

# **Climate Smart Dairy Production and Their Future Prospects of climate change adaptation in Amhara Region, Ethiopia: The studies towards finding the options**

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## **Abstract**

Climate-smart livestock production is an approach for transforming and reorienting livestock sector development under the new realities of climate change through enhancing climate smart dairy production under the new realities of climate change and their future prospects. The studies were conducted in South Gondar and West Gojjam zones. The climate data were gathered from the regional meteorological services of the region. The ruminant livestock population size data were collected from reports released by the central statistical agency of Ethiopia. Dairy type conformation traits were identified through measurements and field observation. The milk yield data was collected through monitoring studies. Correlation, regression and multivariate analyses techniques were used for data analyses. The results revealed that sheep (-2.68,-0.280) and (-8.16, -0.40) cattle population dynamics were negatively affected by maximum temperature and annual rainfall distribution, respectively. On the contrary, goats (13.3, 0.43) were having positive relationship and seems not to be affected. The indigenous cattle population possesses dairy type traits comparable with crossbred cattle that need selection and improvement (high percent of rear udder height (RUH) was laid an intermediate level (>68%) for indigenous cattle and about 31.82 % for crossbred cattle, crosses between indigenous and Holstein Frisian). The traits related to milk production for indigenous dairy type goats is also comparable to other internationally known dairy goat breeds. That the average rear udder diameter (RUD) for dairy, dual and meat type female goats were  $10.04\pm 0.22$ ,  $8.66\pm 0.37$  and  $8.01\pm 0.30$  cm, respectively. Rear udder length (RUL), udder circumference (UCC) and teat length (TTL) were  $17.14\pm 0.28$ ,  $31.39\pm 0.59$  and  $3.71\pm 0.07$ cm,  $14.21\pm 0.48$ ,  $26.75\pm 1.01$  and  $3.41\pm 0.12$ cm and  $13.44\pm 0.38$ ,  $24.67\pm 0.81$  and  $3.01\pm 0.09$  cm, respectively as goats adapt the existing climate change impacts, it is advisable to undertake specialized and intensive dairy goat production and enhance food security. The quantities of milk produced from crossbred do not differ significantly from indigenous cattle. Therefore, Selection of indigenous cattle and breeding for dairy production has paramount importance since the cattle possess dairy associated traits.

**Keywords:** Climate Smart, Dairy production, Indigenous breeds, Selection

## INTRODUCTION

Livestock systems in developing countries are characterized by rapid change, driven by factors such as population growth, increases in the demand for livestock products as incomes rise, and urbanization (Delgado et al., 1999; Thornton et al., 2007). Climate change is likely to present significant problems for production systems where resource endowments are poorest and selected here the ability of livestock keepers to respond and adapt is most limited (FAO, 2007b).

Climate Change affects in the primary productivity of forages and rangelands and the most visible effect of climate change on feed resources for ruminants. However, the effects are significantly different depending on location, production system and pasture species (Kefyalew and Tegegn, 2012; Kefyalew and Addisu, 2016). Changes in species composition and breed / species distribution pattern are significantly different across altitude base agro-ecological differences which are the results of change in climate related factors (Kefyalew, 2016). Species composition of animals managed grasslands is an important determinant of livestock productivity. As temperature and CO<sub>2</sub> levels change due to climate change, the optimal growth ranges for different species also change; species alter their competition dynamics, and the composition of mixed grasslands changes (Thornton et al., 2007).

Heat stress is known to alter the physiology of livestock, reduce male and female reproduction and production, and increase mortality. Livestock water requirements increase with temperature. Heat stress suppresses appetite and feed intake; thus feeding rations for high-performing animals need to be reformulated to account for the need to increase nutrient density. Body temperatures beyond 45-47 °C are lethal in most

species. Heat stress is an important factor in determining specific production environments already today. The vulnerability of livestock to heat stress varies according to species, genetic potential, life stage and nutritional status. Increasing intensification of dairy systems in the developing world through the use of temperate-breed genetic stock could lead to greater vulnerability to increasing temperatures (Thornton et al., 2009). The ability to thermo-regulate depends on complex interactions among anatomical and physiological factors (Hall, 2004). With increasing milk yield in dairy cattle, growth rates and leanness in pigs or poultry, metabolic heat production has increased and the capacity to tolerate elevated temperatures has declined (Zumbachet al., 2008; Dikmen and Hansen, 2009). In the long term, single-trait selection for yields will therefore result in animals with lower heat tolerance. The effect of heat stress on milk yield at specific test days is more immediate and easier to measure than growth (Zumbachet al., 2008). In general, the high-output breeds originating from temperate regions that provide the bulk of market production today are not well adapted to heat stress. Milk production, fertility and longevity, in Holstein Friesian cattle, for example, decline as temperature increases (St- Pierre et al., 2003) On the other hand, many species and local breeds, particularly those from the Near East and Africa, are already adapted to high temperatures and harsh conditions (Steinfeld et al., 2006).

Breeding and selection aim to improve the use value of animal genetic diversity. Climate change projections suggest that further selection for breeds with effective thermoregulatory control may be needed (Hoffmann, 2010). Breeding indices should include traits associated with thermal tolerance, low quality feed and disease resistance, and give more consideration of

genotype-by-environment interactions to identify animals most adapted to specific conditions (Hoffmann, 2010). Climate-smart agriculture is an approach for transforming and reorienting agricultural development under the new realities of climate change for enhancing productivity, adaptation and mitigation (Lipper et al., 2014). Therefore, the objective of this paper was to identify climate smart dairy production under the new realities of climate change and their future prospects in of Amhara region, Ethiopia.

## MATERIALS AND METHODS

### Description of the study area

The study was conducted in three districts of (Estie, Simada, Farta) South Gondar zone and in other three districts (Quart, Finotesalam, and Debecha) of West gojam zone, Amhara national regional state, Ethiopia. The characteristic of each district are summarized in Table 1.

### Data collection methods

#### Climate Data

The climate data were gathered from reports released by the Regional Meteorological Services (RMS)

of the region. The ruminant livestock data were collected from literature reviews and reports released by the Central Statistical Agency of Ethiopia (CSA).

### Dairy related traits identification for both indigenous and crossbred cattle

The linear conformation traits were measured in centimeter (cm) using graduated measuring stick and flexible tape. A separate form was prepared for each animal measured. Visual observations were made and morphological features were recorded based on cattle morphological characteristics descriptor list of FAO (2012) and International Committee for Animal Recording (ICAR, 2015), breed descriptor list. About 262 indigenous cows and 42 crossbred cows were considered in the study. Traits for both sexes had been calculated with Angularity (ANG) (number of finger between last ribs and point given for angularity), Rump angle (RA), Rear legs set (RLS) and seven udder measurement traits (Teat Length (TL), Udder Depth (UD), Rear Udder Height (RUH), Central Ligament (CL), Rear Teat Placement (RTP), Front teat placement (view from behind) (FTP), Fore Udder Attachment) (FUA)). All above measurements were classified on a scale of

**Table 1.** Agro-ecological and animal and animals (livestock and human) population characteristics of the study districts

Districts	Altitude (a.s.l)	Temperature (°C)	Annual rainfall (mm)	Human populations (No)	Cattle populations (No)		Other livestock population	
					local	Cross	Sheep	Goats
Estie	1500-4231	8.3-25	1307.7-1500	393,243	149,09	22,360	114,833	105,507
Farta	2700-2870	9-25	1250-1599	243,629	165,388	26,540	104,612	39,834
Simada	1196-3801	23	900-1100	254,020	142,334	247	96,102	106,521
Quarit	1920-3000	16 - 25	1250	166,848	293, 118	-	84,245	119,926
FinoteSelam	1862	14- 32	1250	42,069	7821	-	2580	1403
Debecha	2080	18-24	1006	55,066	133052	175	45763	12714

Popn=Population, °C =Degree Celsius T=Temperature, ARF=Annual Rain Fall, H/popn = Human Population

1 to 9, which is an international scale to measure dairy traits. Traits on the shape and appearance of the animals were recorded in pre-coded format. For dairy goat trait selection and identification, a total of 235 dairy (109), dual (50) and meat (76) type goats were measured following the same procedures used in cattle.

### Milk yield studies

For 60 households about 36 lactating crossbred and 29 indigenous cows were identified based on the availability of crossbred cows and (with different exotic blood level 25%, 50% and 75% of crossbred). The blood levels of crossbred animals were identified from their history told by owners and from their body conformation characteristics the study include urban, peri-urban and mixed crop-livestock production systems. Monitoring of milk yield of individual cows was held for six months (from February to June, 2016). A total of 65 lactating cows were classified by stage of lactation (early = 1-2 months; mid = 3-4 months and late = 5-6 months) and parity (parity 1, 2, 3, 4 and 5). Hand milking was practiced to milk cows. Daily milk yield (morning and evening) was measured by using calibrated plastic Jogs/ measuring cylinder/ for a period of three days/month.

### Data and Statistical Analysis

The raw data collected from the study entered in to Microsoft Excel (2007) for data arrangement. The entered data was transported and analyzed using descriptive statistics of statistical package for social sciences (SPSS version 16.0, 2007) software. Trends of both for climate and livestock data were analyzed using regression analyses and the effect of climate change on ruminant livestock dynamics were quantified using correlation analyses. In both cases, SPSS 16 (2007) was used for analyses.

The General Linear Model (GLM) procedure of Statistical Analyzed (SAS Version 9.1) software and model used for daily milk yield of local and crossbred cows was:-

$$Y_{ijk} = \mu + B_i + S_j Y_k + PI + (BP)_{il} + e_{ijkl}$$

$\mu$  = overall mean

$B_i$  = fixed effect of  $i^{\text{th}}$  breed (indigenous, 25%, 50% and 75% exotic)

$S_j$  = fixed effect of  $j^{\text{th}}$  parity class ( $j = 1, 2, 3, \dots, 5$ )

$Y_k$  = fixed effect of  $k^{\text{th}}$  phase of lactation (1, 2 and 3)

PI = fixed effect of the production systems ( $j =$  urban, peri-urban and mixed crop-livestock)

(BP) $_{il}$  = effect of interaction between the  $i^{\text{th}}$  blood level and the  $l^{\text{th}}$  production system

$e_{ijkl}$  = random error associated with each observation

General Linear Model (GLM) of multivariate analysis of SAS 9.1.3 was used to quantify fixed effects such as the goat type, agro-ecology and sex. The model used for GLM analysis was:-

$$Y_{ijkl} = \mu + A_i + S_j + D_k + B_l + D_k * B_l + e_{ijkl}$$

Where  $Y_{ijk}$  is the observed measurement

$\mu$  is the overall mean;

$A_i$  is the effect of  $i^{\text{th}}$  age group;

$S_j$  is the effect of  $j^{\text{th}}$  sex (male and female);

$D_k$  is the effect of  $k^{\text{th}}$  district or agro-ecology;

$B_l$  is the effect of  $l^{\text{th}}$  breed (dairy type goat, dual purpose goat and meat type goat);

$D_k * B_l$  interaction effects of goat types with agro-ecology and

$e_{ijkl}$  is the random residual error.

## RESULTS AND DISCUSSIONS

### Climate change and ruminant livestock trends in the region

Competition for land is a serious challenge for the livestock sector in many areas of the world (Gerber et al 2009). Considerable pressures exist in mixed crop-livestock systems and land use for feed crop production is increasingly competing with food production. The livestock production systems is facing a challenge by the pressures of increasing human population and livestock product demands are seriously limiting production as land per capita decreases significantly (Herrero et al., 2009b). In

Ethiopia in general and in Amhara region in particular, human population growth is one of the driving force that makes difficult getting livestock the grazing lands for feed and water resources accesses. As a result, the population sizes of the ruminant livestock population size show fluctuating trend especially in 1985, 1993 and 2006 (Figure 1). Besides the pressure created on the grazing lands, there is also a shift of ranges due to the inability of breeds to produce and reproduce in a given set of environments, or the choice of particular breeds for specific environments (Hill & Zhang, 2009; Kefyalew and Addisu, 2016).

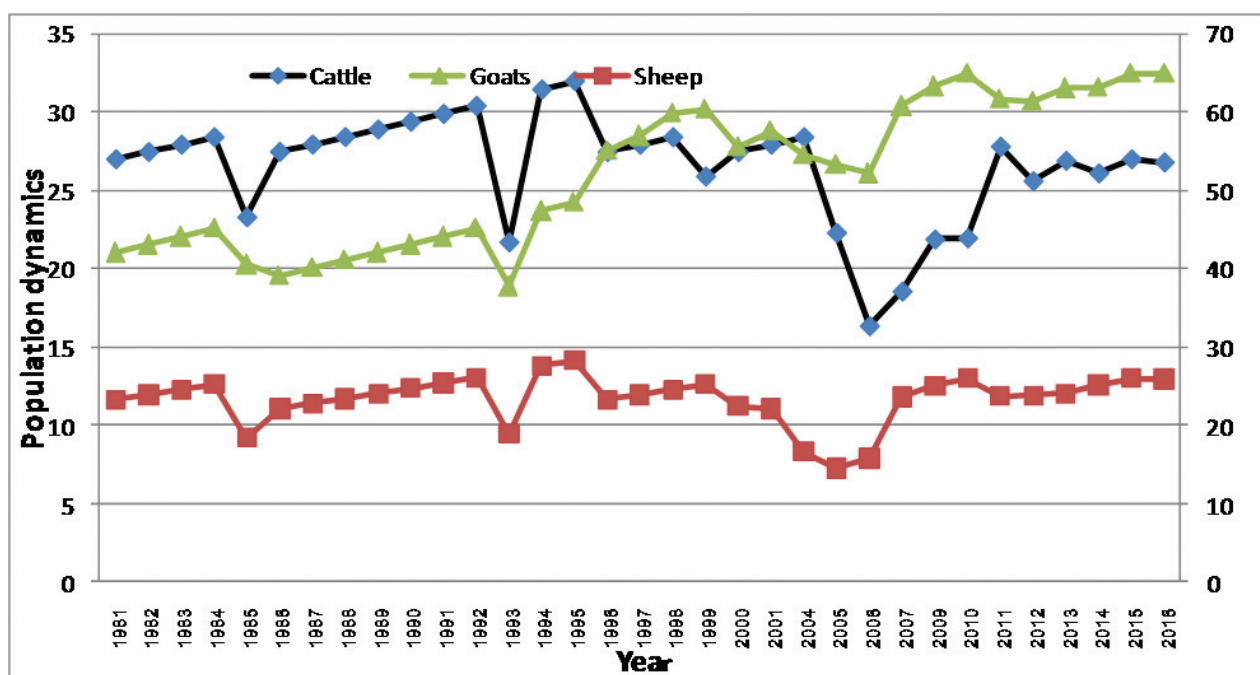


Figure 1. Thirty Six years Ruminant population dynamics of Amhara region (1981-2016)

Adaptation and mitigation of the detrimental effects of extreme climates has played a major role in combating the climatic impact on livestock (Sejian et al., 2015a). Climate change manifests itself as rapid changes in climate in a couple of years or more subtle changes over decades. This result of this study also indicate that, in Amhara region there is a fluctuation of climate related variables like maximum temperature and annual rainfall distribution from years 1981-2016 (Table 3).

The seasons, between 1984-1985, 1992-1993 and 2005-2006 were the most difficult for ruminant livestock population size, production and productivity in the region (Figure 2). Gaughan and Cawsell- Smith (2015) predicted also that in addition to production losses, extreme events results in livestock death. Animals can adapt to hot climates, however the response mechanisms that are

helpful for survival may be detrimental to performance and by the year 2100, mean global temperature may be 1.1-6.4 °C warmer than in 2010. In this region, the mean maximum temperature and annual rainfall distribution affected negatively the sheep (-2.68,-0.280) and cattle (-8.16, -0.40) population and positively goat population (13.3, 0.43), respectively (Table 2).

A correlation analysis was used to quantify impacts of temperature and rainfall on ruminant livestock population dynamics. The analyses revealed that sheep ( $r = -0.21, P < 0.05$ ) and cattle ( $r = -0.44, P < 0.001$ ) were negatively affected by maximum temperature change. On the contrary, goats were having positive relationship ( $r = 0.075, p < 0.001$ ) and seems not affected by maximum temperature (Table 2).

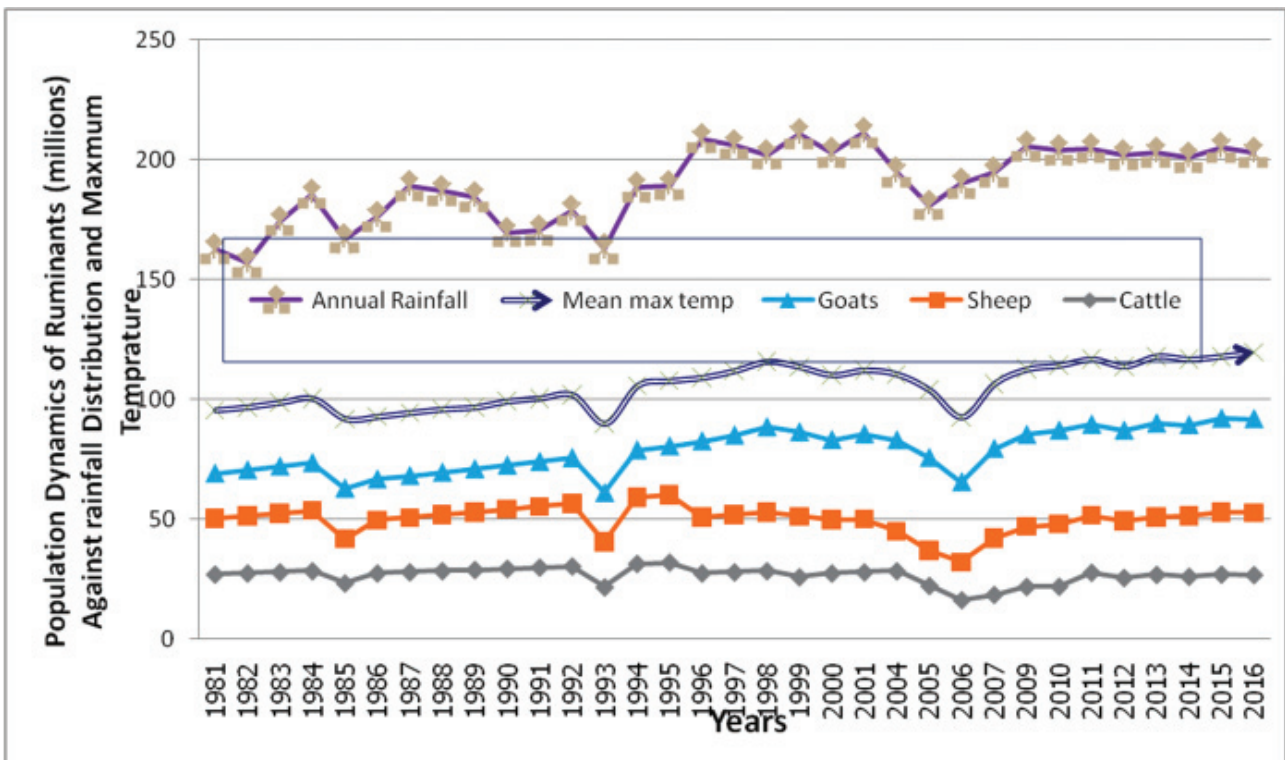


Figure 2. Thirty Six years Ruminant population dynamics against annual rainfalls and maximum Temperatures (1981-2016)

**Table 2.** Associations between ruminant livestock dynamics and climate change in Amhara region

Species		Unstandardized Coefficients		Standar. Coeffi.	t value	P-value	95% Confidence Interval for B		Correlation
		B	Std. Error	Beta			Lower Bound	Upper Bound	
cattle	(Constant)	257.13	68.93		3.9	0.001	106.93	388.20	R <sup>2</sup>
	Temperature	-8.16	2.86	-0.44	-2.63	0.010	-13.45	-1.97	-0.44
	Rainfall	-0.40	0.15	-0.48	-3.23	0.004	-0.64	-0.13	-0.53
sheep	(Constant)	106.92	53.62		2.12	0.022	-2.66	213.4	
	Temperature	-2.68	2.4	-0.25	-1.22	0.02	-6.45	1.78	-0.21
	Rainfall	-0.280	0.201	-0.47	-2.59	0.018	-0.47	-0.05	-0.53
Goats	(Constant)	-366.7	75.41		-5.13	0.000	-509.08	-213.3	
	Temperature	13.3	2.78	0.72	4.89	0.000	7.55	19.81	0.75
	Rainfall	0.43	0.15	0.43	2.95	0.009	0.12	0.66	0.45

### Selection and Breeding for Climate Change Adaptation

Selection and breeding helps to improve the performances of indigenous animal genetic resources. Selection and breeding for climate change adaptation or mitigation should include traits associated with high productivity, thermal tolerance, survival with low quality feed and disease resistance (Hoffmann 2010). The case studies conducted in Finoteselam, Quarit and Achefer districts of west gojam zone for identification, selection and assessment of dairy type traits among cattle population revealed that high percent of rear udder height (RUH) was laid an intermediate level (>68%) for

indigenous cattle and about 31.82 % for crossbred cattle (crosses between indigenous and Holstein Frisian). About 63.64% of crossbred cattle were laid low RUH but not more than 5% of indigenous cows. High percent of Central Ligaments (CL) was found by dairy type which is an indicator of cows with good teat placement. Strong CL was found in dairy type cow 43.33% than the rest (dual type 21.43%, meat type 4.17% and cross cow 0% (Table 3). Therefore, Selection and breeding of indigenous cows with good central ligaments will improve rear teat placement and teat length indirectly and then dairying characteristics directly.

**Table 3.** Comparative evaluation of dairy related conformation traits of indigenous and crossbreed cattle

Phenotypic variance	Cattle Type				Over all
	Dairy N (%)	Dual N (%)	Meat N (%)	Cross N (%)	
<b>For udder attachment (FUA)</b>					
Weak and loose (1-3)	1(1.67)	0	0	11(50)	12(20.23)
Intermediate (4-6)	54 (90)	42(100)	24(100)	11(50)	131 (85)
Extremely strong and tight (7-9)	5(8.33)	0	0	0(0)	5(2.08)
<b>Udder Depth (UD)</b>					
Deep (1-3)	2(8.33)	1(2.38)	2(3.33)	1(4.55)	6(4.65)
Intermediate(4-6)	21(87.50)	40(95.24)	47(78.33)	13(59.09)	121(77.79)
Shallow(7-9)	1(4.17)	1(2.38)	11(18.67)	8(36.36)	21(15.40)
<b>Rear Udder Height (RUH)</b>					
Low (1-3)	1(1.67)	2(4.76)	1(4.17)	14(63.64)	18(18.49)
Intermediate (4-6)	41(68.33)	35(83.33)	16(66.67)	7(31.82)	110(67.12)
High (7-9)	18(30.00)	5(11.90)	7(29.17)	1(4.54)	22(14.45)
<b>Central Ligament (CL)</b>					
Convex to flat floor (flat), broken ligament (1-3)	2(3.33)	14(33.33)	15(62.50)	6(27.27)	35(31.61)
Intermediate (4-5)	32(53.33)	19(45.24)	8(33.33)	16(72.73)	75(51.16)
Deep cleft/strong ligaments (7-9)	26(43.33)	9(21.43)	1(4.17)	0(0)	36(17.23)
<b>Rear Teat Placement (RTP)</b>					
Outside of quarter (1-3)	5(8.33)	16(38.10)	0	2(9.09)	23(13.88)
Intermediate (4-6)	44(73.33)	19(45.24)	24(100)	17(77.27)	104(73.96)
Inside of quarter (7-9)	11(18.33)	7(16.66)	0	3(13.64)	21(12.16)
<b>Front teat placement (view from behind) (FTP)</b>					
Outside of quarter (1-3)	2(3.33)	1(2.38)	1(4.16)	3(13.64)	7(5.88)
Intermediate (4-6)	48(80.00)	32(76.19)	19(79.17)	17(77.27)	116(78.29)
Inside of quarter (7-9)	10(16.67)	9(21.43)	4(16.67)	2(9.09)	25(15.90)

### Production performances of indigenous and crossbreed cattle across the production system

The case studies conducted in another three districts of west Gojam zone in urban, peri-urban and rural areas production systems revealed that the average daily milk yield of indigenous animal across all the production system was  $1.56 \pm 0.50$ ,  $2.33 \pm 0.44$  and  $3.20 \pm 1.58$  in rural, peri-urban and urban, respectively. The daily milk

yield for crossbred with exotic blood level of 25% were  $3.87 \pm 0.80$ ,  $4.53 \pm 1.94$  and  $5.06 \pm 1.43$  in rural, peri-Urban and Urban, respectively. For those 50% exotic blood level of was  $5.60 \pm 1.75$ ,  $7.81 \pm 3.77$  and  $8.61 \pm 2.23$  in rural, peri-Urban and Urban, respectively. For crossbred exotic with blood level of 75% was  $7.27 \pm 1.64$ ,  $8.73 \pm 1.01$  and  $10.33 \pm 2.41$  in rural, peri-urban and urban, respectively (Table 4).

**Table 4.** Daily milk yields (litter/day/cow) of indigenous animal and their crossbred with different exotic blood level cows in different production system

Blood level	Rural mean $\pm$ SD	Peri-urban mean $\pm$ SD	Urban mean $\pm$ SD	Total
Indigenous	1.56 $\pm$ 0.50	2.33 $\pm$ 0.44	3.20 $\pm$ 1.58	2.36 $\pm$ 0.84
25%	3.87 $\pm$ 0.80	4.53 $\pm$ 1.94	5.06 $\pm$ 1.43	4.49 $\pm$ 1.39
50%	5.60 $\pm$ 1.75	7.81 $\pm$ 3.77	8.61 $\pm$ 2.23	7.34 $\pm$ 2.61
75%	7.27 $\pm$ 1.64	8.73 $\pm$ 1.01	10.33 $\pm$ 2.41	8.78 $\pm$ 1.69

Another study was also conducted in three districts (Estie, Farta, and Simada) of South Gondar zone to see whether production systems have an impact on milk yield and stage of lactation between indigenous and crossbred cattle in the area. The results revealed that milk yield decreased progressively from the first lactation in all production systems and all breed types at all blood level (Table 5). The quantities of milk produced were also much higher than those produced in west go jam zone (Table 4 and 5). These show that breed with environmental interaction had significant contribution to

these differences. The overall average daily milk yield of cross F1 (50%), F2 (25%) and F2 (75%) were 5.06 $\pm$ 1.667, 3.55 $\pm$ 1.478 and 7.83 $\pm$ 2.318 liters and an overall 5.48 $\pm$ 1.821 liters per day, respectively. This result was less than (Dessalegn Genzebuet al., 2016) (11.6 $\pm$ 3.1 and 10.8 $\pm$ 2.4 liters per day/cows). The average daily milk yield for indigenous scows was also less than Tsegay Lijalem and Gebreegziabher Zeru results (2016) (1.989 $\pm$ 0.063 liters per day per cow), but greater than reported by (CSA 2004) (1.54 liters).

**Table 5.** Daily milk yield per stage of lactation in urban, peri-urban and mixed livestock production system for indigenous and crossbred cattle (N=180)

Breed type	Urban mean $\pm$ SD	Peri-urban mean $\pm$ SD	Mixed mean $\pm$ SD	Overall mean $\pm$ SD
Local1 <sup>st</sup> L	2.86 $\pm$ 1.490	1.85 $\pm$ .893	1.73 $\pm$ .700	2.00 $\pm$ 1.053
Local2 <sup>nd</sup> L	2.59 $\pm$ 1.436	1.52 $\pm$ .640	1.63 $\pm$ .636	1.78 $\pm$ .938
Local3 <sup>rd</sup> L	1.45 $\pm$ .912	0.95 $\pm$ .815	1.06 $\pm$ .626	1.10 $\pm$ .774
<b>Cross</b>				
25%1 <sup>st</sup> L	4.30 $\pm$ 1.160	5.50 $\pm$ 2.121	3.40 $\pm$ 1.673	4.18 $\pm$ 1.468
25%2 <sup>nd</sup> L	3.80 $\pm$ 1.033	5.50 $\pm$ 2.121	2.60 $\pm$ 1.517	3.65 $\pm$ 1.498
25%3 <sup>rd</sup> L	2.90 $\pm$ 1.101	5.00 $\pm$ 1.414	1.80 $\pm$ 1.304	2.82 $\pm$ 1.468
50%1 <sup>st</sup> L	6.30 $\pm$ 1.720	6.40 $\pm$ 1.673	5.11 $\pm$ 1.167	6.00 $\pm$ 1.633
50%2 <sup>nd</sup> L	5.70 $\pm$ 1.809	5.40 $\pm$ 2.793	3.89 $\pm$ 1.364	5.18 $\pm$ 1.977
50%3 <sup>rd</sup> L	4.25 $\pm$ 1.410	4.20 $\pm$ 1.643	3.33 $\pm$ 1.118	4.00 $\pm$ 1.393
75%1 <sup>st</sup> L	10.13 $\pm$ 2.356	9.38 $\pm$ 2.774	6.25 $\pm$ 1.708	9.33 $\pm$ 2.689
75%2 <sup>nd</sup> L	8.73 $\pm$ 2.017	7.75 $\pm$ 2.252	5.25 $\pm$ 1.893	7.93 $\pm$ 2.336
75%3 <sup>rd</sup> L	6.53 $\pm$ 1.598	6.75 $\pm$ 2.121	4.00 $\pm$ 1.414	6.22 $\pm$ 1.928

Mixed = Mixed crop-livestock, L = Lactation, SD = Standard Deviation

### Searching for Climate oriented dairy production options

Human population increases from time to time and grazing lands are decreasing due to subsistence cash crops as well as keeping livestock. Many farmers would like to keep dairy cows but do not build zero-grazing units or sufficient land to grow enough feed. However, goats require less land than dairy cows (CTA, 2007). In this case keeping dairy goats as a more affordable and appropriate option than cows (Legesse et al., 2008). Goat milk provides more nutritional and therapeutic value than dairy cow that can be satisfied with small amount of goat milk. The goat milk contains more small fat globules, i.e. globules of less than 1.5 mm in size, that goat milk is better digested than cow's milk (Ohiokpehai O, 2003). Therefore, consuming goat milk is very useful for both adult and growing children; processing of goat milk will preserve and improve the nutritive value of the milk. Therefore, identification of the presence of dairy producing traits of goats (RUD=Rear Udder Diameter, RUL=Rear Udder Length, UCC=Udder Circumference, TTL=Teat Length) were the attentions given. Three

districts Farta, Ebinat in south Gondar zone and Gonjji Kollala in West gojam zone were those selected with goat population potentials. The results revealed that the average rear udder diameter (RUD) for dairy, dual and meat type female goats were  $10.04 \pm 0.22$ ,  $8.66 \pm 0.37$  and  $8.01 \pm 0.30$  cm, respectively. Rear udder length (RUL), udder circumference (UCC) and teat length (TTL) in these breeds averaged were  $17.14 \pm 0.28$ ,  $31.39 \pm 0.59$  and  $3.71 \pm 0.07$  cm,  $14.21 \pm 0.48$ ,  $26.75 \pm 1.01$  and  $3.41 \pm 0.12$  cm and  $13.44 \pm 0.38$ ,  $24.67 \pm 0.81$  and  $3.01 \pm 0.09$  cm, respectively (Table 6). In this finding, dairy type female goats have significantly higher ( $p < 0.001$ ) values for all udder and teat measurements than dual and meat type female goats. These results are greater than two years West African Dwarf (WAD) goats which had  $12.00 \pm 0.34$  cm udder widths in semi-intensive management system but lower results of Abu et al 2013 in rear udder diameter. Selection and breeding with appropriate production system can be one of the options towards following climate smart dairy production for enhancing milk production and food security in the area.

**Table 6.** Rear Udder Diameter, Rear Udder Length, Udder Circumference, Teat Length, for goat type and agro-ecological effects of dairy goat types

Effects and Level	RUD LSM±SE	RUL LSM±SE	UCC LSM±SE	TTL LSM±SE	SW LSM±SE	SCC LSM±SE
Grand	9.21±0.17	15.55±0.24	28.63±0.48	3.46±0.05	8.88±0.35	23.56±0.66
Goat type	***	***	***	***	NS	NS
Dairy	10.04±0.22 <sup>a</sup>	17.14±0.28 <sup>a</sup>	31.39±0.59 <sup>a</sup>	3.71±0.07 <sup>a</sup>	9.37±0.89	23.75±1.74
Dual	8.66±0.37 <sup>b</sup>	14.21±0.48 <sup>b</sup>	26.75±1.01 <sup>b</sup>	3.41±0.12 <sup>b</sup>	9.20±0.56	24.26±1.10
Meat	8.01±0.30 <sup>b</sup>	13.44±0.38 <sup>b</sup>	24.67±0.81 <sup>b</sup>	3.01±0.09 <sup>c</sup>	8.44±0.52	22.92±1.00
District	NS	NS	NS	NS	*	*
Ebnat	9.07±0.29	15.78±0.40	28.52±0.82	3.42±0.09	9.45±0.43 <sup>a</sup>	24.71±0.82 <sup>a</sup>
Farta	9.10±0.31	15.24±0.43	28.14±0.88	3.52±0.10	8.09±0.50 <sup>b</sup>	22.00±0.95 <sup>b</sup>
Gonjiko	9.45±0.29	15.60±0.40	29.16±0.82	3.44±0.09	Nm	Nm

RUD=Rear Udder Diameter, RUL=Rear Udder Length, UCC=Udder Circumference, TTL=Teat Length, \* significant at 0.05 level ( $p \leq 0.05$ ), \*\* significant at 0.01 level ( $p \leq 0.01$ ) and \*\*\* significant at 0.001 level ( $P \leq 0.001$ ) and NS (Not Significant), LSM=least square mean, SE= Standard error.

### Conclusion

From this study, it was possible to see that the cattle and sheep population size was fluctuating than goats due to the direct (thermal stress) and indirect (shortage of feed and water resources) negative impacts of climate change. Therefore, goats can be an alternative animal to undertake climate smart livestock production. Selection and breeding helps to improve the performances of indigenous animal genetic resources. Selection of indigenous cattle and breeding for dairy production has paramount importance since the cattle possess dairy associated traits. Improving indigenous breeds towards milk production will help to have sustainable production as they do have the capacity of adapting climate related factors as they have thermal tolerance, survival with low quality feed and disease resistance. On the other hand, the production performances of indigenous and crossbred cattle across the production system revealed that there was

no significant difference in the milk between indigenous and crossbred cattle across all the production systems and all breed types though the quantity of milk produced differ from agro-ecology to the other. The traits related to dairy production for indigenous dairy type goats is comparable to other internationally known dairy goat breeds. However, there is no specialized goat farming and production system in the region. Therefore, specialized and intensive dairy goat production including proper management practice with selection and multiplication of superior dairy type goats are important to increase dairy goat milk productivity as they adapt climate change related factors and thereby improving the livelihood of the farmers. This will also enhance quality of food since goat milk has higher nutritional and medicinal value than cow milk. It can be also one of the options towards climate smart dairy production.

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