

# ASSESSMENT OF DAIRY VALUE CHAIN SUSTAINABILITY, CONSTRAINTS AND OPPORTUNITIES IN AKSUM, CENTRAL TIGRAY, ETHIOPIA

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➤ Supporting Information

**ABSTRACT:** Describing the sustainability of dairy value chain and showing the clear gaps of the sector is important for bringing continual improvement that can support the livelihoods of dairy farmers and the wellbeing of environment. To facilitate a balanced practice on the three pillars of sustainability (people, planet and profit), a regular updating of the existing situation of dairy production is crucial. Therefore, the objective of this report was describing the sustainability of dairy value chain in Aksum district, and shows clearly the gaps of the sector that needs urgent action for continual improvement. Desk study for gathering secondary information was employed. Different analytical tools were used to analyze and present the result. In Aksum, milk is produced by mainly smallholder farmers, dairy cooperatives and few commercial medium scale farms. The production system is operated by gender inclusive system which is in line with sustainable dairy. The production potential of milking cows is very poor that is mainly due to poor genetic makeup and management system. The common feed is roughage that causes to the low production performance (poor economic viability) and high greenhouse gas emissions from enteric fermentation (risky for environment). The highest value addition, risks and costs are belonged to producers but the high share of margin is for processors and retailers. Therefore, this unfair share of profits, costs and risks is not a good sign of sustainable dairy development. Hence, an attempt to improve the dairy sector should consider the three pillars of sustainability.

**Keywords:** Dairy value chain, gender inclusive, smallholder farmers, Sustainability

## INTRODUCTION

Sustainable dairy farming refers to a system based on three pillars, which are environmentally sound, socially responsible and economically viable. Sustainable dairy farming requires a commitment to continuous improvement, which means that performance gaps are identified and addressed, and actions taken must maintain an appropriate balance among the three interdependent pillars of sustainability (Allan et al., 2017). General improvement of crop and livestock production practices can also contribute to climate adaptation due to improved resilience of animals and increased farm productivity and income; which means all pillars of sustainable farming would be considered (Marion et al., 2016).

Dairy farms in Ethiopia known by low milk production on average about 1.7 liters per cow/day (Yilma et al., 2011) and poor reproductive performance. Therefore, improving general dairy management, such as breeding, feeding and animal health, will lead to increased efficiency of dairy production (economic viability) and a decrease in greenhouse gas (GHG) emissions to the environment (Gerber et al., 2013). In Ethiopia's Livestock Master Plan, crossbreeding with exotic dairy breeds, and AI and synchronization, combined with better feed and health services is already in the development roadmap for dairy farming (ILRI, 2015). This is a good kickoff of sustainable dairy development in the country. Domestic demand of milk is projected to grow by 47% towards 2020 (GTP II, 2015). This can offer chances for the dairy farmers to increase their income from selling dairy products and enhance their livelihoods.

Efficient milk production is a key to sustainable development of dairying. In Tigray regional state, there are about 862,441 milking cows. The average lactation performance of the cow was 415 and 1712 litres of milk for local and crossbreed cows respectively (CSA, 2016). Milk is a vital cash income sources for household consumption expenses. There are many opportunities for the development of sustainable milk production including the presence of suitable agro-ecology for the realisation of potential dairy production and the enormous market potential for dairy products (Haregeweyni, 2015).

However, information is scant on the existing situation of dairy production from the three pillars of sustainability point of view; which is important for researchers and policy makers to set out improvement considering people, planet and profit. Therefore, this study focused on reviewing and analyzing of different secondary information to describe the

RESEARCH ARTICLE

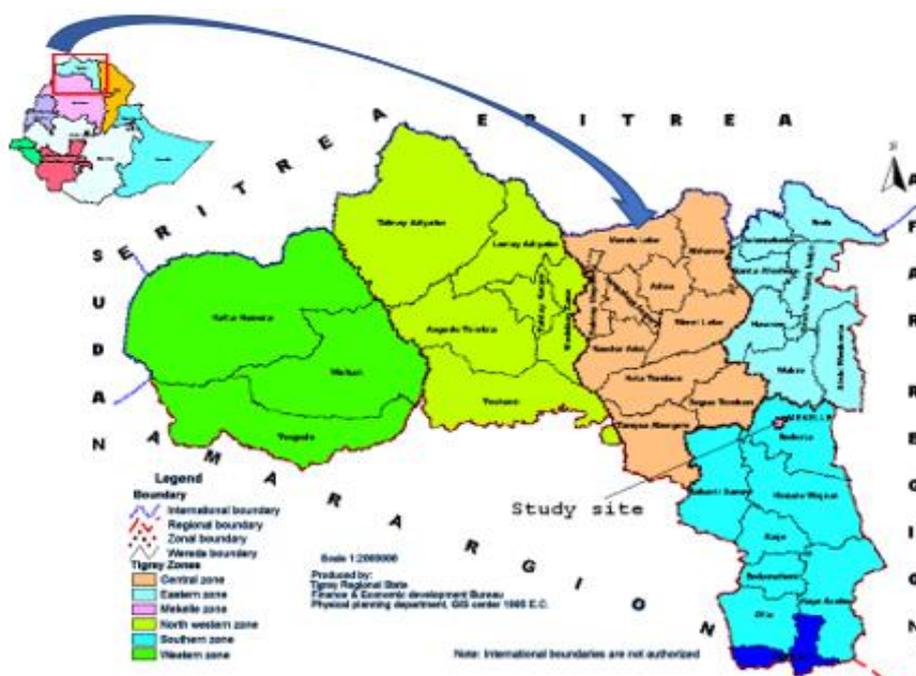
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magnitude of dairy production sustainability and clear gaps of the sectors in Aksum district which needs urgent action for continual improvement.

## MATERIALS AND METHODS

### Description of study area

The study was conducted in central Zone of Tigray regional state. Aksum is the capital city of the zone and located in Northern Ethiopia. Aksum is situated 1024 kilometres far from Addis Ababa the capital city of the country (Figure 1). The altitude of the zone is mainly falls within the category of 2000 to 3000 meters above sea level. A Large part of the district receives mean annual rainfall ranging from 400 to 800 mm. The mean monthly maximum and minimum temperature of the zone are 30°C and 10°C, respectively. The district has the largest human population in the region. Tigray region has a total of 4,791,341 cattle, and 18% are milking cows (CSA, 2016).



**Figure 1 - Map of Central Zone of Tigray (Aksum)**

### Data collection

This study was mainly done based on the secondary information from others work such as articles and institution papers from an internet search. Besides, personal experience and practical field visit were employed to generate the information.

### Data analysis

Both qualitative and quantitative methods of data analysis were employed. For qualitative data, PESTEC (Political, Economical, Social, Technological, Ecological and Cultural) and SWOT (Strength, Weakness, Opportunity and Threat) analytical tools were used to analyze and describe the strength and weakness of dairy value chain in the area. Problem tree was also applied to identify the core problem, its causes and effects of milk production. Narrative description was used to assess the sustainability profiles of dairy production from People, Planet and profit point of view (3p profile). For quantitative information, different economic parameters have used to find out the distribution of added value and share of margins among dairy value chain actors. An economic parameter like gross margin was used to analyse the benefit share and added value of dairy chain actors in the area. The gross income was estimated by subtracting the cost price of the product/unit from the sale price (revenue) of that product. Or in short:  $Gross\ income = Revenue - Variable\ cost$  (KIT and IIRR, 2008). A gross margin (GM) shows the percentage of the actor's revenue that is gross profit per unit of produce and was calculated as follows:

$$GM = \left( \frac{Gross\ income}{Sale\ price\ (revenue)} \right) * 100 \text{ (KIT and IIRR, 2008)}$$

Added value is the difference between the price the actor pays for the produce, and the price she or he sells it for. It was calculated as follows.

$$Added\ Value = Price\ received\ by\ actor - Price\ paid\ by\ actor \text{ (KIT and IIRR, 2008)}$$

Like gross margins, the size of the value share also reflects the number of costs and risks appear in the product flow by that actor. Value share was estimated by using the following formula:

$$\text{ValueShare} = \left( \frac{\text{Addedvalue}}{\text{Finalretailprice}} \right) * 100 \text{ (KIT and IIRR, 2008)}$$

## RESULTS AND DISCUSSION

### Description of dairy value chain actors

In central zone of Tigray, milk production is mainly carried out by many smallholder farmers, few medium scale commercial farmers and cooperatives. Dairy cooperatives in Aksum and Adwa town was composed from some smallholder farmers and college graduated youths (Misganaw et al., 2017). Tsehaye private dairy enterprise is one of the commercial dairy farm and act as producers, milk collectors from the neighbours, processors and wholesaler/retailer (Figur 2). Private milk and milk products shops are also play an important role in the distribution of milk to the consumers. The detailed description of available dairy chain actors is depicted in table 1.

### Available supports for dairy sector in Aksum

All milk producers are fully dependent on the support of districts livestock office and some private veterinary clinics. Besides, Dedebit Credit and Saving Institution (DCSI), Livestock and Irrigation Value Chains for Ethiopian Smallholders project (LIVES), Aksum University (AKU) and Aksum Research Center (ARC) are also involved the support of milk production in Aksum. Most of these supporters provide inputs and skills that help to realize sustainable dairy development in the area. The detail functions of supporters were presented in table 2.

**Table 1 - Key actors play role in milk production and marketing**

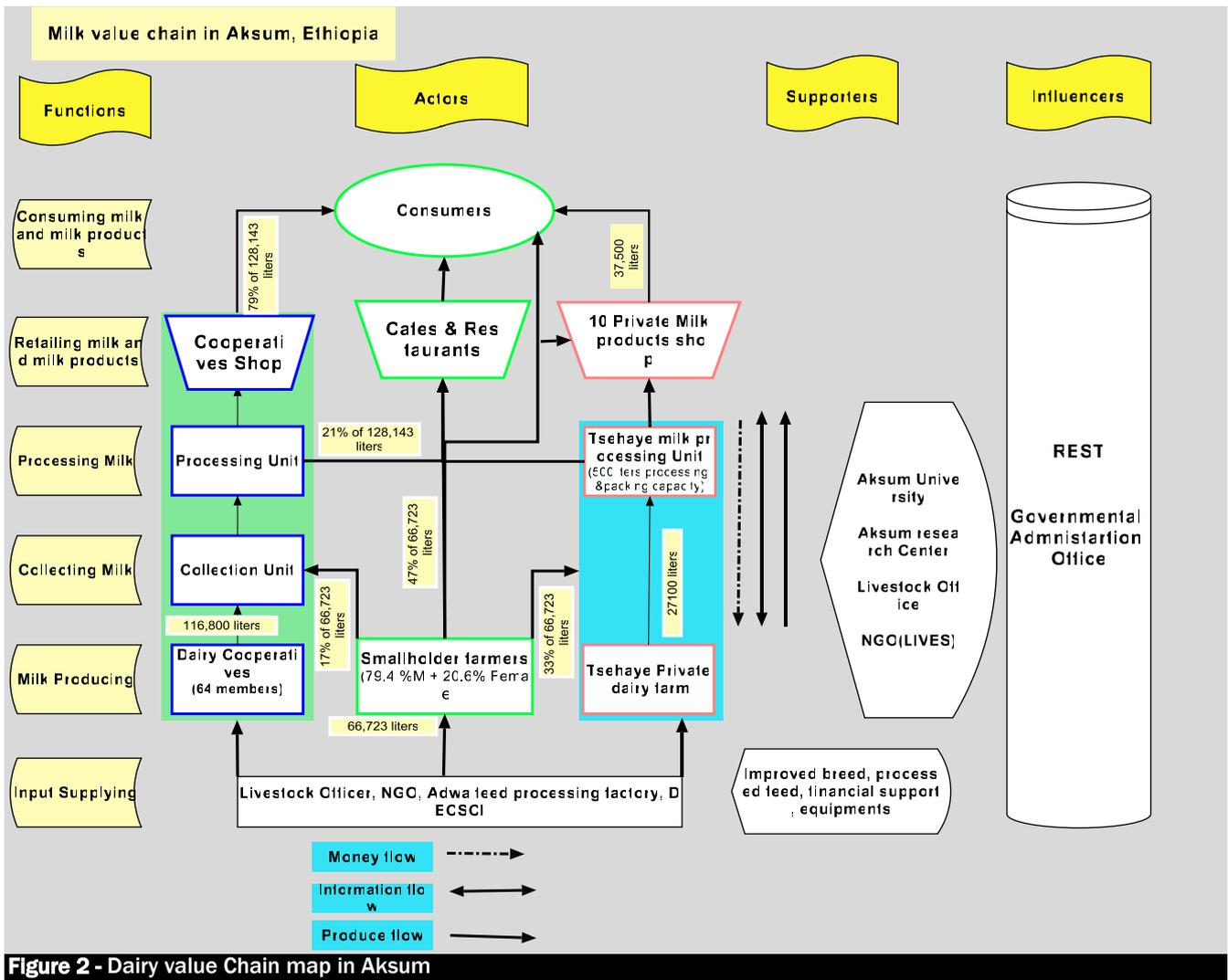
No.	Actors	Functions	Remark/Output
1	Smallholder farmers	Producing milk	Produce and supply fresh milk to collectors, retailers and consumers
2	Dairy cooperatives	Producing, collecting and processing and then retailing milk products	Produces Pasteurized milk, Yoghurt & cheese, and distribute it to consumers and hotels
3	Tsehaye dairy enterprise	Producing, Collecting and Processing milk	Pasteurized milk, cheese, sometimes cream & supplied to retailers
4	Private milk products shops	Selling milk and milk products	Receive processed milk from processors & fresh from farmers, &sell it to consumers
5	Cafes and Restaurants	Selling milk and milk products	Receive processed milk from processors & fresh from farmers, &sell it to consumers
6	Consumers	Consuming fresh and processed milk	Purchasing milk & milk products from different retailers

Sources: (Aksum University, 2016; Misganaw et al., 2017; Yaynished et al., 2018)

**Table 2 - Key supporters play role for sustainable dairy production**

No.	Supporters	Functions	Remark/Outputs
1	Aksum Livestock Office	Providing extension services	<ul style="list-style-type: none"> <li>✓ Train and advice farmers, cooperatives and retailers.</li> <li>✓ Transfer information and technology,</li> <li>✓ Providing AI and health service through experts</li> </ul>
2	Dedebit credit and saving institute (DCSI)	Providing financial source	They offer credit for <ul style="list-style-type: none"> <li>✓ farmers to purchase breeds, drugs,</li> <li>✓ Cooperatives and retailers as initial capital</li> </ul>
3	NGO (LIVES, ILRI)	Providing training and some inputs	<ul style="list-style-type: none"> <li>✓ Organizing farmers in a cooperative, providing technical skills and some processing equipment's as starting point</li> </ul>
4	Aksum Research centre	Disseminating research findings to stakeholders	<ul style="list-style-type: none"> <li>✓ Support producers and processors through research findings on constraints, quality assessment, breed improvement strategy</li> </ul>
5	Aksum University	Providing training, involved in research and community service.	<ul style="list-style-type: none"> <li>✓ Support dairy farmers in providing practical based training</li> <li>✓ Monitor and give professional feedbacks to processors and retailers</li> </ul>
6	Adwa Feed Processing Factory	Supplying formulated feeds	<ul style="list-style-type: none"> <li>✓ Formulate feeds for different class of dairy and distribute it to the dairy farmers</li> </ul>
7	Relief Society of Tigray (REST)	Infrastructure development	It's local NGO that control all foreign aid of the region and influences value chain through infrastructure development
8	Aksum governmental administration	Policy, rules and regulation	Try's to control everything and influence the milk value chain

Sources: (Aksum University, 2016; Misganaw et al., 2017; Yaynished et al., 2018)



**Figure 2 - Dairy value Chain map in Aksum**

### Sustainability profile (3P)

Sustainability measure is an essential and newly adapted parameter for successful and continual operation of a business. Any business will be sustainable if it is environmentally sound (Planet), socially responsible (People) and economically viable (Profit). Hence, sustainability of milk production in Aksum is examined according to people, planet and profit profiles, and discussed as follows.

### Socially responsible (People) dairy production

The social responsibility component of sustainability in dairy production includes elements such as: improving and maintaining the societies and communities where dairy food products are produced; good working and social conditions are valid regardless of gender, age, personal preferences, or conviction; guaranteeing food safety and public health, and improving and safeguarding animal health and welfare (Allan et al., 2017). Besides, farmers' cooperation to improve their bargaining power and existence of long-term relations among chain actors are important indicators for sustainability. These elements were used as a reference to evaluate and assess the sustainability of milk production in Aksum districts from the perspective of people profile (Table 3).

**A) Gender Involvement:** Dairy cooperatives in Aksum and Adwa are principally established from many jobless youth females, and few college graduated males (Misganaw et al., 2017). The role of women was high in the collection of milk, processing and retailing functions in their cooperative. Similarly, the ten private milk products shops in Aksum and Adwa towns owned by eight women and only two men (LIVES, 2015). But, in the case of smallholders, the contribution of women is limited to activities performed around the home. Therefore, activities like cleaning dairy shade, caring dairy cow and calves, milking, milk container cleaning and milk quality control, milk processing, butter selling were mainly performed by females while selling milk, buying and selling dairy cows and feed collection and animal breeding were also given principally for males (Zemeda, 2015). Similarly, (Gebrekidan et al., 2012) reported that in central zone of Tigray the highest participation of adult female family members was observed in milking, making and selling dairy products and calf caring in the urban areas. Besides, (Haregewoyini, 2015) also indicated that, men and women are moderately involved in feed collecting, feeding, health follow up, cleaning and herding. Therefore, this active involvement of gender in dairy production and marketing has a positive contribution for improvement and sustainability of dairy sector in the area.

**B) Chilled labor:** Family children boys were mainly involved in herding, watering and barn cleaning in both urban and peri-urban areas of Aksum district. Family children girls had less involvement in the farms and none of the hired children girls were involved in any dairy activities (Gebrekidan et al., 2012). In contrary, (Haregeweyni, 2015) reported that in Central zone of Tigray, women and female child are highly involved in milking (72.5%), processing (75%) and selling of dairy products (54%). Therefore, child labor is common in both urban and peri urban dairy production and marketing system in the study area. However, sustainable dairy operation should be free from child labor.

**C) Farmers' cooperative:** Dairy Cooperatives play a significant role in ensuring sustainable supply of raw milk to the dairy industry by coordinating the flow of milk from their members and assisting them by providing the required dairy farm inputs (FAO, 2011). Farmers' cooperation is the main tool of empowering the bargaining power of dairy farmers in Aksum and there are two female-dominated milk cooperatives in the town (Misganaw et al., 2017) which has its own positive contribution for sustainable dairy production. Some of these contributions are creating fair value share through improving their bargaining power, maintaining products quality, reducing market barriers and spoilage, improving productivity.

**D) Job creation for local community:** Dairy production is therefore an important source of self-employment, especially for rural households. A significant proportion of dairy operators also hire long-term or casual labour, which creates employment among some of the poorest segments of society, including landless households in rural areas (Staal et al., 2008). In central zone of Tigray, income and employment opportunity are common under market-oriented dairy production system. The type of labour that employed in dairy producer around Aksum district is herder, milkier, cleaner and processor. The availability of employment creation for herding of local and cross breed cow owners was 5% and 11%, respectively. The average amount of salary payment for one hired labor in Aksum was 3906 Ethiopian Birr (ETB) per year (Haregeweyni, 2015). Therefore, the dairy sector in Aksum is giving only a limited number of employment opportunities for local communities with very low salary rate. Thus, this practice contributes negatively for the sustainability of dairy production in the area. Because the communities in general and youths in particular are not well benefited from the dairy sector through obtaining decent job and income; sense of ownership and support will be reduced and they try to devastate or rob the resource.

**E) Guaranteeing food safety and public health:** In central zone of Tigray, milk production and prestige value were the main purpose of keeping dairy cattle both in urban and peri-urban areas (Gebrekidan et al., 2012). Dairy products are an essential component of the diet in the area. Fresh milk, yoghurt, butter, buttermilk, cheese and whey are among the common milk products produced and consumed by the local communities. About 51% of the communities prefer to consume milk either after boiling or souring, but, the rest proportion consumed raw milk which is not safe for health and consumption. The major proportion (75%) of produced butter is sold and the remaining proportion is used for various purposes like cooking and cosmetic. The income generated from the sale of milk products is used to purchase farm inputs, food item, education materials for their children and health services for the household (Haregeweyni, 2015).

**Table 3 - Summary of milk production sustainability performance from people profile**

Sustainability Indicators of People profile	Current situation in dairy sector	Remarks for sustainable development
Gender involvement	Better gender involvement	It should be kept the contribution of gender for sustainable development
Chilled labor	High chilled labor	Using chilled labor must be stopped in dairy sector
Farmers' Cooperative	Positive contribution	Even if their power and capacity is weak, a good start is observed (gender inclusive jobless youths are emerging to dairy sector in the form cooperatives)
Job creation for local community	Minimal and insignificant	The dairy sector can generate more jobs for the local community and has to be pay a fair wage in order to be sustained
Guaranteeing food safety and public health	Has potential risks	Especially in peri-urban areas, half of the community consumes milk in a raw state. Therefore, strict quality measurement and awareness should be made

There are no any legally registered standard quality measures for milk and milk products in Aksum. Traditionally, the communities have a mechanism to check the quality of milk products. This measurement is dependent on sensory reflections. Color (pure white), Smell (not offensive or attractive odour), and taste are the major intrinsic fresh milk quality attributes. The texture is also considered as intrinsic quality for yoghurt and cheese along with the others. Shelf life for milk by-products released from processing units is even considered as intrinsic quality attributes in the area. Packing materials for yoghurt, pasteurized milk and cheese is the extrinsic quality attributes used to check the safety of dairy products in Aksum. Even for milk and milk products, there are no international quality management systems in the country. But, the Ethiopian Food, Medicines and Healthcare Administration and Control Authority (EFMHACA) is the National Regulatory Body of Ethiopia which is under the Ministry of Health. The Authority is responsible for ensuring the quality, safety and efficacy of medicines and foods. This authority takes a sample of milk and milk products randomly at producers, processors and retailers, and then checks it in a laboratory. Later, the feedback and corrective measures are addressed through extension officers.

### **Environmentally sound (planet) dairy production**

An environmentally sound dairy production system is characterized by the adoption of practices and technology for more efficient use of natural resources per unit of animal food produced. Increasing production and improve environmental impacts through reducing emission intensity of greenhouse gas and decrease air, water, and soil pollution (ammonia, nitrate, phosphorus) are the basic elements of environmentally sound dairy production. Implementing practices to improve air quality; manage manure in ways that ensure recycling of nutrients and energy, and minimize release of gases with high global warming potential, and applying efficient grazing systems are also considered as environmentally friend practices (Allan et al., 2017).

With regard to the environmental aspect, the analysis demonstrates that the most serious impact in terms of CO<sub>2</sub> equivalent per unit of product is due to the emissions of methane in the enteric fermentation of animals; these emissions are directly connected to the type of diet fed to cattle. Besides, the production of feed and fodder, either self-produced by the companies themselves or purchased from external suppliers have also contribution for the rise of emissions (Lucio et al., 2016). In order to improve these aspects in terms of sustainability, among others, two key factors have to be considered in conventional livestock breeding such as management of feeding practices and annual milk production per hectare and per cow which means efficiency of production (Dillon et al., 2010 and O Brein et al., 2015).

**A) Efficient use of resources and milk production:** In Central zone of Tigray, the average milk yield potential of local and cross breed cows was reported approximately 2 and 7 liters/day per cow respectively. The overall average lactation length of local and crossbred cows was 193 and 233 days, respectively (Haregeweyni, 2015). Both the milk yield and lactation length are under the standard performance of dairy cows. However, the cows will consume feed throughout the year and contribute greenhouse gas emissions. According to Mulugeta (2015), the daily feed intake of local cows was ranged from 7.8 to 9.4 kg in dry matter (5.28 to 7.07 roughage and 2.68 to 2.74 concentrate feed). Hence, we can conclude that dairy animals in Central zone of Tigray are not as such efficient producers and there is a probability of high greenhouse gas emission per unit of products. About 99% of dairy farmers have access to get Artificial insemination service and the average conception efficiency was 85.5% (Haregeweyni, 2015). Possible reasons for these low performances of dairy animals in central zone of Tigray are poor production genetic potentials of the animals and weak management system such as feeding, health follow-up, housing and the like factors.

**B) Efficient grazing system:** Grazing was practiced by small farmers and mostly for local animals in peri-urban areas, though there was a practice to some extent in urban areas. Majority of the urban dairy producers rely on zero grazing but smaller proportions were used roadsides, hillsides and vacant plots for grazing to their dairy cattle (Gebrekidan et al., 2012). Tigray region is a model for the country in the conservation practices and wise use of natural resources; and Aksum is the one that found at the center of the region and known by conservation of natural resources that mainly practicing intensive or semi-intensive dairy farming in urban and peri-urban area. This practice supports the sustainability of dairy farming since damage of natural vegetation and soil compaction minimized. So that, lands that are not suitable for crop production are used for animal grazing and the possible competition of land between dairy and crop production will be reduced.

**C) Feed types:** The main feed resources available for smallholder dairy producers are grass and hay (Zemeda, 2015). The average amount of grass and hay produced in the dairy farmers from own lands were 184.75 quintal /year. Whereas the average amounts of grass and hay purchased from other farmers were 276.5 quintal/year (Haregeweyni, 2015). Likewise, Gebrekidan et al. (2012) reported that, the major sources of feed for milking cows in Central zone of Tigray were hay, crop residues, grazing, crop after math and non-conventional feedstuffs (like: 'Atela', kitchen waste and weeds). Concentrate feeds were rarely supplied to dairy producers by the private feed traders in Aksum and Adwa. Therefore, dairy cows in Aksum is mainly dependent on roughage feed stuffs that are not easily digested and converted to animal products. The less digestibility of the feed would increase the time of enteric fermentation and methane gas production and emission. The production efficiency of the animals will be reduced and their contribution for global warming raised; these features negatively treat the sustainability of dairy production in the area.

**D) Waste management:** In central zone of Tigray, wastes from dairy farm such as manure, urine, wastewater, and feed leftover were removed either manually as was the case in small and medium farms or through concrete drainages in the case of large farms. Urban farmers were obliged to pile the cow dung outside of the farm which caused a nuisance to the area, including the risk of local pollution due to nutrient leaching. But in the peri-urban areas, due to alternative uses of manure as organic fertilizer, waste disposal was not well thought-out as a serious problem (Gebrekidan, 2014).

Manure from the urban areas is also supplied to a limited extent to the peri-urban areas, particularly to crop producing farms. Hence, urban to peri-urban linkage is evolved informally and this should be recognized and strengthened to promote nutrient recycling and benefit both urban and peri-urban producers (Gebrekidan, 2014). On the other hand, waste disposal and its valorization thorough renewable energy production technologies (in particular the anaerobic digestion of sewage) allow for not inconsiderable reductions in the Carbon Footprint of milk production. Otherwise, piling of manure hips outside of the dairy farm is also responsible for phenomena such as the eutrophication and acidification of waters along with GHG emissions (Lucio et al., 2016).

**Table 4 - Summary of dairy production sustainability from planet profile**

Sustainability Indicators of Planet profile	Current situation in dairy sector	Remarks for sustainable development
Efficient use of resources and milk production	Very poor production and reproduction performance	Upgrading the genetic makeup of the milking cows could help to them utilize resources efficiently
Efficient grazing system	Little dependency on grazing, urban producers uses zero grazing system	Efficiently utilizing road and hill side grazing good practice and must be maintained
Feed types	Roughage feeds are common diet	Instead of fully depending on less digestible feeds that increase emission and reduces production, using concentrate feeds has double advantage
Cultivation of forage	Negligible due to land shortage	Cultivating forages through intercropping system has paramount important for sustainable dairy production
Waste management and nutrient recycling	Poor manure handling system in urban but used it as organic fertilizer in peri-urban	A promising start was observed between dairy producers and crop cultivars. Scaling up of this practices and linkage must be considered for sustainable development

### Economically viable (profit) dairy production

Food production must be economically viable: the producers and other food chain stakeholders must be able to prosper and sustain investment, while consumers need access to quality food in affordable prices. From an economic standpoint, sustainable dairy farming systems are therefore characterized by elements such as: enabling economically viable food production along the food chain, while accomplishing social and ecological goals; ensuring that farm operations obtain a fair share of the profits achieved in the food chain; supporting the ability of dairy producers to invest in sustainability improvements; adopting innovation and approaches that help farmers deal with market volatility and hence the prices of products and inputs (Allan et al., 2017). Economic viability was assessed by determining fixed and variable, direct and indirect costs, with regard to all factors involved in the milk production process (Lucio et al., 2016). However, due to information limitation; fixed cost is not accounted in the economic analysis of present study.

#### A) Revenue and variable cost of milk production

The average cost of production per liter of milk in Aksum was reported to be 6.5 Ethiopian Birr (ETB). As indicated from Figure 3, the revenue generated by milk producers from a litre of milk was 12.5 ETB. Estimation of the average variable cost includes cost of milk production, cost of transportation, labour, electricity, water, detergents and government tax, and it was 8.7 ETB for a liter of milk (Haregeweyni, 2015; Misganaw et al., 2017). Therefore, based on this information producers earn a gross income of 3.8 ETB from a liter of milk.



**Figure 3 - Average revenue and gross income of milk producers in Aksum**

#### B) Cost and selling prices of milk and milk products

C) For the producers, cost price includes the costs of feed, hired labor, transport and opportunity cost. For the processors and retailers, the cost of milk purchased, labor and transport costs were included. On top of these, processors have an additional expensereLATED to processing and packing. Producers sell a litre of milk in 12.5 ETB to processors and retailers. Then the processor processed it into at least three by-products (fluid milk, cheese and yoghurt/curd) and sells it by (18.85, 68.3 and 20.5 ETB/unit respectively) on to retailers (Table 5). Retailers purchase fresh milk directly from producers and the processed products from processors. Finally, the retailer sells these dairy products to consumers.

**Table 5 - Cost and sale prices of milk and milk products**

Items (measured ETH Birr/liter)	Producers	Processors	Retailers
<b>Total Cost price/unit</b>			
Fresh milk	8.7	–	12.5
Pasteurized milk	–	15.75	15.75
Cheese/kg (4-liter milk = 1kg cheese)	–	57.49	65.3
Curd/Yoghurt	–	16.1	17.5
<b>Sale Price/unit</b>			
Fresh milk	12.5	–	16.8
Pasteurized milk	–	18.85	25.75
Cheese	–	68.3	72.35
Yoghurt	–	20.5	21.65

Sources: Haregeweyni (2015); Yaynished et al. (2016) and Misganaw et al. (2017)

#### D) Gross margins and value share

Based on the above data (Table 6), gross margin and value share were calculated and presented as follows. Gross margins show the percentage of the actor's revenue that is profit. It's calculated as the gross income divided by the revenue and multiplied by 100 (KIT and IIRR, 2008). We can see that producer have a gross margin of 30.4% from pasteurized milk sales, while the retailers have highest gross margin 51.5 % from this product (Table 6).

Value share is calculated by the actor's added value divided by the final retail price and then multiplied by 100 (KIT and IIRR, 2008). Note that the percentage sum of value shares equals to 100%, but the gross margins do not. In the fluid milk, producers earn 48.5% of the final retail price, while the processors receive 24.3% and the retailers gain 27.2%. The value share of producers is high (69.1%) in cheese product, but it is low for final retailers (5.6 %). In yoghurt, the trend is the same as cheese; producers have a high-value share.

Like gross margins, the size of the value share also reflects the number of costs and risks appeared in the chain by that actor. Also, the distribution of value share tells us something about the type of product. When the consumer buys a product as it produced, such as fresh milk, then there has been little value added (only transport). So that, it expected that producers have the highest value share (74.4 %) than retailers (25.6 %) (Table 6). Therefore, processors and retailers are taking the profit/advantage on the expense of producers. This type of unfair share of values is not a good sign of sustainability. Because, the major value is added by producers and the highest costs and risks of milk production are laid on producers.

**Table 6 - Gross margins and value share per dairy products among actors.**

Products	Actors	Cost price	Sale price (revenue)	Gross income	Added value	% Gross margin	% Value share
Fresh Milk	Producers	8.7	12.5	3.8	12.5	30.0	74.4
	retailers	12.5	16.8	4.3	4.3	25.6	25.6
Pasteurized milk	Producers	8.7	12.5	3.8	12.5	30.4	48.5
	Processors	12.5	18.75	6.25	6.25	33.3	24.3
	retailers	12.5	25.75	13.25	7	51.5	27.2
Cheese	Producers	34.8	50	15.2	50	30.4	69.1
	Processors	50	68.3	18.3	18.3	26.8	25.3
	retailers	65.3	72.35	7.05	4.05	9.7	5.6
Yoghurt	Producers	8.7	12.5	3.8	12.5	30.4	57.7
	Processors	16	20.5	4.5	8	22.0	37.0
	retailers	17.5	21.65	4.15	1.15	19.2	5.3

#### Constraints for sustainable dairy production

In the vicinity of cities or large towns of Ethiopia, milk producers have a ready market for their liquid milk. However, in rural areas outlets for liquid milk are limited due to lack of accessible infrastructure that links producers with traders and consumers. For example, a study in Tigray by the Regional Bureau of Agriculture (2006) has shown that about 45,000 litres of fresh milk/per-day is remained to be wastage due to lack of access to the market. Hence, the government should take the lead in building infrastructure and providing technical service to the dairy sector (Tsegaye, 2010).

The significant constraints of dairy production in the Central zone one Tigray (Aksum) are high cost of inputs, low volume of milk, lack of training access and low household income/low purchasing power. Unavailability of cooling facilities for milk storing, long distance and rugged topography to reach the market, fluctuation of supply and demand, low breed performance and limited transport access were also reported by (Haregeweyni, 2015) as the major hindering factors for sustainable dairy production in Aksum district. Also, the high bargaining power of milk traders, weak relationship of the dairy cooperative with its members, extended fasting period of Ethiopia Orthodox Church are also identified as the significant factors affecting sustainable dairy production.

Moreover, the lack of milk processing facilities and skills, insufficient production area, poor sanitation, unpredictable marketing system, shortage of water are treating sustainability of the dairy sector negatively (Misganaw et al., 2017). There is also a problem of linkages among dairy value chain actors, and inadequate information on how to improve animal breeding, marketing, and processing aspects that critically affect dairy production in the area. To analyze these factors, Problem tree was used to identify the main problem, its causes and possible effects on milk production in Aksum district (Figure 4).

#### Opportunities for sustainable dairy production

Dairy production in Ethiopia is expected to increase rapidly in response to the fast-growing demand for milk and milk products resulting from growing human population and rising consumer income. Provided that, appropriate interventions are made along the dairy value chain and given the considerable potential for smallholder income and employment generation from high-value dairy products (Tegegne et al., 2013). Other opportunities for the development of sustainable dairy production in Aksum are the presence of suitable agro-ecology for undertaking of potential breeds, growing of different crops and forages. Presences of supporting institutions responsible for technology adoption of artificial

insemination, estrus synchronization and health services; the huge market potential of dairy products is also considered as an opportunity (Gebremedhin and Dawit, 2013). As Aksum is the center of tourists, the hotels and restaurants require a massive amount of fluid milk and processed dairy products to satisfy tourists demand (Getachew et al., 2016). As a result, different cheese and butter types are regularly transported from Addis Ababa to Aksum town (Misganaw et al., 2017). Also, the existence of many cultural and religious holidays that creates high consumption of animal products are also favoured for sustainable milk production. To analysis and summarize the different constraints and opportunities of milk production in the area, PESTEC and SWOT analysis is integrated and presented (Table 7).

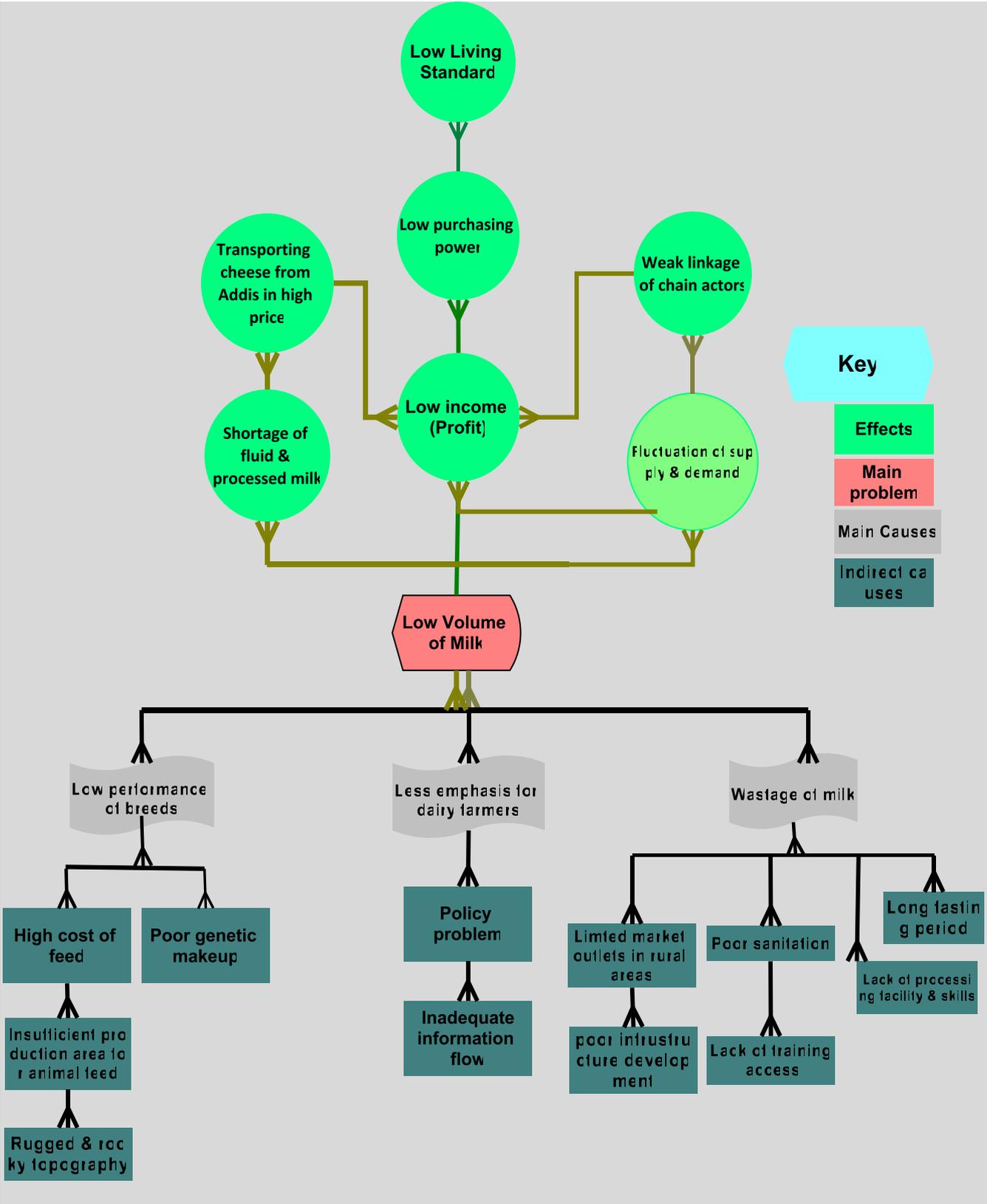


Figure 4 - Problem tree of dairy production in Aksum

**Table 7 - Analysis milk production and marketing constraints and opportunities in Aksum**

PESTEC	SWOT			
	Strength	Weakness	Opportunity	Threat
Political	- Presence of supporting institutions	- Insufficient production area - Lack of infrastructure - Inadequate data and flow of information	- Considerable employment generation	-Policy decision based on scant information -Transporting cheese from Addis Ababa
Economical	- Fast-growing demand for dairy products - Contribution to poverty reduction - Cash income sources	- High cost of inputs - Low household income - Low volume of milk	- Rising consumers income - High tourist flow to the area	- High inflation rate
Social	High bargaining power trader	- Weak coordination of dairy cooperative - the problem of linkages among chain actors -lack of training access	- Contribution to nutrition and health	- Rapid increasing of human population
Technological	- Provision of AI and Health services	- Unavailability of cooling facilities - lack of processing equipment's	- Availability of breeding technologies	
Environmental	- Suitable agroecology for forage development	- Poor sanitation	Presence of suitable agro-ecology to bring potential breeds	- Rugged and rocky topography
Cultural	- Celebration of holidays by consuming dairy products	- Use of child labour - Religion prevents consumption of Animal products during fasting time	- Existence of many religion holidays	Long fasting period

## CONCLUSION

Milk production in Aksum is operated by a different segment of smallholder farmers, dairy cooperatives and few commercial private enterprises. The services and inputs provided by dairy sector supporters are overlapping one over the other. Involvement of chilled labor, principally utilizing of roughage feeds and unfair share of margins along the chain actors are main indicators against sustainable dairy production system. Many constraints that hinder the sustainability of milk dairy production in Aksum are identified, and organized with the opportunities and strengths in PESTEC-SWOT integrated matrix. As indicated from problem tree, the main problem for sustainable dairy production is low volume of milk due to poor breeds' performance and wastage of milk due to the lack of market outlets to the consumers and less government emphasis for smallholder dairy farmers. The owner of this problem is the government office that involved in breed improvement and infrastructure development. The effect of the problem is shortage of produces in the market, unpredictable marketing system and results to low incomes of farmers which enforces them to live in a low living standard.

### Recommendations

Depending on the analysis of the report, the following recommendations are suggested for the leading supporters of dairy sector

#### For livestock office

The local and central livestock office should present most productive breeds that could be easily adapted and effective to the area. This could help to minimize carbon footprint of milk, increase income of producers and improves efficient utilization of resources.

Facilitate the possible ways realization of infrastructure development to link the rural producers with urban consumers through extending necessary infrastructure like accessible road.

Advising producers not to use child labor and children should be sent to school instead of giving task and duties in dairy farming that impedes their mental development.

Facilitate dissemination of market information to producers and providing trainings to improve their bargaining power and the share of margins.

#### For Aksum research center

Bringing and testing efficiency of modern breeding technologies (like, estrus synchronization, sex determination, multiple ovulation and embryo transfer) that speed up the improvement of genetic potentials of dairy farmers, and possible ways to change dairy wastes to worth should be considered

#### For Aksum university

Providing training on proper husbandry practices, production of quality milk, feeding and health aspects of dairy cows.

Create awareness how to contribute and lead sustainable dairy production farming from the three pillars perspective

## DECLARATIONS

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Biruh T. and Demeke H. participated in the design of study and Girma G. critically revised the manuscript for important intellectual contents

### Competing interests

The author declares that they have no competing interests.

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