# Feed Resource Bases and Farmers' Perceived Uses of Grain Legume Haulms in the Mixed Crop-Livestock Farming System of Ethiopia

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## *ABSTRACT*

*Survey was conducted from January 2016 to March 2016 to assess feed resource bases and grain legume haulms use practices in the mixed crop-livestock farming system of Ethiopia. Three districts (Ada'a, Sinana and Damot-Gale) were selected purposively based on their accessibility and intensity of crop production from the mixed farming areas. Then, single visit formal survey was conducted to collect data from 90 purposively selected grain legume producers. The collected data were analyzed using descriptive statistics in SPSS software. The results revealed significant difference (P<0.05) among study districts in livestock holding per household and overall mean livestock holding was 5.86±0.42 TLU per head. Except grazing land, total land size and land allocated for different uses were significantly (P<0.05) different among the districts. The results showed that crop residues (33.3%, consisting of cereal residues 23.8% and legume haulms 9.5%), natural pastures (22.6%), stubble grazing (18.1%), non-conventional feeds (11.7%, composed of Enset leaves, farmyard weeds, poultry litter, grain screening), cut and carry forages (8.3%), agro industrial byproducts (5.3%) and hay (0.7%) were the feed resources available in the three districts. The main use of grain legume haulms was as source of livestock feed (76.3%) and about 89.8% of the interviewed farmers reported increasing trends of using haulms as a livestock feed in the studied districts. Mixing of haulms with cereal straws during feeding and conservation of the haulms for dry period use were practiced by 62.2% and 60.1% of the respondents, respectively.To boost the role of grain legumes production in the mixed crop-livestock production system of Ethiopia, smallholder farmers' need to be supported technically and institutionally with promotion of technologies which have potential to improve grain human and haulm animal nutrition traits.*

**Key words:** Crop-livestock farming, Grain legume, Haulms

## INTRODUCTION

Mixed crop-livestock farming system dominated the highlands of Ethiopia and maintains about 85% of human population (Aklilu*et al*., 2014). Nearly two thirds of the ruminant livestock population of the country is also found in this farming system (Alemneh, 2003). This production zone is suitable for cultivation of diverse crops and rearing of different livestock species for various ends by smallholder farmers (Birhan and Adugna, 2014).

In this zone crop and livestock production are highly interdependent and complementary (Bogale *et al*., 2009). Livestock play a crucial role in crops cultivation through provision of draft power, organic fertilizer (manure), and cash availability for purchase of agricultural inputs whereas crops provide in return inputs for livestock production in the form of crop residues (Powell *et al*., 2004). In this way the two systems are integrated with each other through crop residues and draught power.

Despite such opportunities, inadequate feed supply and low quality of available feeds is the main bottleneck that hinders the development of livestock in the mixed farming system (Duguma *et al*., 2013; Birhan and Adugna, 2014; Defar, 2018). With the rapid conversion of grazing lands into cultivation, crop residues are increasingly becoming the major sources of feed for livestock. Estimation made in different parts of the country show that the contribution of crop residues is more than 50% of the annual feed dry matter (Abera *et al*., 2014; Defar, 2018).

The utilization of crop residues as an ultimate year round feed source is limited due to their low nutritive value and considerable fluctuation in availability with the season of the year. Grain legume haulms have relatively better nutritional values such as protein and metabolazable energy contents and digestibility than cereal straws and stovers (Lopeze *et al*., 2005). Grain legume haulms produced in Ethiopia can be categorized under medium quality roughages depending on their crude protein content (Tolera, 2008). Thus, grain legume haulm is a good option in ruminant feeding.

Grain legumes are the second largest crops produced next to cereals in Ethiopia and annually around 1.6 million hectare of land is planted to grain legumes (CSA, 2015). The intensity of legume haulms use as livestock feed is determined based the quantity of crop residue produced on the farm which is a function of land size allocated to cultivated legumes (Akinola *et al.*, 2015). The lower legume haulms utilization for animal feeding in Ethiopia may be associated with smaller annual production of the legume residues due to the smaller land allocation for these crops by smallholder farmers (Gebrehiwot and Mohammed,1989; Bogale *et al.*, 2008) and lower straw yielding potential of legume crops as compared to cereals (Lopez *et al.*, 2005). As stated by Akinola *et al*. (2015), awareness of the farmers on the nutritional values of legume haulms can determine the extent of utilization in livestock feeding which could be mentioned in Ethiopian scenario also. Therefore, assessment and documentation of farmers' perception and current practices of grain legume haulms uses along the major feed resources available in the mixed crop-livestock farming areas of Ethiopia is important for more integration and exploitation of grain legume haulms in livestock feeding.

## MATERIAL AND METHODS

### Description of the Study Areas

The study was conducted in the N2-Africa project target districts in the mixed farming system of Ethiopia. N2 Africa project with a theme of 'Putting nitrogen fixation to work for smallholder farmers growing legumes in Africa' was a project implemented in Ethiopia in partnership with ILRI. Goal of the project was increasing inputs from nitrogen fixation (by targeting technologies for legume production in farming systems). N2 Africa was had also a strong interest in looking at integration of legume production with livestock by advising and collaborating on aspects relating to the use of legume crop residues for animal feeding across different African countries including Ethiopia. Common bean, faba bean, soybean, chickpea and forage legumes were the target legumes of the project in Ethiopia.

Accordingly Ada'a and Sinana districts from Oromia Regional State and Damot-Gale district from South Nations Nationalities and People Regional State were used for the survey (Figure 1). Ada'a, Sinana and Damot-Gale districts are located in the altitude range of 1500-2250, 2000-2500 and 1501-2950 m.a.s.l, respectively. Ada'a district receives mean annual rainfall 877.2 mm and has annual temperature of 12.4-26.6 $^{0}$C. Sinana district has bimodal rainfall (900-1150mm) with two main cropping seasons. Annual

mean temperature in Sinana district varies 15-18 $^{0}$C. The annual average rainfall and temperature of Damot-Gale district are 1200-1300mm and 12-26$^{0}$C, respectively. Major grain legumes cultivated in Ada'a district are chickpea, faba bean, field pea, lentil and grass pea. Chickpea and haricot bean is widely grown by smallholder farmers of Damot-Gale district whereas faba bean, field peas and lentil are the main grain legumes widely produced in Sinana district.

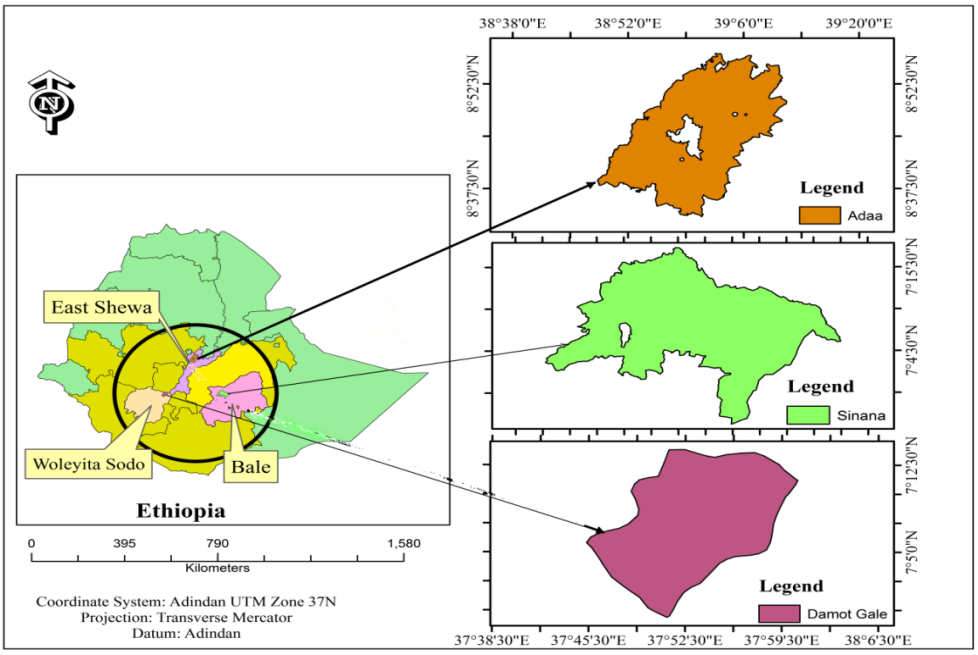


**Figure 1: Map of study area**

**Selection of Respondents and Data Collection**

The three survey districts (Ada'a, Sinana and Damot-Gale) were selected purposively based on their accessibility and intensity of crop production. A total of 90 grain legumes producers (28 from Ada'a and Sinana districts, each and 34 from Damot-Gale district) were selected and used as source of data. Sampling technique used was purposive which targeted only households who grown grain legumes by excluding households who do not cultivate grain legumes. Then selected grain legumes producers interviewed individually using single-visit-formal survey method (ILCA, 1990). Data were collected on socio-economic characteristics, livestock holding and feed sources, landholding and land use pattern, type of grain legumes grown in earlier year, household level uses of legume haulms, haulm management practices, trends in use of grain legume haulms for livestock feeding etc.

**Calculation of Livestock Holding in Tropical Livestock Unit (TLU)**

Livestock holding of the surveyed households was calculated in TLU using conversion factors developed by Janke (1982). Accordingly, conversion factors of ox/bull=1, cow=0.7, heifer= 0.5, calf =0.2 sheep/goat=0.1, horse = 0.8, donkey = 0.5 were used.

**Data Analysis**

The collected data were analyzed using Statistical Package for Social Science (SPSS, Ver.16). Descriptive statistics (percentage, mean and standard error) were used to present the survey result. Data on household age, livestock and land holding, and land use pattern were subjected to general linear model (GLM) of SPSS for analysis of variance to declare significant variation among districts at the P value of <0.05. In case of significant difference in means among districts, Duncan Multiple Range Test was used to locate mean separation. Model used was: $Y_{ij} = \mu + T_i + eij$; Where: $Y_{ij}$ = the $j^{th}$ observation in the $i^{th}$ district level, $\mu$ = overall mean, $T_i$ = districts effect and eij = random error. Index mean was calculated in Microsoft Excel as shown below and multiplied with hundred to get aggregate value for ranking of feed sources and uses of grain legumes haulms in the study areas.

$$\text{Index mean} = \frac{\Sigma[(n \times \text{no of R for 1st rank}) + (n\text{-}1 \times \text{no of R for 2nd rank}) + \ldots\ldots + (1 \times \text{no of R last})]}{\Sigma[(n \times \text{total R for 1st rank}) + (n\text{-}1 \times \text{total R for 2nd rank}) + \ldots + (1 \times \text{total R for last})]}$$

Where: R=number of response, n=value given for the factor, no=number

# RESULTS

**Household Characteristics**

The demographic characteristics of the sampled households are presented in Table 1. Majority of the respondents were male headed households (95.6%). The overall mean age of the household heads was 42.6±0.9 years, with a range of 39-68 years. There was significant difference (P<0.05) among districts in mean age of the household heads which was 39.3±1.06, 43.6±1.87 and 45.5±1.70 years at Damot-Gale, Ada'a and Sinana districts, respectively. About 62.2% and 17.8% of the respondents attended primary (grade 1-8) and secondary (above grade 8) school education, respectively (Table 1). About 12.2% of the respondents also had the ability to read and write (obtained through basic/traditional education), while the remaining 7.8% were illiterate.

**Table 1: Basic households' characteristics of surveyed farmers**

| Descriptors | | Ada'a (N=28) | Sinana (N=28) | Damot-Gale (N=34) | Overall (N=90) |
|---|---|---|---|---|---|
| Age | Years (Mean ±SE) | 43.6 (1.9)[a] | 45.5 (1.7)[a] | 39.3(1.1)[b] | 42.6 (0.9) |
| Sex (%) | Male | 92.1 | 100 | 94.1 | 95.6 |
| | Female | 7.1 | - | 5.9 | 4.4 |
| Educational status (%) | Illiterate | 10.7 | 7.1 | 5.9 | 7.8 |
| | Basic education | 25 | 10.7 | 2.9 | 12.2 |
| | 1-8 grade | 64.3 | 71.4 | 52.9 | 62.2 |
| | Above grade 8 | - | 10.7 | 38.2 | 17.8 |

[abc] Mean values with different superscript within the rows are significantly different at P<0.05

**Livestock, Land Holding and Land Use Patterns**

Livestock holding of the households was assessed based on the ownership of cattle, sheep, goats, donkey and horse. The survey result showed that the overall mean livestock holding of the smallholder farmers in the study area was 5.86±0.42 TLU per household. The average livestock holding per household was significantly higher (P<0.05) in Ada'a district (8.63±0.61 TLU) than the other two districts. Significantly lower (P<0.05) livestock holding was observed in Damot-Gale district (3.04±0.56 TLU) while it was an intermediate in Sinana district (Table 2).

The overall average total land holding per household in the study area was 2.10±0.13ha (Table 2). Total land (3.24±0.14 ha) and cultivated land (2.57±0.12 ha) holding per household in Sinana district was higher (P<0.05) than Ada'a (2.52±0.14 ha total land and 2.02±0.12ha cultivated land) and Damot-Gale (0.81±0.13 ha total land and 0.53±0.11 ha cultivated land) districts. Land allocated for grain legumes production in Ada'a district (0.95±0.07ha) was higher (P<0.05) than Sinana (0.21±0.07 ha) and Damot Gale (0.24±0.06ha) districts. Common food legumes (pulse crops) grown by smallholder farmers in the surveyed districts are shown in Figure 2. The result showed that farmers from Ada'a district with medium cultivated landholding from studied districts integrated more numbers of food legumes in their cropping activity.

The average grazing landholding per household was very small and not significantly different (P>0.05) among the study districts. The overall mean grazing land owned per household in the study area was 0.12±0.02 ha (Table 2). Moreover, land allocated for cultivated fodder per household was significantly different (P<0.05) among the surveyed districts. The average farm size (0.11±0.02ha) allocated for fodder production per household in Sinana district was significantly larger than the remaining two districts. Whereas in proportion, 0.99%, 4.28% and 3.68% of cultivated land is allocated to fodder production by farmers at Ada'a, Sinana and Damot-Gale districts, respectively.

**Table 2: Mean livestock holding and land holding and land use patterns of the farming households**

| Particulars | Ada'a | Sinana | Damot-Gale | Overall | SL |
|---|---|---|---|---|---|
| | Mean (±SE) | Mean (±SE) | Mean (±SE) | Mean (±SE) | |
| Livestock holding (TLU) | 8.63 (0.61)$^{a}$ | 6.51 (0.61)$^{b}$ | 3.04 (0.56)$^{c}$ | 5.86 (0.42) | *** |
| Total land (ha) | 2.52 (0.14)$^{b}$ | 3.24 (0.14)$^{a}$ | 0.81 (0.13)$^{c}$ | 2.10 (0.13) | *** |
| Cultivated land (ha) | 2.02 (0.12)$^{b}$ | 2.57 (0.12)$^{a}$ | 0.53 (0.11)$^{c}$ | 1.63 (0.11) | *** |
| Land allocated for pulses (ha) | 0.95 (0.07)$^{a}$ | 0.21 (0.07)$^{b}$ | 0.24 (0.06)$^{b}$ | 0.45 (0.05) | *** |
| Grazing land (ha) | 0.14 (0.03) | 0.11 (0.03) | 0.10 (0.03) | 0.12 (0.02) | Ns |
| Land allocated for cultivated fodder (ha) | 0.02 (0.02)$^{b}$ | 0.11 (0.02)$^{a}$ | 0.04 (0.01)$^{b}$ | 0.06 (0.01) | *** |

$^{abc}$ Mean values with different superscript within the rows are significantly different at P<0.05, SL: significant level, ns: not significant.

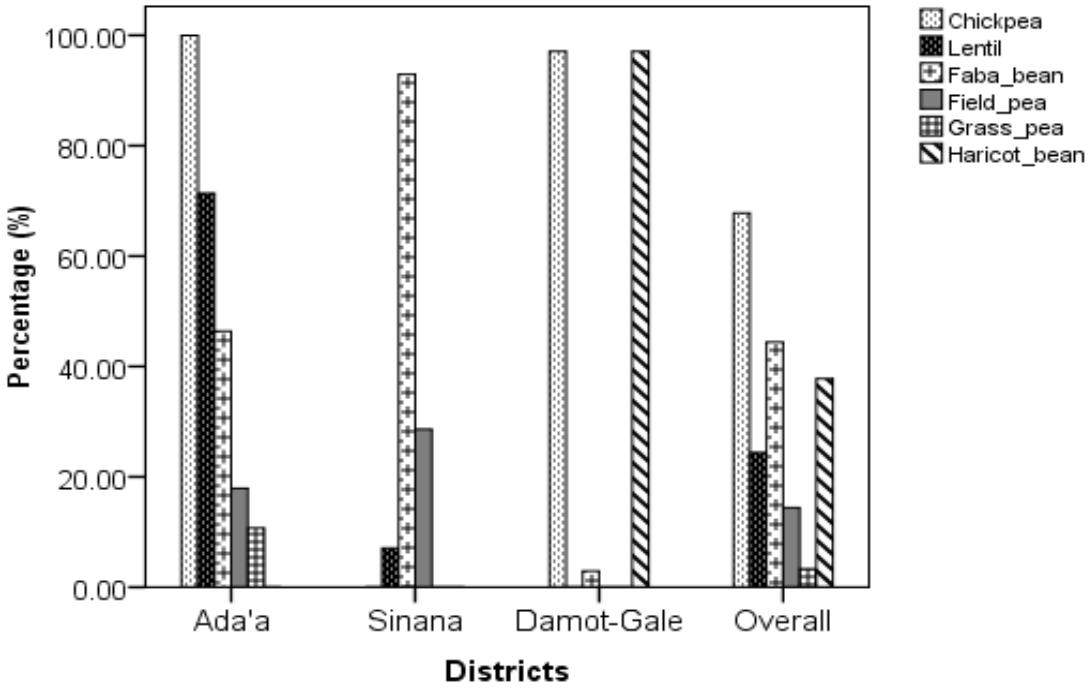


Figure 2: Percentage of respondents growing common legumes in the surveyed districts

**Major Household Feed Sources in the Study Area**

The major feed resources prioritized by the sampled households according to their perceived contribution to total feed supply in the study area are presented in Table 3. The result showed that cereal residues (23.8%), natural pasture (22.6%), stubble grazing (18.1%), other feeds (11.7%), legume haulms (9.5%), cut and carry forages (8.3%), agro-industrial by products or concentrates (5.3%) and hay (0.7%) were the major feed resources utilized by smallholder farmers in the study area. Similar to the aggregate bases, feeds obtained from the farming system which consists of cereal residues, legume haulms and stubble grazing were reported to be the most commonly used by all surveyed farmers across all districts.

In the study areas, about 72.2% of the households reported feed shortage as first important constraint of livestock production. According to the current study feed scarcity occurred over different periods of the year. Majority (73%) of the households reported that they experienced feed shortages in the dry season of the year (Figure 3A), whereas the remaining 25.0% and 1.6% of the respondents reported feed shortage to be a critical challenge during wet season and throughout the year, respectively. The farmers of all study districts adopted different coping strategies in time of limited feed availability (Figure 3B). The major coping strategies identified in the present survey includes efficient utilization of crop residues (32.8%), use of different farm and home by-products (29.7%), use of purchased feed (18.8%) and exploration of other alternative like moving animals where better grazing (including stubble grazing) is available during the day time and obtaining from fellow farmers (18.7%).

**Table 3: Major feed resources available in the surveyed districts**

| Feed Resources | Proportion of respondents (%) | | | Overall |
|---|---|---|---|---|
| | Ada'a | Sinana | Damot Gale | |
| Cereal residues | 29.3 | 24.0 | 18.2 | 23.8 |
| Legume haulms | 10.0 | 6.0 | 12.6 | 9.5 |
| Natural pasture | 19.6 | 19.8 | 28.2 | 22.6 |
| Stubble grazing | 17.1 | 27.2 | 10.0 | 18.1 |
| Cut and carry forage | 2.9 | 12.9 | 9.1 | 8.3 |
| Agro-industrial by products | 5.4 | 2.3 | 8.2 | 5.3 |
| Hay | 1.8 | 0.0 | 0.3 | 0.7 |
| Others feeds** | 13.9 | 7.8 | 13.2 | 11.7 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 |

**: Lists of other feeds include weed plants collected from farms, *Enset* leaves (pseudo banana) and different household by products and grain screenings

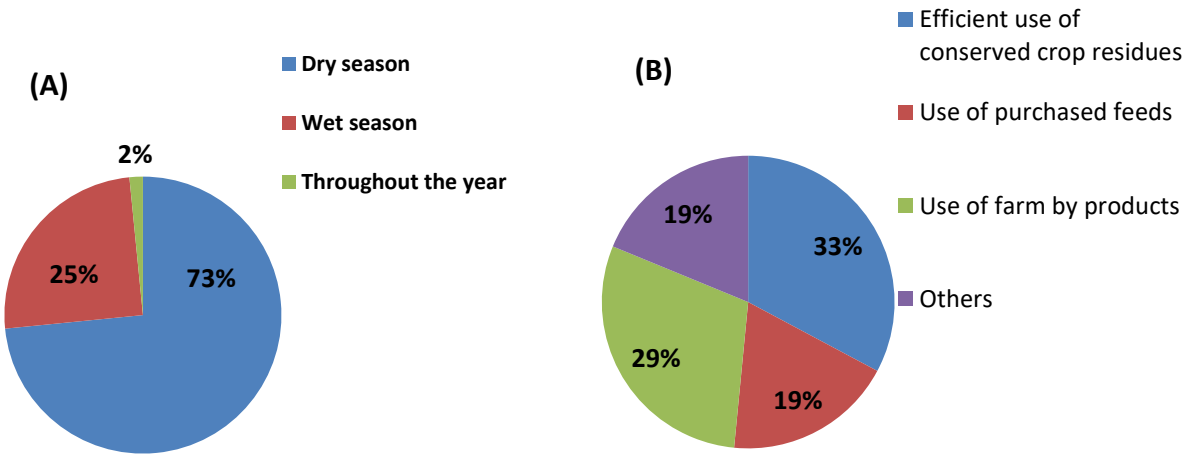


***Figure 3: Time of feed scarcity (A) and farmers' coping strategies (B) in the study areas***

**Uses of Grain Legume Haulm in the Study Area**

Grain legume haulm has multiple uses for the smallholder farmers of the study area (Table 4). The farmers prioritized and ranked the importance of grain legumes haulm in their area based on the amount of residues allocated for different alternative uses. Regardless of the variations among the districts, the result showed that primary use of grain legume haulm in the study areas was reported to be as source of feed (76.3%) and followed by source of household fuel (11.6%), for mulching and compost making (8.7%). About 7.8% and 2.4% of legume haulms produced sold by households to generate additional income in Ada'a and Damot Gale districts, respectively.

**Table 4: Household prioritized use of grain legume haulms in the surveyed districts**

| Uses of haulms | Proportion of respondents (%) | | | Overall |
|---|---|---|---|---|
| | Ada'a | Sinana | Damot Gale | |
| Feed source | 64.7 | 80.0 | 84.1 | 76.3 |
| Domestic fuel | 19.0 | 7.3 | 8.5 | 11.6 |
| Mulching/bio-fertilizer | 8.6 | 12.7 | 4.9 | 8.7 |
| For sale/income generation | 7.8 | 0.0 | 2.4 | 3.4 |
| Total | 100 | 100 | 100 | 100.00 |

**Table 5: Trends of haulm use as feed and reasons for the increasing trends in using as livestock feed in the survey districts**

| Variables | Indicators | Proportion of respondents (%) | | | Overall |
|---|---|---|---|---|---|
| | | Ada'a | Sinana | Damot Gale | |
| Trend of haulms use as feed | Increasing | 90 | 79.3 | 100 | 89.8 |
| | No change | 4 | 13 | 0 | 5.7 |
| | Don't know | 6 | 7.7 | 0 | 4.6 |
| | **Total** | **100** | **100** | **100** | **100.0** |
| Reasons for increasing | Feed shortage and lack of other option | 59.1 | 72.2 | 48 | 59.8 |
| | Improved awareness of nutritional advantage | 22.7 | 27.8 | 33.4 | 28.0 |
| | Increased annual production | 18.2 | 0 | 18.6 | 12.3 |
| | **Total** | **100** | **100** | **100** | **100.0** |

Majority (89.8%) of the sampled households stated that the trend of haulm utilization in livestock feeding is increasing from time to time (Table 5). There are many factors that triggered a rapid shift to legume haulm use as livestock feed source in the mixed crop-livestock farming areas. Shortage of livestock feed

and lack of other options, better awareness on the nutritional advantages of legume haulms than cereal residues and increased annual production of grain legume haulm are the three main drivers prioritized by the respondents for the increasing interest in including grain legume haulm in livestock diets.

**Table 6: Grain legumes haulm feeding methods, time of feeding and storage methods in the surveyed districts**

| Variables | Feeding practices | Proportion of respondents (%) | | | Overall |
|---|---|---|---|---|---|
| | | Ada'a | Sinana | Damot Gale | |
| Haulm feeding method | Mixed with cereal straws | 64 | 66.7 | 55.9 | 62.2 |
| | Feed alone | 28 | 33.3 | 32.4 | 31.2 |
| | Mixed with other supplements | 8 | 0 | 11.8 | 6.6 |
| | **Total** | **100** | **100** | **100** | **100.0** |
| Time of haulm use as feed | During dry season | 28 | 66.9 | 85.3 | 60.1 |
| | Throughout the year | 44 | 27.1 | 11.8 | 27.6 |
| | During wet season | 24 | 0 | 2.9 | 9.0 |
| | Immediately after harvesting | 4 | 6 | 0 | 3.3 |
| | **Total** | **100** | **100** | **100** | **100.0** |
| Haulm storage methods | Traditional heap/stack without shelter | 100 | 4.8 | 28.5 | 44.4 |
| | House constructed from locally available materials | 0 | 62.7 | 17.6 | 26.8 |
| | House with plastic or tin roof | 0 | 26.5 | 4.5 | 10.3 |
| | Home side | 0 | 0 | 25 | 8.3 |
| | Not practiced conservation | 0 | 6 | 4 | 3.3 |
| | Others (like use of old sacks) | 0 | 0 | 20.4 | 6.8 |
| | **Total** | **100** | **100** | **100** | **100.0** |

The survey showed majority of the respondents (62.2%) feed grain legumes haulms to livestock by mixing with cereal straws and, 31.2% and 6.6% of them feed haulm to livestock alone and by mixing with other supplement, respectively (Table 6). According to the respondents, mixing of grain legume haulms with cereal straws and concentrates are mainly done to improve intake of the haulm. In the study area, grain legume haulm mainly collected and used during dry period of the year by 60.1% of the households. Proportion of the farmers used grain legume haulms throughout the year, during wet season and immediately after harvesting and threshing accounts about 27.8%, 8.9% and 3.3% respectively. In district bases, largest proportion of the respondents of Sinana (66.9%) and Damot Gale (85.3%) districts used

legume haulms during dry period of the year, whereas in Ada'a district about 44% of the respondents fed their animals on grain legume haulm throughout the year. Conservation method of crop residues including grain legumes haulms has considerable impacts on both quality and quantity of the residues. Majority (96.6%) of the respondents used different haulm conservation and storage techniques (Table 6). In Ada'a district all (100%) the respondents replied that they store haulm in traditional stack without shelter and mainly they put the haulm inside the stack and covered outer parts of the stack with cereal straws. Haulms storage in shelter constructed from locally available materials was practiced by 62.7% of the farmers in Sinana district. About 28.5%, 25% and 20.4% surveyed farmers of Damot Gale district practiced use of traditional heap without shelter, home side and old sacks for storage of legume haulms, respectively.

## DISCUSSION

### Landholding and Land Use Pattern

The household land holding observed in Sinana and Ada'a districts was above the national average (1.77 ha) and Oromia region average (1.98 ha) rural land holding (ERSS, 2013). The average total land holding (0.81 ha) of the households recorded in Damot Gale district is comparable with the average rural land holding in the South Nation Nationality and People region (0.88 ha) but below the national data (ERSS, 2013). The land holding (0.81ha total land and 0.53ha cultivated land) of the households observed in Damot-Gale district is comparable with 0.6 ha reported in Wolayta Area (Aliyi, 2013) and 0.7 ha in Umbulo-Watershed of Southern Ethiopia (Funte *et al*., 2010). Consistent to current report in Damot Gale district, decreasing trend of average land holding of the household to about 0.25-1ha could be due to very high population density in Wolayta zone as reported by Ayele (2008).

Differences were observed among the districts in the proportion and area of land used per household for grain legume production (Table 2). About 47.03%, 45.3% and 8.17% of cultivated land was allocated for grain legumes production in Ada'a, Damot-Gale and Sinana districts, respectively. Unlike farmers from Ada'a and Damot-Gale districts, farmers of Sinana district give more priority for production of cereal crops than grain legumes. This might be due to increased trends of using mechanized crop harvester in wheat production and availability of more productive modern wheat varieties suitable for agro-ecology of the area. This is in agreement with the result of Abate *et al*. (2012), which showed that the farming system of Sinana district to be a predominantly mixed cereal-livestock type.

The grazing land holding of the households was very small and comparable among surveyed districts (Table 2). The overall mean grazing land holding (0.12 ha) per household in the study area was comparable with the findings reported in central highlands of Ethiopia (Tsegaye *et al*., 2008) and Umbulo-Wacho watershed of Southern Ethiopia (Funte *et al.,* 2010). The current study indicated that grazing land holding is smaller than the reports of Bosana, Meta-Robi and Halaba districts of mixed farming area (Hassen 2006; Kocho, 2007; Yadessa, 2015), respectively. The small grazing land holding per household indicated in the present study may be due to continuous conversion of productive grazing land to crop fields. In the highlands of Bale where mixed farming is dominantly practiced conversion of grazing land to cropland is estimated to be 99.22% over 29 years period from 1986 to 2014 (Defar, 2018). As noted by Mengistu (2004) the current available grazing land in Ethiopian highlands is limited to the areas which have no farming potential.

The relatively higher share of cultivated forage from the total farm land in Damot-Gale, the district with the smallest total land holding per household, negates the notion that shortage of land is the main barrier to adoption of cultivated forage production. This calls for more in-depth research to identify and address barriers to adoption of improved forage production and use. Smallholder farmers in Sinana area were reported to grow oat and maize fodder for livestock feeding. Abate *et al*. (2012) reported experience of smallholder farmers in Sinana district who have been growing fodder oat and maize solely for livestock feeding purpose. The continuous distribution of fodder oats varieties adaptive to the area by Sinana Agricultural Center and the presence of two favorable cropping seasons for fodder production might be positively contributed in better adoption of cultivated forage by smallholder farmers of Sinana district. In Damot-Gale district sampled households were also reported to have established Desho and Elephant grasses on the border of their farm field to serve dual purposes *i.e*. soil conservation and feed source.

**Livestock Holding and Feed Resources**

Livestock holding of the households of the surveyed districts was assessed based on the ownership of cattle, sheep, goat and equines. The overall average livestock holding of 5.86TLU per household in the study areas was much closer to the figures reported earlier in the mixed farming areas of BasonaWorana district of North Shewa, highlands of Blue Nile basin and highlands of Bale (Hassen, 2006; Eba, 2012; Defar, 2018), but lower than the figures reported by Kocho (2007) in Halaba and Yadessa (2015) in Meta-Robi districts. Significantly smaller livestock (3.04 TLU) holding reported in Damot-Gale district might be associated with limited land holding of the households in the area. The mean livestock of farmers in Damot-Gale district is comparable with the figure reported in Umblo-Wacho watershed of Southern Ethiopia (Funte *et al*., 2010).

Different feed resources were available in the study areas with different levels of contribution. The major feed resources in the study areas are cereal residues and legume haulms followed by natural pastures and stubble grazing. The current findings on the available feed resources in the study districts is in agreement with the results reported earlier in similar agricultural production system of Ethiopia (Zewdu *et al*., 2014; Yadessa, 2015; Defar, 2018; Asmare and Mekuria, 2019).

However, the contribution of each types of feed to annual household feed demand fluctuates with the season of the year. According to the current study, feed shortage was a major constraint of livestock production in in the study areas which is in agreement with the finding reported earlier in the mixed farming system of Ethiopia (Duguma *et al.,* 2013; Yadessa, 2015; Zewdu *et al.,* 2014; Defar, 2018). Dry season was a critical period of feed scarcity in the study areas and different coping strategies is adopted by smallholder farmers of all study districts to feed their animals during feed scarcity. Consistent to current study Duguma and Greet (2016) and Funte *et al*. (2010) reported that smallholder farmers have their own experience of using various available options to feed their animals when they faced limited feed availability.

**Grain Legumes Haulm Use Practices**

Farmers of all study districts used grain legume haulms for various purposes. The majority of the respondents in Ada'a, Sinana and Damot Gale districts reported that the primary use of grain legume haulm was as feed for livestock. The finding is in agreement with research result reported in the highlands of Ethiopia (Alkhtib *et al.,* 2014). In the study area the haulm refusals from feeding systems have

alternatives uses like bio-fuel, fertilizer and compost making. Additionally, sale of haulm is an alternative source of income for the households in the study area. The amount of crop residues (including grain legume haulm) allocated for other purposes rather than livestock feeding in mixed farming systems is very small (Hassen, 2006; Alkhtib *et al*., 2014).

An increasing trend of grain legume haulms use as feed resource was reported by the respondents, which is in agreement with the findings of Alkhtib *et al.* (2014) who reported increasing trends of grain legume haulm use as livestock feed by smallholder farmers in the highlands of Ethiopia. Various studies (Akinola *et al*., 2015; Valbuena *et al*., 2015) indicated that many interacting factors determine farmers' decision to use crop residues for various alternatives. As identified in the current study, livestock feed shortage and lack of other options, improved awareness on the nutritional advantages of legume haulms than cereal residues and increased annual production of grain legume haulms are the main factors contributing for the increasing interest of farmers in including grain legume haulms in livestock diet.

## CONCLUSION

The farming households of the study areas mainly used grain legume haulms as source of livestock. The use of grain legume haulm as livestock feed has been steadily increasing over the past few years in the study area due to feed shortage and lack of other options, better awareness of their nutritional quality and increased annual production of annual grain legumes. Generally, in the mixed farming systems of Ethiopia, both grain and haulms of grain legumes have significant importance for the livelihood of the farming households. Thus, agricultural technologies such as new cultivars and agronomic packages which have potential to improve grain and haulm attributes of grain legumes should be a priority in the area.

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