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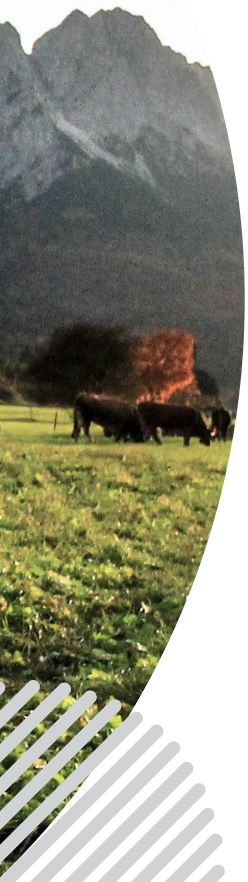
# EMPOWERING SMALLHOLDER DAIRY PRODUCTION THROUGH OFF-GRID SOLAR ENERGY IN ETHIOPIA:

## Challenges and The Way Forward

MARCH **2022**

## Disclaimer

This report was co-authored by Precise Consult's Ethiopia Market Accelerator Programme (EMA), Selco Foundation, and Selco Foundations initiative Global SDG 7 Hubs.



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# Acronyms

| | |
|---|---|
| **ACSI** | Amhara Credit and Savings Institution |
| **ATA** | Agricultural Transformation Agency |
| **CBE** | Commercial Bank of Ethiopia |
| **CSA** | Central Statistical Agency |
| **DBE** | Development Bank of Ethiopia |
| **EAFIA** | Ethiopian Animal Feed Industry Association |
| **EIAR** | Ethiopian Institute of Agricultural Research |
| **EMPPA** | Ethiopian Milk Producers and Processors Association |
| **ESAP** | Ethiopian Society of Animal Production |
| **ETB** | Ethiopian Birr |
| **EVA** | Ethiopian Veterinary Association |
| **FAO** | Food and Agriculture Organization |
| **GoE** | Government of Ethiopia |
| **LED** | Light-Emitting Diode |
| **MFIs** | Micro-Finance Institutions |
| **MoA** | Ministry of Agriculture |
| **NAIC** | National Artificial Insemination Center |
| **NVI** | National Veterinary Institute |
| **OCSSCO** | Oromia Credit and Saving Share Company |
| **RARI** | Regional Agricultural Research Institutes |
| **REB** | Regional Water and Energy Bureaus |
| **SNNPR** | Southern Nation Nationalities and People's Region |
| **TVET** | Technical and Vocational Training and Education |
| **USD** | United States Dollar |
| **VDFACA** | Veterinary Drug and Feed Administration and Control Authority |

# Executive Summary

Dairy production is a source of nutrition and income for smallholder farmers across Ethiopia. Despite having the largest number of cattle in Africa, the country is a net importer of dairy products due to inefficient production, collection, and transportation methods. The dairy sector faces several obstacles that need to be overcome to unlock its full potential. This assessment identifies the challenges smallholder dairy farmers face and how solar energy interventions can address these challenges. The ecosystem approach was used to holistically evaluate the sector in technology, policy, finance, linkage, and capacity building. Primary data from end-users and other stakeholders; and secondary data collected from relevant sources were used to conduct the assessment. The study focuses on smallholder urban, peri-urban, and mixed crop-livestock dairy farmers with market linkages that can benefit from solar energy usage.

The critical challenges identified in the dairy value chain include feed shortage, low milk quality, and inefficient butter churning methods. The scarcity and expensiveness of feed are the significant constraints that cause low milk production. Low milk quality drives collectors to reject it, causing revenue loss to farmers. The quality issue can be traced back to manual milking methods practiced widely by dairy farmers and the absence of cold storage across the various stages of the value chain. Another major challenge identified was in butter production as smallholder farmers use traditional and inefficient methods of butter churning, which typically require 2-4 hours to produce butter.

The assessment shows how solar appliances can help dairy farmers overcome these challenges and increase their efficiency and productivity. Solar milking machines can reduce the time and labor costs needed to run a dairy farm. They also improve the quality of milk produced. Additionally, cold storage systems can increase farmers' revenue by reducing the rejection rate of milk. At the same time, solar butter churners decrease the amount of time and toil required to produce butter. Solar-powered hydroponic fodder production, which utilizes solar water pumps to increase efficiency in water usage, can supplement dairy feed and increase milk production.

# Dairy Sector **Overview**

## Country Context

Ethiopia has the largest cattle population in Africa but still imports dairy products to satisfy its local demand. According to FAOSTAT, 173 tons of whole fresh cow milk, 181 tons of butter, and 178 tons of cheese have been imported to the country during 2019. Even though the number of cattle has been increasing throughout the years, the daily milk yield per cow has shown very little improvement. Among the 65.3 million cattle in Ethiopia in 2019, indigenous breeds accounted for 97.7% with average daily milk production of 1.48 L/cow, unlike hybrid breeds that can produce 10-15 L/cow per day.

Dairy production is concentrated in the regional states of Oromia (44%), Southern Nations, Nationalities, and Peoples' Region (SNNPR) (22%), and Amhara (19%), with these regions, collectively accounting for about 85% of the national milk production.[1]

There is a high demand for raw milk in urban areas due to consumer preference, and milk processing companies in these areas promote dairy farmers to engage in milk production and sale. Meanwhile, rural consumers prefer butter and cheese due to their longer shelf-life. Rural dairy farmers process milk using traditional methods and sell butter and cheese in local markets.[2]

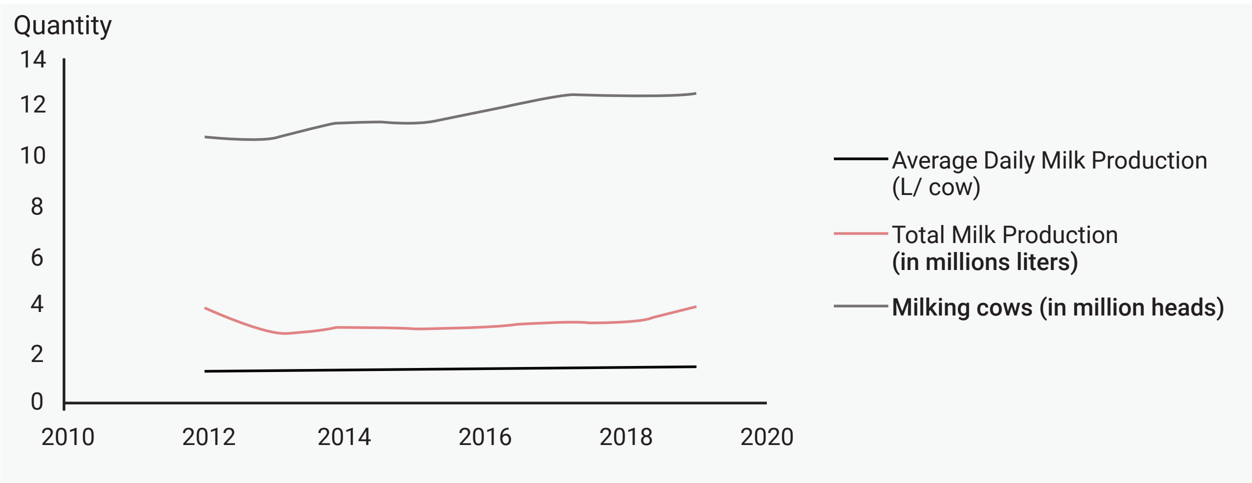



*Figure 1: Changes in the milk production and cattle population over the years*[1]

[1] *CSA Report on Livestock and Livestock Characteristics, 2019*

[2] *Productive Uses of Energy in Ethiopia, 2021*

# The Dairy-Energy Ecosystem

The dairy-energy ecosystem approach assesses the status of the dairy sector from the perspective of technology, finance, policy environment, capacity building, and linkage. This holistic approach ensures an all-rounded overview of the sector to contextualize the challenges and sustainable energy interventions.

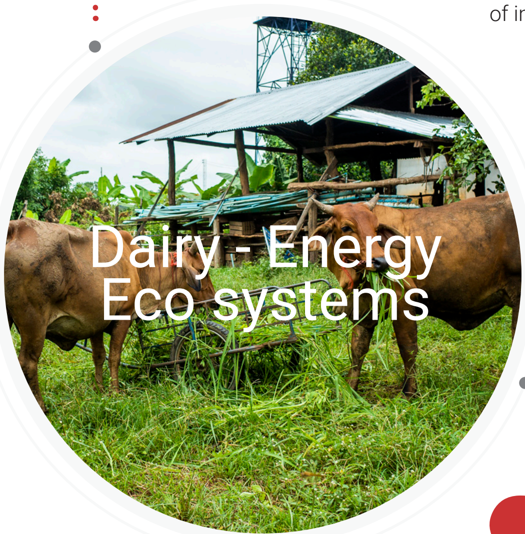
## Technology

Several companies import and assemble various solar and productive use appliances. But, the off-grid sector is still nascent in Ethiopia. The use of these technology products is generally low and most of the machinery currently in use is imported.

## Policy

The government of Ethiopia plans to develop the dairy sector to raise the average daily milk yield and total milk production of all breeds of cows, and to increase the quantity of milk-producing livestock.

The government also put in place policies to support off-grid electrification, including tax exemptions for the import of solar systems and regulations for quality control of imported products.




## Linkage

Suppliers in both the dairy and off-grid energy sectors face challenges in accessing the markets for their products as the existing supply chains have weak links. Dairy product suppliers, for instance, cite demand shortage for milk during fasting seasons as a challenge.

## Finance

Dairy farmers can obtain loans from microfinance institutions and banks to fund their purchases and scale their production. MFIs are also supporting consumer financing in the off-grid sector to improve the affordability of the products. However, the high collateral requirement and tight repayment schedules are reasons behind the low uptake of these loans. Few private solar companies are piloting PAYGo as a new way of consumer financing.

## Training and Capacity Building

Institutions such as cooperatives, associations, universities, and research centers provide training for dairy farmers on production, quality control, and health management. Stakeholders in the off-grid sector also provide training and technical assistance for youth enterprises and end-users. However, the training in both sectors is intermittent. Lack of skills to support the sectors remains a crucial challenge.

# Why Dairy?

Dairy farming has the potential to improve the livelihood of the rural population by adding nutritional value, generating income, and creating new job opportunities.

### Income and Employment Generation

The dairy sector has the potential to generate employment opportunities in milk production, collection, processing, and marketing as dairy farming is widely practiced across the country and milk production is increasing. Many smallholder farmers rear cattle and sell milk and other dairy products like butter and cottage cheese to generate income. According to CSA, 14.14 million households reported rearing cattle in 2019.[5] Growth in the dairy sector also provides rural women with the opportunity to manage cattle as well as process and sell dairy products.

### Government Focus

The government has an objective of increasing the total quantity of annual milk production from cows, goats, and camels from 4.37 billion liters to 11.8 billion liters by 2030.[4]

The government plans to distribute improved breeds and increase the average daily milk yield per cow for all breeds to achieve this goal. To encourage investment in dairy production, the government also provides incentives for investors such as tax exemption for machinery, equipment, and raw material.

### Nutritional Value

Milk has a high density of essential nutrients like protein and minerals that are important for human health, strength, and body growth, which makes it especially essential for children and patients. In 2019, nearly 36.8% of the children in Ethiopia were stunted due to a lack of nutritious diets.[3] Integrating dairy products into children's daily meals is one of the ways to lower this number. Furthermore, as urbanization and population growth rates increase, the demand for raw and processed milk as well as other dairy products has also increased. Processed dairy products like butter and cottage cheese are used to diversify the diet of families with low incomes.

[3] *The DHS Program STAT compiler*

[4] *Ten Years Development Plan 2021-2030, 2020*

[5] *CSA Report on Livestock and Livestock Characteristics, 2019*

# The Dairy Value Chain

The dairy value chain in Ethiopia consists of several stages of production and processing done by various stakeholders. The value chain includes dairy producers, collectors, and processors.

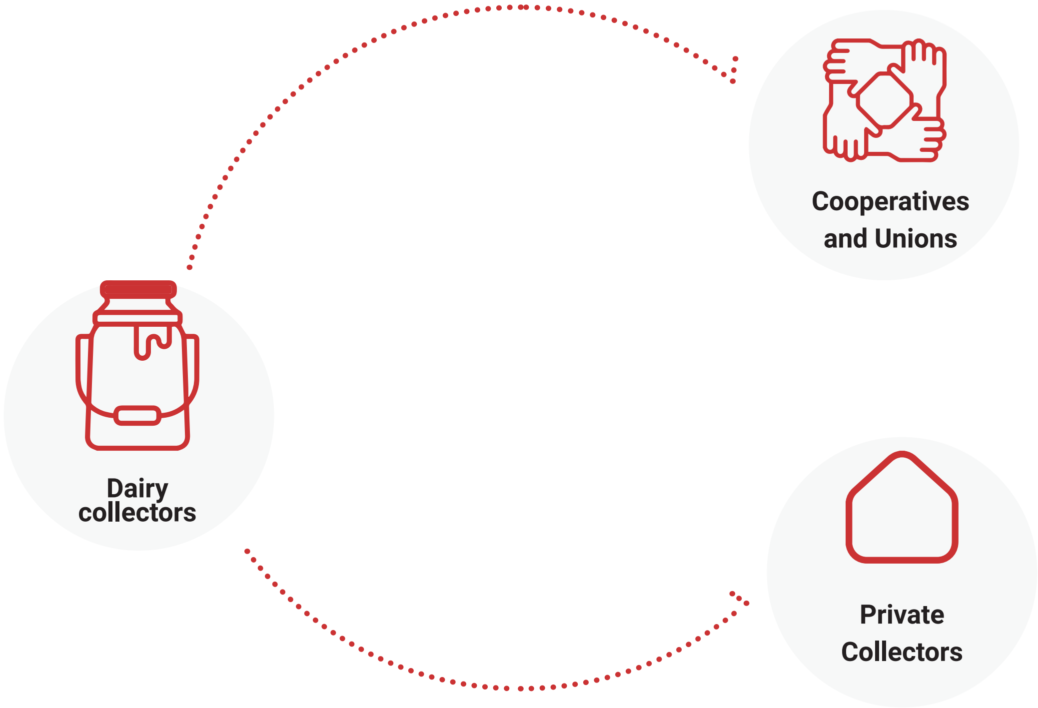
## Dairy Production Systems

Dairy producers across the country range from commercial dairy farmers that rear many improved breed livestock for commercial purposes to smallholder farmers in highlands or pastoral areas rearing a few indigenous cows for household consumption of dairy products. 98% of the total national milk production in the country is produced under mixed crop-livestock, pastoral, and agro-pastoral production systems. In comparison, only 2% of it is produced under commercial, urban, and peri-urban production systems.[6]

| | Commercial | Urban and Peri-urban | Mixed Crop-Livestock | Pastoral and Agro-pastoral |
|---|---|---|---|---|
| Location | Near major cities and town | Urban and peri-urban areas | Rural highland regions | Rural lowland regions |
| Description | Specialized farms with business licenses | Usually practiced by landless urban and peri-urban households | Dairy production is practiced together with crop production | Farmers that move seasonally to follow water sources. |
| Average daily yield | 15-20 L per cow | 10-15 L per cow | 1.9 L per cow | 1.5 L per cow |
| Breed | Exotic or crossbred | Crossbred or indigenous breeds | Indigenous breeds | Indigenous breeds |
| Feed | Hay, concentrate dairy feed and industrial by-products | Hay, concentrate dairy feed and industrial by-products | Crop residue and natural pasture | Natural pasture whose availability depends on season. |
| Aim of Production | Market-oriented | Market-oriented | Home consumption or sold for local consumers | Home consumption or sold for local consumers |
| Processing | Some produce yogurt and butter | Produce dairy products for sale | Household processing | Household processing for butter and other dairy products |
| Retail | Sell to supermarkets | Sell to private vendors, cooperatives, or milk processors | Sell to consumers through local markets | Sell to consumers through local markets |

*Table 1: Types of Dairy Production Systems in Ethiopia*

[6] *FAO Livestock, Health, Livelihoods and The Environment in Ethiopia. An Integrated Analysis, 2019*




## Dairy Collection Systems

Dairy collectors collect milk from smallholder farmers either to sell directly to consumers, sell it to dairy processors, or process it into other dairy products such as yogurt, butter, and cheese. They can be cooperatives and unions of dairy farmers, or they can be private collectors.[7,8]

**Cooperatives and Unions:** Cooperatives are formed to provide better access to markets and financial services for smallholder farmers. Some cooperatives and unions also provide inputs to their members like animal feed, financial loans, and training about livestock management.

Dairy cooperatives and unions collect milk from smallholder dairy farmers. The collected milk can be sold directly to individual customers or milk processing companies as raw milk. Alternatively, the cooperatives and unions can also process it into other dairy products to be sold to consumers.

**Private Collectors:** Private dairy collectors assemble milk from producers and sell it directly to consumers or milk processing companies. Some of these collectors also sell milk to cafes, hotels, and restaurants.

[7] *FAO Gender Assessment of Dairy Value Chains: Evidence from Ethiopia, 2017*

[8] *Investment Opportunities in the Ethiopian Dairy Sector, 2015*

## Dairy Processing Systems

**Dairy Processing Companies:** Dairy processing companies produce pasteurized milk, yogurt, butter, and cheese that can be sold in shops, supermarkets, cafes, and hotels. They collect milk from farmers, dairy cooperatives, unions, or private collectors. Processing companies are mostly concentrated in urban areas and collect milk from dairy farmers in their surrounding areas. Some cooperatives and unions are also engaged in processing milk and selling dairy products to consumers.

**Household Processers:** Smallholder farmers use traditional methods to process milk into local yogurt, butter, and cottage cheese at home. The products are then used for household consumption or sold in local markets.

# Key Challenges in the Dairy Sector

Across the dairy value chain, various challenges affect the productivity of dairy farmers and processors. Some of the key challenges observed to be mitigated by access to energy include shortage of feed, low quality of milk, and inefficient methods of butter churning. Eleven urban, peri-urban, and mixed crop-livestock dairy farmers were surveyed to identify the key challenges faced in the sector.

| | Input | Production | Collection | Processing | Retail |
|---|---|---|---|---|---|
| **Overall Challenges** | **Feed**<br>Shortage of land for fodder production. Feed is expensive and unavailable.<br><br>**Breed**<br>Inefficient artificial insemination services.<br><br>**Vaccine**<br>Inadequate vaccine provision. | **Milking and Storage**<br>Unhygienic milking and storing methods resulting in low-quality milk.<br>Absence of cooling systems on farms for storing raw milk.<br>Shortage of water for drinking and cleaning the shed<br><br>**Waste management**<br>Shortage of efficient waste disposal system for urban farmers. | **Collection**<br>Low quality of collected milk caused by the absence of cold chain for transportation and storage. | **Formal Processing**<br>Shortage of raw milk for processing causing processing plants to operate under capacity.<br><br>**Household Processing**<br>Inefficient processing methods on smallholder farms. | **Retail**<br>Seasonality of demand for dairy products which causes fluctuation in revenue for farmers.<br>Spoilage due to lack of cold storage and erratic power supply for storing dairy products. |
| **Energy Needs** | **Feed**<br>Hydroponic fodder production<br>Feed processing units<br><br>**Vaccine**<br>Vaccine cold-chain storage | **Milking and Storage**<br>Solar milking machines<br>Cold-chain for storage on the farm<br>Water pumping systems<br><br>**Waste management**<br>Biogas systems | **Collection**<br>Cooling systems for transportation and storage | **Formal Processing**<br>Butter churner | **Retail**<br>Cold storage Units |

*Table 2: Overall Challenges in the Dairy Sector of Ethiopia*

# Shortage of Feed

The quantity of milk produced in Ethiopia is very low compared to the potential production capacity, making the country a net importer of milk. Most milk processing plants that source their milk from smallholder farmers are not working at full capacity due to a shortage of input of raw milk and the low quality of the delivered milk by smallholder farmers. It is estimated that less than 10% of the total milk produced enters the formal market where cooperatives and milk processing companies collect milk from smallholder farmers for processing.[9]

Among other causes, the low quantity of milk can be traced back to insufficient feed resources. Rural dairy farmers are highly dependent on grazing for quality feed as 37% of animal feed is sourced from these lands.[10] However, due to the increase in population around urban areas, land that can be utilized for grazing is growing scarce, and stall feeding is dominating these areas. Shortage of land also inhibits farmers from growing fodder themselves to use as feed.

Dairy farmers integrate crop residue, agro-industrial by-products, local brewery by-products, and concentrate feed produced by commercial feed mills into their cattle feed. However, the inputs and supplements in cattle feed are becoming more expensive and unaffordable to smallholder farmers.

82% of the surveyed dairy farmers stated that feed is scarce, and commercially available feed is too expensive. Currently, dairy feed provided by these farmers include hay, maize, wheat or rice bran, brewery by-products, concentrate feed, and other crop remnants. One surveyed farmer had indigenous cows and depended solely on grazing. In contrast, another such farmer supplements his dairy feed with alfalfa grown in his yard.

[9] *FAO Gender Assessment of Dairy Value Chains: Evidence from Ethiopia, 2017*

[10] *CSA Report on Livestock and Livestock Characteristics, 2019*

# Low Quality of Milk

At the farm level, the milk quality can be affected by factors related to harvesting and storing methods. Unhygienic milking methods and the absence of cold storage at the farm level are the major causes of the low-quality milk collected from smallholder farmers.

**Unhygienic milking methods:** Usually, the milking of cows at a farm takes place in the morning and the evening. After harvesting, farmers deliver their milk to collectors at certain collection points where the milk is subjected to a field test. If the delivered milk does not satisfy the required quality, the milk gets rejected, adversely affecting the farmers' income.

The low quality of the harvested milk can be traced back to the manual milking method widely used by smallholder farmers which allows the milk to be contaminated by dust, fur, and/or other foreign materials. Manual milking also requires a longer amount of time, increasing the labor cost of milk production.

All farmers surveyed use manual milking to extract milk from their cows. Time required for milking crossbred cows range from 5 minutes to 20 minutes depending on the cow's behavior, the amount of milk harvested, and the experience of the person milking the cow. On the other hand, indigenous cows require 20 to 40 minutes, twice as long as some crossbred cows. Several farmers stated they have cows with clogged cow teats because they fail to extract all of the milk from the cows, which frequently happens during manual milking.

**Absence of cold storage:** It is estimated that 40% of the total milk produced across Sub-Saharan Africa is lost due to spoilage or contamination.[11] Due to the absence of cooling systems at the farm level, milk that is produced on the farm at night becomes sour and shows a high microbial count in the morning when tested at collection points. This causes the milk to be rejected, reducing the revenue of the smallholder farmer. Cooperatives and private milk collectors also require cold storage to ensure the quality of milk they collect.

55% of the surveyed farmers store evening milk in water-filled or sand-filled containers, while 36% stated that they sell milk immediately to cooperatives, vendors, or consumers to not store it and risk spoilage (9% refrigerate their milk). Some farmers have their milk rejected by collectors multiple times a month due to lack of quality.

[11] *Productive Uses of Energy in Ethiopia, 2021*

## **Case Box I:** Experiencing a decreased milk production due to inefficient milking methods: **Engida, Smallholder**

Engida is a dairy and poultry farmer in Bishoftu who currently owns 24 crossbred cows. 11 of these cows are currently providing milk. Each cow, on average provides 13 – 14 L of milk daily. The collected milk of around 150 L, is immediately sold to regular customers in the city to avoid spoilage.

Milking is done manually every morning and evening. 15-20 minutes is required to milk each cow, and it takes two workers more than an hour to milk all the cows. Since manual milking requires a lot of drudgery, as the owner stated, some workers can't extract all the milk from the cows and leave some milk in the udder. The milk then turns toxic and causes permanent blockage in some cow teats, decreasing milk yield.

During the fasting period, demand for milk decreases. So, milk is churned to produce butter as it has a longer shelf life.

Feed and medicine for the cows are also expensive for Engida. The cows are currently being fed only dried grass, bran, and maize since the other ingredients are unaffordable.

## **Case Box II:** Facing rejections and loss of revenue due to a lack of cooling: **Ararsa, Smallholder Farmer**

Ararsa is a dairy farmer and a member of a farmer cooperative. He has 13 cattle, out of which 3 are crossbreeds. They are currently providing 30 L of milk per day which is sold to the cooperative daily for ETB 21.75 per liter. He also has two indigenous cows that provide 6 L of milk daily.

Milking is done manually both in the morning and in the evening and it requires about 20 minutes for each crossbreed cow and about 40 - 60 minutes for each indigenous cow. About 5 liters of milk from the indigenous cows are churned manually for 3 and a half hours to produce butter. Ararsa sells the butter produced for ETB 480 per kilo in the local market.

Ararsa and other farmers near him that are members of the cooperative live 40 minutes to an hour away (on foot) from the cooperative in an area without proper road access. They bring milk to the cooperative either on foot or using donkeys. They store milk produced in the evening in a container filled with water and sand. They then take the evening milk together with the morning milk to the collection center, where the milk can be rejected due to low quality. But since the cooperative collects milk once a day and the milk is not properly refrigerated, it has trouble signing a contract with milk processing companies that requires quality milk with sustainable supply. Lack of the ability to store milk has also inhibited the bargaining power of the cooperative since milk cannot be stored to regulate supply.

## **Case Box III:** Making two trips daily to collect milk due to a lack of milk cooling systems: **Ada'a Cooperative**

Ada'a Dairy Cooperative is a cooperative located in Bishoftu with 421 members. Of these,103 are currently providing milk to the cooperative. Its major mandate is improving the livelihood of its member farmers by creating market linkages as it collects milk from them and sells it to end-users and factories. It used to produce and sell yogurt, butter and cheese but since the machines it owns are being maintained, it currently only sells raw milk.

Milk is collected from members in 11 collection centers after a quality check. Currently, 1000 L of milk is collected daily. A vehicle from the cooperative then collects the milk from each collection point twice a day. One trip through all collection points spans 44.4 km (88.8 km per day) and requires ETB 551 for fuel for one trip (ETB 1102 per day). Two trips are required daily as the collection points do not have refrigerators to store milk, adding to the cost of transport.

The milk is tested before collection using an alcohol test and a lactometer test and if it is determined to be spoiled, it will be rejected. The highest rate of spoilage is recorded during fasting periods as demand for dairy products decrease. Last year during the fasting period before Easter, around 27% of the milk was spoiled. Members produce local yogurt and cheese from the rejected milk.

# Inefficient Methods of Butter Churning

Due to the high perishability of raw milk, dairy farmers process milk using traditional methods to obtain yogurt (ergo), butter (kibe), and cottage cheese (ayib). There is a higher demand for butter and cheese compared to raw milk in rural areas due to their longer shelf life. Dairy farmers sell butter and spiced butter to their neighbors or at the local market. They also process milk during fasting periods as the demand and price for raw milk decrease.

According to CSA, in 2019/20 across Ethiopia, around 50.11% of the total annual milk production was consumed at home, 9.97% was sold to the market, while 39.36% was used for other purposes which include further processing to produce butter and cheese. Among the butter produced, 54.89% of it was consumed at home, and 38.6% was sold in the market which makes butter a contributor to the farmers' revenue.

Traditionally, butter is made by collecting sour milk in a pot over a few days and churning it by shaking it back and forth on the lap or on the ground until butter granules are formed. The processing and retail of home-processed dairy products are often done by women and processing can require 2-4 hours. The amount of butter collected depends on the surrounding temperature and the acidity of the milk.

The traditional butter churning method is considered time-consuming and inefficient as the amount of butter that is extracted from the milk is small, which causes revenue loss to the farmer. After the butter is extracted, the buttermilk can be used to produce cottage cheese. 73% of the surveyed farmers churn butter manually or use electric churners. Some of the farmers churn butter from indigenous cow milk to sell at the local market, while others only produce butter for home consumption or when there is lower demand for raw milk during fasting seasons. The price of butter in the local market fluctuates with the season.

## **Case Box IV:** Spending 2 hours churning milk to get one cup of butter: **Gimja, Smallholder Farmer**

Gimja and her husband Girma have two cows that are of indigenous breed and two cows that are crossbreeds. They are members of a cooperative. They buy feed for the cows from the cooperative. The cows are milked manually in the morning and evening. Each crossbreed cow provides 11-12 L of milk daily, which is sold to the cooperative for ETB 22 after a quality check. But the milk from the indigenous cows is not sold to the cooperative since it is more profitable to churn it and sell butter and cheese as it has more fat content.

Butter churning is done manually by putting the milk in a pot that can hold 10 jugs of milk and shaking it back and forth. Manual churning requires two hours, with 2-3 L of milk churned at once. Gimja gets a cup of butter from it and each cup of butter is sold for ETB 100 in a local market every Thursday and Saturday. The price of butter varies seasonally. The liquid left from the churning is used to produce cheese which is sold for ETB 300 per gallon.

All the dairy products are stored in a container filled with water due to lack of access to electricity and refrigerators. During the past month, the cooperative rejected milk from the farm three times due to lack of quality. The rejected milk is churned manually to produce butter for the local market despite its low quality.

# Potential Renewable **Energy Interventions**

Solar productive use appliances have a high potential to enhance the productivity of the dairy sector both at the farm level and across the other stages of the value chain. These appliances can increase the efficiency and quality of the milk production process, reduce milk spoilage and loss, and enable farmers to add value to their dairy products to generate more income.

Studies have shown that the financial viability of milk production decreases with the increase in distance from urban markets. Rural dairy farmers have lower daily milk yields, which is usually fermented to produce butter and cheese manually, primarily for subsistence purposes. Hence, energy usage in dairy production has the highest impact near the urban and peri-urban markets where there is high demand for dairy products and better market linkage because of cooperatives and milk processing companies.[12]

## Solar Milking Machines

Solar milking machines utilize motors and suction pumps to extract milk from the cow using a constant vacuum and convey the milk to a suitable container. Some milking machines have lighting mechanisms to assist nighttime milking and wheels for easy mobility.

Milking machines allow farmers to reduce drudgery and additional labor cost caused by manual milking. They reduce the time required for milking cows. They also help farmers avoid diseases generated from unhygienic milking practices and collect high quality milk to generate additional revenue.

Solar milking machines give farmers the ability to be independent of electric grids. They create a comfortable environment for the cows by applying constant pressure. These machines have been observed to increase the quantity of milk produced by up to 20% in some countries.[13]

## Solar Milk Cooling Systems

To inhibit microbial growth in raw milk, it is required to be stored below 4°C after being harvested from the cows. Solar milk cooling systems use chillers with batteries. They sometimes utilize ice to store energy which increases the sustainability and profitability of the system.

Milk cooling systems reduce the spoilage of milk at the farm level. This enables smallholder farmers to increase their income by selling high quality milk to collectors without being rejected due to low quality. Refrigerators can also be used to store other dairy products.

Additionally, milk chillers are essential for cooperatives and unions as they can be used to store milk at collection points enabling the cooperatives to collect high quality milk and regulate their supply.

[12] *Productive Uses of Energy in Ethiopia, 2021*

[13] *Solar Powered Technologies for the Smallholder Dairy Industry in Malawi, 2020*

# Solar Butter Churners

A butter churner works by agitating milk using a rotating device to produce butter. Churning efficiency is measured in terms of the amount of milk fat recovered and the time consumed. Solar butter churners enable women in areas without grid connection to reduce the drudgery and the duration of time needed by the traditional methods of manual butter churning. As butter has a longer shelf life when compared with milk, churning butter enables farmers to store and utilize it for sale or diversify their diet. Processing butter enables farmers to add value to their products and generate additional revenue.

# Solar-Powered Hydroponic Fodder Production

Hydroponics is a method of growing fodder crops that can be utilized as cow feed without soil. Crops like barley and alfalfa can be produced in nutrient-enriched water. Solar energy can be used to power water and air pumps to increase the system's efficiency. Solar energy can also be used to supply adequate lighting for an indoor hydroponic system.

Dairy farmers that do not own enough land for grazing or crop production can use this method to grow green fodder that can be used to supplement dairy feed and increase the quantity of milk produced. It has a more efficient utilization of water, which makes it suitable for farmers who live in areas with a water shortage. The production cycle in hydroponic production can be as short as 7-9 days, enabling farmers to produce on-demand feed. It also allows farmers to avoid diseases and pests that would have been enabled by growing crops on the soil.

# Enabling Ecosystem **for Solar Interventions**

To enable smallholder farmers to acquire the maximum impact from solar interventions, a strong ecosystem that can sustain the technology solutions and unlock their potential is essential. Testing the efficiency of the existing ecosystem on pilots among smallholder dairy farmers is important to identify business models that are sustainable, scalable, as well as profitable.

**Technology Solutions**

Viable ownership models need to be explored to make solar interventions available for dairy farmers across Ethiopia. Solar interventions like milking machines and solar-powered hydroponic fodder production increase productivity at the farm level while being owned by individual farmers. Solar milk chillers are required at all value chain levels to ensure milk quality that reaches consumers and can be owned individually or shared among a group of farmers. Some of the interventions, such as hydroponic feed production and solar butter churners can be used to start and build a business by some farmers to provide products and services to other farmers.

**Finance Solutions**

To make solar home systems affordable to farmers, solar companies in Ethiopia have partnered with microfinance institutions in various regions to provide loans for end-users. However, the high collateral requirement to acquire the loans and the short repayment periods are challenges these farmers face. Smallholder dairy farmers also face challenges accessing loans to purchase the inputs needed to sustain their farms.

In addition, productive use equipment has a higher cost, hence a higher risk margin relative to solar home systems, making MFIs reluctant to provide loans. Availing viable

end-user financing models is important. If groups of farmers or cooperatives can own solar interventions such as solar milk chillers and solar butter churners, the initial costs and risks of the appliances will be minimized. Then, the farmers can reap the benefits of economy of scale.

### Policy Solutions

Government bodies play a fundamental role in creating a suitable environment for solar interventions. These policy measures include implementing accessible importing procedures for dairy inputs and solar products and harmonizing the requirements to conduct business in the off-grid sector across regions. The government can also support communicating the lessons from the interventions to farmers across the country and creating awareness of the benefits of using productive use equipment on the farm.

### Linkage Solutions

A strong and sustainable value chain is required to unlock the full potential of solar interventions in the dairy sector. The interventions also require an enhanced understanding of the end-users' benefits of productive use equipment. Existing solar companies utilize various linkage models, including youth enterprises, microfinance institutions, and farmer cooperatives, to avail their products near the farmers and provide after-sales service. However, for a far-reaching impact, more engagement in providing productive use equipment across the country is needed.

Dairy farmers have challenges acquiring affordable input like feed and finding a sustainable market for their dairy products, especially during fasting periods. Solar milk chillers would enable farmers to acquire additional income for high-quality milk and solar dairy processing solutions can unlock new market opportunities for the farmers through value-added products. As cooperatives are also mandated with looking for new markets for their members, owning cold solar storage or solar processing solutions would help them regulate their supply and engage new customers.

### Training and Capacity Building Solutions

Improving the skilled manpower in the areas around the farmers gives them easy access to technicians that operate and maintain these systems. Providing consistent training for local youth enterprises about solar products and how to install and maintain them increases the human resource base for the farmers to consult and creates new jobs for the youth.

Dairy farmers also require guidance on best practices in dairy management, business ownership, and the benefits and operation of solar interventions.

# Appendix I: Stakeholders in the **Dairy-Energy Ecosystem**

## Dairy Processing Companies

Dairy processing companies in Ethiopia, often concentrated in major urban areas, usually collect milk from nearby smallholder dairy farmers and process it into various dairy products to sell to consumers. Below are some of the largest dairy processing companies in the country.

| Company Name | Company Profile | Major Products |
|---|---|---|
| Sebeta Agro Industry | Established in 1998 G.C, it is one of the leading dairy processing and producing companies in Ethiopia | Pasteurized milk, UHT milk, pasteurized butter, cream and cheese, yoghurt, fruit juice, and nectar |
| Lame Dairy PLC | It was acquired from a state-owned dairy products development enterprise. | Fresh Milk, pasteurized milk, yogurt, cheese, cream butter, and butter products |
| Elemtu Milk Integrated Industry | It is a private share company established in 2009 G.C | Pasteurized milk, cream, butter, yogurt, and cheese |
| Etete Dairy | It is a private share company established in 2013 G.C | Pasteurized milk, yoghurt, butter, cream, and cheese |
| Holland Dairy | Established in 2009 | Milk and yoghurt |
| MB PLC | Established in 2006 to process pasteurized milk and milk products | Milk, yoghurt, cheese |

# Dairy Technology Companies

Several companies are currently engaged in importing or manufacturing machinery that can be utilized in agriculture, particularly in dairy production. Below are some of these companies.

| Company Name | Company Overview | Products for the Dairy Sector |
|---|---|---|
| Agro-Vet PLC | Engaged in importing and distributing equipment for dairy, beekeeping, veterinary drugs and artificial insemination, poultry, and laboratory equipment. | Dairy equipment – milk processing equipment, milk cans, milk testing equipment, cream separators, electronic milk analyzer, milking machines, animal feed, vitamins, minerals premixes, and additives. |
| Amio Engineering PLC | Engaged in providing machinery and tools, manufacturing for industrial, agricultural, and construction implementations as well as trading. | Milk processing machine. |
| AgriFarm | Imports agricultural inputs and equipment and operates in Addis Ababa. It currently imports veterinary equipment, dairy product accessories, and poultry equipment. | Dairy equipment – Churners, cream separators, lactometers, milking machines, and milking cans, veterinary drugs. |
| Marast General Mechanics | Located in Addis Ababa, it manufactures various machinery used in various sectors. | Dairy equipment – a tri-phase milk chiller with 2000 L capacity. |
| AFEsol Technology PLC | An innovation company that manufactures small and medium scale machinery. | Dairy equipment – milk processing equipment, milk cans, milk testing equipment, cream separators, butter churners, electronic milk analyzers and milking machines. |
| Electro Mecce Engineering | Engaged in manufacturing of animal feed processing equipment. | Hammer mills, vertical mixers, maize thresher, compound animal feed mill and mixer. |

# Off-grid Solar Enterprises in Ethiopia

Currently, hundreds of companies are registered as solar importers in Ethiopia. Most of these companies are distributors, while some work on assembly, productive use programs, and other innovative solutions. Below are some of the biggest off-grid solar enterprises that have an influence on Ethiopia's off-grid sector.

| Company Name | Company Overview | Off-grid Products for Agriculture | Distribution Channels |
|---|---|---|---|
| Yasart Engineering PLC | Engaged in supplying, installing, testing, and commissioning electromechanical solutions. | Currently importing productive use appliances, specifically solar pumps. | Direct sales |
| LYDETCO PLC | Engaged in importing and distributing solar products and components. | Currently importing solar pumps and lanterns. | MFI<br>Youth Enterprise<br>Sales Agents |
| Solar Development | Engaged in importing, distributing, consulting, and installation of solar products. | Works on solar pumps and solar lanterns. | MFI<br>Youth Enterprise<br>Sales Agents |
| ACME Engineering and Trading PLC | Engaged in importing and distributing solar products. | Currently working on solar pumps and solar lanterns. | Sales Agents<br>Representatives |
| Sun Transfer PLC | Services include the import and distribution of solar products. | Currently working on importing solar pumps and solar lanterns. | MFI<br>Youth Enterprise<br>Sales Agents |
| Rensys Engineering and Trading PLC | Engaged in distribution and marketing of solar products. | Currently working on solar lanterns and solar pumps. | Hidase Telecom<br>Youth Organization |

# Government Institutions

Below are government institutions relevant to the dairy sector that work on formulating policies, conducting research, and implementing solutions.

| Institution | Mandate |
|---|---|
| Ministry of Agriculture (MoA) | • The Ministry of Agriculture has a livestock department that consists of three main departments: Animal Production, Animal Health, and Pastoralists.<br>• It is responsible for the development of policy and strategy in the agriculture sector and oversees their implementation at the federal and regional levels.<br>• The Agricultural Offices at the regional level and woreda (district) level also implement regional-level policies and strategies. |
| Ethiopian Meat and Dairy Industry Development Institute (EMDIDI) | • It has the objective of developing the meat and dairy sector and improving the competitiveness of the sector in the global arena. It has prioritized the agro-processing sector. |
| Veterinary Drug and Feed Administration and Control Authority (VDFACA) | • Accountable to the Ministry of Agriculture, VDFACA formulates policies and legislation governing veterinary drugs and feed.<br>• It is responsible for controlling the quality and safety of veterinary drugs and animal feed in the country, issuing certificates, and setting standards for those who intend to import and distribute vet supplies.<br>• It is also responsible for preparing the list of veterinary drugs and feed additives for the country and revising the list when necessary. |
| Ethiopian Institute of Agricultural Research (EIAR) | • It is a federal agricultural research institute responsible for running research centers, conducting research at its federal center, as well as operating Regional Agricultural Research Institutes (RARIs) at various locations across the country.<br>• It is also mandated with advising the government on agricultural research policy formulation. |
| National Veterinary Institute (NVI) | • It has been the major provider of vaccines for livestock production in Ethiopia, including poultry. Its core business is the production of vaccines for livestock diseases.<br>• It also provides feed analysis services and laboratory tests. |
| Agricultural Transformation Agency (ATA) | • It is an agency created to help accelerate the growth and transformation of Ethiopia’s agricultural sector.<br>• It conducts studies to identify constraints in agricultural development and recommends solutions to ensure sustainable transformation. It also supports the implementation of the solutions to ensure the effectiveness of agricultural development activities. |
| Regional Water and Energy Bureaus (REBs) | • These are government bodies that sign Memorandums of Understanding with solar companies to enable the companies to operate and distribute solar products in their respective regions.<br>• They support rural electrification in off-grid areas and oversee issues related to product quality and marketing in their regions. They also help link companies with youth enterprises as well as develop regulations for using youth enterprises to distribute solar products and provide maintenance.<br>• They also provide direct support in the promotion of solar products to farmers using REB experts. |
| National Artificial Insemination Center (NAIC) | • Established under the MoA, it is the main provider of artificial Insemination services. It produces and distributes semen and liquid nitrogen based on the requests of regions.<br>• The center maintains bulls of 50% and 75% of Friesian and Jersey breeds, crossed with indigenous cattle of Ethiopian Boran, Arsi, Begait, Fogera and Horro. |

# Financial Institutions

## Banks

There are currently 18 banks in Ethiopia, 17 of which are commercial banks, and one is a development bank. All banks provide loans and credits for agricultural operations. Out of these 18 banks, 2 are public, while the rest are private. The two large state-owned banks in Ethiopia are:

**Development Bank of Ethiopia (DBE):** It is one of the state-owned financial institutions engaged in providing short-, medium-, and long-term credits. The bank provides loans for commercial, agriculture, agro-processing, manufacturing, and extractive industries.

**Commercial Bank of Ethiopia (CBE):** It is the biggest bank and the leading loan provider in the country. It provides loans for agricultural operations.

The commercial banks and DBE disbursed ETB 271.2 billion in fresh loans in 2020, which was 14.8% higher than what was disbursed a year ago. About 24.95 billion birr (9.2%) of the loans went to agriculture. About 55.3% of these loans were disbursed by the two state-owned banks (i.e. CBE and DBE), while the private banks provided 44.7%.

## Micro Finance Institutions (MFIs)

38 MFIs hold 6% of all financial sector assets across the country. While almost all lend to agriculture (including dairy producers and processors), 14 MFIs lend to off-grid solar companies and end-users. The sector saw a 25% asset growth between 2018 and 2019.

The government has a plan for creating access to financial institutions that aims to place an MFI branch in each woreda of the country, serving an average household number of 24,000 each.

The five prominent MFIs that provide loans in Ethiopia; Amhara Credit and Saving Institution (ACSI), Oromia Credit and Saving Share Company (OCSSCO), Dedebit Saving and Credit Institution (DECSI), Omo Microfinance Institution (OMO), and Addis Credit and Savings Institution.

Amhara Credit and Savings Institution and Oromia Credit and Saving S.C are the largest among them.

- **Amhara Credit and Savings Institution (ACSI)**
  ACSI is the largest microfinance institution in Ethiopia and one of the largest in Sub-Saharan Africa. It operates primarily in the Amhara region and is working to improve the economic situation of low-income people in the Amhara region through increased access to lending and saving services. It grants loans to farmers engaged in small ruminant fattening, poultry, and related livestock businesses. These loans are usually provided on a group guarantee basis and are mostly short term.

- **Oromia Credit and Saving S.C (OCSSCO)**
  OCSSCO is a microfinance institution that works to strengthen the economic base of low-income rural and urban people in Oromia. The institution provides credit, saving, money transfer, and micro-insurance services for smallholder farmers and low-income urban residents in the region via its branches.

Interest rates are 13% for micro, small and medium enterprise and farmers (monthly declining interest rates based on outstanding loan balance), 16% for women entrepreneurs' development loans, and 17.5% for business loans.

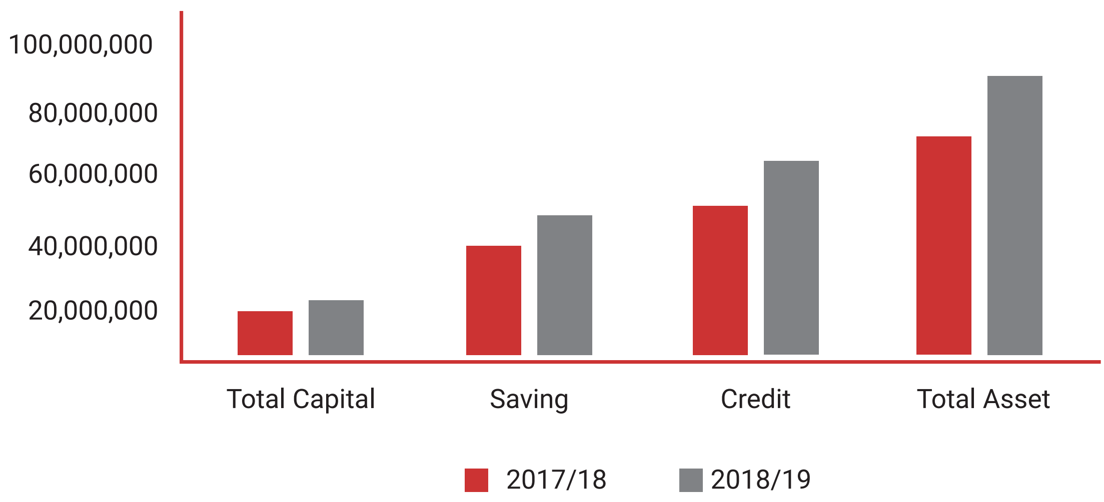



*Figure 2: Micro Finance Institution Performance as of 2019*

# Dairy Associations

The dairy sector has associations working to promote the interest of the association members among the government and other relevant stakeholders. Below are some of these associations:

**Ethiopian Milk Producers and Processors Association (EMPPA)**

| Overview | Association Objectives | Arrangement and membership |
|---|---|---|
| Established in 2006, EMPPA works together with various stakeholders to address challenges faced by the dairy sector. | The association has the objective of solving dairy farm input supply and market outlet problems. | EMPPA members include milk producers, collectors, processors, as well as input suppliers. |

**Ethiopian Dairy Cattle Breeders Association**

| Overview | Association Objectives | Arrangement and membership |
|---|---|---|
| Ethiopian Dairy Cattle Breeders Association was established in 2005. | It has the objective of providing networking and knowledge-sharing platforms for its members. It also advocates for policies that can contribute to the development of the dairy sector. | |

**Ethiopian Veterinary Association (EVA)**

| Overview | Association Objectives | Arrangement and membership |
|---|---|---|
| EVA contributes to the emergence of an efficient, effective, and competitive livestock industry. It is dedicated to policy advocacy, development, promotion, and dissemination of knowledge and good practice in the livestock sector. | It strives to protect the interests and rights of veterinarians. It serves as a bridge between veterinary medicine and other professions by creating a networking platform. It also supports veterinary and educational activities, qualities, and standards. | EVA has a general assembly of two executive boards. Its members are veterinarians. |

# Dairy Associations

**Ethiopian Society of Animal Production (ESAP)**

| Overview | Association Objectives | Arrangement and membership |
|---|---|---|
| ESAP is a platform and knowledge hub of animal scientists, policymakers, researchers, farmers and pastoralists, and stakeholders in the private sector. | It mainly works on creating a sustainable and resilient livestock sector. | It has a General Assembly with an executive body. Members include charities and social agencies. |

**Ethiopian Livestock Traders Association**

| Overview | Association Objectives | Arrangement and membership |
|---|---|---|
| The association is established with the main objective of promoting domestic and international livestock trade. | Provides linkage from producers to the export market.<br><br>Advocates for the sector as well as conditions animals in feedlot areas for export. | Members are domestic livestock traders and feedlot operators. |

**Ethiopian Animal Feed Industry Association (EAFIA)**

| Overview | Association Objectives | Arrangement and membership |
|---|---|---|
| It is a non-profit organization established to transform the Ethiopian animal feed industry. | It engages in enhancing the understanding and cooperation between the members and the public sector regarding the animal feed industry.<br><br>Has the objective of improving the quality and availability of necessary production inputs. | General Assembly and a board govern it. Members include feed factory owners, private dairy farmers, and dairy cooperatives. |

# Training and Research Institutions

Several institutions, including TVETs, actively engage in dairy-related research and development activities. They offer courses to students, farmers, and extension workers.

| Institution | Poultry Research Activities |
|---|---|
| The TVET system (Technical and Vocational Training and education) | All the regions have two or more Agricultural TVETs, all of which include livestock training in their programs.<br>They offer short courses for farmers, extension officers, and government extension workers at woreda level. |
| The Pan African Veterinary Vaccine Center (AU-PANVAC) | Provides training and technical support services to veterinary vaccine and quality control laboratories.<br><br>Controls the quality of veterinary vaccines produced in and imported to Africa and facilitates the standardization of veterinary vaccine production and quality control techniques in Africa.<br><br>Produces and distributes essential biological reagents for animal disease diagnosis and surveillance and promote the transfer of appropriate vaccine production technologies in Africa. |

# Appendix II: Dairy Value Chain for Various Dairy Production Systems

## The Dairy Value Chain for Commercial and Urban and Peri-urban Farmers

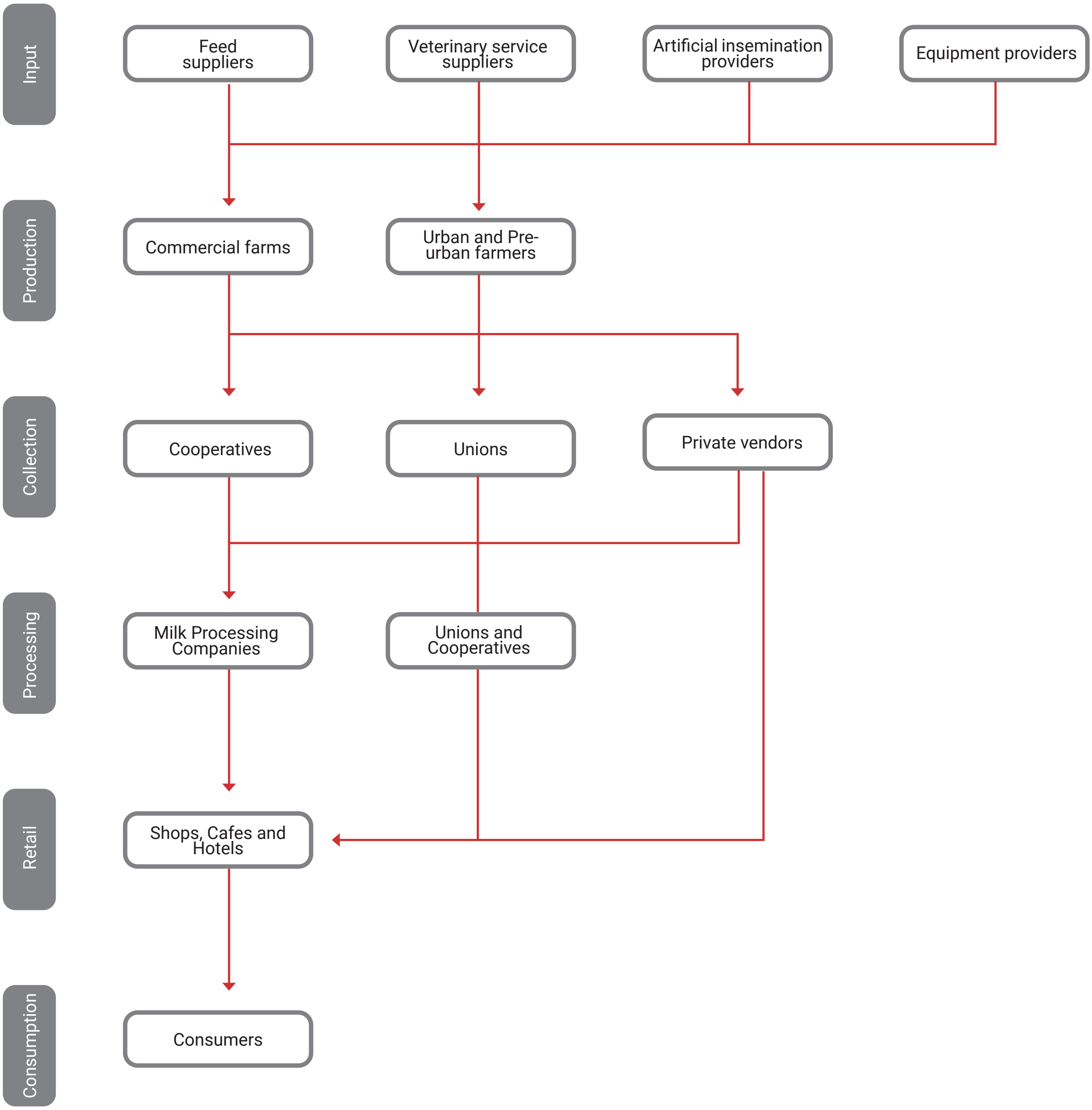



*Figure 3: The Dairy Value Chain for Commercial and Urban and Peri-urban Farmers*

# The Dairy Value Chain for Mixed Crop-Livestock and Pastoralist Farmers

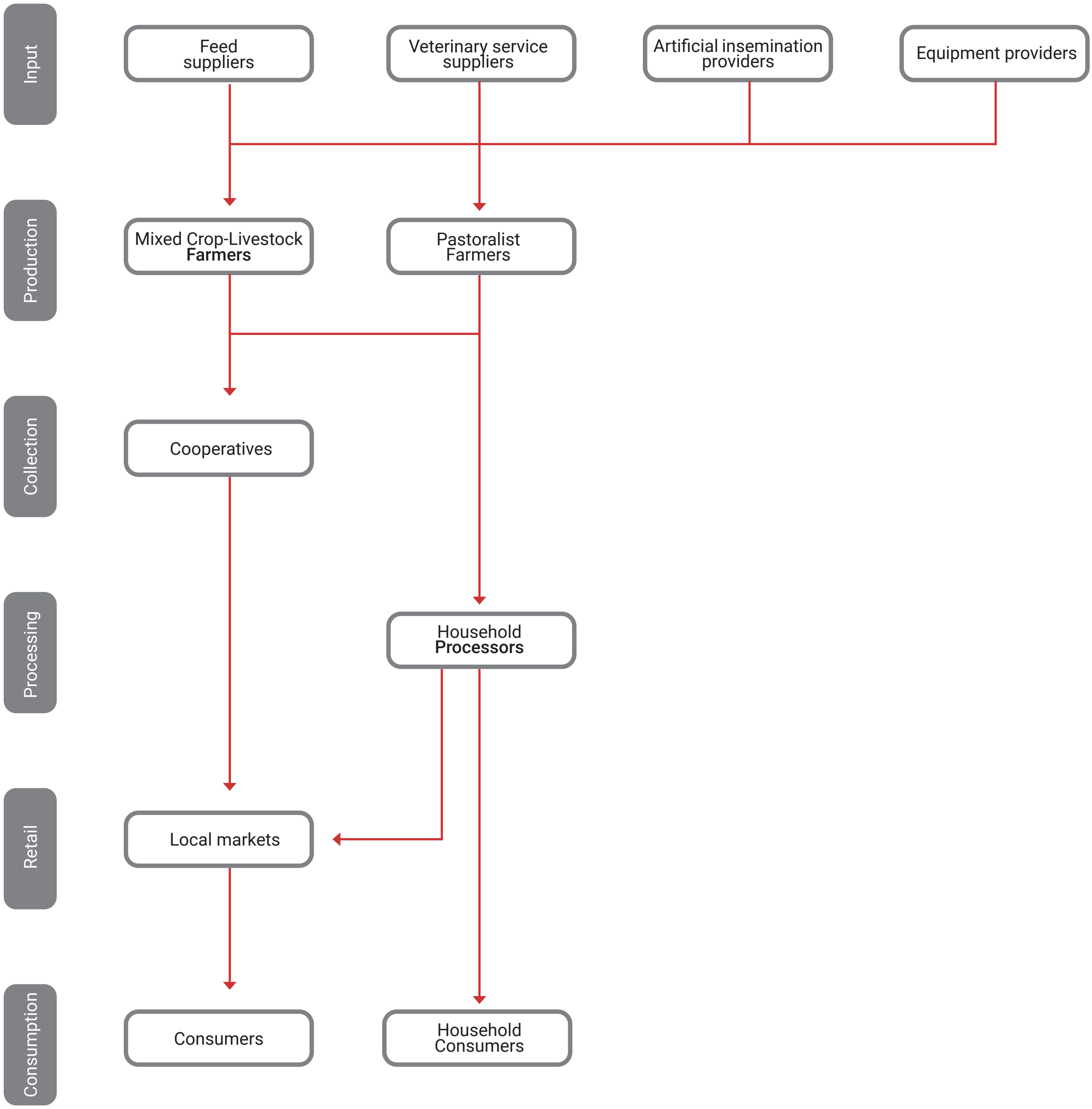



*Figure 4: The Dairy Value Chain for Mixed Crop-Livestock and Pastoralist Farmers*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