ASSESSMENT OF FORAGE PRODUCTION, FEED RESOURCE UTILIZATION AND SUBSTITUTION EFFECT OF OAT-VETCH FORAGE FOR CONCENTRATE MIX ON PERFORMANCE OF SHEEP FED DESHO GRASS AS A BASAL DIET IN DAMOTE GALE DISTRICT OF WOLAITA ZONE, SNNPR

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APPROVAL SHEET

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DEDICATION

I dedicated this thesis manuscript to my beloved families and best friends who wished me all the best and success in my expedition.

STATEMENT OF THE AUTHOR

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ACRONYMS

ADF	Acid detergent fiber
AVG	Average Daily Gain
ADL	Acid detergent lignin
AOAC	Association of Official Analytical Chemists
CP	Crude Protein
DM	Dry matter
EE	Ether Extract
ESGPIP	Ethiopian Sheep and Goat Productivity Improvement Program
ILRI	International Livestock Research Institute
IVOMD	In Vitro Organic Matter Digestibility
MCal	Mega calorie
ME	Metabolisable Energy
MJ	Mega Joule
MP	Metabolizable Protein
MRR	Mariginal Rate of Return

NDF	Neutral Detergent Fiber
NRC	National Research Council
SIMLESA	Sustainable Intensification of Maize-Legume Cropping Systemin East and South Africa
WoA	Woreda office of Agriculture

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Assessment of Forage Production, Feed Resource Utilization and Substitution Effect of Oat-Vetch Forage for Concentrate Mix on Performance of Sheep Fed Desho Grass as a Basal Diet in Damot Gale District of Wolaita Zone, SNNPR

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ABSTRACT

This study was comprised of field survey and animal performance evaluation. Questioner based survey was conducted in project intervention and non-intervention sites where a total of 160 households participated with objective of assessing the status of improved forage production, feed resource utilization and forage seed and feed marketing in Damot Gale district. Growth and digestion experiments were conducted on 32 yearling ram lambs with mean body weight of 21.08±2.29 kg using RCBD to evaluating the substitution effect of oat-vetch forage for concentrate mix on performance of sheep fed desho grass as a basal diet. The supplementary feed treatments used over the basal diet in the study were T1 (300 g concentrate), T2 (200 g concentrate + 100 g Oat-vetch hay), T3 (100 g concentrate + 200 g oat-vetch hay) and T4 (300 g oat-vetch hay). Feed intake and body weight gain were collected during the 75 feeding days and fecal output data during 7 days of digestion trial. Mean family size (6.56), land holding (0.64) and livestock holding (3.73TLU) were discovered by the field survey. The major feed resource were desho grass (index=0.22), Crop residue (index=0.21) and grazing (index=0.21). Desho grass split was the only marketable forage planting material. Feed shortage was the primary problem (index=0.33) for livestock production. Desho and elephant grass were the dominant forage species adopted in the area. The DM intake under T1 and T2 were similar ($P>0.05$) but higher ($P<0.05$) than T3 and T4, and that of T3 was higher ($p<0.05$) than T4. OM, CP and ME intake were highest ($P<0.05$) in sheep fed T1 followed by T2 which was higher ($P<0.05$) than T3 and T4. T4 had lower ($P<0.05$) OM, CP and ME intake. T2 had highest ($P<0.05$) DM, OM, and NDF digestibility.. T3 had higher ($P<0.05$) DM, OM, CP, NDF and ADF digestibility than T1 and T4. T2 had highest ($P<0.05$) ADG and FCE. For 1.0 Birr investment in sheep production, Birr 3.54 and 1.45 could be obtained in T3 and T2 respectively. Hence, sheep feeding on desho grass supplemented with 100g concentrate mix and 200g oat-vetch mixed forage is a profitable business at on-farm.

Keywords*:* Damote Gale, Project intervention, Weight gain, Desho ,Oat-vetch, on-farm substitution effect.

1. INTRODUCTION

Ethiopia has large small ruminant population, with estimated number of 30.7 million sheep and 30.2 million goat (CSA, 2017) that are widely adapted to different agro ecological zones and are found in almost all types of production system (EARO, 2000; Kassahun, 2004). Small ruminant production serves as major source of meat and immediate cash income for smallholders, in addition to its role on creation of employment opportunity. Requirement of easy management and small investment as well as short generation interval (Otte and Chilonda, 2002) make small ruminant production a choice enterprise for smallholder producers.

Despite their large number and importance their productivity is low due to a number of factors such as inefficient management, poor infrastructure, poor marketing and credit facilities, feed shortage both in quality and quantity and health constraints (Markos 2006;Tsedeke 2007;Getahun 2008). Feed scarcity is often indicated as the primary constraint to livestock productivity in crop-livestock mixed farming systems (Adugna *et al.*, 2000; EEA, 2006; Shapiro *et al.*, 2015).This is because nutrition is the most important factor affecting performance of livestock, particularly small ruminant and plays a major role in the overall productivity, health, and well-being of the flock. As a result of these constraints, producers are not getting the required benefit. Short term intensive feeding can reduce production costs and enhance the overall benefit made from the enterprises. Moreover, burden on the environment as a result of over grazing can be reduced by applying controlled grazing and avoiding part of stocks which are less relevant for breeding purpose through sale upon short period of feeding.

“Send a Cow’ in collaboration with SIMLESA project was working on forage technology scaling up like desho grass and Oat-vetch mixed fodder. It is needed to link this forage development effort with animal feeding operation so as to evaluate those forages for their contribution on the growth and productivity of animals at farm level.

Desho grass plays multipurpose roles in southern Ethiopia such as soil conservation, animal feed and cash source. Research work indicated that desho grass is low in protein, hence it was recommended to supplement with protein source feed (Asmare *et al*., 2016). Concentrate feeds and forage legumes can be used as a supplement. But concentrate are expensive and may not be accessible by all farmers in a given area. On the other hand, forage production on farm land may compete for food crop production as a result of small land holding. Hence, information on the substitution effect of protein source forages for major industrial by products used in the area is required to assess optimum feeding options in line with forage technology scaling up process. This will help farmers practice and adopt profitable feeding options for sheep production. The current status of feed utilization system and improved forage production, adaptation, adoption and feed and forages seed marketing issues need to be assessed to identify contribution of different development interventions. This study was, therefore, initiated to assess the feed resources utilization system, feed marketing and improved forage production status in the area and evaluate the substitution of oat-vetch mixed forage for concentrate mixture as a supplement to desho grass based diet in Damot Gale woreda of Wolaita zone.

1.1. OBJECTIVES

1.1.1. General objective

- To assess feed resource utilization, current status of improved forage production, and evaluate substitution effect of oat-vetch mixed forage for concentrate mix on performance of growing lamb fed desho grass as basal diet.

1.1.2. Specific objectives

- To assess livestock feeding practice, improved forage adaptation status and forage seed and feed marketing.
- To evaluate substitution effect of oat-vetch mixed forage for concentrate mix on feed intake, digestibility, and body weight gain of growing lamb fed desho grass.
- To determine profitability of substitution level of oat-vetch mixed forage for concentrate mix.

2. LITERATURE REVIEW

2.1.Small Ruminant Production Challenges and Opportunities

Although small ruminants have significant role in improving house hold livelihood, their productivity is constrained by a number of challenges including feed shortage, poor genetic potential, disease and poor management system (Tsedeke, 2007; Mengistu, 2006; Getahun, 2008). Feed cost accounts for 60-65 % of the total production for sheep (Lemus and Brown, 2008).

Shortage of feed has become the major constraint hindering livestock productivity (Adugna *et al*., 2000; Desta and Oba, 2004; EEA, 2006; Shapiro et al., 2015). Feed shortage resulted from continuous shrinking of grazing land and small land holding, land degradation, poor productivity (Haileslassie *et al.*, 2005), limited technology distribution and poor extension system. The increasing demand for small ruminant, the government's current attention for livestock and presence of different forage production strategies are the opportunities for better production and utilization of existing sheep resource.

2.2. Nutrient Requirement of Sheep

Proper nutrition is a primary issue to be given due attention to improve sheep production and productivity as it has a large influence on wellbeing, flock reproduction, milk production and lamb growth (ESGPIP, 2008) and to efficiently exploit genetic potential. Nutrient required by Sheep include water, energy, protein, vitamins, and minerals of which energy usually become the most limiting factor in a diet to sustain life, produce and reproduce. A ration composed of quality forage and concentrate mix can supply energy required by animals. Protein is also critical nutrient for the growth of sheep, especially for young stock. Protein enhances the growth of rumen microorganisms which play vital role in facilitating digestion of fibrous feeds and serving as source of microbial protein. Male sheep of about 20 kg with average daily weight gain of 150gm requires 6.4MJ/kg ME, 76 g/day MP and 0.56 kg dry matter feed (McDonald *et al*., 2010).

Table 1: Energy and protein requirement of growing male sheep

Sheep class	Nutrient	Daily weight gain (g/day)				DM intake
		0	50	100	150	(kg/day)
Female	ME (MJ)	3.4	4.5	5.8	6.5	0.56
	MP (g)	21	45	58	71	
Castrated male	ME (MJ)	3.4	4.5	5.7	6.2	0.56
	MP (g)	21	47	61	76	
Growing male sheep	ME (MJ)	3.9	4.8	5.8	6.4	0.56
	MP (g)	21	47	61	76	

(Source: McDonald, 2010)

2.3. Major Feed Resources

Major feed resources in Ethiopia include natural pasture, crop residues, collected fodders, agro industrial byproducts, multipurpose trees and shrubs, stubble grazing, cultivated forage and conserved forages (Berhanu *et al*., 2009; Adugna *et al*., 2012; Dawit*et al*., 2013; Geleti *et al*., 2014; Derbe, 2015). The contribution of these resources varies depending on agro ecology, season and farming system. Accordingly, the contribution of major feed resources is indicated as grazing (56.23%), crop residue (30.6%), hay (7.44%), agro industrial by products (1.21%), Concentrate/other feeds (4.76%), and improved fodder/pasture (0.3%)(CSA, 2015). Descriptions of some of the most common feed resources are listed below.

Table 2: Coverage in proportion of animal feed resources in Ethiopia

S/N	Type of feed resources	Coverage in percent
1	Natural grazing	56.23
2	Crop Residue	30.6
3	Hay	7.44
4	Agro industrial by products	1.21
5	Other feeds (concentrates)	4.76
6	Improved forage	0.3

(Source: CSA, 2015)

2.3.1. Natural pasture

Natural pasture is the major livestock feed resource (Solomon *et al.*, 2008; CSA, 2015) which currently is being declining in coverage due to conversion of pasture lands in to crop lands (Haileslassie *et al.*, 2005; Mekasha *et al.*, 2014). The productivity of currently existing pasture lands is low due to poor management and overstocking which causes fluctuation in yield and nutrient density in different season (Funte, 2010). The grazing capacity of natural pasture depends on the amount of herbage biomass produced in a specific season. During dry season, the grazing capacity of a give pasture land is low but high during rainy season. Due to the deterioration of natural pastures that caused lower carrying capacity, animals are forced to forage on farm lands with minimum litter cover resulting in over degradation of land, damage of physical and biological soil and water conservation structures. This situation in turn has resulted in reduction on yield of food crop and incurring additional cost for construction and maintenance of natural resource conservation structures every year. Degraded natural pasture land can be rehabilitated either by proper management and/or allowing it to be free from freely roaming livestock. Over and above proper management, controlled grazing or cut and carry system of feeding is an option for natural pasture land to have fast and potential re-growth so that sufficient forage can be harvested to be fed as fresh or to be conserved as hay.

2.3.2. Crop residue

Crop residue includes cereal and legume residue like wheat straw, barley straw, teff straw Faba bean straw, field pea straw, and maize stover. Currently, conversion of grazing land to crop land is increasing from time to time resulting in more biomass of crop residues which contribute about 50% (that grow up to 80%) of ruminant feeds during the dry season of the year and are becoming the most important feed resource covering significant amount of livestock feed in the highland of Ethiopia especially during dry season (Adugna, 2007). But, quality and digestibility is very low with less than 50% digestibility, high fiber content (more than 70% NDF) and low crude protein (< 5% CP) (Gizachew and Smit, 2005).

2.3.3. Agro industrial by products

Agro industrial by products includes brewery, oil processing and flour milling industry by products. They have special value in feeding livestock mainly in urban and peri-urban livestock production system, as well as in situations where the productive potential of the animals is relatively high and require high nutrient supply. As compared to other feed resources, agro industrial byproducts are rich in energy and protein contents (35% CP) with low fiber and high digestibility value (50-70% IVOMD) (Alemu *et al.*, 1991). Currently, oil seed cake and grain processing byproducts are the major agro industrial byproducts (Firew and Getnet, 2010). Most oil extraction is done almost entirely by mechanical processing method (CSA, 2015). Wheat bran is by product of wheat flour milling plant and is the cheapest and mostly available energy concentrate feed with CP content ranging from 80 – 140 g/kg DM (McDonald *et al.*, 2010). Whereas, Noug seed cake is very good protein concentrate with 30.8% CP, 32.4% NDF and 29.7% ADF on DM basis (Abebe, 2008).

2.3.4. Improved forage

There are a number of improved forage varieties of both grass and legume species suitable for various agro ecologies (ESGPIP, 2008). Among these, desho grass, oat and vetch forage species are widely known and distributed.

2.3.4.1. Desho grass (*Pennisetum pedicellatum*)

Pennisetum pedicellatum, locally known as desho grass, is a multipurpose herbaceous plant that can grow up to 120 cm with a high biomass productivity based on the moisture and condition of soil fertility (Shiferaw, *et al*., 2011) and can be used through cut-and carry system with more frequent harvesting in the presence of a little moisture. Initially, it was investigated in Southern Ethiopia, 'Chencha' area and its distribution is increasing to other regions of the country (Smith, G. 2010). The grass belongs to the Poaceae family of monocot angiosperm plants. It is ideal grass species for livestock feed, soil and water conservation (Welle *et al*., 2006; Leta *et al*., 2013) and cash source (IPMS, 2010; Shiferaw *et al*., 2011) as it can be cultivated on small plots of land. Suitable soil type is mostly black clay loam, rich in organic matter (InterAid, 2014). The grass has a productivity potential up to 15 ton/ha (Asmare, 2016), suitable to different forage production strategies (backyard, around fence and on soil & water conservation structures), acceptable to different livestock species and increases productivity of livestock.

Geographically, desho grass is well adapted in the humid highland of Ethiopia with best performance from mid to high altitude area up to 2800 meter above sea level. Desho grass can be multiplied by split at different spacing level and grows rapidly once established. According to research work conducted by Areka agricultural research center, a spacing level of 0.25m by 0.5mshowed the higher biomass yield (11-15 ton/ha) which was similar result (13.71 ton/h) (Asmare, 2016) obtained with recommended spacing of 0.1m by 0.5m (Leta *et al.,* 2013). It was reported that about 45% soil loss was reduced which gave it second rank next to vetiver grass in this regard (Welle *et al*., 2006).

2.3.4.2.Oat (*Avena sativa*) and Vetch (*Vicia Species*)

Oat forage is erect annual grass that can grow up to 1.5 m tall especially in areas with altitude ranging from 1700–3000 meter above sea level. It requires well prepared seed bed for better establishment. Seed rate of 75–100 kg is required for a hectare of land and can have 10-52 ton/ha of fresh herbage and can be used either as fresh or in the form of hay. The crude protein content, of oat ranges from 70 g/kg DM to 150 g/kg DM, (MacDonald *et al*., 2010)

Vetch is herbaceous legume that can grows in area with an altitude ranging from 1500-3000 meter with versatile soil type with minimum moisture as low as 400mm (ESGPIP, 2008). Vetch varieties are very good source of protein especially *Vicia dasycarpa* species with higher CP content (25-26%) than other varieties (Gezahegn *et al*., 2014). Recommended seed rate may range from 20-30 kg per hectare depending on different factors including seed quality and soil condition.

These two species can be grown mixed at a ratio of 3:1 taking in to account 90 kg oat and 30 kg vetch seed rate per hectare respectively. It has reported that mixture of oat-vetch fodder have 9.5 MJ/kg DM Metabolisable energy (ME) and 15 % crude protein (CP) content (Bezabih *et al*., 2016). Oats-vetch mixed forage was categorized under medium to high quality forage groups with a potential of supplementing low quality feeds like crop residue and natural pasture in mixed farming system of Ethiopia (Negash et al., 2017 quoting Tesema, 2000).

3. MATERIALS AND METHODS

3.1.Description Of The Study Area

Damot Gale is one of the districts of Wolaita zone in the Southern Nations, Nationalities, and Peoples' Region of Ethiopia within the coordinate of 7° 00′ N and 37° 50′ Eand an altitude range of 1612 – 2964 m.a.s.l. It is located in East Rift valley at a distance of 370 km to the south of Addis Ababa and at about 140 km to the West of Hawassa, which is the capital city of Southern Nations Nationalities and Peoples Regional State (SNNPR). The district has the area of 410.1 km^2 with 151,079 (CSA, 2007) human populations. Annual rainfall in the area ranges from 900 mm to 1400 mm with minimum and maximum temperaturesof12°c and 24°c (District report). The woreda has three agro ecology namely ‘Dega’ (26%), ‘Weyina Dega’ (40.7%) and Dry ‘Weyina Dega’ (33.3%) (District report). Damot Gale is bordered on the southwest by Sodo Zuria, on the northwest by Boloso Sore and Damot Pulasa, on the north by the Hadiya Zone, on the east by Diguna Fango, and on the southeast by Damot Weyde. The administrative center of Damot Gale is Boditi.

3.2.Survey on Forage Production, Feed Resource Utilization and Marketing

There are a total of 27 rural kebeles with 9 ‘Send a cow’ project interventions. Four representative kebeles, 2 from project intervention and 2 from non-project intervention ones were purposively selected based on road accessibility followed by random selection of 40 farmers from each kebele for the purpose of individual interview with involvement of the NGO and Woreda office of agriculture (WoA). Socio economic characteristics, livestock production constraints and coping mechanisms, income contribution of agricultural activities, livestock feeding practices, improved forage production challenges, and forage seed and feed marketing information were collected from farmers through questioner survey, and from experts and forage seed traders through key informant interview. The effect of project intervention on feed availability, utilization and marketing was also addressed.

4.4.On-farm Feeding and Digestibility Experiment

4.4.1.Animal Management, Experimental Design and Treatments

Thirty two (32) male sheep with an average age of about 8 months old and weighing 21.08 ± 2.29 kg were purchased from the local market. The age of animals was identified through dentition and oral history. All sheep were ear-tagged, vaccinated against major diseases like Sheep pox, Anthrax and Ovine pasteurellosis and treated against ecto and endo-parasites using ivermectin and anthelmintics.

The sheep were assigned to the treatment feeds using Completely Randomized Block Design (RCBD) based on initial weight. Farmers, each with two sheep, were purposively assigned to each treatment group based on oat-vetch proportion grown at farm. Experimental animals were kept tied separately while they stay feeding in the barn. They spent some part of the day time (8:00 AM to 4:00 PM) tethered under shade outside their pen without contact with other animals. The feeding period lasted for 75 days excluding fifteen days of adaptation periods.

Energy to protein concentrate at a ratio of 2:1 (based on the feed formulation for the purpose of this experiment) and 3% of live weight dry matter intake (DMI) was considered (ESGPIP, 2008) to evaluate the replacement effect of oat-vetch mixed hay for concentrate mix. The concentrate mix was composed of wheat bran and Noug cake at 2:1 ratio. Accordingly, treatments employed are indicated in Table 3.

Table 3: Experimental feed treatment group

Treatments	Basal Diet	Supplement (g DM /Day)	
	Desho Grass	Oat-Vetch	Concentrate
Desho Grass + 100 % Concentrate (T1)	ad libitum	0	300
Desho Grass + 67 % concentrate + 33% OV (T2)	ad libitum	100	200
Desho Grass + 33% Concentrate + 67% OV (T3)	ad libitum	200	100
Desho Grass + 100 % Oat-Vetch (OV) (T4)	ad libitum	300	0

The above treatment compositions were made based on the information that desho (with 6.83 MJ/kg ME and 9.55 % CP) (Asmare, 2016), Oat-vetch (with 15% CP and 9.5 ME MJ/kg DM) (Bezabih, *et al*., 2016) and concentrate mix (with 10-12MJ/kg DM ME and 17% CP) can satisfy the nutrient requirement of sheep (11% CP and 6.4 MJ/kg DM ME) having 20 kg live weight and with 150 g daily weight gain on average (McDonald *et al*., 2010).

4.4.2. Experimental feed preparation and Feeding

Oat-vetch mixed forage (with 1:2 ratio) was harvested at about 3 month age, cured as hay, chopped at about 5 cm and stored in clean sack for further feeding. Desho grass was harvested daily starting at about 3 months of age to feed as green. This age of harvest was chosen to obtain the forage with optimum dry matter and higher protein content as compared to advanced cutting age (Asmare, 2016). Desho grass was chopped at about 10 cm before being offered to animals. Actual feeding trial was conducted for 75 days following the adaptation period and experimental feed preparation. The basal feed (desho grass) was offered as fresh ad libitum and the supplemental forage (oat-vetch) was presented in the form of hay. Basal feed sample was collected every month for the purpose of dry matter determination. Water was available free choice and 8 gram salt (with supplemental concentrate mix) was provided for each animal per day. For those experimental animals receiving oat-vetch hay alone as a supplement, dissolved salt was sprayed over and mixed with oat-vetch hay of the daily offer. Oat-vetch hay supplement was offered at 8:00 AM before other feeds were given followed by concentrate and desho grass at 1:30 and 2:30, respectively, in the afternoon.

Daily feed offer and refusals were measured using sensitive balance and sub samples (100 g) of the offer and refusals were collected throughout the feeding period to form a bulk from which representative samples were taken for chemical analysis at the end of feeding experiment. Feed offer samples were also collected for the purpose of feed dry matter determination through oven drying at 105^{o}C over night. Intake was determined by taking the difference between feed offer and refusal.

4.4.3. Weight gain and feed conversion efficiency

Initial animal body weigh was taken at the start of actual feeding experiment. Then after, weight was measured every 15 days in the morning before feed offer. The final weight measurement was taken at the end of feeding experiment. The weight of animals was measured using 50 kg size suspended balance with 200 g graduation. The daily weight gain of sheep was determined by dividing the difference between the final and initial body weight for the number of feeding days. Feed conversion efficiency (FCE) was calculated by dividing the average daily weight gain for average daily feed intake in gram.

FCE= (Average weight gain)/(Average feed intake)

4.4.4. Digestion trial

The digestibility trial was conducted at the end of the feeding trial using the same feed treatments that were used for growth experiment. Fecal sample was collected from 16 sheep using fecal collection bag fitted to experimental animals for 7 consecutive days after 3 days of adaptation. Feed residue and feces were collected and weighed every day in the morning before new feed offer. After thorough mixing, about 20 % fecal sample for chemical analysis and about 30-40 g for the determination of fecal dry matter were collected using polyethylene bag. Daily fecal samples collected for chemical analysis were kept in refrigerator at district animal health clinic until the end of collection period. Composite sample (about 200 gm) of 7 days collection per individual animal was taken after thorough mixing and again kept in refrigerator until drying in an oven at 60^{o}C for 48 hour for further chemical analysis. The collected fecal sample for dry matter digestibility determination was air dried and kept in tightened polyethylene bag until oven drying at 105^{o} C. Daily feed offer and refusals were measured using sensitive balance and about 100 gm offer and refusal sample were collected every day to form a bulk for chemical analysis. Apparent digestibility was calculated using the following formula.

% Apparent digestibility = ((Nutrient in feed – Nutrient in Faces)/Nutrient in feed)*100

4.4.5. Chemical analysis

All collected feed, refusal and fecal samples were taken to ILRI animal nutrition laboratory for analysis of chemical composition. Samples were kept in an oven and dried at 60°C for 48 hour. The dried samples were grounded at 1mm sieve size and kept packed in a paper bag for further laboratory analysis. Near Infrared Reflectance Spectroscopy (NIRS) was used for the analysis of chemical compositions of feed offer, refusal and fecal samples. For scanning purpose, already ground sample was dried overnight at 60°C in oven to standardize the moisture conditions. Then, the partially dried sample was filled into NIRS cup and scanned using Foss NIRS 5000 with software package WinISI II in the 1108-2492nm spectra ranges (Win Scan version 1.5, 2000, intrasoft international).

Accordingly, all samples were scanned for predication of dry matter (DM), Ash, crude protein (CP), Neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and in-vitro organic matter digestibility (IVOMD). The NIRS scanned information were used for the prediction of the above mentioned nutritional values, using predictive equations developed based on previously conducted conventional analyses (AOAC, 1990). Metabolisable energy (ME) was estimated from digestible energy (DE) which in turn was estimated from the in vitro organic matter digestibility (IVOMD) using NRC equation (NRC, 2001) as per the following.

DE= (0.01*(OM/100)*(IVOMD+12.9)*4.4)-0.3

ME (MCal/kg) = 0.82*DE. Where: DE = digestible energy, OM = organic matter, IVODM = in vitro organic matter digestibility, ME = metabolisable energy.

4.5. Statistical Data Analysis

Performance of sheep was evaluated using randomized complete block design (RCBD). Survey data was analysed using descriptive statistics of SPSS 20 while feeding and digestion experiment data were subjected to analysis of variance (ANOVA) using the general linear model (GLM) of SAS 9.2 version (SAS, 2007). Duncan multiple range taste at 5 % probability was used to separate means. The model statement for growth and digestion trial is the following.

$$Y_{ij} = \mu + A_i + B_j + €_{ij}$$

Where Y_{ij} = response variable, μ = over all mean, A_i = effect of feed (treatment effect), B_l = block effect, $€_{ij}$ = random error.

4.6. Partial Budget Analysis

Information on all costs of production including medication, animal and feed purchase costs were collected. The market value of feeds was estimated based on local market price collected during survey work. At the end of feeding trial, the selling price of sheep was estimated by two well experienced sheep traders and one selected farmer based on his experience on sheep marketing. The economic analysis was employed using the procedure recommended by CIMMYT (1988).

Gross benefit (GB): The gross benefit for each treatment was calculated by multiplying selling price (estimated by experienced sheep traders) with final body weight.

Total variable costs (TVC): This is the sum of all the costs that vary for a particular treatment.

Net benefit (NB): This was calculated by subtracting the total costs from the gross field benefit for each treatment. NB = GB – TVC

Dominance analysis (D): This was carried out by first listing the treatments in order of increasing costs that vary. Any treatment that has net benefits which are less or equal to those of a treatment with lower costs that vary is dominated.

Marginal rate of return (MRR): This was computed by dividing the marginal net benefit (i.e., the change in net benefits) with the marginal cost (i.e., the change in costs) multiplied by hundred and expressed as a percentage.

MRR (%) = (ΔNR/ΔTotal Variable Cost)*100, where MRR (marginal rate of return) is a measure of increase in net income that is associated with each cost.

4. RESULTS

4.1. Survey on Forage Production, Feed Resource Utilization and Marketing

4.1.1. Household Characteristics

Information on family size, age and educational level of farm households are presented on Table 4. The male and female headed households were 77.5 % and 22.5 %, respectively. Majority of the households (>95 %) were in the active productive age (18-46 old). About 69 % of household heads were literate (primary school and above). Average family size of a household was 6.56.

Table 4: Age, sex, educational level and family size of a household

Description	N	%
Household sex		
Male	124	77.5
Female	36	22.5
Household age		
18-30	19	11.88
31-45	101	63.13
46-65	38	23.75
>65	2	1.25
Education level		
Illiterate	49	30.6
Primary(1-4)	54	33.8
Primary(5-8)	37	23.1
Secondary (9-10)	15	9.4
Preparatory (11-12)	2	1.3
Household family size	Mean	SD
Total family size	6.56	2.15
Active worker	5.3	0.41

4.1.2. Farming characteristics

4.1.2.1. Occupation and land holding

Occupation and land holding is presented in Table 5. Major occupation in the district is farming (70.00 % and 86.25%) followed by both farming & petty trading (25 % and 8.75%) in both intervention and non-intervention sites, respectively. The mean cultivated land holding was 0.42 ± 0.33 ha in both study locations. There was no significant variation in land holdings among farmers in project intervention and non-project intervention areas except land allocated for fodder production which was higher ($P<0.05$) in intervention sites. Major crops grown in the area includes wheat, teff, sweet potato, Irish potato, haricot bean, field pea, enset and coffee.

Table 5: Major occupation and land holdings

Description	Intervention		Non-intervention		X^2	Sig
	N	%	N	%		
Major occupation					8.754	0.033
Farming	56	70.00[b]	69	86.25[a]		
Both farming and trading	20	25.00[a]	7	8.75[b]		
Farming and labor	4	5	3	3.75		
Farming, trading and labor	0	0	1	1.25		
Land holding	Mean	SD	Mean	SD	F	Sig
Cultivated land	0.42	0.29	0.42	0.38	0.00	0.999
Grazing land	0.06	0.06	0.08	0.10	2.10	0.149
Wood land and settlement	0.06	0.06	0.07	0.07	0.07	0.787
Fodder land (cultivated)	0.10	0.08	0.05	0.07	17.06	0.000

4.1.2.2.Livestock holding

As per the information collected from respondents, almost all farmers (99.4%) possess livestock regardless of number and species with an average total holding of 3.73 ± 2.25 TLU. Cattle holding (4.87 ± 3.03) was highest followed by small ruminant (2.58 ± 3.28) and chicken (1.7 ± 2.73). Sheep account for major small ruminant holding. Equine holding was almost negligible (0.09 ± 0.29).

Table 6: Livestock holding per individual household as per the response (N=160)

Livestock species	Mean ± SD	Range
Cattle	4.87 ± 3.03	0 - 9
Cow	1.77 ± 1.34	0 - 3

Ox	0.56 ± 0.59	0 - 3
Bull	0.28 ± 0.48	0 - 2
Heifer	0.46 ± 0.57	0 - 2
Calf	1.81 ± 2.01	0 - 5
Small ruminant	2.58 ± 3.28	0 - 6
Sheep	2.49 ± 3.28	0 - 6
Goat	0.08 ± 0.65	0 - 1
Equine	0.09 ± 0.29	0 - 1
Donkey	0.09 ± 0.28	0 - 1
Horse	0 ± 0.00	0 - 0
Mule	0.01 ± 0.08	0 - 1
Chickens	1.7 ± 2.73	0 - 17
TLU	3.73 ± 2.25	0 - 6.9

4.1.3. The contribution of agricultural activities to the household income

Income contributions of different agricultural activities are indicated in Table 7. Farmers in the area had different sources of income where crop production is the main source of cash income (1st rank) followed by cattle (2nd rank) and sheep (3rd rank) production but there were no significant variation among project intervention and non-intervention sites. Improved forages also serve as income source (5th rank) where the contribution was significantly higher in project intervention sites as compared to non-project intervention areas.

Table 7: The contribution of different agricultural activities to the household income

Income source	Intervention		Non-intervention		X^2	Sig
	Index	Rank	Index	Rank		
Crop	0.31	1	0.32	1	3.186	0.527
Cattle	0.28	2	0.28	2	4.654	0.459

Sheep	0.21	3	0.21	3	7.264	0.202
Poultry	0.10	4	0.15	4	12.597	0.027
Forage	0.07	5	0.03	5	28.808	0.000

4.1.4. Livestock production challenges

Different livestock production challenges identified in the study area are presented in Table 8. The major constraints in both project intervention and non-intervention includes feed shortage, water shortage, disease, market problem and poor breed performance.

Table 8: Major livestock production challenges

Constraints	Intervention		Non-intervention	
	Index	Rank	Index	Rank
Feed shortage	0.33	1	0.32	1
Water shortage	0.24	2	0.23	3
Disease	0.23	3	0.25	2
Market problem	0.12	4	0.12	4
Poor breed performance	0.08	5	0.08	5

4.1.4.1. Livestock feed shortage and coping mechanisms

Percent of farm households with feed shortage, time of shortage and coping mechanisms are presented in Table 13. About 60 % in project intervention and 91.25 % in non-project intervention areas suffered from feed shortage. Most farmers faced the challenge during dry season starting from February to May in which the problem was significantly higher ($P<0.05$) in non-project intervention sites. Farmers used different coping mechanisms to alleviate the problem of feed shortage. Purchasing grass and concentrate, and feeding enset leaf are most ($P<0.05$) adopted coping mechanisms in non project intervention area compared with the intervention site.

Table 9: Feed shortage problems and coping strategy

Description	% of respondent (N=80)		X^2	Sig
	Intervention	Non-intervention		
Feed shortage			21.19	0.000
Yes	60[b]	91.3[a]		
No	40[a]	8.8[b]		
Seasons of feed shortage			22.474	0.000
Sept_Nov	0	0		
Dec_Feb	0	2.5		
Mar_May	22.5	33.8		
June_August	0	0		
Feb-May	37.5[b]	55.0[a]		
Coping mechanisms			27.844	0.000
Purchase grass	17.5[b]	37.5[a]		
Purchase crop residue	12.5[a]	5.0[b]		
Purchase concentrate	32.5	22.5		
Feed enset leaf	12.5[b]	25.0[a]		
Reduce stock	0	5.0		

4.1.5. Feed sources, their availability and utilization

Identified feed resources in the area include improved forages (desho and elephant grass), crop residues, grazing, local grass, hay, concentrates and collected fodders (weeds, trees and shrub leaves, maize and sorghum leaves). The contribution of these different feed resources as feed ration components was ranked for different classes of livestock particularly for cattle and sheep.

4.1.5.1.Cattle feed sources

The major feeds used for cattle are given in Table 10. Among major cattle feed sources identified, desho grass, crop residue and grazing were given 1st, 2nd and 3rd rank in project intervention sites. Whereas, grazing, crop residue and elephant grass contribution was ranked 1st, 2nd and 3rd in non-project intervention sites.

Table 10: Major cattle feed sources in the district (N=80)

Feed type	Intervention		Non-intervention		District level	
	Index	Rank	Index	Rank	Index	Rank
Desho grass	0.31	1	0.12	5	0.22	1
Crop residue	0.20	2	0.22	2	0.21	2
Grazing	0.19	3	0.23	1	0.21	3
Local grass (harvested)	0.12	4	0.12	4	0.12	4
Concentrate	0.04	5	0.04	7	0.04	7
Enset leaf	0.04	6	0.04	8	0.04	8
Elephant grass	0.03	7	0.14	3	0.09	5
Hay	0.03	8	0.06	6	0.05	6
Collected fodder	0.02	9	0.02	9	0.02	9

4.1.5.2. Sheep feed sources

Most commonly used feed sources for sheep are presented in Table 14. Feed resources used for sheep were similar with that of cattle except crop residues that were not commonly used by sheep. But the contributions of different feed resources were different for cattle and sheep. In the case of sheep, grazing took the 1st rank followed by desho grass and concentrate feeds in non-project intervention sites. But desho grass was given similar weight with grazing to serve as major feed resource for sheep in project intervention areas.

Table 11: Feed sources commonly used for sheep (N=80)

Feed resource	Intervention		Non-intervention		District level	
	Index	Rank	Index	Rank	Index	Rank
Grazing	0.33	1	0.41	1	0.37	1
Desho grass	0.33	2	0.17	2	0.25	2
Concentrate	0.14	3	0.13	3	0.14	3
Local grass (harvested)	0.06	4	0.02	8	0.04	7
Food waste	0.03	5	0.01	10	0.02	8
Collected fodder	0.03	6	0.07	5	0.05	5
Local brewery by-product	0.02	7	0.01	9	0.01	9
Enset leaf	0.02	8	0.05	6	0.04	6
Elephant grass	0.02	9	0.10	4	0.06	4
Hay	0.01	10	0.02	7	0.01	10

4.1.5.3.Seasonal livestock feed availability and utilization

The seasonal availability and utilization of existing feed resource are presented in Table 12. Crop residues, enset, hay and concentrate were the major feed resources available and utilized during dry season in both project intervention and and non-intervention areas. Local grass (harvested), grazing, and collected fodders were the major available feeds and frequently utilized in wet seasons. But availability and utilization of grazing was higher in non-project intervention than project intervention site while that of harvested local grass was more in project intervention during wet periods. Improved forages were mostly utilized in both dry and wet season of the year.

Table 12: Seasonal availability and utilization of feed resources (N=80)

Feed resources	% of respondents

	Dry season		Wet season		Both season	
	Intervention	Non-intervention	Intervention	Non-intervention	Intervention	Non-intervention
Collected fodder	0.0	0.0	12.5	16.3	0.0	0.0
Concentrate	10.0	12.5	1.3	0.0	22.5	22.5
Crop residue	88.8	81.3	0.0	1.3	2.5	6.3
Cultivated forage	0.0	0.0	1.3	0.0	3.8	0.0
Desho grass	2.5	0.0	2.5	7.5	95^{a}	35^{b}
Elephant grass	1.3	0.0	0.0	2.5	12.5^{b}	55^{a}
Enset	16.0	26.3	0.0	0.0	0.0	1.3
Food waste	1.3	1.3	0.0	0.0	1.3	0.0
Grazing	1.3	1.3	7.5^{b}	17.5^{a}	51.3	53.8
Hay	17.5	21.3	0.0	0.0	1.3	5.0
Local grass	1.3	6.3	28.8^{a}	6.3^{b}	10^{b}	26.3^{a}
X^2	6.440		21.597		57.522	
Sig.	0.598		0.003		0.000	

4.1.5.4. Livestock feeding practice

Seasonal feeding practice

Seasonal animal feeding practices identified are given in Table 13. Majority of the farmers were practicing individual night time feeding and controlled grazing during day time where the practice was higher ($P<0.05$) in project intervention areas. Feeding practice through free grazing was most common in non-project intervention site during dry season.

Table 13: Seasonal livestock feeding practice

Season	Feeding practice	% of respondents	X^2	Sig

		Intervention	Non-intervention		
Wet	Controlled grazing	2.0[b]	15.0[a]	22.03	0.001
	Free grazing	0.0	1.5		
	Indoor + controlled grazing	78.0[a]	59.5[b]		
	Indoor + free grazing	0.0	4.0		
Dry	Controlled grazing	2.0	5.0	24.96	0.000
	Free grazing	2.0[b]	15.0[a]		
	Indoor + controlled grazing	64.0[a]	37.0[b]		
	Indoor + free grazing	12.0[b]	23.0[a]		

Means with different suppescripts along the row are significantly different ($P<0.05$)

Supplementary feed utilization

Supplementary feed users, major supplements used and animals with access to supplementary feed are given in Table 4. Majority of the farm household both in project intervention and non-project intervention sites did have experience to use supplementary feeds including 'Atela' (local brewery by products), wheat bran, cake (noug and/or linseed), concentrate mix (balanced for fattening and dairying) and others (food grains, enset corm, food wastes, root crop tubers, sweet potato vine). Wheat bran was the most adopted supplementary feed in the study area. There was no significant ($P>0.05$) variation in supplementary feed utilization practice between project intervention and non-project intervention areas under study.

Table 14: Supplementary feed users, major supplementary feeds and animals with access to the supplementary feeds

Description	% of respondents	X^2	Sig

	Intervention	Non-intervention		
Response			3.451	0.630
Yes	71.3	82.5		
No	28.7	17.5		
Supplementary feeds			4.171	0.939
‘Atela'	6.8	4.2		
Wheat bran	63.6	63.5		
Cake	5.7	4.2		
Concentrate mix	5.7	9.4		
Others	18	19		
Animal with access			12.55	0.324
Lactating cow	35.00	40.42		
Lactating ewe	6.25	3.75		
Fattening sheep	11.25	15.42		
Fattening cattle	3.13	0.42		
Draught oxen	15.00	19.38		
Poultry	8.75	6.75		
Equine	0.63	0.63		

4.1.6. Improved forage production and forage seed and feed marketing

4.1.6.1. Improved forage production

Improved forage producers and major forages type are presented in Table 15. Majority of the farm households both in project intervention (99%) and non-intervention (82.5%) sites have experience to produce improved forage particularly desho and elephant grasses which are most common in the study area. Oat-vetch and Guatemala grass are newly introduced forage species in project intervention kebeles.

Table 15: Improved forage producers and forage type produced (N=80)

Description	% of respondents		X2	Sig
	Intervention	Non-intervention		
Do you use improved forage			12.43	0.000
Yes	99[a]	82.5[b]		
No	1	17.5		
Forage type			102.42	0.000
Desho grass	99[a]	43.75[b]		
Elephant grass	19[b]	66.25[a]		
Guatemala grass	38	0		
Oat-Vetch fodder	36	0		
Sesbania	1	0		
Vetiver	1	0		

Means with different superscript along the row are significantly ($P<0.05$) different

4.1.6.2. Purpose of forage production

Farmers produce improved forage for the purpose of cash source, feed, prevent erosion or for two or more of these functions (Table 16). Majority of the farm households produce forage for more than one function. In project intervention sites, most farmers produce desho grass as a source of feed, cash and to prevent erosion as compared to elephant grass where its production is mainly targeted for feed and prevention of erosion. Whereas, majority of farm households in non-project intervention sites produced improved forages mainly targeted for feed and to prevent erosion.

Table 16: Purpose of improved forage production by farmers as per the response (N=80)

Forage type	Purpose of production	% of respondents		X^2	Sig
		Intervention	Non-Intervention		

Desho grass	Feed	22	20	21.51	0.000
	Feed and cash source	20	0.0		
	Feed and conservation	20[b]	60[a]		
	Feed, cash and conservation	37[a]	20[b]		
Elephant grass	Feed	33	15	6.9	0.075
	Feed and cash source	13	2.0		
	Feed and conservation	47	70		
	Feed, cash and conservation	7.0	13		
Guatemala grass	Feed	57	0		
	Feed and cash source	17	0		
	Feed and conservation	3.0	0		
	Feed, cash and conservation	23	0		
Oat-Vetch fodder	Feed	86	0		
	Feed and cash source	7.0	0		
	Feed, cash and conservation	7.0	0		

Means with different superscript along the row are significantly ($P<0.05$) different

4.1.6.3.Forage seed/planting material availability

Farmers with forage planting material access, forage seed providers and available forage seed//planting materials are indicated in Table 17. About 76% and 32.5 % of farm households had access to improved forage seed/planting material in project intervention and non-intervention areas, respectively. Desho grass planting material was more accessible (99%) than elephant grass (15%) in project intervention sites and vice versa is true in non-project intervention areas. The forage seed/planting material transfer system is free gift except in cases when few farmers purchase from others. Inter Aid and 'Send a Cow' were the main providers of desho and elephant grass seed/planting material providers in project intervention area. Major forage seed/planting material provider in project intervention were NGOs ('send a Cow' and Inter Aid). Whereas, the district office of agriculture was the main provider in non-project intervention area.

Table 17: Improved forage seed/planting material accessibility (N=80)

Descriptions	% of respondents Intervention	Non-intervention	X^2	Sig
Response for accessibility			30.86	0.000
Yes	76.0[a]	32.5[b]		
No	24.0[b]	67.5[a]		
Forage seed provider			127.89	0.000
Agriculture office	7.5[b]	78.8[a]		
NGO	75.0	0.0		
Purchased from others	3.8	0.0		
Relatives	3.8[b]	21.3[a]		
WoA and NGO	10.0	0.0		
Available forage seed			77.863	0.000
Desho grass	99.0[a]	37.5[b]		
Elephant grass	15.0[b]	43.8[a]		
Guatemala grass	5.0	0.0		
Oat-Vetch forage	40.0	0.0		

NGO=Non-governental organization, WoA=Woreda office of agriculture

Means with different supperscipts along the row are significantly different (P<0.05)

4.1.6.4. Niches adopted and land allocation for forage production

Percent of farmers who allocate cultivated land common niches adopted for improved forage production are given in Table 18. Major niche types adopted for improved forage production includes farm land, soil and water conservation structures and around fence. More farmers (P<0.05) allocate more land in project intervention area than in non-project intervention one. Larger (P<0.05) area of farm land is allocated for forage production in project intervention sites.

Table 18: Niche type land allocation (ha) for improved forage production

Descriptions	Intervention	Non-intervention	X^2	Sig
	% response	% response		

Land allocation in hectare			25.354	0.000
0 - 0.05 ha	26.3[b]	65.0[a]		
0.05 - 0.1 ha	28.7[a]	17.5[b]		
0.1 - 0.25 ha	43.8[a]	17.5[b]		
More than 0.25 ha	1.3	0		
Production niches (ha)	Mean area	Mean area		
Farm land	0.08[a]	0.03[b]	8.671	0.034
Terrace	0.02[a]	0.02[a]		
Around fence	0.01[a]	0.02[a]		

**Means with different letters (a,b) along the row are statistically significant (P<0.05)*

4.1.6.5.Constraints for improved forage production

Major constraints that hampered improved forage productions are presented in Table 19. Shortage of improved forage seed/planting material was the primary constraints followed by land shortage and lack of awareness. Farmers with planting material shortage were highest ($P<0.05$) in non-project intervention. Whereas, farmers with land shortage were higher ($P<0.05$) in project intervention than those in non-project areas.

Table 19: Major constraints for improved forage production in the area (N=80)

List of constraints	% of respondents		X^2	Sig
	Intervention	Non-intervention		

Material shortage	36.3[b]	58.8[a]	13.51	0.004
Land shortage	33.8[a]	20.0[b]		
Lack of awareness	18.8[a]	20.0[a]		
Financial problem	11.3[a]	1.3[b]		

Means with different letters (a,b) along the row are statistically significant (P<0.05)

4.1.6.6.Forage seed marketing

The type of forage planting material sold and major buyers from farmers are indicated in Table 20. There was no direct marketing linkage between traders and farmers in all kebeles and there were no forage seed traders at all in the district. Accordingly, desho grass (in the form of split) was the only marketable forage planting material in the area. Farmers sold desho grass planting material for governmental, non-governmental organizations and traders. Only 13.8 % in project intervention and 1.3 % in non-project intervention areas had experience to sale desho grass as planting material.

Table 20: Forage seed marketing experience of farmers (N=80)

Description	% of respondents		X^2	Sig
	Intervention	Non-intervention		
Forage seed sale response				

Yes	13.8^{a}	1.3^{b}	9.01	0.003
No	86.3^{b}	98.8^{a}		
Planting material sold				
Desho grass splits	100	100		
Planting material buyers				
Traders	9.1	0	9.68	0.022
NGO	63.6	0		
WoA	27.3^{b}	100^{a}		
Mean selling price	100 birr/M^3	100 birr/M^3		

NGO=Non-governental organization, WoA=Woreda office of agriculture

Means with different supperscipts along the row are significantly different ($P<0.05$)

Additional information on forage seed marketing were collected from forage seed traders in Wolaita Sodo town using a checklist prepared for forage seed marketing (both buying and selling). Traders had experience to buy and sale forage seed that varied in kind and amount over different seasons and year. Major seed sources for traders over the last one year include farmers (21%), traders (65%), and research organizations (4%), collectors (2%) and own production (6%). On the other hand, they sold forage seeds for woreda office of agriculture (53%), NGOs (27%), traders (7%), research centers (11%) and individual producers (2%).

4.1.6.7.**Livestock feed marketing in the district**

a. Feed purchasing

Major feed purchased by farmers

Farmers in both project intervention and non-intervention kebeles respectively had experience to purchase different feeds (Table 21). Among these, 62.23 % and 52.02 % were concentrate feed buyers while 30% and 41.32 % were roughage feed buyers in project and non-project intervention sites, respectively.

Table 21: Major feed types purchased by farmers in the area

	% of feed buyers					
	Intervention		Non-intervention			
Feed purchased	N	%	N	%	X^2	Sig
Concentrate feeds	56	62.23	63	52.07	8.59	0.038
Bran	43	47.78	53	43.8		
Cake	5	5.56	4	3.31		
Concentrate mix	8	8.89^{a}	6	4.96^{b}		
Roughage feeds	27	29.99	50	41.32		
Crop residue	2	2.22	5	4.13		
Green forage	21	23.33^{b}	38	31.4^{a}		
Hay	4	4.44	7	5.79		
Local brewery by product	7	7.78	8	6.61		
Total response	90	100	121	100		

Means with different supperscipts along the row are significantly different (P<0.05)

Feed purchase price and quantity

Feed purchase and price information is indicated in Table 22. Purchase price for a given feed was similar in both target study sites. Farmers in non-project intervention areas purchased more feeds (P<0.05) as compared to those in project intervention sites.

Table 22: Feed quantity purchased at a time, price (birr/kg) and frequency of purchase per year

Feed type	Project status	Quantity at 1 purchase (kg)	Purchase price	Purchase frequency

		Mean	SE	Mean	SE	Mean	SE	Total
Atela	Intervention	26.57[a]	7.32	0.74	0.21	16.86	7.56	447.92[a]
	Non-intervention	21.13[b]	6.85	0.71	0.20	13.25	7.07	279.97[b]
Bran	Intervention	14.02	2.96	4.74	0.08	36.51[a]	3.05	512.01[a]
	Non-intervention	14.15	2.66	4.73	0.08	21.58[b]	2.75	305.45[b]
Cake	Intervention	2.00	8.67	12.20	0.25	10.80[a]	8.94	21.60[a]
	Non-intervention	2.25	9.69	10.50	0.28	5.00[b]	9.99	11.25[b]
Concentrate mix	Intervention	4.50	6.85	6.10	0.20	7.88	7.07	35.44
	Non-intervention	6.17	7.91	6.48	0.23	5.83	8.16	35.97
Crop residue	Intervention	124.00	13.70	1.30	0.39	2.00[b]	14.13	248.00[b]
	Non-intervention	121.00	8.67	0.95	0.25	5.00[a]	8.94	605.00[a]
Hay	Intervention	35.00[b]	9.69	2.06	0.28	4.75[b]	6.99	166.25[b]
	Non-intervention	44.43[a]	7.32	1.82	0.21	13.57[a]	7.56	602.96[a]
Green forages	Intervention	47.73[b]	8.04	1.44	0.23	5.11[b]	8.29	243.78[b]
	Non-intervention	58.57[a]	6.46	1.55	0.18	10.93[a]	16.67	632.54[a]

Market access and seasonal purchase of concentrate feeds

Information on seasonal concentrate feed purchase and market access is presented in Table 23. Majority of the farmers (70.3% in project intervention and 71.2% in non-project intervention) purchase concentrate feed during dry season of the year.

Table 23: Season of purchase and market access of concentrate feeds

Description	% of respondents		X^2	Sig
	Intervention	Non-intervention		
Season of purchase			2.81	0.422

Dry season	70.3	71.2		
Wet season	10.9	18.2		
Both dry and wet season	18.8	10.6		
Sources of concentrate			13.663	0.034
Shop in kebele	0	4.5		
Shop in district town	64.5	71.2		
Kebele local market	3.2[b]	12.1[a]		
District market	29.0[a]	9.1[b]		
Out of district	0	0		
Kebele and district market	1.6	1.5		
Shop in the district and WoA	1.6	1.5		

WoA= Woreda office of agriculture.

Means with different superscripts along the rows are significantly different (P<0.05)

Shops in district town and district market were the main sources of concentrate feeds with sufficient supply for majority of the farmers. Concentrate availability was high for majority of the farmers in both target sites in all seasons (Figure 1).

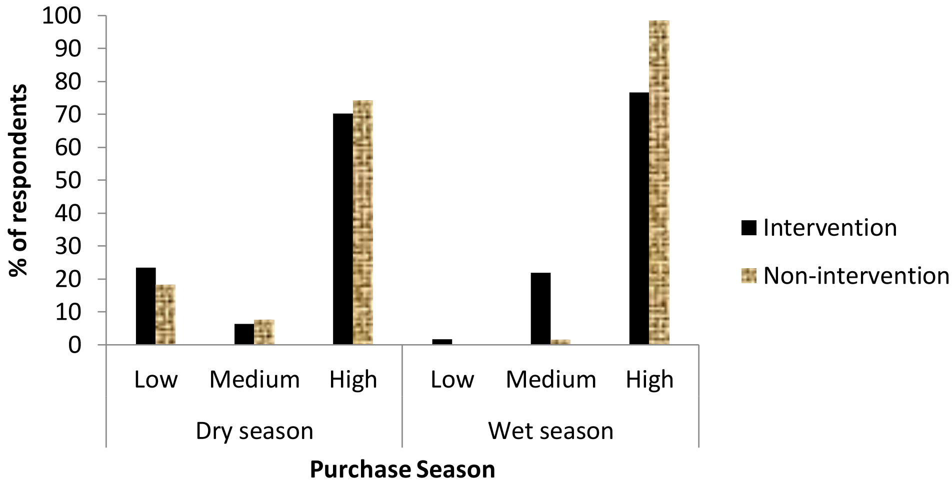

Figure 1: Seasonal availability of concentrate for purchase

b. Feed selling

Feed selling experience of farmers investigated is presented in Table 24. Accordingly, 22.5 % in project intervention and 7.5 % in non-intervention area had experience to sale feeds with the objective of covering cash sources. Desho grass was the major feeds sold by majority of farmers in project intervention areas while as elephant grass and hay were feeds sold by farmers in non-project intervention sites.

Table 24: Feed selling experience of farmers

Description	% of respondents				X^2	Sig
	Intervention		Non-intervention			
Response						
No	62	77.5[b]	74	92.5[a]	7.06	0.008
Yes	18	22.5[a]	6	7.5[b]		
Feed sold						
Desho	12	66.7[a]	1	16.7[b]	14.96	0.001
Elephant	2	11.1[b]	3	50.0[a]		
Hay	0	0.0	2	33.3		
Crop residue	4	22.2	0	0		

Means with different superscripts along the rows are significantly different (P<0.05)

4.2. On-farm Feeding and Digestion Experiment

4.2.1. Chemical Composition of Experimental Feeds

The CP and ME content of desho grass was 8.53% and 8.22 MJ/kg DM, respectively (Table 25). Noug seed cake and wheat bran used to formulate mix for this experiment had 46.79% CP and 17.43% CP. The CP and ME content of oat-vetch mixed hay used for this feeding experiment was 132.9 g/kg DM and 9.5 MJ/kg DM, respectively.

Table 25: Nutrient composition of feed ingredients (% DM, unless specified)

Feed type	DM (%)	Ash	CP	NDF	ADF	ADL	IVOMD	ME (MJ/Kg)
Desho	25.83	14.83	8.53	67.13	38.15	3.93	59.14	8.22
Oat-Vetch	86.89	9.55	13.29	61.74	35.82	6.71	60.78	9.5
Concentrate mix	89.33	6.61	24.68	46.96	11.61	2.43	71.74	10.9
Wheat bran	89.33	1.3	17.43	47.55	8.61	0.25	77.25	12.4
Noug cake	89.53	17.23	46.79	45.78	17.61	6.77	60.72	8.17

4.2.2. Dry Matter and Nutrient Intake

Dry matter and nutrient intake of sheep is shown in Table 27. Oat-vetch DM intake increased, but CP and ME intake decreased with increasing proportion of oat-vetch in the supplement. The intake of desho grass for T2 was significantly higher than that of T1 and T4. The highest (P<0.05) concentrate and OM intake was for T1. The highest (P<0.05) total DM intake was in sheep fed T1 and T2 diets. When expressed to the metablic body weight the highest (P<0.05) total DM intake was for T1.

Table 26: Daily dry matter and nutrient intake in sheep fed different proportion of concentrate and oat-vetch

Feed parameter	Treatments				SEM	CV	SL
	T1	T2	T3	T4			
Oat-vetch DM intake (g day $^{-1}$)	0.00	91.71^{c}	183.73^{b}	256.02^{a}	3.98	2.99	0.000
Desho grass DM intake (g day $^{-1}$)	439.49^{b}	440.66^{a}	440.44^{ab}	434.80^{c}	0.93	0.23	0.000
Concentrate DM intake	302.60^{a}	204.70^{b}	106.80^{c}	0.00	0	0	0.000
Total DM intake (g day $^{-1}$)	742.09^{a}	737.07^{a}	730.96^{b}	690.83^{c}	3.96	0.55	0.000
DMI (% BW)	2.95^{a}	2.85^{c}	2.91^{b}	2.84^{c}	0.02	0.56	0.000
DMI per kg $W^{0.75}$	66.06^{a}	64.24^{c}	65.18^{b}	63.02^{d}	0.36	0.55	0.000
OM intake (g day $^{-1}$)	665.56^{a}	655.33^{b}	641.46^{c}	601.92^{d}	3.18	0.50	0.000
CP intake (g day $^{-1}$)	112.65^{a}	105.19^{b}	94.57^{c}	79.61^{d}	1.04	1.06	0.000
NDF intake (g day $^{-1}$)	446.12^{d}	454.66^{b}	460.61^{a}	449.96^{c}	2.18	0.48	0.000
ADF intake (g day $^{-1}$)	199.69^{d}	222.63^{c}	244.08^{b}	257.57^{a}	1.27	0.55	0.000
ME (MJ/kg DM) intake	7.00^{a}	6.94^{b}	6.68^{c}	6.44^{d}	0.03	0.51	0.000

Means along row with different subscripts (a,b,c,d) are significantly different at P<0.05. T1=Desho+100% Concentrate, T2=Desho+67% concentrate+33% oat-vetch, T3=Desho+33%

concentrate+67% oat-vetch, T4=Desho+100% oat-vetch, SEM= Standard error of mean, CV= Coefficient of variation, SL= Significance level

4.2.3. Dry Matter and Nutrient Digestibility

Dry matter and nutrient digestibility in sheep fed different proportion of concentrate and oat-vetch are presented in Table 28. Sheep fed T2 had highest (P<0.05) DM, OM, and NDF digestibility. The CP digestibility in T2 and T3 were similar (P>0.05) but higher (P<0.05) than T1 and T4 which had no difference (P>0.05) to each other. The highest (P<0.05) ADF digestibility was for T2 and T3.

Table 27: Apparent digestibility of dry matter and nutrients in sheep fed different proportion of concentrate and oat-vetch mixture

Parameters	Treatments				SEM	CV	SL
	T1	T2	T3	T4			
DM	64.94^{c}	82.83^{a}	76.87^{b}	66.97^{c}	2.06	2.83	0.001
OM	72.71^{c}	86.52^{a}	81.34^{b}	74.91^{c}	1.56	1.98	0.001
CP	79.60^{b}	90.68^{a}	88.15^{a}	81.46^{b}	2.91	3.43	0.003
NDF	70.67^{c}	85.61^{a}	81.48^{b}	75.46^{c}	1.55	1.98	0.001
ADF	54.42^{c}	78.87^{a}	76.89^{a}	70.72^{b}	1.95	2.77	0.001

Means along row with different subscripts (a,b,c,d) are significantly different at P<0.05. T1=Desho+100% Concentrate, T2=Desho+67% concentrate+33% oat-vetch, T3=Desho+33% concentrate+67% oat-vetch, T4=Desho+100% oat-vetch; DM= Dry Matter, OM=Organic matter, CP= Crude protein, NDF= Neutral detergent fiber, ADF= Acid detergent fiber, SEM= Standard error of mean, CV= Coefficient of variation, SL= Significance level

4.2.4. Weight gain and Feed conversion efficiency

Initial and final body weight, average daily gain and feed conversion efficiency of sheep fed different proportion of concentrate and oat-vetch mixture are given in Table 29. Sheep fed T2 diet showed highest (P<0.05) average daily gain and feed conversion efficiency.

Table 28: Weight gain and feed conversion efficiency in sheep fed different proportion of concentrate and oat-vetch

Descriptions	Treatments				SEM	CV	SL
	T1	T2	T3	T4			
Initial weight (kg)	21.08^a	21.04^a	20.99^a	21.20^a	0.43	2.02	0.781
Final weight (kg)	29.25^b	30.71^a	29.21^b	27.49^c	1.16	3.97	0.000
Average daily gain (g)	109.0^b	130.0^a	110.0^b	86.2^c	0.02	14.9	0.000
FCE	0.146^b	0.17^a	0.15^b	0.12^c	0.02	14.7	0.002

Mean along rows with different superscript letters (a,b,c) are significantly different (P<0.05). T1=Desho+100% Concentrate, T2=Desho+67% concentrate+33% oat-vetch, T3=Desho+33% concentrate+67% oat-vetch, T4=Desho+100% oat-vetch, FCE= Feed conversion efficiency.

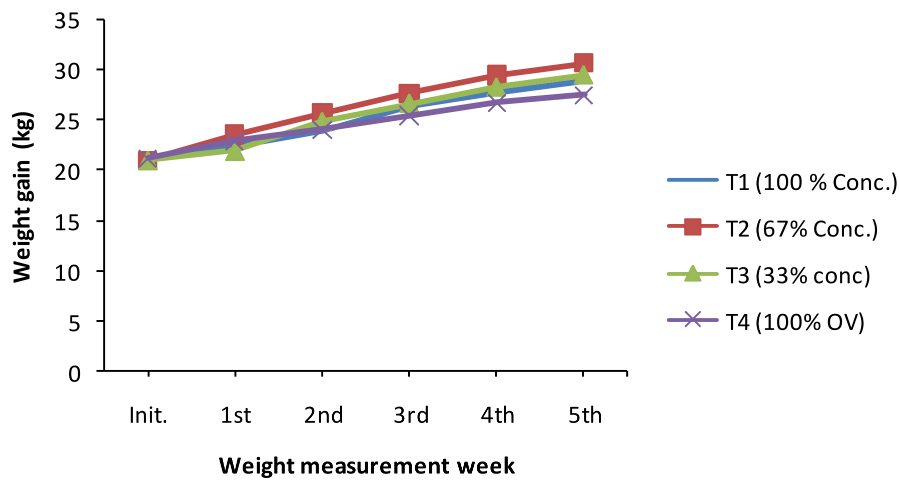

Figure 2: The weight gain trend of sheep

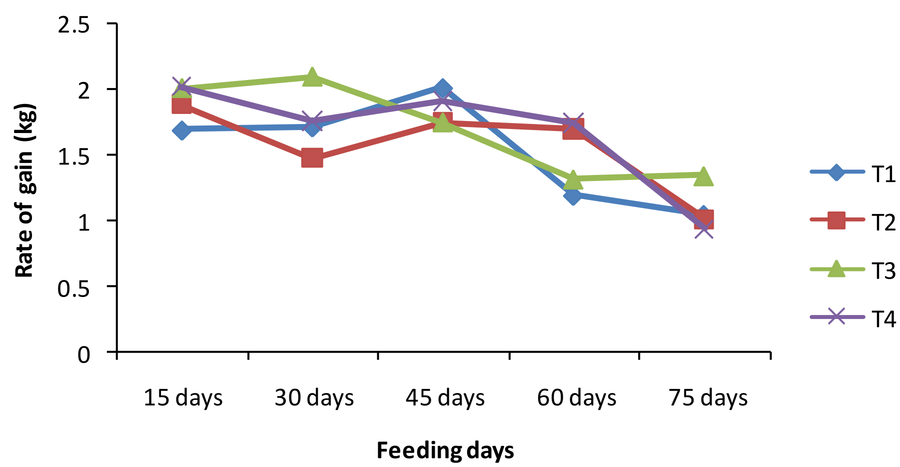

Figure 3: Rate of weight gain of sheep under different treatment

There was decrease in rate of gain with an increase in experimental duration. The mean rate of gain on 15th, 30th, 45th, 60th and 75th days were 1.9 kg, 1.76 kg, 1.86 kg, 1.49 kg and 1.1 kg, respectively.

4.2.5. Partial Budget Analysis

Total variable costs, gross return, net benefit and marginal rate of return are indicated in Table 30. The mean purchase and selling price were 38 and 43 Ethiopian birr per kg live weight, respectively. According to the results of partial budget analysis, the highest net benefit was obtained from the use of T2 (433.09 birr/head), followed by T3 (394.86 birr/head), T1 (344.40 birr/head) and T4 (337.20 birr/head). According to dominance analysis, T1 and T4 were dominated by other treatments, hence, eliminated from further economic analysis. Based on the marginal analysis, T3 (353.74% ^{MRR}) and T2 (145.48% ^{MRR}) were superior to other treatments.

Table 29: Partial budget analysis in sheep fed different proportion of concentrate and oat-vetch mixture

	Treatment			
Description	T1	T2	T3	T4
Initial wt	21.08	21.04	20.99	21.2
Final wt	29.25	30.71	29.21	27.49
Cost of Oat-Vetch	0	13.13	26.25	39.38
Cost of concentrate	112.5	112.5	112.5	0
Variable feed cost (total)	112.5	125.63	138.75	39.38
Animal purchase cost	800.85	799.43	797.53	805.6
Total variable cost (A)	913.35	925.05	936.28	844.98
Animal selling price (B)	1257.8	1320.64	1256.14	1182.2
Net income (C) = (B-A)	344.4	395.59	319.86	337.2
Change in Total Variable Cost (TVC)	25.8	26.28	16.3	0
Change in Net Benefit (NB)	-88.69	38.23	57.66	0
MRR (%) = (ΔNR/ΔTV Cost)*100	DM	145.4718	353.7423	DM

MRR = Marginal Rate of Return

T1=Desho+100% Concentrate, T2=Desho+67% concentrate+33% oat-vetch, T3=Desho+33% concentrate+67% oat-vetch, T4=Desho+100% oat-vetch

5. DISCUSSION

5.1. Survey on forage production, feed resource utilization and marketing

5.1.1. **Household characteristics**

Average family size of a household (6.56) in the current study is in agreement with previous assessment report (7.3) (Biruk, 2014) conducted in the same location from different agro ecology and in Anelemo district (6.47) (Salo et al., 2017). It was also similar with reports in Horro and Gududru districts (Kassahun et al., 2015), and Fogera, Jeldu, and Diga districts (Ayele *et al.*, 2012). However, it was in contrary with reports (9.92) for Adami Tulu Jiddo-Kombolcha district (Dawit *et al*., 2013). In most rural part of Ethiopian, family members are the main source of household labor. Hence, large family size could be taken as an opportunity with regard to accomplishing laborious farm activities. However, large family size could have negative impact on the livelihood of the family if economic activities and income sources are limited (Abba, 2010).The presence of large family size might be attributed to labor demanding agricultural activities in the area (Yadessa, 2015) and/or lack of awareness on proper family planning methods.

Education plays great role in transferring technology and in initiating farmers' willingness to adopt different technologies. Accordingly, presence of large number of educated people who attended primary and secondary education in the study area can be considered as an opportunity to easily disseminate different technologies through strengthened trainings. Majority of the household head being in the range of active working age groups is also a big opportunity to undertake multiple tasks. The average age of household in the current study was similar with average household age of 39.5 (25-75 years) reported for Dandi district of west Shewa zone (Mamaru and Tadele, 2017).

5.1.2. Farming characteristics

5.1.2.1. Occupation and land holding

Major occupation in the district being farming followed by both farming & petty trading in both intervention and non-intervention sites, respectively, indicated that farming (both crop and livestock), is the main means of living in the in the study area.

The total average land holding per household in the project intervention and non-intervention areas in the current study were similar with reports for average land holding (0.66 ha) in Anelemo district (Salo *et al*., 2017) and for Doyogena district (0.5-1 ha) (Mekonnen *et al*., 2014). However, the value in the current study was lower than a report for Burie district (Abebe *et al*., 2013), for Horro and Gududru district (Kassahun *et al*., 2015) and for Gambella region (Bizelew *et al*., 2016). This indicate that the land holding size was not in line with household family size which could have an impact on the livelihood of farmers in the study area due to shortage of cultivated land. This situation further will exacerbate the problem unless development options are arranged for landless groups, and intensive and wise land resource use practices are applied.

5.1.2.2. **Livestock holding**

Cattle and sheep holding report in the current study was similar with reports for Anelemo district of Hadiya zone, SNNPR. Keeping small number of animals is related to the availability of feed resources (Österle *et al*., 2012). The higher number of cattle could be attributed to the high demand of cultivation activities, cash source and for animal source foods (Salo *et al*., 2017). The small number of small ruminant holding could be due to shortage and poor productivity of grazing land (Ahmed *et al*., 2010), where sheep frequently could satisfy their dry matter requirement through grazing, and less forage availability to be offered through cut and carry system.

5.1.3. Household income contribution of agricultural activities

The highest contribution of crop as cash source of farm households could be associated with production of coffee and root crop like sweet potato and Irish potato, and cereals like wheat and teff . This result is in consistent with report for Lemu district of Hadiya zone (Workneh *et al*., 2015). The lower contribution of small ruminant as compared to cattle is related with small sheep holding.

5.1.4. Livestock production challenges

Based on the current study, feed shortage which was identified as a primary constraint hindering the production and productivity of livestock in the study area was due to limited forage production and poor forage species diversification that in turn was linked with small land holding and low planting material distribution. Water shortage, disease, poor animal performance and market were the other constraints investigated in the study area. These problems were in line with reports for Horro and Gududru districts (Kassahun *et al*., 2015). Consideration of breed performance as least important problem by majority of the farmers among others indicate the existing breed can have untapped productive potential as far as proper feeding, health care and all other necessary husbandry practices are properly employed. Moreover, local breeds are resistant to disease and can perform better under limited feed availability and easy management condition (Getahun, 2008; ESGPIP, 2008; Marufa *et al*., 2017).

5.1.4.1. Livestock feed shortage and coping mechanisms

As per the current study result, major farm households were suffered from livestock feed shortage with significant difference between project intervention and non-project intervention. The main season with livestock feed deficiency in the area started from the end of January to the beginning of May which is in line with reports for highland of Ethiopia (Yami *et al*, 2015). The feed shortage problem during dry seasons in the study area is related with moisture stress that resulted in low herbage growth on existing grazing land (Ashenfi et al., 2013). Crop residues which are serving as the main source of roughage during dry season (Mekasha et al., 2014; Salo et al, 2017) are low in their nutrient content (Deribe, 2015). Many farmers relayed on purchased roughage and concentrate, and enset feeding in response to the existing feed shortage. More roughage feed purchase in non-project intervention is related with limited forage development efforts.

5.1.5. Feed resources, their availability and utilization

The highest rank given for desho grass in project intervention kebeles indicated that the grass was the most important green feed resource and is replacing contribution of natural pasture that have been depleted over time (Mekasha et al., 2014). In contrary, improved forage contribution was low in non-project intervention areas due to limited forage development and that is why crop residue and grazing took the highest contribution. The highest index value for grazing as sheep feed resource doesn't mean sufficient grazing is available for sheep. Rather, it was based on the assumption that sheep can satisfy their need from existing grazing land relative to large ruminants.

The major livestock feed resources identified in the study area were similar with reports for Anelemo district of Hadiya zone (Salo *et al.*, 2017) and their availability varied with season (Asefa *et al*., 2015). Regardless of the biomass, most farmers in both project intervention and non intervention sites use improved forages in both dry and wet season. But still there were farmers who use improved forages during dry season of the year in non-project intervention sites where the trend was in agreement with reports with other areas in which farmers use improved forage during dry periods (Asefa, 2015; Salo *et al.*, 2017). During dry period, there are feed shortage, especially green feeds as common problem in other areas of the country (Yami et al, 2015). Crop residues which are poor in nutritive value (Gizachew and Smit, 2005), and hay to some extent are the major feed resource used during dry season in the study areas with similar pattern in other area (Salo *et al*., 2017).This indicated that improved forages are playing big role in covering the gap for green feed during dry periods. The situation call for the scaling up of improved forage using different production strategies and niches.

Concentrate feed utilization in the study area was high during dry period. Farmers do this with the objective of supplementing poor quality roughages that are available during dry season. As a result of grazing land shortage that resulted in less animal holding, majority of farm households practice day time controlled/tethered grazing and night time feeding in individual pen with significant variation between project intervention and non-intervention sites. This trend is advantageous to facilitate watershed based soil and water conservation activities in the district. But, it needs to boost feed availability through intensive improved forage production.

5.1.6. Improved Forage Production, Seed and Feed Marketing

5.1.6.1. Improved forage production

Desho grass was the most dominant improved forages species adopted in the study area which was also reported as common improved forage in other areas of the region (Mekonnen *et al*., 2014; Asefa *et al.*, 2015; Salo *et al*., 2017). This situation calls for additional effective extension service so as to encourage farmers to use improved production and utilization systems. There were little attempts made for introduction and development of legume forage which needs due attention by development and research practitioners in order to boost protein source feeds in the district.

Improved forage production is believed to overcome feed shortage but is constrained by many challenges including small land holding, encroachment of food crop production, lack of forage seeds, and limited knowledge on forage species and their production systems. This situation was exacerbated by absence of improved forage seed provision and transfer system in the area. In contrary to report for Anelemo district (Salo *et al*., 2017) and Robi district (Yadessa, 2015), in which land was primary constraint, forage seed/planting material shortage was the primary constraint followed by land shortage and lack of awareness in the current study area.

5.1.6.2. Purpose of forage production

The objective of improved forage production targeted for multipurpose role in the study area is consistent with the results reported for Shashego district of Hadiya zone (Asefa et al., 2015). The limited role (feeding and erosion only) of forage production in non-project intervention is related with the lower availability of intensification of improved forage. As a result the forage produced was not sufficient enough for sale. More farmers in non-project intervention purchase more feed especially green roughage feed to cover feed gap during dry season of the year.

5.1.6.3. Forage seed/planting material marketing

Farmers experience in buying forage seeds was very minimum due to lack of access to the required forage seeds, high seed price (forage seeds from traders are very expensive that cannot be afforded by farmers), and lack of awareness (limited knowledge of improved forage seed varieties). Hence, farmers were limited to buy small amount of desho grass from other neighboring farmers. This situation was similar with reports for Doyogena district of Kembata Tembaro zone (Zekarias *et al*., 2016). Though presence of forage seed marketing is considered to ensure forage seed availability and consequent forage production (Bassa *et al*., 2016), there was no direct marketing linkage between traders and farmers in the district and even there were no forage seed traders at all in the study area. Desho grass (in the form of split) was the only marketable forage planting material in the district.

5.1.6.4. Niches adopted and land allocation for forage production

Forage production niches adopted in the area were similar with reports for Doyogen district of Kembata Tembaro zone where terrace plantation was the most common niche (Bassa et al., 2016). Larger area of farm land was allocated for forage production by majority of the farmers in project intervention areas, which might be related to better provision of seed/planting material and better adoption of improved forages for their multipurpose roles including cash source. This indicated that choice of niches in the study area depends on the availability of planting material and the role of production (Asmare *et al*., 2016) rather than farm land size which was not in consistent with report by Njarui et al. (2017). Moreover larger farm land allocation by more number of farmers in project intervention indicated strong interest of farmers for improved forage production if they are provided planting material with necessary trainings on production and utilization systems.

5.1.6.5.Constraints of improved forage production

The higher number of farmers with forage planting material shortage in non-project intervention sites could be associated with the limited forage seed supply (Bassa *et al*., 2016). Whereas, the higher number of farmers with land shortage problem in project intervention could be attributed to more production of improved forage grass that took additional land. Lack of awareness on different improved forages and production strategies over the shortage of land and improved forage seeds had hampered the scaling up of improved forage technologies. Hence, this situation calls attention for application of different forage development strategies and introduction of legume forages that can be integrated with other cropping system.

5.2.On-farm Feeding and Digestion Experiment

5.2.1. Chemical Composition of Experimental

In the current study, The mean CP content of desho grass in the current study is in agreement with result obtained from highland (8.17 %) and midland area (9.55 %) (Asmare, 2016), that was harvested at 3 months of age. The CP content in the current study is greater than the CP content (6.5%) of the same species reported by other researchers (Waziri *et al*., 2013; Heuze and Hassoun, 2015) in other locations. The mean energy content (8.22 MJ/kg) of desho grass used in the current experiment was greater than another finding reported by Asmare (2016) in both highland (6.69 MJ) and midland (6.82 MJ) areas at three month cutting age .This result indicates that desho grass can satisfy the energy requirement (6.4MJ/kg DM) of growing male sheep with 20 kg live body weight and 150 gram mean daily gain, but require protein supplement to satisfy the metabolisable protein requirement (61-76 g) of the same class of animal (McDonald *et al.*, 2010). The mean CP content of Oat-vetch hay (13.29 %) was lower than CP content of the same mixed forage species reported in another finding (15 %) by Bezabih *et al*. (2016). The CP content of oat-vetch used in the current feeding experiment was above the minimum level of 7.5 % required for optimum rumen function (Negash *et al*., 2017 quoting Van Soest, 1982) and is sufficient enough to satisfy the nutrient requirement of sheep when supplemented to desho grass. The CP content of Noug seed cake (46.79%) was higher than the report (30.8 %) by Abebe (2008) . The difference between the CP content of Noug seed cake used in the current study and other study might be due to the oil extraction methods. Wheat bran used in the current study (17.43 %) was similar with CP content (17 %) reported (McDonald *et al.,* 2010).

5.2.2. Feed dry matter and nutrient intake

As per the current finding, the higher total dry matter intake observed in T1 could be related with the high intake of concentrate in this treatment group. The highest basal diet intake observed in T2 might be attributed to increased preference to green feed and higher rate of digestion of oat-vetch supplement (supplemented in lower amount) that have lower NDF concentration (Negash *et al*., 2017). The highest OM, CP and ME intake in T1, T2 and T3 in respective order could be attributed to the higher nutrient concentration in mixed concentrate supplement. This result is in agreement with Ajebu and Yunus (2014) where they observed increased DM and CP intake on malt sprout and 'atela' supplementation over grass hay for sheep. The increase in NDF intake in T3 and then T2 could be attributed to the increased amount of oat-vetch inclusion. On the contrary, the lower NDF intake in T4 (with the highest amount of oat-vetch inclusion) and T1 (with no oat-vetch inclusion) could be attributed with lower total dry matter intake in T4 and limited fibrous feed proportion in T1 (Negash *et al*., 2017). The mean total daily dry matter intake in this experiment was higher than the requirement (560 g/ day) indicated by McDonald et al. (2010). Moreover, mean basal feed dry matter, OM intake, DMI per kg $W^{0.75}$ and crude protein intake were higher than the value reported by Asmare (2016) for Washera sheep fed on different proportion of desho and local grass hay. The mean CP intake in the current study was also higher than the CP intake of Adilo sheep (71-103g) (Ajebu and Yunus, 2014); Black Headed Oganden (83 g), Horro (93 g) and Washera (89 g) sheep breeds fed

150-350 gram concentrate fed grass hay basal diet (Ayele *et al*., 2017) and that of Washera sheep breed fed desho and local grass hay with 300 g concentrate (77.6 g) (Asmare, 2016). The mean total dry matter intake per kg $W^{0.75}$ (64.63 g) was also higher than Washera sheep breed feed desho and local grass hay as a basal diet. The intake variation with other findings may be attributed to feed palatability, mechanism of feed preparation (including chopping), feed offer (being fresh in the current study) and feeding management including proper storage (McDonald *et al*., 2010; Karimizadeh *et al*., 2017).

5.2.3. Dry matter and Nutrient Digestibility

Digestibility can be affected by feed chemical composition, ration composition, feed processing, level of feeding and animal factor (McDonald *et al*., 2010). Higher DM, OM and NDF digestibility in T2 and T3 could be attributed to the lower NDF content of oat-vetch mixed forage in the treatment diets which was supported by other reports indicating legume fibers ferment more rapidly in the rumen (Negash et al., 2017). The lower digestibility of DM, OM and CP in T1 (with highest concentrate inclusion) could be associated with decreased activity of cellulolytic microorganisms (‘pH effect’) and/or preference to starch feeds (carbohydrate effect) (MacDonald et al., 2010). It could also be attributed to the physical size reduction of green basal diet which would result high passage rate which is supported by other findings (Karimizadeh *et al*., 2017). The mean digestibility of DM, OM, CP, NDF and ADF in the current study were higher than the values reported for black headed Ogaden, Horro and Washera breeds fed local grass hay and concentrate (Ayele *et al*., 2017). As per the current study, T2 and then T3 diet combinations were the best for their higher digestibility of major nutrients.

5.2.4. Weight Gain and Feed Conversion Efficiency

The highest body weight gain attained in T2 could be attributed to the higher DM and nutrient digestibility and the higher DM, CP and ME intake as well. The similarity of weight gain in sheep fed T1 and T3 could be associated with the higher DM, OM and CP intake but lowest digestibility of these nutrients in T1 and lower intake of DM, OM and CP but with highest digestibility in T3. The lowest daily weight gain of sheep fed T4 was related with lower intake and digestibility DM and other nutrients. The highest feed conversion efficiency of sheep fed T2 diet could be associated with highest digestibility of the treatment diet. The average daily weight gain achieved in the current performance study was higher than reports for Horro breed (63-75 g) and Menze breed (15-51 g) with on-farm management (ICRDA, 2017); Washera breed fed different proportion of desho and local grass hay (52-76.4 g) (Asmare, 2016), on local grass hay with concentrate (43.3 g) (Ayele *et al*., 2017), on local grass hay supplemented with different proportion of lupin and concentrate (73.7-91.3g) (Likawent, 2012), on treated rice straw with concentrate supplementation (25-34 g) (Hailu *et al*., 2011); Horro breed (59.8 g) and black head Ogaden (49.2 gm) fed on local grass hay plus concentrate (Ayele *et al*., 2017), Horro breeds fed *Vernonia amegdalina* and sorghum grain (60.4-956 g) (Firisa *et al*., 2013); and Afar breed (36.95-79.36 g) and Black head Ogaden (33.48-65.19 g) that fed on wheat straw with 300 gm concentrate supplementation (Getahun, 2014). The mean daily weight gain in the current study was also higher than Bonga and Doyogena sheep (95-107 g) (ICARDA, 2017); Doyogena sheep (52-110 g) kept on grazing with 200 gram oat-vetch and 200 g concentrate supplementation (Bezabih *et al*., 2016); and local sheep breeds in Hawassa zuria district (89-111 g) kept on grazing with multinutrient block supplementation (Estifanos *et al*., 2014). The weight gain variations between the results obtained in the current study and other findings probably is attributed to differences feed quality (both offer and supplement), form of feed offer (fresh versus dried), form of feed preparation and handling (chopping and storage), farmers' care and management, animal movement (restricted versus free movement), environmental variation, and probably breed and age. Most basal feeds used in the previous findings indicated above were local grass hay and straw that are expected to be lower than green desho grass. The higher performance of sheep in the current study is attributed to sufficient nutrients contents, higher dry matter and nutrient intake and higher digestibility of diets in the treatment compositions.

The decreased on growth rate of experimental animals under each feed treatments towards advanced feeding period might be due to the increased lignifications and decreased quality of basal feed (desho grass). It also might be related with deceased biological potential of animals with advancement of age. The sheep performance evaluation result in the current study revealed that T2 is the best diet composition followed by T3.

5.2.5. Partial budget analysis

As per the current finding, higher net benefit can be obtained from T2 followed by T3 diet compositions. The marginal rate of return obtained from T3 (353.74 $\%^{MRR}$) and T2 (145.48 $\%^{MRR}$) implies that for 1.0 Birr investment in sheep production, the producer can get Birr 3.54 and 1.45 in T3 and T2, respectively, and they were recorded above the minimum acceptable rate of return (CIMMYT, 1988). Hence, T3 diet composition is affordable and economical for majority of the farmers as there might be financial constraint to purchase more concentrate.

6. CONCLUSION RECOMMENDATION

6.1.Conclusion

The top most livestock production challenge in the study area was feed shortage where the common feed shortage season started from end of January to the beginning of June. The feed shortage problem was severe in non-project intervention areas as a result of limited improved forage production. Purchased feeds and enset leaf were used as a coping mechanism against feed shortage.

Desho grass which is the dominant improved forage and major contributor of livestock feed in the area need strong extension work to promote its production and utilization in line with introducing additional and new improved forage legumes. Presence of development projects brought some improvements on improved forage production, feed availability and utilization, which could be taken as best practice by other concerned stake holders to scale up improved forage technology packages.

Desho grass is a very good energy source but needs protein supplements for better animal performance. In this regard, oat-vetch mixed forage could play in covering this gap. As per the current animal performance evaluation study conducted at on-farm in the district, using desho grass as a basal diet with 200 g mixed concentrate (wheat bran and noug cake at 2:1 ratio) with 100 gram oat-vetch mixed forage at dry matter level can result in highest growth performance on growing lambs. The highest growth potential of sheep in T2 was attributed to the higher intake, nutrient content and digestibility of the treatment diet compositions. Economically, the highest return can be obtained using T3 (100 g concentrate with 200 g oat-vetch forage as a supplement over desho grass). Hence, desho has become promising forage grass for improving production and productivity of livestock when provided as green at its young stage of growth (2-3 months age). Oat-vetch mixed fodder which is very good source of protein and energy which can satisfy the nutrient requirement of growing animals especially if supplemented with small amount of concentrate feeds. Highest Marginal rate of return can be obtained in T3 diet (using 100g concentrate and 200g oat-vetch) which is the best option for farmers with financial scarcity to purchase more concentrate.

6.2. Recommendation

Based on the current research work, the following issues are recommended to be employed in the area.

- Distribution of promising desho grass cultivars with management and utilization package is essential from concerned stake holders (research and development organizations).
- Strong and continuous training and extension service is due attention on improved forage technologies packages.
- Sustainable improved forage seed/planting material transfer system need to be established.
- Introduction and intensification of multipurpose legume forages should be given attention so as to improve the availability of protein source feed.
- Further study is recommended on the effects of those forages on carcass quality.

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APPENDIXES

APPENDIX 1

Questionnaire for "Assessment of *feed resource management and utilization*" in Damote Gale district of Wolaita zone

The information obtained from this interview questionnaire will be used only for academic purpose and the personal information will be kept confidential. I, therefore, kindly request you to feel free in answering the questionnaire. Thank You.

I. General Information

Region	SNNPR	Starting time: ___
Zone	Wolaita	
Woreda	Damot Gale	
Kebele		
Got/ village		
Household Head Name:____ Sex: 1.Male 2.Female Age:_____		
Respondent Name (if different from HH): ___________________________Sex: 1.Male 2. Female Age:_____		
Enumerator Name:________________________________ Phone No. _____________________		
Date of interview:		
GPS location: Latitude _______________________ Longitude________________________		

II. Socio economic characteristics

1. **Household characteristics**

1.1. Age, sex and educational status of family members

Age	Total		Educational status (indicate number)						
	1. Male	2. Female	1. (Illiterate)	2. (1-4)	3. (5-8)	4. (9-10)	5.(11-12)	6.Diploma	7.Degree
0-5									
Jun-14									
15-30									
31-65									
>65									
Total									

2. Religion: 1. Orthodox 2. Protestant 3. Muslim 4. Catholic 5. Others
3. Marital status of HH: 1. Single 2. Married 3. Divorced 4. Widowed 5. Others (specify)
4. Family members participate on active works

Age	Number of active workers	
	1. Male	2.Female
0-5		
6 - 14		
15-30		
31-65		
>65		
Total		

2. Farming characteristics

1. Occupation and land holdings

2.1.1. What is your major occupation? 1. Farming 2. Trading 3. Laborer 4. Others (specify)

2.1.2. In which wealth group do you get yourself? 1. Low income 2. Middle income 3. High income

2.1.3. How much area is your land holding (please specify the unit if different from hectare)?
1. Cultivated land (ha) ______ 2. Grazing land (ha)_______ 3. Woodlot(ha) _______
4. Fodder crop (ha)_________ 5. Others (specify)(ha)_____ 6. Total land (ha)_______

2.1.4. Do you rented in land? 1. Yes 2. No

2.1.5. If yes, why do you rented in land? 1. For crop production 2. For forage production 3. Others (specify)_

2.1.6. If yes for Q 2.1.4, how much do you rented in? ________ ha.

2.1.7. Do you rented out land? 1. Yes 2. No

2.1.8. If yes for Q 2.1.7, how much area do you rented out? ______ ha.

2. Crops grown on a farm

2.2.1. What food crops do you grow in your farm? How much would you normally expect these areas to yield (in quintals)? What do you do with the residue materials (as a percentage)? (detail for these crops will follow in the table).

Crops	Area (ha)	Yield (qt/ha)	Residue use (%)				
			Feeding	Burnt	Mulching	Sold	Other (specify)

3. Livestock Production

2.3.1. Do you have farm animals/livestock? 1. Yes 2. No

2.3.2. If yes for Q 2.3.1, describe the type and quantity of animals you have currently.

Type of animals	Number of animals		
	Local	Cross	Total
Cow			
Milking cow			
Dry cow			
Ox			
Bull			
Heifer			
Calf			
Male			
Female			
Sheep			
Ewe			
Ram			
Lamb			
Male			
Female			
Goat			
Doe			
Buck			
Kid			
Male			
Female			
Equine			
Donkey			
Horse			
Mule			
Poultry			
Cock			
Hen			
Chicken			

2.3.3. What is the major purpose of keeping animals? (fill the following table)

Type of animals	Purpose of keeping (Tick)					
	1.Cash source	2. Food source	3. Manure	4. draught power	5.Transport	6. Rearing
Ox						
Cow						
Sheep						
Calf						
Goat						
Equine						
Poultry						

2.3.4. Household Income contribution of different farming activities (in ranking order)

Farming activity	Rank (1-6)
Cattle production	
Sheep/Goat production	
Poultry production	
Apiculture/bee keeping	
Equine (cart donkey & horse)	
Crop production	
Others (specifiy)	

2.3.5. Livestock production challenges (Rank in order of importance)

Farming activity	Rank (1-5)
Feed shortage	
Disease	
Poor breed performance	
Water shortage	
Market problem	
Others (Specify)---------	

4. Feed resources utilization, Forage Production and Marketing

2.4.1. What are the major feed resources you used to feed for your animals?

S/N	Livestock class	Rank in coverage of the diet	Source of feed (Tick)			Seasonal availability (Tick)		
			1.Grow naturally	2.Produced	3.Purchased	1.Dry season	2. wet season	3. Both season
Large ruminant (Cattle)								
Small ruminant (sheep & Goat)								
Equines								
Poultry feed sources								

2.4.2. Do you produce improved forages? 1. Yes 2. No

2.4.3. If yes for Q 2.4.2, describe type of forages, purpose and site of production in the table below. If no, escape to Q 2.4.13.

2.4.4. Do you have sufficient access to improved forage seed/planting materials? 1. Yes 2. No

2.4.5. What is your source of forage planting material? 1. Agriculture office 2. NGO 3. Research centers 4. Purchase from other farmers/market 5. Others(specify) ______

2.4.6. If NGO is source of forage planting material, what is the name of NGO? ________________________

2.4.7. How do you get forage seeds from organizations? 1. Free gift 2. Through credit 3. Through sale

2.4.8. Describe Type of forages plating materials you have sufficient access to. ____

2.4.9. Do you sell improved forage seeds/planting material? 1. Yes 2. No

2.4.10. If yes, list type of forage planting materials you sale. _______________________________

2.4.11. What is the selling price for each type? ____

2.4.12. If yes, for whom do you sell forage seed? 1. Farmers 2. Traders 3. NGO 4. Research center 4. WoA

2.4.13. If you do not produce improved forages, what are the reasons behind?1.Shortage of land 2. Shortage of planting material 3. Lack of awareness 4. Financial problem 5. Others (specify)________________

2.4.14. Do you purchase feed? 1. Yes 2. No; If yes, fill the following table (put price in range)

Feed purchased	Price/local unit	Local unit name	Local unit how many Kg	Quantity purchased each time (local unit)	Number of times purchased per year

2.4.15. Do you sell feed? 1. Yes 2. No; If yes fill the following table (put price in range)

Feed sold	Price/local unit	Local unit name	Local unit how many Kg	Quantity sold each time (local unit)	Number of times sold per year

2.4.16. How do you feed your animal during dry season/Bega? (Fill the following table)

Livestock type	Feeding system (tick)				
	1.Indoor individual	2.Indoor in group	3. Controlled grazing	4. Free grazing	5.Others (specify)
Ox					
Lactating cow					
Dry cow					
Calf					
Shoat/rearing					
Shoat/Fattening					
Lamb/kid					

2.4.17. How do you feed your animal during wet season/Meher? (Fill the following table)

Livestock type	Feeding system (tick)				
	1.Indoor individual	2.Indoor in group	3. Controlled grazing	4. Free grazing	5.Others (specify)
Ox					
Lactating cow					
Dry cow					
Calf					
Shoat/rearing					
Shoat/Fattening					
Lamb/kid					

2.4.18. Do you use supplementary feed for your animal? 1. Yes 2. No

2.4.19. If yes, list type of supplementary feeds.
____

2.4.20. If yes, for which animal you use supplementary feeds? 1. Lactating cow 2. Dry cow 3. Lactating ewe/due 4. Fattening sheep 5. Fattening cattle 6. Draught oxen 7. Others (specify)__________

2.4.21. At what age do you sell sheep? 1. 6 month 2. 9 month 3. 1 year 4. More than 1 year

2.4.22. How much do sell sheep through normal feeding? Minimum______ birr, maximum_______ birr.

2.4.23. Do you fatten sheep? 1. Yes 2. No

2.4.24. If yes, what are the feeds you used for fattening sheep?____

2.4.25. How much do you sell your fattened sheep? Minimum ________birr, Maximum _________ birr.

2.4.26. For how long do you feed fattening sheep? 1. For 2 month 2. For 3 month 3. For 4 month 4. For 6 month 5. For 8 month 6. For a year. 7.Others (specify)___________

2.4.27. Do you face feed shortage for your livestock? 1. yes 2. no

2.4.28. If yes, what measures do you take to alleviate problems of feed shortage? 1. Purchase concentrates 2. Purchase grass (rent grazing land) 3. Purchase crop residues 4. Feed Enset 5. Reduction of stock 6. Other (specify) ___________________________

2.4.29. If yes for Q 2.4.27, at which season do you face feed shortages? 1. First Bega (Sept-Nov) 2. Second Bega (Dec-Feb) 3. Belg/Short wet season (Mar-May) 4. Meher/Long wet season (June-Aug)

2.4.30. If you purchase concentrate, where do you purchase? 1. Shop in the kebele 2. Shop in district town 3. Kebele local market 4. District market 5. Out of the district (specify) _______________

2.4.31. How is concentrate availability in dry season? 1. Low 2. Medium 3. High

2.4.32. How is concentrate availability in wet season? 1.Low 2. Medium 3. High

2.4.33. Which season do you use more concentrate? 1. Dry season 2. Wet season 3. Both season
2.4.34. Do you de-worm your animal? 1. Yes 2.No
2.4.35. Which animal do you de-worm? 1. Cattle 2. Sheep 3. Both
2.4.36. If yes, in which season do you de-worm your animals? 1. During dry season 2. During wet season 3. In both season
2.4.37. Why do you de-worm in the above mentioned season? 1. High parasite infestation 2. Common fattening season 3. Others (specify)
2.4.38. Do you use mineral supplement for your sheep? 1. Yes 2. No
2.4.39. If yes, list types of mineral supplements?_____________________________________
2.4.40. Where do you get these mineral supplements? _____________________

Thank you very much for your kind cooperation!

APPENDIX 2

SAS Analysis Outputs

1. Dry matter and nutrient intake

Oat-Vetch intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	296873.8997	29687.3900	1875.10	<.0001
Error	21	332.4805	15.8324		
Corrected Total	31	297206.3802			

R-Square	Coeff Var	Root MSE	OV Mean
0.998881	2.994773	3.978995	132.8647

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	296815.1167	98938.3722	6249.11	<.0001
block	7	58.7830	8.3976	0.53	0.8017

Desho intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	188.1423750	18.8142375	21.55	<.0001
Error	21	18.3352250	0.8731060		
Corrected Total	31	206.4776000			

R-Square	Coeff Var	Root MSE	Desho Mean
0.911200	0.212922	0.934401	438.8475

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	180.5731250	60.1910417	68.94	<.0001
block	7	7.5692500	1.0813214	1.24	0.3266

Concentrate intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	404763.1000	40476.3100	Infty	<.0001
Error	21	0.0000	0.0000		
Corrected Total	31	404763.1000			

R-Square	Coeff Var	Root MSE	Concentrate Mean
1.000000	0	0	153.5250

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	404763.1000	134921.0333	Infty	<.0001
block	7	0.0000	0.0000	.	.

Total dry matter intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	13200.69116	1320.06912	84.30	<.0001
Error	21	328.83857	15.65898		
Corrected Total	31	13529.52972			

R-Square	Coeff Var	Root MSE	Total Mean

R-Square	Coeff Var	Root MSE	Mean
0.975695	0.545635	3.957143	725.2366

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	13128.07066	4376.02355	279.46	<.0001
block	7	72.62050	10.37436	0.66	0.7008

Roughage intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	287825.0097	28782.5010	1838.08	<.0001
Error	21	328.8386	15.6590		
Corrected Total	31	288153.8482			

R-Square	Coeff Var	Root MSE	Roughage Mean
0.998859	0.692157	3.957143	571.7116

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	287752.3892	95917.4631	6125.40	<.0001
block	7	72.6205	10.3744	0.66	0.7008

Dry Matter intake (% Body weight)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	0.06740625	0.00674063	26.63	<.0001
Error	21	0.00531563	0.00025313		
Corrected Total	31	0.07272188			

R-Square	Coeff Var	Root MSE	DMIBdWt Mean
0.926905	0.551171	0.015910	2.886563

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	0.06630938	0.02210313	87.32	<.0001
block	7	0.00109688	0.00015670	0.62	0.7344

Dry Matter intake per kg $W^{0.75}$

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	41.27365625	4.12736562	32.56	<.0001
Error	21	2.66214062	0.12676860		
Corrected Total	31	43.93579687			

R-Square	Coeff Var	Root MSE	DMIkgLWt Mean
0.939408	0.550939	0.356046	64.62531

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	40.69578437	13.56526146	107.01	<.0001
block	7	0.57787187	0.08255312	0.65	0.7095

Ash intake

Sum of

Source	DF	Squares	Mean Square	F Value	Pr > F
Model	10	725.8211750	72.5821175	609.15	<.0001
Error	21	2.5022250	0.1191536		
Corrected Total	31	728.3234000			

R-Square	Coeff Var	Root MSE	Ash Mean
0.996564	0.413682	0.345186	83.44250

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	725.1399250	241.7133083	2028.59	<.0001
block	7	0.6812500	0.0973214	0.82	0.5839

Organic matter intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	18753.21108	1875.32111	185.23	<.0001
Error	21	212.60541	10.12407		
Corrected Total	31	18965.81649			

R-Square	Coeff Var	Root MSE	OM Mean
0.988790	0.496330	3.181834	641.0719

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	18700.63154	6233.54385	615.72	<.0001
block	7	52.57954	7.51136	0.74	0.6398

Crude Protein intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	4944.595081	494.459508	455.47	<.0001
Error	21	22.797491	1.085595		
Corrected Total	31	4967.392572			

R-Square	Coeff Var	Root MSE	CP Mean
0.995411	1.063138	1.041919	98.00406

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	4931.606284	1643.868761	1514.26	<.0001
block	7	12.988797	1.855542	1.71	0.1611

Neutral detergent fiber (NDF) intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	963.176931	96.317693	20.25	<.0001
Error	21	99.881216	4.756248		
Corrected Total	31	1063.058147			

R-Square	Coeff Var	Root MSE	NDF Mean
0.906044	0.481603	2.180882	452.8378

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	937.9936094	312.6645365	65.74	<.0001

block	7	25.1833219	3.5976174	0.76	0.6288

Acid Detergent Fiber (ADF) intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	15430.85393	1543.08539	963.65	<.0001
Error	21	33.62722	1.60130		
Corrected Total	31	15464.48115			

R-Square	Coeff Var	Root MSE	ADF Mean
0.997826	0.547823	1.265423	230.9913

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	15422.40678	5140.80226	3210.40	<.0001
block	7	8.44715	1.20674	0.75	0.6309

Acid Detergent Lignin (ADL) intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	594.3118250	59.4311825	1080.22	<.0001
Error	21	1.1553750	0.0550179		
Corrected Total	31	595.4672000			

R-Square	Coeff Var	Root MSE	ADL Mean
0.998060	0.810221	0.234559	28.95000

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	594.0336250	198.0112083	3599.04	<.0001
block	7	0.2782000	0.0397429	0.72	0.6547

Metabolizable Energy (ME)intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	1.58505000	0.15850500	133.48	<.0001
Error	21	0.02493750	0.00118750		
Corrected Total	31	1.60998750			

R-Square	Coeff Var	Root MSE	ME Mean
0.984511	0.509341	0.034460	6.765625

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	1.57881250	0.52627083	443.18	<.0001
block	7	0.00623750	0.00089107	0.75	0.6334

2. Dry Matter and Nutrient digestibility

Dry Matter digestibility

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	885.8078500	147.6346417	34.67	<.0001
Error	9	38.3261250	4.2584583		
Corrected Total	15	924.1339750			

R-Square	Coeff Var	Root MSE	DM Mean
0.958528	2.830683	2.063603	72.90125

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	852.2049250	284.0683083	66.71	<.0001
block	3	33.6029250	11.2009750	2.63	0.1140

Organic Matter digestibility

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	507.8818000	84.6469667	34.63	<.0001
Error	9	21.9960000	2.4440000		
Corrected Total	15	529.8778000			

R-Square	Coeff Var	Root MSE	OM Mean
0.958489	1.982160	1.563330	78.87000

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	472.7702500	157.5900833	64.48	<.0001
block	3	35.1115500	11.7038500	4.79	0.0292

Crude Protein digestibility

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	362.5326875	60.4221146	7.12	0.0050
Error	9	76.3879562	8.4875507		
Corrected Total	15	438.9206437			

R-Square	Coeff Var	Root MSE	CP Mean
0.825964	3.428593	2.913340	84.97188

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	335.5136187	111.8378729	13.18	0.0012
block	3	27.0190688	9.0063563	1.06	0.4126

Neutral detergent fiber digestibility

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	567.5685875	94.5947646	39.21	<.0001
Error	9	21.7138063	2.4126451		
Corrected Total	15	589.2823937			

R-Square	Coeff Var	Root MSE	NDF Mean
0.963152	1.983598	1.553269	78.30563

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	519.3493687	173.1164562	71.75	<.0001
block	3	48.2192187	16.0730729	6.66	0.0116

Acid detergent fiber digestibility

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	1545.521538	257.586923	68.08	<.0001
Error	9	34.051856	3.783540		
Corrected Total	15	1579.573394			

R-Square	Coeff Var	Root MSE	ADF Mean
0.978442	2.769833	1.945132	70.22563

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	3	1476.326169	492.108723	130.07	<.0001
block	3	69.195369	23.065123	6.10	0.0150

3. Average daily weight gain and Feed conversion efficiency

Initial weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	158.1025000	15.8102500	86.97	<.0001
Error	21	3.8175000	0.1817857		
Corrected Total	31	161.9200000			

R-Square	Coeff Var	Root MSE	IWt Mean
0.976424	2.023076	0.426363	21.07500

Source	DF	Type I SS	Mean Square	F Value	Pr > F
trt	3	0.1975000	0.0658333	0.36	0.7810
block	7	157.9050000	22.5578571	124.09	<.0001

Final weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	189.1744250	18.9174425	14.12	<.0001
Error	21	28.1276625	1.3394125		
Corrected Total	31	217.3020875			

R-Square	Coeff Var	Root MSE	FWt Mean
0.870560	3.967960	1.157330	29.16688

Source	DF	Type I SS	Mean Square	F Value	Pr > F
trt	3	41.6118375	13.8706125	10.36	0.0002
block	7	147.5625875	21.0803696	15.74	<.0001

Average daily weight gain

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F

Model	10	0.00862500	0.00086250	3.28	0.0105
Error	21	0.00552500	0.00026310		
Corrected Total	31	0.01415000			

R-Square	Coeff Var	Root MSE	DWG Mean
0.609541	14.91514	0.016220	0.108750

Source	DF	Type I SS	Mean Square	F Value	Pr > F
trt	3	0.00767500	0.00255833	9.72	0.0003
block	7	0.00095000	0.00013571	0.52	0.8124

Feed conversion efficiency

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	0.01452500	0.00145250	3.09	0.0141
Error	21	0.00987500	0.00047024		
Corrected Total	31	0.02440000			

R-Square	Coeff Var	Root MSE	FCE Mean
0.595287	14.70168	0.021685	0.147500

Source	DF	Type I SS	Mean Square	F Value	Pr > F
trt	3	0.01162500	0.00387500	8.24	0.0008
block	7	0.00290000	0.00041429	0.88	0.5378

BIOGRAPHICAL SKETCH

The author, Shimelis Mengistu was born in 1983 in Kutaber district, South Wollo Administrative Zone, Amhara National Regional State. He attended his elementary education in Kone Primary Schools, Wadla district of North Wollo Adminstrative Zone. He completed his secondary education at Kutaber Senior Secondary School. After passing Ethiopian High School Certificate Examination successfully, he joined Awassa College of Agriculture (the current Hawassa University) in 2001 academic year and graduated with B.Sc. degree in Animal Production and Rangeland Management in July 2004. After his graduation, the author had worked in different governmental and non-governmental organization on different development, humanitarian and research positions. Shimelis Joined Hawassa University, College of Agriculture, School of Animal and Range Sciences in October 2016 to pursue his MSc in Animal Nutrition.