be due to a shift in land use pattern from natural pasture to crop production to satisfy the increasing grain demand of human population pressure.

The balance between feed supply and requirement found in the study area is similar with the national average value of 63 % (Salo, 2017) and lower than those of Abera *et al*. (2014), Tesfay *et al*. (2016), Demeke *et al*. (2017) and Gizaw *et al*. (2017) who reported 69.9 %, 70 %, 67.5 % and 70 % for Meskan, central Tigray, North Achefer district and in four regions (Amhara, Oromia, SNNPRS and Tigray), respectively; it is much lower than findings of Assefa *et al.* (2013), Wondatir and Mekasha (2014), Amsalu and Addisu (2014), Worku *et al*. (2016), Gashe *et al*. (2017), Geremew *et al*. (2017) who reported (83 %, 86 %, 72 %, 83.3 %, 79.5 %, 83.34 %) for Adami Tullu Jiddo Kombolcha district, central rift valley of Ethiopia, Gummara-Rib watershed, Jimma zone, Gozamen district and Chire district, respectively. On the other hand, the current finding was higher than earlier reports (39.59 %, 54.53 %, 31.4 %) for Jimma zone, Meta Robi, Kedida Gamela district, respectively (Husen *et al*., 2016; Yadessa *et al*., 2016a; Lemma *et al*., 2016).

Firew and Getnet (2010) reported about 36 % DM deficit in different parts of Amhara National Regional State. About 42 % feed DM deficit is reported at national level (CSA, 2013). The variations might have been mainly caused by differences in size of grazing and crop lands, yield and variety of crops. Similar observations were found in different parts of the country (Mengistu *et al*., 2016; Worku *et al*., 2016; Geremew *et al*., 2017; Gizaw *et al*., 2017).

Poor utilization efficiency of the available feeds in the study area was observed which is similar with the report of Gelayenew *et al*. (2016). The major utilization problems related to private grazing lands are land shortage, competition with crop production, poor conservation of forages and management of natural pastures such as continuously grazing leading to overgrazing of more palatable species and trampling over less palatable species which are common practices in many parts of the country (Debela *et al*., 2017; Ebro *et al*., 2017; Gashe *et al*., 2017; Oncho *et al*., 2017 and Zeleke and Getachew, 2017).

Less attention was given to collection, storage and conservation of crop residues. Uncontrolled feeding of maize stover in the storage place is common which is not efficient as the stover was trampled while animals compete to get easily palatable and leafy part of the stover and excreta of animals is mixed with and thus it is refused by the cattle. Mechanical, chemical and physical treatment options are not used in the study area which limits utilization. However, chopping, urea and EM treatment is practiced by very few farmers to improve this poor quality feeds which is consistent with earlier reports (Gurmessa *et al*., 2016; Husen *et al*., 2016; Gashe *et al*., 2017; Gizaw *et al*., 2017).

CONCLUSION

Crop residues, crop aftermath and natural pasture were the major feed resources. Natural pasture is major feed resources in wet season in the three agro-ecologies and is predominantly of communal type and poorly managed. Larger proportions of farmers conserve natural pasture as hay in high altitude than mid and low altitudes. Crop residues and aftermath are the primary feed resources during dry season in all agro-ecologies. Most crop residues come from maize stover; teff, finger millet, wheat and barley straws; fava bean and field pea haulms and noug (*Guizotia abyssinica*) chaff. The availability of crop residues varied according to size of farm land and type of crops grown across agro-ecologies.

Utilization of crop residues by livestock was low and improvement technologies such as chopping, urea treatment and use of microbes (EM) are less common. Most households did not produce improved forages due to shortage of land and forage seeds and lack of awareness. The use of agro-industrial by-products as animal feed source was also not common due to high cost and less availability.

The major livestock feed resources (crop residues and natural pastures) were of low quality and less efficiently utilized. The mean annual DM produced was 12.87±0.41 t/HH/year and annual maintenance DM requirement was 20.37±4.14 t/HH/year. Hence, the annual utilizable feed DM satisfied only 63.18 % of livestock maintenance requirement. This shortage is mainly caused by improper collection, conservation and low adoption of feed quality improvement technologies. Hence, training farmers on appropriate utilization and feed resources processing methods could alleviates feed problem in Burie Zuria District.

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