Characterization of Sheep Production Practices in Mixed Crop-livestock and Agro-pastoral Systems of Central and Eastern Ethiopia

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Abstract: The study was conducted in Digelu-Tijo and Meiso districts representing the mixed crop-livestock and agro-pastoral production systems, respectively with an objective of characterizing sheep production practices. A total of 150 households from six rural kebeles (75 households from each production system) were selected randomly based on sheep population and accessibility. Data were collected through structured questionnaire, focus group discussion and field observation. The average number of sheep per household in mixed crop-livestock (12.5±0.99) was higher ($p<0.001$) than that of agro-pastoral production system (6.2±0.34). The purposes of keeping sheep in both production systems were to generate income followed by saving, meat, and manure. Natural pasture and crop residues were the major feed resources in both production systems. Water sources were largely rivers, springs, ponds and pipe with different magnitude of use during wet and dry seasons. The major diseases and parasites of sheep during the dry season were pasteurellosis, sheep pox, orf, parasites, peste des petits ruminants (PPR), foot and mouth disease (FMD) and blackleg, while, liver flukes and lungworms were common across the production systems during the wet season. The survey revealed predominance of uncontrolled mating (97.7%) in mixed crop-livestock than the agro-pastoral (50.7%) production system ($p<0.05$). Despite diverse production management practices identified, overall sheep production systems were affected by constraints related to feed and water shortages and prevalence of infectious and parasitic diseases. Thus, to increase sheep productivity, designing and implementing sustainable sheep production improvement programs targeting at solving these constraints are crucial.

Keywords: *Breeding practices, Constraints, Feed sources, Production objectives, Sheep*

Introduction

Ethiopia is home for 9 breeds and 14 traditional sheep populations (Solomon *et al*., 2007) with an estimated 33.02 million heads (CSA, 2019). In Ethiopia, sheep are the second numerous farm animals distributed across the different agro-ecologies ranging from cool alpine climate of the mountains to the arid pastoral areas of the lowlands (Solomon *et al*., 2010). Sheep have multipurpose functions, which include provision of food, mainly meat in Ethiopia, manure, and source of income (Shigdaf *et al.,* 2013). They are also considered as a living bank against the various environmental calamities and have socio-cultural values for diverse traditional communities (Zewdu *et al*., 2010). The prevailing sheep production systems have evolved in relation to the availability of land, the overall pattern of crop production and farming systems (the type of crop production practiced and the frequency or intensity of cropping), the area of uncultivated wasteland and the density of animal populations (Solomon *et al*., 2010).

Mode of livestock production in Ethiopia is broadly classified into pastoral, agro-pastoral, mixed crop-livestock and the emerging peri-urban and urban production systems. Solomon *et al.* (2008) classified sheep production system in Ethiopia into five sub systems, which includes highland sheep-barely, mixed crop–livestock, pastoral and agro-pastoral, ranching and urban and peri-urban production systems. In pastoral systems, extensive livestock production is the main source of livelihood with little or no cropping. Livestock production is mostly a secondary enterprise in the highland mixed crop–livestock systems, although livestock assumes a major importance in areas, where crop production is unreliable.

Although the sheep production systems in the country is well defined, the systems lack up-to-date and location specific information regarding production practices, constraints and marketing strategy. Moreover, the vibrant nature of livelihood, agro-ecology, level of input, intensity of production, reliability of crop production, availability of land and type of commodity produced require dynamic information. Therefore, understanding sheep production practices under the different systems would enable to know the opportunities and constraints prevailing in the system and to design appropriate

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strategy to lessen the production bottlenecks. The objective of this study was, therefore, to characterize sheep production practices in agro-pastoral and mixed crop-livestock production systems to generate information that support the setting up of sustainable production improvement strategy within the specific system.

Materials and Methods

Description of the Study Areas

The study was conducted in Digelu-tijo and Meiso districts of Oromia National Regional State, located in the Central and Eastern Ethiopia, respectively. Digelu-tijo district is located between 7°5'0" and 7°52'30"N latitude and 39°0'0" and 39°25'0"E longitude. Its altitude ranges 1107 to 3106 meters above sea level (masl). The annual rainfall and temperature ranges 900 to 1400mm and 10-22°C, respectively. The sheep population of the district is estimated at 119,544 (DWOA, 2014). Mieso is a district where pastoral/agro-pastoral farming system prevails. The district is located between 40°9'30.1" and 40°56'44"E longitude and 9°19'52" and 8°48'12"N latitude, with an altitude ranging from 1107 to 3106 masl The most parts of the district are situated at about 1700 masl and it receives average annual rainfall of 635-945 mm, while its mean annual temperature is 21°C (MBPRD, 2014).

Sampling Procedure and Data Collection

Prior to the actual data collection, discussions were made with zonal and district livestock experts and development agents (DAs) to get actual information on the sheep population, production area coverage and production potential of the rural kebeles in the districts. Arsi and East Haraghe zones were selected purposively based on sheep population, difference in production system and accessibility. Similarly, the districts and three rural kebeles from each district were selected purposively based on the same criteria. Simple random sampling was used to select target households. The total number of households taken for the study was 150 (75 from each production system). A formal interview using structured questionnaire was employed to collect data from the selected households. The questionnaire was tested before the actual interview to ensure that all questions were of sufficient clarity to the interviewees. Data on general household information, purpose of keeping sheep, labor utilization, feeds and feeding, watering, housing, reproductive performance and major constraints of sheep rearing were collected.

Data Analysis

Data collected through questionnaire was organized and analyzed using SPSS version 20 (SPSS, 2011) and presented as descriptive statistics such as mean and percentages. Pearson's Chi-square ($\chi 2$) test was used for categorical variables to assess a statistical significance of a particular comparison. One-way ANOVA was applied for quantitative variables using the statistical model:

$$Y_{ij} = \mu + PS_i + \varepsilon_{ij}$$

Where:

Y_{ij} = the observed production management in the i^{th} *production systems*

μ = overall mean

PS_i = the effect of i^{th} production systems (i = 1 and 2)

ε_{ij} = random residual error

Indices were calculated to provide overall ranking of a particular trait according to the formula: Index = sum of [4 for 1 + 3 for rank 2+2 for rank 3 + 1 for rank 4] given for an individual trait divided by the sum of [4 for 1 + 3 for rank 2+2 for rank 3 + 1 for rank 4] summed for overall traits (Kiflay *et al.*, 2019).

Results and Discussion

Household Socio-economic Characteristics

The majority of the households in the study area were male headed ($p<0.001$) (Table 1). Female headed households represent only about 6.7% and 36% for mixed crop-livestock and agro-pastoral production system, respectively. Higher proportion of female headed household in agro-pastorals as compared to mixed crop-livestock might be due to polygamy (Helen *et al.*, 2015). Shewangzaw and Adis (2016), Admasu *et al.* (2017) and Hizkel *et al.* (2018) also reported 6%, 5.4% and 14.1% of female headed households, respectively in their studies. The high proportion of male headed household indicated that men play a dominant role in decision making over livestock production management and the utilization of benefits generated from live animal sale.

The average age of the household head was higher ($P<0.001$) in mixed crop-livestock than agro-pastoral production system implying that young people are more engaging in livestock rearing in agro-pastoral areas presumably due to inadequate and erratic rainfall and crop failure. It is well known that the family size has an implication on household labor force for sheep production related activities. There was no significant difference in family size between the production systems. About similar number of persons per household were also reported for Meiso (Kedija, 2007; Zelalem, 2007) and Alaba (Endeshaw, 2007) districts. About 93.3% of the head of the households in mixed crop-livestock system had education of different types and levels indicating that the majority can read and write. This could be considered as an opportunity since educated farmers are more receptive to adopt improved sheep management practices, technologies and newly disseminated innovations (Tassew and Seifu, 2009) and are easily trainable. On the other hand, majority of the respondents in agro-pastoral production system were illiterate (cannot read and write) mainly because, children are made to look after the livestock at early age rather than schooling. Moreover, there are few primary schools in the pastoral and agro-pastoral areas

(Zelalem, 2007) indicating that less opportunity exists to send children to school. This finding agrees with the result of Shiferaw (2006) who noted 90% illiteracy rate in pastoral and agro-pastoral areas of eastern Ethiopia. High rate of illiteracy has a negative effect on the acceptance and dissemination of new technologies and thus, agro-pastoralist need mainly a face to face training in order to acquaint them with improved sheep production technologies. Similarly, Hizkel *et al.* (2018) reported only 25.75% illteracy rate in southern Ethiopia indicating that access to education varies from area to area.

Table 1. Socio-economic characteristics of respondents by production system

Parameters		Production systems			
		Mixed crop-livestock (n=75)	Agro-pastoral (n=75)	Overall (n=150)	P-value
Sex (%)	Male	93.3	64	78.7	<0.001
	Female	6.7	36	21.3	<0.001
Age (year±SE)		43.3±1.38	36.2±0.82	39.8±0.86	<0.001
Family size		6.1±0.28	6.8±0.24	6.4±0.18	0.095
Educational level (%)	Illiterate	6.7	80	43.3	<0.001
	Read and write	21.3	12	16.7	<0.001
	Primary	48	5.3	26.7	<0.001
	Secondary	22.7	2.7	12.7	<0.001
	Higher education	1.3	0	0.7	<0.001

n= Number of respondents; SE= Standard error.

Income Source

There was variation in the contribution of income sources between the production systems (Table 2). Food crop is the primary and livestock is the secondary income sources in mixed crop-livestock system, while it was the reverse in the agro-pastoral system. This result showed that livestock production has given the highest priority than crop in agro-pastoral area due to frequent crop failure as a result of erratic and insufficient rainfall. The current result is in agreement with the finding of Arse *et al.* (2013) who illustrated that farmers in Adami Tulu and Arsi Negelle districts ranked income from crop production to be first compared to other sources.

Table 2. Ranking of income sources for households by production system

Variables	Mixed crop-livestock system (n=75)					Agro-pastoral system (n=75)				
	1	2	3	4	Index	1	2	3	4	Index
Food crop	65	3	7	0	0.36	26	15	34	0	0.28
Cash crop	6	0	55	14	0.19	21	21	32	1	0.28
Livestock	3	68	0	4	0.28	29	39	6	1	0.32
Manure	2	7	36	30	0.17	1	4	4	66	0.12

1, 2, 3 and 4= Ranks for traits; n= Number of respondents/households.

Livestock Holding and Species Composition

Significant differences were observed in average number of livestock species kept between the production systems (Table 3). Except camel, which is not reared in mixed crop-livestock system, and goats, higher number of sheep, cattle, chicken and horses were recorded in mixed crop-livestock production system. This revealed that, the number and type of livestock holding is affected by production systems, production objective, demand for meat, type of feed resources and land availability (Zelealem *et al.,* 2012). The existence of a higher number of sheep per household in the present study is similar to the findings of Tesfaye (2008) who reported large proportion of sheep in mixed crop-livestock than pastoral areas.

Although livestock is ranked as a first source of income in agro-pastoral production system, the number of cattle and sheep are lower than those owned by mixed crop-livestock households, which could be due to low feed availability in the lowland as a result of erratic rainfall, high heat, and high prevalence of disease. According to Solomon (2011) the unpredictable rainfall and temperature variation induces a huge challenge to sorghum production and in turn to feed and food availability. Similarly, EPCC (2015) noted that 96%, 94.7% and 74.7% of the respondents perceive that climate change resulted in crop failure and feed and water shortage in Meiso district, respectively. In pastoral areas, climate change resulted in deterioration of the rangelands and its encroachment with woody browse. This has induced change in the species of livestock to be kept towards mixed herds of browsing animals (camels and goats) with smaller numbers of cattle and sheep (Kefyalew and Tegegn, 2012).

Sheep flock Structure

The breeding ewes and rams made-up about 30% and 36% of the total flock in mixed crop-livestock and agro-pastoral production systems, respectively (Table

4). Admasu *et al.* (2017) reported breeding ewes to represent 51.4% and 48.3% of the total flock of highland and midland agro-ecology, respectively. Other studies (Tesfaye *et al.*, 2010; Fsahatsion *et al.*, 2013; Hizkel *et al.*, 2018) from different locations in Ethiopia also recorded much greater proportion of breeding ewes in a flock than obtained in the present study. The proportion of different sheep categories appears to be generally similar between the two production systems.

Table 3. Average number of livestock holding (mean ± SE) by production system

Parameters	Production systems		
	Mixed crop-livestock (n=75)	Agro-pastoral (n=75)	P-value
Cattle	6.2±0.34	4.1±0.38	0.018
Sheep	12.5±0.99	6.2±0.34	<0.001
Goat	0.12±0.08	6.7±0.99	<0.001
Chicken	7.3±0.41	3.7±0.31	<0.001
Donkey	0.61±0.08	0.48±0.08	0.252
Mule	0.01±0.01	-	-
Camel	-	1±0.34	-
Horses	1.35±0.13	-	-

n= Number of respondents; SE= Standard error.

Table 4. Flock size and composition by production system

Sheep categories	Production systems							
	Mixed crop-livestock				Agro-pastoral			
	N	Mean±SE	Range	% of total flock	N	Mean±SE	Range	% of total flock
Lambs < 6m	244	3.25±0.03	0-20	21	104	1.79±0.11	0-4	16
Ram lambs	186	3.15±0.54	0-32	16	72	1.67±0.16	0-7	11
Ewe lambs	175	2.82±0.20	0-9	15	102	2.08±0.20	0-5	16
Breeding rams	170	3.33±0.48	0-21	15	135	2.25±0.23	0-10	20
Breeding ewes	344	4.57±0.27	0-23	30	240	3.12±0.35	0-16	36
Castrated	30	2.31±0.37	0-4	3	5	1.25±0.25	0-2	1

6m= Six months; N= Total number of animals.

Purpose of Keeping Sheep

The purpose of keeping sheep in the study area were primarily for income generation followed by saving, meat and manure production in order of importance with no significant difference (P>0.05) between production systems (Table 5). Studies from different parts of Ethiopia also noted primary utility of sheep to be source of income (Tesfaye *et al.*, 2010; Zelealem *et al.*, 2012; Fsahatsion *et al.*, 2013; Nigatu, 2017; Mengistu, 2018). None of the respondents mentioned keeping of sheep for milk production, which is associated with the tradition of not consuming sheep milk in the area.

Table 5. Ranking of purpose of keeping sheep by production system

Purposes	Mixed crop-livestock (n=75)					Agro-pastoral (n=75)				
	1	2	3	4	Index	1	2	3	4	Index
Income	48	10	12	5	0.37	41	12	11	0	0.38
Meat	5	25	3	2	0.22	10	20	2	2	0.25
Manure	1	5	12	1	0.15	6	4	3	0	0.09
Saving	22	13	10	2	0.26	18	11	10	1	0.29

1, 2, 3 and 4 = Ranks for traits; n= Number of respondents/households.

Labor Division in Sheep Husbandry and Decision Making

All members of the households were involved in sheep management operations (Table 6). However, women and children below 15 years shouldered greater responsibility for several important routine tasks. Boys were more responsible for flock herding and feeding, which is in agreement with that indicated by Admasu *et al.* (2017) who reported that the younger members of the family were mainly engaged in herding. Although children are engaged in agricultural activities to render labor needed by the family, intensive engagement of children may be one of the reasons for the high rates of school dropout, contributing to the high illiteracy rate in rural areas, implying that livestock husbandry practices may require changes that allow family to engage in schooling or there must be options for schooling of children. Most of the women and girls were engaged in barn cleaning and providing feed supplements to animals as they usually stay at home

while males are engaged in outside agricultural activities. In line with the present study, Kedija (2007) reported that 100% barn cleaning was done by girls.

Sheep marketing is primarily done by men in mixed crop-livestock, whereas women play the primary role in agro-pastorals system. In line with the current study, Fsahatsion *et al.* (2013) reported that purchasing and selling of sheep in most part of Ethiopia was the responsibility of husbands and they possess more power in deciding on the expenditure of incomes generated from sale of animals. Similarly, Zewdu *et al.* (2012) reported that 95.6% of purchasing and 97% of selling of sheep were mainly performed by males above 15 years of age, particularly by the head of the household, in mixed crop-livestock as opposed to the corresponding 38.3% and 60.7% by females above 15 years of age in pastoral/agro-pastoral areas.

Table 6. Proportion (%) of the family members involved in sheep husbandry practices by production system

Responsible members		Production systems		P-value
		Mixed crop-livestock (n=75)	Agro-pastoral (n=75)	
Herding				0.054
	CMF	77.3	70.7	
	CMHI	6.7	2.7	
	CFF	4[b]	17.3[a]	
	AMF	6.7	8	
	AMHI	4	0	
	AFF	1.3	1.3	
Feeding				0.001
	CMF	60	48	
	CMHI	6.7[a]	0[b]	
	CFF	6.7	16.7	
	AMF	18.7[a]	6.7[b]	
	AMHI	4	0	
	AFF	4[b]	29.3[a]	
Barn cleaning				0.049
	CMF	6.7	9.3	
	CMHI	0	1.3	
	CFF	52[a]	28[b]	
	AMF	4	6.7	
	AMHI	1.3	0	
	AFF	36[b]	54.7[a]	
Marketing				0.001
	CMF	0.0[b]	6.7[a]	
	CMHI	0.0[b]	8[a]	
	CFF	0.0	0.0	
	AMF	93.3[a]	18.7[b]	
	AMHI	1.3	2.6	
	AFF	5.4[b]	64[a]	

[a,b]Values among production systems are significantly different (P<0.001); CMF= Children male family< 15 years; CMHI= Children male hired< 15 years; CFF= Children female family < 15 years; AMF= Adult male family > 15 years; AMHI= Adult male hired> 15 years; AFF= Adult female family > 15 years; n= Number of respondents.

Feed Resources and Grazing Management

The main feed resources in the study areas were pasture and crop residues in the wet season and pasture and crop stubble in the dry season in both production systems (Table 7). However, natural pasture was the major feed resource for sheep during dry and wet seasons and ranked first in both production systems. The quality and quantity of feed resources available for animals primarily depend upon seasonal factors such as temperature and rainfall. According to Zewdu *et al.* (2012), the major feed resources for sheep during the wet season were natural pasture followed by crop residues across the production systems, while crop residues followed by natural pasture are the main dry season feeds. In general, feed resources are adequate during the rainy season, but become depleted during the dry season (Adugna and Aster, 2007). The grasses also over mature in dry season and become very low in nutritive value being rich in fiber content, but low digestibility and low voluntary intake by animals (Adugna and Aster, 2007) and the situation is more aggravated when the dry season is prolonged.

Management with respect to grazing, tethering and herding was significantly ($p<0.05$) different between production systems (Table 8). In dry season, the majority of mixed crop-livestock farmers and agro-pastoralists practice free grazing. In wet season, herding and tethering were the major practice in both

production systems with the main reason to prevent crop damage. The farmers in mixed crop-livestock system use mainly their own land, while those in the agro-pastoral system use mainly communal land for grazing.

Table 7. Ranking of feed resources for sheep by production system

Seasons	Feeds	Mixed crop-livestock (n=75)					Agro-pastoral (n=75)				
		1	2	3	4	Index	1	2	3	4	Index
Wet	Pasture	58	13	2	1	0.42	67	5	3	0	0.40
	Fallow land	3	15	27	21	0.15	0	-	-	-	-
	CRs	9	39	17	7	0.23	6	46	21	2	0.29
	Browse	-	-	-	-	-	-	14	36	11	0.18
	Concentrate	5	5	23	29	0.20	-	4	5	53	0.13
Dry	CS	47	27	1	0	0.36	19	52	0	4	0.21
	CRs	28	45	2	0	0.23	55	20	0	0	0.12
	Pasture	0	0	42	32	0.26	0	0	14	58	0.44
	Concentrate	0	3	30	42	0.15	0	0	61	13	0.23

1, 2, 3 and 4 = Ranks for traits; n= Number of respondents/households; CRs= Crop residues; CS= Crop stubble.

Table 8. Grazing management and grazing land type by production system

Variables	Mixed crop-livestock (n=75) %	Agro-pastoral (n=75) %	P-value
Grazing management in dry season			0.035
Free grazing	68	80	
Herding	21.3	6.7	
Tethering	10.7	13.3	
Grazing management in wet season			0.032
Free grazing	10.7	14.7	
Herding	60	38.7	
Tethering	29.3	47.6	
Grazing land type			0.000
Own	85.3	20	
Rented	6.7	0	
Communal	8	80	

n= Number of respondents.

Water Source and Watering

River water was the major source of water for sheep in wet season in both production systems (Table 9). The findings of the current study are similar with those reported by Admasu *et al.* (2017) and Hizkel *et al.* (2018) who reported river to be the major source of livestock drinking water in wet season in Woliyta Zone and Bensa district of southern Ethiopia. In dry season, spring water in crop-livestock and pond water in agro-pastoral production systems are the major source of water. Zelalem (2018) noted that pond is the main source of water in dry season in different agro-ecologies of southern Ethiopia.

Table 9. Ranked water sources for livestock drinking by production system

Seasons	Variables	**Production systems**									
		Mixed crop-livestock (n=75)					Agro-pastoral (n=75)				
		1	2	3	4	index	1	2	3	4	Index
Wet	River	58	14	0	0	0.43	58	13	0	0	0.40
	Spring	15	52	0	0	0.34	13	54	0	0	0.32
	Pond	1	0	0	26	0.05	1	0	13	15	0.07
	CTW	1	2	57	0	0.18	2	4	52	12	0.21
	Total	**75**	**68**	**57**	**26**	**1.0**	**74**	**71**	**65**	**27**	**1.0**
Dry	River	17	7	0	27	0.19	1	1	2	35	0.07
	Spring	26	20	12	0	0.30	13	0	23	0	0.16
	Pond	14	29	6	5	0.26	59	13	0	0	0.44
	CTW	15	14	26	6	0.25	2	58	13	0	0.33
	Total	**72**	**70**	**44**	**38**	**1.0**	**75**	**72**	**38**	**35**	**1.0**

1, 2, 3 and 4= Ranks for traits; n= Number of respondents/households.

The distances to watering points and frequency of watering varied with seasons and production systems (Table 10). In the mixed crop-livestock system, animals mainly travel less than 1 km to get water. The majority of the respondents in agro-pastoral production system take animals up to 10 km to find water sources during the dry season. Zelealem (2007) noted that the mean time taken to reach at watering points by agro-pastoralist in Meiso district were 2.73 and 2.89 hours by small ruminant fattening package adopters and non-adopters, respectively. The distance of water resource from home is very important consideration as it affects the application of improved management such as frequency of watering. Frequency of watering in the study areas is once per day in both production systems except during the dry season when watering of animals is once per two days in agro-pastoral system due to less accessibility to water sources.

Table 10. Proportion (%) of watering frequency and distance travelled during dry and wet seasons by production system

Descriptors	Mixed crop-livestock (n=75)		Agro-pastoral (n=75)	
	Dry %	Wet %	Dry %	Wet %
Distance				
At home	10.7	14.7	4	8.3
<1km	61.3	85.3	4	34.7
<5km	28	0	12	21.3
6-10km	0	0	80	32
Frequency				
Available free	0	8	1.3	5.3
Once in a day	100	88	12	82.7
Twice in a day	-	4	-	-
Once in two days	-	-	86.7	12

n= Number of respondents.

Sheep Housing and Breeding Practices

Type of housing used for sheep significantly (P<0.001) varies between production systems (Table 11). Majority of the households in mixed crop-livestock and agro-pastoral production systems keep sheep in adjoining family houses followed by keeping within the family house. Moreover, agro-pastoral households also use kraals to keep their animals. In line with the present study, Helen *et al.* (2015) reported practice of keeping sheep in the family leaving house during the night. According to Admasu *et al.* (2017) keeping the animals within the family house is thought to be a safe way to protect the animals from predators and theft. However, zoonotic diseases transmission risk and poor sanitary conditions due to poor ventilation are expected to affect both household members and animals. In this regard, Animut and Wamatu (2014) noted that the practice of sharing family house for animals is common among smallholder farmers across the rural areas of Ethiopia; may be because of low awareness and lack of understanding of the risk and space requirement of animals.

Table 11. Type of sheep housing and breeding practices of households by production system

		Mixed crop-livestock (n=75) %	Agro-pastoral (n=75) %	Overall	P-value
Housing type					
	WFH	40	32	36	0.001
	AFH	60	41.3	50.7	
	KWR	0	26.7	13.3	
Breeding practice					
	Controlled	1.3	50.7	26	0.001
	Uncontrolled	97.7	49.3	74	
Ram ownership and utilization					
	HOBR	28	56	42	0.01
	HNBR	72	44	58	
	Use of ram from:				0.001
	Near neighbors	79.6	42.4	65.5	
	Far neighbors	20.4	57.6	34.5	

n= Number of respondents; WFH= Within the family house; AFH= Adjacent to the family house; KWR= Keraal without roof; HOBR= Having own breeding ram; HNBR= Having no breeding ram.

The result of sheep breeding practice of households showed that indiscriminate breeding (uncontrolled mating) is prevalent in the area as rams and ewes are run together throughout the year sharing common grazing land and watering point (Table 11). However, a significant proportion of the agro-pastoralist in Meiso practiced controlled mating. The majority of sheep owners in Meiso reported that they try to avoid dry season lambing and indiscriminate mating, through methods like ram isolation and castration.

Majority of the crop livestock farmers as opposed to the agro-pastoralists also use rams from near neighbors in addition to their rams (Table 11). Solomon *et al.* (2010) stated that 100% of the respondents used their own breeding rams in Mieso district. Helen *et al.* (2015) reported that 70% and 45.5% of the pastoral and agro-pastoral respondent's herded sheep flock alone without mixing with other flocks, indicating that agro-pastoralists to have better understanding about the benefit of controlled breeding. Pastoralists, using long tradition of animal breeding practices select better quality herds by using different traditional management practices such as castration, culling, offspring testing and pedigree keeping with social restrictions on the sales of genetically valuable breeding animals that lead to closed gene pool with varieties of selection objectives (FAO, 2003).

Reproductive Performance

Reproductive performance of indigenous sheep in both production systems are summarized in Table 12. Sexual maturity of sheep for both sexes was higher ($P<0.05$) in agro-pastoral production system than mixed crop-livestock, but it is lower than reported by Hizkel *et al.* (2018), which were 7±0.12 and 7.15±0.2, and 7.68±0.23 and 7.8±0.12 months for male and female in high and mid altitude of Bensa district, respectively. Age at first lambing was also higher ($P<0.001$) in agro-pastoral production than mixed crop-livestock system. Lambing interval and litter size are greater in mixed crop-livestock than agro-pastoral production system. The value for lambing interval obtained in the current study were higher than the previous report of Helen *et al.* (2015), which were 6.63±0.13,8.81±0.24, 10.2±0.19 months for mixed crop-livestock, agro-pastoral and pastoral production systems, respectively. The average litter size observed in the current study was similar to Hizkel *et al.* (2018) who reported 1.3±0.34 for high land and 1.2±0.15 for mid land of Bensa district of Southern Ethiopia.

Table 12. Average reproductive performance (Mean ± SE) of sheep by production systems

Particulars	Mixed crop-livestock (n=75)	Agro-pastorals (n=75)	Overall (n=150)	P-value
Age at puberty for male (months)	6.24±0.63	6.49±0.58	6.36±0.05	0.12
Age at puberty for female (months)	6.52±0.66	7.06±0.72	6.8 ±0.61	0.001
Age at first lambing (months)	12.21±0.07	13±0.06	12.61±0.06	0.001
Lambing interval	12.17±0.06	10.68±0.11	11.43±0.09	0.001
Average litter size	1.2±0.05	1.04±0.02	1.12±0.03	0.002

n= Number of respondents; SE= Standard Error.

Table 13. Major sheep diseases and parasites by production systems

Seasons	Variables	**Production systems**										
		Mixed crop-livestock (n=75)					Agro-pastoral (n=75)					
		1	2	3	4	Index	Variables	1	2	3	4	Index
Wet	IP	44	10	10	1	0.31	Orf	49	15	10	1	0.35
	Pasteurellosis	16	30	20	9	0.28	FMD	16	20	15	15	0.23
	Sheep pox	5	15	30	30	0.21	IP	5	25	40	35	0.28
	Lungworm	10	15	15	35	0.20	CCPP	5	15	10	19	0.14
	Total	**75**	**70**	**75**	**75**	**1.00**	**Total**	**75**	**75**	**75**	**70**	**1**
Dry	IP	44	20	10	1	0.34	PPR	55	12	5	3	0.37
	Pasteurellosis	16	30	20	9	0.27	Pasteurellosis	5	25	45	9	0.27
	Sheep pox	5	10	30	30	0.19	EP	10	21	10	28	0.21
	Lungworm	10	15	15	35	0.2	CCPP	5	7	15	35	0.15
	Total	**75**	**75**	**75**	**75**	**1.00**	**Total**	**75**	**65**	**75**	**75**	**1**

1, 2, 3 and 4= Ranks for traits; IP= Internal parasite; FMD= Foot and mouth disease; CCPP= Contagious caprine pleuropneumonia; PPR= Peste des petits ruminants; EP= External parasite; n = Number of respondents.

Diseases and Parasites

The result showed that pasteurellosis, sheep pox, orf, liver fluke (fasciolosis), blackleg, peste des petits ruminants (PPR), parasites and contagious caprine pleuropneumonia (CCPP) were affecting the health of sheep although their prvalence differs between the production systems and seasons (Table 13). It is well known that diseases have numerous negative impacts on livestock herds and flocks. It causes death of animals, loss of weight, slow down growth, results in poor fertility, and decreases physical power (CSA, 2019). Similar types of diseases were reported across different part of the country to occur in any of the seasons (Zelealem *et al.,* 2012; Fsahatsion *et al.,* 2013;

Hizkel *et al*., 2018). However, the occurrence and severity of the effect posed by the diseases vary across the agro-ecology and season indicating the need for season and area specific animal health intervention strategy (Homann *et al*., 2007).

According to the focus group discussants and key informant interviewees, the veterinarians assigned are not sufficient to reach all rural kebeles. As a result, the housholds in the study area use their own indigeneous knowledge to treat diseases and parasites. Improper use of drugs by livestock owners was also reported, which they said caused serious problems and adverse effects. Animal health services delivery in the country is characterized by lack of drugs, inadequacy of service, and lack of skilled personnel (Hulunim, 2014). Zelealem *et al*. (2012) also noted that most of the respondents encountered serious problems and adverse effects as a result of improper use of medicines. Hence, provision of better health service that suit the production system would be recommended as a strategy to enhance livestock productivity (Hulunim, 2014). According to Tsedeke (2007), women had higher responsibility in managing different mix of species of livestock like cattle, sheep, goats and equines and the care they provide to animals is thought to be better.

Table 14. Sheep production constraints by production system

Constraints	Production systems									
	Mixed crop-livestock					Agro-pastoral				
	Rank					Rank				
	1st	2nd	3rd	4th	Index	1st	2nd	3rd	4th	Index
Feed shortage	55	13	0	0	0.38	24	34	9	1	0.36
Water shortage	0	0	19	0	0.26	0	0	10	5	0.15
Disease prevalence	17	29	1	0	0.36	4	3	14	3	0.19
Drought	0	0	0	0	0	45	26	2	0	0.24

Sheep Production Constraints

Among the constraints of sheep production, feed shortage ranked first in both production systems followed by disease prevalence and water shortage (Table 14). The current finding is similar with previous studies (Kedija, 2007; Helen *et al*., 2015; Admasu *et al*., 2017; Mengistu, 2018; Shgute and Anja, 2018). Recurrent drought and crop failures, which are directly related to feed availability, appear to be major problems in agro-pastoral system (EPCC, 2015). Hence, designing intervention and implementation strategies to solve the feed shortage should be given priority in the effort to improve sheep productivity across the study area.

Conclusion

The average flock size of sheep per household was relatively larger for crop-livestock than agro-pastoral production systems. The purpose of sheep keeping was mainly for cash income, saving, meat and manure in order of importance. Selection and controlled mating were less practiced. Feed shortage, high disease and parasite prevalence, water shortage and drought were the major constraints in mixed crop-livestock and agro-pastoral production systems. As a result, productivity of sheep in both production systems is very low. Therefore, designing strategies that improve sheep management practices and addressing the prevailing challenges is necessary in order to enhance sheep productivity and thereby producers income.

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Conflict of Interests

The authors declare that they have no competing interests.

References

Admasu, Lakew, Aberra, Melesse & Sandip Banerjee (2017). Traditional sheep production systems and breeding practice in Wolayita Zone of Southern Ethiopia. *African Journal of Agricultural Research*, 12 (20): 1689-1701.

Adugna Tolera & Aster Abebe (2007). Livestock production in pastoral and agro-pastoral production systems of southern Ethiopia. *Livestock Research for Rural Development,* 19 (12).

Animut, G. & Wamatu, J. (2014). Prospects to improve the productivity of sheep fattening in Ethiopia: Status, challenges and opportunities. Addis Ababa: ICARDA.

Arse Gebeyehu, Feyisa Hundessa, Gurmessa Umeta, Merga Muleta & Girma Debele (2013). Assessment on challenges and opportunities of goat farming system in Adami Tulu, Arsi Negelle and Fantale districts of Oromia Regional State, Ethiopia. *African Journal of Agricultural Research*, 8 (1): 26-31.

CSA (Ethiopia Central Statistical Agency) (2019). Agricultural Sample Survey 2018/19: Volume II Report on Livestock and Livestock Characteristics (Private Peasant Holdings), Central Statistical Agency, Addis Ababa, p: 38.

DWOA (Digelu-tijoWoreda Office of Agriculture) (2014). Annual report for livestock production.

Endeshaw Assefa (2007). Assessment on production system and marketing of goats at Dale district, Sidama Zone, MSc Thesis, Hawassa University, Ethiopia.

EPCC (Ethiopian Panel on Climate Change) (2015). First Assessment Report, Working Group II Agriculture and Food Security, Published by the Ethiopian Academy of Sciences.

FAO /GTZ/ (2003). Proceedings of the Workshop "Community-Based Management of Animal Genetic Resources – A Tool for Rural Development", held in Mbabane, Swaziland.

Fsahatsion Hailemariam, Aberra Melesse & Sandip Banerjee (2013). Traditional sheep production and breeding practice in Gamogofa Zone, Southern Ethiopia. *International Journal of Livestock Production Research,* 1 (3): 26-43.

Helen Nigussie, Yoseph Mekasha, Solomon Abegaz, Kefelegn Kebede & Sanjoy Kumar Pal (2015). Indigenous sheep production system in eastern Ethiopia: Implications for genetic improvement and sustainable use. *American Scientific Research Journal for engineering, technology, and Sciences (ASRJETS),* 11: 136-152.

Hizkel Kenfo, Yoseph Mekasha & Yosef Tadesse (2018). A study on sheep farming practices in relation to future production strtegies in Bensa district of southern Ethiopia. *Tropical Animal Health and Production*, 50 (4): 865-874.

Homann, S, Van Rooyen, A., Moyo, T. & Nengomasha, Z. (2007). Goat production and marketing: Baseline information for semi-arid Zimbabwe. Bulawayo, Zimbabwe: International Crops Research Institute for the Semi-Arid Tropics, p: 84.

Hulunim Gatew (2014). On-farm phenotypic characterization and performance evaluation of Bati, Borena and short eared Somali goat populations of Ethiopia. MSc Thesis, Haramaya University, Ethiopia.

Kedija Hussen (2007). Characterization of milk production system and opportunity for market orientation: A case study of Mieso district, Oromia region, Ethiopia. MSc Thesis, Alemaya University, Ethiopia.

Kefyalew Alemayehu & Tegegn Fantahun (2012). The effect of climate change on ruminant livestock population dynamics in Ethiopia. *Livestock Research for Rural Development*, 24 (10).

Kiflay Welday, Mengistu Urge & Solomon Abegaz (2019). Sheep Production Systems and Breeding Practices for Selected Zones of Tigray, Northern Ethiopia. *Open Journal of Animal Sciences*, 9: 135-140

MBPRD (2014). Meiso office of Pastoralists and Rural development Annual Report. Meiso Wereda.

Mengistu Regassa (2018). Performances of Highland Sheep under Community-based Breeding Program in Atsbi Wenberta District, Tigray, Ethiopia, MSc Thesis, Bahir Dar University, Ethiopia.

Nigatu Dejene (2017). 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 Gamo Gofa Zone. MSc Thesis, University of Hawassa, Awassa, Ethiopia.

Shewangzaw Addisu & Adis Kassahune (2016). Sheep Production and Marketing System in North Gondar Zone of Amhara Region, Ethiopia. *Advances in Biological Research*, 10 (5): 304-308.

Shiferaw Gomaz (2006). *In-situ* phenotypic characterization of Kereyu cattle type in Fentalle District of Oromia Region, Ethiopia, MSc Thesis, Haramaya University, Ethiopia.

Shigdaf, M., Zeleke, M., Mengistie, T., Hailu, M., Getnet, M. & Aynalem, H. (2013). Reproductive performance and survival rate of Washera and Farta sheep breeds under traditional management systems in Farta and Lay Gayint Districts of Amhara Regional state, Ethiopia. *Ethiopian Journal of Animal Production,* 13: 65- 82.

Shigute Etalema & Anja Abera (2018). Small ruminant production and constraints in Misha Woreda, Hadiya Zone, Southern Ethiopia. *International Journal of Livestock Production*, 9 (8): 192-197.

Solomon Abegaz, Girma Abebe & Kassahun Awugichew (2008). Sheep and Goat Production Systems in Ethiopia. In: Alemu Yami and R.C. Merkel (Eds.), Ethiopia sheep and goat productivity improvement program (ESGPIP), Branna Printing Interprise. Addis Ababa, Ethiopia, pp: 27-32.

Solomon Gizaw, Azage Tegegne, Berhanu Gebremedhin & Dirk Hoekstra (2010). Sheep and goat production and marketing systems in Ethiopia: Characteristics and strategies for improvement. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 23. ILRI (International Livestock Research Institute), Nairobi, Kenya, pp: 58.

Solomon Gizaw, Van Arendonk, J.A.M., Komen, H., Windig, J. J. & Hanotte, O. (2007). Population structure, genetic variation and morphological diversity in indigenous sheep of Ethiopia. *Animal Genetics*, 38: 621–628.

Solomon T. Wodajo (2011). Assessing the Effect of climate variability and change on production on and productivity of Sorghum (Sorghum bicolar) in Meiso area Eastern Ethiopia, MSc Thesis Haramaya University, Ethiopia.

SPSS (2011). Statistical Package for Social Sciences Study. Version 20, Chicago, Illinois, USA.

Tassew, A. & Seifu, E. (2009). Smallholder Dairy Production System and Emergence of Dairy Cooperatives in Bahir Dar Zuria and MechaWoredas, Northwestern Ethiopia. *World Journal of Dairy Food Sciences,* 4 (2): 185-192.

Tesfaye Getachew, Aynalem Haile, Markos Tibbo, Sharma, A. K., Sölkner, J. & Wurzinger, M. (2010). Herd management and breeding practices of sheep owners in a mixed crop livestock and a pastoral system of Ethiopia. *African Journal of Agricultural Research*, 5 (8): 685-691.

Tesfaye, G. (2008). Characterization of Menze and Afar Indigenous Sheep Breeds of Smallholders and Pastoralist for Designing Community Based Breeding Strategies in Ethiopia, MSc Thesis, Haramaya University, Ethiopia.

Tsedeke Kocho (2007). Production and marketing system of sheep and goat at Alaba district. MSc Thesis, University of Hawassa, Ethiopia.

Zelalem Abate (2018). Performance evaluation of Bonga Rams and their Progenies in different Agro-ecologies of Southern Ethiopia, MSc Thesis, Jimma University, Ethiopia.

Zelalem Tamerat (2007). Adoption of Small Ruminants' Fattening Package in Agro pastoral areas, MeisoWereda, Eastern Oromia. An MSc Thesis presented to the School of Graduate Studies of Alemaya University.

Zelealem Tesfay Gebretsadik, Anal, A. K. & Gebrezgiher Gebreyohanis (2012). Assessment of the sheep production system of northern Ethiopia in relation to sustainable productivity and Sheep meat quality. *International Journal of Advanced Biological Research*, 2 (2): 302-313.

Zewdu Edea, Aynalem Haile, Markos Tibbo, Sharma, A. K, Dejene Assefa, Johann Sölkner & Maria Wurzinger (2012). Sheep production systems and breeding practices of smallholders in western and south-western Ethiopia: Implications for designing community-based breeding strategies. *Livestock Research for Rural Development,* 24 (7).

Zewdu, E., Haile, A., Tibbo, M., Sharma, A. K., Assefa, D., Sölkner, J. & Wurzinger, M. (2010). Morphological characterization of Bonga and Horro indigenous sheep breeds under smallholder conditions in Ethiopia. *Ethiopian Journal of Animal Production,* 1: 117-133.