



**ASSESSMENT OF PRODUCTION AND MARKETING SYSTEMS, AND  
ON-FARM EVALUATION OF THE EFFECT OF SUPPLEMENTING  
THE LEAVES OF *Balanites aegyptiaca* AND MAIZE GRAIN ON  
GROWTH PERFORMANCE AND ECONOMIC RETURN OF  
INDIGENOUS GOATS IN GAMOGOFA ZONE**

**MSc THESIS**

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**HAWASSA UNIVERSITY**

**COLLEGE OF AGRICULTURE, HAWASSA, ETHIOPIA**

**MARCH, 2017**

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**NIGATU DEJENE DENEKE**

**A THESIS SUBMITTED TO THE  
SCHOOL OF ANIMAL AND RANGE SCIENCES,  
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**SCHOOL OF GRADUATE STUDIES**

**HAWASSA UNIVERSITY**

**ADVISORS' APPROVAL SHEET**

**(Submission Sheet-1)**

This is to certify that the thesis entitled “**Assessment of Production and Marketing Systems, and On-farm Evaluation of the Effect of Supplementing the Leaves of *Balanites aegyptiaca* and Maize Grain on Growth Performance and Economic Return of Indigenous Goats in Gamogofa Zone**” submitted in partial fulfillment of the requirements for the degree of Master's of Science with specialization in Animal Production, the graduate program of the School of Animal and Range Sciences, and has been carried out by Nigatu Dejene Deneke under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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Date

## **DEDICATION**

I dedicate this Thesis manuscript to my lovely mother W/ro Tsamate G/wold, whom I lost after I completed first semester class of this study. May God rest her soul in the heaven.

## **DECLARATION**

I declare that this thesis is my original work and that all sources of material that are used for this thesis have been duly acknowledged. This thesis is submitted in partial fulfillment of the requirements for an MSc degree at Hawassa University and is deposited at the university library to be made available for users under the rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the awards of any academic degree, diploma, or certificate.

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## TABLE OF CONTENTS

<b>Content</b>	<b>Page</b>
<b>ADVISORS' APPROVAL SHEET</b> .....	<b>III</b>
<b>DEDICATION</b> .....	<b>IV</b>
<b>DECLARATION</b> .....	<b>V</b>
<b>ACKNOWLEDGEMENTS</b> .....	<b>VI</b>
<b>TABLE OF CONTENTS</b> .....	<b>VII</b>
<b>ACRONYMS AND ABBREVIATIONS</b> .....	<b>XII</b>
<b>LIST OF TABLES</b> .....	<b>XIII</b>
<b>LIST OF TABLES (CONTINUED)</b> .....	<b>XIV</b>
<b>LIST OF FIGURES</b> .....	<b>XV</b>
<b>LIST OF APPENDIX</b> .....	<b>XVI</b>
<b>ABSTRACT</b> .....	<b>XVII</b>
<b>1. INTRODUCTION</b> .....	<b>1</b>
1.1. Background of the Study.....	1
1.2. Objectives of the Study .....	4
<b>2. REVIEW OF LITERATURE</b> .....	<b>5</b>
2.1. Goat Production Systems in Ethiopia .....	5
2.1.1. Pastoral and agro-pastoral system .....	5
2.1.2. Mixed crop and livestock system.....	6
2.1.3. Urban and peri-urban (landless) system .....	6
2.2. Feed Resources and Feeding System of Goats .....	6
2.2.1. Natural pasture .....	7
2.2.2. Crop residues.....	7

## TABLE OF CONTENTS (Continued)

Content	Page
2.2.3. Browse .....	8
2.2.3.1. Desert date ( <i>Balanites aegytiaca</i> ).....	9
2.3. Reproductive Performances of Goats .....	10
2.3.1. Age at first service (AFS) .....	10
2.3.2. Age at first kidding (AFK).....	11
2.3.3. Kidding interval (KI) .....	11
2.3.4. Average litter size (LS).....	12
2.4. Major Constraints of Goat Production in Ethiopia .....	13
2.4.1. Feed shortage and quality .....	13
2.4.2. Diseases and parasites .....	13
2.4.2.1. Mortality of goats .....	14
2.4.3. Lack of infrastructure, improved technologies and inputs .....	15
2.5. Goat Marketing Channel and its Constraints.....	16
2.5.1. Goat marketing channel.....	16
2.5.2. Goat marketing constraints .....	17
<b>3. MATERIALS AND METHODS.....</b>	<b>18</b>
3.1. Description of the Study Area .....	18
3.2. Part I: Assessment of Goat Production and Marketing System, and Constraints along the Value Chain .....	20
3.2.1. Sampling techniques.....	20
3.2.2. Focus group discussion (FGD) .....	20
3.2.4. Questionnaire survey .....	21
3.3. Part II: On-farm Evaluation of the Effect of Supplementing with desert date ( <i>Balanites aegyptiaca</i> ) and Maize Grain on Growth Performance and Economic Return of Indigenous Goats .....	23

## TABLE OF CONTENTS (Continued)

<b>Content</b>	<b>Page</b>
3.3.1. Study site and household selection.....	23
3.3.2. Experimental feed preparation .....	23
3.3.3. Experimental animals selection and management .....	23
3.3.4. Experimental design and treatments.....	24
3.3.5. Feed intake .....	25
3.3.6. Body weight gain and feed conversion efficiency .....	25
3.3.7. Chemical analysis of the experimental feeds .....	25
3.3.8. Partial budget analysis .....	26
3.4. Data Analysis.....	26
<b>4. RESULTS AND DISCUSSION.....</b>	<b>28</b>
4.1. Part I: Assessment of Goat Production and Marketing System, and Constraints along the Value Chain .....	28
4.1.1. Socio-economic characteristic of the households .....	28
4.1.1.1. Household (HH) characteristics .....	28
4.1.1.2. Land holding and allocation.....	31
4.1.1.3. Livestock holdings.....	33
4.1.1.4. Purpose of goat farming.....	35
4.1.2. Goat production system in the study area .....	35
4.1.2.1. Feed resources, feeding and its seasonal availability .....	35
4.1.2.2. Source of water for goats in the study area.....	39
4.1.2.3. Housing of goats.....	40
4.1.2.4. Methods of castration, fattening and culling of goats .....	42
4.1.2.5. Utilization of goat products .....	45
4.1.3. Goat health management .....	46

## TABLE OF CONTENTS (Continued)

<b>Content</b>	<b>Page</b>
4.1.4. Goat breeding management and reproductive performance of goats .....	49
4.1.4.1. Goat breeding management .....	49
4.1.4.2. Reproductive performance of goats.....	50
4.1.4.2.1. Age at first service (AFS) .....	50
4.1.4.2.2. Age at first kidding (AFK).....	51
4.1.4.2.3. Kidding interval (KI) .....	53
4.1.4.2.4. Average litter size .....	53
4.1.4.2.5. Life time kid production .....	54
4.1.4.2.6. Weaning age of kids .....	54
4.1.4.2.7. Reproductive lifespan .....	54
4.1.5. Marketing of goats in the study area .....	55
4.1.5.1. Market locations .....	55
4.1.5.2. Market participants .....	56
4.1.5.3. Mode of marketing and price setting .....	57
4.1.5.4. Household marketing and reasons for selling goats .....	57
4.1.5.5. Annual income from the sale of goats .....	58
4.1.5.6. Goat marketing channels and routes.....	61
4.1.6. Constraints and prospects of goat production and marketing .....	63
4.1.6.1. Constraints of goat production .....	63
4.1.6.2. Constraints of goat marketing .....	64
4.1.6.3. Prospects of goat production and marketing .....	66
4.1.7. Labor, extension and socio economics in goat production .....	67
4.1.7.1. Household labor division and gender role in goat management .....	67
4.1.7.2. Institutions and innovations in development of goat production .....	68

## TABLE OF CONTENTS (Continued)

Content	Page
4.2. Part II: On-farm Evaluation of the Effect of Supplementing with the leaves of <i>Balanites aegyptiaca</i> and Maize Grain on Growth Performance and Economic Return of Indigenous Goats .....	70
4.2.1. Chemical composition of experimental feeds .....	70
4.2.2. Dry matter and nutrient intake .....	72
4.2.3. Body weight change and feed conversion efficiency .....	73
4.2.4. Partial budget analysis .....	75
<b>5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS .....</b>	<b>78</b>
5.1. Summary & Conclusion .....	78
5.2. Recommendations .....	80
<b>6. REFERENCES.....</b>	<b>82</b>
<b>7. APPENDIX.....</b>	<b>98</b>
<b>BIOGRAPHICAL SKETCH .....</b>	<b>114</b>

## **ACRONYMS AND ABBREVIATIONS**

ADF	Acid Detergent Fiber
ADG	Average Daily Gain
ADL	Acid Detergent Lignin
BW	Body Weight
BWG	Body Weight Gain
CCPP	Contagious Caprine Pleuro Pneumonia
CP	Crude Protein
DA	Development Agent
DM	Dry Matter
DMI	Dry Matter Intake
FAO	Food and Agricultural Organization of United Nation
FGD	Focus Group Discussion
GDP	Gross Domestic Product
IPMS	Improving Productivity and Marketing System
LIVES	Livestock and Irrigation commodities Value chain for Ethiopian Smallholders
LSD	Lumpy Skin Disease
masl	meter above sea level
M	Mortality
N	Nitrogen
NDF	Neutral Detergent Fiber
OM	Organic Matter
PA	Peasant Association
PLW	Pilot Learning Woreda
PPR	Pest Des Petit Ruminants
SNNPRS	Southern Nations Nationalities and Peoples Regional State
T	Treatment
TDMI	Total Dry Matter Intake

## LIST OF TABLES

<b>Table</b>	<b>Page</b>
Table 1 Age, family size, sex and educational status of the households	30
Table 2 Mean land holdings (ha/HH)	32
Table 3 Mean ( $\pm$ SE) livestock holding per households	34
Table 4 Overall ranks of purpose of keeping goats	35
Table 5 Major feed resources for goats as ranked by the households	36
Table 6 Agro-ecologically ranked results of available feed resources for goats	38
Table 7 Seasonal availability of major feed resources for goats	39
Table 8 Sources of water for goats	40
Table 9 Types of goat houses reported by the respondents	41
Table 10 Methods of castrating goats	43
Table 11 Feed supplements for goat fattening	44
Table 12 The major reasons for culling goats	45
Table 13 Mean death and mortality (%) /HH of goats in the last 12 months of this study	48
Table 14 Desirable traits for selection of male and female goats for breeding	50
Table 15 Mean ( $\pm$ S.E.) reproductive performances of goats as reported by the HHs	52
Table 16 The major reasons for selling goats as ranked by the households	58
Table 17 Estimated mean ( $\pm$ SE) annual income (Birr) of the respondents from the sale of goats	60
Table 18 Major constraints of goat production as ranked by the households	63

## LIST OF TABLES (Continued)

Table	Page
Table 19 Major constraints of goat marketing as ranked by sampled households	65
Table 20 Division of labor in goat management by family members	69
Table 21 Chemical composition of feed stuff	71
Table 22 The mean ( $\pm$ SE) dry matter and nutrient intake (g/day/animal) of indigenous bucks fed natural grass hay supplemented with the leaves of desert date ( <i>Balanites aegyptiaca</i> ) and maize grain.	72
Table 23 Mean ( $\pm$ SE) body weight gain of indigenous bucks fed natural grass hay supplemented with the leaves of desert date ( <i>Balanites aegyptiaca</i> ) and maize grain.	74

## **LIST OF FIGURES**

<b>Figure</b>	<b>Page</b>
Figure 1 Diagrammatic description of goat marketing channel in the study area.....	62
Figure 2 The graph showing body weight change of experimental bucks. ....	75

## LIST OF APPENDIX

Appendix	Page
Appendix 1 Questionnaire used for goat production system and marketing survey in Gamogofa Zone	98
Appendix 2 Summery of ANOVA Table for the dry matter and nutrient intake (g/day/animal) of indigenous bucks fed natural grass hay supplemented with the leaves of desert date ( <i>Balanites aegyptiaca</i> ) and maize grain	113
Appendix 3 Summery of ANOVA Table for the body weight gain of indigenous bucks fed natural grass hay supplemented with the leaves of desert date ( <i>Balanites aegyptiaca</i> ) and maize grain	113

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RETURN OF INDIGENOUS GOATS IN GAMOGOFA ZONE**

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**ABSTRACT**

*The study was conducted in Arbaminch Zuria and Mirab Abaya districts of Gamogofa Zone of SNNPRS of Ethiopia. The objectives of the study were to assess goat production and marketing system, identify and prioritize goat production and marketing constraints and opportunities, and evaluate the effect of supplementing with the leaves of *Balanites aegyptiaca* and maize grain on growth performance & economic return of indigenous goats in the study area. The study involved 2 parts. The survey part of the study assessed goat production and marketing system using cross sectional survey, focus group discussion and key informants interview. A total of 120 representative households (2 districts x 2 Agro-ecology x 2 PA x 15 households) were selected for the study following multi-stage stratified sampling, the action research part evaluated growth performance and economic return of indigenous bucks supplemented with maize grain and leaves of *Balanites aegyptiaca*. Thus, 20 intact 8-10 month age indigenous bucks with an average initial body weight of  $16.13 \pm 0.3$ kg (Mean  $\pm$  SE) were drawn from volunteer goat producers. The bucks were blocked into five blocks/farmers of four bucks based on initial BW and randomly assigned to one of the four treatment feeds within a block/farmer allowing five bucks per treatment feeds. Dietary treatments consisted of feeding natural grass hay ad libitum supplemented with 50g wheat bran (T1); feeding natural grass hay ad libitum supplemented with mixtures of 50g wheat bran and 200g cracked maize grain (T2); feeding natural grass hay ad libitum supplemented with mixtures of 50g wheat bran and 200g dried leaves of *Balanites aegyptiaca* (T3), and feeding natural grass hay ad libitum supplemented with 50g wheat bran, and mixture of 200g of dried leaves of *Balanites aegyptiaca* and cracked maize grain at 1:1 ratio (T4). The experiment was laid down using randomized complete block design. According to the respondents, income generation was the primary reason for keeping goats with the highest index values of 0.277 followed by saving, use of manure, as social capital and meat consumption with an index values of 0.269, 0.177, 0.163 and 0.114, respectively. Road side browsing ranked as the first source of feed for goats according to the average rank results from interviewed households with the highest index value of 0.246 and followed by Communal and private browsing lands with an index values of 0.229 and 0.227, respectively. Among the available water sources, rivers contribute the highest 40% of the water required for goats. Disease and parasites were the major constrains for the sector and caused higher 13.2%, 13.6%, 14.7% and 13.3% death of unweaned male kids, unweaned female kids, weaned male kids and weaned female kids, respectively in Arbaminch Zuria district from the studied areas 12 months before the start of this study. Male and female goats achieve AFS at 9.4 and 7.9*

months and also fertile at ages below 54.6 and 95.5 months respectively. AFK, KI, LS, weaning age of kids and lifetime kid productions were 13.9, 7.8, 1.24, 4.1 months and 14.5 respectively. Brokers are the major marketing constraint and about 95% and 31.7% of the midland and lowland respondents, respectively reported that they sales their goats by eye ball price estimation. The action research showed that supplementing goats with maize grain and Balanites aegyptiaca (T2-T4) improved ADG (48.7, 48.9 and 66.8g/day for T2, T3 and T4, respectively) compared to the control (33.2g/day). However, among the supplemented groups, bucks fed on T4 gained superior ADG than bucks fed on T2 and T3 diets. Moreover, partial budget analysis confirmed that T4 was more profitable compared to other supplementary treatments. Therefore, it is concluded that supplementing growing bucks with T4 could be recommended for smallholder goat fatteners.

**Key words:** Goats, production system, marketing, *Balanites aegyptiaca*, reproductive performance, ADG

# **1. INTRODUCTION**

## **1.1. Background of the Study**

Ethiopia is believed to have the largest livestock population in Africa. This livestock sector has been contributing considerable portion to the economy of the country, and still promising to rally round the economic development of the country. It is eminent that livestock products and by-products in the form of meat, milk, honey, eggs, cheese, and butter supply etc. provide the needed animal protein that contributes to the improvement of the nutritional status of the people (CSA, 2013). According to the same author, Livestock also plays an important role in providing export commodities, such as live animals, hides, and skins to earn foreign exchanges to the country.

Ethiopia possesses a large goat population with diverse breed types that are distributed in all parts of the country (Solomon *et al.*, 2014) and home to approximately 24 million goats (CSA, 2013) excluding some pastoral areas of Afar and Somali regions. Also the country accounts for 7.2% of African and 2.6% of the global goat population (FAOSTAT, 2015). This puts the country eighth among the top ten countries in the world and third in Africa next to Nigeria and Sudan (FAOSTAT, 2013).

Goats are among the common farm animal species which maintain the livelihood of smallholders, pastoralists and agro-pastoralists in Ethiopia. They fulfill various functions such as generating cash income, serving as household security, accumulating capital, and fulfilling cultural obligations (Grum, 2010; Dhaba *et al.*, 2012). Compared to other ruminants, goats possess unique abilities to adapt harsh tropical environments and are closely associated with resource-poor households often found in marginal and harsh environments. As such,

investments in improving goat productivity can contribute to livelihood and the food security of producers in equitable ways (poor rural households also benefit) (Homann *et al.*, 2007; Solomon *et al.*, 2014). They play an important role in smallholder mixed, agro-pastoral and pastoral production systems due to their low initial capital investment and ability to produce multiple products (meat, milk, skin, manure etc.) at low input costs (Solomon *et al.*, 2014), high rates of reproduction and high turnover rates due to short time they take to mature (Homann *et al.*, 2007; Solomon *et al.*, 2014).

Human population growth in Ethiopia is forcing the conversion of grazing areas into croplands needed for increased food production. For this reason, raising large ruminants is becoming difficult due to shrinkage of grazing areas. The importance of small ruminants in fulfilling meat, milk and manure is increasingly recognized in densely populated areas where land holding is below 0.5 ha and the increased demand for meat from them has also increased their importance in lowland pastoral areas (Adane and Girma, 2008).

Despite the wide distribution and large size of the Ethiopian goat population, the productivity per unit of animal and the contribution of this sector to the national economy is relatively low. This may be due to different factors such as poor nutrition, prevalence of diseases, lack of appropriate breeding strategies and poor understanding of the production system as a whole (Tesfaye, 2009).

In the midlands and lowlands of Gamogofa Zone, goat rearing and fattening was increasing from year to year due to seasonal fluctuation of rainfall which causes the failing of crops at the young stage on rain fed crop lands. Although, there is fluctuation of rainfall pattern in the area, its influence on the availability of browses such as dessert date is minimum. Keeping

small ruminants, particularly goats, is an alternative and preferred strategy to fulfill family needs and generate income in moisture stress areas such as the present study area. Therefore, generating information on the smallholder goat production and marketing system, production constraints, production potential & opportunities and improvement options is crucial for goat development.

Poor nutrition is one of the main factors that affects the production and productivity of goats. Traditional goat production, the dominant production system in Ethiopia, limits the production and productivity of goats mainly due to poor capacity by actors and service providers, poor quality of feed resources & poor management, and under developed marketing system. As a result, smallholder goat producers and pastoralists in Ethiopia are not receiving sufficient income from their goats. Market oriented goat production requires improved capacity and supplementation with energy and protein sources from locally available feeds.

There have been massive campaigns underway on natural resource conservation and watershed development in Ethiopia including Gamogofa Zone, where this study was conducted. Consequently, the watersheds have been enclosed and protected from humans and livestock for the last few years. Hence, it gives an opportunity for the introduction of cut and carry system and feed conservation for dry season in a form of standing hay. Though, the enclosures can be used as a source of roughage feeds (basal diet), it cannot provide the required nutrients for optimum growth and fattening performance of goats. On the other hand, due to lack of access and higher prices, smallholder farmers are not in a position to supplement goats with formulated commercial concentrate feeds and agro-industrial by-products. Hence, to alleviate the feed quality and quantity problems, it is important to look for

alternative feed resources which are locally available, can replace concentrates and are less expensive. Desert date (*Balanites aegyptiaca*) locally known as Bedena is one of the browse species, commonly available in the study area, where farmers use its leaves as livestock feed mainly during dry season, contains good protein and could serve as protein supplement for goats. Moreover, maize (*Zea mays*) is commonly grown in the area and could serve as energy supplement for goats. It is therefore, envisaged that feeding the combination of maize and desert date (*Balanites aegyptiaca*) have a positive effect on growth performance and economic return of goats. Hence, this study was conducted with the following objectives.

## **1.2. Objectives of the Study**

The general objective of this research was to assess goat production and marketing system, and to evaluate the performance of indigenous goats supplemented with the leaves of desert date (*Balanites aegyptiaca*) and maize grain at farmers' management level in Mirab Abaya district of Gamogofa Zone, Southern Ethiopia.

The specific objectives of the study were:

- To assess goat production and marketing system in the study areas.
- To identify and prioritize goat production and marketing constraints and opportunities.
- To evaluate the effect of supplementing with the leaves of desert date (*Balanites aegyptiaca*) and maize grain on growth performance of indigenous goats.
- To evaluate the economic feasibility of supplementing the leaves of desert date (*Balanites aegyptiaca*) and maize grain.

## **2. REVIEW OF LITERATURE**

### **2.1. Goat Production Systems in Ethiopia**

Farmers or pastoralists choice of agricultural enterprises in Ethiopia depends on the production environment (availability of resources, particularly land, water and climate), long-standing tradition of agricultural production in the community, socio-economic circumstances (awareness and skill, access to inputs and markets), and government support (inputs and services) which stems from agricultural policies. In Ethiopia goat production system is broadly classified into pastoral & agro-pastoral, mixed crop-livestock, peri-urban and urban production systems (Solomon *et al.*, 2010).

#### **2.1.1. Pastoral and agro-pastoral system**

Pastoral systems are related with agro-ecologies that are too dry to sustain crop production. These are characterized by little or no crop agriculture and high mobility and mortality of livestock due to scarcity of moisture and feed. Under Ethiopian conditions, pastoral systems of production are found at altitudes below 1500 m.a.s.l and where the annual precipitation is less than 500 mm (Solomon *et al.*, 2008). According to the same author, rangeland is the main feed resource in this system and the major livestock species consist of camels, cattle, sheep, goats and donkeys. In Ethiopia, agro-pastoralism is the main mode of production in the sub-moist/moist lowlands. Crop and livestock production are both important activities in the areas, and the system is either transhumant or sedentary (Solomon *et al.*, 2010).

### **2.1.2. Mixed crop and livestock system**

According to Solomon *et al.* (2008) this system is found in areas where the altitude ranges between 1500 and 3000 m.a.s.l. The area has adequate rainfall and moderate temperature and is thus suitable for grain production. The integration of crops and livestock is high in most areas. The integration is lower in the perennial crop-livestock system (coffee growing areas) in southern Ethiopia where animals are of minor importance. Livestock in general and small ruminants in particular play an important role in food security and food self sufficiency in this production system. Cattle are the dominant livestock species and are kept mainly for draft power. Sheep and goats are kept to meet small and immediate cash needs. The major feed resources in this system are natural pasture and crop residues and there is year-round nutritional stress due to increases in cultivated land area. However, according to Dhaba *et al.* (2012) and Tegegne (2012) the major feed sources include natural pastures, crop residues, industrial by-products, and tree legumes in cut and carry system.

### **2.1.3. Urban and peri-urban (landless) system**

This system is the production of small ruminants within and at the periphery of cities. Quantitative data is not available on the importance of urban and peri-urban production systems but it is common to observe sheep and goats in urban areas including the capital Addis Ababa. Feed resources are usually leftovers from home, market area, mill, by-products and roadside grazing (particularly in the peri-urban system) (Solomon *et al.*, 2008).

## **2.2. Feed Resources and Feeding System of Goats**

The major feed resources for goat production in Ethiopia are natural pasture, crop residues, browses and agro-industrial by-products.

### **2.2.1. Natural pasture**

Natural pasture is an important source of livestock feed in Ethiopia. Natural pasture could be utilized as grazing, conserved in a form of hay or used as cut and carry. However, the quality and supply of these resources is seasonally variable. Moreover, the availability of natural pasture in the highlands is diminishing due to increase in cropping land associated with increasing human population and poor productivity due to poor grazing land management (Yoseph *et al.*, 2015; Adugna, 2007). On the other hand, bush encroachment and overgrazing have tremendously reduced the availability of grazing resources in the pastoral areas (Quinn *et al.*, 2007). Poor management of rangelands, inappropriate grazing management, rangeland fires and seasonal droughts have also limited the availability of fodder in the communal areas (Ben Salem and Smith, 2008). Further, the same authors reported that the quality and availability of natural pastures is highly variable in the tropics with crude protein dropping below 8% in dry mature tropical grasses, especially during the dry season.

### **2.2.2. Crop residues**

Seasonal changes throughout the year caused shortage of feedstuffs and resulted in the fluctuation of animal production and, therefore, many farmers in Ethiopia feed their livestock with crop residues (Xianjun *et al.*, 2012) mainly various straws. However, these feed resources contains low crude protein (3-5%), high fiber fraction (>70% NDF) and low dry matter digestibility (<60%) which depresses feed intake and performance of the animals (Girma *et al.*, 2014). For this reason, the use of such straw has limitations due to their low nutritive value indicated by their high cellulose, hemicelluloses and lignin contents, and their low protein content and digestibility. Therefore, developing feeding packages that support the existing traditional production and the emerging private producers and exporter is the timely

intervention to increase production and productivity in order to meet the demand for meat and live animal export market (Asfaw *et al.*, 2011).

Crop residues are important feed resources for livestock in mixed crop-livestock production system. The major crop residues for livestock could be broadly grouped into cereals, pulses, fruits, root crops, and others such as vegetables & sugar cane. According to the study conducted in Alaba district of southern Ethiopia (Tsedeke, 2007) crop residues and stubble grazing had significant contribution to total livestock feed supply.

### **2.2.3. Browse**

Browse has been defined as leaves, shoots and sprouts including tender twigs and stems of woody plants, which are cropped to a varying extent by domestic animals (Gidado *et al.*, 2013). The incorporation of browse species into diets is one of the ways of making affordable improvement to quantity and quality of feed available to ruminants and can also compensate for seasonal fluctuations. This is the reason why fodder trees and shrubs have been the focus of ruminant nutrition research in recent times, more so because these feed resources are locally available perennial sources of feed (Fadiyimu *et al.*, 2015).

The study conducted in Taraba State of Nigeria revealed that browse plant species can conveniently be utilized in formulating quality rations for fattening and maintenance of ruminant feeding as most of them including desert date (*Balanites aegyptiaca*) evaluated appear to have high CP and low NDF and lignin contents as well as palatable level of anti-nutritive factors (Liman *et al.*, 2016). Similarly, the study conducted in Borena rangelands of Southern Ethiopia revealed that the browse species including desert date (*Balanites aegyptiaca*) evaluated have good potential as livestock feed and particularly as supplement for

low quality roughages during the dry season. However, the results need to be further confirmed in animal experiments whether the potential could be translated into animal performance (Aster *et al.*, 2012).

#### **2.2.3.1. Desert date (*Balanites aegytiaca*)**

Desert date (*Balanites aegytiaca*) is a small to medium-sized dry land tree or shrub belonging to the family Zygophyllaceae (Balanitaceae). It is found in arid and semi-arid regions to sub-humid savannas of most African countries where it provides food, medicines, cosmetics, fodder, fuel wood and pesticides valued for subsistence living (NRC, 2008). According to the study conducted in Adjumani and Katakwi districts of Uganda, desert date was essential for sustaining livestock during the dry season when grasses are inadequate. The young leaves and fruit pulp are source of food for goats, cows and sheep (Akaia *et al.*, 2011).

The study conducted in Tatton Farm of Egerton University, Kenya confirmed that the use of browses such as *Acacia tortilis* and *Balanites aegytiaca* as a supplement in addition to offer feed maize (*Zea mays*) stover greatly improved the intake, digestibility and ADG of growing goats. However, *Balanites aegytiaca* supplemented at 10g/kg metabolic weight supported a higher ADG of 20.3 g/d and, therefore, has better potential as a protein supplement to maize stover for growing Small East African Goats (James *et al.*, 2013).

#### **2.2.4. Agro-industrial by-products**

By-product feed stuffs in the diets of ruminants support growth, lactation and in the production of human edible food. Consequently, by-product feed stuffs are becoming increasingly more important in the food and fiber system because they are available at competitive prices relative to other commodities (Mussato *et al.*, 2006). The major agro-

industrial by-products used for feeding goats are flour mill by products and oil seed cakes. Moreover, there are other non-conventional feeds which emanate from agro industries. Agro-industrial by-products contain high nutrients and, thus, used as supplements to enhance the feeding value of low quality feeds and thereby improve livestock production. The utilization of agro-industrial products may be economically worthwhile, since conventional feed stuffs are often expensive. However, livestock have historically utilizes large amount of well-known and widely available traditional by- products such as bran, middling, brewers grain, distillers grain and others (Aghsaghali and Maheri, 2008).

### **2.3. Reproductive Performances of Goats**

#### **2.3.1. Age at first service (AFS)**

Age at first service is generally considered to be related more to growth than age in tropical goats with first estrous occurring with the attainment of 60-70% of adult live weight (Devendra and Burns, 1983). The recent finding of Age at first service for Black Bengal goats was 4.6 and 6.6 months in intensive and semi-intensive production systems, respectively (Farque *et al.*, 2010) which is comparable with the corresponding value 4-5 months for Red sokoto goats of Nigeria and younger than 24 months reported for Afar goats (Wilson, 1991).

The study conducted in Dirre and Moyale districts of Borana Zone in Oromia Regional State and in Moyale district of Liben Zone in Somali Regional State in southern Ethiopia bordering Kenya indicated that goats in the area attain sexual maturity at 14.6 months (Adugna and Aster, 2007) which is higher than the average value of 9.7 months reported from Sidama Zone of Southern Ethiopia (Endeshaw, 2007).

### **2.3.2. Age at first kidding (AFK)**

In the traditional goat production systems of the tropics, few breeding males are maintained in the flocks for breeding purpose throughout the year. Hence, the average age at first kidding for tropical goats is longer and ranges between 12 and 24 months (Devendra and Burns, 1983). On the other hand, the average age at first kidding of 13 months was reported for German fawn goats (Cinkulov *et al.*, 2009).

According to the study conducted in Dale district of Sidama Zone, Southern Ethiopia (Endeshaw, 2007) age at first kidding was significantly different ( $p < 0.05$ ) among the three-agro ecologies. The overall mean of age at first kidding is  $14.88 \pm 0.245$ . In Moist Kola the lowest mean age at first kidding  $13.73 \pm 0.77$  months was reported and it is significantly different ( $p < 0.05$ ) from the mean age of  $16.13 \pm 0.61$  months in Moist Dega. In Moist Woina Dega, the mean age at first kidding was  $14.86 \pm 0.29$  months and it is intermediate between the values of the two agro-ecologies. These estimates were shorter than the average value reported by Wilson (1989) for indigenous African goats which is 17 months and longer than 12.1 months reported for Arsi-Bale goats from Alaba district (Tsedeke, 2007).

### **2.3.3. Kidding interval (KI)**

Kidding interval is one of the major components of reproductive performance that has significant influences on production systems. Its high contribution to the productive efficiency can be affected by nutrition, suckling, parity and breed (Banerje *et al.*, 2000). Available evidence shows that indigenous African goats have subsequent births at about every 10 months (Wilson, 1989) which was lower than 11.2 months reported for German fawn goats (Cinkulov *et al.*, 2009).

According to Deribe (2009) on his study in Alaba districts of southern Ethiopia, parturition interval of indigenous goats was 9 months. The previous study conducted in Dale district of Sidama Zone, Southern Ethiopia founded that the overall mean kidding interval of 8.6 months for goats in the three agro ecologies of the area (Endeshaw, 2007). However, the above results were higher than the finding of Tatek *et al.* (2004) who reported 8.1 months for Arsi-Bale goats.

#### **2.3.4. Average litter size (LS)**

In the central highlands of Ethiopia, LS have been recorded to be 1.21, with twin births accounted for about 17% (FARM-Africa 1996). However, the same author reported that the lower litter size of 1.07 and twinning rate of 2.5% for Short-eared Somali and Afar goats kept under on-station management system. Both of above results were relatively lower than the finding 1.47 for local goats in Alaba, Southern Ethiopia reported by Deribe (2009) and the recorded litter size of 1.28 for Tanzanian goats in semi-arid condition (Ahmadu and Lovelace, 2002).

The study conducted in Bangladesh Livestock Research Institute showed that production system influenced litter size in Black Bengal goats (Faruque *et al.*, 2010). Litter size of 1.5 in intensive production system was higher than 1.06 in semi-intensive system reported by the same author. On the other hand, the average litter size of 2.64 was reported from the study conducted in three regions of Bangladesh (Rume *et al.*, 2011). Litter size varies between 1.08 and 1.75 with an average of 1.38 for tropical breeds (Girma, 2008).

## **2.4. Major Constraints of Goat Production in Ethiopia**

### **2.4.1. Feed shortage and quality**

Sheep and goat production in Ethiopia suffers from feed shortages at all levels with an estimated 40% deficit in the national feed balance. This is aggravated by seasonal availability of forage and crop residues in the highlands and by recurrent and prolonged drought in the lowlands (Alemu, 2008). Feed and water scarcity in quality and quantity is among noted production constraints along the goat value chain (Getachew *et al.*, 2008). Feed shortage is one of the limiting factors for increasing production and productivity of small ruminant in most of the agro-ecological zones in Ethiopia. The gravity of feed shortage in quantity can be seen from the feed balance in the highland and lowland ecologies. A deficit of 8.6 and 56.1% in moist and sub moist highlands, respectively and an excess of 71.7% in lowland mixed system have been estimated (Solomon *et al.*, 2010).

Poor nutrition is one of the major impediments which limit the performance of goats (Felekech *et al.*, 2013). The natural pasture which supply the bulk of ruminants feed in the tropics becomes dry and low in nutritive value during the dry season leading to a marked decrease in voluntary intake and digestibility (Yusuf *et al.*, 2013). The low nitrogen and mineral contents of the crop residues as well as their high lignin and silica contents are considered the major reason for their low digestibility and thus low utilization by ruminant animals (Malgwi and Mohammed, 2015).

### **2.4.2. Diseases and parasites**

Diseases and parasites are major constraints limiting goat production and productivity in Ethiopia. These diseases and parasites are endemic in many regions of Africa (Githiori *et al.*,

2006). The impact of diseases and parasites may be through high morbidity, mortalities, abortions and stillbirths or subclinical effects manifested as weight loss reduced gains. The negative impact of diseases and parasites may also be through the financial implications involved in controlling the effects of disease and mortality (Sissay *et al.*, 2006).

The prevalence of different animal diseases can exclude a country from profitable international markets. That is why Ethiopia has suffered from repetitive banning of meat and live animal export by Middle East countries. Major diseases of goats in Ethiopia include anthrax, sheep and goat pox, PPR, fascioliasis, pasteurellosis and other respiratory diseases (Solomon *et al.*, 2014). The most prevalent diseases contributing to heavy mortalities, morbidity wastage and reduced skin quality are respiratory disease (CCPP), skin disease (complex skin necrosis, LSD) and external parasitic (babesiosis, tick paralysis) (Grum, 2010).

#### **2.4.2.1. Mortality of goats**

Mortality is documented as the main factor adversely affecting goat production in the tropics. According to the study conducted in Kenya (Harun *et al.*, 2007) the overall mortality from birth to 8 months of age were 27.8% in Gabra goat kids and 16.7% in Rendille goat kids especially mortality of kids at age 3 to 8 months for the Gabra goats was higher (24.5%) than for the Rendille goats (12.8%). Mortality of Kids at the age of 0 to 3 months in both goat populations had almost similar i.e. mortality rate of 3.8% in Gabra goats and 3.7% in Rendille goats.

Average mortality rate of most Ethiopian indigenous goats range between 12 to 26% with the highest loss occurring before weaning (Dereje *et al.*, 2015). The overall pre-weaning mortality rate recorded for Somali goat kids under station management at Haramaya University was

about 11.5% (Zelege, 2007) which is lower than 25.4% reported for different indigenous goats in Ethiopia (Grum, 2010). Mortality rate of 34.2% and 26.7% before and after weaning, respectively, was reported for Arsi-Bale goats around the Mid Rift valley of Ethiopia (Girma *et al.*, 2011), which is higher than an average annual mortality (25%) reported for all classes of stock for goats in the central highlands (Adane and Girma, 2008).

#### **2.4.3. Lack of infrastructure, improved technologies and inputs**

The lack of infrastructure leads to the need of transport for livestock or livestock products from remote areas, where production is concentrated, to urban markets. Sheep and goats are generally trekked long distances for marketing, often without adequate water and feed. There are very limited market centers and stock routes with the necessary facilities such as feeding and watering points (Solomon *et al.*, 2008).

Availability of improved technologies and inputs are critical to transform the traditional subsistent production systems into market-oriented profitable enterprises. Both generation of technologies and devising efficient delivery systems are essential in this endeavor. Quite a number of improved livestock technologies and inputs (improved breeds, forage seeds, feeding practices including fattening packages, veterinary inputs) have been generated and/or adopted from elsewhere. However, because of inefficient delivery of these services, improved technologies and inputs remained unavailable or inaccessible to the producers (Solomon *et al.*, 2010).

## **2.5. Goat Marketing Channel and its Constraints**

### **2.5.1. Goat marketing channel**

The 2008 World Development Report ‘Agriculture for Development’ identifies ‘Enhance smallholder competitiveness and facilitate market entry’ and ‘Improve market access and establish efficient value chains’ as milestones to support an agriculture-for-development agenda (World Bank, 2008). Available agricultural data and statistics, however, are insufficient for governments and private investors in sub-Saharan Africa to design and implement interventions which efficiently and equitably link farmers to agricultural markets: ‘Many countries, especially in the developing world, lack the capacity to produce and report even the minimum set of agricultural data necessary to monitor national trends’ (World Bank, 2011).

The study conducted in Alaba Pilot Learning Woreda (PLW) indicates that a typical livestock marketing structure of Ethiopia follows a four-tier system. The main actors of the 1<sup>st</sup> tier are local farmers and rural traders/rural assemblers who transact at farm level. Those small traders from different corners bring their animals to the local market (2<sup>nd</sup> tier). Traders or wholesalers purchase a few large animals or a fairly large number of small animals for selling to the secondary markets. In the secondary market (3<sup>rd</sup> tier), both smaller and larger traders operate and traders (wholesalers or retailers) and butchers from terminal markets come to buy animals. In the terminal markets (4<sup>th</sup> tier), big traders and butchers (wholesalers or retailers) transact larger number of mainly slaughter type animals. Consumers get meat through direct purchase of live animals or from butchers (Ayele *et al.*, 2003; Tsedeke, 2007).

### **2.5.2. Goat marketing constraints**

The attitude of farmers, existence of different animal diseases, lack of animal health care professionals and needed vaccines or other medicaments, low feed quality and quantity, poor marketing infrastructure such as shade, watering and feeding facilities, loading and unloading ramps and animal weighing facilities or absence of these facilities in most markets, Absence of well-defined stock routes, Lack of standards and grading procedures and finally lack of an integral and systematic connection between the stakeholders involved in the production and marketing chain are the major impediments in small ruminant marketing (Assefa, 2011).

Livestock marketing constraints identified by exporters include lack of adequate supply of appropriate and good quality animals, poor marketing infrastructure, livestock diseases, lack of adequate sanitary and phytosanitary services to support exports, long market channels (usually 3-5 stages between producer and the abattoirs), and problems with airfreight transport services (Berhanu *et al.*, 2007).

### **3. MATERIALS AND METHODS**

#### **3.1. Description of the Study Area**

The study was conducted in Gamogofa Zone of SNNPRS of Ethiopia. Arbaminch, the capital of Gamogofa Zone is located at 505 km and 275 km south west of Addis Ababa and Hawassa cities, respectively. The predominant agricultural system of Gamogofa Zone is mixed crop-livestock production system. Gamogofa Zone has a total area of 12,581.4km<sup>2</sup> (Fсахatsion *et al.*, 2013). It is situated between 680 to 4207 m.a.s.l and 36<sup>0</sup> 37'-37<sup>0</sup> 98' E longitude and 5<sup>0</sup> 57'-6<sup>0</sup> 71' N latitude. The topography of the land is characterized by undulating feature that favors for the existence of different climatic zones in the area. The average temperature ranges from 20 to 25<sup>0</sup>C and the average annual rainfall ranges from 200 to 2000 mm (Defaru and Tuma, 2013). Agro-ecologically the zone is 30.16% Dega, 41.44% Woina Dega and 28.4% Kolla. The total livestock population of the zone has been estimated to be 1,639,088 cattle; 477,556 goats; 1,000,384 sheep; 1,332,519 chickens and 317,833 equines (OZLFRD, 2015).

Arba Minch Zuria district has 29 rural PA administrations and the total area of the district is 152,409 hectare. It has an altitude ranging from 1001-2500 m.a.s.l. Its latitude and longitude are 6<sup>0</sup>N and 37<sup>0</sup> E, respectively (Defaru and Tuma, 2013). Agro-ecologically the district is 14% Dega, 53% Woina Dega and 33% Kolla. The Annual temperature ranges from 12.5-27.5<sup>0</sup>C, while the Annual rainfall is between 801-1600mm. Rainfall distribution in the study area is bimodal with a long rainy season from beginning of March to end of May and a short rainy season from mid-August to mid-October (Shegena *et al.*, 2014). The district has 164,529 total human populations, out of this 82,199 are males and 82,330 are females (CSA, 2007).

The livestock population of the district is 104,642 cattle; 4,616 equines; 35,226 sheep; 20,894 goats and 56,555 chickens (ODLFRD, 2015).

Mirab Abaya district is located at 455 km south of Addis Ababa. It has 23 rural PA administrations and has a total land of 107,971 hectare. The district is situated between 1100 and 2800 m.a.s.l. Its latitude and longitude are 6<sup>0</sup>N and 37<sup>0</sup>E respectively (ODLFRD, 2015). The district is divided into three agro-ecological zones, namely, Dega, Woina Dega and Kola which account for about 11%, 27% and 62% of the total area, respectively. The rainfall regime in the district is bimodal. The first round of rain occurs between March and May and the second round of rain occurs from June to August. The total population of the district is 89,718 of which 44,903 are female and the rest are males. The district has 46,417 cattle; 2,165 equines; 8,102 sheep; 29,869 goats and 24,071 chickens (Yilikal, 2015).

The present study has two parts: Cross-sectional survey to understand goat production and marketing system in Arbaminch Zuria and Mirab Abaya districts and, action research to evaluate the effect of supplementation with locally available feeds on growth performance of indigenous goats in Mirab Abaya district.

## **3.2. Part I: Assessment of Goat Production and Marketing System, and Constraints along the Value Chain**

### **3.2.1. Sampling techniques**

Out of fifteen districts in Gamogofa Zone, two districts (Arbaminch Zuria and Mirab Abaya) have been purposively selected based on potential of high value livestock commodities selected by the Livestock and Irrigation Value Chain for Ethiopian Smallholders (LIVES) project ([www.lives-ethiopia.org](http://www.lives-ethiopia.org)). This was followed by identification of eight rural PAs (four from each district) based on goat population, accessibility for transportation and agro-ecology (two lowland and two mid altitude PAs from each district). From each PA, 15 households comprising 13.3% women were selected for the interview based on their experience and knowledge on goat production and marketing. Thus, the total number of households interviewed was 120.

### **3.2.2. Focus group discussion (FGD)**

Summarized version of open-ended questionnaire was prepared for the FGD. The focus group discussants were composed of village leaders, women, youngsters and socially respected individuals who have better experience in goat production & marketing in the area. The number of FGD participants' was 8 to 10 in each PA and a total of eight (8) FGD were carried out (one FGD per PA). Focused areas of discussions were general goat production and marketing systems, and on major production and marketing challenges and opportunities in the study area.

### **3.2.3. Key informant interview**

The key informants were interviewed separately about the general goat production and marketing system. The number of key informants included in the study were 10 per district of which 4 were experienced goat producers, two Development Agents (DA's), one Office of District Livestock and Fish Resource Development expert, one Office of District Marketing and Cooperative expert, one local shoat trader and one local butcher.

### **3.2.4. Questionnaire survey**

The questionnaire was pre-tested before administering and some rearrangement, refining and correcting was done after FGD and key informants interview. A rapid reconnaissance survey was made prior to the actual survey work to locate the distribution of goat population and production activities. The community members were made aware of the rationale behind the study. Care was taken to obtain prior permission from the respondents and all cultures were respected to the best extent possible.

One development agent was identified from each PA to conduct the interview, and orientation was given for half day on the data collection methods using the questionnaire. Structured questionnaire were used to collect the primary data from the households and summarized version of the questionnaire were used to collect data from FGD and key informants interview. Data were collected by the DAs with a close follow up of the researcher. The secondary data were collected from zonal and district Livestock and Fishery Development Offices and Marketing and Cooperative Offices in zonal and district levels by the researcher. Information on the socio-economic characteristics of the farmers like sex, age, family size, land holding, farming activity, number of livestock kept, feed resources and feeding, major goat production challenges, common diseases, goat selection criterion, reproductive traits,

market access and routine production system etc. were collected during the survey and subjected to statistical analysis.

### **3.3. Part II: On-farm Evaluation of the Effect of Supplementing with desert date (*Balanites aegyptiaca*) and Maize Grain on Growth Performance and Economic Return of Indigenous Goats**

#### **3.3.1. Study site and household selection**

The action research was conducted at Doronje PA community based goat breeding cooperative of Mirab Abaya district. Five voluntary farmers who were experienced in goat rearing and fattening, and able to contribute 4 uniform bucks each were selected for the study from the breeding cooperative.

#### **3.3.2. Experimental feed preparation**

The experimental feed consisted of a basal diet of natural grass hay and Supplements such as the leaves of desert date (*Balanites aegyptiaca*), cracked maize grain and wheat bran. The natural grass hay was purchased from the participated households in the action research. The leaves of *Balanites aegyptiaca* was collected from the participant farmers farm using their children. The collected leaves of desert date were dried under shade before packing in the sacks. The maize grain and wheat bran were purchased from the district town. The maize grain was cracked by shredder, which was introduced and demonstrated to smallholder livestock producers by LIVES project.

#### **3.3.3. Experimental animals selection and management**

Twenty intact indigenous bucks aged between 8 to 10 months average initial body weight of  $16.13 \pm 0.3$ kg (Mean  $\pm$  SE) were contributed by volunteer smallholder producers. The age of the bucks was determined based on the information from producers and by dentition (Solomon and Kassahun, 2009). Prior to actual study, the experimental animals were

vaccinated for commonly known small ruminant diseases in the study area such as Pest Des Petit Ruminants (PPR), Contagious Caprine Pleuro Pneumonia (CCPP) and Ovine pasteurellosis and also treated for internal and external parasites. The bucks were provided with plastic tag on their necks for the ease of identification. The initial body weight of the bucks was determined by two consecutive weighing after overnight fasting. The animals were allowed to adapt to treatment feeds for 15 days. The experiment was conducted for 90 days.

#### **3.3.4. Experimental design and treatments**

The experiment was conducted using a randomized complete block design (RCBD). The number of producers participated in the trial were five and each contributed four bucks according to the number of treatments. Thus, each of the five participant producers served as a block. In each block, dietary treatments were randomly allocated to the four bucks independently. The difference in initial body weight was adjusted using covariate analysis. The treatments consisted of feeding natural grass hay *ad libitum* supplemented with 50g wheat bran (T1; positive control); feeding natural grass hay *ad libitum* supplemented with mixtures of 50g wheat bran and 200g cracked maize grain (T2); feeding natural grass hay *ad libitum* supplemented with mixtures of 50g wheat bran and 200g dried leaves of *Balanites aegyptiaca* (T3), and feeding natural grass hay *ad libitum* supplemented with 50g wheat bran, and mixture of 200g of dried leaves of *Balanites aegyptiaca* and cracked maize grain at 1:1 ratio (T4). The quantity of supplements provided was on dry matter basis. The supplement was offered at 17:00 hour. The basal feed was provided in such a way that it consists of 15% refusal. When the amount of refusal was less than 15%, it was adjusted on weekly basis. All animals had free access to mineral (Bole) lick and water.

### **3.3.5. Feed intake**

Daily offered feed and refusal of each buck was measured and recorded throughout the experimental period to assess the daily feed intake. Daily feed intake of the individual bucks was recorded as a difference between the feed offered and the refusal. The feed intake was calculated by subtracting the refusal from the daily offered feed on dry matter basis. Feed samples were taken from the offer of treatment and basal diets and refusal weekly and bulked across the feeding trial. Fresh samples of the offer of test feeds were taken before feeding separately while refusals were collected and bulked on individual animal basis separately.

### **3.3.6. Body weight gain and feed conversion efficiency**

Live weight changes of the animals were measured at 15 day interval after overnight fasting. Average daily body weight change was calculated as the difference between the final body weight and initial live weights of the bucks divided by the number of experimental days. Feed conversion efficiency (FCE) was calculated by dividing average daily body weight gain by total average daily feed intake as dry matter basis.

$$\text{FCE} = \text{g ADG/g TDMI}$$

### **3.3.7. Chemical analysis of the experimental feeds**

Chemical analysis of the experimental feeds and refusals were carried out at Hawassa University Animal Nutrition Laboratory. Prior to analysis, air dried feed samples were milled to pass through 1mm Willey mill sieve size and labeled for easy identification. The chemical analysis was run in duplicates. The DM, OM and ash contents of sample feed offered and refusal were analyzed according to the procedure of proximate method of AOAC (1990). The N content was determined by Kjeldahl technique and the crude protein (CP) content was

calculated by multiplying N content with 6.25. Neutral detergent fiber (NDF), Acid detergent fiber (ADF) and Acid detergent lignin (ADL) were analyzed as described by Van Soest and Robertson (1985).

### **3.3.8. Partial budget analysis**

Partial budget analysis was used to determine the profitability of the feeding regime (Upton, 1979). The purchase price of experimental feed was recorded and also market price of experimental goats at the beginning and at the end of the experiment was assessed in local animal market and estimated by experienced goat dealers. In the analysis, the difference between the purchase and selling prices of animals was considered as total return (TR). Net return (NR) was calculated by subtracting the total variable costs (TVC) or feed cost from the total return (TR).

$$NR = TR - TVC$$

The change in net return ( $\Delta NR$ ) was calculated as the difference between change in total return ( $\Delta TR$ ) and the change in total variable costs ( $\Delta TVC$ ).

$$\Delta NR = \Delta TR - \Delta TVC$$

The marginal rate of return (MRR) measures increase in net return ( $\Delta NR$ ) associated with each additional unit of expenditure ( $\Delta TVC$ ), which is the difference among the three treatments excluding positive control and normally expressed as percentage.

$$MRR = \Delta NR / \Delta TVC * 100$$

### **3.4. Data Analysis**

The data collected from the survey were analyzed using Statistical Package for Social Sciences (SPSS ver. 16.0, 2007). Data on percentages and means were analyzed using descriptive statistics and cross tabulation. Indexes were calculated for all ranking data

according to the formula: Index = sum of [(5 for rank 1)+(4 for rank 2 )+(3 for rank 3)+(2 for rank 4 )+(1 for rank 5 )] given for an individual reason divided by the sum of [(5 for rank 1)+(4 for rank 2 )+(3 for rank 3)+(2 for rank 4 )+(1 for rank 5 )] for overall reasons. Data from the action research (feeding trial) was stratified into treatment and block and analyzed by using the General Linear Model procedure (GLM) in SPSS software. Initial body weight was considered as covariate in the analysis. Treatment means were separated by using the least significant difference and declared significance at  $p < 0.05$ .

The statistical model used for the analysis of data from the feeding trial was:

$$y_{ijk} = \mu + \alpha_i + \beta_j + b(\text{FBW} - \text{IBW}) + e_{ijk}$$

Where: -  $y_{ij}$  = the observation in the  $i^{\text{th}}$  treatment &  $j^{\text{th}}$  block;

$\mu$  = the overall mean;

$\alpha_i$  = the  $i^{\text{th}}$  treatment effect ( $i=1-4$ );

$\beta_j$  = the  $j^{\text{th}}$  block effect ( $j=1-5$ );

$b$  = linear regression;

IBW = initial body weight;

FBW = final body weight and

$e_{ijk}$  = the random error associated with  $y_{ijk}$

## **4. RESULTS AND DISCUSSION**

### **4.1. Part I: Assessment of Goat Production and Marketing System, and Constraints along the Value Chain**

#### **4.1.1. Socio-economic characteristic of the households**

##### **4.1.1.1. Household (HH) characteristics**

Household characteristic of the targets in the study area is presented in Table 1. The average age of the household was significantly different ( $p < 0.05$ ) between the agro-ecologies of Arbaminch Zuria district whereas it was not significantly varied ( $p > 0.05$ ) between the agro-ecologies of Mirab Abaya district. The overall mean total number of family members was consistent across the districts. However, it was higher ( $p < 0.05$ ) for households in midland agro-ecology compared to the ones in lowland agro-ecology in both districts. There was no significant variation ( $p > 0.05$ ) in total, male and female family size between midland and lowland of Arbaminch Zuria district whereas the corresponding values except for female family size were significantly varied ( $p < 0.05$ ) in Mirab Abaya district. The average total, male and female family size in Arbaminch Zuria district was  $8.5 \pm 0.37$ ,  $4.4 \pm 0.24$ , and  $4.1 \pm 0.2$ , respectively whereas the corresponding values were  $8.3 \pm 0.33$ ,  $4.0 \pm 0.22$  and  $4.3 \pm 0.22$ , respectively in Mirab Abaya district.

There was no significant variation ( $p > 0.05$ ) among households in goat farming experience. The study showed that about 86.7% of the interviewed households were males while the remaining 13.3% were females across both districts. The present findings also demonstrated that about 38.3% and 58.3% of the survey households were illiterate in Arbaminch Zuria and Mirab Abaya districts, respectively. The average family size of 8.5 and 8.3 in Arbaminch

Zuria and Mirab Abaya districts, respectively in the current study area was lower than the average family size of 10.5 reported from the Central Rift Valley of Ethiopia (Zewdie and Yoseph, 2014) and higher than the average values 5.1 and 5.3 reported for the national level and SNNPRS, respectively (CSA and World Bank, 2013). The average total family sizes in both districts of the current study area were also higher than the report 6.29 from Ilu Abba Bora Zone (Dhaba *et al.*, 2012). The high family size in the studied districts of the current study area might be due to lack of awareness on family planning and towards the culture of polygamy. Unlike the present findings, the contribution of female headed household was higher in Mada walabu (15%), Sawena (30.8%) and Rayitu (32%) districts of Bale Zone, Oromia region (Belete, 2013). The illiteracy rate of the households in the current study was lower than 67.4% and 65% reported by Tesfaye (2009) and Tsedeke (2007), respectively and higher than 30% reported from Goma district of Jimma Zone (Belete, 2009).

Table1 Age, family size, sex and educational status of the households

Descriptions	Districts						
	Arbaminch Zuria			Mirab Abaya			
	Agro-ecology			Agro-ecology			
	Midland n=30 Mean± SE	Lowland n=30 Mean± SE	Average n=60 Mean± SE	Midland n=30 Mean± SE	Lowland n=30 Mean± SE	Average n=60 Mean± SE	
Age of the HH (years)	47.0±1.38 <sup>a</sup>	42.8±1.20 <sup>b</sup>	44.9±0.95	46.2±1.79	45.9±1.71	46.1±1.23	
Total family size	9.20±0.51	7.8±0.52	8.5±0.37	9.0±0.47 <sup>a</sup>	7.5±0.44 <sup>b</sup>	8.3±0.33	
Male family size	4.8±0.33	3.9±0.34	4.4±0.24	4.6±0.37 <sup>a</sup>	3.4±0.22 <sup>b</sup>	4.0±0.22	
Female family size	4.5±0.29	3.8±0.26	4.1±0.20	4.4±0.27	4.1±0.35	4.3±0.22	
Experience in goat farming(years)	15.8±1.21	16±0.96	15.9±0.76	14.8±0.67	15.6±1.05	15.2±0.62	
	%	%	%	%	%	%	
Sex of the HH	Male	86.7	86.7	86.7	86.7	86.7	
	Female	13.3	13.3	13.3	13.3	13.3	
Educational status of the HH	Illiterate	60	16.7	38.3	76.7	40	58.3
	Grade 1-6	30	70	50	13.3	33.3	23.3
	Grade 7-12	10	13.3	11.7	10	26.7	18.3

HH= households; n=number of households; SE=standard error; <sup>a,b</sup> means with the different superscripts across rows are significantly different at ( $p<0.05$ )

#### 4.1.1.2. Land holding and allocation

The overall mean land holdings of the interviewed households are presented in Table 2. The mean total land holding of Arbaminch (1.9 ha) and Mirab Abaya (1.8 ha) districts were consistent. However, the mean land holding per household was significantly higher ( $p<0.05$ ) for lowland compared to midland agro-ecology. Similarly, the mean land holding for crop production was higher ( $p<0.05$ ) for lowland compared to highland agro-climate.

The mean land holding observed in the present study was comparable with  $1.96\pm 0.26$  and  $1.83\pm 0.17$  ha reported for lowland and midlands agro-climates of Bonke district in the same Zone (Guyo, 2016) and higher than the overall mean of  $1.5\pm 0.07$  ha reported by the previous study conducted in the highland and midland of Gamogofa Zone (Fсахatsion *et al.*, 2013). However, it was lower than 5.01ha/HH reported for Central Rift Valley of Ethiopia (Felekech *et al.*, 2013). The average crop land holding ( $1.1\pm 0.10$  ha/HH for Arbaminch Zuria and  $1.3\pm 0.12$  ha/HH for Mirab Abaya districts) in the present study was higher than  $0.94\pm 0.05$  ha/HH reported for the Zone this study was conducted (Fсахatsion *et al.*, 2013). On the other hand, the mean grazing land holding per household observed in the present study ( $0.24\pm 0.04$  ha/HH for Arbaminch Zuria and  $0.32\pm 0.06$  ha/HH for Mirab Abaya districts) was comparable with  $0.24\pm 0.02$  ha/HH reported by Fсахatsion *et al.* (2013) for the highlands and midlands of Gamogofa Zone.

Table 2 Mean land holdings (ha/HH)

Descriptions	Districts					
	Arbaminch Zuria			Mirab Abaya		
	Agro-ecology			Agro-ecology		
	Midland n=30	Lowland n=30	Overall n=60	Midland n=30	Lowland n=30	Overall n=60
Mean± SE	Mean± SE	Mean± SE	Mean± SE	Mean± SE	Mean± SE	
Total land holding of the HH	1.0±0.11 <sup>b</sup>	2.8±0.34 <sup>a</sup>	1.9±0.21	1.0±0.08 <sup>b</sup>	2.6±0.20 <sup>a</sup>	1.8±0.15
Crop land	0.7±0.07 <sup>b</sup>	1.5±0.17 <sup>a</sup>	1.1±0.10	0.7±0.06 <sup>b</sup>	2.0±0.16 <sup>a</sup>	1.3±0.12
Fruit land	0.0±0.0 <sup>b</sup>	0.8±0.13 <sup>a</sup>	0.4±0.08	0.0±0.0 <sup>b</sup>	0.2±0.06 <sup>a</sup>	0.1±0.03
Vegetable land	0.04±0.05	0.12±0.06	0.08±0.03	0.04±0.01 <sup>a</sup>	0.0±0.0 <sup>b</sup>	0.02±0.0
Fallow land	0.06±0.02	0.13±0.05	0.09±0.03	0.08±0.01 <sup>a</sup>	0.0±0.0 <sup>b</sup>	0.04±0.01
Grazing land	0.22±0.04	0.25±0.08	0.24±0.04	0.21±0.02	0.42±0.11	0.32±0.06

n=number of households; SE=standard error; HH=household; ha=hectare; <sup>a,b</sup> means with the different superscripts across rows are significantly different at ( $p<0.05$ )

#### 4.1.1.3. Livestock holdings

The farmers in the study areas keep different species of livestock. The major livestock species kept included cattle, goat, sheep, donkey, mule and chicken. The mean livestock species holding of the households in the study area is presented in Table 3. In most instances the mean livestock species holding per household varied significantly ( $p < 0.05$ ) between agro-ecologies of both districts. However, there was no significant variation ( $p > 0.05$ ) in cattle and castrated yearling goat holding in the midland and lowland of Mirab Abaya district. Similarly, the average household holding of mature castrates, mature females other than does, sheep, mule and chicken was not significantly different ( $p > 0.05$ ) for both agro-ecologies of each district.

The overall mean cattle, castrated yearling goats and sheep holding per household observed in Arbamich Zuria district was higher than the corresponding values observed in Mirab Abaya district. However, the overall mean household holding of donkey and different classes of goats except for castrated yearling goats was comparable across both districts.

The overall mean cattle holding ( $7.1 \pm 0.47$  for Arbaminch Zuria and  $4.8 \pm 0.32$  for Mirab Abaya districts) in this study was higher than  $3.9 \pm 0.29$  and  $1.7 \pm 0.26$  reported for Bati and Siti areas of Amhara and Somali regions, respectively (Hulunim, 2014). However, the overall mean cattle holdings of the households in the studied districts were lower than  $10.4 \pm 1.21$  reported by the same author for Borena area of Oromia region.

Table 3 Mean ( $\pm$  SE) livestock holding per households

Livestock species	Districts					
	Arbaminch Zuria			Mirab Abaya		
	Agro-ecology			Agro-ecology		
	Midland n=30	Lowland n=30	Overall n=60	Midland n=30	Lowland n=30	Overall n=60
Cattle	5.3 $\pm$ 0.29 <sup>b</sup>	8.8 $\pm$ 0.78 <sup>a</sup>	7.1 $\pm$ 0.47	4.3 $\pm$ 0.32	5.2 $\pm$ 0.54	4.8 $\pm$ 0.32
Goats						
○ Does	3.3 $\pm$ 0.28 <sup>b</sup>	6.9 $\pm$ 0.45 <sup>a</sup>	5.1 $\pm$ 0.35	3.4 $\pm$ 0.31 <sup>b</sup>	6.6 $\pm$ 0.62 <sup>a</sup>	5.0 $\pm$ 0.40
○ Unweaned male kids	1.9 $\pm$ 0.23 <sup>b</sup>	4.2 $\pm$ 0.35 <sup>a</sup>	3.1 $\pm$ 0.25	1.7 $\pm$ 0.20 <sup>b</sup>	4.0 $\pm$ 0.53 <sup>a</sup>	2.9 $\pm$ 0.32
○ Unweaned female kids	1.7 $\pm$ 0.17 <sup>b</sup>	4.1 $\pm$ 0.43 <sup>a</sup>	2.9 $\pm$ 0.28	2.3 $\pm$ 0.26 <sup>b</sup>	3.6 $\pm$ 0.34 <sup>a</sup>	2.9 $\pm$ 0.23
○ Weaned male kids	0.8 $\pm$ 0.14 <sup>b</sup>	2.8 $\pm$ 0.24 <sup>a</sup>	1.8 $\pm$ 0.19	1.8 $\pm$ 0.18 <sup>b</sup>	2.9 $\pm$ 0.30 <sup>a</sup>	2.3 $\pm$ 0.18
○ Weaned female kids	1.3 $\pm$ 0.14 <sup>b</sup>	3.5 $\pm$ 0.29 <sup>a</sup>	2.4 $\pm$ 0.21	1.7 $\pm$ 0.22 <sup>b</sup>	2.6 $\pm$ 0.32 <sup>a</sup>	2.2 $\pm$ 0.20
○ Castrated yearlings	0.4 $\pm$ 0.09 <sup>b</sup>	0.9 $\pm$ 0.15 <sup>a</sup>	0.7 $\pm$ 0.09	0.13 $\pm$ 0.08	0.20 $\pm$ 0.09	0.2 $\pm$ 0.06
○ Non-castrated yearlings	0.6 $\pm$ 0.14 <sup>b</sup>	2.2 $\pm$ 0.29 <sup>a</sup>	1.4 $\pm$ 0.19	1.2 $\pm$ 0.14 <sup>b</sup>	2.8 $\pm$ 0.32 <sup>a</sup>	1.9 $\pm$ 0.20
○ Yearling females	0.7 $\pm$ 0.19 <sup>b</sup>	2.7 $\pm$ 0.37 <sup>a</sup>	1.7 $\pm$ 0.24	0.8 $\pm$ 0.16 <sup>b</sup>	2.9 $\pm$ 0.36 <sup>a</sup>	1.8 $\pm$ 0.24
○ Mature castrates	0.2 $\pm$ 0.11	0.9 $\pm$ 0.21	0.6 $\pm$ 0.13	0.4 $\pm$ 0.10	0.4 $\pm$ 0.13	0.4 $\pm$ 0.08
○ Mature non-castrates	0.5 $\pm$ 0.10 <sup>b</sup>	1.3 $\pm$ 0.23 <sup>a</sup>	0.9 $\pm$ 0.14	0.9 $\pm$ 0.09 <sup>b</sup>	2.0 $\pm$ 0.25 <sup>a</sup>	1.4 $\pm$ 0.15
○ Mature females other than does	0.9 $\pm$ 0.16	1.9 $\pm$ 0.36	1.4 $\pm$ 0.21	1.3 $\pm$ 0.16	2.0 $\pm$ 0.36	1.7 $\pm$ 0.20
Total goats	12.3 $\pm$ 1.75 <sup>b</sup>	31.4 $\pm$ 3.37 <sup>a</sup>	22 $\pm$ 2.28	15.6 $\pm$ 1.9 <sup>b</sup>	30 $\pm$ 3.62 <sup>a</sup>	22.7 $\pm$ 2.26
Sheep	1.5 $\pm$ 0.42	0.7 $\pm$ 0.55	1.1 $\pm$ 0.34	0.10 $\pm$ 0.10	0.0 $\pm$ 0.0	0.05 $\pm$ 0.05
Mule	0.1 $\pm$ 0.06	0.0 $\pm$ 0.0	0.05 $\pm$ 0.03	0.03 $\pm$ 0.03	0.0 $\pm$ 0.0	0.02 $\pm$ 0.02
Donkey	0.4 $\pm$ 0.09 <sup>b</sup>	0.7 $\pm$ 0.12 <sup>a</sup>	0.6 $\pm$ 0.08	0.8 $\pm$ 0.08 <sup>a</sup>	0.2 $\pm$ 0.07 <sup>b</sup>	0.5 $\pm$ 0.06
Total livestock other than chicken	19.6 $\pm$ 2.61 <sup>b</sup>	41.6 $\pm$ 4.82 <sup>a</sup>	30.8 $\pm$ 3.2	20.8 $\pm$ 2.43 <sup>b</sup>	35.4 $\pm$ 4.23 <sup>a</sup>	28.1 $\pm$ 2.71
Chicken	10.3 $\pm$ 0.77	9.9 $\pm$ 1.23	10.1 $\pm$ 0.72	8.1 $\pm$ 0.80	9.2 $\pm$ 1.35	8.6 $\pm$ 0.78

n=number of households; SE=standard error; <sup>a,b</sup> means with the different superscripts across rows are significantly different at ( $p<0.05$ )

#### 4.1.1.4. Purpose of goat farming

The ranked result of purpose of goat keeping as by the respondents is presented in Table 4. Accordingly, income generation was ranked as the primary reason for keeping goats with the highest index values of 0.277 followed by saving. This was consistent across the districts and agro-ecology involved in this study. The finding was in agreement with the report from Ilu Abba Bora Zone (Dhaba *et al.*, 2012) and from Uganda (Charles *et al.*, 2015).

Table 4 Overall ranks of purpose of keeping goats

Parameters	Ranks given by the households					Index
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	
Source of income	49	42	28	1	-	0.277
Saving	41	48	26	5	-	0.269
Meat consumption	-	-	11	62	47	0.114
Use of manure	8	14	43	39	16	0.177
Social capital	22	16	12	13	57	0.163

Index = sum of [(5 for rank 1)+(4 for rank 2)+(3 for rank 3)+(2 for rank 4)+(1 for rank 5)] given for an individual reason divided by the sum of [(5 for rank 1)+(4 for rank 2)+(3 for rank 3)+(2 for rank 4)+(1 for rank 5)] for overall reasons.

#### 4.1.2. Goat production system in the study area

##### 4.1.2.1. Feed resources, feeding and its seasonal availability

Although, communal grazing land is the common feed source for goats and other livestock in the study area, road side browsing was ranked first based on average rank result of both agro-ecologies followed by communal browsing lands and private browsing land (Table 5). According to the Focus Group discussants, the available feed resources in both agro-ecologies were almost the same with the exception of some browse species which are mostly found in the lowland compared to midland agro-ecology. However, the major feed resources used for

goats as ranked by households was different for different agro-ecology, Thus, road side browsing followed by private browsing and communal browsing lands was ranked from first to third in the midlands whereas communal browsing followed by road side browsing and private browsing lands were ranked from first to third in the lowlands agro-ecology (Table 6). Despite, difference in priorities, similar feed resources were reported from Metema district of North Gonder Zone (Tesfaye, 2008) and Rayitu district of Bale Zone (Teshome, 2006).

The major feed resources prioritized in the study area were covered mainly by shrubs and indigenous browse species which are very crucial during dry season when feed shortage occurs. The FGD with experienced goat producers revealed that one of the major browse species commonly used as a source of feed for goats and cattle in the lowlands in dry season was desert date (*Balanites aegyptiaca*), locally known as Bedena which was considered and evaluated as a potential supplement for goats in this MSc thesis research.

Table 5 Major feed resources for goats as ranked by the households

Feed resources	Ranks						Index
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	6 <sup>th</sup>	
Private browsing land	29	40	46	5	-	-	0.227
Road side browsing	43	53	24	-	-	-	0.246
Communal browsing land	47	21	35	16	1	-	0.229
Crop residue	-	4	1	64	31	20	0.118
Improved forages	-	-	-	-	42	78	0.064
Aftermath grazing	1	2	14	35	46	22	0.116

Index = sum of [(6 for rank 1)+(5 for rank 2)+(4 for rank 3)+(3 for rank 4)+(2 for rank 5)+(1 for rank 6)] given for an individual reason divided by the sum of [(6 for rank 1)+(5 for rank 2)+(4 for rank 3)+(3 for rank 4)+(2 for rank 5)+(1 for rank 6)] for overall reasons.

The FGD participants in the lowland explained that during dry seasons (January to March), farmers prune the leaves of *Balanites aegyptiaca* & feed goats & cattle. The other feed resources commonly used during the dry spell as reported by the FGD participants were Acacia pod and leaf. Consistent with the present findings, livestock producers in Halaba district of Southern Ethiopia use browses to feed goats (Yeshitila, 2007).

Although ranked fourth, small quantity of crop residues, mainly from cereals such as wheat, barley, teff and maize were used as livestock feed in the midland agro-ecology while teff and maize residues were used in the lowland agro-ecology during the dry season. Improved forages such as Elephant and Desho grasses have been introduced in the area, but its production and utilization by smallholders is insignificant.

Seasonal availability of different feed resources used for goats in the study area is presented in Table 7. Accordingly, the major feed resource available during the dry season were browses from private and communal areas, crop residues and grazing on crop aftermath in midland while it was browsing from communal area in lowland agro-climate. On the other hand, the dominant feed resources for goats during the rainy season across both agro-ecology were browses from private, communal and roadside areas. Consistent with the current study, seasonality in availability of feed resources for livestock was also reported from Burie district of West Gojjam Zone (Yenesew, 2010) and Metema district of North Gondar Zone (Tsfaye, 2008).

Table 6 Agro-ecologically ranked results of available feed resources for goats

Feed resources	Ranks in agro-ecology													
	Midland ranks						Lowland ranks							
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	6 <sup>th</sup>	Index	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	6 <sup>th</sup>	Index
Private browsing land	18	24	13	5	-	-	0.234	11	16	33	-	-	-	0.221
Road side browsing	30	20	10	-	-	-	0.254	13	33	14	-	-	-	0.237
Communal browsing	11	10	25	14	-	-	0.205	36	11	10	2	1	-	0.253
Crop residue	-	4	1	34	13	8	0.127	-	-	-	30	18	12	0.110
Improved forages	-	-	-	-	30	30	0.071	-	-	-	-	12	48	0.057
Aftermath grazing	1	2	11	7	17	22	0.109	-	-	3	28	29	-	0.122

Index = sum of [(6 for rank 1)+(5 for rank 2)+(4 for rank 3)+(3 for rank 4)+(2 for rank 5)+(1 for rank 6)] given for an individual reason divided by the sum of [(6 for rank 1)+(5 for rank 2)+(4 for rank 3)+(3 for rank 4)+(2 for rank 5)+(1 for rank 6)] for overall reasons.

Table 7 Seasonal availability of major feed resources for goats

Feed resources	Agro-ecology					
	Mid-land			Low-land		
	Sept-Dec	Jan-Mar	Apr-Aug	Sept-Dec	Jan-Mar	Apr-Aug
Private browsing land	+++	++	+++	+++	+	+++
Road side browsing	+++	+	+++	+++	+	+++
Communal browsing	+++	++	+++	+++	++	+++
Crop residue	+++	++	-	+++	+	++
Improved forages	+	-	+	+	-	+
Aftermath grazing	++	++	-	+	-	+

+++ = good feed availability; ++ = moderately available; + = less available; - = not available.

#### 4.1.2.2. Source of water for goats in the study area

The major source of water for goats in the study area included rivers, wells, springs, lakes (Lake Abaya) and tap water (Table 8). The highest (40%) proportion of annual water for goats comes from river. The other source of water for goats and other livestock in the selected lowland PAs of Mirab Abaya district was tap water and which contributes 22.5% of the total annual water required for goats. According to FGD, this was constructed 22 years ago by a non-governmental organization. The spring water, Lake Abaya and wells contribute to about 21.7%, 8.3% and 7.5% of the water supply for goats, respectively, in the study area. The finding was in line with the study from Dale district of Sidama Zone where river and well water were the major source of water for goats (Endeshaw, 2007). Similarly, river water as a major source of water for goats was reported from Ebnat and Farta districts of Amhara region (Damitie *et al.*, 2015). In corroborate with the current study, Lakes and rivers were one of the major water sources for goats in Central Rift Valley of Ethiopia (Felekech *et al.*, 2013).

Table 8 Sources of water for goats

Source of water	Agro-ecology		Total n (%)
	Midland n (%)	Lowland n (%)	
River water	28 (46.7)	20 (33.3)	48 (40)
Well water	6 (10)	3 (5)	9 (7.5)
Spring water	26 (43.3)	-	26 (21.7)
Lake Abaya	-	10 (16.7)	10 (8.3)
Tap water	-	27 (45)	27 (22.5)

n= number of households interviewed

Agro-ecologically, rivers, springs and wells provide 46.7%, 43.3% and 10% of the water supply for goats in the midlands, whereas tap water, rivers, Lake Abaya and wells contribute about 45%, 33.3%, 16.7% and 5% of water supply in the lowlands, respectively. Frequency of watering is twice a day, early morning when the animals are moving for browsing and returning back from browsing in the late afternoon.

#### 4.1.2.3. Housing of goats

Housing goats is a common practice in the study area. The respondents confine all sex and age groups together including kids. This study showed that about 94.2% of farmers constructed shelter for their goats and the remaining 5.8% of the households in the lowland of Arbaminch Zuria district confines their goats in Kraals near to family houses and in corridors. The size of the house depends on the flock size of each producer. Providing shelter to goats in the adjoining houses to the family house is predominant in the midlands (60%) and confining goats in purposely constructed separate houses (88.3%) is predominant in the lowlands (Table 9).

Of the total respondents in both districts, 64.2% provide separate houses followed by adjoining houses (30%) and the least 5.8% of the households confine their goats in the corridor of the family house and Kraals near to the family house. All goat houses in the study area were constructed from locally available materials that reduce cost of production except for 8.3% of the respondents who used corrugated iron sheet as a roof. The majority (91.7%) of the respondents use grass to cover the roof of goat houses. All of the midland and the majority of the lowland farmers reported that they plastered the wall of goat house with mud and the floor is made of earth for all households. The main purpose of providing shelter for goats in the study area was to protect from predator, unpleasant weather such as rain, sun and frost. In agreement with the current study, about 36% and 35% of the households in Burie district of West Gojjam provide separate and adjoining houses, respectively (Yenesew, 2010). Contrary to the current study, the highest proportions (72%) of the interviewed households in the same study used corrugated iron sheet for the roof of goat houses. Provision of house for goats was also reported by Belete *et al.*, (2015) from Bale Zone where the dominant housing system was kraal (45.6%) followed by separate house (28.10%) and yards (25.3%).

Table 9 Types of goat houses reported by the respondents

Type of house	Agro-ecology		Total
	Midland	Lowland	
	n (%)	n (%)	n (%)
Adjoining house	36(60)	-	36(30)
Separate housing	24(40)	53(88.3)	77(64.2)
No house or around the main house	-	7(11.7)	7(5.8)

n= number of interviewed households

#### **4.1.2.4. Methods of castration, fattening and culling of goats**

Castrating of bucks is common practice in the study area. According to the response of respondents, the methods of castration used in the study area are presented in Table 10. Most of the respondents (73.3%) in the midland use traditional method of castration and only 26.7% of the interviewed goat producers have access to modern castration services whereas in the lowlands, about 70% of the households use modern castration and only 30% castrate their goats traditionally. From the total households interviewed, about 51.7% and 48.3% castrate their goats in traditional and modern method, respectively. The result is comparable with the reports from Bati, Borena and Siti area of Amhara, Oromia and Somali regions, respectively (Hulunim, 2014), where more than 50% of the respondents castrate their bucks traditionally. On the other hand, higher proportion (91%) of respondents had access to modern castration services in Ilu Abba Bora Zone (Dhaba *et al.*, 2012).

According to the FGD participants, the perception of intervention households to modern castration method was wrong. They believe that modern castration would delay fattening period. For this reason, some farmers prefer traditional method of castration. Lack of access to modern castration also forces producers to use traditional castration methods. The focus group discussants in the midland area revealed that they have no access to modern method castration at the time they requires.

The average age of castration was 21 and 17 months in the midland and lowland, respectively. The average age of castration reported in the present study area was comparable with the report of Belete *et al.* (2015) for Madawalabu, Sawena and Rayitu districts. The highest number of farmers in the midland (73.3%) and lowland (71.7%) offer food leftovers and available grains to castrated bucks. Generally, all households practice castration to fetch more

money from the sale of fattened goats. The observation was in agreement with the previous studies from different parts of the county (Belete, 2009; Takele *et al.*, 2006).

Table 10 Methods of castrating goats

Castration methods	Agro-ecology		Total
	Mid-land	Low-land	
	n (%)	n (%)	
Modern method	16(26.7)	42(70)	58(48.3)
Traditional method	44(73.3)	18(30)	62(51.7)

n=number of households

With regard to fattening animal selection, almost all of the interviewed households responded that there was no any unique criterion for selecting goats for fattening. In contrast, the use of body conformation, physical characteristics, age and breed as a criterion to select small ruminants for fattening was reported by Selamawit and Matious (2015) and Belete (2009) from Gedio Zone and Goma district, respectively. The major feed supplements used for fattening goats in the study area were food left over from family along with mineral source (Table 11). Although grain was used, its contribution was less compared to food leftover. Wheat bran and mill house waste was accessed by fatteners in the lowland. About 36.7% of farmers in the midland agro-ecology practice extensive fattening of castrated bucks. In agreement with the present study, supplementing goats with food leftovers, grains and mill by-product was reported from other parts of the country (Dhaba *et al.*, 2012; Mulugeta *et al.*, 2015).

Table 11 Feed supplements for goat fattening

Type of supplements	Agro-ecology		Total n (%)
	Mid-land n (%)	Low-land n (%)	
Food leftovers with local mineral(bole)	25(41.7)	23(38.3)	48(40)
Grains (maize, wheat, barley etc...)	13(21.6)	14(23.3)	27(22.5)
Wheat bran and mill house refusals	-	18(30)	18(15)
Fruit leftovers	-	5(8.4)	5(4.2)
Browsing only	22(36.7)	-	22(18.3)

n=number of households

The present study also revealed that about 81.7% of the interviewed households in the study area fatten goats semi-intensively while the remaining 18.3% fatten extensively. In accordance to the present study, farmers in Kobo and O'itu PAs of Oromia Regional State fatten goats traditionally. However, contrary to the present findings, goat producers in Fantale administrative district of Oromia region do not fatten goat. Instead, they simply rear goats mainly for milk (Arse *et al.*, 2013). The most common periods of goat fattening in the study area targets the Ethiopian New Year (September), Christmas/Gena (January) and Easter (April). According to interviewed households, the most common duration of goat fattening in the study area was 3 to 4 months.

The major reasons of culling goats in the study area are given in Table 12. Breeding females with poor mothering ability, that fail to conceive after repeated mating and abort due to unknown reasons were primarily culled from the flock with an index 0.297 followed by physical damage with an index 0.219.

Table 12 The major reasons for culling goats

Culling reasons	Ranks					Index
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	
Kidding problem	74	24	22	-	-	0.297
Physical defect	7	26	62	25	16	0.219
Unwanted physical characteristics	28	35	5	18	13	0.192
Sickness	-	-	1	31	88	0.086
Oldage	12	30	30	48	3	0.206

Index = sum of [(5 for rank 1)+(4 for rank 2 )+(3 for rank 3)+(2 for rank 4 )+(1 for rank 5 )] given for an individual reason divided by the sum of [(5 for rank 1)+(4 for rank 2 )+(3 for rank 3)+(2 for rank 4 )+(1 for rank 5 )] for overall reasons.

The other reasons that trigger producers to cull goats from the flock included old age of breeding females, unwanted phenotypic characteristics such as black color which reported by small number of farmers. The primary reason for culling goats in the present study area was in agreement with the previous report for Daro-Labu district of West Hararghe (Dereje *et al.*, 2013).

#### 4.1.2.5. Utilization of goat products

This study demonstrated that there was no cultural, traditional and religious taboo that prohibits the use of goat products and by-products in the study area. Slaughtering and consumption of goat meat or chevon is common in the study area. All of interviewed households responded that they prefers and slaughter male goats for festivals. The FGD and interview result from the households revealed that consumption of goat milk is not common in the study area. Kids suckle the whole milk of their mother until they wean which creates favorable condition for them to grow quickly. This may increase the survival rate of kids and minimize mortality. In accordance with the current study, consumption of goat milk was not

familiar in Goma district (Belete, 2009). Contrary to the current study, about 98.3% of respondents in Siti, 94.7% in Borena and 28.6% in Bati area consume goat milk (Hulunim, 2014). Goat milk consumption was also reported for 92%, 99% and 42% of respondents in Kombolcha, Gursum and Konso districts, respectively as reported by Kidus (2010).

#### **4.1.3. Goat health management**

According to cross sectional survey and FGD results, the most common diseases and parasites that hamper goat production and productivity in the study area included Tuberculosis, Trypanosomiasis, Coccidiosis, foot rot, pink eye, sheep and goat pox, PPR and CCPP, ovine pasteurellosis, internal parasite(tape worm), external parasites such as ticks and mites.

According to the survey, FGD and key informants interview results; disease occurrence was higher in the months from January to April in the study area. About 70%, 100% and 85% of respondents in the midland, lowland and overall, respectively, reported that they receive animal health treatment services in the previous 12 months of this study from animal health technicians employed by the government. Even though there is some access to medical services, the FGD revealed that it is limited because of the insufficient number of veterinarians to reach all the PAs. For this reason, about 86.7% of the midland, 8.3% of the lowland and overall 47.5% of the households reported that they purchases drugs from illegal traders. This calls for an intervention of concerned governmental and non-governmental organizations. .

This study also showed that about 48.3% of the midland and 96.7% of the lowland households vaccinated their goats 12 months before the start of this study due to the outbreak of one of the diseases explained above. This may have contributed for low mortality rate of

goats reported in the present study. Of all the respondents, about 65% in midland, 48.3% in lowland and overall 56.7% reported that they have lost one to three goats due to different health problems in the past 12 months of the present study.

The reported mean death and mortality by the households over the last 12 months of this study is given in Table13. Higher mortality of 28.5% and 20.7% were reported for unweaned female kids and weaned male kids, respectively for the midlands of Arbaminch Zuria district whereas higher mortality of 18.2% and 15.3% were reported for unweaned male kids and weaned female kids, respectively for the midlands of Mirab Abaya district. The highest mortality reported in the lowlands of Arbaminch Zuria district was 11.1% for unweaned male kids, whereas in the lowlands of Mirab Abaya district, the highest (11.8%) mortality was recorded for unweaned female kids. The lowest average of (6.3%) mortality was reported for castrated yearling and mature non-castrated goats from Arbaminch Zuria district, whereas the lowest (2.7%) mortality was reported for mature castrated goats from Mirab Abaya district.

The average mortality of 7.1% and 6.7% was reported for does from Arbaminch Zuria and Mirab Abaya districts, respectively. Overall, higher mean mortality of 13.2%, 13.6%, 14.7% and 13.3% was reported for unweaned male kids, unweaned female kids, weaned male kids and weaned female kids, respectively from Arbaminch Zuria district whereas the corresponding values of 10.4, 11.9, 5.3 and 7.1, respectively were recorded in Mirab Abaya district. The pre-weaning death of 2.1% male and 2.5% for females in the lowland and also 0.6% for male and 1.5% for females in the midlands reported from the study conducted in Daro-Labu district of West Hararghe, Eastern Ethiopia (Dereje *et al.*, 2013) was very lower than the mortality reported in the current study for the same age groups in both studied altitudes of both districts.

Table 13 Mean death and mortality (%)/HH of goats in the last 12 months of this study

Classes of goats	District											
	Arbaminch Zuria						Mirab Abaya					
	Agro- ecology						Agro- ecology					
	Midland		Lowland		Average		Midland		Lowland		Average	
Mean	M	Mean	M	Mean	M	Mean	M	Mean	M	Mean	M	
death	(%)	death	(%)	death	(%)	death	(%)	death	(%)	death	(%)	
Does	0.13	7.2	0.33	6.7	0.23	7.1	0.30	10.7	0.20	4.1	0.25	6.7
Unweaned male kids	0.20	15.4	0.30	11.1	0.25	13.2	0.40	18.2	0.10	3.4	0.25	10.4
Unweaned female kids	0.37	28.5	0.23	7.4	0.30	13.6	0.17	12.1	0.33	11.8	0.25	11.9
Weaned male kids	0.27	20.7	0.23	8.2	0.25	14.7	0.10	6.2	0.10	4.5	0.10	5.3
Weaned female kids	0.17	15.4	0.23	10	0.20	13.3	0.23	15.3	-	-	0.12	7.1
Castrated yearling	-	-	0.03	7.5	0.02	6.3	-	-	-	-	-	-
Non castrated yearling	0.07	7	0.13	8.1	0.10	7.7	0.07	5	0.07	4.7	0.07	5
Mature castrates	-	-	-	-	-	-	0.03	5	-	-	0.02	2.7
Mature non castrates	-	-	0.10	9.1	0.05	6.3	0.07	8.7	-	-	0.03	3.3

M=Mortality

The average mortality of unweaned female kids in Mirab Abaya district of the current study was consistent with 12% reported for kids in the highlands of Ethiopia (Gebremedhin *et al.*, 2015). Mean mortality of unweaned and weaned age categories of both sexes in Arbaminch Zuria district of the current study area was higher than 11.5% pre-weaning mortality reported for Somali goat kids under station management at Haramaya University (Zelege, 2007). The average mortality of does in the present study area was lower than 9.7% reported from the highland of Ethiopia (Gebremedhin *et al.*, 2015).

#### **4.1.4. Goat breeding management and reproductive performance of goats**

##### **4.1.4.1. Goat breeding management**

In the current study area, producers select goats for breeding particularly at a time when they purchase from the market. However, goat breeding is uncontrolled, and thus, mating could occur year round. Uncontrolled breeding could also result in inbreeding which causes low production and productivity of goats. Consistent with the present findings, uncontrolled breeding of small ruminants was reported at Alaba district of southern Ethiopia (Tsedeke, 2007).

Goat selection traits of producers in the study area are presented in Table 14. About 82.4% of the respondents in both agro-ecologies select goats for breeding. Despite good mothering ability is the major desirable trait for female goat selection explained in the culling section, conformation and physical characteristics are common desirable selection criteria's for male and female goats in the study area. Thus, majority of the respondents (51.7%) in midland agro-ecology prefer conformation as a major trait for selection of both sexes of breeding goats

whereas majority of the respondents (51.7%) in the lowlands combine both conformation and physical characteristics.

There are two main goat breeding seasons in the study area. The first season extends from April to June while the second season extends from October to December. About 35% of the sampled households from the midland and 30% from the lowland reported that mostly goat mating occurs from April to June whereas the higher number of households (65-70%) from the study area observed that high mating of goats occurs from October to December. This may be due to the availability of good feed during both seasons. Similarly, Tsedeke (2007) and Takele *et al.* (2006) reported the contribution of feed availability to improved mating of goats.

Table 14 Desirable traits for selection of male and female goats for breeding

Descriptions	Agro-ecology		
	Midland	Lowland	Total
	n(%)	n(%)	n(%)
Conformation(body length, height and appearance)	31(51.7)	12(20)	43(35.8)
Physical characteristics(tail & ear length & width, color)	11(18.3)	14(23.3)	25(20.8)
Both conformation and physical characteristics	-	31(51.7)	31(25.8)
Not uses selection criteria	18(30)	3(5)	21(17.6)

n=number of households

#### 4.1.4.2. Reproductive performance of goats

##### 4.1.4.2.1. Age at first service (AFS)

The mean reproductive performances of goats as reported by the households in the study area are given in Table 15. There was significant variation ( $p < 0.001$ ) in AFS of male and female goats between the agro-ecologies across the districts. Thus, the mean AFS of both sexes of

goats was lower in the lowland ( $p < 0.001$ ) compared to midland agro-ecology. This may be due to the availability of different species of browses in the lowlands as compared to the midland agro-ecology. This study also showed that male goats reach puberty at mean age of  $9.4 \pm 0.27$  and  $9.3 \pm 0.24$  months in Arbaminch Zuria and Mirab Abaya districts, respectively whereas female goats reach puberty at the age of  $8.0 \pm 0.24$  and  $7.8 \pm 0.19$  months, respectively for both districts.

The mean AFS of male goats in the current study was higher than 7.4 months reported for Metema district (Tesfaye, 2009) and 6.6 months reported for Alaba district (Tsedeke, 2007) but lower than 12.3 months reported for Abergelle goats from Metema district (Solomon, 2014). The corresponding value for female goats in the present study was similar with 8.2 months reported for Metema district of Amahara Region (Tesfaye, 2009) but higher than 7 months reported for goats in Alaba district (Tsedeke, 2007).

#### **4.1.4.2.2. Age at first kidding (AFK)**

There was significant variation ( $p < 0.05$ ) in AFK between goats in the midland and lowlands of the study districts. The average AFK of goats (13.9 months) in the present study was in line with 13.75 months reported for goats from coastal regions of Bangladesh (Rume *et al.*, 2011), but higher than 11.9 months reported for indigenous goats in Alaba district of southern Ethiopia (Deribe, 2009) and lower than 16.7 months reported for Lare and Jikawo districts of Gambella region, South-Western part of Ethiopia (Tsigabu, 2015). The age at first kidding of goats reported in the present study was also lower than 24 months reported for Afar goats (Wilson, 1991) and 15.5 months reported for Abergelle goats (Solomon, 2014).

Table 15 Mean ( $\pm$ S.E.) reproductive performances of goats as reported by the households

Descriptions	Districts					
	Arbaminch Zuria			Mirab Abaya		
	Agro-ecology			Agro-ecology		
	Midland n=30	Lowland n=30	Overall n=60	Midland n=30	Lowland n=30	Overall n=60
AFS in male goat (m)	10.7 $\pm$ 0.29 <sup>a</sup>	8.10 $\pm$ 0.29 <sup>b</sup>	9.40 $\pm$ 0.27	10.0 $\pm$ 0.33 <sup>a</sup>	8.5 $\pm$ 0.28 <sup>b</sup>	9.3 $\pm$ 0.24
AFS in female goat (m)	9.20 $\pm$ 0.35 <sup>a</sup>	6.90 $\pm$ 0.13 <sup>b</sup>	8.0 $\pm$ 0.24	8.50 $\pm$ 0.28 <sup>a</sup>	7.20 $\pm$ 0.19 <sup>b</sup>	7.8 $\pm$ 0.19
Age at first kidding (m)	15.2 $\pm$ 0.34 <sup>a</sup>	12.9 $\pm$ 0.13 <sup>b</sup>	14.0 $\pm$ 0.24	14.5 $\pm$ 0.28 <sup>a</sup>	13.4 $\pm$ 0.25 <sup>b</sup>	13.9 $\pm$ 0.19
Kidding interval (m)	8.30 $\pm$ 0.08 <sup>a</sup>	7.50 $\pm$ 0.08 <sup>b</sup>	7.90 $\pm$ 0.08	8.30 $\pm$ 0.11 <sup>a</sup>	7.40 $\pm$ 0.10 <sup>b</sup>	7.80 $\pm$ 0.09
Average litter size (N)	1.13 $\pm$ 0.02 <sup>b</sup>	1.36 $\pm$ 0.02 <sup>a</sup>	1.24 $\pm$ 0.02	1.10 $\pm$ 0.02 <sup>b</sup>	1.34 $\pm$ 0.02 <sup>a</sup>	1.23 $\pm$ 0.02
Natural weaning age of kids (m)	4.60 $\pm$ 0.09 <sup>a</sup>	3.40 $\pm$ 0.10 <sup>b</sup>	4.20 $\pm$ 0.08	4.50 $\pm$ 0.08 <sup>a</sup>	3.60 $\pm$ 0.08 <sup>b</sup>	4.10 $\pm$ 0.08
Life time kid production (N)	13.5 $\pm$ 0.31 <sup>b</sup>	15.3 $\pm$ 0.27 <sup>a</sup>	14.4 $\pm$ 0.23	13.9 $\pm$ 0.33 <sup>b</sup>	15.4 $\pm$ 0.19 <sup>a</sup>	14.6 $\pm$ 0.21
RP lifespan of male goat (m)	54.4 $\pm$ 1.11	55.0 $\pm$ 1.04	54.7 $\pm$ 0.75	54.4 $\pm$ 1.38	54.6 $\pm$ 1.09	54.5 $\pm$ 0.87
RP lifespan of female goat (m)	96.8 $\pm$ 2.07	92.1 $\pm$ 1.24	94.4 $\pm$ 1.23	100 $\pm$ 1.53 <sup>a</sup>	93.2 $\pm$ 0.98 <sup>b</sup>	96.6 $\pm$ 1.01

n=number of households; m=months; N=number; SE=standard error; AFS=age at first service; RP=reproductive; <sup>a b</sup> means with the different superscripts across rows are significantly different at ( $p<0.05$ )

#### **4.1.4.2.3. Kidding interval (KI)**

The mean kidding interval of goats in the study area was significantly varied ( $p<0.001$ ) between the agro-ecologies across both districts. The overall mean kidding interval (7.8 months) reported in the present study was in line with 7.9 months reported for goats in Goma district of Oromia region (Belete, 2009) and comparable with 8.3 months reported for goats in Gedio Zone of southern Ethiopia (Selamawit and Matious, 2015).

The mean kidding interval of goats in the current study was higher than 6.3 months reported for western lowland goats of Amhara region (Solomon, 2014) and 5.5 and 6.6 months reported for Woito guji and Central highland goats, respectively (Netsanet *et al.*, 2016). However, it is lower than 9 month reported from Alaba district, southern Ethiopia (Deribe, 2009) and 10.5 months reported for Saanen goats raised in Sudan (Safaa *et al.*, 2015).

#### **4.1.4.2.4. Average litter size**

According to the response of the respondents, the average litter size of goats was higher ( $p<0.001$ ) in the midlands compared to lowland. The finding in the present study was similar with 1.21 reported for goats in the central highland of Ethiopia (FARM-Africa 1996). Moreover, the mean litter size reported in the current study was higher than 1.04 reported for Abergelle goats (Deribe, 2008) and 1.06 reported for Black Bengal goats managed in semi-intensive system in Bangladesh (Faruque *et al.*, 2010). However, the mean litter size reported in the current study was lower than 1.38 reported for tropical goat breeds (Girma, 2008) and 2.64 reported for goats in selected coastal regions of Bangladesh (Rume *et al.*, 2011).

#### **4.1.4.2.5. Life time kid production**

The mean lifetime kid production of goats was significantly different ( $p < 0.001$ ) between the agro-ecologies across both districts. The average life time kid production (14.5) reported in the current study is comparable with the 13.5 reported for goats in Metema district of Amhara region (Tesfaye, 2009), but higher than 11 reported for goats in pastoral and agro-pastoral production systems of Southern Ethiopia (Adugna and Aster, 2007) and 12.2 reported for Abergelle goats in Amhara region, Ethiopia (Solomon, 2014). However, the life time number of kid production in the current study was lower than 17.3 reported for western lowland goats (Solomon, 2014).

#### **4.1.4.2.6. Weaning age of kids**

The mean weaning age of kids reported in this study was significantly lower ( $p < 0.001$ ) for goats in lowland agro-ecology compared to midland. The overall mean weaning age (4.1 months) of goats reported in the current study was in agreement with 4 months reported for goats in Alaba district of southern Ethiopia (Tsedeke, 2007) and Metema district of Amhara region (Tesfaye, 2009). However, the overall mean weaning age of goats in the current study was lower than 5.5 months reported for central highland and Woito guji goats (Netsanet *et al.*, 2016).

#### **4.1.4.2.7. Reproductive lifespan**

There was no significant variation ( $p > 0.05$ ) in mean reproductive age of male goats across the studied agro-ecologies in both districts. However, the reproductive lifespan or longevity of female goats showed variation ( $p < 0.001$ ) between the studied agro-ecologies of Mirab Abaya

district. The average reproductive lifespan of goats as reported in this study was 54.6 and 95.5 months for male and female goats, respectively.

The reproductive lifespan of female goats in the present study was higher than 79.2 and 77.4 months reported for western lowland goats in Metema district (Solomon, 2014) and indigenous goat types in Nuer Zone of Gambella region (Tsigabu, 2015). On the other hand, the reproductive lifespan of female goats in the current study was comparable with 96 months reported for does in Bati area of Amhara region and lower than 100.8 and 122 months reported for does in Borena and Siti areas of Oromia and Somali Regions, respectively (Hulunim, 2014). The reproductive lifespan of male and female goats in the current study area was also lower than 98 and 102 months, respectively reported for indigenous goat types in Bale Zone (Belete *et al.*, 2015). The reproductive lifespan of does founded in the present study was lower than 140.4 and 104.4 months reported for indigenous and cross breed does, respectively reported from eastern and southern Ethiopia (Kidus, 2010).

The reproductive performances observed in the current study showed similarity with the results of some studies and differences with others. The similarity or variations in reproductive performances observed may be due to similarity or variations in breed, climatic condition, the quantity and quality of available feed resources in the areas and management system of producers.

#### **4.1.5. Marketing of goats in the study area**

##### **4.1.5.1. Market locations**

According to FG discussants, there are ten market places in the study area, from which seven markets are found in Arbaminch Zuria district and while the other three, are allocated in

Mirab Abaya district. The major livestock markets in Arbaminch Zuria districts included Shelle, Chano, Lante and Arbaminch city market. The major livestock markets in Mirab Abaya district included Birbir, district capital, and Wajifo market, 20km north from the district town in the lowland.

#### **4.1.5.2. Market participants**

Producers, retailers, small traders, brokers, medium traders, bigger traders, butcher houses and consumers are the main participants in goat marketing. Producer, small traders, brokers, butchers and consumers were also the main goat market participants reported by Hulunim (2014), Belete (2009), Tesfaye (2009) and Tsedeke (2007). Farmers keep goats and sell when they need cash and also purchases goats for breeding purpose. Retailers are also one of participants in goat marketing in the study area. They purchases goats from producers at the entrance of secondary markets before peak market time in both districts and sales to medium traders and for all late coming buyers at peak market time in secondary markets.

According to key informants interview, small traders in both districts purchases goats from small (primary) markets and trek to main (secondary) market for sale to medium traders and butcher houses. It was also reported that butcher houses across both districts mostly prefer male goats especially castrated and non-castrated matured bucks to supply meat to consumers. Butcher houses or hotels in the Zonal city and district towns purchase goats from main markets in the lowlands. Since the demand for small ruminant meat is high, hotels established market linkage with small traders who supply the animals.

Medium traders purchases small ruminants from producers, small traders and retailers at secondary or main or district markets. Brokers play crucial role in establishing marketing

linkage between medium traders and other participants in the market. Brokers facilitate negotiations between buyers and sellers and play key role in price setting. In the study districts, brokers lower market price after secret communication with traders to collect higher commission. As a result, smallholders who are in need of cash for immediate purpose are obliged to sale with low price which benefit brokers and medium traders. The result was in agreement with the reports from other parts of the country (Belete, 2009; Tsedeke, 2007; Endeshaw, 2007).

#### **4.1.5.3. Mode of marketing and price setting**

Due to absence of standardized marketing system, producers have less power in deciding price. The dominant (95% of the midland and 31.7% of the lowland) respondents reported that they sale their goats by eye ball price estimation. The remaining households' sale their goat by both eye ball price estimation and live weight basis based on access to mode of marketing in the market. Goat price setting by eye ball estimation was traditional method of marketing and also reported from other parts of the country (Hulunim, 2014; Belete, 2009; Endeshaw, 2007). It was also noted that some buyers guess price of goats through traditional methods of body condition estimation, touching the loin of the goats by their palm, observing physical appearance and distinguish its muscle accumulation. According to the interviewed households, the mode of goat marketing depends on the willingness of the buyers, which is consistent with the results from other selected areas of Ethiopia (Getachew *et al.*, 2008).

#### **4.1.5.4. Household marketing and reasons for selling goats**

In the study area producers sell goats for various reasons (Table 16). Accordingly, purchasing grains for family consumption (index= 0.294) was ranked first followed by family and animal

health treatment (index= 0.293). The other reasons for selling goats included covering cost of children school material and cloth, pay tax for land tenure and purchase farm input. Similar reasons for selling goats were reported from Alaba district of southern Ethiopia where more farmers sale small ruminants to purchase food items (Tsedeke, 2007). On the other hand, the study conducted in the highlands of Ethiopia reported meeting planned household expenses (73.5%) as a major reason for selling small ruminants followed by meeting emergency household expenses (10.6%) reported by Gebremedhin *et al.* (2015).

Table 16 The major reasons for selling goats as ranked by the households

Major reasons	Ranks					Index
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	
Purchase grain for family consumption	54	61	5	-	-	0.294
Family and animal health treatment	61	45	14	-	-	0.293
Buy cloth and school materials for children	5	8	58	31	18	0.173
Pay tax for land tenure	-	5	37	55	23	0.146
Buy agricultural inputs	-	1	6	34	79	0.094

Index = sum of [(5 for rank 1)+(4 for rank 2 )+(3 for rank 3)+(2 for rank 4 )+(1 for rank 5 )] given for an individual reason divided by the sum of [(5 for rank 1)+(4 for rank 2 )+(3 for rank 3)+(2 for rank 4 )+(1 for rank 5 )] for overall reasons.

#### 4.1.5.5. Annual income from the sale of goats

The average estimated annual incomes of the respondents from the sale of goats by physiological stage are given in Table 17. There was significant variation ( $p<0.05$ ) in the income from the sale of bucks, weaned male kids and weaned female kid goats across the agro-ecologies compared whereas in Mirab Abaya, significant variation ( $p<0.05$ ) was observed in the incomes from the sale of does and castrates or fattened goats. The average total amount of income generated from the sale of different class of goats was 2044. 4 Birr for households in Arbaminch Zuria district while it was 2,225.20 Birr for households in Mirab Abaya district (the latter is higher by 9%). The income generated from the sale of does and

weaned male kids was higher for Mirab Abaya district while the income from the sale of castrates/fatten goats was higher for Arbaminch Zuria district. However, the amount of income generated from the sale of goats was higher by 53-62% for households in lowland agro-ecology compared to households in midland.

Table 17 Estimated mean ( $\pm$ SE) annual income (Birr) of the respondents from the sale of goat

Variables	Districts					
	Arbaminch Zuria			Mirab Abaya		
	Agro-ecology			Agro-ecology		
	Midland n=30	Lowland n=30	Average n=60	Midland n=30	Lowland n=30	Average n=60
Sale of does	369.3 $\pm$ 71.26	561.3 $\pm$ 1.15	465.3 $\pm$ 68.35	363.3 $\pm$ 91.57 <sup>b</sup>	677.0 $\pm$ 91.24 <sup>a</sup>	520.2 $\pm$ 67.25
Sale of bucks	520.3 $\pm$ 81.24 <sup>b</sup>	811.7 $\pm$ 98.93 <sup>a</sup>	666.0 $\pm$ 66.24	984.3 $\pm$ 72.54	1023.3 $\pm$ 70.3	1003.8 $\pm$ 50.2
Sale of weaned male kid	0.0 $\pm$ 0.0 <sup>b</sup>	111.0 $\pm$ 39.25 <sup>a</sup>	55.50 $\pm$ 20.75	40 $\pm$ 31.29	33.30 $\pm$ 25.07	36.60 $\pm$ 19.88
Sale of weaned female kid	10.0 $\pm$ 10.0 <sup>b</sup>	122.7 $\pm$ 52.45 <sup>a</sup>	66.30 $\pm$ 27.47	36.6 $\pm$ 26.6	26.70 $\pm$ 26.67	31.60 $\pm$ 18.64
Sale of castrate/fatten	643 $\pm$ 1.07	939.7 $\pm$ 1.35	791.3 $\pm$ 87.97	335 $\pm$ 88.35 <sup>b</sup>	931.0 $\pm$ 1.43 <sup>a</sup>	633.0 $\pm$ 91.91
<b>Total annual income</b>	<b>1542.60</b>	<b>2546.20</b>	<b>2044.40</b>	<b>1759.20</b>	<b>2691.30</b>	<b>2225.20</b>

n=number of households; SE=standard error; <sup>a,b</sup> means with the different superscripts across rows are significantly different at ( $p<0.05$ )

#### **4.1.5.6. Goat marketing channels and routes**

According key informants interview and physical observation of the market, five main marketing channels were identified in the study area as listed below.

**Channel 1:** Producer => Consumer: This marketing channel directly connects producers with consumers. Thus, consumers in the local area purchase goats directly from the producers for various purposes.

**Channel 2:** Producer=>Butcher=Consumer: This marketing channel involves 3 actors connecting producer with consumer through butchers. In this case, some butcher house owners in the district town or in the Zonal city (Arbaminch) purchase animals directly from producers and supply meat to consumers after value addition.

**Channel 3:** Producer =>Small traders =>Butcher =>Consumers: In this channel, all small traders buys goats from producers at local markets in the rural areas and trek goats to district towns or Zonal City and sell to butcher houses which then after slaughter sell meat to consumers.

**Channel 4:** Producer =>Small trader =>Medium trader =>Big traders= abattoirs and live animal exporters: In this marketing channel, small traders purchase goats from producers at local market and trek to secondary market and sold to medium traders. Then after, medium traders transports goats to Humbo (terminal) market in Wolaita Zone, which borders the study districts in the Northern direction. Humbo is 105 and 45 Km far from Arbaminch Zuria and Mirab Abaya districts towns, respectively. At Humbo, medium traders sell goats to big traders who latter on transports the animals to export abattoirs and live animal exporters located in

Modjo, Adama (Nazreth) and Addis Ababa. Consumers and butcher houses in Humbo town & Sodo City also purchases animals from medium traders in Humbo market.

**Channel 5:** Producer =>Medium trader =>Big trader =>Consumer: In this marketing channel, producers’ sales goats to medium traders in the medium (secondary) market. Then after, medium trader transports goats to Humbo (terminal) market and sale to bigger traders as described above. Unlike channel 4 which connects producers with medium traders through small traders, this channel connects producers with medium traders directly and thereby makes the channel shorter.

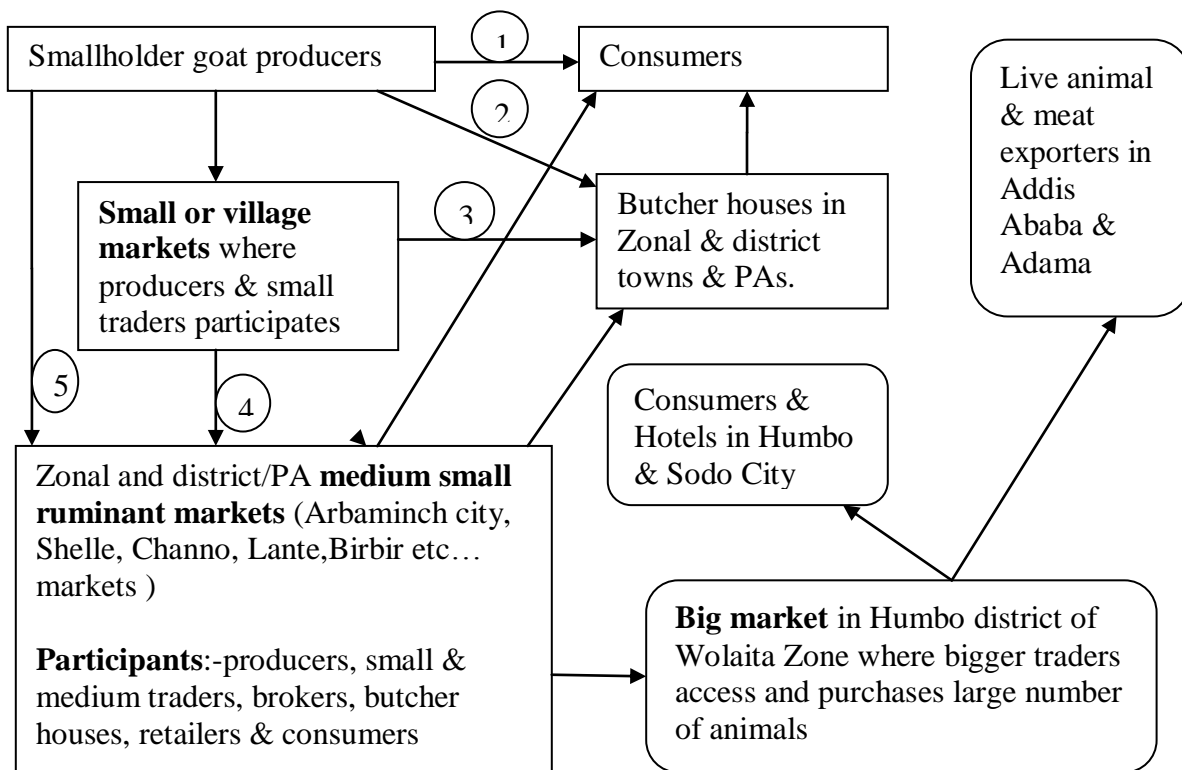


Figure 1 Diagrammatic description of goat marketing channel in the study area

## 4.1.6. Constraints and prospects of goat production and marketing

### 4.1.6.1. Constraints of goat production

The major constraints of goat production as ranked by the sampled households in the study area are given in Table 18. Accordingly, disease and parasites are the most limiting constraints of goat production (index=0.235) in the study area followed by predators (index=0.224) which attacks goats at the night and on the browsing area during the day time. According to focus group discussants, the major predators that attack goats in the study area included fox, monkey, leopard/tiger and hyena. Predators such as fox, monkey and tiger attacks goats during at the day time where as hyenas attack all classes of goats at the night. Monkey attacks young goats less than five month of age and foxes and tigers attack all classes while browsing during day time.

Table 18 Major constraints of goat production as ranked by the households

Parameters	Ranks							Index
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	6 <sup>th</sup>	7 <sup>th</sup>	
Predators	45	62	9	4	0	0	0	0.224
Disease and parasites	68	47	5	0	0	0	0	0.235
Labor shortage	5	2	16	47	28	24	0	0.134
Shrinkage of browsing land	0	0	0	15	39	24	42	0.080
Inadequate extension support	0	0	62	14	10	18	16	0.135
Lack of animal health professionals	2	4	27	34	19	29	0	0.127
Lack of veterinary institutions	0	0	1	6	24	27	62	0.065

Index = sum of [(7 for rank 1)+(6 for rank 2)+(5 for rank 3)+(4 for rank 4)+(3 for rank 5)+(2 for rank 6)+(1 for rank 7)] given for an individual reason divided by the sum of [(7 for rank 1)+(6 for rank 2)+(5 for rank 3)+(4 for rank 4)+(3 for rank 5)+(2 for rank 6)+(1 for rank 7)] for overall reasons.

Moreover, inadequate extension support, labor shortage, lack of animal health technicians, shrinkage of browsing land and lack of veterinary institutions were ranked from 3<sup>rd</sup> to 7<sup>th</sup> in the study area. The major production constraints reported by the households in this study were in accordance with the reports from Metema district (Tesfaye, 2009; Solomon, 2007). Moreover, consistent with the current study, high prevalence of disease and parasites were the most important factors limiting goat production in Metema and Abergelle districts of the Amhara Region (Solomon, 2014).

#### **4.1.6.2. Constraints of goat marketing**

The major constraints limiting goat marketing as ranked by the sampled household in the study area is presented in Table 19. Thus, dominance of broker, lack of market information, seasonal fluctuation of market price and lack of transportation were ranked from 1<sup>st</sup> to 4<sup>th</sup> with an index of 0.305, 0.289, 0.236 and 0.170, respectively. The reported goat marketing constraints in the current study were in agreement with Getachew *et al.* (2008). Brokers are the major factors influencing goat marketing system. According to key informants' interview, brokers create linkage with medium traders who purchase medium number of animals to transport to Humbo district market in Wolaita Zone. Brokers also lower the price of animal during bargaining with producers because of the fact they collect better commission from medium traders. The finding was in line with the report from western Ethiopia where brokers were mentioned as one of constraints of goat marketing (Yilma *et al.*, 2015).

Access for market information is crucial for profitability of goat production of smallholder producers. However, only less than half (42.5%) of the interviewed households in the study area had access for market information. The major source of market information for these households was neighbors who visited market a week or before. Generally, there was no

public market information source for goat value chain actors in the study area. It is believed that absence of market information exposes smallholder producers for exploitation by brokers. In consonance with the current study, lack of market information was one of the main constraints of small ruminant (sheep) marketing in Burie district (Yenesew *et al.*, 2013) and other parts of the country (Getachew *et al.*, 2008).

According to focus group discussants across both agro-ecology, the presence of goat market was better during festival seasons and low during the non-festival period. Similarly, seasonality in goat market price was reported from Western Ethiopia (Yilma *et al.*, 2015). On the other hand, smallholder goat producers from midland agro-ecology reported that they trek animals long distance for market (usually 5 to 6 hours), which is expected to have an effect on market price. This is because animals trekked from long distance loses condition and weight and inactive at the market, which creates better opportunity for brokers and traders to lower of the price. Consistent with current findings, trekking animals' long distance to market has been reported to be one of the marketing constraints in other parts of the country (Gebremedhin *et al.*, 2015; Yilma *et al.*, 2015).

Table 19 Major constraints of goat marketing as ranked by sampled households

Marketing constraints	Ranks				Index
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
Lack of market information	37	37	42	4	0.289
Dominance of brokers	43	47	23	7	0.305
Seasonal fluctuation of market price	31	21	28	40	0.236
Lack of transportation	9	15	27	69	0.170

Index = sum of [(4 for rank 1)+(3 for rank 2)+(2 for rank 3)+(1 for rank 4)] given for an individual reason divided by the sum of [(4 for rank 1)+(3 for rank 2)+(2 for rank 3)+(1 for rank 4)] for overall reasons.

#### **4.1.6.3. Prospects of goat production and marketing**

**Establishment of the Ministry of Livestock and Fisheries:** Unlike the contribution of livestock to economic development of the country at large, the sector did not receive proper attention from the government up until the establishment of the new ministry specific to livestock and fisheries. Consequently, most of the livestock experts and extension staff from federal to district and PA level had been involved in crop production activities. Consequently, livestock extension activities including goat rearing lacked attention and extension support for farmers. Starting from the year 2015/16 (2008 E.C), the livestock sector separated from crop sector from federal to district level. Although it is early (the sector has not been budgeted properly), this will create better opportunity for the sector to provide enough extension support which has been lacked in the previous years for small holders engaged in goat production and other livestock activities.

The availability of plenty of feed resources mostly in the road sides, communal browsing lands and private browsing lands is essential for smallholders to expand goat flock size and production in the future. According to 81.7% of the midland and 70% of the lowland respondents, Feed shortage is not important goat production limitation and as a result, they did not registered feed scarcity as a production constraint because of the availability of different types of browse species in the major goat feed sources. In months (January to March), other livestock encounter feed scarcity but not for goats because drought resistant browse species like *Balanites aegyptiaca* and others are available on the browsing lands.

**Growing demand for goat meat:** Currently, there is increasing demand for goat meat in both the domestic and export markets. There is huge demand for red meat (yearling intact bucks) for export (both live animal and carcass) to Middle East. Moreover, the demand for castrate

and fattened goat has been on rise in different part of the country in connection with income growth with some segments of the society and change in feeding habit (improved preference for goat meat than meat from other livestock species) in urban areas. This encourages smallholder producers to expand goat production in the future.

#### **4.1.7. Labor, extension and socio economics in goat production**

##### **4.1.7.1. Household labor division and gender role in goat management**

Division of labor in goat management by family members is presented in Table 20. All family members participates (46.7%) and (28.3%) in herding or tethering activity in the midland and lowlands, respectively. Cleaning goat barns is the responsibility of women and girls 85% and 81.7% in the midlands and lowlands, respectively. Activities such as fattening management and deciding on use of incomes from sale of goats are usually the responsibility of husband and wife where as selling of goats and take care of sick goats is mostly the duty of husband in both agro-ecologies. Husband and boys participates (75%) and (60%) in goat shelter construction in the midlands and lowlands, respectively. Participation of hired labor in herding and goat house construction is 20% and 8.3%, respectively in the lowland whereas no any participation of hired labor in goat management was reported from the midland households.

According to the response of the respondent households, all the family members participate in all goat management activities with the variations in degree of participation in each activity in both agro-ecologies. The result was in agreement with the reports of (Solomon *et al.*, 2010) for small ruminant management from Alaba PLW and (Charles *et al.*, 2015) from Teso region, Uganda, where all family members contributed to labor with regard to goat

production. In line with the current study, the highest or more than 87% of the small ruminant sales were done by the household head reported from the highlands of Ethiopia (Gebremedhin *et al.*, 2015).

#### **4.1.7.2. Institutions and innovations in development of goat production**

Accessibility to credit service is significant for smallholders to engage in goat production and fattening business. Accordingly, all interviewed households in the study area explained that there is institution in each peasant associations that provides credit for farmers known as Omo Microfinance. About 38.3% of the sampled households from the midland, 23.3% from the lowland responded that they received credit from Omo Microfinance in recent years, of which, 69.7% reported that they used the credit to buy fertilizer for crop production.

The FGD revealed that the livestock development agents employed by the government at peasant association are not providing the required extension support for livestock sector rather they are involved still in crop extension and natural resource management.

Table 20 Division of labor in goat management by family members

Activities	Agro-ecology	Participation of family members in goat management										
		H (%)	W (%)	B (%)	G (%)	AF (%)	H&W (%)	W&G (%)	B&G (%)	H&B (%)	TT (%)	HL (%)
Herding/tethering	Mid-land	-	-	-	-	46.7	-	-	33.3	6.7	13.3	-
	Low-land	-	-	1.7	3.3	28.3	1.7	-	15	11.7	18.3	20
Fattening management	Mid-land	-	8.3	-	-	20	40	-	-	-	-	-
	Low-land	-	3.3	-	-	15	73.3	-	-	8.3	-	-
Construction of shelter	Mid-land	18.3	-	-	-	1.7	5	-	-	75	-	-
	Low-land	26.7	-	5	-	-	-	-	-	60	-	8.3
Cleaning goat barns	Mid-land	-	3.3	-	1.7	10	-	85	-	-	-	-
	Low-land	-	13.3	-	1.7	3.3	-	81.7	-	-	-	-
Take care of sick goats	Mid-land	58.3	1.7	-	-	1.7	36.6	-	-	1.7	-	-
	Low-land	45	3.3	-	-	5	43.4	-	-	3.3	-	-
Selling goats	Mid-land	75	-	-	-	1.7	23.3	-	-	-	-	-
	Low-land	55	-	3.3	-	1.7	25	-	-	15	-	-
Decision on income from goats	Mid-land	25	-	-	-	-	73.3	-	-	1.7	-	-
	Low-land	15	-	-	-	5	80	-	-	-	-	-

H=husband, W=wife, B=boys, G=girls, AF=all family, H&W=husband and wife, W&G=wife and girls, B&G=boys and girls, H&B=husband and boys, TT=turn by turn with neighbors, HL=hired labor

## **4.2. Part II: On-farm Evaluation of the Effect of Supplementing with the leaves of *Balanites aegyptiaca* and Maize Grain on Growth Performance and Economic Return of Indigenous Goats**

### **4.2.1. Chemical composition of experimental feeds**

Chemical composition of feed stuff in the present study is presented in Table 21. The CP content of basal diet (natural grass hay) (5.28%) observed in the present study was lower than 6.23% reported by Birhanu *et al.* (2013). However, it is comparable with 5.5% reported for natural pasture hay in the central highlands of Ethiopia (Yoseph *et al.*, 2003). The NDF content of natural grass hay in the present study was lower than 80.87% reported for the same type of basal feed hay (Birhanu *et al.*, 2013). However, the CP content of natural grass hay in the current study was not sufficient to meet maintenance requirement of ruminants (Van Soest, 1994). Therefore, supplementation of natural grass hay with feeds that contain better nutrients is important to catalyze more efficient utilization of poor-quality roughages (Alemu, 2008).

According to Nyako *et al.* (2014) the CP content of the browse plant species varies from 8.98% to 36.50%. The CP content of *Balanites aegyptiaca* (15.1%) evaluated in the present study and used as a supplement in the current study also lies between the ranges explained above. The CP content 15.11% of desert date (*Balanites aegyptiaca*) observed in the present study was comparable with 15.2% reported by Belete *et al.* (2012) and higher than the finding 14.45% of Liman *et al.* (2016). It is lower than 15.86% reported by Kubmarawa *et al.* (2008).

Table 21 Chemical composition of feed stuff

Feed Ingredients	Chemical composition					
	% DM					
	DM (%)	OM	CP	NDF	ADF	ADL
Natural grass hay	94.5	85.4	5.28	64.6	63.0	11.4
<i>Balanites aegyptiaca</i>	95.2	87.6	15.11	38.6	37.5	10.2
Maize grain	91.3	97.0	9.23	32.2	5.30	1.20
Wheat bran	92.4	94.4	14.12	36.2	13.4	3.70
Treatments						
T1	92.4	94.4	14.12	36.2	13.4	3.7
T2	92.0	96.4	10.28	33.8	7.9	2.1
T3	94.0	88.8	14.21	37.2	36.6	9.7
T4	93.4	91.5	13.29	34.5	29.5	7.3

DM = Dry matter; OM= Organic matter; CP = Crude protein; NDF = Neutral detergent fiber; ADF = Acid detergent fiber

The ADF and ADL content of desert date (*Balanites aegyptiaca*) in the present study were higher than 23.1% and 5.2%, respectively reported by Liman *et al.* (2016). On the other hand, the NDF value of the leaf of desert date (*Balanites aegyptiaca*) in the present study was lower than 49.2% reported by the same author. The CP, NDF and ADF content of maize grain observed in the present study was comparable with 9.73%, 29.21% and 3.87%, respectively reported for the same feed by Guyo (2016). The CP content of wheat bran in the present study (14.12%) was lower than 17.5% reported by Neamn *et al.* (2014) and 17.4% reported by Endashaw *et al.* (2013). However, it is comparable with 13.8% reported by Tesfaye (2009). The variation in chemical constituents of the feeds might be due to difference in soil composition, agro-climate, stage of harvesting and processing methods.

#### 4.2.2. Dry matter and nutrient intake

The mean daily DM and nutrient intakes of experimental bucks fed basal diet natural grass hay supplemented with the leaf of desert date (*Balanites aegyptiaca*) and cracked maize grain is given in Table 22. The DMI from the basal diet increased ( $p<0.01$ ) in the order of T4 and T2>T3>T1. Among the bucks involved in the current experiment, animals in T1 had low ( $p<0.01$ ) hay DM intake because voluntary feed intake declines in forages containing less than 7% CP (NRC, 2000). According to Lazzarini *et al.* (2009) optimum rumen function requires adequate amount of protein in the diet. The total DM intake in the current study was higher ( $p<0.001$ ) for the supplemented goats than the positive controls.

Table 22 The mean ( $\pm$ SE) dry matter and nutrient intake (g/day/animal) of indigenous bucks fed natural grass hay supplemented with the leaves of desert date (*Balanites aegyptiaca*) and maize grain.

Parameter	Treatments				
	T1	T2	T3	T4	SL
DM intake					
• Hay	432.6 $\pm$ 3.55 <sup>d</sup>	452.7 $\pm$ 4.62 <sup>b</sup>	444.7 $\pm$ 4.00 <sup>c</sup>	455.5 $\pm$ 4.82 <sup>a</sup>	**
• Supplement	46.20 $\pm$ 0.00 <sup>d</sup>	230 $\pm$ 0.00 <sup>c</sup>	235 $\pm$ 0.00 <sup>a</sup>	233.5 $\pm$ 0.00 <sup>b</sup>	***
• Total	478.8 $\pm$ 3.55 <sup>d</sup>	682.7 $\pm$ 4.62 <sup>b</sup>	679.7 $\pm$ 4.00 <sup>c</sup>	688.9 $\pm$ 4.82 <sup>a</sup>	***
Total OM intake	410.6 $\pm$ 3.05 <sup>d</sup>	605.9 $\pm$ 3.96 <sup>a</sup>	586.2 $\pm$ 3.44 <sup>c</sup>	600.5 $\pm$ 4.15 <sup>b</sup>	***
Total CP intake	30.3 $\pm$ 0.18 <sup>d</sup>	48.5 $\pm$ 0.23 <sup>c</sup>	57.8 $\pm$ 0.20 <sup>a</sup>	56.2 $\pm$ 0.24 <sup>b</sup>	***
Total NDF intake	292.0 $\pm$ 2.31 <sup>d</sup>	361.9 $\pm$ 3.07 <sup>c</sup>	364.6 $\pm$ 2.67 <sup>b</sup>	369.1 $\pm$ 3.15 <sup>a</sup>	***
Total ADF intake	276.4 $\pm$ 2.25 <sup>d</sup>	299.9 $\pm$ 2.94 <sup>c</sup>	362.0 $\pm$ 2.54 <sup>a</sup>	340.8 $\pm$ 3.07 <sup>b</sup>	***
Total ADL intake	49.1 $\pm$ 0.41 <sup>d</sup>	54.5 $\pm$ 0.54 <sup>c</sup>	72.2 $\pm$ 0.47 <sup>a</sup>	63.8 $\pm$ 0.58 <sup>b</sup>	***

SE=standard error; SL=significant level; T1= natural grass hay *ad libitum* +50g wheat bran; T2= natural grass hay *ad libitum* +200g maize grain + 50g wheat bran; T3= natural grass hay *ad libitum* +200g dried leaves of *Balanites aegyptiaca* + 50g wheat bran; T4= natural grass hay *ad libitum* + 200g of maize grain and leaves of *Balanites aegyptiaca* at 1:1 ratio + 50g wheat bran; DM=dry matter; OM=organic matter; CP=crude protein; NDF=neutral detergent fiber; ADF=acid detergent fiber; ADL=acid detergent lignin;\*\* =(p<0.01); \*\*\* =(p<0.001).

The result was in accordance with the report for Somali goats fed hay *ad libitum* supplemented with Cactus and selected browses (Daniel *et al.*, 2014). Similar to the current study, previous study showed that the basal DM intake was low in non supplemented sheep compared to the sheep supplemented with *Acacia alibidae* and *Acacia seyal* leaves (Neamn *et al.*, 2014).

The higher DMI in supplemented bucks might be attributed due to higher nutrient content (CP) in the supplement as compared with bucks in control which facilitates the digestion activity of microorganisms in the rumen. The low total DM intake for goats fed on the supplement (T3) as compared to T4 and T2 may be due to the higher ADF (36.6%) and ADL (9.7%) content, and the presence of anti-nutritional substance known as saponin in the leaf of desert date (*Balanites aegyptiaca*).

#### **4.2.3. Body weight change and feed conversion efficiency**

The current study showed that final body weight (FBW), body weight change (BWC), average daily gain (ADG) and feed conversion efficiency (FCE) of goats were positively affected by supplementation (Table 23). Among the supplemented groups, bucks in T4 gained the highest ADG as compared to bucks in T2 and T3. The highest average daily body weight gain ( 66.7g/d) was recorded for bucks supplemented with mixture of the leaves of desert date (*Balanites aegyptiaca*) and maize grain (T4), followed by bucks in T3 and T2 which were supplemented with maize grain and sole leaves of desert date (*Balanites aegyptiaca*). The mean live weight change of experimental goats across the feeding period revealed higher body weight increment for goats in T4, T3 and T2 as compared to the control. The higher body weight gain over the feeding period by supplemented goats might be attributed to better

nutrient supply, higher feed digestibility, and metabolic efficiency of absorbed nutrients as compared with the control (T1).

The higher body weight gain for T4 compared to T3 indicate that the leaves of desert date (*Balanites aegyptiaca*) have a better impact on body weight change of animals when mixed with energy sources such as maize grain. Similarly, FARM-Africa (2008) reported that the overall performance of goats grazing pasture and supplemented with *Prosopis juliflora* pods mixed with corn was higher compared to supplementing with *Prosopis juliflora* pods alone.

Table 23 Mean ( $\pm$ SE) body weight gain of indigenous bucks fed natural grass hay supplemented with the leaves of desert date (*Balanites aegyptiaca*) and maize grain.

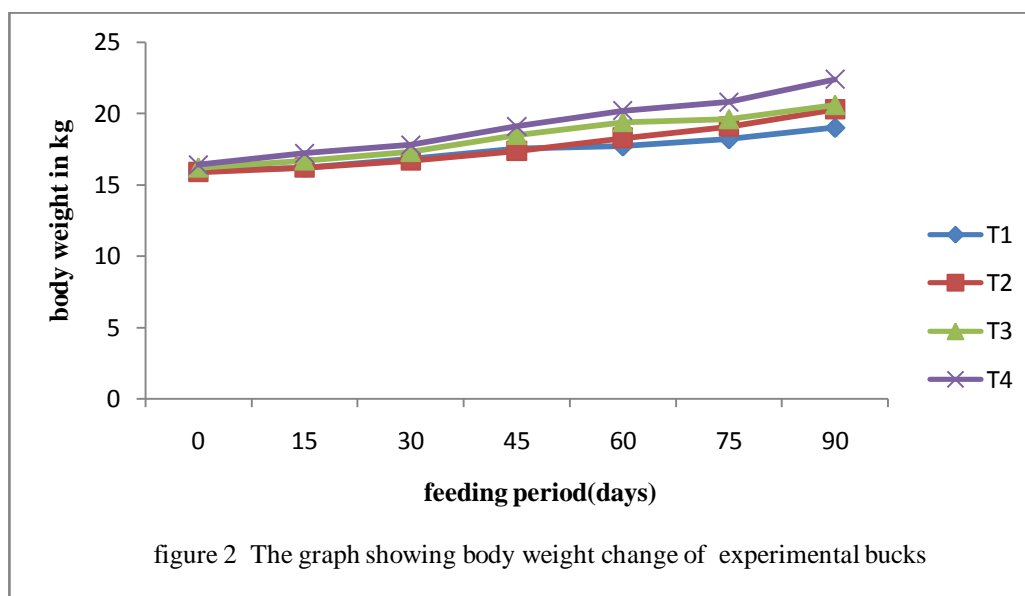
Parameter	Treatments				
	T1	T2	T3	T4	SL
Initial body weight (kg)	16.0 $\pm$ 0.28	15.9 $\pm$ 0.28	16.2 $\pm$ 0.28	16.4 $\pm$ 0.28	NS
Final body weight (kg)	19.12 $\pm$ 0.22 <sup>c</sup>	20.51 $\pm$ 0.23 <sup>b</sup>	20.53 $\pm$ 0.22 <sup>b</sup>	22.14 $\pm$ 0.23 <sup>a</sup>	***
Body weight change (kg)	2.99 $\pm$ 0.22 <sup>c</sup>	4.38 $\pm$ 0.23 <sup>b</sup>	4.40 $\pm$ 0.22 <sup>b</sup>	6.02 $\pm$ 2.60 <sup>a</sup>	***
Average daily gain (g)	33.24 $\pm$ 2.52 <sup>c</sup>	48.72 $\pm$ 2.57 <sup>b</sup>	48.94 $\pm$ 2.51 <sup>b</sup>	66.86 $\pm$ 2.60 <sup>a</sup>	***
FCE (g ADG/g TDMI)	0.069 $\pm$ 0.004 <sup>b</sup>	0.072 $\pm$ 0.004 <sup>b</sup>	0.072 $\pm$ 0.004 <sup>b</sup>	0.097 $\pm$ 0.004 <sup>a</sup>	**

SE=standard error; SL=significant level; NS=not significant; FCE = feed conversion efficiency; ADG=average daily gain; TDMI=total dry matter intake; T1= natural grass hay *ad libitum* +50g wheat bran; T2= natural grass hay *ad libitum* +200g cracked maize grain + 50g wheat bran; T3= natural grass hay *ad libitum* +200gm dried leaves of *Balanites aegyptiaca* + 50g wheat bran; T4= natural grass hay *ad libitum* + 200g of cracked maize grain and leaves of *Balanites aegyptiaca* at 1:1 ratio + 50g wheat bran; NS (Not significant)=( $p>0.05$ ); \*\*=( $p<0.01$ ); \*\*\*=( $p<0.001$ ).

The ADG of bucks observed in the present study was consistent with 66.4g reported by Dereje (2014) for sheep fed basal diet of natural grass hay and supplemented with 300g mixture of concentrate and Tagasaste (*Chamaecytisus palmensis*) forage. Moreover, the ADG of goats in T4 in the current study was also comparable with 60.6 - 63.7g/day reported by Horro rams (Bahran, 2014). The ADG of bucks in T3 of the current study was lower than 20.3 g/d ADG of Small East African goats fed *ad libitum* maize (*Zea mays*) stover supplemented

with 10g of the leaves of desert date (*Balanites aegytiaca*) per kg metabolic weight reported by James *et al.* (2013).

The low BW of bucks in T1 might be attributed to the lower total DM and CP intake as compared with supplemented groups. The improved FCE in the supplemented groups as compared with the controls appeared to be related to higher nutrient concentration in the supplement feeds and the consequent increase in BWG and the ability of bucks to convert feed efficiently to flesh. The finding was in accordance with the work of Ebrahimi *et al.* (2007) who noted that high protein and energy levels in the diet improves ADG and FCE of animals.



#### 4.2.4. Partial budget analysis

Partial budget analysis helps the farmer or pastoralist to evaluate the economic feasibility in the small ruminant business and used to decide about the future use of new technology or practice (Adane, 2008). In the current experiment, the partial budget analysis was done to evaluate the smallholder farmers' profitability through supplementing bucks with the leaves

of desert date (*Balanite aegyptiaca*) and maize grain (Table 24). The result of partial budget analysis revealed that supplementing indigenous bucks with desert date (*Balanites aegyptiaca*), maize grain and the mixture of both resulted relatively higher return as compared to bucks in positive control.

Table 24 Partial budget analysis of goats fed on natural pasture hay and supplemented with the leaves of desert date (*Balanites aegyptiaca*) and maize grain

Descriptions	Treatments			
	T1	T2	T3	T4
Purchasing price (ETB/buck)	480	480	490	490
Selling price (ETB/buck)	722	860	864	982
Cost of natural grass hay (ETB/buck)	192.42	192.42	192.42	192.42
Cost of wheat bran (ETB/buck)	24.75	24.75	24.75	24.75
Cost of maize grain (ETB/buck)	-	100.8	-	50.4
Cost of the leaf of desert date (ETB/buck)	-	-	90	45.0
Total variable cost/TVC (ETB/buck)	217.17	317.97	307.17	312.57
Total return/TR (ETB/buck)	242.0	380.0	374.0	492
Net return/ NR (ETB/buck)	24.83	62.03	66.83	179.43
Change in total variable cost/ $\Delta$ TVC(ETB/buck)	-	100.8	90.0	95.4
Change in total return/ $\Delta$ TR (ETB/buck)	-	138.0	132	250
Change in net return/ $\Delta$ NR (ETB/buck)	-	37.2	42	154.6
Marginal rate of return /MRR (%)	-	36.9	46.7	162.1

T1= natural grass hay *ad libitum* +50g wheat bran; T2= natural grass hay *ad libitum* +200g cracked maize grain + 50g wheat bran; T3= natural grass hay *ad libitum* +200g dried leaves of *Balanites aegyptiaca* + 50g wheat bran; T4= natural grass hay *ad libitum* + 200g of cracked maize grain and leaves of *Balanites aegyptiaca* at 1:1 ratio + 50g wheat bran; ETB=Ethiopian birr

Although the net return was positive across all the treatments, it was higher for bucks supplemented with T4 (179.43 ETB) compared to the other treatments. The result of this study showed that per unit of expenditure could result in return of 0.37, 0.47 and 1.62 ETB per bucks for T2, T3, and T4, respectively. Therefore, supplementing the bucks with mixture of desert date (*Balanites aegyptiaca*) and maize grain (T4) was economically feasible because it returned high net return than the other treatments and it could be recommended for smallholder goat producers as a supplementary feed.

## **5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS**

### **5.1. Summary & Conclusion**

This study was conducted to assess goat production system and marketing, identify and prioritize goat production constraints and opportunities in both of representative districts and evaluate the effect of supplementing with the leaves of desert date (*Balanites aegyptiaca*) and maize grain on growth performance and economic return of indigenous goats in Mirab Abaya districts of Gamogofa Zone, Southern Ethiopia. The districts were purposively selected from Gamogofa Zone based on the potential of high value livestock commodities by the LIVES project of ILRI. The districts were stratified into 2 based on agro-ecology (midland and lowland) of which 2 PAs were selected based on goat population and accessibility for transportation. This was followed by FGD and key informants' interview with individuals and institutions knowledgeable in goat production and development in the area prior to the actual survey. Questionnaire was developed and pre-tested before administering. After a rapid reconnaissance survey, fifteen households were selected from each PA and the total number of households involved in the survey was 120 (2 districts x 2 agro-ecology x 2 PA x 15 households) households were interviewed.

For evaluation of the effect of supplementation with locally available feeds on biological and economic performance of indigenous goats, 5 households who have experience in goat production and fattening and willing to participate in the study and able to contribute 4 bucks were selected. A total of 20 intact indigenous bucks aged between 8 to 10 months with an average initial body weight of  $16.13 \pm 0.3$ kg (Mean  $\pm$  S.E.) were involved in the study. The treatments consisted of feeding natural grass hay *ad libitum* supplemented with 50g wheat

bran (T1; positive control); feeding natural grass hay *ad libitum* supplemented with mixtures of 50g wheat bran and 200g cracked maize grain (T2); feeding natural grass hay *ad libitum* supplemented with mixtures of 50g wheat bran and 200g dried leaves of *Balanites aegyptiaca* (T3), and feeding natural grass hay *ad libitum* supplemented with 50g wheat bran and mixture of 200g of dried leaves of *Balanites aegyptiaca* and cracked maize grain at 1:1 ratio (T4). The experiment was laid out using randomized complete block design (RCBD) with 4 treatments and 5 replications. Animals were blocked by households since the level of management may differ from one to other. The animals were housed individually and provided with the basal and test diet separately. Initial body weight of goats was considered as covariate to adjust final measurement.

The results of this study showed that about 86.7% of the interviewed households were males while the remaining 13.3% were females across both districts. The present findings also demonstrated that about 38.3% and 58.3% of the survey households were illiterate in Arbaminch Zuria and Mirab Abaya districts, respectively. Income generation is the primary reason for keeping goats in the study area followed by saving, manure, social capital and meat consumption, respectively. The major feed resources in the study area were browsing lands (road side, communal and private), crop residues, aftermath and improved forages. The two main goat breeding seasons reported by the households were April to June and October to December when availability of feed is good while goat breeding was totally uncontrolled. Breeding females with poor mothering ability that fails to conceive after repeated mating and has abortion problem are primarily culled from the flock. Male and female goats achieve AFS at 9.4 and 7.9 months and also productive lifespan at ages below 54.6 and 95.5 months,

respectively. AFK, KI, LS, weaning age of kids and lifetime kid productions are 13.9, 7.8, 1.24, 4.1 months and 14.5, respectively.

Disease and parasites are the most limiting constraint in goat production of the study area. Mostly disease occurs from January up to April in the study area which caused higher 13.2%, 13.6%, 14.7% and 13.3% death of unweaned male kids, unweaned female kids, weaned male kids and weaned female kids, respectively in Arbaminch Zuria district from the studied areas 12 months before the start of this study. Dominance of brokers, Lack of market information and seasonality of price are the major marketing constraints. Involvement of institutions for the development of the sector is very low. The second part of the study showed that supplementing goats with maize grain and *Balanites aegyptiaca* (T2-T4) improved ADG (48.72, 48.9 and 66.8 g/day for T2, T3 and T4, respectively) compared to the control (33.2g/day). However, among the supplemented groups, bucks fed on T4 gained superior ADG than bucks fed on T2 and T3 diets. Moreover, partial budget analysis confirmed that T4 was more profitable compared to other supplementary treatments. Therefore, it is concluded that supplementing growing bucks with T4 could be recommended for smallholder goat fatteners.

## **5.2. Recommendations**

- This study showed that there is shrinkage of browsing land for goats due to expansion of arable farming. On the other hand, most of the browse species are tolerant to draught, contain high protein and better support ruminant production during the dry season. Thus, the comparative advantage of goat farming over crop production should be looked into in these areas, and effort should be made to conserve and sustainably use these resources.

- Since disease and parasites are among the major bottlenecks hindering goat development in the study area, the causes and predisposing factors and seasonal occurrence should be adequately studied for introduction of pertinent interventions. Moreover, disease surveillance should be done to control the disease before it causes morbidity and mortality.
- In the future, another on-farm feeding experiment should be conducted on supplementation with maize grain and desert date to confirm its efficiency and this technology should be scaled out to other areas with similar agro-climate and feed resources for higher benefit.
- Since it is expected that browse species contain different types and levels of anti-nutritional factors, which have negative effect on feed utilization, further study should focus on quantifying the level of anti-nutritional factor of *Balanites aegyptiaca* and its possible effect on the efficient utilization of the forage.
- Since the technical support provided to livestock sector by public extension system and other development facilitator (e.g. NGOs) has been marginal as compared to the contribution of the sector to the livelihood of smallholders, future strategy should focus on improving the production, productivity and income of livestock producers following the value chain framework and market oriented extension approach.

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## 7. APPENDIX

Appendix 1 Questionnaire used for goat production system and marketing survey in

Gamogofa Zone

1. Name of Enumerator .....
2. Name of Peasants Association.....District: .....Date of Interview.....

### Part One: General information

1. Name of the interviewee .....sex .....Age.....
2. Educational status of the HH head: A) Illiterate B) Grade 1-6 C) Grade 6-12
3. Position in the household A) Household head B) Spouse/wife of head
4. Household family size (number): Male .....Female ..... Total .....
5. Educational level of Family members.  
Illiterate .....; Grade 1-6 .....; Grade 6-12 .....; Higher education .....
6. What is the size of your total land holding in timad? .....
7. How much is your land allocated for the followings?
  - Crop land.....timad;
  - Fruit land .....Timad;
  - Vegetable land .....timad;
  - Fallow land.....timad,
  - Grazing/pasture land .....timad,
  - Others .....timad;

8. How many of the following animals you keep?

Type of livestock	No of animals owned			
	Indigenous			
	At the start of 2014	No animals sold	No of animals died	At the End of 2014
Cattle				
Goats				
Does				
Un-weaned Kids (<4 months)				
• Male				
• Female				
Weaned kids (4-12 months)				
• Male				
• Female				
Yearlings (12-24 months)				
• Male				
➤ Castrate				
➤ Non-castrate				
• Female				
Matured goats				
• Male				
➤ Castrate				
➤ Non-castrate				
• Female other than does				
Sheep				
Equines				
• horses				
• Mules				
• donkey				
Chickens				

9. What is your major farming activity? A) Livestock production B) crop production

C) Both D) others, specify .....

10. What type of livestock production system you practice? A) Extensive (grazing only)

B) Semi-intensive (controlled grazing with supplementation) C) Intensive (staff feeding)

11. How long have you been involved in goat farming? For ..... Years

12. Why do you keep goats? (Rank by putting 1, 2, 3,4,5,6 in descending order)

No	Purpose of keeping goat	Rank
1		
2		

**Part Two: Goat production**

A. Feed and water resources, seasonal calendars and feeding managements

1. What are the major feed resources for goats in your area?

No	Feed types	Rank
1		
2		
3		

➤ The below table is about feeding calendar to collect the list of feed resources from the previous table.

2. What are the major feed resources available for goats & their Seasonal availability?

No	Feed types	Seasonal availability		
		Sep-Dec	Jan-Mar	Apr-Aug
1				
2				
3				

3. Do you usually provide your goats with supplementary feeds in addition to grazing?

A) Yes                                      B) No

4. If yes, what type of feed and others?

No	Supplementary feed types	Classes of goats supplemented			
		Does	Kids	Buck	Castrates
1					
2					
3					

5. When do you usually offer your goats with supplements? A) Dry season

B) Wet season      C) Both      D) others, specify .....

6. How often do you offer supplements to your goats? A) Daily      B) Twice a day

- C) Whenever available D) others, specify .....
7. If you not provide with supplements, why? A) Not accessible B) Expensive  
C) Not want to offer goats D) others, specify.....
8. Do you conserve feed? A) Yes B) No
9. If yes, which type of feed? A) Natural pasture grass B) crop residues  
C) Banana residue D) others (specify) .....
10. If not why? A) Not skilled and experienced B) Shortage of grasses/fodder  
C) Labor shortage D) others, specify .....
11. Do you practiced tether feeding of goats A) Yes B) No
12. If yes, why? A) To avoid crop and vegetation damages B) To save labor  
C) Protect from predators D) Utilize marginal land and hillsides  
E) To control breeding F) others, specify .....
13. Is there feed shortage for your goats? A) Yes B) No
14. If yes, when? A) Dry season B) Wet season C) Both
15. If feed shortage in your locality, why? (Rank & put 1,2,3,4,5,6 in descending order)

No	Cause of feed shortage	Rank
1		
2		
3		

16. What are the common water sources for goats in your area?

No	Source of water	Rainy season	Wet season	Estimated distance in km
1				
2				
3				

17. In what intervals you offer goats with water in dry season? A) Any time required  
B) Once a day C) Twice a day D) Every two day E) every three day F) others, specify.....

18. In what intervals you offer goats with water in wet season? A) Any time required  
 B) Once a day C) Twice a day D) Every two day E) Every three day
19. Is there any water shortage to your goats? A) Yes B) No
20. If yes, when? A) Dry season B) Wet season C) Both
21. Why shortage of water? A) Drying of water sources B) Far distant from water sources  
 C) Not allowed to use sources D) Provide other livestock than goats
22. Do you provide your goats with mineral supplements? A) Yes B) No
23. If yes, which type of mineral do you provide for your goats?

No	Type of mineral supplement	Quantity provided	Frequency	Classes of Goats Supplemented			
				Does	Kids	Buck	Castrates
1							
2							
3							

**B. Goat health management**

1. What are the common diseases and parasites that affect health and production of goats?

No	Name of the disease	symptoms	Season or month of occurrence	What action do you take?
<b>Major diseases</b>				
1				
2				
3				
4				
<b>Major internal parasites</b>				
1				
2				
3				
<b>Major external parasites</b>				
1				
2				
3				

2. Are you accessible to veterinary services? A) Yes B) No

3. If no, what would you do when your goats sick? A) Treat with ethno veterinary practices  
B) Sales immediately C) Slaughters immediately D) Treat with medicaments himself;
4. If yes, how far? .....km
5. Where do you usually obtain veterinary services? A) Office of agriculture  
B) kebele animal health technicians C) NGOs D) Private institutions E) Open markets
6. How you obtain services in these institutions?  
A) Free of charge B) Payment C) Credit D) others, specify.....
7. Do your goats vaccinated? A) Yes B) No
8. If yes, how? A) After report of disease outbreak B) After certain animals died
9. If yes, for which disease? .....
10. If yes, in which year and season? Year ..... season .....
11. Do your goats treated against internal or external parasites? A) Yes B) No
12. If yes, in which year and season? Year ..... season .....
13. In which months do disease outbreak occurs in your area? .....
14. Do you use medicines and drugs from illegal traders or open markets for goats?  
A) Yes B) No
15. If yes, why? A) low cost B) Not accessible to veterinary center  
C) Not want to use veterinary center D) others, specify .....
16. If not use, why? A) Not cures B) DAs and health experts advised not to use  
C) Expensive D) Not accessible E) others, specify .....
17. Do you cut and/or brand with hot iron your goats? A) Yes B) No
18. If yes, why? A) Ethno veterinary treatment to sick animals  
B) Identify/tag the animals C) others, specify .....



8. How is the reproductive performance of goats in your farm?

No	Details	Male	Female
1	Age at first service/mating		
2	Age at first kidding (months)	-	
3	kidding interval (months)	-	
4	Average litter sizes(single, twin, triplets)	-	
5	Infertile at age in month		
6	Slaughter age (months) or marketing age		
7	Longevity (life time production)		
8	Year of disposal/culling		

**D. Kid rearing, castration, culling and fattening**

1. Do you allow goat kids to suck their dam after birth? A) Yes      B) No
2. If yes, duration of sucking (months)? .....
3. Do you practice weaning kids?      A) Yes      B) No
4. If yes, when? After ..... months
5. Do you practice castration of goats?      A) Yes      B) No
6. If yes, how? A) Use Burdizo by yourself    B) ask service from veterinarians  
                   C) Traditional method, specify .....    D) others, specify.....
7. Why you castrate your goats? A) To fetch more prices by fattening  
                   B) To avoid mating of flock with unwanted male goats    C) others, specify .....
8. At what age you castrate your goats? After ..... months
9. Do you offer specific feed and other management practices for castrated goats?  
                   A) Yes      B) No
10. If yes, what and for how long? Feed types .....  
                   Duration of feeding.....
11. Do you practice fattening of goats?      A) Yes      B) No
12. If yes, why? .....

13. If not, why? .....
14. If yes, do you fatten males or females? .....
15. If yes, do you fatten castrates or uncastrates? .....Why?.....
16. If yes, do you have any specific period for fattening?   A) Yes        B) No
17. If yes, please list them and explain duration of fattening (months)

No	Period/time for fattening	rank	duration of fattening
1			
2			

18. What are the Criteria's for selecting fattening goats?

No	Criterion for selecting fattening goats	rank
1		
2		
3		

19. How do you fatten your goats? A) Stall fed (intensive)   B) semi-intensive  
C) Extensive (grazing)
20. What is the source of goats for fattening? A) Produced on-farm  
B) Purchased from market C) others, specify.....
21. Is there any emerging opportunity of increased demand and incentive price for fattened goat?        A) Yes                        B) No
22. If yes, please mention. ....
23. Do you practice culling of goats from your flock?        A) Yes                        B) No
24. If yes, why? (Rank by putting 1,2,3,4,5,6 in descending order)  
A) Old age                B) Sickness        C) kidding problems  
D) Physical defect    E) Unwanted physical characteristic G) others, specify.....

**E. Provision of shelter for goats**

1. Do you provide shelter for your goats?   A) Yes                        B) No



5. If yes, what is the amount of milk produced per does at your farm?

Minimum:.....Maximum: ..... average: .....

6. If no, why?      A) Cultural taboo      B) Religious taboo  
                          C) Not common in the area      D) others, specify .....

**Part Three: Marketing of goats**

1. Have you sold goats in the past 12 months?      A) Yes      B) No

2. If yes, why? (List and rank by putting 1,2,3,4,5,6 in descending order)

No	Reasons for selling goats	rank
1		

3. Where do you sell your goats?      A) Farm gate      B) Farmers in the same village

                         B) Farmers in nearby village      C) Market, specify .....

4. Have you purchased goats in the last 12 months?      A) Yes      B) No

5. If yes, from where did you purchase?      A) Farmers in the same village

                         B) Farmers in nearby village      C) Market, specify .....

6. Why did you purchase goats?      A) To slaughter for festivals

                         B) To slaughter for ceremonies/rituals      C) Breeding      D) fattening

7. How many goats have you sold and purchased in the past 12 months and how much?

No	Classes of animals	sold				purchased			
		Number	When/ Months	Unit Price	Total price	Number	When/ Months	Unit Price	Total price
1	Doe								
2	Buck								
3	Male kid								
4	Female kid								
5	Castrate/fatten								

8. How do you sale or purchase your goats?      A) Live weight basis

                         B) ‘Eye ball’ Estimation      C) Both      D) others, specify .....

9. Why do you prefer this mode of marketing?

- A) Incentive prices      B) Traders make mischief with weighing scale  
C) Purchasers like this      D) Reliable and save my time      E) other, specify .....

10. Did you ever get goat price and market information?      A) Yes      B) No

11. If yes, from where?      A) DAs      B) Governmental organizations specify .....  
C) NGOs      D) others, specify .....

12. Do you know the criteria/preference of local markets?      A) Yes      B) No

13. If yes, what are the criteria's/preference of local markets?.....

S14. Do you have any access for export market (Mojo/Debre Zeit export abattoirs)?

A) Yes      B) No

15. If yes, what are the preferences of export market/ abattoirs compared to domestic market?

.....

**Part Four: Constraints and prospects of goat production and marketing**

1. What are major constraints hinder production of goats in your area? (list and rank)

No	Constraints that hinder goat production	rank
1		
2		
3		
4		

2. What are the potentials of goat production in your area?

No	potentials of goat production	rank
1		
2		
3		
4		

3. What are major constraints hinder marketing of goats in your area?

No	Constraints that hinder goat marketing	rank
1		
2		
3		
4		

4. Explain the potentials of marketing in your area

No	potentials of marketing	rank
1		
2		
3		

5. Do you want to expand goat flock sizes and production in the future? A) Yes B) No

6. If yes, Reasons? A) High market demand B) Incentive market price  
 C) Easy to manage and keep E) Immediate returns  
 F) Appropriate for slaughter and home consumption G) others, specify .....

7. If no, why? A) Shortage of grazing lands and feeds B) Shortage of labor  
 C) Prefer another animal species D) Marketing problem  
 E) Lack of capital to purchase goats and inputs F) others, specify.....

**Part Five: Labor, extension and socio-economics**

**A. Gender, labor allocation and decision on benefits from goats**

1. Do you encounter labor shortage in goat production aspects? A) Yes B) No

2. For what major tasks you face labor shortage? A) Herding and tethering B) Watering  
 C) Looking after kids D) Construction of shelter E) Take care of sick goats

3. How you overcome the labor shortage? A) Hire laborer B) use family labor  
 C) Keep turn by turn with neighbor D) others, specify.....



5. Are you satisfied with the lending regulations and terms to repay the credit?

A) Yes

B) No

6. Did you receive goats from any source?      A) Yes      B) No

7. If yes, from which sources?      A) Credit      B) Gift from NGOs, specify .....

C) Gift from Government Organizations      D) Share arrangements

E) Exchange (crop, other livestock, inputs, etc)

8. Is there any cooperative in your area?      A) Yes      B) No

9. If yes, in what sector?

A) Crop production (storage, marketing, deliver inputs to members, etc)

B) Livestock (Marketing, deliver inputs, assemble products, etc)

C) Inputs (deliver different inputs, credits, insurance, etc)

D) Others, species .....

Appendix 2 Summary of ANOVA Table for the dry matter and nutrient intake (g/day/animal) of indigenous bucks fed natural grass hay supplemented with the leaves of desert date (*Balanites aegyptiaca*) and cracked maize grain.

Intake	DF	MS	F	P
Hay DM intake	3	47251.286	5.732	0.001
Supplement DM intake	3	3920575.125	390.432	<.001
Total DM intake	3	4733654.099	574.228	<.001
Organic matter intake	3	3963710.085	651.982	<.001
Crude protein intake	3	71709.006	3395.3	<.001
NDF intake	3	607030.369	169.270	<.001
ADF intake	3	675158.399	202.797	<.001
ADL intake	3	47022.177	407.421	<.001

Means with different lowercase letters in the same row are significantly different ( $p<0.05$ ); DF=degree of freedom; MS=mean square; DM=dry matter; NDF=neutral detergent fiber; ADF=acid detergent fiber; ADL=acid detergent lignin

Appendix 3 Summary of ANOVA Table for the body weight gain of indigenous bucks fed natural grass hay supplemented with the leaves of desert date (*Balanites aegyptiaca*) and cracked maize grain.

Parameter	DF	MS	F	P
Initial body weight (kg)	3	0.246	0.156	0.924
Final body weight (kg)	3	9.812	5.880	0.007
Total body weight change(kg)	3	7.517	24.544	<.001
Average daily gain (g)	3	927.984	24.544	<.001
Feed conversion efficiency	3	0.001	9.308	<.001

Means with different lowercase letters in the same row are significantly different ( $p<0.05$ ); DF=degree of freedom; MS=mean square

## **BIOGRAPHICAL SKETCH**

The author was born in Arbaminch Zuria district of Gamogofa Zone, Southern Ethiopia, on March 10, 1987 G.C. He attended elementary school in Chano Dorga and junior school in Arbaminch Kulufo junior school. He had completed his secondary and preparatory education at Arbaminch secondary and preparatory school in 2005 G.C. Then after, he joined Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) and graduated with Bachelor of Science degree in Animal Science in 2008.

Soon after graduation, he was employed by Ministry of Agriculture as Animal production and nutrition expert in Mirab Abaya district Office of agriculture, Gmogofa Zone and served for seven years till he joined the School of Graduate Studies of Hawassa University to pursue his MSc study in Animal production.