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Smallholder Dairy Production in Mixed Farming Systems of Southern Ethiopia: Constraints and Options for Intervention

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Abstract: The study was conducted in KemabataTembaro zone, located in Southern Ethiopia, with the aim of characterizing smallholder dairy production of the area and identifying constraints limiting the dairy production thereby providing a basis for development interventions. To do so, two peasant associations were selected, one from highland and the other from lowland agro-ecology. Then in each peasant association smallholder dairy farms were categorized as 'high production farms' and 'low production farms' based on the presence and absence of crossbred dairy cattle in the farms, respectively. A total of 38 smallholder farmers were sampled and individually interviewed using structured questionnaires in their respective farms. The information obtained was analyzed in descriptive statistics, chi-square test, correlation and General Linear Model procedures using SPSS computer software. Findings of interview revealed that high production farms had larger family size, land size and better education than low production farms. Cattle were primarily kept for milk production followed by draught power. Feed type and availability in the areas were affected by season of the year and agro-ecology which resulted in seasonal variation of milk production. The mean milk yield of dairy cows in high production farms (7.6 liters per cow per day) was significantly higher ($P<0.001$) than in low production farms (1.8 litres per cow per day). High production farms were also better in other reproductive performances and smallholders attributed these differences to poor genetic performance of indigenous cattle. Feed was top rated constraint in dry season in the areas and more severe in lowlands than highlands whereas water was scarce in highlands. Cash was also a major constraint in the areas. Smallholders need cash primarily to purchase feed and its importance was high for high production farms as they were supposed to buy concentrates. Other major constraints of smallholder dairy farming of the areas were: lack/inadequacy of artificial insemination or improved bull services, credit services and improved milk market schemes.

Key words: smallholder dairy · High production farms · Low production farms · Constraint analysis · Southern Ethiopia

INTRODUCTION

Ethiopia possesses the largest cattle population of the African continent. In 2008/09, the population of cattle was 59 million head and cattle in pastoral areas accounted for about 20% of this number [1]. Despite this huge number, the cattle productivity of the country is very low and the direct contribution it makes to the national economy is limited compared to its potential [2].

Livestock are closely related to the social and cultural life of several millions of Ethiopian farmers and milk plays a very important role in the diet both in rural and urban areas. According to FAO report [3], milk constitutes 56% of all livestock product consumption of the country. The demand for milk and milk products is ever increasing due to fast growing population, urbanization and growing economy [4]. There is an immediate and growing shortage of milk and its products in all major cities of the country [5].

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On the other hand, the dairy sector of the country remains among the ones with lowest milk production in the world [6]. Belete [7] reported that the per capita consumption of milk in Ethiopia is 19 kg/year and it is much lower than the world's standard, which is 100kg/year. In order to bridge the huge gap between demand and supply, milk production in Ethiopia has to grow by 4% per annum [8]. In addition to low milk production levels, there is no development in areas of milk collection, processing and marketing. The dairy sector lacks a chain approach which aims at sustainable development [5]. The demand-supply variation due to the mentioned and other related problems offers major challenges and opportunities to explore and improve the current dairy production systems.

The mainstay of people of KembataTembaro zone, the study area, is rain-fed subsistence agriculture and the majority of people practice smallholder crop-livestock farming. Dairying is an integral part of the farming system in the smallholder farmers of the area. In addition to being a food, milk has a significant social and cultural importance in the society, for instance, if one of household members gets sick or give birth, other members of the society will visit with milk. In Kembata society "Do you have milk?" is a part of greetings. Farmers mainly use indigenous zebu cattle for milk production and at the moment keeping crossbred dairy cattle is in an increasing trend.

The study area has a potential for milk production, but little is known about the existing production system, constraints and opportunities associated with dairying. An important first step in addressing the development needs of smallholder dairy farmers in the area is to diagnose the existing and future constraints and opportunities facing them. These may be between farms with different production levels and between different agro-ecologies of the area. After this step, appropriate development interventions could be designed and implemented. Therefore, the overall objective of the present study is to enhance the productivity of smallholder dairying in the study area by identifying constraints limiting dairy productivity and identifying possible improvement options.

MATERIALS AND METHODS

Study Area: The study was conducted in two districts, namely Kachabira and Hadero-Tuntozuria, of KembataTembaro zone, 280 km South of Addis Ababa, Ethiopia. The people of the area practice mainly smallholder crop-livestock mixed farming system. The zone has two main agro-ecologies: lowland and highland. According to Wakitola [9], agri-ecological zones with altitude of 500-1500 meters above sea level are categorized as 'kola' or lowlands and those with altitude of 2300-2400 meters above sea level as 'dega' or highlands.

The zone possesses 317,239 cattle population and from this 287,468 heads were indigenous, 25,430 were hybrid and 759 were exotic breeds. Sex wise, 60.7% of indigenous cattle, 80.6% of hybrids were females whereas all exotic genotypes are males [10].The main crops grown in highland area (highlands of this particular study) include enset (*Ensete ventricosum*), wheat, barley, potato, beans and peas. Enset is a dominant perennial crop and a staple food both for human being and livestock. Crops grow mainly in lowland areas include coffee, ginger, maize, teff, sorghum, yam, sweat potato and some fruits.

Kachabira district is located 7°10'-7°34'N latitude and 37°58'-37°86'E longitude. Altitude of the district ranges from 1650-2450 meters above sea level. In terms of topography, the district has a suitable land for agriculture except some hilly areas. The annual rainfall varies from 900 to 1500 mm where the main rainy season is from June to September. The annual mean temperature varies from 14 to 26°C. The major soil types are clay and black, but in few areas there is loam soil [11].

The woreda (district) consists of 20 rural and 6 urban kebeles (Peasant associations). The total human population of the district (in 2010) was 133,303. The total number of households is 18,605 where 15,238 are male headed and 3,367 are female headed. The total land area is 36,790 hectares out of this 21,875 hectare is suitable for agriculture [11].

Hadero-Tuntozuria district is located 7°15'N latitude and 37°30' East longitude. The altitude ranges from 1100-2,500 meters above sea level, the annual rainfall varies from 800 to 850 mm and the annual temperature is 16-30°C. The district is characterized by mainly red and unfertile soil type. This district consists of 14 rural and 2 urban kebeles. The total human population is 121,715. The total land area of the district is 16,689.64 hectare and out of this 11,119.48 hectare is suitable for agriculture [11].

Sources and Methods of Data Collection: In a first step, a meeting was held with experts of Animal Sciences in Agriculture and Rural Development offices of the districts to identify peasant associations that represent lowland and highland agro-ecologies. Then a peasant association called 'Hobicheka' was selected from Kachebira district to

represent highland agro-ecology and 'Lalo-Hadero' was selected from Hadero-Tunto district to represent lowland. Then another discussion was held at each peasant association with development agents and few key informants to identify smallholder dairy farms of 'high production 'and 'low production'. The only criteria set by the stakeholders to categorize the farms were presence or absence of crossbred dairy animals (Zebu x Friesian) in the farms. Farms owning crossbred animals were categorized as 'high production farms' otherwise 'low production farms'. Based on this criterion, a total of 38 farmers were chosen from the two agro ecologies. Farms of 'Low production' were selected randomly, but purposive sampling was used to select farms of 'high production' due to their limited availability.

After a pre-test of questionnaire, smallholder farmers were individually interviewed. The interview with farmers was in their respective farms and local language was used as a media of communication. The questionnaire covered a large range of variables and has two main parts. The first part is about production system characterization and includes variables such as demography, education status of the household heads, land and livestock ownership, breeding practices, feed and water availability,milk production and other related reproduction performances of dairy cattle in the study areas.

The second part of the questionnaire was dealt with analysis of constraints of dairying in two production levels (farm types) and two agro-ecologies. The constraints were categorized as 'farm level' and 'outside farm border' constraints. Farm level constraints include: feed, water, genetics, disease, labor, competition of dairying with other farm works and capital. External (outside farm border) constraints include: credit service, government's extension services and market.

Data Analysis: Data collected was managed in such a way that the qualitative as well as quantitative variables can be analyzed. Data were entered into computer software SPSS (version19) and coded for analysis. Descriptive, inferential statistics, chi-square test and correlations were used for data analysis.

Farm types (low production and high production), agro-ecologies (lowland and highland) and their interactions were used as a fixed factors for most of the dependent variables such as family size, farm size, herd structure and composition, objective of keeping cattle, milk yield and other reproductive and breeding performances and various constraints. These data were analyzed using General Linear Model procedures. The model was

$$Y_{ijk}=\mu + A_i + P_j + AP_{ij} + \varepsilon_{ijk,}$$

where, Y_{ijk} is dependent variable, μ is the overall mean, A_i is the fixed effect of agro-ecology i, i= lowland, highland; P_j is the fixed effect of farm type j, j= high production, low production; AP_{ij} is the interaction of agro-ecology and farm types and $\varepsilon_{ijk}$is the random error. Chi-square test was used to determine differences in percent frequency of nominal data. Correlation analysis was done to determine the degree of relationship of random variables like land size and milk yield. For all analysis, the level of significance was set at anα of $P<0.05$.

RESULTS

Demographic Characteristics: Some demographic characteristics of the households are presented in Fig. 1 and Table 1. All interviewed households were from Kembata ethnic group and follow protestant religion. The average family size of the households was 7.7±0.41. High production farms had significantly higher ($P<0.05$) family size than low production farms, but a family size was not different across agro-ecologies. Similarly, female family size was higher ($P<0.05$) at high production farms than at low production farms. Majority of the household heads (84.2%) were married and 71.1% of the households were headed by men. The average age of the household head was 45.3±2.14 years and not different across agro-ecologies and farm types.

Of the household heads in the study area, 47.4% of them had the education level of grade 1-8 followed by 28.9% illiteracy. Educational status of household heads differed significantly ($P<0.05$) across the agro-ecologies and farm types. Illiteracy rate was higher in highland and for low production farms. Thus, 50% of household heads in highland and 40% in low production farms were illiterate. Household heads in low land and high production farms were better in educational status (Fig. 1).

Land Holding and Use: The average land holding per household in the study areas was 0.80±0.05 hectares. It was within the range of holdings of 0.25 to 2.00 hectares. The land holding was significantly different ($P<0.05$) across farm types. Farms of high production owned significantly ($P<0.05$) higher land sizes irrespective of difference in agro-ecology. The study also showed a significant positive correlations of family size and land size ($r=0.385$, $P<0.05$) and total land size and land for pasture ($r=0.460$, $P<0.01$).

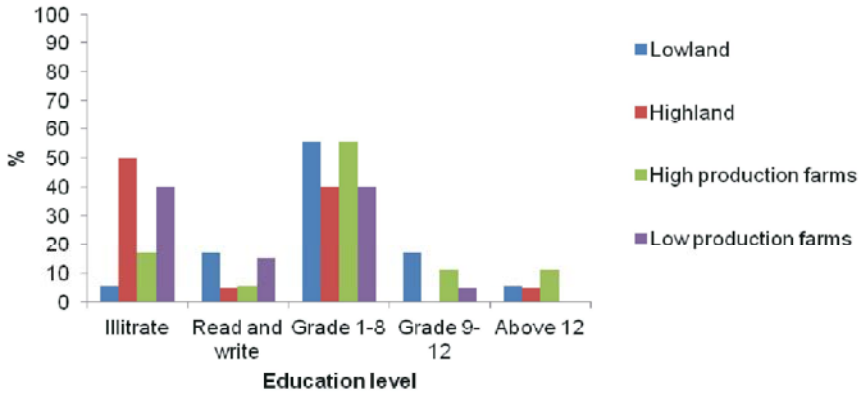

Fig. 1: The educational status of household heads of study areas.

Table 1: Average household size and age of household heads in the two agro-ecologies and farm types in the study areas (N=38).

	Agro-ecology	Lowland (M±SE)		Highland (M±SE)				
Factors	Farm type	High production	Low production	High production	Low production	P_A	P_F	P_{AxF}
Age		41.4(3.23)	49.8(4.79)	47.7(4.64)	41.6(3.83)	NS	NS	NS
Family size								
	Male	4.0(0.50)	3.1(0.31)	4.4(0.70)	3.9(0.50)	NS	NS	NS
	Female	4.6(0.87)	3.4(0.34)	4.1(0.28)	3.4(0.37)	NS	*	NS
Total		8.6(1.29)	6.5(0.52)	8.5(0.75)	7.2(0.61)	NS	*	NS

^{PA}= effect of agro-ecology, ^{PF}= effect of farm type, ^{PAxF}= effect of interaction of agro-ecology and farm type ^{NS}= Non-significant. *=P<0.05, **=P<0.01, ***=P<0.001.

Table 2: Land holdings and the average area covered by crops in the study areas (N=38).

	Agro-ecology	Lowland (N=18) Mean(SE)		Highland (N=20) Mean(SE)				
Land holding (ha)	Farm type	High production	Low production	High production	Low production	P_A	P_F	P_{AxF}
Total		0.9 (0.14)	0.7(0.08)	0.9 (0.14)	0.6(0.06)	NS	**	NS
All crops		0.9(0.13)	0.5 (0.05)	0.6 (0.08)	0.5(0.05)	NS	***	NS
Enset		0.1(0.02)	0.1 (0.01)	0.2(0.03)	0.2(0.02)	***	NS	NS
Coffee		0.1(0.03)	0.1(0.01)	0.0(0.00)	0.0(0.00)	***	NS	NS
Ginger		0.2(0.05)	0.2(0.04)	0.0(0.00)	0.0(0.00)	***	NS	NS
Wheat		0.0(0.00)	0.0(0.00)	0.4(0.06)	0.3(0.07)	***	NS	NS
Teff		0.1(0.04)	0.1(0.03)	0.0 (0.00)	0.0(0.00)	***	NS	NS
maize		0.2(0.04)	0.1 (0.02)	0.0(0.03)	0.0(0.00)	***	NS	NS
Other crops		0.1(0.02)	0.1(0.02)	0.1(0.05)	0.1(0.03)	NS	NS	NS

^{PA}= effect of agro-ecology, ^{PF}= effect of farm type, ^{PAxF}= effect of interaction of agro-ecology and farm type ^{NS}= Non-significant. *=P<0.05, **=P<0.01, ***=P<0.001

The types of crops grown are mainly dependent on agro-ecology rather than farm types. Highland areas grow enset, wheat and barley whereas lowlands grow coffee, ginger, teff and maize. Except barely, the types of crops grown were not affected by farm type. Barley was grown only in farms of high production (Table 2).

Livestock holding and Composition: The household animal species composition and holdings are presented in Table 3. The overall average number of livestock per household was 3.4±0.18 TLU ranging from 1.5 to 6.6. The average number of cattle, equines, sheep, goats and chickens owned in the study area was 4.5±0.24, 0.2±0.08, 1.0±0.26, 0.2±0.10 and 3.7±0.52 respectively. The average livestock holdings (TLU) were not different across the farm types and agro-ecologies. The number of zebu cattle in lowlands was higher than in highlands and the number of crossbred cows was not different across the agro-ecologies.

Table 3: Herd structure and composition per household in the study areas (N=38).

	Agro-ecology	Lowland Mean (SE)		Highland Mean(SE)				
Type(numbers)	Farm type	High production	Low production	High production	Low production	P_A	P_F	P_{AxF}
Calves		1.1(0.29)	1.7(0.21)	1.7(0.21)	1.4(0.16)	NS	NS	NS
Bull		0.1(0.12)	0.0(0.00)	0.1(0.10)	0.1(0.10)	NS	NS	NS
Heifer		0.4(0.18)	0.5(0.17)	0.3(0.15)	0.5(0.17)	NS	NS	NS
Cow (Zebu)		0.8(0.16)	1.7(0.15)	0.2(0.13)	1.1(0.10)	***	***	NS
Crossbred cow (HF x Zebu)		1.0(0.00)	0.0(0.00)	1.3(0.15)	0.0(0.00)	NS	***	NS
Ox		0.9(0.23)	0.9(0.18)	1.1(0.18)	0.3(0.15)	NS	*	*
Equines		0.1(0.13)	0.0(0.00)	0.6(0.22)	0.2 (0.15)	*	NS	NS
Sheep		0.0(0.00)	0.0(0.00)	2.2(0.68)	1.6(0.43)	***	NS	NS
Goats		0.0(0.00)	0.5(0.31)	0.2(0.20)	0.1(0.10)	NS	NS	NS
Chicken		3.90(1.13)	3.9(0.61)	5.0(1.53)	1.9(0.46)	NS	NS	NS
TLU		3.1(0.29)	3.7(0.36)	3.9(0.41)	2.8(0.30)	NS	NS	NS

^{PA}= effect of agro-ecology, ^{PF}= effect of farm type, ^{PAxF}= effect of interaction of agro-ecology and farm type ^{NS}= Non-significant. *=P<0.05, **=P<0.01, ***=P<0.001

Table 4: Purposes of keeping cattle in the study areas (scores 1-10, where 1= not important, 10= very important).

	Agro-ecology	Lowland (N=18) Mean(SE)		Highland (N=20) Mean(SE)				
Purposes	Farm type	High production	Low production	High production	Low production	P_A	P_P	P_{axP}
Milk production		9.8(0.13)	9.8(0.13)	8.2(0.53)	9.1(0.35)	**	NS	NS
Manure		5.8(0.25)	7.1 (0.28)	5.7(0.62)	7.2(0.25)	NS	***	NS
Draft power		9.1(0.29)	9.2(0.33)	7.3(0.45)	7.0(0.75)	***	NS	NS
Bank and Insurance		8.0(0.59)	7.2(0.36)	7.6(0.64)	8.80(0.39)	NS	NS	NS
Meat production		1.0(0.00)	1.0(0.00)	1.0(0.00)	1.0(0.00)	-	-	-
Status		3.6(0.63)	2.4(0.71)	4.1(0.64)	4.9(0.43)	*	NS	NS

^{PA}= effect of agro-ecology, ^{PF}= effect of farm type, ^{PAxF}= effect of interaction of agro-ecology and farm type ^{NS}= Non-significant. *=P<0.05, **=P<0.01, ***=P<0.001

Dairy farms of high production had higher (P<0.05) number of oxen than dairy farms of low production. There was also a strong positive correlation between the mean livestock units (TLU) and land size of households (r=0.544, P<0.001) and the number of oxen and land holdings (r=456, P<0.01).

The number of equines was significantly (P<0.05) higher in highlands than lowlands and not affected by farm type. Sheep did exist in highland in higher amount (P<0.05) regardless of farm type. All other livestock species did not differ in number across the farm types and agro-ecologies.

Purposes of Keeping Cattle in the Study Areas: The mean score why the smallholder farmers keep cattle in the study areas is presented in Table 4. In the study areas, cattle were kept as multi-purpose animals: source of milk, draught power, as bank and insurance and for status.

The primary objective of cattle keeping in the study areas was milk production. But, the importance of milk was significantly (P<0.01) higher in lowlands than in highlands and was equally important in both high and low production farms regardless of the amount of milk produced.

Next to milk production, draught power was the most important function of cattle in lowlands whereas a function as bank and insurance in highland areas. Draught power was significantly (P<0.001) more important in lowlands than highlands, but it was not different across the farm types. In third place, cattle were kept to substitute bank and insurance in lowlands and for draught power in highlands.

In all farming systems, manure and status were the fourth and fifth important functions. But the level of importance of manure was higher (P<0.001) in farms of low production than in farms of high production irrespective of agro-ecology. Keeping cattle for status was more important for smallholder farmers of highland than for farmers of lowland areas. Keeping cattle for meat was not important at all in the study areas.

Table 5: Grazing systems of farming systems in the study areas.

	Grazing system			
Farm type	Zero grazing N(%)	Semi-grazing N(%)	X^2	P-Value
High production	10(55.6)	8 (44.4)	11.772	0.001
Low production	1(5)	19(95)		
Lowland	7(38.9)	11(61.1)	1.643	0.200
highland	4(20)	16(80)		

Table 6: The mean scores of the importance of feed resources of the study areas (scores 1-10, 1= not important, 10=very important).

	Agro-ecology	Lowland (N=18) Mean(SE)		Highland (N=20) Mean(SE)				
Feed source (N=38)	Farm type	High production	Low production	High production	Low production	P_A	P_F	P_{axF}
Wet season								
Enset		1.4(0.26)	1.9(0.23)	7.6(0.60)	6.8(1.02)	***	NS	NS
Weeds inside crops		6.0(1.25)	7.6(1.17)	4.1(0.57)	7.3(0.58)	NS	*	NS
Cut and carry (own pasture)		9.9(0.13)	9.9(0.10)	5.4(0.56)	6.3(0.78)	***	NS	NS
Road side grass		1.8(0.75)	1.0 (0.00)	1.6(0.31)	1.9(0.38)	NS	NS	NS
Concentrates		4.5(0.76)	1.8(0.39)	4.9(0.66)	2.0(0.54)	NS	***	NS
Communal grazing lands		0.9(0.13)	2.0(0.73)	2.4(0.64)	3.1(1.03)	NS	NS	NS
Maize (as wet crop)		9.0(0.13)	8.0(0.41)	0.9(0.10)	1.0(0.00)	***	NS	NS
Cultivated forage		1.7(0.67)	2.5(0.50)	9.7(0.21)	9.3(0.26)	***	NS	NS
Dry Season								
Enset		8.1(0.52)	8.8(0.33)	9.3(0.30)	9.1(0.41)	NS	NS	NS
Crop residues		9.4(0.18)	9.5(0.99)	7.5(0.50)	8.5(0.34)	***	NS	NS
Hay		5.3(1.16)	5.8(0.99)	2.5(0.69)	2.7(0.70)	**	NS	NS
Grazing on crop stubbles		1.0(0.00)	1.2(0.65)	3.8 (0.71)	3.2(0.77)	***	NS	NS
Concentrates		9.0(0.42)	2.4(0.65)	7.0(0.42)	2.4(0.67)	NS	***	NS

^{PA}= effect of agro-ecology, ^{PF}= effect of farm type, ^{PAxF}= effect of interaction of agro-ecology and farm type ^{NS}= Non-significant. *=P<0.05, **=P<0.01, ***=P<0.001

Feed and Water Resources: Grazing systems of the study areas include zero grazing and semi-grazing. In zero grazing system, animals get all necessary feed and water in confined environment. In semi-grazing system animals are allowed to graze outside for some hours and supplemented at night. There was a significant difference (P<0.001) in grazing system between high and low production farm types. Majority (55.6%) of high production farms practiced zero grazing, but only 5% of low production farms. The grazing systems were not different across highland and lowland agro-ecologies (Table 5).

The average grazing hours per day in lowland, highland, high production farms and low production farms were 3.33, 4.56, 1.86 and 5.75, respectively. The grazing time in highland areas was significantly (P<0.05) higher than lowland areas; similarly, animals in low production farms grazed more hours than animals in high production farms (P<0.001).

There was seasonality of feed availability. The seasons could be broadly categorized as dry (November-March) and wet (the left months). The importance of feeds in wet and dry season is indicated in Table 6.

The sources of feed in wet season were not different in low and high production farms except concentrate and weeds inside crops. Concentrates, mainly wheat bran, were significantly (P<0.001) important for high production farms than low production ones whereas weeds inside crops were more important (P<0.05) for low production farms than high production farms.

In wet season, the most important feed for highland smallholder farmers was cultivated forage whereas for lowland smallholders it was 'kalo'. 'Kalo' is a local name for own pastures for cut and carry. Enset and maize are the second most important wet season feeds in highland and lowland areas, respectively. The importance of these feed sources were significantly (P<0.001) different across the two agro-ecologies. Communal grasslands and roadside grasses were not important feed resources.

Table 7: Water availability and watering system of the study areas.

	Farm types		Agro-ecology	
	High production N(%)	Low production N(%)	Lowland N(%)	Highland N(%)
Watering method				
Transporting water to animals	15(83.3)	7(35)	8(44.4)	14(70)
Bringing the animals to water	3(16.7)	13(65)	10(55.6)	6(30)
X^2		9.079		2.538
P-value		0.003		0.111
Water shortage in dry season				
Yes	8(44.4)	10(50)	1(5.6)	17(85)
No	10(55.6)	10(50)	17(94.4)	3(15)
X^2		0.117		23.983
P-value		0.732		0.000

Table 8: Breeding practices of the study areas.

	Farm type		Agro-ecology	
Breeding technique	High production N(%)	Low production N(%)	Lowland N(%)	Highland N(%)
Artificial insemination	4(23)	0(0)	4(23.5)	0(0)
bull for free	0(0)	17(89.5)	9(52.9)	8(42.1)
Bull paid	13(76.5)	2(10.5)	4(23.5)	11(57.9)
X^2		29.045		7.237
P-value		0.000		0.027

In dry season, enset was the most important and the second most important feed source in highland and in lowland areas, respectively. Crop residues were the most important in lowland areas in this season. In this season, in both agro-ecology, farms of high production use concentrates and its importance was significantly ($P<0.001$) higher than farms of low production. Among crop residues in dry season, teff and maize/sorghum were the most important for lowland smallholder farmers whereas barley and wheat were for highlanders (Table 6).

The majority of smallholders (68.4%) get water to their animals from pipelines (water points were developed in farmers residence area in lowlands and it's for free, but in highlands it was in nearest town and smallholders supposed to pay) and others from nearby rivers. Only 2.6% of respondents had their own pond. Smallholder farmers in highlands had to travel significantly ($P<0.01$) longer distances (1.1km) to a water point than smallholders in lowland areas (0.16km). Majority of high production farms had to transport water to the animals (83.3%) and majority (65%) of low production farms had to take their animals to water points. Water was scarce in dry season in highland areas (Table 7).

Breeding Practices: Both artificial insemination (AI) and natural mating were practiced in the areas. Bulls for natural mating could be paid or for free.Only artificial insemination service was owned by government.These breeding practices were significantly different across farm types ($P<0.001$) and agro-ecology ($P<0.05$). Majority of farms of high production (76.5%) use paid bull (privately owned) followed by artificial insemination (23.5%) whereas from interviewed smallholders of low production farms (89.5%) use bulls without payment. When agro-ecology is considered, AI service was not accessible at all in highland areas (Table 8).

Milk Production and Reproduction Performances: The mean milk yield of dairy cows was 7.6 and 1.8 liters per cow per day in high and low production farms, respectively. Thus, milk yield in high production farms was significantly ($P<0.001$) higher than in low production farms. The average milk yield per cow per day in highland and lowland areas was 4.8 and 4.3 liters and the difference was not significant ($P>0.05$). There was a strong positive correlations ($r=0.484$, $P<0.01$) between milk yield and land holding of households, land covered by crops and milk yield ($r=0.500$, $P<0.001$).

Table 9: Milk yield and some other reproduction performances of dairy cattle in the study areas (N=38).

	Agro-ecology	Lowland (N=18) Mean(SE)		Highland (N=20) Mean(SE)				
Factors	Farm type	High production	Low production	High production	Low production	P_A	P_F	P_{axF}
Milk yield/day/cow (litres)		7.0(0.53)	2.1(0.18)	8.1(0.60)	1.5(0.17)	NS	***	*
Lactation length (months)		9.0(0.46)	10.9 (0.43)	8.9(0.67)	7.1(0.59)	***	NS	***
Calving interval (months)		18.5(1.20)	25.9(2.29)	17.5(1.50)	18.6(1.40)	*	*	NS
Age at first calving (months)		35.3(2.40)	54.6(2.60)	27.3(3.05)	52.8(3.56)	NS	***	NS

^{PA}= effect of agro-ecology, ^{PF}= effect of farm type, ^{PAxF}= effect of interaction of agro-ecology and farm type ^{NS}= Non-significant. *=P<0.05, **=P<0.01, ***=P<0.001

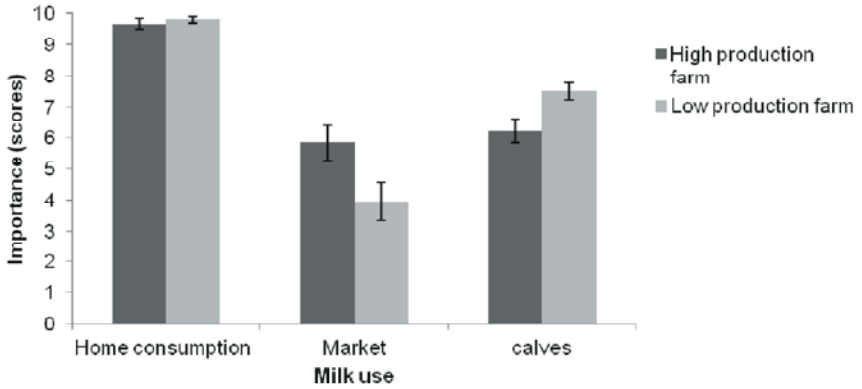

Fig. 2: Some functions of milk in the study areas (scores 1-10, 1=not important, 10= very important).

There was a seasonal variation in milk yield between the agro-ecologies. Higher milk yields are obtained from September to November in highland areas whereas May to August in lowland areas. In both agro-ecologies, the lower milk yield is obtained between January and March.

Age at first calving (AFC) was significantly (P<0.001) different between farm types but not between agro-ecologies. The mean AFC in low production farms was 53.7 months whereas in high production farms it was 30.8 months. In highlands cows mostly give birth from September to November and in lowlands from May to August.

The average lactation length (months) of dairy cows in high and low production farms were 8.9 and 9.0 and not different (P>0.05). But, agro-ecology had a significant effect (P<0.001) on lactation length. The mean lactation lengths in highland and lowland areas were 8.0 and 10.1 months respectively and there was a significant interaction between agro-ecology and farm types.

Both farm types and agro-ecology had a significant effect (P<0.05) on calving interval of dairy cows. Dairy farms of Low production had longer average calving interval (22.3 months) than farms of high production (17.9 months). Concerning agro-ecology, highlands were better than lowlands. The average calving intervals in highlands and lowlands were 18.1 and 22.6 months respectively. Milk yield and reproduction performances of dairy cattle across farm types and agro-ecology are presented in Table 9.

Milk Use: The mean score of milk use in the study areas is shown in Fig. 2. Milk uses include home consumption, market and calves feeding. The primary function of milk in the study areas, regardless of agro-ecology or farm type, was for home consumption. Next to home consumption smallholder farmers gave an emphasis to feeding calves and it was more important to low production farms than farms of high production (P<0.01). Milk production for market was the least important compared to other functions of milk, especially on farms of low production. Soured butter and cheese were the only milk products marketed in the areas.

Constraints of Dairying in the Study Areas

Farm Level Constraints

Feed: Feed was top rated farm level constraint. The severity of the problem was significantly (P<0.05) higher in lowlands than highlands and not different across farm types (Table 12 and 13). Out of 38 respondents interviewed 56.8% of them related the feed problem of the areas to seasonality of feed availability.

Some other responses include land scarcity to grow improved forages (29.7%), low feed quality (5.4%), less communal grazing land (2.7%), labour scarcity to herd or harvest of grass in cut and carry systems (2.6%) and unavailability of concentrates in the areas (2.7%).

Water: Water was scarce in highland areas during dry season and it was not an important problem for lowland areas (P<0.001) (Table 10 and 11). And the problem was not different across farm types. Smallholders in highland areas had to travel on average 1.1 kmto water points and spent more times to access it. Farmers using rivers also complained aquatic leech problems. Aquatic leech (*Lymnatisnilotica*) is segmented worm which attack animals getting into mouth when animals drink infested water.

Table 10: Mean scores of constraints in the study areas (scores 1-10, 1=not important, 10=very important)

	Agro-ecology	Lowland (N=18) Mean(SE)		Highland (N=20) Mean(SE)				
Constraints (N=38)	Farm type	High production	Low production	High production	Low production.	P_A	P_F	P_{AxF}
Feed		9.4(0.32)	10.0(0.00)	8.6(0.49)	8.9(0.35)	*	NS	NS
Water		1.0(0.00)	1.1(0.10)	5.3(0.88)	5.0(0.75)	***	NS	NS
Genetics		3.3(0.90)	9.5(0.22)	3.0(0.37)	9.6(0.22)	NS	***	NS
Disease		3.6(0.73)	4.9(0.59)	5.0(0.80)	3.0(0.65)	NS	NS	*
Labour		5.0(1.10)	2.4(0.31)	3.4(0.99)	1.7(0.44)	NS	**	NS
Competition with crops		2.8(0.98)	4.6(1.05)	2.4(0.52)	2.4(0.43)	NS	NS	NS
Cash		6.6(0.98)	8.2(0.33)	7.0 (0.59)	6.3(0.70)	NS	NS	NS
Credit service		6.0(0.93)	8.9(0.18)	5.2(1.06)	6.0(0.45)	*	*	NS
Government's extension service		7.1(0.52)	7.8(0.36)	7.0 (0.72)	4.2(0.76)	**	NS	**
Market		5.3(1.01)	3.2(0.73)	1.9(0.48)	2.1(0.41)	**	NS	NS

^{PA}= effect of agro-ecology, ^{PF}= effect of farm type, ^{PAxF}= effect of interaction of agro-ecology and farm type ^{NS}= Non-significant. *=P<0.05, **=P<0.01, ***=P<0.001.

Table 11: Constraints prioritized based on farm type and agro-ecology of the study areas (score 1-10, 1=not important, 10= very important).

	Farm type				Agro-ecology			
	High production		Low production		Lowland (N=18)		Highland (N=20)	
Constraint	(N= 18) Mean±SE	Rank	(N =20) Mean±SE	Rank	Mean±SE	Rank	Mean ± SE	Rank
Feed	8.9±0.31	1	9.5±0.21	2	9.7±0.16	1	8.8±0.29	1
Water	3.4±0.71	8	3.1±0.58	8	1.1±0.06	10	5.2±0.56	6
Genetics	3.1±0.44	9	9.6±0.15	1	6.7±0.86	5	6.3±0.79	3
Disease	4.4±0.56	5	4.0±0.48	6	4.3±0.47	6	4.0±0.55	7
Labour	4.1±0.74	6	2.1±0.27	10	3.6±0.59	9	2.6±0.58	8
Competition with crops	2.6±0.51	10	3.5±0.61	7	3.8±0.74	8	2.4±0.33	9
Cash	6.8±0.53	3	7.3±0.44	4	7.5±0.49	4	6.7±0.46	2
Credit service	5.6±0.71	4	7.5±0.41	3	7.6±0.74	3	5.6±0.59	5
Government extension service	7.1±0.45	2	6.1±0.58	5	7.5±0.31	2	5.7±0.60	4
Market	3.5±0.67	7	2.7±0.43	9	4.1±0.64	7	2.0±0.31	10

Table 12: The score of importance of cash for smallholder farmers in the study areas (score 1-10, 1=not important, 10=very important).

	Agro-ecology	Lowland (N=18) (M±SE)		Highland (N=20) (M±SE)				
Capital needed	Farm type	High production	Low production	High production	Low production	P_A	P_P	P_{AxP}
Feed purchase		10.0±0.00	9.2±0.59	8.4±0.31	7.0±0.54	***	*	NS
Medication		7.1±0.44	8.2±0.42	6.2±0.76	5.8±0.79	*	NS	NS
Hiring labour		3.8±0.98	1.0±0.00	2.0±0.42	1.5±0.27	NS	**	NS
Increase of herd size or Change of breed		7.0±0.96	2.7±0.86	8.9±0.59	9.6±0.18	***	*	***

^{PA}= effect of agro-ecology, ^{PF}= effect of farm type, ^{PAxF}= effect of interaction of agro-ecology and farm type ^{NS}= Non-significant. *=P<0.05, **=P<0.01, ***=P<0.001.

Table 13: Constraints in the study areas: The causes, effects, farmers controlling strategies, suggested intervention options and available opportunities.

Constraint	Cause	Effect	Smallholder farmers' control strategy	Suggested intervention Option	Available opportunities
Feed shortage	-Land scarcity - Inconsistent availability due to fluctuating weathers - lack of tradition of feed conservation for dry seasons - lack of cash to purchase	Low milk yield, lower reproduction performances, mortality of young stocks, lower disease resistance and low animal weights	-Rely on enset in dry seasons - Strategic supplementation of available feeds to a specific type of animals like calves and milking cows	Hay and silage making for critical periods, introduction of improved forages (especially for lowlands), Credit services	Development workers to train farmers how to conserve feed, availability of NGO's to facilitate trainings and introduce forages
Water	-Harsh weather condition -less development of water facility	Low animal production performances, spending more time and energy searching for water	-Travelling long distances to water points with their animals - Decreasing watering frequency - Use of pack animals to transport water	Developing streams and pipelines, introducing water harvesting technologies	Availability of NGO's in the area that can support water development works, long rainy seasons to harvest rain water
Genetics	Low genetic make-up of indigenous breeds for milk production	Low milk production, low feed conversion efficiency	Few started keeping crossbred animals	-Cross breeding with exotic bloods -Selection of good performing animals	Demand of smallholders to change the breed type/improve the current productivity level
Cash	-Low agricultural productivity -Dairying is not market oriented -Lack of credit services	Inability to purchase feeds, veterinary services, breeding services	Borrowing money from village lenders with high interest rates	Linking smallholders to credit institutions, improving milk markets	-High milk demand -availability of micro-finances in the areas
Diseases	-Inadequate veterinary services and infrastructures - medicines are unaffordable -Poor managements: inadequate feeding and watering, poor hygiene	Animal deaths, Low production performances, Zoonotic effects	-Traditional medicines -Traveling long distance to get veterinary services - Purchasing medicines from informal markets	Training veterinarians, building more clinics, regular vaccination programs	Availability of animal health departments in agricultural offices of locality, Profitability of the sector for private clinics
Breeding services	-Lack of well-designed breeding policy -Shortage of AI/bull centres -Lack of electricity in rural areas: for AI service - Shortage of AI technicians	-Crossbreeding hardly possible - low conception rates - Expensive payment for privately owned exotic bulls - Transmission of reproductive diseases	- travelling long distances to access AI service - Use of indigenous bulls -Use of privately owned exotic blood bulls	- Designing proper breeding policy - Developing infra-structures like electricity in rural areas - Building AI/ bull service centres -Training AI technicians	- Demand of AI/bull services
Credit services	-Lack of linkages between smallholders and local micro-finance institutions and banks	Cash is lacking	-Borrowing money from relatives, village lenders if available	Facilitating the linkages between smallholder farmers and finance institutions	-Availability of micro-finances in the areas e.g. Omo micro- finance and Wisdom micro-finance -Banks e.g. commercial bank of Ethiopia
Market	- Raw milk is not marketed in rural areas - No dairy cooperatives - Lack of market information	-Production is not market oriented so that subsistence milk production system	Raw milk is processed in to cheese and butter to be marketed	- Organizing farmers into dairy cooperatives - Designing proper market schemes which benefits smallholder farmers	- High demand of raw milk in urban and semi-urban areas - No fasting period in areas as most people are protestants

Genetics: Low production farms had only indigenous cattle and farmers in this category complained that the low milk production performance of their farms is largely due to genetic differences. Genetics was not a major problem in high production farms, which possess crossbred cows. But, some farmers in this category had a desire to upgrade their animals to higher exotic blood level. Cows in high production farms were less resistant to diseases compared to cows in low productive farms (Fig. 3).

Of interviewed smallholders of low production farms, 90% of them think that crossbreeding or changing breed type is a remedy for the genetically related problems and the rest (10%) suggest selection of good performing animals from available breed at hand. And 69% of smallholder farmers of high production farms still want to upgrade their dairy animals to higher exotic blood levels and 23% of them chose selection of good performing animals as means of solution. The others in this category

think that medication of animals is important means to solve genetically related problems, particularly for lower disease resistance.

Cash (Money): This is the 3rd and 4th ranked constraint in high and low production farms respectively. It was equally important both in highland and lowland areas (Table 10). Smallholders need cash mainly to purchase feed, increase herd size or change breed type and medication in order of importance. The importance of cash to purchase feed was significantly higher in lowland ($P<0.001$) than highland areas and in a high production farms ($P<0.05$) than low production. Next to feed purchase, cash was important for low production farms to replace indigenous cattle by crossbreds whereas to enlarge farm size in high production farms. Cash for medication was significantly more important ($P<0.05$) for smallholders in lowland than highland areas (Table 12).

Disease: According to respondents, disease was not a serious problem in the study areas compared to other dairying constraints. However, there was a seasonal break out of black leg in lowlands and higher infestation rates of internal and external parasites in highland areas (Fig. 4). Black leg is a fatal disease of young cattle caused by bacteria known as *Clostridium chauvoei*. The animal health related constraints of the areas include: scarcity of veterinarians, shortage/lack of animal health clinics, absence of regular vaccination programs, scarcity and/or unaffordability of medicines. Scarcity of veterinarians and lack of health clinics were the major constraints in highland and lowland areas respectively (Fig. 5).

Constraints Outside Farm Border

Government's Extension Services: Extension services for dairy development in the study areas were weak, especially in providing improved genotypes.

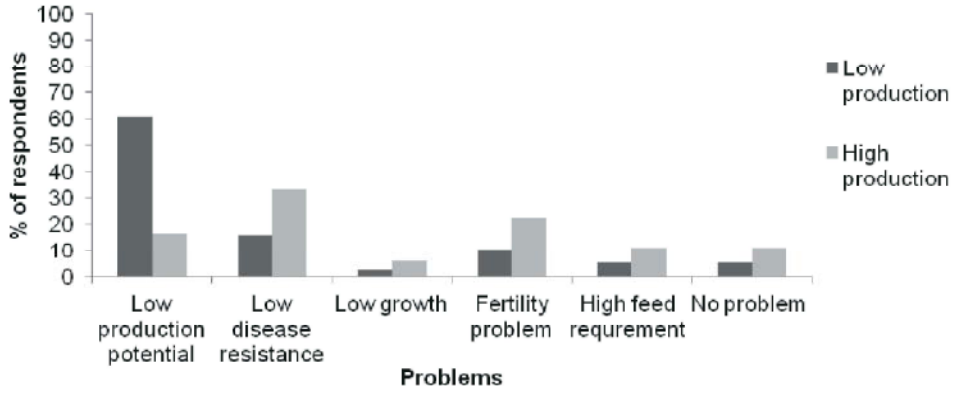

Fig. 3: Genetically related constraints of dairying in the study area based on type of farms.

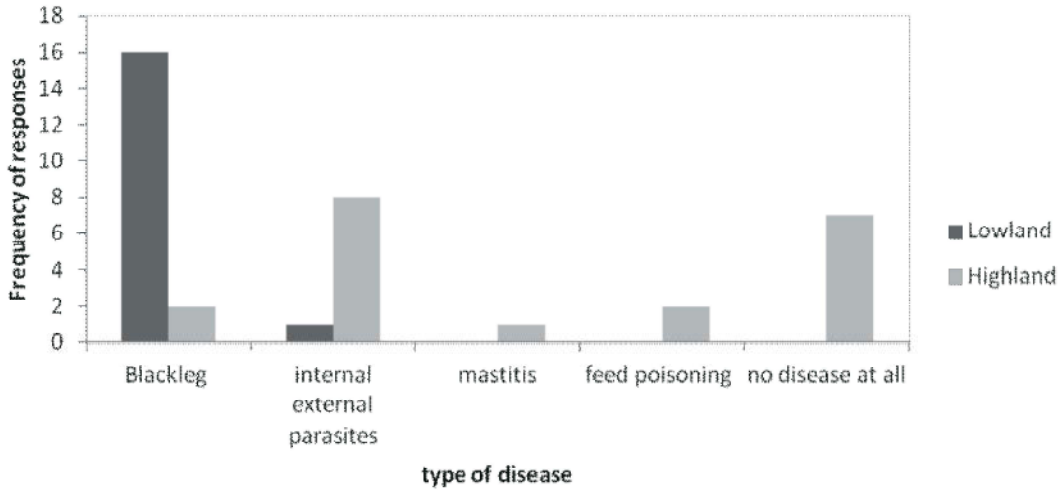

Fig. 4: Disease occurring in smallholder dairy farms based on agro-ecology of the study areas.

Fig. 5: Animal health related constraints of the study areas.

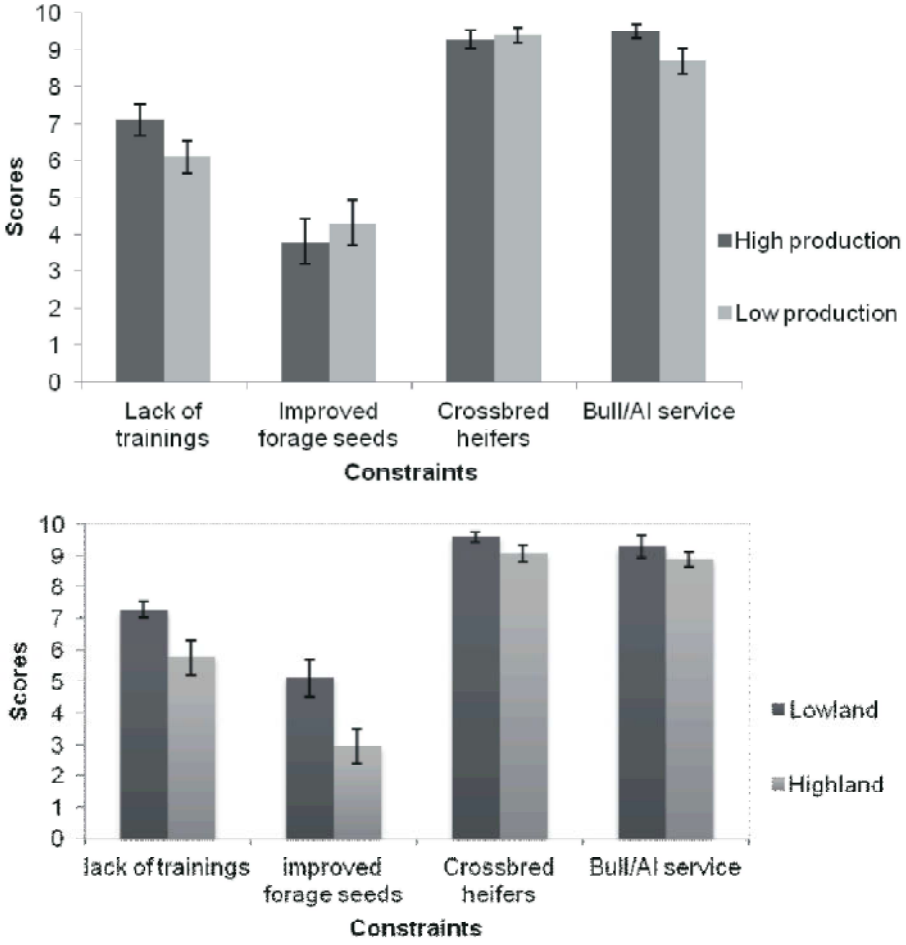

Fig. 6: Smallholder farmers responses to some shortcomings of extension services in the study areas (scores 1-10, 1= not important, 10= very important).

These include inadequacy/ non-existence of breeding services (AI and/ or improved bull services) and lack of crossbred heifers. Trainings were also lacking in the areas on modern dairy production. The problems were common to both agro-ecologies and farm types (Fig. 6).

Credit Service: This was also an important constraint of dairy development. Its importance as a constraint was significantly ($P<0.05$) different between agro-ecologies as well as farm types. Lack of this service was more important for smallholders of low production farms than

for those of high production farms and for lowland than highland areas (Table 10).From interviewed respondents, 27.8 and 5% of smallholders of high and low production farms, respectively, had participated in credit services for their dairying purpose. Of all respondents, 68% of them think that credit service is very important in their dairy farm but they were lacking the service.

Smallholders of low production farms plan to change dairy cattle breeds (93%) if credit service is available and others plan to enlarge herd size with a breed type they have at hand. On the other hand, given the credit service is available, smallholder farmers of high production farms will buy high grade animals (41.7%), concentrate (25%) and enlarge farm size (33.3%).

Market: From interviewed smallholder farmers, 74% of them did not consider market as a constraint of dairying in the areas. But some (26%, all from high production farm category) complained that "raw milk is not marketed in the area and, therefore, we are forced to process it into butter and cheese which costs extra labour and time." The most important criteria of smallholders to choose market outlet was price.

DISCUSSION

Demographic Characteristics: The average family size of the area, 7.7 persons per household is comparable to West Shoa (8) [4] and Dale district of Sidama zone which was 7.5. But, it was higher than the average values reported in Wolaita zone (6.9) [12], Umbulo-Wacha watershed of Boricha woreda, Sidama zone (6.3) [13] and the national (5.1) [12]. Hence, having more family size in the area was considered as an asset and a factor which increases social security.

The significantly greater family size in high production farms is likely related with size of land holdings. These farms had larger land sizes than low production farms and, therefore, need more family members as labour for crop and livestock production. High production farms had also significantly higher female family size. The likely reason behind is that smallholder farmers of high production farms adopt female children from their relatives in order to fulfil labour requirements of higher milk production. Culturally, in the study areas, most of milk production works are done by women such as milking cows, churning of milk, cheese preparation, milk marketing, cleaning of barns and feeding of calves.

The higher illiteracy rate in highlands compared to lowlands could be attributed to lack of access to education in highland areas. The educated households tend to have higher production level as they can better adopt new technologies and manage their farms in a better way. Thus, dairy farms of high production had lower illiteracy rate than low productive farms.

Land holding and Use: The average landholding per household of the area (0.8 ha) was lower compared to Baherdar zuria and Mecha districts (2.7 ha) [14], North-eastern Amhara region (1.5 ha) [15], West Shoa zone (4.1 ha) [4] and Alaba district (2.3 ha) [16]. This shows that the area is one of the most populated areas of the country.

The significantly lower land size of low production smallholder farms compared to high production farms shows that land size is an important factor for smallholders to start improved dairy production. On the other hand, a strong positive correlation between farm size and family size indicates that smallholders owning larger land size need more labour to manage their land and, thus, may tend to build higher family size.

Livestock Holding and Composition: The average livestock holding per household of the study areas (3.38 TLU) was lower than some other reported areas. For instance, it was 9.85 TLU in Bahirdar zuria and Mecha districts[14], 10.6 heads in North-eastern Amhara region [15], 9 TLU in West Shoa zone [4] and 8 TLU in Alaba district [16]. This lower number of livestock in the study area is possibly related to lower landholdings. As shown in Fig. 7 (derived from above literature), having larger land size likely leads to possession of higher number of livestock.

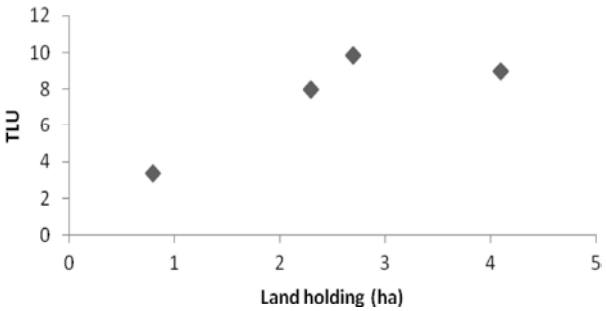

Fig. 7: The scatter plot of livestock unit and smallholder landholdings of some districts of Ethiopia.

The positive correlation between the number of livestock units and land size has to be seen in connection with feed availability to livestock. As communal grazing lands are scarce in the study areas, smallholder farmers mainly depend on their own land for animal feed resources. Thus, farmers with larger land size can keep more animals than farmers with low land size. Similarly, a positive correlation between land size and number of oxen implies that cultivation of more land requires ownership of more oxen.

The existence of significantly higher number of equines in highland than lowland areas is mainly related to water scarcity in highland areas. Smallholder farmers in highland area use pack animals, especially donkey, to transport water from distant water sources to their homes in dry season.

Purposes of Keeping Cattle: Keeping cattle for milk production as primary function in the study areas is in agreement with findings of Ayenew *et al*. [17] and Sintayehu *et al*. [18], who conducted similar studies in North western Ethiopian highlands and Shashamane-Dilla areas of southern Ethiopia, respectively. But, Asaminew and Eyasu [14] reported draught power as a primary function of cattle in north western Ethiopia.

The more importance of draught power in lowland areas than highlands can be explained as the availability of more lands to cultivate in lowlands. In highlands enset occupies larger portion of the land holdings and it does not need draught animals. Concerning manure, its higher importance as a fertilizer in low productive farms might be related to incapability of smallholders in this category to timely purchase of artificial fertilizer. Previously, artificial fertilizers were given to smallholders on loan, but currently the local government stopped the loan due to low repayments. As a result, smallholders of low production farms couldn't afford the price of artificial fertilization and relied on manure.

Feed and Water Resources: The significant difference between grazing systems between farms of high production and low production is mainly related to higher feed requirement of crossbred dairy animals in high production farms. The areas were densely populated and, therefore, land was mainly used for crop cultivation. Communal grazing lands were scarce and the grass quality was low in some available roadside and river side areas due to overgrazing. So, smallholders having crossbreds do not allow them to go out. Smallholders in this category also want to protect their animals from insects bite.

Grazing for a longer hours in highland areas compared to lowland areas is likely related with climates of the agro-ecologies. Thus, animals in lowlands could not stay out door for a long period of time due to hot weather.

The higher availability of improved forage grasses in highland areas is related with the use of these forages for water and soil conservation due to hilly topography. So, the forages were grown on terraces of croplands. These forages were developed by support of Inter-aide France. But, in lowlands smallholders did not grow improved forages as there was no major erosion problem. Instead, they grow local grasses at the bottom of croplands or around their homes for cut and carry system. This is not possible in highlands as most of their land is covered by enset.

The water related problems of highland areas in dry season is related to less developed water infrastructures. But, this was not a problem in lowland areas, particularly in peasant association this study was conducted, due to a well-developed water pipelines with support of Non-governmental organization called Inter-aide France. Therefore, introducing improved forages to lowland areas and expanding pipeline systems to highlands can be a solution for feed and water problems of the areas.

Breeding Practices: The main cause of the significant differences in breeding practices across the agro-ecologies is likely the degree of accessibility of the breeding services or bulls. Smallholders in lowlands have relatively better accessibility to artificial insemination due to presence of the service in nearby town called Hadero, which is a capital of Hadero-Tunto district. But, smallholders had to travel a long distances even though the town is nearer to lowlands compared to highland areas. Only high production farms use either artificial insemination or improved bulls and the negligence of these practices by low productive farms might be due to smaller size of indigenous cattle, just to avoid dystocia.

Milk Production and Reproduction Performances: The daily milk yield of crossbred cows in this study (7.6 litre/cow) is comparable to 7.7 liter/cow reported by Yitaye *et al*. [19] in the north western Ethiopia, 7.8 liters per cow by Asaminew and Eyasu [14] in Bar dar Zuria and Mecha districts of Northern Ethiopia and 8.45 liters per cow by Duguma *et al*. [20] of small-scale farmer in Jimma Town.

The significantly higher milk yield of crossbred than of indigenous cows in present study is in agreement with previous studies in different parts of Ethiopia [15, 21, 22, 23]. The lower milk yield from indigenous cows is mainly related to their low genetic potential.

The positive correlation between milk yield and land holding shows that there is a better feed availability in smallholders with larger land size. And the positive correlation between milk yield and land covered by crops indicates the importance of green feeds like enset and maize and crop residues for better milk production in the areas. The seasonal variation in milk yield is associated with the seasonal feed availability in the areas.

The average value of 53.7 months of AFC for indigenous cows in this study is higher than reported in [24] of 41 months for Boran, [22] of 43 months for highland zebu and [25] of 33 months for Arsi cattle, but comparable to report of [5] of 53 months, to [26] of 55 months of Horro cattle and [21] of 57 months of zebu cattle in North-eastern Amhara region of Ethiopia. The mean AFC of 30.7 months for crossbred cows found in this study is lower than the mean AFC of 47 months reported by [21] in North-eastern Amhara, 36 months reported by Emebet and Zeleke [27] in Eastern lowland of Ethiopia and 41 months reported by Shiferaw *et al*. [28] for crossbred cattle in central highlands of Ethiopia. The lower AFC in crossbred than indigenous cows is probably connected to genetics.

The reason for longer lactation length in lowland areas can be due to longer calving intervals reported. It might also be related with distance of interval between months of animals give birth and dry season. In lowlands most animals give birth between May and August but, in highlands it is between September and November which is closer to dry season (January to March).

The mean calving interval of crossbred cows observed in the present study (17.9 months) is shorter than findings of [20] (21.4 months) and longer than [29] (14.8 months) but, comparable to [28] (18.4 months).

The observed mean calving interval (22.3 months) for indigenous cows in this study is longer than the report of Solomon *et al*. [15] (15.2 months) and Haile *et al*. [24] (14.5 months), but comparable to 25 months reported in [5]. The longer CI of indigenous cows than crossbreds is likely connected to genetics of the breeds and feeding managements. As short calving interval requires good feeding, this investment only pays off in cross breed condition.

Milk Use: Milk is used as a main protein supplement in the diet of the areas that is why it's primarily used for home consumption. In highlands, people need milk to supplement 'Kocho', which is staple food from enset and mainly constitute starch. In lowland areas, breads (locally known as 'kita') made of cereals such as maize and sorghum need to be supplemented with milk. Smallholder farmers mainly use butter milk for home consumption and the butter milk can be further processed in to cottage cheese and whey.

The equal importance of milk for home consumption for both low and high production farms seems to be related with family size. Milk produced in high production farms in a higher amount possibly consumed by higher family size.

Unavailability of milk collecting centers, shortage of other protein sources in the diet of smallholders and lower milk quantities per household due to few cattle possession can be among the reasons behind the less importance of market in milk use in the study areas.

Constraints

Feed: it is the most important factor that contributed to the low productivity of dairy sector not only in the study areas but also in most parts of Ethiopia [4, 5, 18, 30]. The more feed scarcity in lowlands than highlands in dry season is due to limited availability of enset plant in lowlands. Enset is a drought resistant plant and widely available in highland areas. As there was seasonality in a feed availability in the areas, conserving feeds in a form of hay or silage for use in critical period seems to be important. Less involvement of smallholders in feed conservation indicates the importance of developing feed conservation and treatment systems.

Water: Drying up of streams and rivers during dry season and unavailability of water sources in the nearby locality are causes of shortage of water supply in highland areas. But, there were well developed water supplies in lowland areas with support of Inter-aide France.

Genetics: The genetic potential of indigenous cattle for milk production is low in Ethiopia and is one of major constraints in dairy development [5]. This was confirmed by desire of smallholders of low production farms to change the breed type.

Cash: This might be also important for crop production but, here the discussion is within the domain of livestock production. Smallholders need cash primarily to purchase feeds which indicates non-self-sufficiency of home grown feeds in the areas. Cash is more important especially for high production farms as they supposed to purchase concentrates. The higher importance of cash for feed purchasing in lowland areas can be explained as the limited availability/unavailability of enset and improved forages compared to highland areas. The higher importance of cash for medication in lowland areas also indicates more health related problems in lowlands than highland areas.

Disease: Even though it was not a serious problem in the study areas compared to other dairying constraints, the occurrence of blackleg in lowlands and parasites in highlands could affect the milk production. The occurrence of black leg indicates unavailability of regular vaccination programs in the areas. The parasites could be also controlled if there were enough animal health facilities such as veterinarians and clinics and, therefore, it needs some intervention measures to improve the situations.

Government's Extension Services: Services like artificial insemination and improved bull services in Ethiopia are less developed or even do not exist in most parts of the country. But, these services are the major components in the dairy development [5]. The same story is true for this particular study area. The inadequacy of these services in the area can be attributed to lack policies relevant to the smallholder dairy development, distance from large cities where services are available, lack of livestock research centers, lack of infrastructures like electricity in rural areas, scarcity of professionals in dairy farming and interaction of these constraints.

Credit Services: The higher importance of this service to smallholder farmers of low productivity farms is likely related with the desire of changing breed type. The price of crossbred heifers is expensive and, therefore, credit service is very important for smallholder farmers in this category. Inadequacy/ lack of credit service are likely one of the major constraints that inhibits transformation of low production farms to high production category. Freeman *et al*. [31] cited similar idea that the main cause for low adoption rate of dairy technologies in smallholder dairy systems is capital constraints as it limits the farmers' ability to make the initial investments or associated costs with improved dairy technologies. The need of credit for multi-use in smallholders of high production farms indicates the desire for intensification. These include choice of grade animals, improved feeding system and expansion of farm.

Market: It is a potential problem in the study areas though smallholders didn't recognize it. Smallholders only consider the high demand from consumer side. But, there is no tradition of marketing raw milk in rural areas and no party to connect smallholders and urban consumers, no milk cooperatives and the marketing system is totally informal. These points reiterate the need of possible interventions of markets which could be strengthening milk supply, developing milk collection centers and processing units and improving marketing schemes. Development of milk marketing structure is one of the entry points to improve milk production in smallholder farms (SNV, 2008).

Intervention Options on the Identified Constraints: The details of constraints, farmers' strategy being implemented to cope up with constraints and suggested improvement options were presented in Table 13. The Table is developed based on personal observation and interview made with smallholder farmers. Major intervention options identified are

- Introduction of improved forages to lowlands and improving water facilities to highland areas.
- Promoting private companies to facilitate breeding services such as artificial insemination, providing crossbred heifers and bull services as demand from smallholders' side is high.
- Linking credit service providers of the areas with smallholder dairy farmers (N.B. there are micro finances providing credit services for government workers in the urban areas of the districts).
- Developing proper market schemes for raw milk as it promotes the smallholders to produce more.

CONCLUSIONS

This study was dealt on farm characterization, analysis of constraints and identification of some improvement options for smallholder farmer dairying in mixed farming systems of southern Ethiopia.

As the survey results indicated smallholder farms of high production had better landholdings and educational status than farms of low production which shows the importance of these two factors in the adoption of exotic dairy breeds. The higher milk production and reproduction performances of crossbred dairy cows over indigenous ones suggested that extension of these breeds can be a means for intensification of smallholder dairying in the areas. However, this should be accompanied by remedy of the identified dairying constraints of the areas such as feed and water scarcity, inaccessibility of credit services, poor market schemes and poor breeding and health care infrastructures.

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