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Smallholder dairy farming systems in the highlands of Ethiopia: System-specific constraints and intervention options

Smallholder dairy farming systems in the highlands of Ethiopia: System-specific constraints and intervention options

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Acronyms

AI	Artificial insemination
AIT	Artificial insemination technician
LIVES	Livestock and Irrigation Value Chains for Ethiopian Smallholders
masl	Metres above sea level
MoA	Ministry of Agriculture
SNNPR	Southern Nations, Nationalities and Peoples' region

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Executive summary

Blanket recommendations of technologies and improved practices could be one of the reasons for low adoption of interventions by agricultural systems which are highly diverse in agro-ecological and socio-economic conditions. The purpose of classification of farming systems is to develop strategies and interventions relevant to the various systems which may vary in the type and degree of severity of constraints, resource base and enterprise patterns. Dairy farming systems in Ethiopia have been extensively characterized. However, a comprehensive characterization of dairy systems in the highlands across the value chain supported with quantitative data and a valid statistical analysis is rare in the literature. The LIVES project has initiated case studies through its MSc sponsorship program to characterize dairy systems in the highland states of Ethiopia, namely Amhara, Tigray, Southern Nations, Nationalities and Peoples' region (SNNPR) and Oromia. This working paper synthesizes and analyses two case studies in five districts of Amhara and Oromia states. The paper identified characteristic features of smallholder dairy farming in the highlands of Ethiopia, reclassify sample farmers to the highland dairy farming systems with quantitative data and statistical analysis, and identifies system-specific constraints and leverage points for developing the dairy value chain.

The study found that smallholder dairy farming in the highlands is diverse in characteristics and constraints. A multinomial logistic regression analysis was conducted to re-classify the sampled farmers in the study areas into rural, peri-urban and urban categories based on five categorical and seven covariate variables representing scale of production, production resources, production practices, breeds and genotypes used, marketing objective and contributions to livelihood. The statistical model classified 83.5% of the sampled farmers correctly to their observed categories of dairy farming systems. The variables that significantly contributed to the classification were the breeds and genotypes kept, daily milk production, earning from livestock, and cow feeding practice. However, the peri-urban and urban systems classified poorly with 50–65% correct classification, indicating the two systems might share some similar characteristics.

Importance of livestock in general and dairy production in particular varied across systems. While livestock production is most important activity for nearly 100% of the urban dairy farmers surveyed, its role as the most important or sole source of livelihood declines to 3.3% and 13.1% of the farmers in rural and peri-urban areas, respectively. The contribution of livestock to the annual farm income is highest for the urban farmers. However, livestock is also very important source of farm cash income in rural areas, where cropping plays a major livelihood role, for some 44.2% of the interviewed farmers who earn ETB 20,000–40,000 annually. Annual cash income from crop production is lower than ETB 9000 for almost all the urban and peri-urban farmers interviewed, whereas about 84.5% of the rural farmers earn more than ETB 9000 per annum from crop production.

Another classifying characteristics is the type of breeds and genotypes kept by farmers. Using a generalized multinomial regression model, it was found that the rural dairy farmers are 3.3 times more likely when compared to urban farmers to keep low grade crossbred cows with exotic blood level of less than 50%. On the other hand, peri-urban farmers are significantly more likely ($P<0.05$; odds ratio = 0.94) to keep medium-grade cows than urban farmers. Urban farmers are more likely to keep high grade cows with exotic blood level of greater than 75%, but the difference between urban and peri-urban systems was not statistically significant. The urban, and in some cases the peri-urban, systems are generally described as landless dairy farmers. The urban farmers in the major cities and towns

are less likely to practice crop farming. On the contrary, urban farmers in regional towns in the current study are sort of mixed livestock-crop farmers, albeit on very small plots of land, the average crop land holding being 0.025 and 0.15 ha in West Gojam and West Shoa.

The major constraints identified included low scale of production, low productivity that varies across systems, failure to maintain exotic inheritance at farm level resulting in herds with mixed genotypes which are not amenable to recommendation for value chain interventions, least access by the rural system to artificial insemination (AI) service and questions by the urbanites on its efficiency, heifer supply least satisfactory among breeding services, concentrate feed cost threatening urban/peri-urban dairies, unhygienic milk handling and consumption, particularly in rural areas, price of milk generally too low for producers, especially for rural farmers. Leverage points corresponding to the challenges were suggested for developing the dairy value chain in the highlands.

Introduction

Dairy farming systems in Ethiopia

Blanket recommendations of technologies and improved practices could be one of the reasons for low adoption of interventions by agricultural systems which are highly diverse in agro-ecological and socio-economic conditions. The purpose of classification of farming systems is to develop strategies and interventions relevant to the various systems which may vary in the type and degree of severity of constraints, resource base and enterprise patterns. Dairy farming systems in Ethiopia have been extensively characterized. However, a comprehensive characterization of dairy systems in the highlands across the value chain supported with quantitative data and a valid statistical analysis is rare in the literature. Furthermore, research and development strategies and interventions have rarely been system-specific. For instance, the 1996 Ministry of Agriculture (MoA) Ruminant Livestock Development strategy is limited to the broad category of mixed crop–livestock and pastoral systems. Recently, the Ethiopia livestock master plan (Shapiro et al. 2015) addresses a more diverse category of the livestock systems in the country, mainly targeting the smallholder family and commercial specialized production systems, each across the three major production typology zones of Ethiopia, officially categorized by the MoA, namely lowland grazing (including both pastoral and agro-pastoral systems), highland mixed crop–livestock rainfall deficient and highland mixed crop–livestock rainfall sufficient. For such a strategy to be implemented, detailed characterization of production systems across geographic regions is required.

Smallholder dairy farming, which is defined here as production, on-farm processing and marketing of milk and milk products, in Ethiopia can be broadly classified into the lowland system, comprising the pastoral and agro-pastoral systems, and the highland system in the mixed crop–livestock areas (Azage et al. 2013). Yet, various classifications of the smallholder dairy farming in Ethiopia have been suggested by a number of authors. The early classification considered climate, land holdings and integration with crop production and recognized systems there: rural dairy system (which is part of the subsistence farming system and includes pastoralists, agro-pastoralists, and mixed crop–livestock producers), peri-urban system and urban dairy systems (Ketema and Tsehay 1995; Azage and Alemu 1998; Ketema 2000; Tsehay 2001). Later classifications (Getnet 2009; Land O'Lakes 2010; Felleke et al. Azage et al. 2013) recognized a sub-division of the rural system into highland and lowland (agro-pastoral) dairy systems and the commercial sector was also recognized as a separate system from the urban/peri-urban system. On the other hand, some authors categorized the rural and peri-urban system into one mixed-crop livestock dairy system (Ayza et al. 2013). Ketema and Tsehay (1995) distinguish four major systems of milk production. The dairy sector in Ethiopia can also be categorized based on market orientation, scale and production intensity and classified into three major production systems: traditional smallholders, privatized state farms (now commercial large scale farms) and urban and peri-urban systems (Alemu et al. 2000). A more detailed subdivision of dairy farming systems could also be identified. For instance, Azage et al. (2007) classified the dairy systems in and around Addis Ababa into seven sub-systems. The various classifications are described in Table 1.

Smallholder dairy systems in the highlands—A case study

The highland region comprising mainly the four highland states of Amhara, Oromia, SNNPR and Tigray is predominantly a mixed crop–livestock area. The traditional rural smallholder dairy system is the dominant dairy production system in the mixed crop–livestock area. It is also the largest system in terms of the number of dairy cows and total milk production in the country. The urban and peri-urban systems in Ethiopia vary in the scale of production depending on geographic locations. The urban milk system has been defined grossly as consisting of small, medium and large dairy farms (Ahmed et al. 2003). However, this definition may not entirely apply for the urban dairying in small regional towns. Thus the characteristics and constraints in the peri-urban system in the regional towns and big cities could be different because of differences in scale and geographic locations.

The LIVES project has initiated case studies through its MSc sponsorship program to characterize dairy systems in the highland states of Ethiopia with the objective of identifying opportunities and intervention options for identified systems. This working paper synthesizes and analyses two studies in Amhara and Oromia states.

Table 1: Classification of dairy farming systems in Ethiopia

Identified systems and sources	Distinguishing characteristics
Ketema and Tsehay (1995) and others*	
Pastoralist	Pastoralism is the major system of milk production in the low lands; comprises 60% of the total land area and have altitudes below 1500 metres above sea level (masl)
Rural highland smallholder	Covers over 40% of the country; mixed crop–livestock farming; subsistence smallholder farming systems; livestock mainly grazed on natural pastures of non-arable or fallow land, additionally fed crop residues; Improved concentrate feed accounts for only 0.25% (CSA 2011); Two types of dairy systems may be distinguished: the traditional (based on indigenous breeds; milk mainly for home consumption) and the market oriented system (based on crossbred cows)
Urban and peri-urban small scale	In and around major cities and towns located mainly in the highlands of Ethiopia; small and medium sized dairy farms; mainly improved dairy stock; improved shelters; limited access to farming or grazing land, often based exclusively on stall feeding; feed resources are agro-industrial by-products and purchased roughage; primary objective is generating additional cash income; main milk supplier to the urban market, sold to dairy cooperatives, in local market or directly to consumers
Intensive large-scale	Specialized, market oriented dairy operations; in and around Addis Ababa and other regional capitals; mostly use exotic high grade or pure exotic dairy stock; holding size—8.9 ha, 17 cows; specialized input use
Azage et al. (2007)	
Traditional crop/livestock farms in rural areas	25–130 km from Addis Ababa; small farms; little or no external inputs; sell fresh milk and butter and ayib
Intensified dairy/crop livestock farms	Around Addis Ababa; smallholder farms; some form of intensive dairying (improved genotypes, AI, improved forages, concentrate feeding, housing, calf bucket feeding and early weaning); smaller land holding; 15% higher milk yield than traditional farms
Specialized dairy farms	Large farms; 15–60 km from Addis Ababa; holding 8.9 ha and 17 cows; use specialized inputs; sell over 30 litres/day; most owners have additional off-farm activities often generating more income than livestock
Peri-urban farms in secondary towns	In and around secondary towns within 25–50 km from Addis Ababa; grazing on own or rented land; Special inputs; supplementary feeds to grazing and stall-fed roughages; on average five cows
Intra-urban dairy farms in Addis Ababa	Specialized and intensive production; zero grazing, stall-feeding using purchased hay and concentrates; high grade crossbred cows; high milk yield; sell directly to the local market
Urban dairy in secondary towns	Specialized farms in most secondary towns within the milk shed; farmers have more access to grazing; stall-feeding is less intensive; high level of exotic blood; but herd size is the smallest (averages about two cows per farm); milk sold fresh to local markets, processors, or processed into butter and ayib. Most owners have off-farm activities representing about two-third.
Tsehay (2002)	
The urban system	Addis Ababa and regional towns; small- medium- and large-scale dairy farmers exist in and around Addis Ababa
Peri-urban system	Smallholder and commercial dairy farmers in the proximity of Addis Ababa and regional towns; improved dairy stock
Rural system	Farmers in the villages; subsistence system; 97% of total national milk production; mainly indigenous cows, pocket areas with crossbreds; traditional management conditions; most feed from native vegetation, crop residues

* For description of the systems identified by Ketema and Tsehay (1995), the following sources were used: Staal and Shapiro (1996); Anteneh et al. (2010); Desta (2002); Azage et al. (2007); Azage et al. (2013).

Case study methods

Case study sites

This working paper is based on data collected and summarized by two LIVES-sponsored MSc theses (Megersa 2016 and Melku 2016). Published literature on dairy farming systems in the four highland regional states, namely Oromia, SNNPR, Tigray and Amhara was also used to substantiate results of the case studies in describing the dairy systems in the highland region. The case studies were conducted in Amhara by Melku (2016) and Oromia state by Megersa (2016) in five of the LIVES project intervention districts. The case study in Amahara region was conducted in Mecha, Bahir Dar Zuria and YImana-Densa districts in the West Gojam zone of the Amhara region. The altitudes, rainfall and minimum and maximum daily temperatures for Mecha, Bahir Dar Zuria and YImana-Densa districts are, respectively, 1800–2500, 1700–2300 and 1552–3535 metres above sea level; 820–1250 mm, 820–1250 mm and 1270mm; 17 and 30°C, 10 and 32°C and (temperature not available for Yilmana-densa). The study in Oromia was conducted in Adaberga and Ejere districts in the West Shoa zone of Oromia region in Ethiopia. Adaberga has altitude ranges of 1166–3238 masl, receives an average annual rainfall ranging from about 887–1194mm and the minimum and maximum daily temperatures of the area are between 11 and 21°C, respectively. The corresponding figures for Ejere district are 2631–3238 metres, 1107–1194 mm and 11 and 14°C.

Selection of rural kebeles was purposive to capture samples from rural, peri-urban and urban areas. A total of nine kebeles from West Gojam and six kebeles from West Shoa were selected. Sampling also included Merawi and Adet towns in West Gojam and Ejere and Hinchini towns in West Shoa. A total of 360 farmers from West Gojam (80 from rural area, 60 from peri-urban area and 40 from Merawi and Adet towns) and West Shoa (59 from rural, 61 from peri-urban and 60 from urban production systems) were selected.

Data collection and analysis

Two studies were conducted in each zone: A questionnaire survey and herd milk production monitoring study. Data collected in the questionnaire surveys were farmer characteristics and constraints across the dairy value chain (production, input use and marketing). For monitoring herd milk production, from each zone, a sample of 45 farmers that had lactating crossbred cows of varying exotic blood level and 15 farmers that had indigenous cows. The level exotic blood level of cows was determined based on certificates whenever available (certificate were available if the cow is purchased from ranches or agricultural research centres) or based on farmers' recall of the breed and blood level of the sire and dam. Milk production was monitored for six months. Econometric, analysis of variance and descriptive analyses were used as appropriate to analyse the data. Farmer ranking of preferences and constraints were summarized into indexes as follows, for example for a variable with four attributes: Index = [(4 for rank 1) + (3 for rank 2) + (2 for rank 3) + (1 for rank 4)] divided by sum of all weighted reasons mentioned by respondent.

Classifying characteristics of highland smallholder systems

A multinomial logistic regression analysis was conducted to re-classify the sampled farmers into rural, peri-urban and urban categories based on five categorical and seven covariate variables (Table 2). The variables were selected to represent scale of production, production resources, breeding and marketing objectives, management practices and contribution of dairying/livestock production to livelihoods. When all the variables were entered into the model (forced entry model), the model classified 83.5% of the sampled farmers correctly to their observed categories of dairy farming systems (Table 3) with R-square values of 0.61 to 0.83 depending on the method of R-square calculation used. The variables that significantly contributed to the classification are shown in Table 2. When the variables were entered according to their contribution to explain the variation in the model (step-wise model), only ownership of low-grade and local cows and earnings from livestock explained the model which categorized 67.1% of the farmers correctly. The results showed with quantitative data that the rural, peri-urban and urban systems are characteristically different. However, the peri-urban and urban systems classified poorly, indicating they might share some similar characteristics. This distinction between the urban system in regional towns and the peri-urban system might not be so stark and the characteristics of the urban system in the current study differ from the urban system as described for the bigger cities/towns in the literature. Detailed analysis of the characteristics is presented in subsequent sections.

Table 2. Characteristics used to categorize sample farmers into rural, peri-urban and urban systems

		Likelihood Ratio Tests	
Intercept	Variable type	Chi-Square	Significance
Ownership of high grade crosses	Covariate	6.158	0.046
Ownership of low grade crosses	Covariate	14.781	0.001
Ownership of local cows	Covariate	7.362	0.025
Milk sale (as % produced)	Covariate	1.623	0.444
Grazing/hay land (ha)	Covariate	0.358	0.836
Daily milk production (litres)	Covariate	10.546	0.005
Earning (as % of total agricultural income)	Covariate	96.016	0.000
Challenges to dairying	Categorical	3.638	0.888
Objectives of cattle keeping	Categorical	9.317	0.316
Perception and problems on AI	Categorical	17.251	0.069
Crossbred cow feeding practice	Categorical	14.339	0.073
Local cow feeding practice	Categorical	17.987	0.055

Table 3. Classification of farmers using forced entry and step-wise entry methods to identify significant classifying characteristics and percentage of correct classifications

Observed	Predicted (Forced entry model)				Predicted (Step-wise model)			
	Rural	Peri-urban	Urban	% Correct	Rural	Peri-urban	Urban	% Correct
Rural	46	0	1	97.9	44	1	2	93.6
Peri-urban	3	49	8	81.7	6	30	24	50.0
Urban	0	15	42	73.7	2	19	36	63.2
Overall %	29.9	39.0	31.1	83.5	31.7	30.5	37.8	67.1

Contribution to livelihoods

The results of the case studies synthesized in this paper showed that the importance of livestock in general and dairy production in particular varied across systems (Figure 1). Livestock production is the most important activity for nearly 100% of the urban dairy farmers surveyed. However, the role of livestock production declines in rural and peri-urban areas, being the most important or sole source of livelihood to only 3.3% and 13.1% of the farmers, respectively. This could be because of the high crop production potential of the study areas. In areas less suitable for cropping (e.g. North Gondar zone; Kluszczynska 2012) than the location of the current study, livestock production plays the most important role for 31.7% of farmers with an additional 8.3% farmers solely depending on livestock in rural areas.

The contribution of livestock to the annual farm income is highest for the urban farmers (Figure 2). However, livestock is also very important source of farm cash income in rural areas, where cropping plays a major livelihood role, for some 44.2% of the interviewed farmers who earn ETB 20,000–40,000 annually. Annual cash income from crop production is lower than ETB 9000 for almost all the urban and peri-urban farmers interviewed (Figure 3), whereas, about 84.5% of the rural farmers earn more than ETB 9000 per annum from crop production.

The urban, and in some cases the peri-urban, systems are generally characterized by landless dairy farmers. The urban farmers in the major cities and towns are unlikely to practice crop farming. For instance in Boditi town in SNNPR, about 97.0% of the interviewed dairy cattle producers in the town run dairy farming within their own residence compound of about 200–400 m^2 (Asrat et al. 2013). On the contrary, urban farmers in small regional towns in West Gojam and West Shoa in the current study are a sort of mixed livestock–crop farmers, albeit on very small plots of land, the average crop land holding being 0.025 and 0.15 ha, respectively. There is, however, opportunity for renting land in neighbouring rural kebeles (Table 7). This is an opportunity for a more sustainable urban dairy farming in the face of increasing cost of dairy cattle feeding based on purchased concentrate feeds.

Figure 1: Relative importance of farm enterprises.

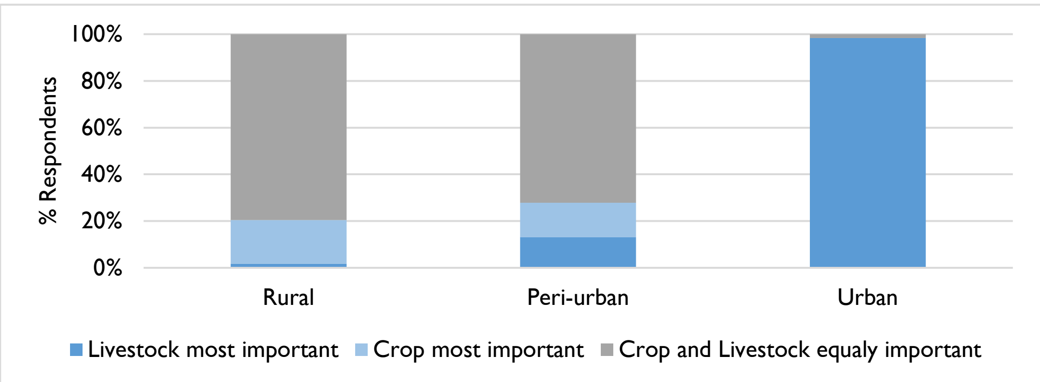


Figure 2: Annual cash income from livestock production.

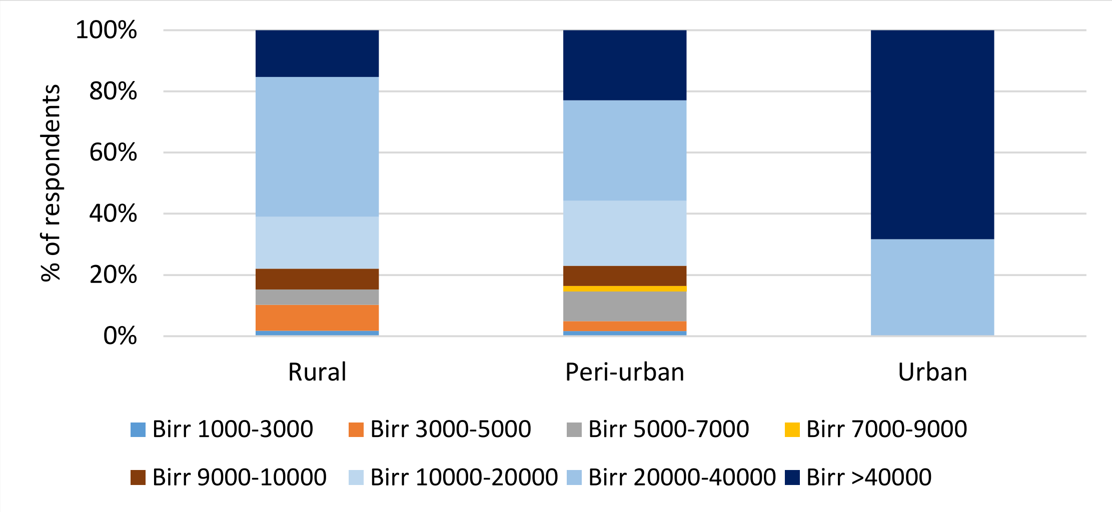
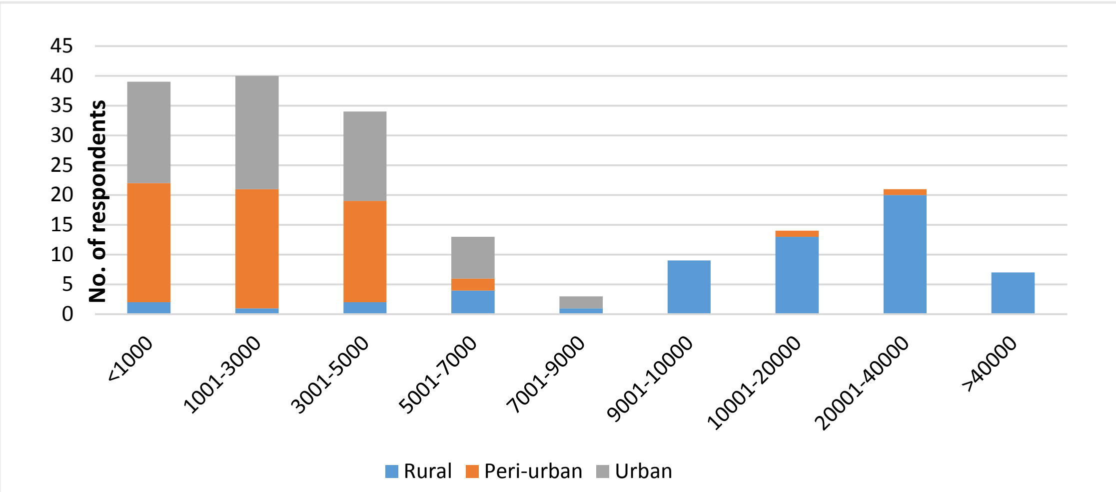


Figure 3: Annual cash income (in ETB) from crop production.



Production resources

Breeds and genotypes

One of the distinctions between the various dairy farming systems is the type of breeds and genotypes kept by farmers (Getnet 2009). In the current study, using a generalized multinomial regression model, it was found that the rural dairy farmers are 3.3 times more likely than urban farmers to keep low grade crossbred cows with exotic blood level of less than 50% (Table 4). On the other hand, peri-urban farmers are significantly more likely ($P<0.05$; odds ratio = 0.94) to keep medium-grade cows than urban farmers. Urban farmers are more likely to keep high grade cows with exotic blood level of greater than 75%, but the difference between urban and peri-urban systems was not statistically significant.

Farmers desired levels of exotic blood levels and their preferences for indigenous cows was elicited through preference ranking (Table 5). Farmer preference ranking roughly corresponded to the actual herd composition kept by the farmers (Table 6). Farmers in all the three systems preferred crossbreds over their indigenous cows. While rural farmers preferred cows with around 50% exotic blood level, those in peri-urban and urban areas preferred medium level exotic blood between 50–75%. High grade crosses were less preferred. Farmers showed more interest to Holstein-Friesian over Jersey breed in all systems, except Jersey being more preferred to Holstein-Friesians by rural farmers in West Shoa (Figure 4).

Table 4. Likelihood of keeping different genotypes of crossbred cows in rural, peri-urban and urban dairy farming systems in Ethiopia

Exotic blood level (%)	Farming system	B (SE)	Significance	Exp(B) (Odds ratio)
Keeping cows with < 50% [a]	Rural	1.20 (0.47)	.010	3.33
	Peri-urban	- 0.019 (0.54)	.972	0.981
	Urban	0[b]		
Keeping cows with 50-75% [a]	Rural	0.109 (0.37)	0.769	1.115
	Peri-urban	0.943 (0.40)	0.019	2.567
	Urban	0[b]		
Keeping cows with >75% [a]	Rural	-1.088 (0.422)	0.007	0.337
	Peri-urban	-0.156 (0.422)	0.712	0.856
	Urban	0[b]		

a. The reference category is: Not keeping cows with < 50% exotic blood level.

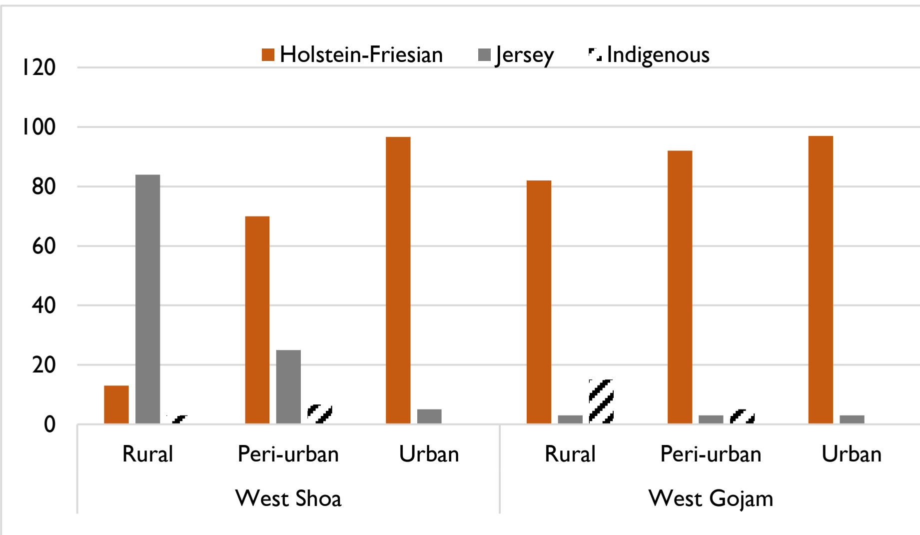
b. This parameter is set to zero because it is redundant.

Table 5: Farmer ranking of preferences (combined into index*) for dairy cow exotic blood level (West Shoa)

	Rural	Peri-urban	Urban	Overall
Indigenous	0.14 *	0.13	0.12	0.15
< 50% exotic blood	0.46	0.16	0.14	0.25
50-75% exotic blood	0.21	0.46	0.50	0.39
>75% exotic blood	0.20	0.25	0.26	0.22

* Index = [(4 for rank 1) + (3 for rank 2) + (2 for rank 3) + (1 for rank 4)] divided by sum of all weighted reasons mentioned by respondent.

Figure 4: Dairy farmer preferences for exotic and indigenous breeds across dairy farming systems



Herd, land and feed resources

The average herd size was 11.8, 10.7 and 8.8 in the rural, peri-urban and urban study sites, respectively. The ratio of crossbreds to indigenous animals was 0.49, 1.07 and 1.76 in rural, peri-urban and urban areas. This is in agreement to previous findings (Felleke 2013) where the rural system was characterized as traditional smallholder dairy system where indigenous genotypes are kept with low input management system. The characteristics of the improved dairy production systems (peri-urban and urban) varied substantially in terms of intensification, management systems, genotypes used, type and methods of marketing and processing of milk and dairy products.

The average crossbred cow/heifer herd size was 2.35, 3.28 and 4.25 in rural, peri-urban and urban systems (Table 6). However, there are variations in herd size and composition within each system across geographic locations. For instance, crossbred cow/heifer herd size was larger in West Shoa zone than in West Gojam zone. Variations across geographic zones could be explained by agro-ecological suitability, access to inputs and markets, as well as socio-cultural-economic conditions. The urban and peri-urban systems are more market-oriented and specialized. One measure of specialization on dairying could be the proportion of other livestock to the dairy herd. The ratio of small ruminants to cattle was significantly higher ($P<0.05$) in rural system (2.26) than peri-urban (1.33) and urban (1.27) system.

Table 6: Indigenous and crossbred herd size in rural, peri-urban and urban dairy farming systems

		Rural		Peri-urban		Urban	
Exotic blood %		W. Shoa	W. Gojam	W. Shoa	W. Gojam	W. Shoa	W. Gojam
Indigenous		7.2	8.7	7.3	3.7	4.0	2.6
Crossbreds		4.1	3.6	5.2	5.3	5.5	5.6
< 50%	Cows/heifer	0.55	1.39	0.13	1.88	0.13	2.51
	Bulls/oxen	0.05	0.26	0.03	0.19	0.02	0.10
	Calves	0.02	1.13	0.05	0.88	0.00	0.16
50–75%	Cows/heifer	0.83	0.44	1.86	0.99	1.35	1.46
	Bulls/oxen	0.18	0.00	0.30	0.32	0.27	0.00
	Calves	0.32	0.12	0.38	0.50	0.30	0.38
> 75%	Cows/heifer	1.37	0.12	1.26	0.43	2.09	0.95
	Bulls/oxen	0.12	0.09	0.11	0.00	0.03	0.00
	Calves	0.65	0.04	1.12	0.07	1.28	0.00

The average farm size in rural, peri-urban and urban areas across the study sites were 3.13, 2.50 and 0.59 ha, respectively. However, there is variation across sites, farmers in West Shoa having relatively larger plots than in West Gojam (Table 7). As for grazing/hay production lands, the urban farmers have significantly smaller grazing plots than peri-urban and rural farmers. As a result, urban farmers rent as much as or more than the grazing plots they own to feed their cattle and most farmers have to practice zero-grazing system. Land holding in the highlands of Ethiopia is generally small and comparable to the land holding in the sampled households in the current study. For instance, reported average household land holdings include 1.33, 2.66, and 2.3 and 2.3 ha in Bure, Mecha, Bahir-Dar-Zuria and Fogera districts (Adebabay 2009; Asaminew 2007; Azage et al. 2013) in the highlands of Amhara state. This is in contrast to the larger farm size of 8.5 ha in the lowlands of Metema (Azage et al. 2013) and the average grazing/fodder production land of 1.32 ha in Mieso district (Kedija Hussen 2007) in the lowlands of Ethiopia. The national average agricultural land holding and grazing/fodder production land per household is 2.5 and 0.26 ha, respectively (CSA 2013).

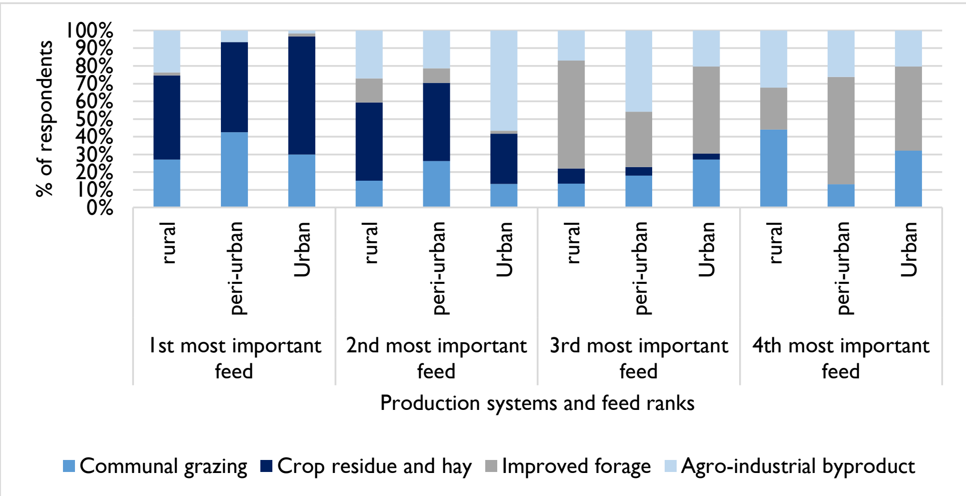
Table 7: Land holding (ha) and use in rural, peri-urban and urban dairy systems in West Gojam zone (Amhara state) and West Shoa zone (Oromia state)

	West Gojam			West Shoa		
	Rural	Peri-urban	Urban	Rural	Peri-urban	Urban
Crop land owned	1.26	0.94	0.025	1.91	1.91	0.15
Crop land rented-in	0.24	0.033	0.194	0.943	0.676	0.485
Private grazing land owned	0.37	0.075	0.018	0.913	0.776	0.092
Crop land rented-in	0.24	0.033	0.194	0.943	0.676	0.485
Private grazing land rented-in	-	0.013	0.015	0.436	0.305	0.150
Other land*	0.013	0.075	0.038	0.111	0.212	0.017
Total	1.89	1.13	0.290	4.36	3.86	0.89

* Eucalyptus and Khat land in West Gojam and irrigated land in West Shoa.

The major sources of feed for cattle in West Gojam in order of importance are crop residue, hay from private grazing land, concentrates, Attela and Brint (local brewery by-products), improved forage and communal grazing land. Contrary to the current observation, Seyoum et al. (2008) and Firew (2007) reported natural pasture, crop residue and stubble grazing as the major basal feed for cattle in the highlands of Ethiopia. The discrepancy between the current and the earlier observations can be explained by the shrinking availability of natural pasture lands. Similarly, the major feed resource in West Shoa is crop residue followed by communal grazing, regardless of the farming systems (Figure 5). The use of improved forages is not common in the study area. More farmers grow improved forage in urban and peri-urban than rural areas. The feeding management practice followed by urban dairy farmers in the current study is contrasting to the literature description of urban dairy farmers in big cities which are described as more dependent on purchased feeds. Concentrate feeding is limited and exclusively to crossbreed cows in all systems. It is, however, more important feed in urban/peri-urban than rural areas (Table 7).

Figure 5: Feed resources and their relative importance in rural, peri-urban and urban dairy farming systems.



Management practices

Breeding practice

The majority of the respondents in the study areas stated 'grading up' as their breeding strategy. The main exotic breed for crossing is Holstein-Friesian used by 92% of the farmers interviewed in West Gojam. Only 8% of the farmers used Jersey semen. AI is more commonly used by farmers keeping crossbred cows; 89% of the farmers keeping crossbred cows and 33% of the farmers keeping local cows used AI. Thirty eight per cent of the interviewed farmers reported use of local bulls, 33% crossbred bulls, 14% unknown bulls and 5% both local and crossbred bulls. In West Gojam urban areas, 60.0, 31.5 and 8.5% of the respondents used AI, both AI and bull and bull services to breed their cows. The corresponding figures were 51.9, 29.8 and 18.3% in peri-urban and 38.3, 24.7 and 24.7 in rural areas.

In the four highland states of Oromia, Amhara, SNNPR and Tigray about 36.0, 39.3 and 27.5% of farmers surveyed used natural mating largely using crossbred bulls, AI and a combination of bull and AI service, respectively, and AI is more widely used in peri-urban areas than in rural areas (Gizaw et al. 2016).

The breed choice of farmers depends on their cattle production objectives: either milk, both meat and milk or draught oxen. Of the farmers interviewed in West Shoa rural, peri-urban and urban areas, 91.5, 82.0 and 71.7% respectively preferred milk type breeds for AI; 0.0, 0.0 and 3.3% preferred beef type and 8.5, 18.0 and 23.3% preferred dual purpose breeds. Selection of bulls for natural mating depends on availability and the criteria to select bulls include body conformation, performance, color and level of exotic blood. Selection criteria in the highlands of Ethiopia in general include milk yield, milk fat content, and age at first calving based on their daughters performance (Desta 2002).

Feeding practice

Feeding strategies differ significantly between farming systems (Table 8). In West Gojam, 97% and 90% of the farmers interviewed in rural and peri-urban areas feed their local cattle differently from their crossbred cattle, whereas in urban areas 66.67% of farmers use the same feeding strategy for both local and crossbred cattle. This could be the access to feed inputs or more profitable market for their product which acts as a pull factor for technology adoption or better management skill of farmers in urban areas. In West Shoa, 93–98% of the farmers in all the three systems provided preferential feeding to crossbred cows according to their stage of lactation. However, feeding local cows according to stage of lactation is provided by 49.2, 0.0 and 11.7% of the interviewed farmers in rural, peri-urban and urban subsystems, showing a moderate preferential treatment of local cows is provided in rural areas.

In all study sites crossbred cattle are grazed for few hours a day mainly on private grazing lands (less frequently on communal lands) and stall-fed for the rest of the day, herded in order to prevent unwanted mating, intake of harmful plants and water which is infested with leech, reduce the chances of being infected with diseases from other herds, parasite infestation, and heat stress.

Table 8: Percentage of farmers practicing differential feeding of local and crossbred cows under different dairy farming systems

	Crossbred cows			Local cows		
Feeding strategy	Rural	Peri-urban	Urban	Rural	Peri-urban	Urban
West Gojam						
All day free grazing	86.7	33.3	13.3	97.0	90.0	66.7
Restricted grazing/ few hours	66.7	87.0	86.7	33.3	33.3	66.7
Zero grazing/ stall-feeding	66.7	95.0	100.0	33.3	66.7	66.7
Seasonal grazing	100.0	95.0	86.7	100.0	100.0	66.7
Grazing on communal land	66.7	33.3	13.3	86.7	66.7	33.3
Grazing on private land	86.7	86.7	86.7	66.7	66.7	66.7
West Shoa						
Noug seed cake	1.9	3.3	3.5	1.7	0.0	1.7
Mixed feeds*	94.2	95.0	80.7	5.1	0.0	0.0
Home grown improved forage	0.0	1.7	1.8	0.0	0.0	1.7
Atella	3.8	0.0	0.0			
Natural grass**	0.0	0.0	14.0	39.0	24.6	20.0
Crop residue mixed with other feeds				52.5	70.5	48.3

* Wheat bran, noug seed cake, improved forage, grass, atella (by-product of home-brewed drinks) and concentrate feed. ** Natural grass mixed with noug seed cake, mixed feeds, wheat bran

Housing and health management

Housing management varied with farming systems in the study area (Table 9). Almost all farmers in urban areas keep their cows in a separate improved housing, whereas only about half of the interviewed farmers do so in peri-urban and rural areas. About 28 and 16.7% of the farmers in rural and peri-urban areas keep their cows in their living room. About 20.7, 40.0 and 81.0% of the farmers in rural, peri-urban and urban areas provide proper feeding and watering troughs in the barns. The housing practice in the study areas similar to the practice in rural areas of Fogera district (Belete 2006), in Bahir Dar and Mecha districts (Asaminew 2007), and in Bure district (Adebabay 2009).

Farmers' health management in the study areas has shifted from traditional indigenous practice to modern medicine with the advent of crossbreeding. Currently crossbred cattle are exclusively treated by veterinarians. Fifty five per cent of the farmers use private veterinary clinics and drug stores and 45% of the farmers use public veterinary clinics. Peri-urban and urban farmers prefer private health services, but the cost of the service is double to that of the public service. Barn cleaning also varied slightly across farming systems (Table 9).

Table 9: Housing management of rural, peri-urban and urban dairy farmers

	Percentage of farmers		
Housing type	Rural	Peri-urban	Urban
West Gojam			
Open house attached to residence	15.9	15.0	7.5
Separate house	50.0	66.7	92.5
Backyard enclose	6.1	1.7	0.0
Together with human	28.0	16.7	0.0
Facilities in barn			
Water trough	11.5	0.0	2.4
Feed trough	40.2	25.0	16.7
Water trough and feed trough	20.7	40.0	81.0
No facility	27.6	35.0	0.0
West Shoa			
Daily barn cleaning	88.1	93.4	100.0

Role of family members

In West Shoa zone of Oromia, milking is almost exclusively the responsibility of the spouse as it is in most other parts of the country (Alganesh 2002; Solomon 2004), whereas in West Gojam in Amhara region, the head (the husband) of the family is mainly responsible for milking (Table 10). Milk processing is often considered as women's duty and as such almost always the work is done by the wife and children. Hired labour is mainly used in West Shoa. The practices in West Shoa and West Gojam are similar to most other highland areas (Anteneh et al. 2010) except that milk delivery is mainly the responsibility of children in in West Shoa.

Table 10: Frequency of participation of household members in farm management activity

	Milking		Milk processing		Milk delivery/sale		Farm management[1]	
	Shoa	Gojam	Shoa	Gojam	Shoa	Gojam	Shoa	Gojam
Head	6.7	55.6	0	0	14.4	9.7	75.0	55.1
Spouse	77.8	18.9	74.4	95.6	7.8	66.6	27.0	22.7
Children	6.7	17.1	14.4	4.4	52.1	17.0	31.0	13.7
Hired labour	8.9	8.3	11.1	0	26.7	6.7	47.0	11.9

[1] This is for feeding management. The roles of family members in other management activities (cleaning and herding) is described in text.

Milk processing and marketing

Milk is produced mainly for sale as fresh milk in all the three dairy systems (Table 11). On the contrary, in West Gojam more of the milk produced in rural and a significant proportion of the milk in peri-urban area is processed on-farm, whereas in urban areas more than half of the milk is sold. A possible explanation for this marketing pattern could be the geographic location of West Shoa within the greater Addis Ababa milkshed where there is good market for milk, including processing milk unions where more than 90% of the farmers sale their milk (Table 11). Farmers in West Shoa also seem to be more market-oriented dairy farmers with the majority of interviewed farmers ranking milk production and generating income as their first purpose of keeping cattle, whereas the West Gojam farmers' primary purpose was draught power. The current high market participation (from about 10% in the past) by West Shoa farmers is associated with the advent of crossbreeding, according to the farmers. Such results are considered as an indication that smallholders have moved from subsistence to market-oriented dairy production (Ahmed et al. 2004), although this varies with geographic locations as evidenced in rural West Gojam where much of the milk is processed on-farm and farmers' primary cattle keeping/breeding purpose is draught power for crop farming. The results from West Gojam are comparable with the report of Zelalem and Ledin (2001a) in the central highlands, Alganesh (2002) in eastern Wollega and Lemma (2004) in the east Shoa zone of Oromia region and seem to be the predominant scenario in the rural highlands. The results from the two zones may lead to the consideration of two sub-systems within the rural system—the butter sub-system with indigenous cows and a fresh milk sub-system with crossbred cattle.

The dairy products sold in the study area include butter, spiced butter and cottage cheese. The sale of dairy products also vary between the three systems. The percentage of farmers who sold butter was higher in rural and peri-urban areas than in urban areas. The end markets also vary with the dairy system in West Gojam, but not in West Shoa where a relatively reliable market is available (Table 11). Table 12 presents farmer estimates of on-farm milk processing efficiency as affected by breed and genotypes. The higher preference of rural farmers for Jersey in this study is justified by their observation on fat production potential of the breed.

Table 11: Milk utilization in three dairy farming systems in the highlands of Ethiopia

		Rural	Peri-urban	urban
	Milk utilization (as % of milk produced)			
West Shoa	Consumed	3.4	5.3	5.3
	Processed	8.8	6.1	3.1
	Sold fresh	88.5	88.5	91.8
	Buyer type (% of farmers selling to)			
	Consumers on monthly contract	3.4	3.3	5.0
	Milk union	96.6	95.1	93.3
	Hotel	0.0	1.6	1.7
West Gojam	Consumed	8.2	3.1	26.0
	Processed	41.1	35.1	13.9
	Sold fresh	32.6	49.2	54.5
	Fed to calf	18.1	12.7	5.6
	Dairy product sale (% of farmers selling)			
	Butter	48.7	33.3	18.0
	Spiced butter	23.0	17.0	13.0
	Cheese	0.0	10.0	30.0
	Yoghourt	0.0	5.0	25.0
	Buyer type (% of farmers selling to)			
	Consumers on monthly contract	0.6	15.0	60.0
	Traders	79.0	37.0	0.0
	Catering shops	20.4	31.0	40.0
	Cooperatives	0.0	17.0	0.0

Table 12: Farmer estimates of amount of milk (litres) required to churn out one kg of butter from different genotypes in rural, peri-urban and urban farming systems

System	Indigenous	Crossbred	*Low grade	Medium grade	High grade	Pure Holstein	Pure Jersey
West Shoa							
Rural	18.5		21	23	26	27.07	21.43
Peri-urban	18.4		21	24	27	29.67	22.08
Urban	18.5		21	23	26	26.21	23.42
West Gojam							
Rural	12.2	21.5					
Peri-urban	16.6	20.6					
Urban	18.8	26.8					

*Low, medium and high grades refer to crossbreds with 25%, 50–62.5%, and ≥75% Holstein-Friesian blood.

System-specific constraints

Production and productivity

Scale of production

Scale of production is one of the reasons for low milk production from the smallholder system. Scale of production in dairy farming could be quantified by the herd size, specifically the milking herd. The farm scale determines the contribution of the enterprise to adequately support the livelihood of the farm family and the farm's economies of scale to access external inputs and services and profitable markets. Scale of production could be determined by production resources, access to external inputs, markets and credit services, as well as farmers' degree of market-orientation. The dairy farms in all the three systems surveyed in the current study are small scale (Table 6). However, urban farmers keep relatively smaller herd than rural and peri-urban farmers. This could be related to the smaller urban land-holding (Table 7) which is a major constraint to increase scale of production. Geographic location could also be a determinant factor for scale of production. The larger herd size in West Shoa compared to West Gojam could be due to the fact that West Shoa is located within the greater Addis Ababa milkshed where there is better access to markets, including consumers in Addis Ababa and milk processing plants. Besides, West Shoa farmers had larger land holdings and there seems to be more land available to rent. Land shortage is a major problem constraining dairy development elsewhere in the country, for instance in Boditi in SNNPR 100% of both rural and urban farmers interviewed identified land shortage as number one constraint (Asrat et al. 2013). The reasons given by interviewed farmers in the current study for the shrinking land holding included population migration to urban areas, population growth, expansion of urbanization, conversion of grazing lands to crop lands, land degradation, and stock exclusion from grazing lands for soil conservation. This has negative implication on household income and livestock production. The urban dairy farmers particularly are most affected by the current land scenario in the country. They have to depend on purchased feed and zero grazing system of dairying.

Low herd productivity

The results of the current studies showed that both reproductive and milk production performance varied between the three dairy farming systems studied. Herd productivity is generally lower in rural areas compared to peri-urban and urban areas. Herd monitoring in the current study (Table 13) showed that average daily milk yield (adjusted for genotype, parity and stage of lactation) was significantly lower in the rural system. Indigenous cows produced about five litres less than the overall herd average. On the average the indigenous cows produced 2.02 (monitored yield) to 2.59 (farmer estimates) kg milk per day, which is very similar to 2.31 litres for other indigenous breeds in the rural highlands (Azage et al. 2013). The advantage of high grade crosses (about 3.78 litres) may not be appreciable and seems their genetic potential underexploited. These variations across farming systems and the low level of production by high grade crossbred cows could be due to the low level of traditional management in the study areas. Generally for the highlands of Ethiopia, Adane et al. (2016) found that input use, adoption of improved technologies and agro-ecology determine the amount of milk production at household level. Variations across systems in farmer estimates of milk production and lactation length are presented in Table 14.

Table 13: Effect of production system, genotype, parity and stage of lactation on mean (± standard error) daily milk production measured once a week (test-day) over a period of six months

Factor	Class	Number of cows	Milk production[2] (litre/day)	Contrast estimate[1]
Production system	Rural	24	6.69 (.84)	-1.19*
	Peri-urban	28	7.97 (.70)	0.09
	Urban	26	8.98 (.97)	1.10
Genotype	Indigenous	24	3.58 (.98)	-5.08***
	25–50% exotic blood	12	8.15 (.98)	-0.51
	50–75% exotic blood	24	10.49 (.80)	1.84***
	> 75% exotic blood	18	12.40 (.80)	3.75***
Parity	1st	20	7.93 (.80)	.05
	2nd	29	8.22 (.69)	.34
	3rd	18	7.07 (.86)	-.81
	4th	11	8.29 (1.11)	.41
Stage of lactation	Early lactation	27	7.57 (.84)	-.31
	Mid lactation	30	9.01 (.69)	1.13*
	Late lactation	21	7.07 (.81)	-.81

1 Contrast estimate: deviation of class mean from the overall mean.
2 Milk yield for each of the four factors (production system, genotype, parity and stage of lactation) is after adjustment for the other three factors.
*, **, *** Value significantly different from zero at 10, 5 and 1% level of significance.

Table 14: Farmer-estimated and researcher-monitored lactation performance of indigenous and crossbred cows across dairy farming systems

	West Shoa			West Gojam		
Exotic blood level	Rural	Peri-urban	Urban	Rural	Per-urban	Urban
Daily milk yield (Farmers' estimates)						
Indigenous	2.59	2.27	2.72	1.03	1.93	2.65
< 50%	5.02	8.01	8.59	2.49	4.68	5.84
50–75%	11.76	14.47	16.07	5.68	6.40	6.49
>75%	13.48	15.19	26.07	5.66	7.36	7.28
Daily milk yield (monitored/measured)						
Indigenous	2.02±.19a	2.27±1.0ab	2.28±.16c	1.56±0.28	2.33±0.22	3.20±0.22
< 50%	4.95±.26a	8.77±2.43b	8.83±2.0c	3.87±0.35	4.53±1.01	5.06±0.58
50–75%	11.86±3.5a	14.59±5.62ab	20.78±8.29c	5.60±0.74	7.81±1.41	8.61±0.86
>75%	13.70±.50a	15.30±6.98ab	26.76±5.87c	7.27±0.73	8.73±0.45	10.33±0.98
Lactation length (Farmers estimate, month)						
Indigenous	7.7±.279a	8.8±.395ab	8.2±.441c	7.98±0.25	8.67±0.27	8.29±0.37
< 50%	8.2±.196 a	8.8±.277 ab	9.3±.309 c	8.90±0.56	7.43±0.33	8.50±0.50
50–75%	9.0±.260 a	10.5±.367 b	10.5±.41bc	8.77±0.15	8.50±0.20	8.00±0.00
>75%	10.2±.260	10.6±.367	10.1±.411	12.57±0.71	9.80±0.14	7.71±0.15

Smallholder farmers largely rely on reproduction of their own herds to build up herd size since the cost of crossbred heifers (approx. ETB 50,000) is extremely unaffordable. In the current study reproductive performance varied consistently between farming systems and genotypes. Age at first service of indigenous cows was highest in rural areas, medium in peri-urban and lowest in urban areas (Table 15). This variation could be due to variation between farming systems in farmer management skills, access to and use of inputs (mainly feed) and access to breeding services. Age at first service declined with increasing exotic blood level within farming system, which could be due to variation in genetic merits and/or farmers' preferential management of higher grade crossbreds. Age at first service marks the beginning of a cow's productive life and influences both the productive and reproductive life of the female, directly through its effect on her lifetime calf crop and milk production and indirectly through its influence on the cost invested for upbringing. Variations were also observed across systems and genotypes in the number of services per conception, calving interval and longevity (Table 15).

Table 15: Reproductive performance of indigenous and crossbred cows across dairy farming systems

	West Shoa			West Gojam		
	Rural	Peri-urban	Urban	Rural	Peri-urban	Urban
Age at 1st service (months)						
Indigenous	46.35±.06a	45.84±.09ab	38.1±.09 c	56.16±0.84	45.00±0.96	39±0.84
< 50% exotic blood	42.68±.09a	40.45±.12 ab	30.83±.14 c	39.84±1.32	32.76±1.56	30.96±3.96
50–75% exotic blood	23.04±.04a	23.1±.05 ab	19.5±.06 c	31.80±10.80	27.48±1.44	27.00±3.00
>75% exotic blood	22.80a	20.75b	18.37c	31.32±1.32	24.36±0.36	19.92±12.00
Number of services per conception						
Indigenous	3.7±.07 a	3.0±.10 bc	3.0±.11 c	2.51±0.08	1.37±0.09	1.13±0.06
< 50% exotic blood	3.5±.07 a	3.0±.10 bc	2.9±.11 c	2.17±0.07	1.95±0.19	1.00±0.00
50–75% exotic blood	1.9±.07	1.8±.09	1.7 ±.10	2.17±0.10	1.35±0.12	1.00±0.00
>75% exotic blood	1.6 ±.08	1.5±.11	1.3±.12	1.95±0.05	1.60±0.11	1.44±0.08
Calving interval (days)						
Indigenous	748.25±.05	743.50±.04	724.53±.03	26.72±0.73	20.52±0.49	19.20±0.37
< 50% exotic blood	557.7±.01	556.6±.02	547.6±.02	24.1±0.89	14.95±0.79	13.5±0.50
50–75% exotic blood	441.65 ±.05a	435.41±.04ab	410.63±.03c	22.90±0.97	14.00±0.23	12.00±1.00
>75% exotic blood	441.6±.05a	419.8±.03ab	389.8 ± .02c	21.90±1.20	13.65±0.53	11.56±0.30
Longevity (years)						
Indigenous	11.9±.32a	14.7±.46bc	13.4±.51c			
< 50% exotic blood	11.8±.28 a	12.9±.39a b	12.2±.44 c			
50-75% exotic blood	10.3±.32	10.1±.45	10.9±.50			
>75% exotic blood	9.1±.20	9.3±.30	9.1±.32			

Traditional management practices

The observed low herd productivity in this study, particularly in rural areas, could be due to farmers' traditional management practices. The traditional practices are rarely supported with information on modern production practices. For instance, in West Gojam rural sites in the current study, about 25% of the farmers did not follow a clear breeding strategy with highly mixed herd with varying exotic blood level, 13% of the farmers were not aware of exotic blood level changes in their herds or cows, and some 5% of farmers backcrossed their crossbred cows to local bulls. Utilization and improvement of the desired crossbred population can only be efficient in situations where breeding programs with well-defined breeding objectives are developed, which is often lacking at smallholder level in the tropics (Kahi 2002). Farmers in the study areas rely on their own traditional knowledge and there was clear evidence that most farmers have some kind of knowledge about exotic inheritance and experiment on appropriate level of exotic blood in their herd.

The feeding practices in rural areas and for local cattle differs from peri-urban areas and crossbred cattle. The use of improved forages is not common in the study area. More farmers grow improved forage species in urban and peri-urban systems as compared to rural areas. Concentrate feeding is generally low. However, those respondents who owned crossbred cows feed concentrate feeds like noug (Gizotia abyssinica) seed cake and wheat bran to their animals. On the contrary, no concentrate was given to local cattle in the study area.

Diseases and food safety

Disease is reported by farmers as a major constraint to livestock production due to poor access to health services and poor herd health management. The top diseases and health problems ranked by farmers in West Gojam were anthrax, black leg, mastitis, contagious bovine pleuropneumonia and bloat (Table 16). The problems are similar across the production systems. In West Shoa, 93.2, 91.8 and 93.3% of the interviewed farmers in rural, peri-urban and urban systems, respectively, reported that the disease problem have worsened since introduction of crossbreds. However, 81.4, 75.4 and 80.0% of the farmers do not see any adaptation problem for crossbreds apart from diseases.

Table 16: Farmer ranking of importance of diseases in rural, peri-urban and urban systems

	Rural	Peri-urban	Urban
Disease ranking in West Gojam (% of farmers)			
Anthrax	14	14	10
Black leg	13	13	13
Mastitis	12	12	12
Trypanosomiasis	11	11	10
Pastuerolosis	10	10	10
Contagious bovine pleuropneumonia	10	10	13
Bloat	13	13	10
Internal parasite	9	9	11
External parasites	8	8	11
Reproductive problems in West Shoa (index of ranks)			
Abortion	0.11	0.15	0.18
Anoestrus cows	0.03	0.00	0.00
Reproductive disorder	0.36	0.21	0.20
Uterine Prolapse	0.01	0.00	0.02
Dystocia	0.02	0.10	0.12
Repeat breeders	0.48	0.54	0.49
Mixed problem	0.00	0.00	0.00

The majority of the respondents in rural West Gojam sites do not follow sanitary milking practices except hand and vessel washing (Table 17). However, use of udder towels is practiced by few farmers in urban areas. Farmers also reported that milkers would dip their fingers into the collected milk to moisten the teats to ease milking. Similar unhygienic practice was reported in the East Shoa zone of Oromia region (Lemma 2004).

Three types of containers are used for milking, processing and storage of milk and milk products (Table 17). These include gourd (Qil), clay pot and plastic containers. Qil and Clay pot are the major containers used for milking and storing of the milk products in the rural area, especially by smallholder farmers in West Gojam. Urban and some peri-urban farmers use a more hygienic plastic utensils. The use of the different utensils in urban and rural areas may not necessarily be due to health concerns but simply due to the utensils relative availability locally. Consumption of raw milk is also very common in rural areas compared to peri-urban and urban areas.

Table 17: Milk production and storage hygiene in rural, peri-urban and urban systems

	Percent of households practicing		
Milking practice	Rural	Peri-urban	urban
Wash hands and vessels	95.0	97.0	100.0
Wash udder before milking	23.8	23.3	80.1
No hygienic practices	39.0	36.0	0.0
Use of individual towel	0.0	1.0	5.0
Use of common towel	0.0	2.0	10.0
Milking and processing utensils			
Milking utensils			
Gourd	90	45	25
Clay pot	-	-	-
Plastic container	10	55	75
Churning utensils			
Gourd	73	45	7.3
Clay pot	27	55	92.7
Plastic container	-	-	-
Fermented milk storage			
Gourd	70	57	35
Clay pot	30	43	13
Plastic container	-	-	52
Butter milk storage			
Gourd	41	23	-
Clay pot	35	34	27
Plastic container	24	43	73
Cottage cheese storage			
Gourd	-	-	-
Clay pot	47	37	25
Plastic container	53	63	75

Access to inputs and services

Farmers' ranking of input/service problems

Interviewed farmers in West Gojam and West Shoa expressed that inputs/service delivery has improved. Yet there are still challenges to access affordable inputs and services timely. Overall across dairy farming systems and geographic locations, availability and affordability of concentrate feeds and improved crossbred heifers are ranked as top priority challenges for dairy farms. Access to health service is still a challenge in rural areas (Table 18). Rural farmers are largely dependent on public veterinary service which is more affordable than the private service, the percentage of interviewed farmers who used the private service in rural and peri-urban/urban areas being 25 and 55–85%, respectively.

Table 18: Farmer ranking of input/service problems in West Gojam and West Shoa, Ethiopia

Type of input/ service	West Gojam (% of farmers)*			West Shoa (ranking index)**		
	Rural	Peri-urban	Urban	Rural	Peri-urban	Urban
Concentrate feed/ AIBP	29	38	38	0.30	0.29	0.26
Improved heifer supply	23	29	29	0.27	0.26	0.31
AI service	10	23	23	0.23	0.25	0.23
veterinary service	38	10	10	0.20	0.24	0.19

* Per cent of farmers ranking problem as 1st. ** Index derived from farmers ranking of problems.

Constraints to efficient AI service

The main breeding service currently available in the country is AI service provided by both the public and the private sector. The service is available in most parts of the country, except in distant rural areas. However, efficiency of the service may not be as would be expected by users. For instance, nearly half of the farmers (46.7%) in Addis Ababa expressed problems with AI service (Desta 2002). In the current study in West Gojam zone, 71.6, 26.7 and 15.0% of the respondents in rural, peri-urban and urban areas reported respectively that there is no access to AI service. Among those that had access to AI, 87.7, 100 and 100% in rural, peri-urban and urban areas perceive problems with the AI service delivery, respectively. The top constraints were distance to AI centre, unwillingness of AI technician (motivation and attitudes) and heat detection problem in rural areas, unwillingness of AI technician and heat detection problem in peri-urban areas and unwillingness of AI technician in urban areas (Table 19). In West Shoa zone, the top problem was heat detection across the three dairy systems. These constraints are similar to constraints reported elsewhere in the highlands of Ethiopia (Hayleyesus 2006). Farmers most often have to travel to AI centres to get the service, with only 25.4 (in rural areas) to 47.5% (in urban areas) of the farmers in West Shoa accessed the services by calling the artificial insemination technician (AIT). Even then, only 18.6, 31.1 and 50.0% of the respondents in rural, peri-urban and urban areas had the option for choosing the exotic breed blood level of the semen. Some farmers in West Gojam also did not know the exotic blood level of the bull with which their cows were inseminated. The positive side of the AI service is the price, which is considered to be very affordable by many farmers.

Table 19: Constraints to efficient AI service

	West Gojam (% farmers)			West Shoa (Rank Index)		
	Rural	Peri-urban	Urban	Rural	Peri-urban	Urban
Unwillingness/shortage of AIT*	55.6	90.0	100.0	0.07	0.03	0.03
Shortage of liquid nitrogen and semen	2.5	0.0	13.6	0.09	0.11	0.06
Poor semen quality	-	-	-	0.00	0.01	0.01
Efficiency of AIT	22.2	18.5	12.3	0.16	0.21	0.18
Perception of AI user about AI	30.9	0.0	0.0	-	-	-
Heat detection system	32.1	14.8	0.0	0.42	0.48	0.44
Distance to AI centre	96.3	30.9	0.0	0.18	0.09	0.06
Disease problem				0.04	0.07	0.16
Means of AI service access						
Daily visit by AIT				0.0	0.0	1.7
Call AIT				25.4	36.1	47.5
Visit to AI centre				74.6	63.9	50.8

* AIT unwillingness in West Gojam and shortage in West Shoa.

Feed and water constraints

Feed problems could be expressed in three interrelated aspects: overall imbalance in feed supply and demand (e.g. feed balance in Amhara region is only 69.1%, BoFED 2006), seasonal fluctuations in feed and water availability and the poor quality of the available feed. The available feed resources are utilized to support maintenance requirements of the animals with little surplus left for production. Dry season feed supply is the paramount problem in Ethiopia. In West Gojam, feed shortage is more severe in peri-urban and urban areas (Table 20). Dry season feed shortage is more severe in rural and peri-urban areas than in urban areas where the major feed resources are purchased crop residue and concentrate feeds which are available during the dry season as well. On-farm feed production is constrained by the small land holdings (Table 7). The average watering frequency was once a day during the wet season and twice a day during the dry season. During the dry season, cattle are trekked on the average for one hour from the homestead to the water point, which results in loss of body weight and substantial decrease in milk production of cows. Regarding concentrate feeds, affordability rather than availability is considered a more important constraint for dairying, especially in West Shoa (Table 20). Table 21 presents current feed prices in West Gojam. Feed conservation in the form of hay is widely practiced by 67.8, 91.8 and 90.0% of the farmers in rural, peri-urban and urban areas, respectively. However, feed conservation in other forms such as silage making and feed processing to improve nutritive values of low quality feeds, such as crop residues, is virtually absent, except silage making by 28.8, 0.0 and 3.3% and feed processing by 3.4, 8.2 and 0.0% of the farmers in rural, peri-urban and urban areas, respectively.

Table 20: Percentage of farmers facing feed problems in West Gojam and West Shoa

	Rural	Peri-urban	Urban
Feed shortage encountered	79.0	87.4	89.5
Feed shortage in wet season	29.5	33.9	62.3
Feed shortage in dry season	70.5	66.1	37.7
Practicing supplementary feeding	67.6	78.9	87.2
Feed (concentrate) not available	11.9%	6.6%	13.3%
Feed (concentrate) cost too high	88.1%	93.4%	86.7%

Table 21. Feed prices (ETB/quintal, cart or sac) in rural, peri-urban and urban areas in West Gojam.

Feed type	Rural	Peri-urban	Urban
Hay	270.0	256.7	275.0
Green grass	-	23.0	40.0
Noug seed cake	440.0	446.7	420.0
Wheat bran	368.7	368.6	362.5
Crop residue	-	77.3	82.5

Low and unhygienic milk consumption

Milk consumption is generally low in Ethiopia amounting to 17 litres per annum per capita. Milk is a valuable commodity as a source of year-round income unlike the income from live animal sale. As a result, only 3–5% of the milk is consumed by the farm household in West Shoa (Table 11). Whole milk is consumed mainly by children, adults in rural areas consuming mainly nutritionally low quality dairy products such as metata ayib, Zure, and buttermilk (Table 22). Butter is mainly consumed in urban areas. Unhygienic raw milk consumption is more common in rural areas of West Gojam. In West Shoa, only 28.2–31.1% and 6.2–11.9% of the interviewed farmers reported to use milk products (commonly buttermilk) as sauce and thirst-quenching drink, respectively.

Table 22. Milk consumption (% of farmers responding) and hygiene in West Gojam

	Rural	Peri-urban	Urban
Consumption of dairy products			
Boiled milk	47	78	95
Raw milk	53	22	5
Sour milk	33	27	17
Use of dairy products			
Butter used for food	35	39	83
Butter used for ointment	35	25	15
Buttermilk consumption	100	89	67
Metata ayib	100	85	43
Zure	100	100	0

Access to profitable markets

The most important constraints encountered by producers and smallholder dairy cooperatives in West Gojam, in order of importance, are lack of market access during fasting period, low product price, less demand for processed dairy products such as cottage cheese and frequent maintenance requirement of cream separators in cooperative dairy plants. The problems in West Shoa are presented in Table 23. The major market problem is the low milk price in view of the high cost of feed across production systems. Milk price is significantly lower in rural areas.

Table 23. Market problems and milk prices in rural, peri-urban and urban areas in West Gojam and West Shoa.

	Rural	Peri-urban	Urban
Market problems in west Shoa (index of ranking)			
Unbalance price of milk and feed	0.47	0.42	0.40
Price fall during fasting period	0.27	0.28	0.31
Price fluctuation	0.20	0.20	0.23
Problem of infrastructure to supply milk	0.07	0.10	0.05
Price of milk in West Shoa			
% of farmers selling milk @ ETB 11.50/litre	92.9	85.2	61.8
% of farmers selling milk @ ETB 12.00/litre	3.6	9.8	25.0
% of farmers selling milk @ ETB 13.00/litre	3.6	4.9	13.2
Milk price range in West Gojam	7-10	7-12	9-15
Irgo price range in West Gojam	-	5-15	14-24

Conclusions, implications and leverage points

Smallholder dairy farming is diverse in characteristics and constraints. This study backs with quantitative data and statistical analysis the classification of smallholder dairy farming in the highlands of Ethiopia into rural, peri-urban and urban systems. The study also identified distinguishing characteristics of the three systems. The data also showed that the urban system in regional towns is distinct from the urban system described for big cities and towns.

A key finding of the study is a description of constraints across the value chain. Some of the constraints and/or their severity varied across the three systems. This confirms the need for system-specific development strategy and interventions. Interventions would adopt a value chain approach.

Production node

i. *Scale of production is small either in rural or peri-urban/urban systems:* The factors determining the scale of production may vary across the systems. For the urban/peri-urban farmers the limiting factor was found to be land shortage to increase herd size. Sustaining urban dairies based on purchased feed (like hay, crop residue and concentrates) has become challenging (personal communication). Expansion of dairy farms in the peri-urban system, which is a major source of milk for the urban population, is stagnating. For the rural system, lack of market orientation, less access to inputs/services, investment capital and profitable markets have contributed for the system remaining at subsistence small-scale level. These scenarios of the smallholder dairy system have impacted on the supply of milk to consumers (milk being preferentially fed to children only) and farmers' income negatively.

   Land policy support for urban/peri-urban dairying: The leverage points to alleviate the problem lies across the dairy value chain. However, the key place is the land issue to increase scale in terms of herd size. It is argued that change in milk production in herd size explains 60% of the increase, but only 20% from technology change (Land O'Lakes. 2010). Dairying, particularly the peri-urban/urban systems, which are the major suppliers of milk to the urban population and the milk processing industry, need to be recognized as a public good investment to provide nutritious food for the population (especially children) which is one of the lowest milk consumers, even by East Africa standards.

   Value chain interventions for sustainable intensification: Increasing production through system intensification could be considered for the rural system. The options for sustainable intensification span across the value chain. These would include technological interventions to improve the production environment and increase productivity per cow, organizational interventions for collective actions to access inputs/services and profitable market, and capacity building in market-oriented dairying.

ii. *Productivity varies between systems for the same breeds/genotypes:* Milk production performance was found to be lower in rural areas than in peri-urban/urban areas for the same breed. A problem analysis using the information generated in this study could identify suboptimal production environment in the rural system: low quality feeds such as crop residue which constitute the major feed source; t*here is very limited adoption of technologies for feed quality improvement; concentrate feeds are less available in rural areas and are more* unaffordable to the rural farmers who receive lower prices for their produce than the other systems; and prevalence of diseases aggravated by less access to veterinary services in rural areas are identified by farmers as major constraints. These have resulted in lower level of cattle productivity in rural areas compared to the other systems. However, the level of productivity of crossbred cattle in both peri-urban and urban systems is also lower than the genetic potential of the breeds.

Sustainable intensification of the rural system: As described above in section (i).

Village-based cooperative selective breeding in rural areas: The predominant breeds in the rural system are indigenous and most have inherently low genetic potential for milk production. So far, organized selective breeding of the indigenous breeds has received less attention than crossbreeding, which may not be feasible in remote rural areas. Public cattle ranches mandated with the conservation and improvement of the local breeds have been dysfunctional. A more sustainable option would be a cooperative village selection scheme, where villagers cooperate in recording, bull selection and communal use. This is an imperative strategy for the 'dairy type' breeds like Fogera and Begait. This scheme would adopt the small ruminant village breeding experience in Ethiopia (Gizaw et al. 2015).

Fodder production, improvement and conservation technologies in rural and peri-urban: There are feed interventions suitable for smallholders and tested by projects like LIVES. Year-round irrigated fodder production, even on crop lands, has been well accepted by farmers and this would be taken as a strategy to integrate dairying with irrigation schemes. A new technology for fodder conservation is small scale bag silage making. Shelved technologies such as urea and effective microorganism treatment of crop residues need to be scaled out. Locally formulated balanced dairy ration development is a research agenda to be considered.

iii. *Preferences of farmers for exotic breeds and genotypes (blood levels) vary with farming system and geographic location:* Jersey breed is more preferred in rural areas, but preference varies with geographic location. The geographic variation for preferences seems to depend on milk marketing objectives or practices: Jersey is more preferred in West Gojam since most of the milk produced is processed into butter on-farm, whereas Holstein-Friesian is more preferred in West Shoa where the primary product marketed is liquid milk.

Preferences for genotypes also vary across systems. While rural farmers preferred cows with around 50% exotic blood level, those in peri-urban and urban areas preferred medium level exotic blood between 50–75%. The consequence of disregarding farmer preferences or randomly providing AI service without considering the genotypes of cows to be inseminated and the semen would result in low productivity in rural areas if high grade semen is used as observed in the current study.

System-specific crossbreeding strategy: Semen of both exotic breeds is produced by the National Artificial Insemination Centre. The approach for the crossbreeding strategy is described in section (iv) below.

iv. *Crossbred herds are of mixed exotic inheritance:* Limited farmer knowledge on cow genotype, lack of options for choosing semen genotype, limited access to AI service (especially for repeat breeders) and the resulting backcrossing to local bulls or mating to *unknown crossbred bulls are some of the reasons for the observed mixed herds and failure to maintain desired exotic inheritanc*e in village herds. Besides the low productivity of backcrosses, hers with mixed exotic inheritances have other implications; for instance it would be difficult to design management and other value chain interventions for such mixed herds.

Village crossbreeding scheme and AI recording in peri-urban/urban system: A key aspect of designing village crossbreeding scheme would be defining exotic breeds (Holstein-Friesian for liquid milk system in peri-urban and urban and Jersey for the butter system), exotic blood levels for the different systems and defining semen genotypes for inseminating the various crossbred cow genotypes found in the farms (50%, 62.5%, 75%, and 87.5%). This requires designing simple AI recording scheme that can be managed by AI technicians. In essence this calls for a documented (and shared to stakeholders) AI-based crossbreeding design for Holstein-Friesian and Jersey crossbreeding programs. The design need to consider improvement in milk production, as well as conservation of genetic diversity.

Inputs and services node

i. *Rural areas have least access to AI service, whereas peri-urban/urban questions efficiency:* The access is as little as 28.4% in rural areas. The primary reasons according to farmers is distance to AI centre, heat detection problem and 'unwillingness' of AIT. These are related to the overall difficulty of providing services in rural areas to individual cows when and whenever it shows heat. The major problem identified in peri-urban/urban areas is 'unwillingness' of AIT. The technical problem is heat detection as the majority of farmers have to travel to AI centre to get the service which impacts conception rates significantly. These constraints have hampered the huge effort by the public sector to increase the crossbred cow population.

   Organizing efficient oestrous synchronization service: Individual AI service is challenging under the current infrastructure. Hormonal oestrous synchronization and AI is already tested and applied by the extension service. However, efficient organization needs to be in place and technological aides need to be adopted for the program to be successful.

ii. *Heifer supply least satisfactory among breeding services:* Crossbred heifer supply was ranked as more important than AI. Heifer supply by the public sector ranches is not meeting demands. Private heifer supply is too costly. This is a key leverage point to improve delivery of improved genetics particularly to expansion of dairying in peri-urban and urban areas.

   *Impr*oved heife*r rearing intervention:* Supporting dairy cattle breeders with improved management interventions for rearing heifers, record keeping to support the heifer supply with pedigree and performance certification.

iii. *Concentrate Feed cost impacting feasibility of urban/peri-urban dairies:* The highest milk production performance of crossbreds in this study was recorded in the urban system. However, the performance level is below expected genetic potential of the breed when compared to the performance of crossbreds under station management. Besides other constraints like diseases, a lack of concentrate feed supplementation based on production level is one of the major causes of low productivity. Farmers gravely complain of the cost of concentrate feeds, especially when compared to price of milk.

   *Urba*n feed shops: Small urban feed shops which could be linked to feed processors could improve access of smallholders to concentrate feeds. This has been tested by the LIVES project and proved effective.

   Policy and research support for affordable concentrate feeds: The intervention could be addressing the means to increase supplies and trade/price issues. What can research provide for alternative low-cost commercial or home-formulated dairy ration?

iv. *Infectious and reproductive diseases/disorder serious problem across systems;* Rural farmers prefer public health service and peri-urban/urbanites prefer private services:

   Leverage points: The public veterinary service has a wide coverage with cheaper service. This sector could be a choice for the rural system. Increasing the efficiency and reliability of the service could be a point of intervention. Developing an affordable and credible private veterinary service could be a point to be considered in the rationalization of the health service in Ethiopia.

Processing, consumption and marketing node

i. *Unhygienic milk handling and consumption, particularly in rural areas:* Milk consumption as proportion of produced varies, and is mainly used as child food, with adults mainly consuming dairy products like buttermilk. Raw milk consumption is reported in some rural areas. Milk handling practices also increase exposure to risks of zoonosis.

   *Hygienic milking technologies: Small-scale milking machines help reduce the risk of milk contamination, maximize milk harvesting and ease rural wome*n's milking labour. The technology can be introduced to cooperatives or groups of rural farmers for own use or as a business providing milking services to villagers. A manual version of the machine is more suitable for rural areas.

ii. *Price of milk too low for producers, varies between systems:* The price paid for milk is not comparable to the cost of feed and other inputs for dairying. Urban and peri-urban farmers fetch more income from milk sale due to higher prices per litre.

Linkages between value chain actors: Linkages among actors and collective action is a means to increase the bargaining power and reduce the costs of transaction for smallholders. Linkages could be established between groups of producers and directly with consumers, particularly institutional consumers like hospitals, hotels, milk shops and medium-scale milk processing plants.

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