Post-Harvest Loss Reduction in Milk Value Chain: A case study of Githunguri Dairy Farmers Cooperative Society in Kiambu County, Kenya



Van Hall Larenstein University of Applied Science
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A research project submitted to Van Hall Larenstein University of Applied Sciences in partial fulfilment of the requirements for the degree of Master in Agricultural Production Chain Management, Specialization Livestock Chain

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By

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DECLARATION

I, Mariam Salum Katarama, hereby declare that the work presented herein is original work done by me and has not been published or submitted elsewhere for the requirement of any degree programme. However, literature work done by others and cited within this thesis has been acknowledged and listed in the reference section.

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DEDICATION

This thesis is dedicated to my dear mother and beloved daughter Genevieve for their endless love, encouragement and support. May the Almighty God bless you.

TABLE OFCONTENTS

DECLARATION *4*
DISSEMINATION CONSENT *5*
ACKNOWLEDGEMENT *6*
DEDICATION *7*
TABLE OFCONTENTS *8*
LIST OF TABLES *10*
LIST OF FIGURES *11*
LIST OF ABBREVIATIONS *12*
ABSTRACT *13*
CHAPTER 1: INTRODUCTION *14*
CHAPTER 2: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK *17*
Information flow and chain relation **22**
Definition of Terms **22**
CHAPTER 3: RESEARCH METHODOLOGY *25*
The formula for calculating milk production and PHL **30**
Formular used in calculating PHL in the value chain **30**
Formular to be used in calculating Economic value loss at production, collection, and processing level **30**
Calculating the share of milk loss at the production, collection, and processing level **31**
Formular to be used in calculating Environmental impacts (CF) **31**
CHAPTER 4: RESULTS *33*
4.1 Results from the Interviews at collection and processing levels of the milk value chain **33**
4.1.1 Interview with Quality Assurance at GDFCS extensionists, graders and inspectors 33
4.1.2 The membership 33
4.1.3 Support services 33
4.2 GDFCS stakeholder analysis **34**
4.3 GDFCS Milk Value Chain **35**
i) Source of input 37
ii) Milk collection and transportation 37
iii) Processing of dairy products 40
4.4 GDFCS organogram **40**
4.5 Causes of milk loss at collection centres and the current strategies in place **41**
4.6 The causes of milk loss at the processing plant and the strategies for loss reduction in place **43**
4.7 Milk intake **44**
4.8 Milk rejection, spillage and loss **45**
4.9 The season difference in milk loss **46**
4.10 Quantification of Post-harvest milk loss at a collection centre **47**

4.11 Comparison of milk loss for the long route and short route 47
4.12 Quantification of milk loss at the processing plant 48
4.13 Disposal of rejected milk at collection centres and processing plants 50
4.14 Interview with District Livestock Officer, KDB, and KALRO 50
Interview with District Livestock Officer 50
Interview with KDB 50
Interview with KALRO 51
4.15 Interview with four transporters 51
Identification of point of intervention 52
i) Age and gender of respondents 54
ii) Respondent's level of education and the main source of income 54
iii) Status of the farmers surveyed 54
i) Breed of livestock kept by farmers in Githunguri. 55
ii) Milk production, lactation length and calving interval 55
i) Amount of milk delivered per week 57
ii) Means of transport used by farmers to deliver milk to collection centres 57
Disposal of spoiled milk 59
i) Farmers whose milk has been rejected at the collection centres 59
ii) Reasons for milk rejection at collection centres 60
i) Route 1F 61
ii) Route 2E 62
iii) Route 6O 62
iv) Route 7E 62
Economic impact resulting from milk loss at farm level. 67
The Carbon footprint impact of all GDFCS milk shed 67
CHAPTER 5: DISCUSSION 74
5.1 Respondents' characteristics 74
5.2 The quantity and share of PHL at the production, collection, and processing level of the value chain 74
Season with high contribution to milk loss 75
CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS 79

LIST OF TABLES

Table 1: Key informants interviewed 29
Table 2: Stakeholders of GDFCS Milk Value Chain 35
Table 3: Milk collection schedule per route 39
Table 4: GDFCS milk test parameters and their specifications 40
Table 5: Causes of milk rejection at the collection centre and the strategies used to reduce the milk loss 43
Table 6: Causes of milk rejection at the processing plant and the strategies used to reduce milk loss44
Table 7: Milk intake per route for six months (January to June 2022) 45
Table 8: The total amount of milk rejected, spillage and missing per route (Jan to June 2022) 46
Table 9: Losses between short and long route 47
Table 10: The average milk intake and loss between short and long route (extra information) 49
Table 11: Total intake and loss at the processing plant 50
Table 12: SWOT of GDFCS from the key informants at GDFCS and processing plant 54
Table 13: Comparison of production and economic parameters between short and long route 57
Table 14: Daily milk use 58
Table 15: Means of transport used by farmers to deliver milk 59
Table 16: Distance to milk collection centres per route 59
Table 17: Milk spoilage per individual farmer (Lt per week) 60
Table 18: Reasons for milk rejection at collection centres with great contribution to rejection per route 63
Table 19: Price of rejected milk 70
Table 20: Currents strategies that contribute to PHL reduction in the GDFCS value chain 76
Table 21: Intervention 80

LIST OF FIGURES

Figure 1: Milk collection channels 16
Figure 2: Kiambu Milk Value Chain 20
Figure 3: Githunguri Milk Value Chain 21
Figure 4:Conceptual framework 24
Figure 5: Operational framework 25
Figure 6: Map of Kenya showing Counties 26
Figure 7: Research framework 27
Figure 8: Sampling of milk collection route for this study 30
Figure 9: GDFCS Milk Value Chain 37
Figure 10: GDFCS feed store 38
Figure 11: milk transportation truck 39
Figure 12: Milk testing at the cooling point 41
Figure 13: GDFCS Organogram 42
Figure 14: Loss at packaging area 45
Figure 15: Milk intake Vs Milk loss 46
Figure 16: Comparison of milk rejected, spilt and missing per route in different months 47
Figure 17: Total amount of milk loss per route per month 47
Figure 18: Milk loss during the dry and wet seasons at a collection centre 48
Figure 19: Milk losses at the processing plant 51
Figure 20: Respondents' level of education 55
Figure 21: The duration of farmer's membership to GDFCS 56
Figure 22: Origin of Milk fed to calves 58
Figure 23: Reasons for milk spoilage 60
Figure 24: Frequency of milk rejection 61
Figure 25: Reasons for milk rejection 62
Figure 26: Reason with great contribution to milk rejection per season 64
Figure 27: Shares of milk loss in the milk value chain 66
Figure 28: Economic impacts resulting from PHL 67
Figure 29: Milk loss calendar 68
Figure 30: Photo was taken after focus group discussion 69
Figure 31: Disposal of rejected milk at farm level 70
Figure 32: Disposal channels of rejected milk 71
Figure 33: Farmers delivering milk in aluminium milk can 72
Figure 34: current strategies toward milk loss reduction at the farm level 72

LIST OF ABBREVIATIONS

AI	Artificial Insemination
CF	Carbon Footprint
CO_2-eq	Carbon Dioxide Equivalent
ECF	East Coast Fever
FAO	Food and Agriculture Organization of the United Nations
FMD	Foot and Mouth Disease
FORQLAB	Food Waste Reduction and Food Quality Living Lab
FPCM	Fat Protein Corrected Milk
GDFCS Ltd	Githunguri Dairy Farmers Cooperative Society Limited
GDP	Gross Domestic Product
GHG	Green House Gas Emission
KALRO	Kenya Agriculture and Livestock Research Organization
KCC	Kenya Co-operative Creameries
KDB	Kenya Dairy Board
MCC	Milk Collection Centre
MoALF	Ministry of Agriculture Livestock and Fisheries
KEBS	Kenya Bureau of Standard
NEMA	National Environmental Management Authorities
N2O	Nitrous Oxide
NGO	Non-Government Organization
NZAGRC	New Zealand Agricultural Greenhouse Gas Research Centre
PEST	Political, Economic, Social, Technology, Environmental, Cultural
PHL	Post-Harvest Milk Loss
SCC	Somatic Cell Count
SNF	Solid Not Fat
SWOT	Strength, Weakness, Opportunity, Threat
UHT	Ultra-Heat Treatment
VC	Value Chain
VHL	Van Hall Larenstein University of Applied Science

ABSTRACT

Despite the effort of different researchers in Kenya, Post-harvest milk loss in the supply chain is a persistent challenge in the dairy sector. This study was about the post-harvest loss reduction in the milk value chain using Githunguri Dairy Farmers Cooperative Society, Kiambu county - Kenya as a case study. The objective was to determine the overview of PHL and develop sustainable interventions for post-harvest milk loss reduction at the production, collection, and processing level of the milk value chain. The interview with the 18 key informants in the value chain, 2 focus group discussions and a survey with 42 farmers registered under the cooperative were the methods for data collection. The information collected from the survey was analysed by using SPSS version 26 where statistical tests such as the Independent Sample T-test were used to compare means and test significance. The descriptive statistics were run on frequency, means, and comparison of means into different groups. The interview information was coded and transcribed. The secondary data were collected by reviewing the existing literature and compared with the finding under this study for comparison. It was revealed that Friesian is the most kept dairy cattle as reported by 95% of the respondents, and farmland size owned per farmer was 2.46 acres. Farmers in Githunguri were aged between 36-60 years where 22.5% were youth. Farmers depended on livestock keeping as a source of income as identified by 90% of the respondents. The survey respondents were not aware of the amount of milk lost yearly and the economic impact incurred annually. Although, they were aware of the causes and influence of season on milk loss. The estimated amount of PHL in the Githunguri milk shed was 2,521,981.6 Lt/year (2.8%) which was equivalent to KES 113,489,172. The PHL share in the milk value chain was high at the production level (94.39%) because of the high amount of PHL (3.6%) compared to collection (0.11%) and processing level (0.01%). The carbon footprint was 183,946,723 kg CO_2-eq FPCM at all GDFCS milk sheds thus contributing 1.5% nationally. This revealed that for each amount of milk produced at the farm annually, 3.6% is lost through spoilage, spillage and rejection. The high amount of PHL at the farm level was due to milk rejection caused by mastitis, a high amount of antibiotic residue in milk, and low/high density of the milk. The milk spoilage was caused by contamination with physical dirt due to poor milk hygiene. At the collection centre, the PHL was highly due to missing milk due to rejection and error during milk measurement. At the processing level, the PHL was highly caused by spillage in packaging areas (49.8%). It was revealed that the amount of PHL between the long and short routes was not influenced by the distance. It was found that with no difference in time taken from the farm to the collection centre between the short and long routes (SD 5.228), the average time taken was 10.53 minutes per route. Additionally, the wet season has a great contribution to PHL due to mastitis incidences and physical dirt resulting from poor milk hygiene (dirt cow shed). The disposal channels of rejected and spoiled milk were feeding to animals (calves, pig and dogs), selling and home consumption and the milk with clinical mastitis were poured on the ground though other farmers were feeding to animals such as pig and dog. To reduce the PHL, the recommended intervention areas include developing information networks, training and motivating staff and farmers. Also, making the evening shift the permanent shift, establishing solar power, a quality-based payment system and a simple and affordable milking machine. However, further research is needed at the national level to determine the extent of antibiotic residue and aflatoxin levels in the milk to make a better decision in reducing the cases of antibiotic residue and aflatoxin in milk.

Keywords: Post-harvest milk loss, Milk loss, milk quality, Githunguri sub-county, disposal channels, quantity loss, carbon footprint, PHL share and economic impacts

CHAPTER 1: INTRODUCTION

1.1 Background information

According to Nyokabi et al. (2021), the dairy sector in Kenya is an important economic pillar, contributing to 40% of the Gross Domestic Product (GDP). In addition, the sector plays a significant role in household food, nutritional security, and a source of income, thus improving 2.6 million people's livelihoods. Kenya has 19,198,692 cattle, of which 6,100,00 are dairy cattle, and milk production is 3,706,796 million tons/year, with a current milk demand of 8 billion litres annually (Molenaar and Blackmore, 2015). The dairy sector has 1.8 million small-scale dairy farmers who contribute 56% of the total milk output, and the remaining 44% is from large-scale farmers. Most production systems employ semi-intensive grazing, extensive grazing, and partly zero grazing. The typical fodder used is Napier grass and maize stoves (Zavala & Revoredo-Giha, 2022; Nyokabi et al., 2018).

Despite the notable performance of the dairy sector in Kenya, it still faces challenges such as post-harvest milk loss due to poor milk quality. The identified challenge in milk quality was poor milk hygiene and bacteria count in milk (Msaddak et al., 2017). The PHL was determined since the rejected milk at different selling points, for example, at collection centres, became high, while the milk processors were under capacity (Minten et al., 2021).

According to Of et al. (2017), PHL is caused by poor or insufficient storage equipment, poor infrastructure (roads), poor market accessibility, transport, and poor milk handling practices such as using plastic buckets, which lead to milk contamination. At the processing level, it was identified that milk losses were due to poor or insufficient milk processing equipment, the processing plants' design, the employees' expertise in milk processing and handling, and the storage capacity of the processing plants.

Globally, the estimated amount of PHL in the (sub-Saharan Africa) supply chain at the production level is 24 %, and a large amount was observed at a collection centre (>34%) (Xue et al., 2017). According to KDB (2019), 0.1 % of milk is lost at the farm level, 11% during handling and storage, 0.1% during processing and packaging, and 11% during distribution and consumption. Anyango (2018) reported that milk losses due to poor handling during bulking and trading were about 1.1% while cooling centres were estimated to be 0.2 to 1.1%. Considering these losses, a large quantity of PHL was at collection centres. The identified reasons for PHL were long distances to the market, poor storage facilities, and poor infrastructure such as roads. Porter et al (2016) suggested that in reducing PHL, it is essential to know the amount of milk lost after harvesting. This study aimed to study the overview of PHL in Kiambu.

1.2 Research Commissioner

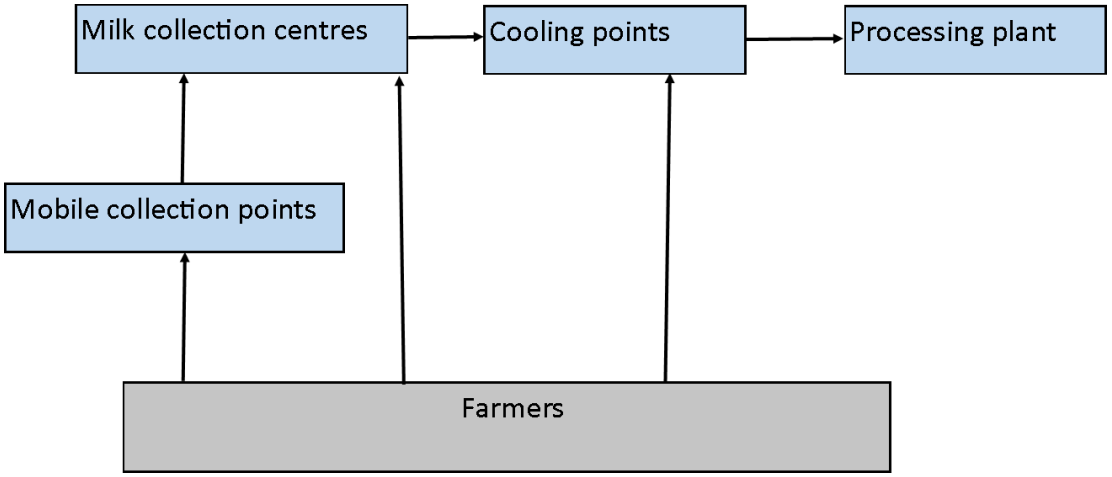
Food waste Reduction and food Quality living LAB (FORQLAB) was the commissioner of this study and owned the problem. The project aims to reduce post-harvest milk losses, improving farmers' livelihood, food, and nutrition security in Central and Western Kenya (VHL, 2022). Githunguri Dairy Farmers' Cooperatives Society Ltd (GDFCS) was a co-commissioner of this study and is more concerned with strategies that will reduce milk losses to increase the amount and quality of milk to be collected.

1.3 Githunguri DFCS

The GDFCS is a cooperative in the Githunguri sub-county owned by dairy farmers. They source raw milk from members registered under the cooperative. However, the cooperative faces challenges with the quality of milk collected from producers (in rural areas) which is not meeting the standards (GDFCS, 2022). Due to insufficient cooling points in most sourcing areas, milk passes through

many channels or levels of collection before reaching the processing plant (Figure 1). In this study, GDFCS aimed to gain insight on how to reduce PHL from farm to processing level to improve the quality of milk collected, thus increasing the quantity of milk collected for processing and contributing toward PHL reduction. Both FORQLAB and GDFCS have the same goal of contributing toward PHL reduction in Kiambu county, including the Githunguri sub-county (Muhande personal contact., 2022) and (GDFCS., 2022).

Figure 1: Milk collection channels



Adapted: Muhande personal contact., 2022

1.4 Problem statement

Milk is a perishable commodity and thus requires good handling to ensure its safety and quality. Furthermore, milk from farms passes through different collection levels to processing plants. Thus, require good management or handling during transportation, testing, and storage to avoid contamination which results in milk rejection. In general, the factors for food loss include high bacteria count, antibiotic residue, inadequate storage facilities, and poor milking methods. What is still not known yet to GDFCS is the overview of milk loss in the value chain. The cooperative business interest is to reduce milk loss and be the best and most efficient cooperative that collects and sells high-quality milk and milk products. Hence the cooperative is thinking of introducing a bucket milking machine to small-scale farmers to improve the milk quality. Also, FORQLAB is interested in improving food security in Kiambu county through technical interventions and improving structural governance. However, both FORQLAB and GDFCS lack an overview of PHL, such as the amount of milk rejected (lost), causes of loss, economic and carbon footprint impacts and what is done with the rejection. This was a knowledge gap to be filled by this study.

1.5 Project Objectives

To determine the overview of PHL and develop sustainable interventions for post-harvest milk loss reduction at the production, collection, and processing level.

1.6 Research question

1.6.1 Main research question

What is the overview of post-harvest milk losses at the production, collection, and processing level of the current milk value chain?

1.6.2 Sub-questions

a) What is the quantity and share of milk loss at the production, collection, and processing level along the milk value chain?
b) What are PHL's economic and carbon footprint impacts at the production, collection, and processing level along the milk value chain?
c) What are the causes or reasons for PHL at the production, collection, and processing level along the milk value chain?
d) What are the means of disposing of the rejected milk at the production, collection, and processing level of the milk value chain?
e) What are the stakeholder's perspectives on losses and current strategies of milk loss reduction practised at the production, collection, and processing level of the milk value chain?

1.7 Justification of the study

Dairy products, including milk, are the most important source of nutritional security, people's income, and employment in most households**.** The study focuses on post-harvest milk loss in Kiambu county using the Githunguri dairy farmers' cooperative as a case study. Four milk routes (1,2,6 and 7) out of 10 were GDCS sources. Raw milk was used in this study to determine the extent of post-harvest milk losses to develop sustainable interventions. Thus, contributing toward reducing PHL to improve food security, employment creation, and income generation for participants in the milk value chain and enhancing farmers' livelihoods.

Reducing PHL in the value chain generates multiple wins such as food security, improved economy due to high returns in their milk business, and environmental benefits (Minten et al., 2021). Quantifying milk loss in the supply chain creates awareness for decision-makers on the current situation, such as how much milk is lost, where it gets lost, and the reason for the loss. This study provides the bases for the implementation of strategies for PHL reduction in the FORQLAB project and GDFCS.

CHAPTER 2: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

This chapter presents literature on the different research topics from various sources, including reports, journals, books, and online sources like Google Scholar and Research Gate.

2.1 The Dairy Sector in Kiambu County

Kiambu county is one of the 47 counties in Kenya with twelve (12) sub-counties and 60 Wards, where Kikuyu is a dominant tribe. Its capital city is Kiambu town, whereas Thika is its largest town and seat of Government and was established in 2013. Kiambu County borders Nairobi and Kajiado Counties to the South, Machakos to the East, Murang'a to the North and Northeast, Nyandarua to the Northwest, and Nakuru to the West. Most dairy farmers are small-scale to medium-scale farmers (Kiambu County, 2018). The county has a 2,417,735 population, whereas 1,187,146 are males, 1,230,454 females, 135 intersex persons, and three persons per household (Kenya Census, 2019).

The county lies between latitude 0^{o} 25' and 1^{o} 20' to the South of the Equator and the Longitude 36^{o} 31' and 37^{o} 15' in the East. It covers a 2 543.5 Kilometers square land area. 85% of households engage in dairy farming, mostly a zero-grazing production system (Kenya Census, 2019). Kiambu county has an average annual rainfall of about 1,200 Millimeters with a temperature range of 7^{O}C to 26^{0}C. The long rains in Kiambu start in mid-March to May, and the cold seasons are between July and August. The organizations involved in the process of livestock products include Githunguri Dairies, Farmers Choice Ltd, Brookside Dairies, Ndumberi Dairies, Limuru Milk, and Palmside Dairies.

The dairy sector in Kiambu county is an important economic activity and source of nutritional security to most families and has an annual turnover of about KES 10 billion. The livestock production system practised is small-scale farming. The total number of dairy cattle in Kiambu County is about 250,000, with a productivity of about 5-9 litres per day per cow (Kiambu County, 2018) and (KDB, 2018).

In Kiambu, the dairy sector is characterized by a formal and informal milk value chain (Figure 1). The informal value chain is preferred by most milk producers due to high price offers, but the milk collected is of low quality. The formal channel markets 30% of milk produced at the farm level, while 70% of produced milk reaches consumers through informal channels. The governance system in some dairy cooperatives is ineffective. The lead actors in the chain have the most power and play a significant role in determining the quality of milk required. The relationship between stakeholders is more elaborate in the formal channel than in the informal channel, where most stakeholders have an agreement on doing business (Trienekens, 2011).

2.2 The Dairy Sector in Githunguri sub-county

The dairy sector in Githunguri is essential for most households as a source of nutritional security, income, and employment. The main dairy production system is zero-grazing, where cattle stay indoors and feed through cut and carry. Also, most livestock keepers are small-scale farmers. The dairy sector is more developed than other Kiambu sub-counties because farmers are organized in groups (Cooperatives). Farmers in Githunguri are known for their willingness to adopt new technologies. Githunguri Dairy Farmers Cooperative Society is one of the leading cooperatives. The cooperative has 26,000 members, primarily small-scale dairy farmers, but only 11,500 are active. Also, has 86 collection centres where 12 collect milk in bulk. The catchment area is about 20 square meters and divided into ten administrative regions (Muhande personal contact, 2022) and (Kiambu County,2018).
GDFCS offer inputs and services to farmers such as Artificial insemination services (AI) with superior genetics and feeds at subsidized prices. Githunguri has a contract with feed suppliers who supply them with feed at lower prices. Additionally, Githunguri Dairies have a health unit that provides extension services to farmers, such as disease treatment and AI service. Furthermore, they provide financial assistance to farmers through SACCOs

Most milk test parameters such as density and milk fat are causatives for milk rejection at collection centres when below or above standards (Muhande personal contact, 2022). This study aimed to determine the quantity of milk rejected at this level and develop interventions for milk loss reduction.

2.3 Value chain concept

The value chain refers to the activities required to bring a product or service from production to delivery to the final consumer (Orregård, 2013). These activities include input supply, milk production, milk collection, processing, distribution, and consumption. Kiambu County's milk value chain comprises chain actors, supporters, and influencers (Figure 2). The milk chain actors are directly involved in the chain and are described based on their functions along with the value chain. The milk value chain supporters are stakeholders in the milk value chain who are indirectly involved in the chain and with different interests who provide services such as financial, training, certification, and policy formulation (Mutura, 2015). These supporters include financial providers (banks), extensionists, Government, and Kenya Dairy Board (KDB). However, Kenya's milk value chain is characterized by informal and formal milk channels (Orregård, 2013) and (Nyokabi et al., 2021)

2.3.1 Milk production

According to Mutavi et al. (2016) and Omunyin et al. (2014), dairy cattle farming in Kenya is integrated with crop production such as maize. The dairy cattle include Friesian (most kept), Jersey, Ayrshire, and their crosses. Cattle farming is faced with low quantity and quality of livestock feeds, livestock diseases such as mastitis, FMD, and ECF, and insufficient financial support for investing in dairy farming. The milk production is estimated to be 5 to 9 Lt per cow per day depending on the breed and season of the year. Whereas low milk production is during the dry season.

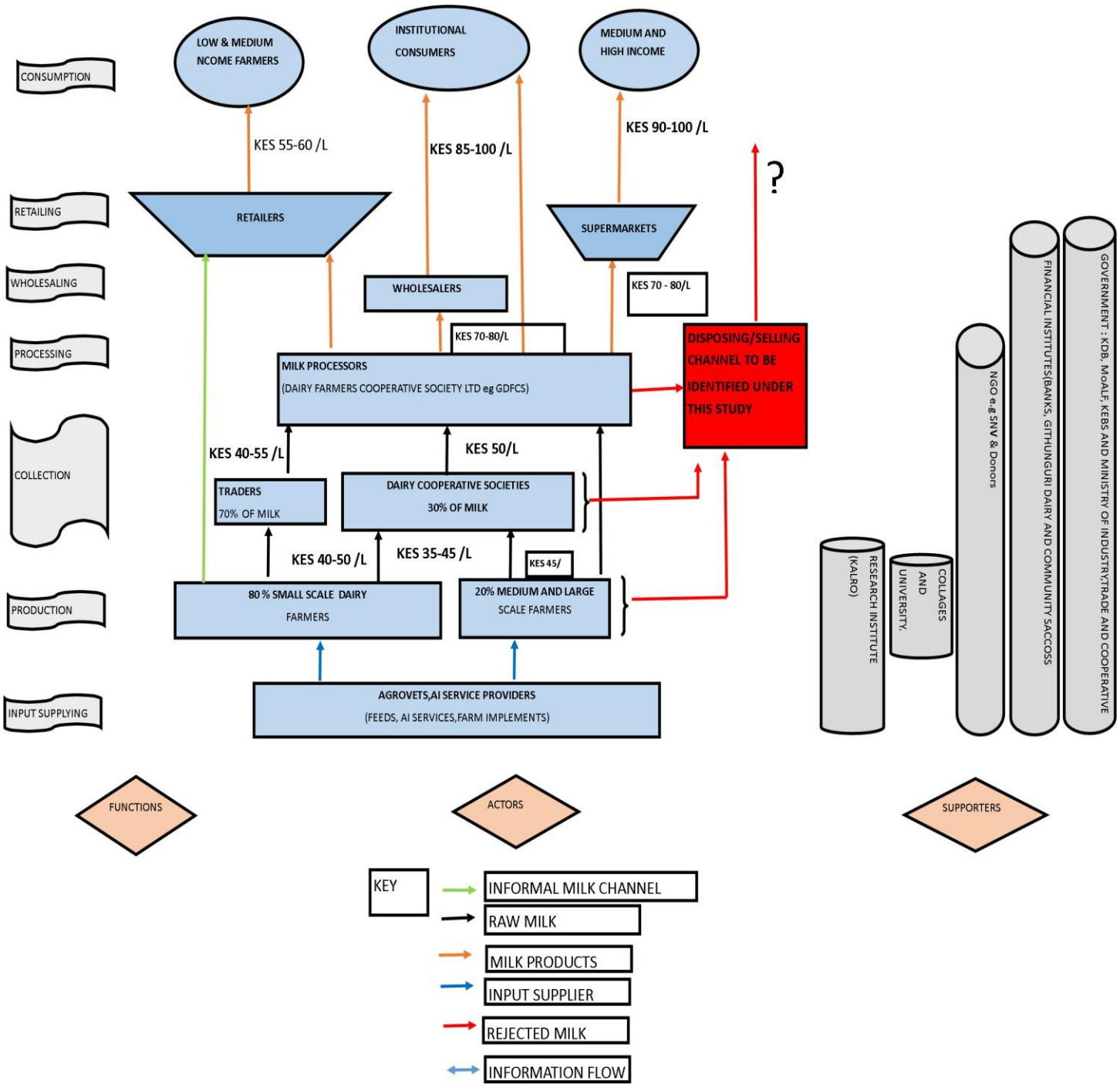
2.3.2 Milk collection

Milk collection describes the process of transporting milk from the production area to the storage point or processing plants. Challenges in milk collection in Kenya include poor infrastructure such as milk handling equipment and rough roads, especially during the rainy season leading to an increase in the cost of milk collection or transportation (Ettema, 2012) and (Cristiane et al., 2015).

2.3.3 Milk processing

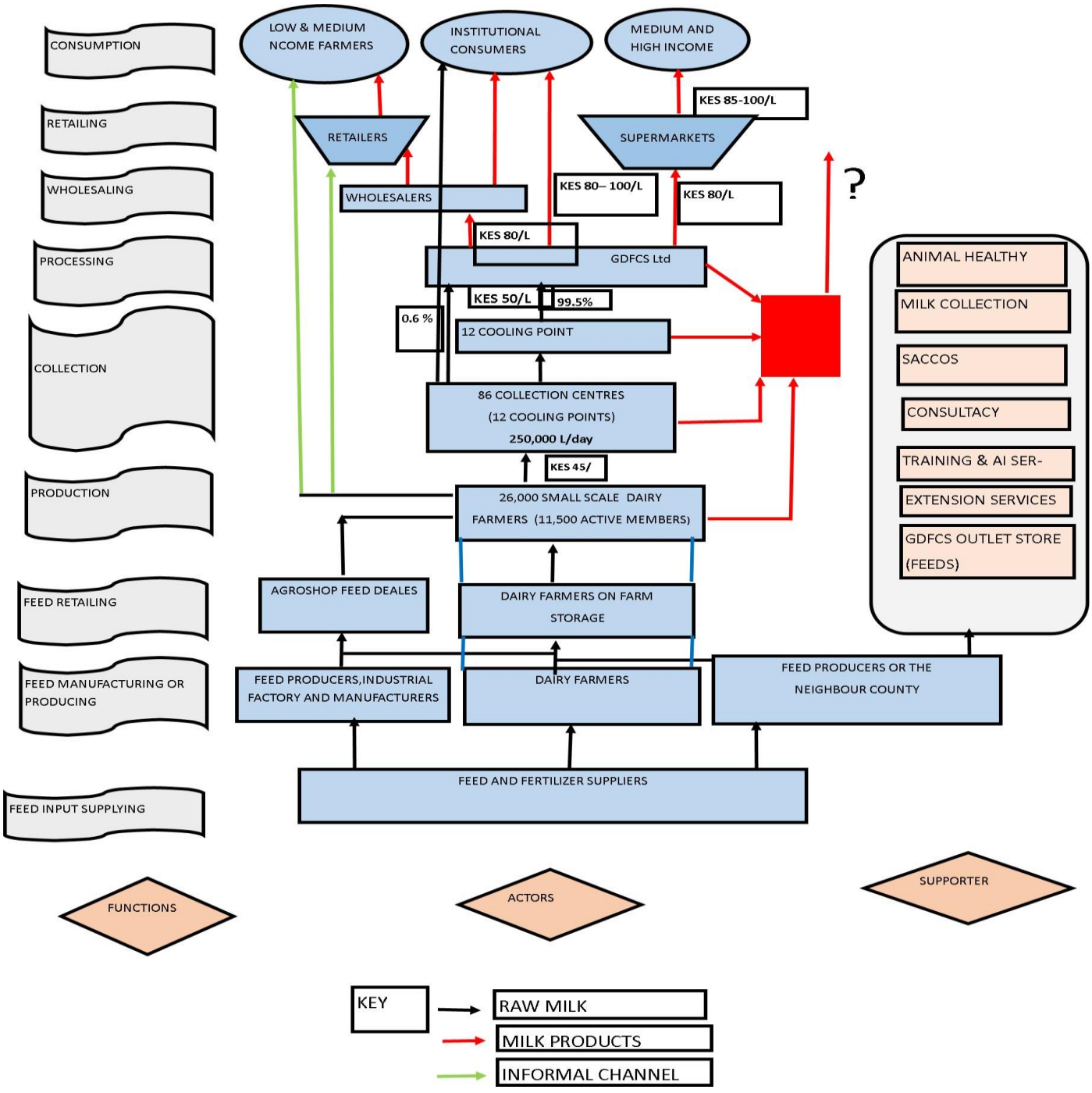
In Kenya, 30% of the total milk produced is passed through a formal market channel and processed into various products such as fresh milk, yoghurt, butter, and ghee. Kenya has about 30 active milk processors, and Brookside Dairies Ltd is a market-leading milk processor. Other dairy cooperatives include GDFCS, Muki Dairy Farmers, Mumberes Farmers, Sabatia Farmers and Cheptiret Dairy Farmers Cooperatives (Ton et al., 2016). Most cooperatives collect milk only from members of the dairy farmer’s cooperative. However, these organisation faces challenges in collecting milk for processing due to poor milk quality.

Figure 2: Kiambu Milk Value Chain



Adapted: (Muhande personal communication, 2022) and Katothya, 2017

Figure 3: Githunguri Milk Value Chain



Adapted: (Muhande personal communication, 2022); (Verschuur et al., 2021) and (Katothya, 2017)

The chain map of Githunguri DFCS differs (Figure 3) from the Kiambu County chain map in the number of players within the chain, especially on the supporting level. GDFCS has a dairy hub that provides essential services to the cooperative members to ensure sustainable production of quality

and quantity of milk for processing. However, both chains have a common interest in improving food security and producing quality milk.

2.4 Quantitative loss

According to KDB (2014), based on the amount of milk produced daily in Kenya, 0.1 % is lost at the farm due to poor quality, 11% in handling and storage, 0.1% at processing and packaging, and 11% at distribution and consumption. These losses have socio-economic and ecological impacts.

2.5 Milk quality parameters

In Kenya, including Kiambu county, the milk parameters tested include protein, density, antibiotics residues, and aflatoxins. At the collection level, milk collected does not meet the standard (microbial) set by the Kenya Dairy Board (KDB) and Kenya Bureau of Standards (KBS) leading to milk rejection before reaching the final user (KDB, 2018).

2.6 **The Greenhouse Gas Emission (GHG)**

According to FAO & NZAGRC (2019), Greenhouse gas emission in dairy cattle is dominated by methane (NH_4), followed by nitrous oxide (N_2O) and carbon dioxide (CO_2), thus contributing about 95.6%, 3.4%, and 1%, respectively. Along the milk value chain, GHG emissions arise from the transportation, Cooling, and processing of milk. Based on the study conducted on 382 dairy farms in Central Kenya, including Kiambu county, it was estimated that the average Carbon Footprint (CF) ranges from 2.2 to 3.1 CO_2-eq FPCM which is in line with FAO 2010 finding which was 1.3 to 2.0 globally. It was reported that the carbon footprint is driven by the milk yield, the use of concentrates in feeding cattle, and the herd structure (Wilkes et al., 2020) and (Ton et al., 2016). The mean CO_2-eq per kg FPCM in this literature was in line with what Vala (2019) found. The mean CO_2-eq per kg FPCM in the intensive and semi-intensive systems was 2.1 and 4.1, respectively (Vala., 2019). The mean CO_2-eq per kg FPCM used to calculate CF impact was 2.1kg CO_2-eq FPCM because GDFC engages in zero grazing (intensive system). The formula used to calculate CF include:

CF impact: total milk yield per farm * average CF/ per kg FPCM and

Total milk intake at cooperative * average CF/ per kg FPCM

2.7 Context analysis of milk value chain

In the milk value chain, environmental factors that influence how a business operates and most affect sourcing milk quality include market accessibility, infrastructure, trust, and policy and regulation. Based on studies conducted in Kenya, PHL in the value chain is associated with several factors, including market inaccessibility, especially in rural areas, poor infrastructure such as roads, and trust within the chain (Wilkes et al., 2020).

2.8 Current strategies and practices in milk loss reduction in Kiambu County

According to Kiambu County (2018), The county government of Kiambu County intends to improve the quality of milk production through improving extension services and commercialisation of dairy farming, supporting cooperatives in accessing financial support and operationalisation shared services in the cooperatives. This effort is to reduce losses and make the dairy sector sustainable.

2.9 Chain governance

Value chain governance refers to the formal and informal arrangement within the value chain between actors or between actors and supporters/influencers. The dairy sector comprises formal and informal

stakeholders along the milk value chain who have different interests in milk quality and differ in their business arrangements. These stakeholders include dairy cooperatives, milk processors, and Government agencies, and they have the power in the chain in terms of a network. The chain governance includes stakeholders' relations (coordination) and information flow along the chain, which differ between the two chains (Nyokabi et al., 2018).

Information flow and chain relation

According to Muloi et al. (2018), Information flow in the milk value chain refers to the movement of information between actors, supporters, or actors and supporters. Information flow is essential for chain sustainability in the milk value chain. Useful information flow can help researchers and policymakers reach or decide how and what to target, regulate and develop to make milk safer for the efficient chain. In addition, the relationship or connection between stakeholders influences the information flow among them, making decision-making easy.

2.10 Conceptual framework

The conceptual framework was used to show an overview of key concepts, research aspects and the research output through the Value chain and food system approach (Figure 4).

Definition of Terms

Post-harvest milk losses - A reduction of milk weight or quality in the supply chain from the production stage and collection to the processing stage (Aragie et al., 2018). According to Secondi et al. (2015), food or milk loss results from infrastructure issues, inadequate storage facilities, poor harvesting methods, and drug residues in food. However, Bellemare et al. (2017) suggested that food waste is an unavoidable waste that is considered unsuitable for consumption. Based on this definition, the study considered milk loss as the losses that occur at the initial stage of the supply chain, such as production, collection, and processing level.

Context analysis- Refers to the macro-environment that influences PHL. These include market accessibility, infrastructure, trust between cooperative members and policy and regulation (adapted: Wilkes et al., 2020).

Milk storage – The process of storing milk appropriately to prevent the growth of pathogens and spoilage of mesophilic bacteria. Thus, by putting more attention to storage equipment, time, and temperature (Hoffmann et al., 2022).

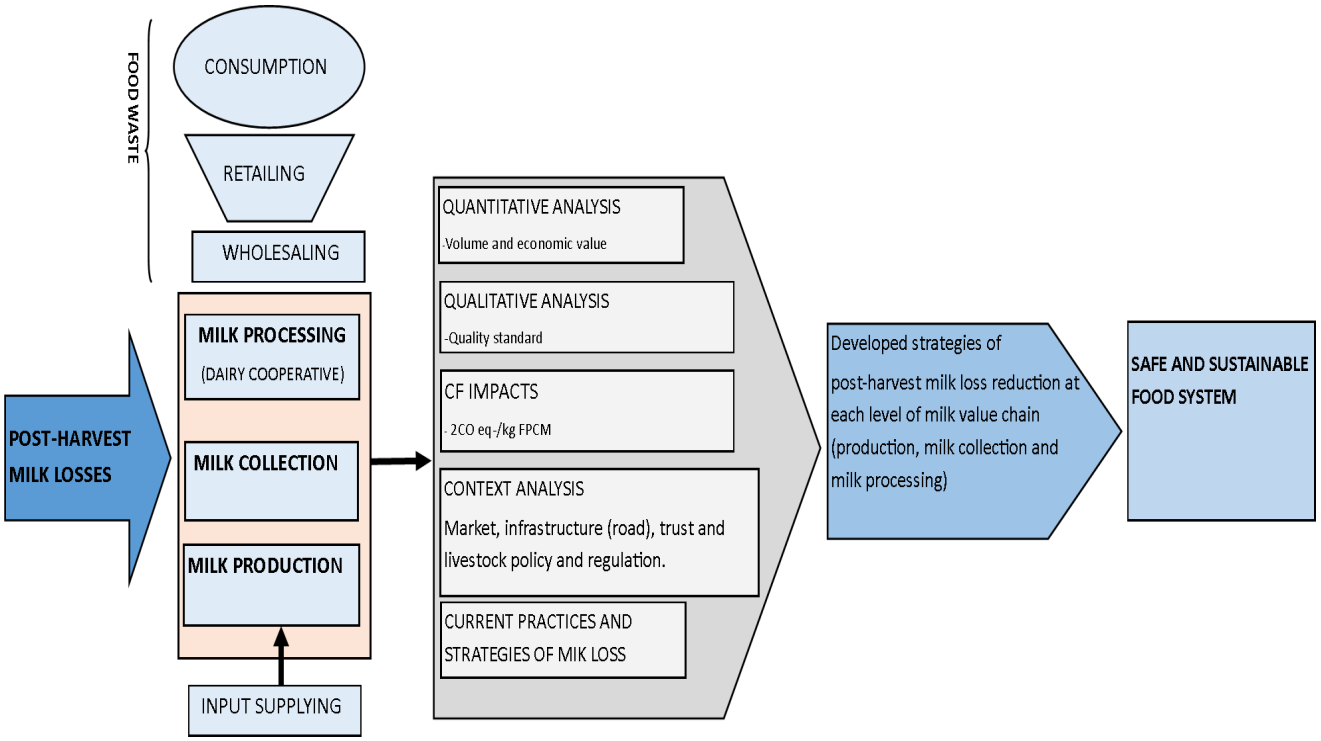
Milk transportation - The collection of freshly produced milk from the production point to the processing plants. In the transportation of raw milk, the time taken from milking to cooling is the most critical factor in measuring milk quality (O'Callaghan et al., 2018).

Milk quantity and quality loss - Refer to the reduction in raw milk volume or quality before consumption or marketing (O'Callaghan et al., 2018).

The value chain - Refers to various activities carried out by different chain actors to bring the product from production to consumption, such as production, collection, processing, distribution, and consumption (Minten et al., 2021). Based on this study, levels to be studied include production, collection, and processing done by cooperatives.

Chain governance - Refers to the formal and informal arrangement within the value chain between actors or between actors and supporters/influencers ((Nyokabi et al., 2018).

Figure 4:Conceptual framework

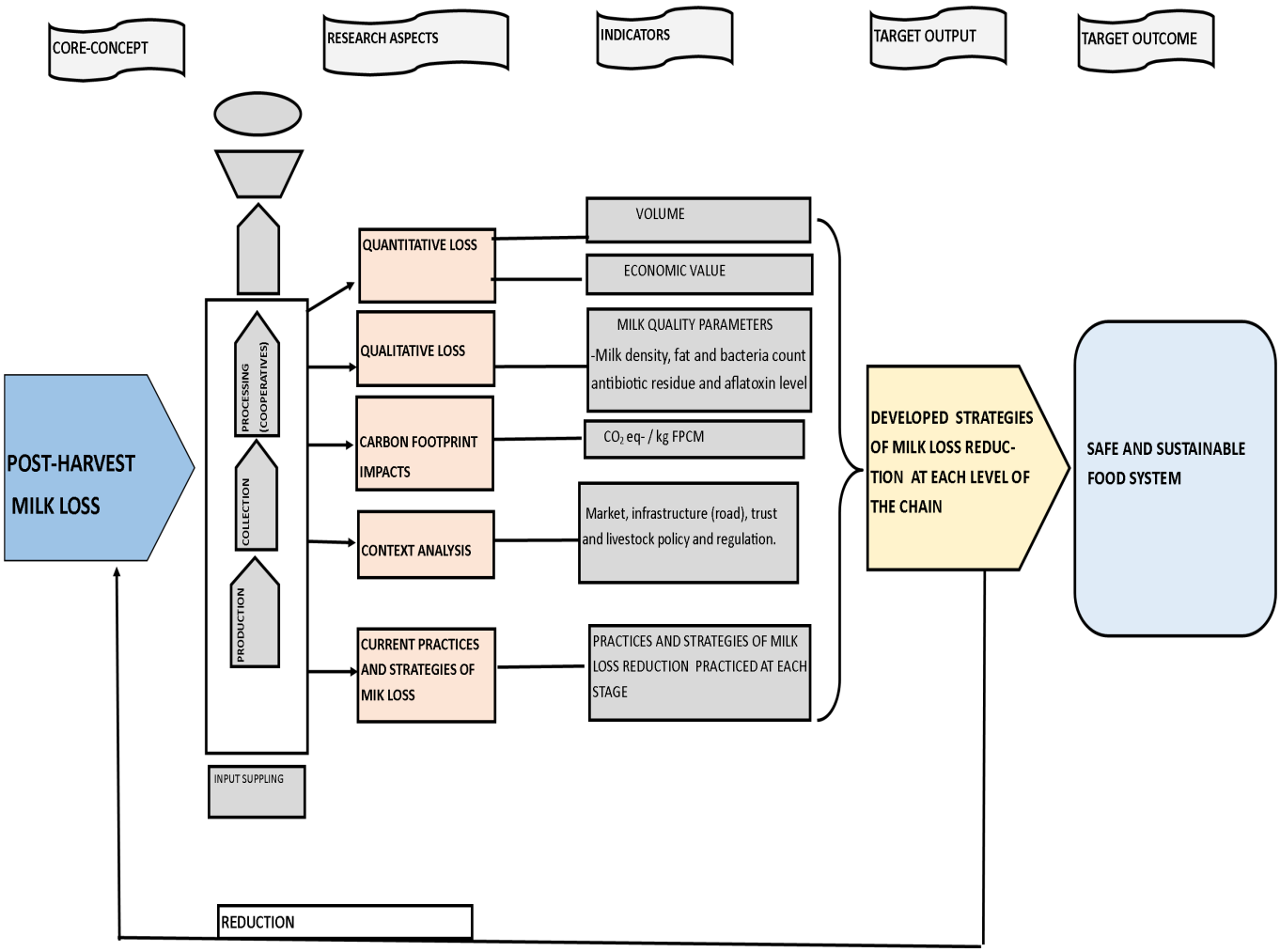


Adapted from Laws et al. (2013)

2.11 Operational framework

The Operational framework is a strategy that helps in focusing on the project objective, unifying, specifying, and organizing a broader concept to achieve the objective of the study (figure 5).

Figure 5: Operational framework



Adapted: Laws et al.,2013

CHAPTER 3: RESEARCH METHODOLOGY

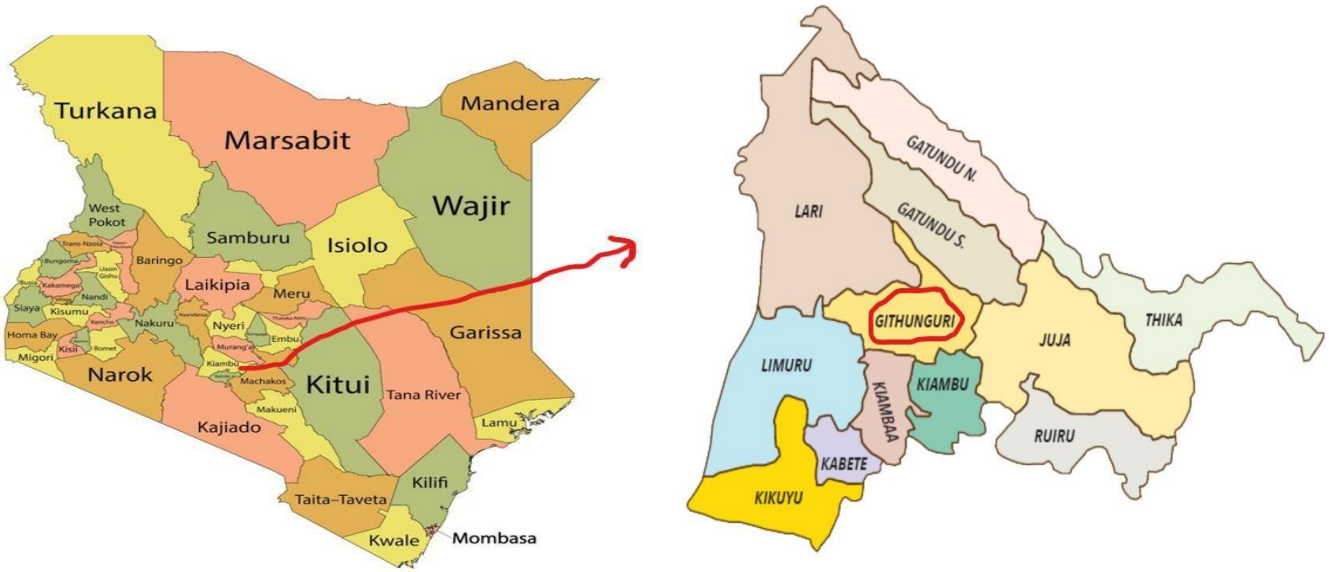
This chapter describes the study areas, research design, research framework, data collection and analysis.

3.1 Geographical location

The study was conducted in Githunguri sub-county in Kiambu county, Kenya. Githunguri sub- county is an agricultural town located in the Central province of Kenya and is one of the administrative centres in Kiambu (Figure 6). GDFCS Ltd is one of the extensive processing cooperatives in the Githunguri sub-county. The sub-county is divided into four zones: Lower highland, upper highland, lower midland, and upper midland zones. Githunguri is in the lower highland zone with an altitude between 15,00 to 18,00 metres above sea level. Also, it has rainfall of about 2000mm with prolonged rain from mid-March to May, a cold season from late June to August, and short rain from October to November (Kiambu County, 2018). Githunguri sub-county has a population of about 10,615, where 5,558 are female, and 5,057 are male, and over 70 % of households engage in dairy farming (Kenya Census Data, 2019).

GDFS LTD was the case study for this research. GDFCS was chosen based on their efforts towards the reduction of post-harvest milk loss such as; having the best governance system in terms of the dairy business hub where farmers are trained on post-harvest milk loss reduction, providing subsidized feeds to farmers and milk storage equipment (milking cans), financial support, and milk testing. Furthermore, GDFCS has an efficient milk collection system and encourages small-scale farmers on the best milk handling practices(Muhande personal contact, 2022). These efforts gave a reason for conducting this research in GDFCS.

Figure 6: Map of Kenya showing Counties



Source: tuzo.co.ke

3.2 Research team

The research involved 8 team members, students from VHL, conducting their study under the FORQLAB project in Kenya with different study topics but with few similar indicators for comparison. Also, one supervisor from VHL supervised this research work. Extension officers from the study area

(four selected milk routes) and at the cooperative were involved in introducing research to the respondents and documenting translation when necessary, during data collection.

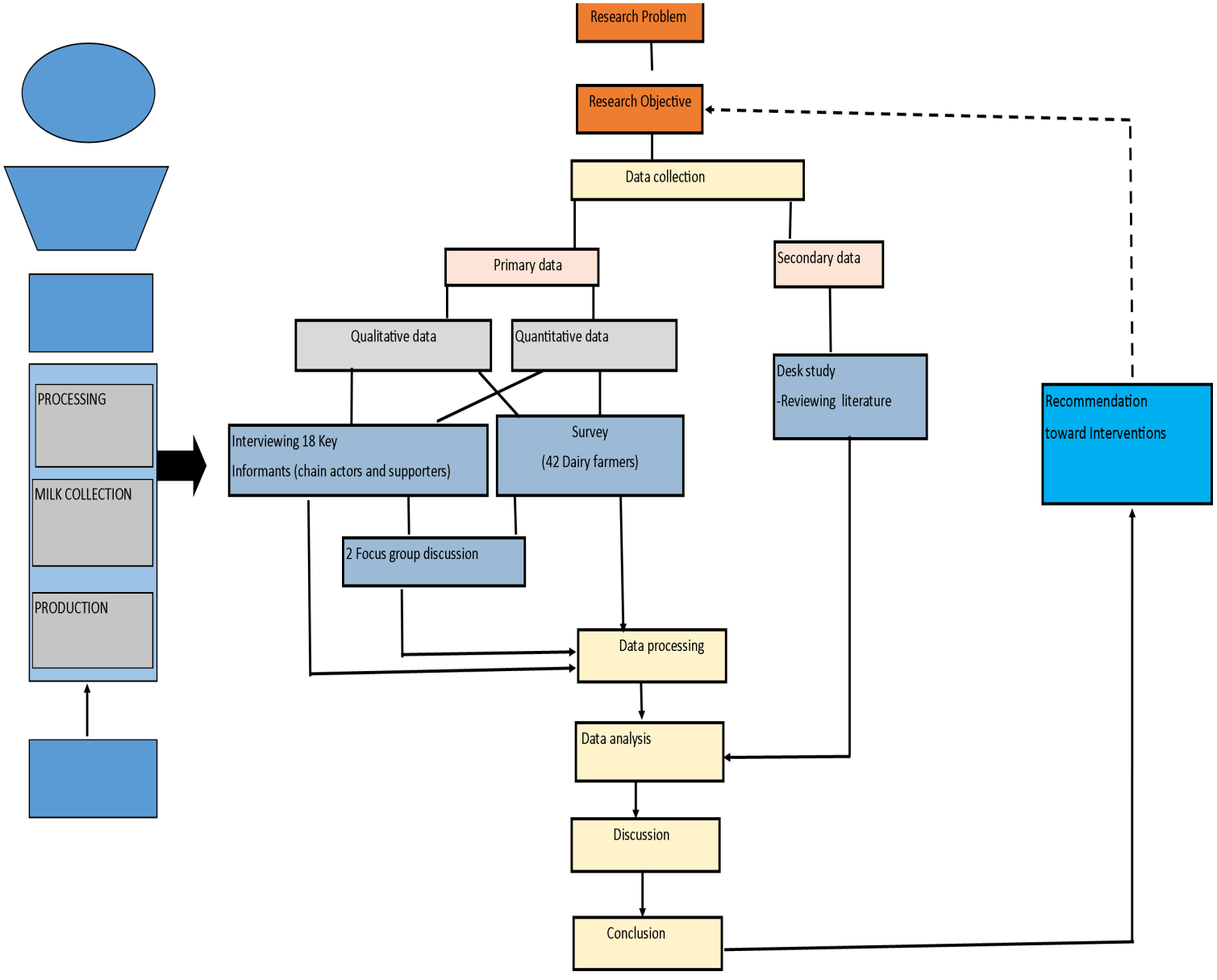
3.3 Research strategy/design

The qualitative and quantitative approaches were used to collect primary data. Whereas semi-structured interviews with the key informants, a survey of farmers and Focus group discussions were used for triangulation.

3.4 Research framework

The research framework was formulated based on the research problem and objective. The framework shows how the study was conducted, step by step, to achieve the research objective. It also gives the focus to the scope of the study (Figure 7).

Figure 7: A research framework



Adapted: Laws et al,.2013.

3.5 Data collection and processing

The type of data collected includes primary and secondary data. The primary data refers to the data collected from the field by the researcher for analysis (Laws et al., 2013) these include qualitative and quantitative data. The method used include:

3.5.1 Desk study/research

A desk review was employed to collect data from existing literature enriching the information collected from the field. The source of this data includes search engines such as Google Scholar, Research Gate, and Greeni through reading journals, articles and books. In searching literature, the keywords such as post-harvest milk loss, milk loss, Githunguri, value chain, and Kiambu were used to search for information on a related topic. To access more information, Boolean operators such as AND, OR, and "" were used to join keywords. Also, the county website and national and international reports, and the GDFCS reports were used as sources of information.

3.5.2 Survey

A structured questionnaire (42 dairy farmers) was used to collect quantitative and qualitative at the production level. The 42 farmers involved in this survey were from four milk collection routes (refer to 3.5.5). Whereby only ten farmers were involved per route. This tool for data collection was chosen as the study requires statistical data which includes quantity and PHL shares. The questionnaire was formulated with open, category, ranking, quantity, and grid questions covering various aspects of PHL (ANNEX 1). These questionnaires were tested for piloting. The survey was done by visiting farmers on their farms and at milk collection centres to fill out the questionnaires depending on the agreement between the researcher and the respondents. The quantity of PHL was collected from milk records from farmers using a milk delivery Application. The participatory tools used during the survey were value chain mapping and the milk loss calendar.

3.5.3 Interview with key informants

Nineteen (18) key informants in the milk value chain and on the supporter level were interviewed to collect in-depth information on PHL (Table 1) using a semi-structured interview. The key informants involved were people within and outside the chain (supporters). The key informants were chosen because they have first-hand knowledge and expertise on the focus topic (post-harvest milk losses). The questions used in the interviews were closed and open and tested on 2 GDFCS extension staff before interviewing the key informants. The milk value chain map was a participatory tool to identify the selling channels of rejected milk. Through appointments, 12 interviews were done at the interviewee's office, and 6 were done at the GDFCS office. Interviewees were asked for their consent of participation which was oral consent. The quantitative data were collected through a cooperative milk record check.

Table 1: Key informants interviewed

Key informants			Number of key informants to be involved
Key informants at the supporting level			
KDB			1
Quality officer at the processing level			1
Quantity Officer at the processing level			1
KALRO & APCM Alumnae			1
Livestock Officer in sub-county			1
The operator at the plant			1
Extension officer within the four milk collection routes		2 from the long collection route	4
		2 from the short collection route	
Quality inspectors		1 from the long collection route	2
		1 from the short collection route	
Graders within for milk routes		1 from the long collection route	2
		1 from the short collection route	
Key informants at the chain level			
Milk collecting agents (Transporters)	MCC to Cooling then to the processing plant within the four milk routes	2 from the long collection route	4
	MCC to the processing plant within the short route	2 from the short collection route	
Total key informants			**18**

Source: Author

3.5.4 Focus group discussion

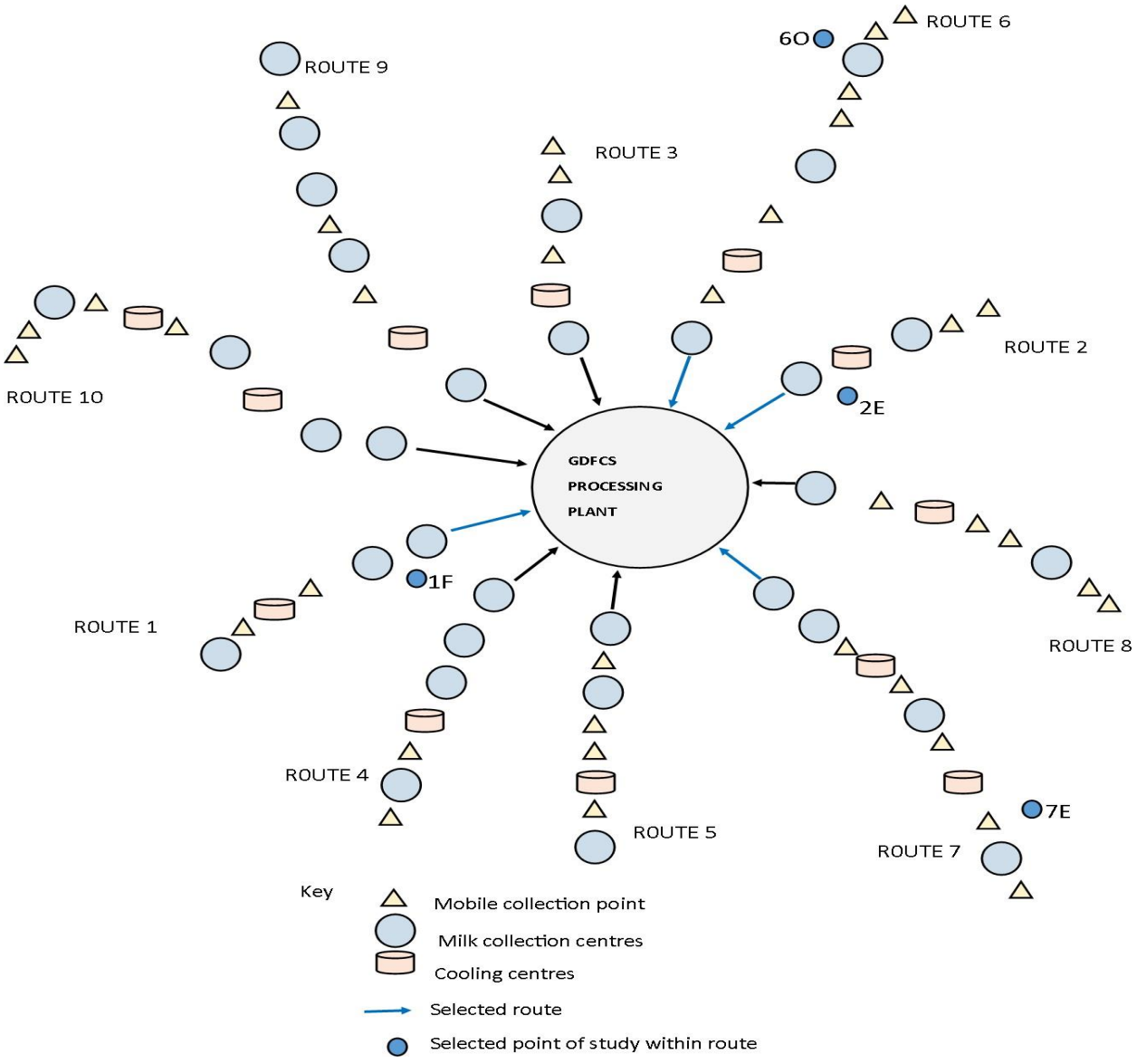
Two focus group discussions with 10 participants per group were conducted at the end of data collection to verify the information collected from surveys and interviews. The participants in each group discussion include seven farmers supplying milk to cooperatives, one extension officer, one quality grader within the four milk routes and a researcher. These two FGDs were one from the long milk collection route (7E) and one from the short collection route (1F) to represent the other routes. The FGD was conducted through questions and answers where participants were given room to discuss and share information on a particular topic of study. The participatory tools used are chain mapping and milk rejection calendar (ANNEX 2).

3.5.5 Sample selection and sample size

According to Law et al. (2013), a sample is a universe unit of analysis presenting a large population under study. Non-probability or purposive sampling methods was used for sample selection. The sample was chosen from clusters, such as 42 small-scale dairy farmers registered under the Githunguri cooperative, supplying raw milk to GDFCS, and located within the four selected milk collection routes such as short route (1F and 2E) and long route (6O and 7E). Ten farmers were purposely selected from

each milk collection route is based on the distance from the farm to the collection centre (2 nearby and 2 faraway routes) and the cooling point. Also, two respondents were added to replace the wrong-filled questionnaire if it occurs thus making a sample size of 42 respondents. The milk collection routes used in this study were sampled in the field. The key informants interviewed were selected based on their role in the value chain. Figure 8 shows the four milk collection routes selected from 10 routes.

Figure 8: Sampling of milk collection route for this study.



Source: Author

3.6 Data analysis

Data analysis refers to taking data apart and again putting them together to form a link between inputs from respondents and the original questions (Laws et al., 2013). These data include qualitative and quantitative data.

3.6.1 Quantitative data analysis

The data collected using questionnaires were coded and cleaned using SPSS version 26 for analysis. Out of 42 questionnaires used during the survey, 40 had all the required information, while two questionnaires were discarded as many questions were not filled in by the respondents. The quantities of milk lost, and economic losses were analysed using Microsoft Excel, to sum up, the amount lost at the collection, and processing level. The statistical test, the independent sample T-test was used to compare the level of significance of PHL between short (1F and 2E) and long routes (6O and 7E). Also, the descriptive statistic was used to find the number in which a variable takes each value (frequency) such as the frequency of milk rejection at MCC. Al. Also, it was used in determining the average, minimum and maximum of different variables such as the average milk yield per cow per day at peak production, among others.

The formula for calculating milk production and PHL

To calculate milk production/cow/year the following information was collected from the farmer; average milk yield per cow per day, peak production in the dry and wet season during the year, average lactation length of the cow during the dry and wet season of the year, and the calving interval. The fat and protein contents of milk were collected from the cooperative. Also, the information on the quantity of milk fed to calves, consumed at home, sold, and rejected was given by respondents. To reduce the bias of gathered information, the peak production was treated as 70% more than the average milk production per cow per year (Rule of thumb). The formula used includes:

Milk/cow/year = peak production/1.7) * lactation length (days) * year (days)/calving interval (days)

Milk yield/cow/year (FPCM) = milk/cow/year x FPCM formula (the formula: [kg FPCM = kg milk*(0.337 + 0.116*fat% + 0.06*protein%] as described by (FAO, 2010; Opio et al., 2013))

Milk/farm/year and in FCPM = milk/cow/year (or in FCPM) * average number of animals

PHL $_{production}$ = Milk yield/farm/year FCPM – (total milk delivered per farm + home consumption (side selling included) + calf consumption / average number of animals).

The percentage of milk loss at the farm level: (PHL $_{production}$ /Milk yield/farm/year FPCM) × 100%

Economic value loss at production = PHL $_{production \times}$ (Average milk price per Litre)

Std factor Fat and Std factor Protein used in this calculation were obtained from the cooperative

Formular used in calculating PHL in the value chain

The total PHL in VC= Σ (PHL $_{production}$ + PHL $_{collection\ centre}$ + PHL $_{processing\ level}$)

Whereby;

PHL $_{Collection\ centre}$= Σ (Rejects +Spillage +Spoiled + Missing)

PHL $_{processing\ level}$ = Σ (Rejects +Spillage +Spoiled)

Formular to be used in calculating Economic value loss at production, collection, and processing level

Total Value of PHL $_{production}$ = PHL $_{production}$ × (Average milk price per Litre)

Total Value of PHL $_{\text{Collection centre}}$ = PHL $_{\text{Collection centre}}$ × (Average milk price per Litre)

Total Value of PHL $_{\text{processing level}}$ = PHL $_{\text{processing level}}$ × (Average milk price per Litre)

The average price used was the average milk price offered by GDFCS which was KES 45

Calculating the share of milk loss at the production, collection, and processing level

Share of milk loss refers to the percentage of milk loss at the production, collection, and processing stage in the milk value chain. Can be calculated from the following;

Formular to be used in calculating Environmental impacts (CF)

The share of PHL in all milk shed of GDFCS = (PHL at each level of the value chain/ Total PHL of milk shed of GDFCS) ×100

CF impact: total milk yield/farm/year FPCM * CF/ per kg FPCM

CF impact GDFCS milk shed = milk intake/year * CF/ per kg

FPCM

3.6.2 Qualitative data analysis

Qualitative data collected through focus group discussion and interviews with key informants were transcribed and coded (ANNEX 3) to identify common themes and concepts by using excel in which graphic descriptions (charts) were developed. Then SWOT was developed from the text to identify the opportunities available for discovering sustainable intervention areas. Additionally, the value chain map was used to indicate the loss and leverage points which were important in developing the interventions.

3.7 Ethical issue

During data collection, the participants in the survey and interview were requested to consent the participate after being informed of the study objective. The interviewees and survey respondents were comfortable with oral consent rather than written consent. Therefore, respondents' participation in this study was based on verbal consent for their privacy.

3.8 Limitations of the research

During data collection, initially, the farmers did not want to participate in this survey with the reason of being afraid to provide their information about milk loss, especially the reason for milk rejection and the amount rejected, because they thought this information will be used by GDCS management to penalize the farmer with the greatest amount of milk rejected. Farmers have this thought because GDFCS punishes the farmers with repeated cases of milk rejection by suspending the farmer from selling milk to a cooperative for a certain period and or penalty. Due to this challenge, the researcher had to explain more about the purpose and outcome of the survey to increase the respondent's awareness. By doing so, respondents were willing to participate, thus making this information collected valid and reliable.

Another limitation was the weather condition. Data collection was done during the rainy season in Kenya, which made it difficult to visit other farmers at their farms, instead farmers were asked to meet at a nearby collection centre for the survey. On the other hand, this weather condition helped a researcher to observe the influence of infrastructure (road) on milk loss. However, the information collected was adequate and valid for this research/thesis. The information collected was sufficient since out of 42 questionnaires, 40 were well filled based on the requirement. To verify the information given, the data provided were verified using the farmer's App, which consists of all information about

their daily delivery and earnings per month.

During data analysis, testing the significant difference between the amount of milk lost between the long route (6O and 7E) and the short route (1F and 2E) using the statistical test Independent Sample T-test and one-way ANOVA was not possible. This was due to a limited number of cases (Route) in which, for this study, the number of cases was four. Also, the presence of an out layer limited the running of the test. The high amount of milk loss caused the out layer in route 6O compared to other routes. For this reason, the differences in milk loss between the long and short routes were compared based on the quantities of milk lost per route.

CHAPTER 4: RESULTS

This chapter gives the results and discussion of the information obtained from the survey, interview, and focus group discussions conducted in Kiambu County using the Githunguri Dairy Farmers Cooperative Society (GDFCS) as a case study. The survey was done with small-scale farmers registered under GDFCS who supply milk to a cooperative society. The interview respondents were the key informants in the milk value chain (table 1), whereas the focus group discussion involved farmers, researchers, graders, and extensionists in verifying the information.

4.1 Results from the Interviews at collection and processing levels of the milk value chain

The results under this section were obtained by interviewing the key informants of the milk value chain and from the focus group discussion conducted on routes 1F (shortest route) and 7E (long route). Of 18 interviewees, 28% were female while 72% were males. Thus, indicating the large participation of males in this study. Although the number of females working in a high position in the cooperative was very low compared to men. At GDFCS, many females were found in the field as extensionists and at the processing plant working as supporting staff.

4.1.1 Interview with Quality Assurance at GDFCS extensionists, graders and inspectors

An interview with the staff at GDFCS identified a wide range of activities undertaken by the cooperative. This section provides information obtained during the interview with key informants at the cooperative. The cooperative was established in 1961 with 31 members who were small-scale dairy farmers and with one collection centre. The core reason for establishing the cooperative was to help dairy farmers access the milk market. The core values of the cooperative, as reported by Githunguri staff, a key informant from KDB and the District livestock officer, include customer services, equality, equity, integrity, continuous improvement, and innovation. An operator at the processing plant reported that; "As a cooperative, we collect and process the milk to different products such as yoghurt, maziwa lala, fresh milk and pasteurized milk; by collecting and processing the milk, we provide the market to farmers who are a member of GDFCS".

4.1.2 The membership

The cooperative members were reported to be small-scale dairy farmers with 1 to 6 cattle and producing 1-15 litres of milk per cow per day. Also, it was mentioned that medium-scale farmers with more than 15 cows are emerging in the cooperative, producing about 52 litres of milk per cow per day.

"In route 7, there are about ten high producers with more than 15 cows. We have 15-20 high producers who produce more than 1500 kg of milk per month" - GDFCS extensionist

4.1.3 Support services

GDFCS has a well-functioning and organised business hub; it revealed that they have a department responsible for providing extension services to farmers. The extension staff at the farm level were given different roles to reduce the workload on extension officers, suchmilk graders, inspectors and extensionists who visited and advised farmers daily. GDFCS provides AI services and dairy feeds sold in the cooperative stores located in each milk collection route, which was reported by different staff at the cooperative during the interview, one of the respondents mentioned that;

"*We visit them every day, at least 20 farmers per day. So, we meet the farmers in the field and train them. For example, I train them on clean milk production to reduce milk loss, such as feeding, milk*

hygiene, cleaning and handling of milk storage equipment and delivering milk to MCC, especially a person responsible for delivering milk on how to handle it. Also, I train them on feed preservation to avoid aflatoxin, disease control such as mastitis and fodder establishment."

4.2 **GDFCS stakeholder analysis**

From the interviewed key informants, different stakeholders in GDFCS Value Chain were identified (Table 2). Some of the stakeholders were mentioned by a key informant from KDB, who reported that;

"KEBS and KDB most of the time work hand in hand, because what KEBS do, they constitute what we call the technical committee where the stakeholders are brought together such as Fresha, KCC, Brooksides, all those people who are involved in the production of particulars products KEBS constitutes them by putting specifications to the products."

Table 2: Stakeholders of GDFCS Milk Value Chain

Stakeholders/Actors	**Role(s)**
Input suppliers	Supply feed to GDFCS feed store (Source from Uganda)
Producers (farmers)	Production and selling of milk to GDFCS daily
Transporters (Hired and contracted)	Transportation of milk from collection centres and cooling points to processing plants
GDFCS (milk collectors)	Collection and processing of milk Distribution of dairy products.
Processors (GDFCS)	Processing milk into quality products
Distributors (Hired and contracted)	Distributing processed milk and milk products to retailers
Retailers	Selling of processed milk and milk products to consumers
Consumers (rural, urban, and institutional consumers)	Buy and consume processed milk and milk products
Supporters	
KDB	• Ensure the quality and safety of milk marketed as they are responsible for managing the compliance of policies and regulations on milk and milk product quality production and distribution. • Negotiate on behalf of cooperatives and processors to acquire equipment such as milk coolers from the government at a low cost.
KALRO	• Conduct research and develop improved technologies important to farmers • Provide training to farmers
KEBS	• Constitute the technical team • Set specifications for the products • Ensures that everything brought into the market conforms to those standards
NEMA	• Environment management • Provide the certificate of compliance to environment protection

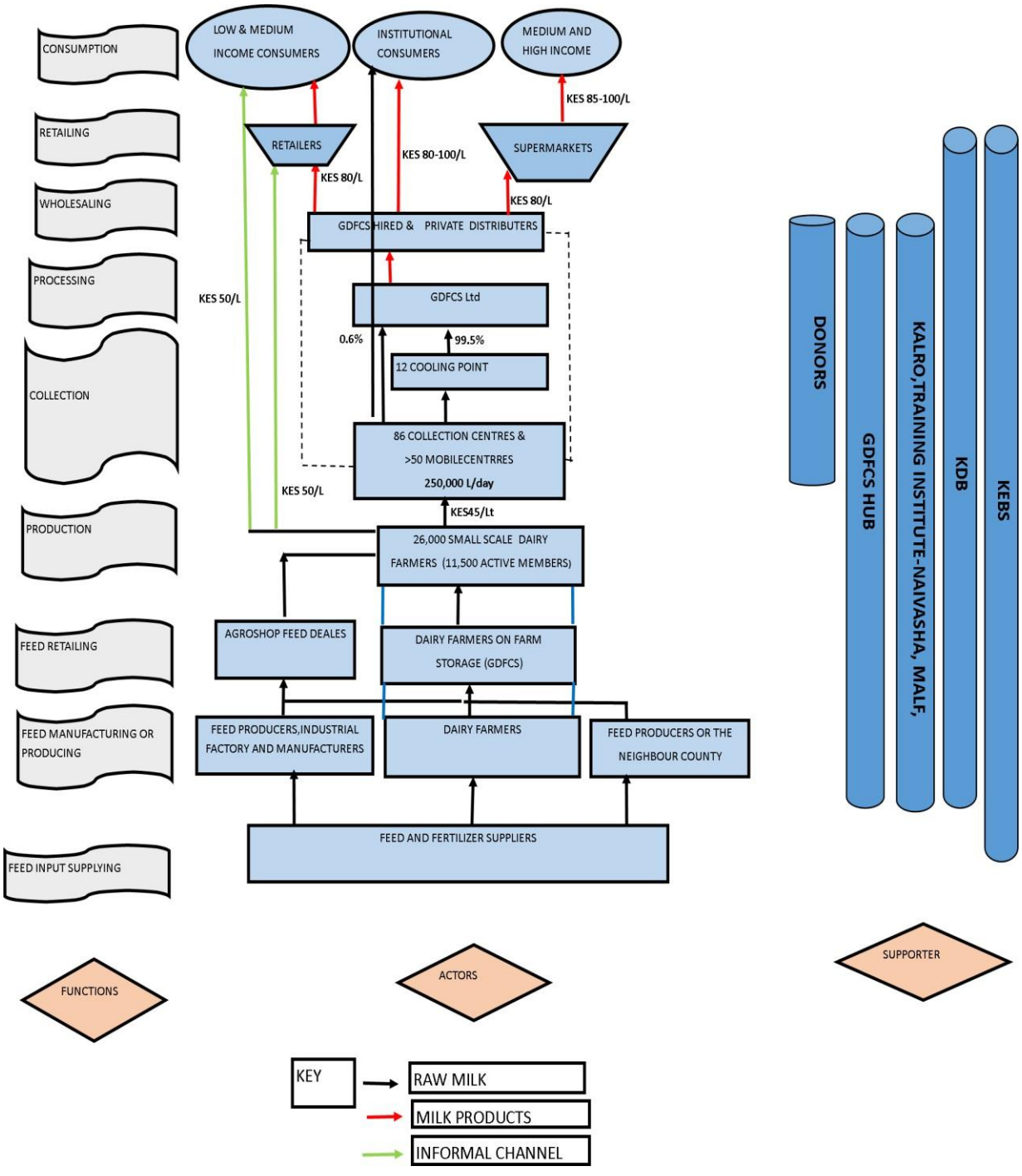
Dairy training institute -Naivasha	• Provide training to farmers
MALF	• Provide extension and advisory services to farmers
GDFCS Dairy Hub	• Provide extension services and sale of inputs (feed and milk cans) to farmers

Source: Interview

4.3 **GDFCS Milk Value Chain**

Based on interviews with cooperatives staff and other key informants, the actors and supporters and their role in the value chain were identified and summarized into a chain map. The chain map shows the actors, supports, and functions (Figure 9).

Figure 9: GDFCS Milk Value Chain



Source: Interview and FGD

i) Source of input

GDFCS sources the dairy feeds from Uganda. Among other services, the cooperative provides dairy feeds, AI services, extension services, dairy equipment such as milk storage equipment (milking can), consumable goods such as food (rice, sugar, and salt), and soap. As stated by GDFCS staff, farmers under the cooperative source their inputs from the cooperative store by credit based on the amount of milk supplied that month. In an interview was stated that;

"Everything you take from the store is reflected in the App where a farmer can see what they received and the milk delivered. At the end of the month, they know what amount of money for milk delivered is remaining. Everything they take is deducted from the milk delivered at the end of the month."

Figure 10: GDFCS feed store

Source: Field data, 2022

ii) Milk collection and transportation

The cooperative was reported to have 86 milk collection centres; 12 of which collect milk in bulk and are equipped with coolers. To reduce the distance from farms to collection centres, the cooperative introduced about 163 mobile collection points located in different places. The number of mobile collection points in routes 1F,2E,6O and 7E were 3, 6, 19 and 2, respectively. The milk collected per day was estimated to be between 230,000Lt to 240,000Lt. The cooperative has three milk collection shifts-morning, afternoon, and evening. The starting and ending time of milk collection differ depending on the distance. The evening milk is kept at the cooling points and transported with the morning shift the following day. Although, the cooperative experiences a high cost of power (high electricity bills) thus looking for a way to reduce the running costs.

Farmers deliver the milk to MCC using aluminium milk cans with 5 to 50Lt capacity. Upon delivery, the accepted milk is poured into another milk can (50Lt) owned by the cooperative. From the cooling point to the processing plant, the milk is collected by using a GDFCS truck installed with a milk tank of 1000 to 1500Lt capacity. Except for long routes, milk collected from short routes was transported directly to the processing plant.

GDFCS has 43 trucks for collecting milk, of which 31 are contracted trucks (Figure 11), and the cooperative owns 12. The division of trucks per collection route depends on the amount of milk collected per route, on average, 2-4. From the four routes under study, the following collection schedule per day was reported (Table 3). Based on the interview with GDFCS, the allocation of milk

collection points and collecting centres in the routes were based on the amount of milk collected in that area.

It was reported that, "The collection centres are allocated in the area where the collected milk is more than 20 cans, and the milk collection point is allocated to farmers where it is impossible to collect more than twenty milk cans. Therefore, the milk collection point is the temporary collection point for farmers living far from the collection centres, and the amount collected at that point is very low".

Table 3: Milk collection schedule per route

Milk collection route	Morning shift		Afternoon milk	
	Starting time	Ending time	Starting	Ending time
1F	5:30 am	6:45 am	1:30 pm	3:00pm
2E	3:50 am	6:00 am	1:45pm	3:30 pm
6O	5:00 am	5:30 am	1:00pm	3:30 pm
7E	4:00 am	6:30 am	1:00pm	3:30 pm

Source: Interview

Figure 11: milk transportation truck

Source: Field data, 2022

Milk tests done at the collection centres and the milk parameters

Currently, Githunguri buys milk from farmers based on volume; the price per litre of milk was KES 45.00/= The tests run at collection centres by graders were a lactometer test for density or adulteration, an alcohol test for mastitis, and an Organoleptic test through sense organs. The test done at processing plants includes Aflatoxin level, antibiotic residue in milk and somatic cell count.

Other parameters were tested but were not given much attention at collection centres, and the milk was not rejected based on parameters such as protein, fat, and aflatoxin level. Table 4 shows the test parameters and their specifications used by GDFCS. Based on specifications used by KEBS and GDFCS, it was revealed that the parameter's specifications used were the same. Although, the difference was found in the level of antibiotic residue in milk as GDFCS specification was not more than 10ppb while KEBS require milk free from antibiotic residue. Other milk parameters were within KEBS' standards.

Table 4: GDFCS milk test parameters and their specifications

Parameter	Testing centre	Specification GDFCS	Specification KEBS
Milk fat	All milk collection centres and cooling point	3.5%	3.61%
Milk protein	All milk collection centres and cooling point	3.2%	3.46%
Freezing point	All milk collection centres Processing plant	-0.550 to -0.525°C	-0.597
Alcohol test	All milk collection centres	Negative	Negative
Clot-on-boiling	All milk collection centres	Negative	Negative
pH	All milk collection centres	6.6 TO 6.8	0.13 - 0.14%
Density at 200C	All milk collection centres	1.028 TO 1.034g/ml	1.031g/ml
Milk SNF	Cooling point Processing plant	Min8.5%	9.18%
Antibiotic residue	Cooling point Processing plant	Not more than 10ppb	Negative
Aflatoxin M1	Cooling point Processing plant	Less or equal to 0.5ppb	≤0.5ppb
Total plate count	Processing plant	max 2,000,000cfu/ml	<200,000 grade A 200,000-1,000,000 grade B ≤2,000,000 grade C
Coliform	Processing plant	Max 50,000cfu/ml	Not given
Somatic cell count (SCC)	Processing plant Cooling point	Mx 300,000	≤300,000

Source: Interview with KDB and MCC

Figure 12: Milk testing at the cooling point | Source: Field data, 2022

iii) Processing of dairy products

Based on the interview conducted with the cooperative dairy staff, the cooperative started processing milk in 2014 under the log of FRESHA. GDFCS processes the raw milk into yoghurt, maziwa lala, long life milk (UHT) and fresh milk. The reported shelf life of fresh milk was three days, maxima lala has 21 days and 6 months UHT shelf life. The operator at the processing plant said;

"The price for milk products differs per buyer and the keeping units or volume of the packaging materials for example yoghurt price is 100 to 192Ksh per litre and fresh milk price is 80-84 KES per litre".

4.4 **GDFCS organogram**

It was identified that the top position of the GDFCS organogram is possessed by the cooperative members, followed by the board members, with 11 members responsible for decision-making. The distribution of work under this cooperative was identified to contribute to the excellent performance of the cooperative. Figure 13 shows the GDFCS Organogram identified during the interview with the

key informants at the cooperative.

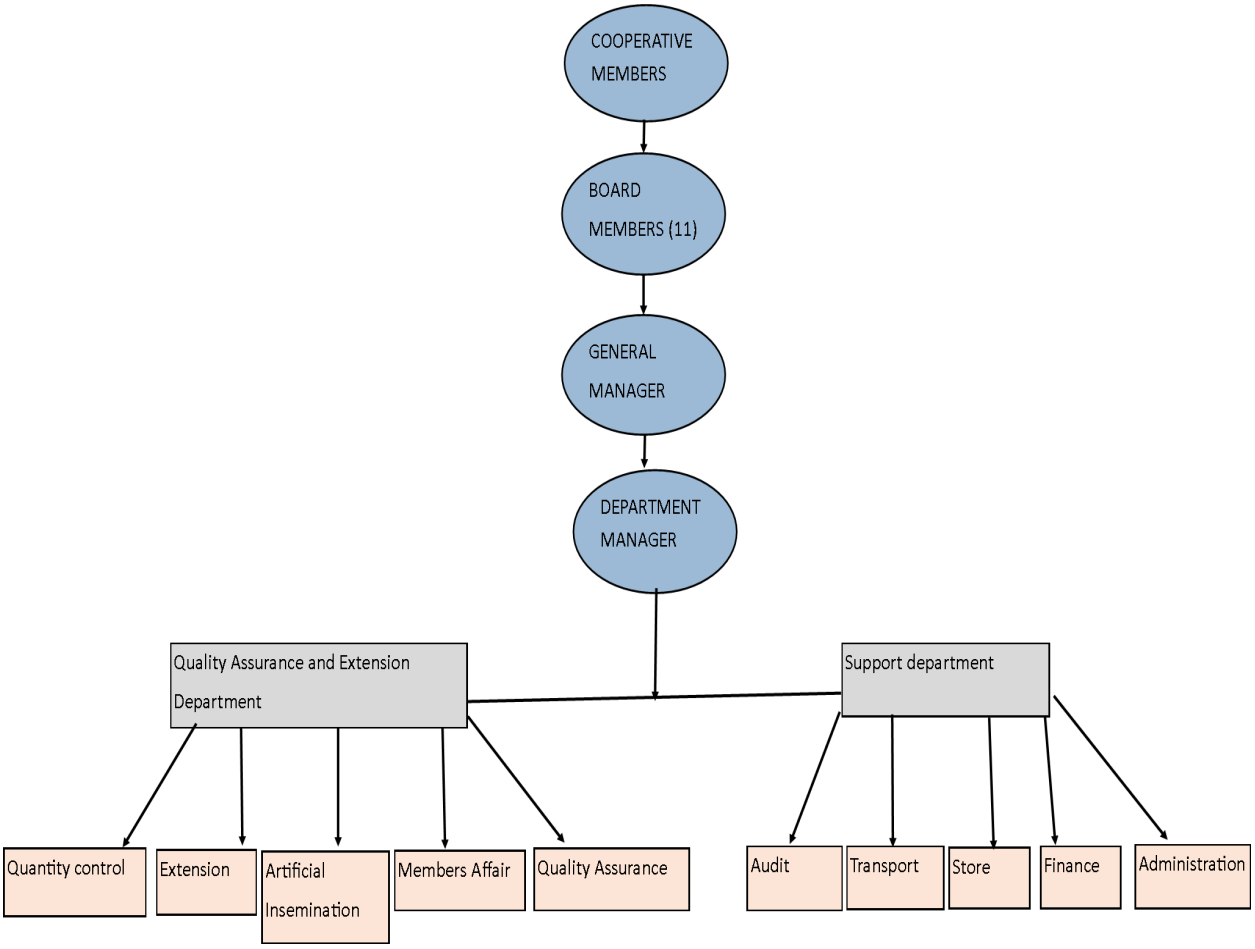


Figure 13: GDFCS Organogram | Source: GDFCS interview

4.5 **Causes of milk loss at collection centres and the current strategies in place**

The information given in table 5 was the findings obtained from interviewing the staff at GDFCS. It was reported that milk loss at the collection centre was due to rejection caused by poor quality milk delivered and contamination during measuring the milk volume. Although, the cooperative has strategies in place to reduce losses such as observing good milk handling practices and security seal on the can for traceability, among others.

Table 5: Causes of milk rejection at the collection centre and the strategies used to reduce the milk loss

Causes	Cases number	Current strategies
Spillage during transportation from different collection centres to cooling point	Few in the dry season Regular in the wet season	Sealing the milking can well More attention during loading and off-loading

Spoilage due to delayed transportation (rare)	Rare	Hiring transporters who can provide rescue trucks in emergency Contract with transporters to ensure the safe delivery of quality and quantity milk. Training staff working directly with milk on good milk handling practices
Rejection of milk delivered by farmers due to poor quality milk caused by Mastitis, antibiotic residue, adulteration, and mineral deficiency, among others	Few in the dry season Regular in the wet season	Milk testing of milk per shift Follow-up of farmers with rejected milk through inspectors and extensionists Penalizing and suspending farmers with repeated rejections Observing good milk handling practices Suspending staff whose area has many repeated cases of rejections Security seals on milk can identify the farmers who put their milk in a particular can for traceability
Truck breakdown during transportation of milk	Few	Transporters were responsible for sending a rescue truck on time The transporters were responsible for spoilage loss made.

Source: Interview

4.6 **The causes of milk loss at the processing plant and the strategies for loss reduction in place**

The information given in table 6 was the findings obtained from interviewing the key informants at GDFCS. Milk spillages was the greatest loss identified at processing plant occurring at packaging due to manual packaging of milk and milk products. The strategies used to reduce milk loss were the use of trained staff and packaging supplier audits before the purchase of packaging materials.

Table 6: Causes of milk rejection at the processing plant and the strategies used to reduce milk loss

Causes	Cases in number	Current strategies
An automation machine causes adulteration during chilling (chilling water).	Few	Controlling chilling temperature and required chilling time Ensure good storage at 4-5°C and short storage before processing and distribution.
Contamination and breakage of packages during sorting and packaging	Regular	Paying attention during sorting Use trained employee Input supplier audit (suppliers of packaging material) before purchase.
Breakdown of machines, for example during packaging	Few	The unsealed package can be reworked Putting more attention to packaging Replacement and maintenance of the machines
Poor handling of milk during transportation to the plant and processing leads to milk and milk product contamination	Few	Good storage of packaging materials to avoid contamination Testing of milk on delivery
Offloading	Rare	Putting attention during off-loading.
Overfilled tank and milking can	Few	More attention when pouring the milk into the milk can and tank.

Source: Interview

Figure 14: Loss in the packaging area | Source: Field data, 2022

4.7 **Milk intake**

From the data collected from the cooperative on daily intake per route, route 1F and 2E (long routes) have more milk intake than route 6O and 7E (short routes) refer to table 7. The difference in milk intake per route is associated with the number of members supplying milk to the collection centres and season difference. The high amount of milk intake was during the wet season (April to June) compared dry season (January to March). From July to the end of August (during the cold season) the milk intake is expected to be lower due to low production caused by the cold. High milk intake was also expected from September to the beginning of December due to the presence of short rainfall.

Table 7: Milk intake per route for six months (January to June 2022)

ROUTE	JAN-INTAKE	FEB-INTAKE	MAR-INTAKE	APR-INTAKE	MAY-INTAKE	JUN-INTAKE	TOTAL-INTAKE
1F	158096.6	141349.8	161236	163455.4	169401.6	168296	961835.4
2E	179952.8	167497.9	188151.5	182726.7	192311.7	189497.4	1100138
6O	215818.3	37861.9	217953.3	42999.4	42763.5	41482.5	598878.9
7E	32529	28235	29651.5	30802.1	28055.1	22602.2	171874.9
TOTAL	586396.7	374944.6	596992.3	419983.6	432531.9	421878.1	2832727.2

Source: GDFCS intake records.

Milk intake versus milk loss per route

The total amount of milk lost due to rejection, spillage and missing were 515.1Lt, 550.3Lt, 1,331.8Lt and 764Lt for routes 1F, 2E, 6O and 7E, respectively. Based on the analysis, the total amount of milk

lost per route is very small compared to the total intake per route (Figure 15). For all routes in this study (1F, 2E, 6O and 7E), the total amount of milk intake for six months was 2,832,727.2 Lt while the total loss was 3,161.2Lt. The total percentage of milk loss at the collection centre for all four routes was 0.11% (Annex 6).

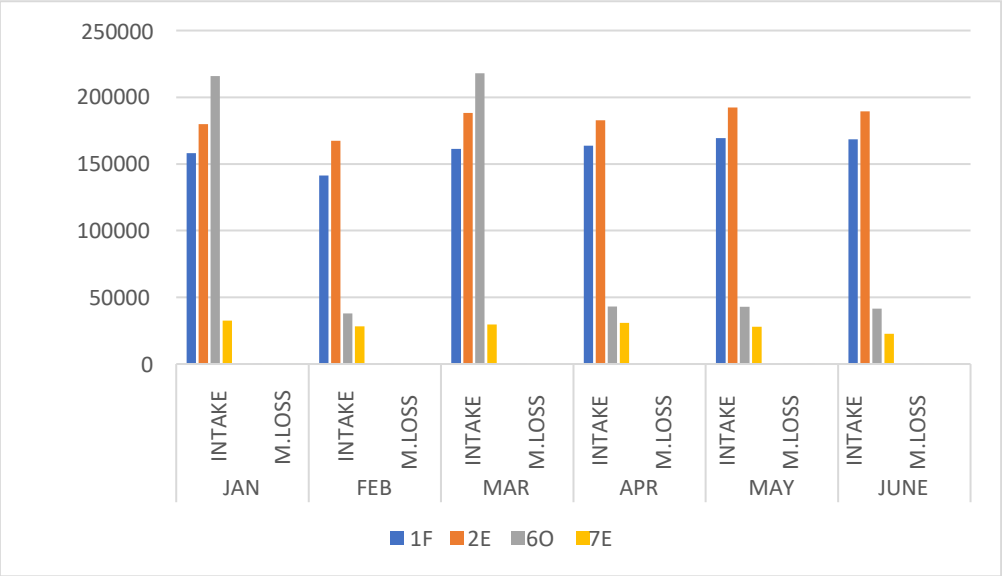


Figure 15: Milk intake Vs Milk loss| Source: GDFCS intake records.

4.8 **Milk rejection, spillage and loss**

The amount of rejected and spilt milk at the collection centre was higher in route 6O when the rejections were 765Lt and spillages 197Lt. A high amount of missing milk was found in routes 6O (369.8Lt) and 7E (669Lt). Although, route 7E was found to have no rejects (Table 8). The high amount of milk loss in route 6O was due to more rejects than in other routes, and in route 7E, high milk loss was due to a high amount of missing milk. The missing milk was reported as the amount of milk lost because of a measurement error during collection. Although when the amount exceeds 50 Lt, the person responsible is required to pay for the loss. The difference in milk loss per route in other months was shown in (figure 16) and (figure 17). The statistical analysis shows that there was no significant difference in the amount of milk rejected between the short and long routes based on the quantified amount of PHL between the short route (1F and 2e) and the long route (6O and 7E). Refer to table 9. Although, it cannot be proven due to the small number of cases.

Table 8: The total amount of milk rejected, spillage and missing per route (Jan to June 2022)

ROUTE	TOTAL REJECT	TOTAL SPILLAGE	TOTAL MISSING	TOTAL LOSS
1F	102	157	256.1	515.1
2E	306	148	96.3	550.3
6O	765	197	369.8	1331.8
7E	0	95	669	764
TOTAL	1173	597	1391.2	3161.2

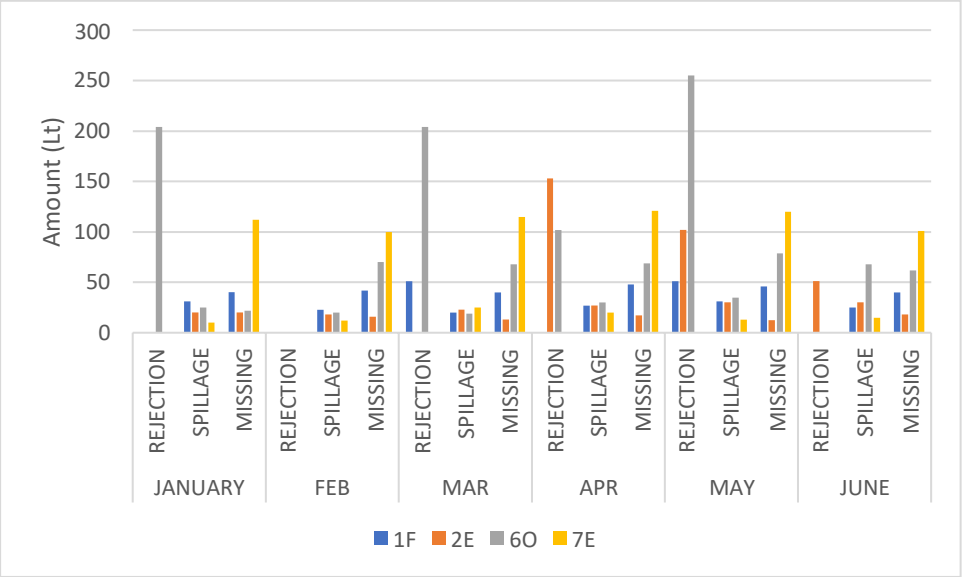
Source: FCS milk records.

Table 9: Losses between the short and long routes

ROUTE	TOTAL REJECT	TOTAL SPILLAGE	TOTAL MISSING	TOTAL LOSS
Short route (1F & 2E)	408	305	352.4	1,065.4
Long route (6O & 7E)	705	292	1,038.8	2,095.8

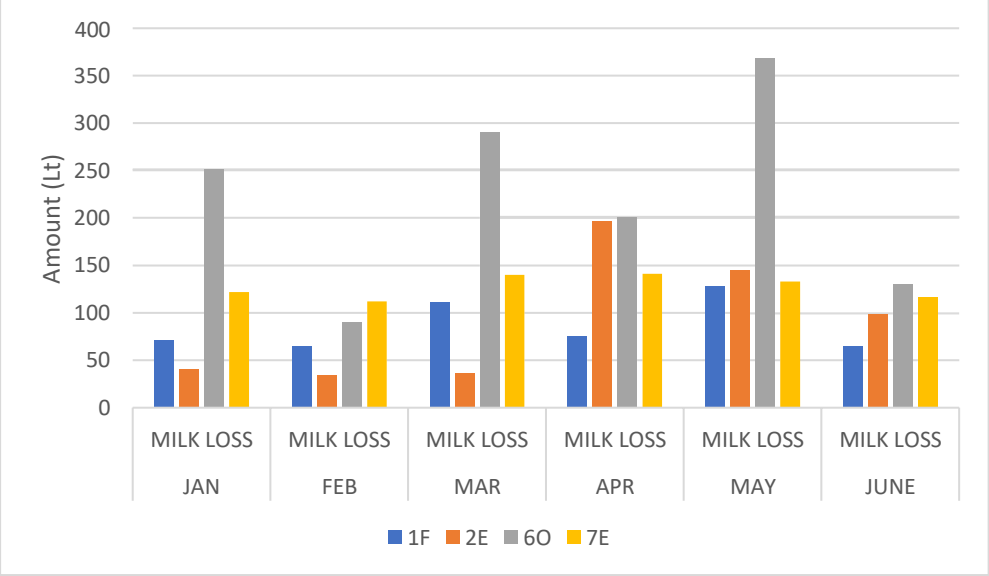
Source: GDFCS.

Figure 16: Comparison of milk rejected, spilt and missing per route in different months



Source: GDFCS milk records.

Figure 17: Total amount of milk loss per route per month



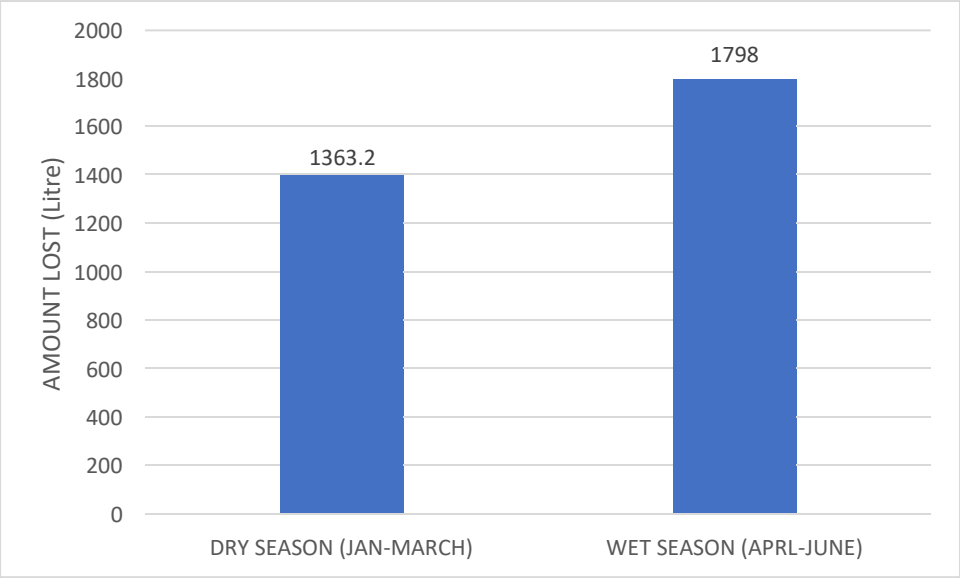
Source: GDFCS milk records.

4.9 **The season difference in milk loss**

Based on the information from the focus group discussion, interviews, and the records from the

collection centres, it was found that a high amount of milk loss occurs during the wet season (April to June). Also, was revealed at collection centres that the highest amount of milk loss was during the wet season, which was 1798Lt (Figure 18). Based on the quantities of milk loss between seasons it shows a difference in milk loss of about 400 Lt, but it cannot be proven using statistical tests due to few cases available.

Figure 18: Milk loss during the dry and wet seasons at a collection centre



Source: GDFCS milk records.

4.10 Quantification of Post-harvest milk loss at a collection centre

The information used to quantify the milk loss at the collection centre was obtained from the GDFCS intake and loss record. The six months records for January to June 2022 were collected for analysis. This statistical information was analysed in excel to quantify the intake, amount of milk rejected, spilt, and missing per route. Based on the data obtained at the cooperative, the quantified milk loss for routes 1F,2E, 6O and 7E were 6,322.2 Lt/year equivalent to 0.11% of the loss. The total value of PHL was KES 2,84,508 per year. The percentage of loss at the collection centre was less compared to the production level which was 3.6%. The formula used (refer 3: 5.1) and for the calculation refer to ANNEX 5.

4.11 Comparison of milk loss for the long route and short route

The means of milk loss for long and short routes were compared using the quantity of PHL per route. The 6O route had a high amount of milk loss compared to other routes (1F, 2E and 7E). This was seen as an out layer in the statistical test, which failed to run the statistical test. The amount of milk loss for the long route was 2,095.8Lt, while the short route had 1,065.1Lt. Therefore, based on the quantified amount of milk loss per route, it is expected that there is no difference in average PHL between the long and short routes. This was not easily proven because the number of cases was few making it impossible to run the test.

From the extra information obtained at the cooperative level for the other 17 short routes and 17 long routes. The statistical test shows the difference in milk intake between the short and long routes (SD 52709.8), while the milk rejection, missing, spillage, total loss/month and total loss/year were not different between the long and short routes (Table 10).

Table 10: The average milk intake and loss between short and long route (extra information)

Production or economic parameter	GITHUNGURI DFCS			
	Short route N=17	Log route N=17	Total N= 34	P-value
Intake (Lt/month)	86531.7 ± 42971.2	131349 ± 53072.6	108940.4± 52709.8	0.011
Rejects (Lt/month)	108.38 ± 99.93	183.5 ± 265.78	150.1 ± 207.33	0.462
Missing (Lt/month)	49.7 ± 55.82	90.84 ± 110.47	70.27 ± 88.68	0.18
Spillage (Lt/month)	35.5 ± 6.36	42.75 ± 6.85	40.3 ± 7.09	0.282
Total loss (Lt/month)	73.03 ± 97.5	206.74 ± 240.6	192.7 ± 231.87	0.11
Total loss (Lt/year)	38275.6 ± 33770.2	75460.5 ± 87821.1	56868.1 ± 68179.93	0.11

Source: GDFCS

4.12 Quantification of milk loss at the processing plant

The information used to calculate the PHL at the processing level was obtained from the milk records at the GDFCS processing plant during the interview with the plant operator. The information was analysed using excel to quantify the amount of milk lost. The cooperative collects about 230,000Lt to 240,000Lt of milk per day and about 7 million litres per month (Table 11).

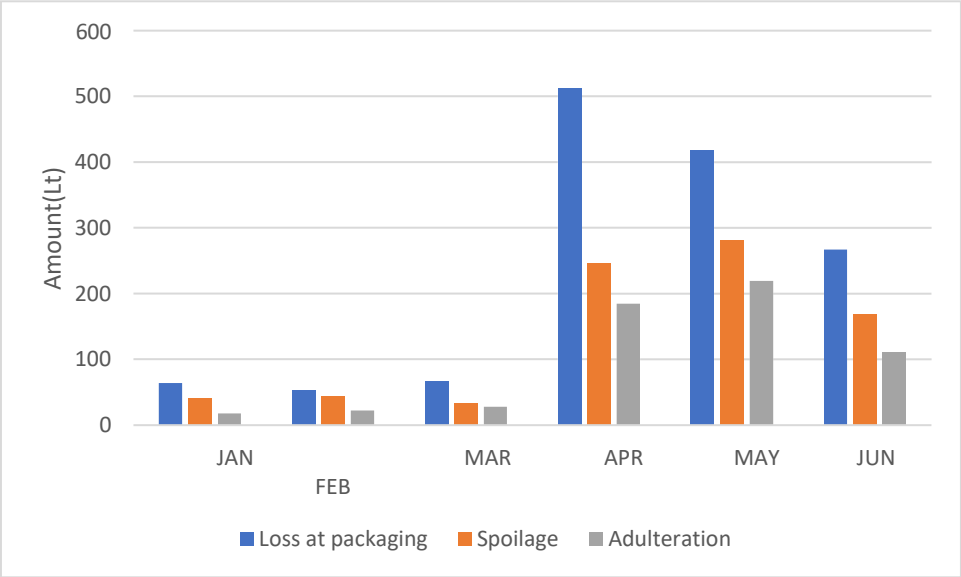
This study revealed that a high amount of milk at the processing plant is lost in the packaging area 49.8% (1,380.8Lt) resulting from spillage and 29.2% (811.7) Lt due to spoilage resulting from contamination from packaging and expired products. On the other hand, less milk 21% (582.5Lt) was lost due to adulteration from chilling milk (Figure 19). The quantified losses were for a period of six months (January to June 2022). Considering the amount of intake (41,868,421Lt) and the total milk loss at the processing plant (2,775Lt), the percentage of milk loss was 0.01% (table 11). The total value of PHL was KES 249,750. Additionally, the formula used to calculate PHL and per cent PHL refer to chapter 3:5.1 and ANNEX 6.

Table 11: Total intake and loss at the processing plant

JAN		FEB		MAR		APR		MAY		JUN	TOTAL INTAKE		TOTAL LOSS
INTAKE	LOSS	INTAKE	LOSS	INTAKE	LOSS	INTAKE	LOSS	INTAKE	LOSS	INTAKE	LOSS		
6723672	123	6420241	118	6932447	128	7045567	943	7437255	918	7309239	545	41868421	2775

Source: GDFCS milk records.

Figure 19: Milk losses at the processing plant



Source: GDFCS milk records

4.13 Disposal of rejected milk at collection centres and processing plants

The rejected and spoiled milk from the collection centres was identified and transported to the processing plant for disposal. At the processing plant, it was reported by the operators at the plants and quality Assurance that the rejects were sold to farmers keeping pigs for feeding their animals. The price of rejected milk at the processing plant was estimated to be Ksh10 per Liter of milk. Selling rejected milk was preferred rather than pouring it on the ground to preserve the environment. Other contaminated milk during packaging and sorting was reprocessed and sold at different grades to retailers (Figure 35).

4.14 Interview with District Livestock Officer, KDB, and KALRO

Interview with District Livestock Officer

The interviewee revealed that mineral deficiency is the main cause of poor quality milk leading to increased rejection at collection centres. The reason was inadequate feed supplementation due to the expensive cost of feedstuff and competition of feed with humans. The interviewee reported that supplementing dairy cattle with minerals in feed increases 10% to 15% of butter fat yield. Due to limited land, farmers were pushed to buy feed outside the farm, resulting in high production costs. Also, the interviewee identified that the causes of milk loss at various levels include mastitis, antibiotic residue, poor hygiene, feeding much concentrates which affect rumination due to acidosis and milk adulteration resulting from adding feed additives in milk deliberately to get the market. The obstacle in reducing milk loss mentioned was poor dosage use when treating dairy cattle, resulting in clinical or sub-clinical mastitis. Poor dosage use was due to the high cost of mastitis treatment, estimated to be KES 600 to KES 2000.

Interview with KDB

The interviewee identified the causes of milk loss at various levels. The interviewee reported that;

"One of the major losses of the milk is perishability. As you know, milk, by nature, is a perishable product.

So, if the distance from collection centres to plant is long probably, we may have losses because the quality might be an issue" Also interviewee added,

"So, the condition of our weather to road contribute much to losses especially when it is raining you find some places, they are impassable even farmers are forced to walk a very long distance to deliver the milk, that is the major factor can cause losses. All of these are tied to perishability. Back then, we used to have a lot of challenges with the roads as the condition of it is, sometimes you find some vehicles stuck in the mud, yet they are carrying uncooled milk and so the temperatures may rise and cause spoilage. This is due to poor logistics from collection centres to the plant."

Interview with KALRO

The respondent had a pleasant experience with dairy cattle and the former APCM alumni network of VHL. The interviewee revealed that by reducing milk loss, we can have sufficient food without putting any resources into production. The interviewee explained that post-harvest milk loss starts after you milk. However, if the cow has a disease such as mastitis can affect one udder or all udders, hence reducing milk production and thus can also be termed milk loss. He added that other factors contribute to milk loss even before milking.

The interviewee said, *"When talking about milk loss, we talk about spoilage, spillage, and adulteration. All three categories are found as different contributors at various levels in the value chain In The studies that have been done, at the production level, the loss was spoilages because of diseases, but there is a little spillage at th*e production level. At the cooperative, more is lost due to spoilage and adulteration. At a retailer/trader level, especially in the informal chain, the loss is due to adulteration, and only consumers will tell you about it. In the formal chain, the main loss is due to spillages because milk overstays there (expired milk) and sometimes inadequate cooling or power failure. So those are some factors that may cause loss at various levels of the value chain."

The interviewee also reported that, "At the farm level, the spoilage was due to mastitis, inadequate cooling where farmers lack cooler and due to this reason, they mix unsold milk or the evening milk with morning milk resulting to further spoilage."

4.15 Interview with four transporters

The transporters reported that the average distance from the faraway route was 20km, while the nearest route was less than 3km. Also stated that the challenges they faced during the transportation of milk were the rough and slippery roads during the rainy season. Rough roads were mentioned to cause spillage due to being rough, even during the dry season. Hence, it was identified that it takes more time to transport the milk to the processing plant during the rainy season. The transporters also reported that the distance from one collection centre to another is less than 30 minutes. To reduce losses during transport, the transporters said they ensure good sealing of milk can and the loaded milk is chilled. Also, the transporters reported that on the long routes, the milk could take 20-30 minutes before cooling, while for the short route, the time from collection to cooling was estimated to be less than 20 minutes. The transporters were seen to have a great role in reducing the milk loss as their contract with the cooperative is very strict on carelessness which may result in spoilage. Therefore, to abide by the rules in contracts, the transporters collected and delivered the milk to the required points on time.

Based on the interview with transporters, it was reported that the time taken to cool the milk after collection on the long routes was 30 to 45 minutes, while for the short routes, it takes less than 30 minutes. But the transporter revealed that regardless of the time difference from collection to cooling between the

long route and fast route, the quality of milk was not affected unless it took more time. Also was reported that,

"The quality of milk is not affected by the time of milk collection because the cooperative has a good plan for milk collection to avoid spoilage. The time between milking and collection is short, which is less than one to two hours. During transportation, truck breakdown may happen. Although it is very rare and causes spoilage, we avoid this risk by sending the rescue truck immediately to avoid the losses."

Identification of point of intervention

During the interview with key informants and focus group discussion, different Strengths, Weaknesses, Opportunities and Threats (SWOT) were identified. Thus, it was used to determine the point of intervention in reducing milk loss at production, collection, and processing levels of the Milk Value Chain (Table 12)

Table 12: SWOT of GDFCS from the key informants at GDFCS and processing plant

STRENGTH	WEAKNESS
• Well organized and functioning dairy hub (GDFCS Dairy Hub) • Have Standard Operating procedures (SOP) • Presence of Milk quality standards for quality control • Good payment system that increase trust with farmers • Good record keeping for traceability • Cooling equipment for chilling milk collected before transportation to processing plant • Transportation of milk from farm to MCC by walking reduce GHG emission. • Educated staff • Good and active management team at all	• Milk losses at collection centres and processing plant • Poor milk handling during testing at collection centre
OPPORTUNITIES	**THREATS**
• Adopting farmers to technologies • Supporting Government (Policy and regulation) • Good access to infrastructure such as water and electricity • Increased consumption of processed products by consumers • The cooperative is located in town making easy to access the market from different cities like Nairobi	• Livestock disease such as Mastitis affecting milk quality • High electricity bill • Geographical location (more scattered farmers) • Weather condition (rain season affecting milk transportation) • Poor infrastructure such as road • Aged farmers • High transportation costs • High processing cost • High price of livestock feed (supplement feed)

Source: Interview

4.1 Results from the survey

Before starting the survey, extension officers (4) working in the four milk routes selected (1F, 2E, 6O and 7E) were informed about the objective of the study and their role in the survey, such as their guide in introducing the researcher and study objectives to respondents for easy access of participants for the survey.

4.1.1 Basic information of respondents (GDFCS Farmers surveyed)

i) Age and gender of respondents

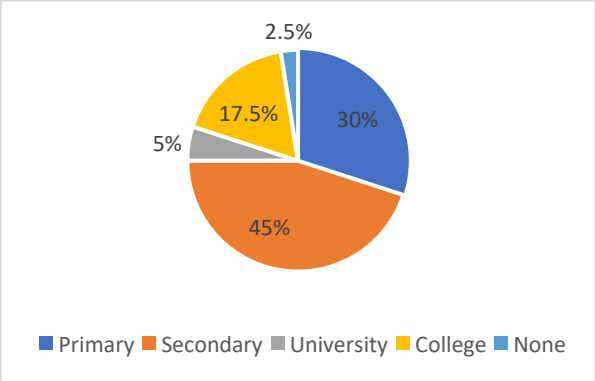
Out of 40 farmers involved in the survey, 9 (22.5%), 27 (67.5%) and 4 (10%) were aged between 18-35 years old, 36-60 years old, and over 60 years old, respectively (Table 11). This indicates that many farmers in the Githunguri sub-county have ages between 36-60 years old quarter of respondents were youth. Also, of the surveyed farmers, 25 (62.5%) were male, and 15 (37.5%) were female. Based on this analysis, the information was collected from a good sample of males and females with different age categories. During the survey, most of the respondents aged between 36 to 60 said they use hired labour to attend farm activities as they are unable to do it especially cutting grasses, milking, and delivering milk to the collection centres. Thus, making it more challenging to reduce milk loss on farms as the labourers do not get any training as livestock owners.

ii) Respondent's level of education and the main source of income

The study indicated that most farmers, 18 (45%), had attained a secondary level of education, 30% (n=12) had primary education, whereas 7 (17.5%) achieved college, but few farmers, 2(5%) a had higher level of education (university) and only 1 (2.5%) did not attain any level of education. Therefore, this study reveals that farmers in Githunguri are more educated at a level of secondary education (Figure 20).

This study revealed that the majority of respondents' primary source of income was livestock keeping 36(90%), and few depended on crop/vegetable production 4(10%) as a source of income. In addition, the study results show that respondents owned land less than four-acre with the average land owned equivalent to 2.48 acres (SD 0.640) and was revealed that there were no significant differences in land owned between long and short routes.

Figure 20: Respondents' level of education

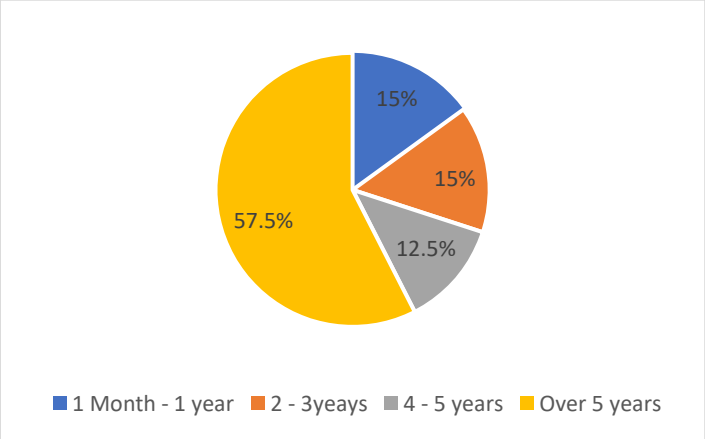


iii) Status of the farmers surveyed

All farmers involved in this survey were members of the Githunguri Dairy Farmers Cooperative Society, where 6 (15%) had 1month-1year, 6 (15%) had 2-3 years, 5 (12%) had 4-5 years, and 23 (57%) were

members for over 5 years, of membership in membership (Figure 21).

Figure 21: The duration of farmer's membership to GDFCS



Source: Survey

4.1.2 Livestock kept and milk production

i) Breed of livestock kept by farmers in Githunguri.

This study indicated that the majority of 38 (95%) respondents were keeping Friesian while 1(2.5%) and 1(2.5%) were keeping Jersey and Ayrshire, respectively. Thus, Friesian was the most kept dairy cattle for milk production, contributing to income generation. The farming system used for all farmers registered under GDFCS was zero grazing, and this was successful. As mentioned by respondents having a zero-grazing system was one of the criteria for becoming a member. The statistical test shows that the number of animals per herd was equivalent to 3 dairy cattle (SD 1.928) and the milking cow were 2 per farm (SD 0.959). Refer to table 13.

ii) Milk production, lactation length and calving interval

The study indicated that the peak production per cow per day was 11.03Litres in the dry season and 17.34Litres in the wet season. The minimum milk production was 10 Lt/cow/day and the maximum 30Lt/cow/day in the wet season at peak production. The respondents said the reduction of milk production during the dry season was associated with feed shortage especially grasses, although they use preserved feed (silage). The average lactation length was 10.80 months, with minimum and maximum lactation lengths of 9 and 12, respectively. It was indicated that the average calving interval for dairy cattle among the surveyed farmers was 12 months. The minimum calving interval was 12 months, while the maximum time was 14 months (Table 13). The statistical test shows that the average milk yield/cow/day and milk yield/farm/year between short and long routes were equivalent to 11.02 Lt (SD 0.157) and 7320Lt, respectively.

4.1.3 Comparison of production and economic parameters between short route and long route

Table 21 provides the general overview of production or economic parameters between the short and long routes, which were statistically compared. The statistical test shows that land size, calving interval, milk yield/cow/day, and milk yield/cow/year were not different between short and long routes. However, there was a significant difference between routes on herd size, milk yield/farm/year, lactation length and the number of milking cows (Table 13)

Table 13: Comparison of production and economic parameters between the short and long routes

Production/economic parameter		**GITHUNGURI DFCS**	
	Short route	Long route	Total
	N=20	N=20	N= 40
Type	Commercial dairy	Commercial dairy	Commercial dairy
Dairy as the main income	90%	90%	90%
Land size [Acre]	2.65 ± 0.475	2.30 ± 0.470	2.48 ± 0.640
Herd size [#]	4.45 ± 1.905	2.0 ± 0.918	3.23 ± 1.928
Milking cows [#]	2.55 ± 0.999	1.87 ± 0.605	2.21 ± 0.959
Calving interval (months)	12.80 ± 0.616	13.50 ± 1.638	13.14 ±1.272
Milk yield / cow / day [litre]	10.05 ± 1.468	10.35± 2.134	10.20 ± 1.814
Lactation length [days]	327	324	324
Milk yield / cow / year [litre]	3570 ± 1163.5	3349.5 ± 1249.86	3459.75± 1197.100
Milk yield/farm/year	6030	6210	6120
Peak production in the dry season (Lt)	12.35 ± 4.416	9.75 ± 3.041	11.05 ± 3.967
Peak production in the wet season Lt)	18.85 ± 5.770	16.10 ± 4.494	17.48 ± 5.291
Distance (farm to collection centre (Minutes)	9.85 ± 4.913	11.20 ± 5.569	10.53 ± 5.228

Source: Survey

4.1.4 The use of milk produced per day

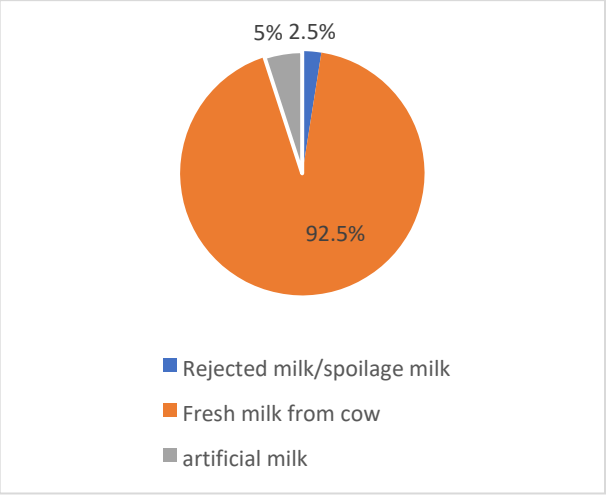
During the survey, over 40 respondents, 21 (52.5%) reported that their cow produces over 15Lt of milk per day per cow, 16 (40%) produce 11 to 15Lt/cow/day, while 3 (7.5%) have 6 to 10 Lt/cow/day. The milk produced was sold to MCC, home consumption and calf feeding, as reported by 32, 39 and 34 of 40 respondents. It was also found that the mean amount of milk consumed at home, feeding the calf, and sold to MCC was 2.15Lt/day, 4.26Lt/calf/day and 14.44Lt/day, respectively (Table 14). Also was indicated that the milk used to feed the calves was fresh milk from cows 37 (92.5%) of respondents, while 2 (5%) fed their calves with artificial milk after feeding colostrum (Figure 22).

Table 14: Daily milk use

	Minimum	Maximum	Mean	Std. Deviation	N
Home consumption	1	6	2.1538	1.22557	39
Calf feeding	1	6	4.26		34
Selling to MCC /day	4.5	30	14.44	5.470	32
Selling to MCC/ week	32	840	230.3	169.782	40

Source: Survey

Figure 22: Origin of Milk fed to calves



Source: Survey

4.1.5 Milk delivered to MCC per week

i) Amount of milk delivered per week

The average amount of milk delivered by farmers to collection centres per week for the individual farmer was estimated to be 230.3Lt with a minimum and maximum delivery of 32 Lt and 840Lt per farmer per week. The study indicates that a farmer with low milk production can deliver 32 Lt of milk per week while high producers from surveyed farmers can deliver 840Lt of milk per week. The statistical test shows a difference in the average amount of milk delivered to MCC per farmer between short and long routes 230.30Lt (SD 169.782). Forty (40) interviewed farmers stated that the cooperative buys milk for KES 45 per Litre of milk (Table 13).

ii) Means of transport used by farmers to deliver milk to collection centres

As reported by farmers from four routes of Githunguri, the majority 32 (80%)) deliver the milk by walking, and 4 (10%) use the motorcycle. Few farmers were using cars 1 (2.5%) and 3 (7.5%) bicycles (Table 15).

Table 15: Means of transport used by farmers to deliver milk

Means of transport used	Valid per	Frequency
Motorcycle	10	4
Car	2.5	1
Walking	80	32
Cycling	7.5	3
Total		40

Source: Survey

4.1.6 The distance from the farm to the collection centres

It was revealed that the mean time taken by farmers from farm to milk collection centre was 10 minutes and 53 seconds for all four milk routes. The result shows that from selected routes, route 7E farmers took more time to deliver milk to the collection centre, which was about 13 minutes and 5 seconds. Route 6O was revealed to have a short distance from the farm to the collection centre (Table 16). The statistical analysis shows no difference in time taken from the farm to the collection centre between the short and long routes, equivalent to 10.53 minutes per route (SD 5.228).

Table 16: Distance to milk collection centres per route

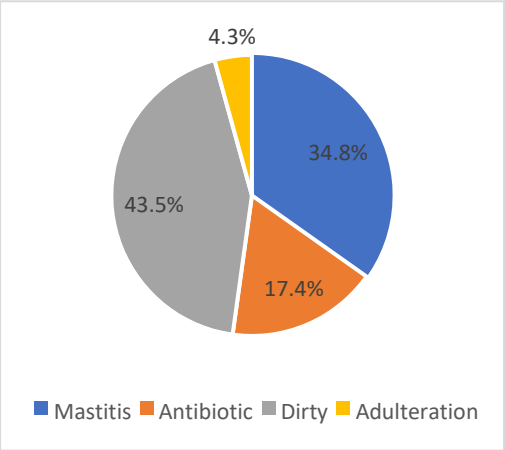
milk collection route	Mean	Maximum	Minimum	Std. Deviation
One	10	20	5	4.714
Two	9.7	20	5	5.355
Six	8.9	20	2	5.065
Seven	13.5	20	5	5.297
Total	10.53	20	2	5.228

Source: Survey

4.1.7 Milk spoilage at farm level

It was indicated that 23 (57.5%) of surveyed farmers had experienced milk spoilage at the farm level, and 17 (42.5%) of their milk had never been spoiled. Respondents with experience in milk spoilage said the reasons for milk spoilage were dirt, mastitis, antibiotic residue, and adulteration (Figure 23). The significant reason for milk spoilage at the farm level was dirt and mastitis, as reported by 43.5% and 34.8% of respondents. Milk adulteration was mentioned to be done unintentionally by the farmer or labourer during milking or storage. The physical dirt resulted from poor hygiene during milk handling at milking and storage. The average amount of milk per week by the individual farmer was estimated to be 11.7Lt with the minimum spoilage of 2Lt/week and 100Lt per week. The maximum amount of milk spoiled was caused by one respondent with greater milk production and spoilage. Hence, the spoilage mean is not varied because it was influenced by one farmer (Out layer) with the largest milk loss (Table 17)

Figure 23: Reasons for milk spoilage



Source: Survey

Table 17: Milk spoilage per individual farmer (Lt per week)

	Minimum	Maximum	Mean	Std.Deviation	N
How much milk was spoiled	2	100	11.7	20.051	23
Total					23

Source: Survey

Disposal of spoiled milk

The 23 respondents with experience in milk spoilage identified that 14 (60.9%) disposed of the spoiled milk by pouring it on the ground, while 9 (39.1%) fed the sour milk to animals such as pigs, calves, and dogs. Also, it was stated that the spoiled milk fed to calves was the milk spoiled by dirt and adulterated milk.

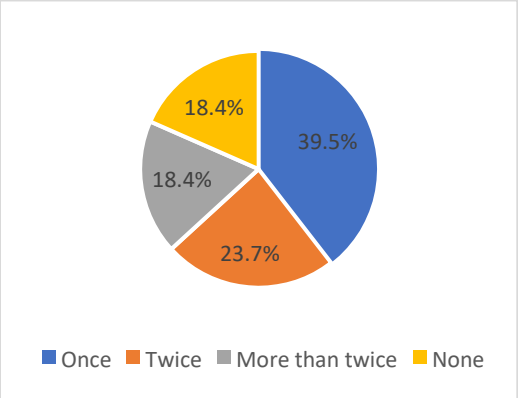
4.1.8 Milk rejection

i) Farmers whose milk has been rejected at the collection centres

From the 40 respondents surveyed, it was revealed that 31 (79.5%) respondents' milk had ever been rejected at the collection centres, while 8 (20.5%) had never experienced milk rejection, and one farmer did not answer the question. For the farmers whose milk has been rejected, it was indicated that the frequency of occurrence per week was once per week 15 (39.5%), 9 (23.7%), and twice per week, while 7 (18.4%) said it could happen for more than twice a week. Based on the findings, the milk rejection per individual farmer occurs once a week (Figure 24). Based on the interview with extensionists, the farmer with repeated cases (persistent farmer) of milk rejection more than twice a week is given a warning. If it persists, the farmer gets penalized by paying KES2 per litre rejected and suspended from selling the milk to the cooperative for a certain period, for example, six months or one year. It was reported that in July

In2022, about 24 farmers were penalized due to milk adulteration (adding water or Na_2CO_3 in milk). The identified reason for adding water to milk was to increase the volume of milk sold. What about Na_2CO_3 as a neutralizer?

Figure 24: Frequency of milk rejection

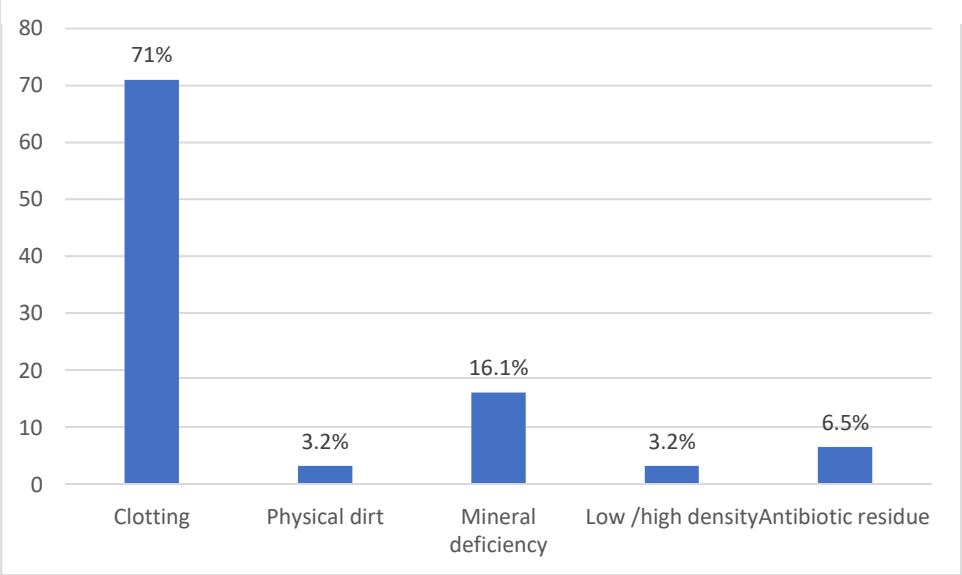


Source: Survey

ii) Reasons for milk rejection at collection centres

The study identified that from the 40 respondents, 22 (71%) of respondents' milk was rejected due to milk clotting on the test, which was caused by mastitis (high bacteria count in milk), 5 (16.1%) mineral deficiency such as Sodium and magnesium. And 2 (6.5%) antibiotic residue, while low/high density and physical dirt contributed to 3.2% rejection for four farmers surveyed (Figure 25). Farmers mentioned the mineral deficiency because of low density during testing, thus making low milk density to be one of the reasons for milk rejection at the collection centre. It was revealed that the reasons for PHL between farmers on long and short routes do not differ (SD 0.885).

Figure 25: Reasons for milk rejection



Source: Survey

4.1.9 Causes of milk rejection per route

i) Route 1F

Among 10 farmers surveyed, only 9 respondents responded to the question on causes of milk rejection, where it was identified that 6 (66.70%) respondents identified that milk rejection was mainly caused by mastitis and aflatoxin, mineral deficiency and antibiotic residues identified to contribute about 11.10% of rejection each, which one farmer per each reason responded. The collection centres did not identify adulteration as the main cause of milk rejection. Hence, from the findings, it was identified that the reason with the greatest contribution to milk rejection in route 1F at collection centres were mastitis (Table 18). Based on the small difference in the percentage of respondents on the causes of loss per route, it is expected that there is no difference in loss between long and short routes.

Table 18: Reasons for milk rejection at collection centres with great contribution to rejection per route

Causes of rejection		milk collection route				Total count
		1F	2E	6O	7E	
Mastitis	Count	6	8	4	8	26
	% Within Route	66.70%	88.90%	40.00%	80.00%	
Aflatoxin	Count	1	0	0	0	1
	% Within Route	11.10%	0.00%	0.00%	0.00%	
Antibiotic residue	Count	1	0	3	0	4
	% Within Route	11.10%	0.00%	30.00%	0.00%	
Mineral deficiency	Count	1	1	3	0	5
	% Within Route	11.10%	11.10%	30.00%	0.00%	
Adulteration	Count	0	0	0	2	2
	% Within Route	0.00%	0.00%	0.00%	20.00%	
Total	Count	9	9	10	10	38

Source: Survey

ii) Route 2E

Among 10 farmers surveyed, only 9 respondents responded to the milk rejection question. It was identified that 8 (88.90%) respondents identified that milk rejection was mainly caused by mastitis and 1(11.10%) said it was due to mineral deficiency. Milk adulteration, antibiotic residue and aflatoxin were not identified as the leading causes of milk rejection at the collection centres. Hence, from the finding was identified that the reason with the greatest contribution to milk rejection in route 2E at collection centres was mastitis (Table 18)

iii) Route 6O

Among 10 farmers surveyed, all respondents responded to the question on causes of milk rejection, where it was identified that 4 (40%) respondents identified that milk rejection was mainly caused by mastitis, mineral deficiency and the antibiotic residue was identified to contribute about 3% of rejection each which three farmers per each reason responded. Aflatoxin and adulteration were not identified as the leading causes of milk rejection at the collection centres. Hence, from the finding was identified that the reason with the greatest contribution to milk rejection in route 6O at collection centres was mastitis (Table 18)

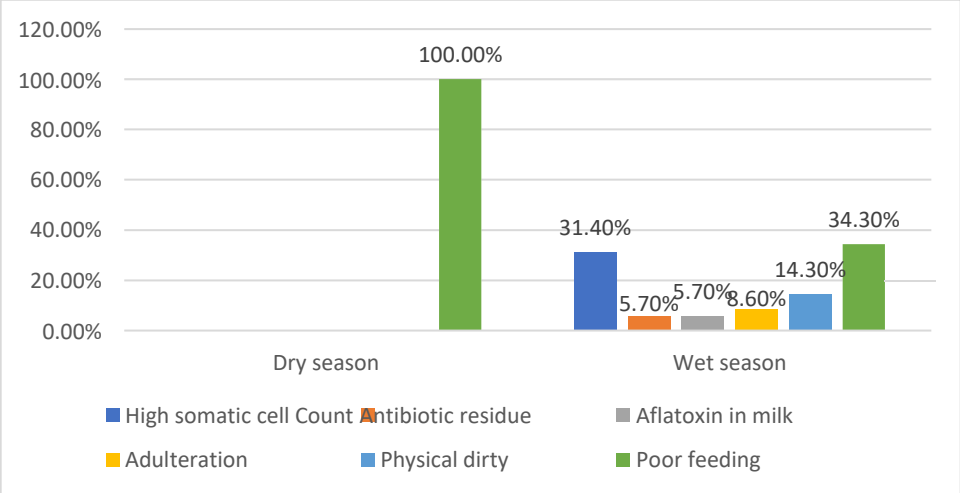
iv) Route 7E

Among 10 farmers surveyed, all respondents responded to the question on causes of milk rejection, where it was identified that 8 (80%) respondents identified that milk rejection was mainly caused by mastitis and 2 (20%) said it was due to adulteration. Mineral deficiency, antibiotic residue, and aflatoxin in the milk were not identified as the main causes of milk rejection at the collection centres. Hence, the finding was identified that the greatest contribution to milk rejection in route 7E at collection centres was mastitis, followed by milk adulteration (Table). Furthermore, adulteration was identified as a great cause of rejection during the wet season due to feeding milking cows feeds with high moisture content, such as fresh grass, fresh forages, banana tubers and their leaves and the addition of water in the milk (Table 18).

4.1.10 Season in which the major milk rejection occurs

As identified by respondents, it was revealed that 92.1% of respondents said during the wet season, there was a high frequency of milk rejection at collection centres. About 34.30% reported that the reason for high milk rejection in the wet season was poor feeding, 31.40% high somatic cell count in milk which was identified to be caused by mastitis, 14.30% identified physical dirty, and 8.60% adulteration. Antibiotic residue and antibiotics were both identified by 5.70% of respondents. During the dry season, it was identified by 100% of respondents that the reason with great contribution to milk rejection was poor feeding (Figure 26). The milk loss calendar was also developed to identify when the loss occurs throughout the year (Figure 29).

Figure 26: Reason with great contribution to milk rejection per season



Source: Survey

4.1.11 Quantification of milk loss at the farm level

To determine the amount of milk lost at the farm level, the information on milk yield at peak production, calving interval, number of milking cows, amount of milk fed to calves, and home consumption and sold to MCC were collected from the 40 respondents (Farmers). Also, the standard factor fat and protein were collected from the MCC. The formula for calculating PHL at production was adapted from (FAO, 2010; Opio et al., 2013). The following data were used to calculate PHL at the farm level:

Milk yield at peak 17.35, calving interval 13.14 months (394.2 days), lactation length 10.80, the average number of milking cows/farm 2, standard factor fat 3.5%, standard factor protein 3.2%, milk consumed by calf/three months 334.8Lt, milk sold to MCC/cow/year 4,477.64 Lt and home consumption 650 Lt (2.1 Lt/day × 310 days), milk yield at peak production 18Lt/cow (Table 13).

From the information gathered from the survey, the milk yield/cow/year was 3060 Lt, milk yield/cow/year FPCM was 2,861.1Lt, milk yield/farm/year FPCM was 5,722Lt, and the post-harvest milk loss was

207Lt/farm/year. Therefore, the total value of the loss was KES 9,315 [1], and the percentage loss obtained was 3.6%. ANNEX 4 shows how the results were obtained. The formula used (Chapter 3.5.1).

4.1.12 PHL (1F,2E,6O and 7E) in the milk value chain

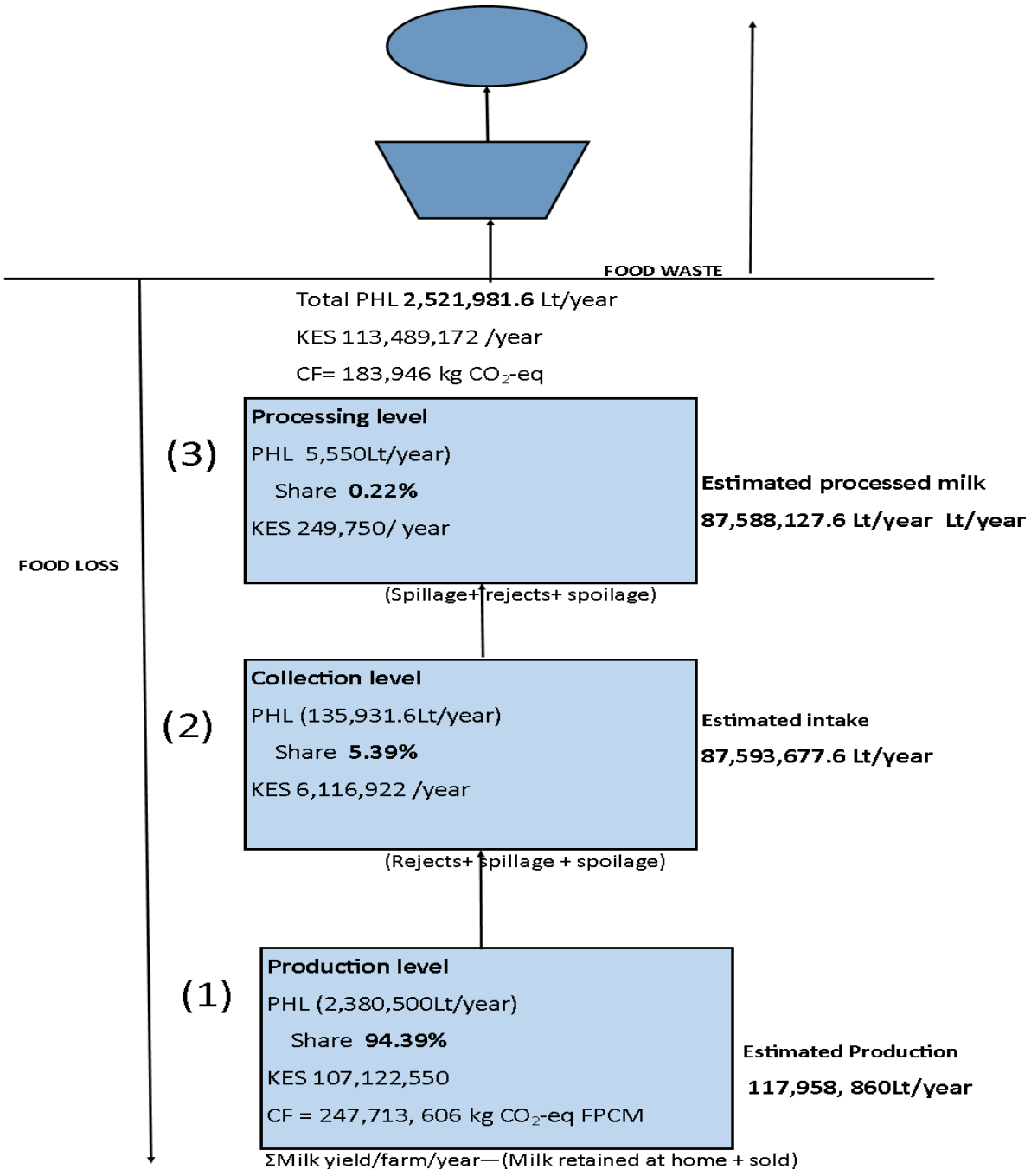
Based on the analysis, the amount of milk loss at the production level was 207Lt per farm per year, 3161.2Lt at the collection centre and 2,775Lt at the processing level, making a total of 6143.2 Lt for a period of six months (January to June 2022). It was found that the highest amount of milk loss occurs at the farm level since they have low production and high losses. At the production level, the milk yield was 5722 Lt/cow/year FPCM and the loss was 207 Lt, equal to 3.6% of losses with an average of 2 milking cows. Furthermore, based on the loss percentage, the highest loss was at the production level as it was 3.6%, whereas at the collection centre was 0.11% and 0.01% at the processing level. The estimated total PHL in all GDFCS milk shed was 2,521,981.6 Lt/year equivalent to KES 113,489,192 (Annex 4,5,6,7 and 8)

4.1.13 The share of PHL in all milk sheds of GDFCS

The share of milk loss refers to the percentage of PHL contributed at the production, collection, and processing stage in the milk value chain. Based on the quantities of PHL at production, collection, and processing level in all GDFCS milk sheds, a higher share was observed at the production level which had a 94.39% share of PHL than the collection centre (5.39%) and processing level (0.22%) refer to ANNEX 9. The production level has a high-value share of 94.39%, compared to the production level was 5.39% and 0.01% at the processing level (Figure 27). In quantifying the milk loss at the processing level, other data, such as the outputs, was unavailable as the cooperative produces a wide variety of products. The loss was calculated by summing up the milk spoiled, rejected, and spilt at the processing plant. The per cent of loss in all GDFCS milk sheds was 2.8%. Refer to annex10 for the formula and estimate of PHL in all GDFCS milk sheds.

[1] The exchange rate was 1 Euro equal to KES 120.77. The average price per litre was KES 45

Figure 27: Shares of milk loss in the milk value chain



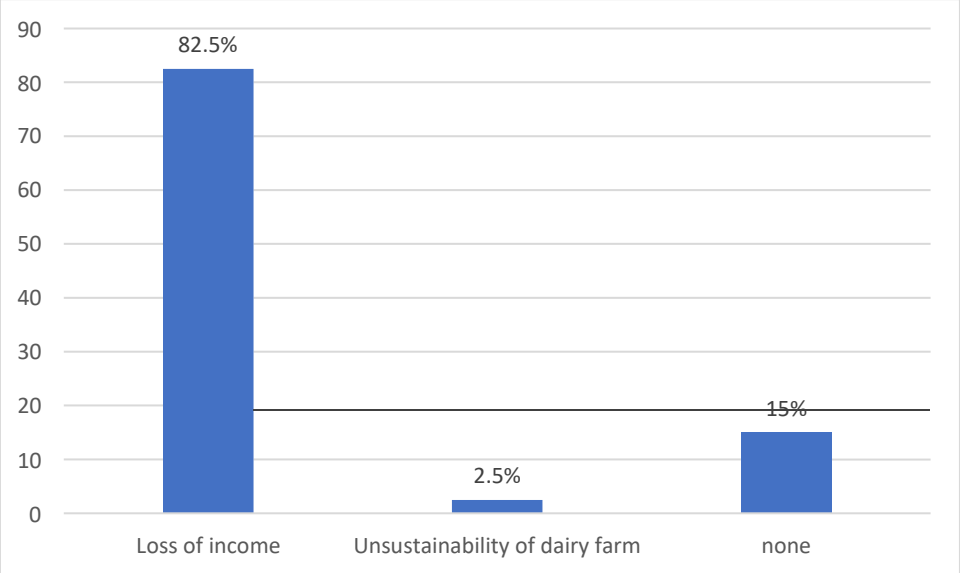
Source: GDFC record and survey

4.1.14 Impact assessment resulting from PHL

Economic impact resulting from milk loss at farm level.

The results from the survey revealed that 82.5% of respondents reported the loss of income due to milk loss to be a significant impact. Respondents reported the high cost of dairy cattle production due to the high cost of feed and treatments; they earn less income when the milk gets rejected. Also, 15% of respondents mentioned that they do not get any economic loss as they use the rejected and spoiled milk to feed their animals and sell all the produced milk for that particular day. Furthermore, 2.5% of respondents mentioned the unsustainability of dairy farms as the economic impact as other farmers were opting to stop farming activities due to repeated losses. The mentioned reason for the dairy farm to be unsustainable was failing to run the farm as it does not make a profit, affecting their economy (Figure 28). Unsustainable farming meant the failure to maintain the farming business. The economic value of PHL per farm per year was KES 9,315 (ANNEX 4) equivalent to 3.6% of the total losses. The price used to calculate the economic loss was the milk price offered by GDFC as the difference from side-selling was small (KES 3).

Figure 28: Economic impacts resulting from PHL



Source: Survey

The Carbon footprint impact of all GDFCS milk shed

The DGFCS milk sheds are more efficient in Carbon emission due to high milk production. However, they were still focused on emission reduction, thus a need to quantify the CF was calculated by multiplying the average CO_2-eq/kg FPCM, which was 2.1, with the total milk yield/farm/year FPCM, which was 5,722Lt. The CF obtained was 12,016.2 kg CO_2-eq/FPCM per farm for route 1F,2E,6O and 7E and 247,713,606 kg CO_2-eq FPCM at production level. The estimated CF of all GDFC milk shed was 183,946,723kg CO_2-eq FPCM (Annex 10).

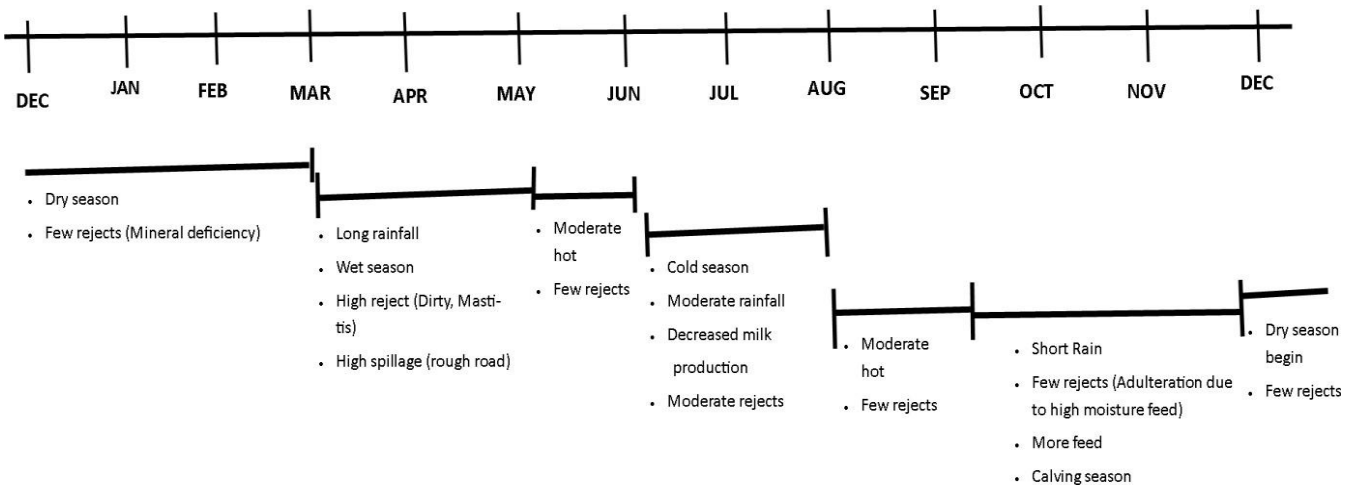
CF impact: total milk yield per farm * CF/ per kg FPCM or CF GDFCS milk shed /year

4.2 Results from focus group discussion (FGD)

4.2.1 Milk loss calendar

Two focus group discussions were conducted on routes 1F and 7E, where each group had 10 participants. All participants were allowed to contribute to the topic. During the focus group discussion, the causes of milk loss at the farm level identified include dirt, antibiotic residues, diseases such as mastitis, and adulteration of milk. Furthermore, the milk loss calendar was drawn to identify different seasons with possibilities of milk rejection and the cause. The milk loss calendar was also used to show the perception of farmers toward milk loss. (Figure 29)

Figure 29: Milk loss calendar



Source: FGD

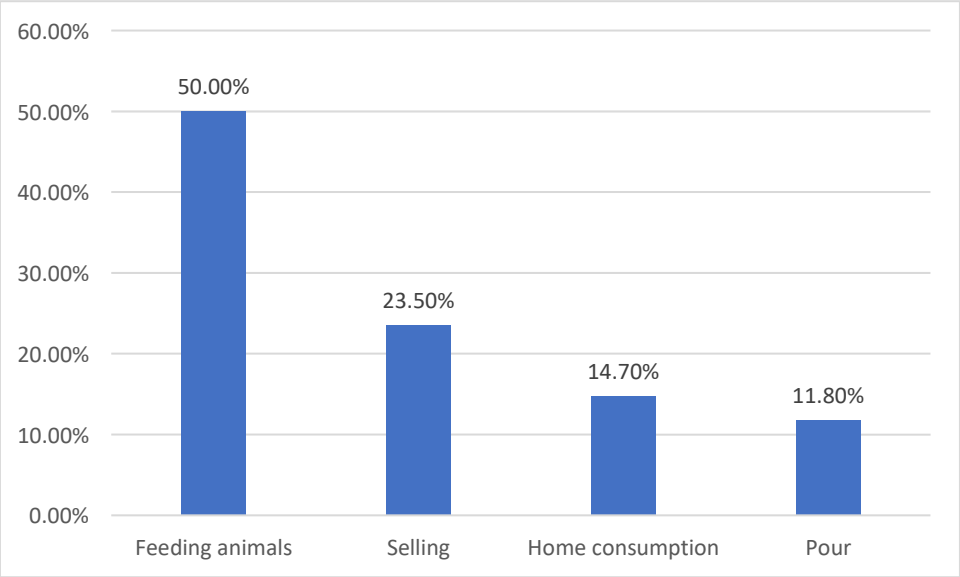
Figure 30: Photo was taken after focus group discussion

Source: Field data, 2022

4.2.2 Disposal of rejected milk

The participants in the group discussion identified the disposal channels of rejected milk, such as feeding animals (calves, pigs and dogs), home consumption, and selling to hawkers and institutional consumers (Figure 31). The survey identified feeding animals (calf, dog, and pig) (50%), selling (23.5%), home consumption (14.7%) and pouring on the ground (11.8%) as the disposal channels for rejected milk (Figure 26). The selling channel for rejected milk includes milk shops, restaurants, hotels, and hawkers found around the collection centre paying an average of KES 48.5 per litre as reported by 10 of 40 respondents who have ever sold the rejected milk, which is higher by Ksh3.5 than the price of quality milk offered by GDFCS (Table 19). The rejected milk fed to calves or consumed by animals was the rejected milk without toxic substances like chemicals, antibiotic residue, or clonic mastitis (bloody spot milk). Figure 32 shows milk rejection channels merged from the information obtained from the interview with the operator at the processing plant and the 2 focus group discussions. All the disposal channels from the mentioned three sources were related, making it possible to come up with one figure (Figure 32).

Figure 31: Disposal of rejected milk at farm level



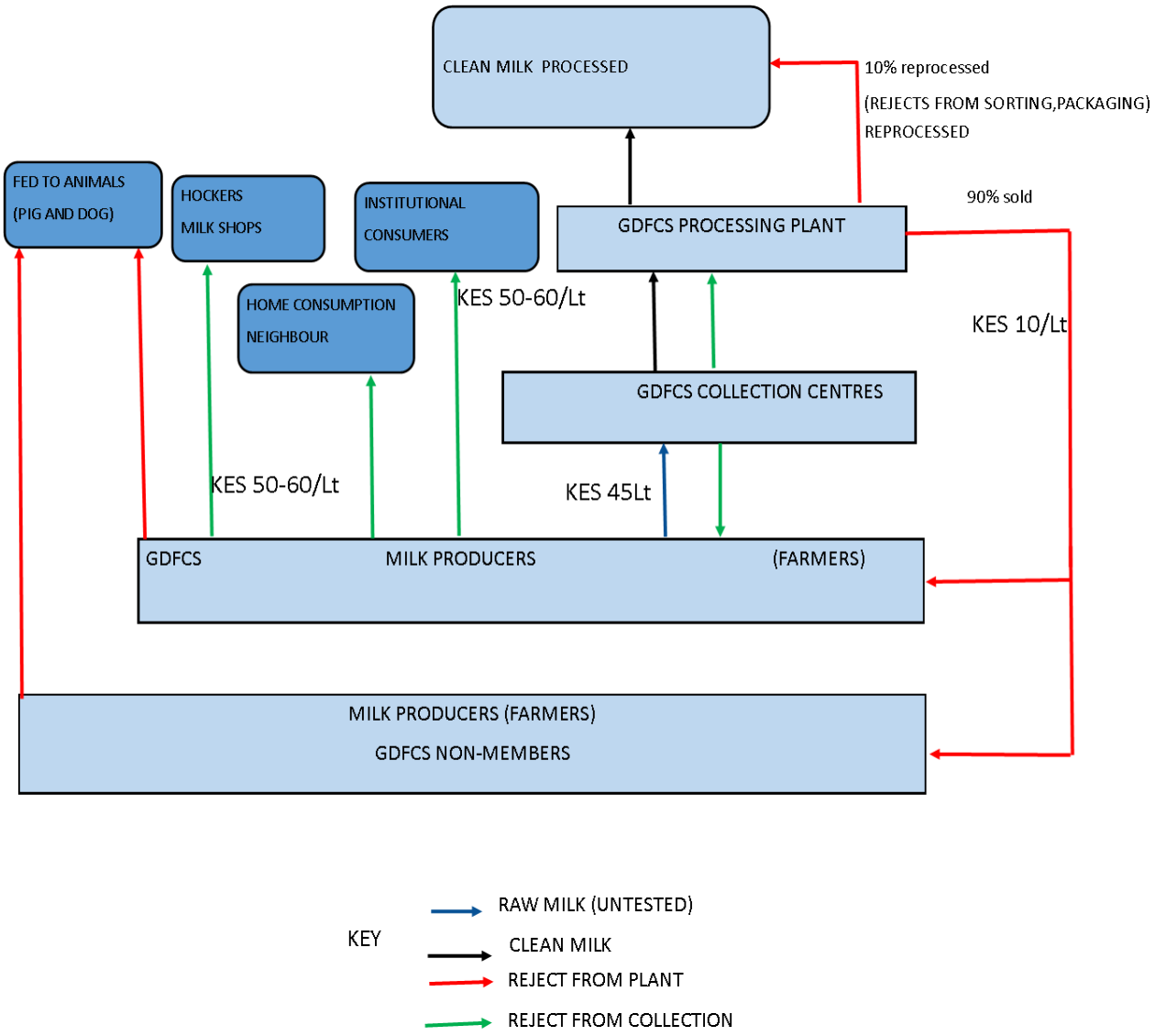
Source: FGD

Table 19: Price of rejected milk

	Minimum	Maximum	Mean	N
Price for rejected milk (KES/Lt)	45	50	48.5	10
Total				10

Source: FGD

Figure 32: Disposal channels of rejected milk



Source: FGD and interview

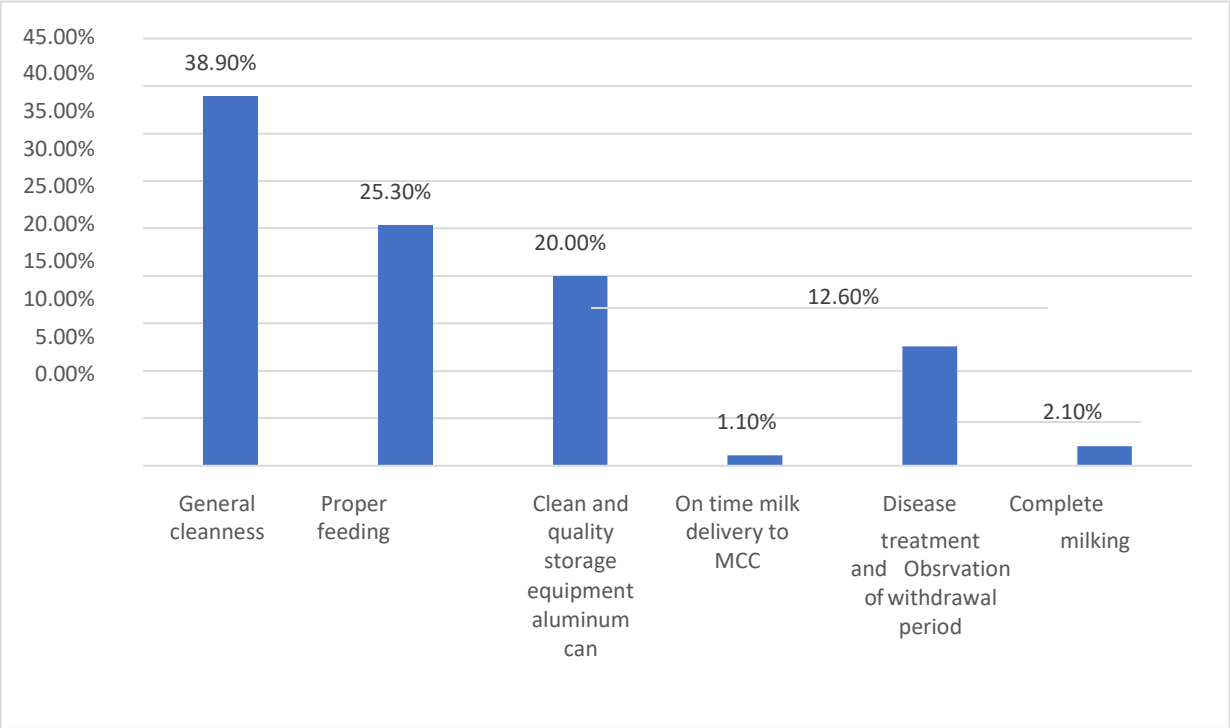
4.2.3 Current strategies for milk loss reduction at the farm level

This study identified that 38.90% of respondents observed general cleanliness, and 25.30% reported proper feeding by feeding feed with low moisture contents and supplementing cattle. Other 20% of respondents said they use cleaning and quality milk storage equipment to protect milk from contamination. It was identified that 100% of respondents were using aluminium cans/buckets in milking and milk delivery. Also, 12.60% of respondents were paying more attention to disease treatment and observing the withdrawal period. Few respondents (about 1.10% and 2.10%) reported on-time milk delivery to MCC and complete milking, respectively (Figure 34). The results obtained during the survey on strategies used in reducing milk loss at the farm level were the same in the focus group discussion.

Figure 33: Farmers delivering milk in aluminium milk can

Source: Field data,2022

Figure 34: current strategies toward milk loss reduction at the farm level



Source: FGD

CHAPTER 5: DISCUSSION

This chapter builds up the previous chapter where the results from this study were compared to the existing literature done by other researchers on the same topic.

5.1 Respondents' characteristics

According to Kiiza (2018), most respondents, 58%, were male, and 67% of respondents were aged below 50 years, whereas the youth were 27% aged below 50 years which was in line with this study where 22.5% of respondents were youths. The literature indicated that the youth are getting more motivated to engage in dairy production due to the profitability of the dairy sector. Most of the respondents had a secondary level of education (77%) which attributes to the adaptability of the farmers to modern technologies, and the land size was 2.85 acres (SD 2.107).

Also, this study revealed that 62.5% of the respondents were male, while 67.5% were aged between 36 and 60 years. The respondent's level of education was secondary education, as revealed by 45% of respondents this was also reported by a study conducted in 2018. The major activities of respondents (79%) used as a source of income was livestock keeping, and the most kept breed of dairy cattle was Friesian, as reported by 92% of respondents. This was also revealed in this study where 90% of respondents depend on dairy farming as a source of income through selling milk and dairy cattle, where 95% of dairy cattle kept were Friesian under a zero-grazing system. The respondents in Githunguri own a land size of about 2.48 acres (SD 0.640) which was close to what Kiiza (2018) found.

5.2 The quantity and share of PHL at the production, collection, and processing level of the value chain

This study found that from the total milk produced per day, about 90% was sold and 10% was retained at home for other use such as home consumption and calf feeding. It was revealed that a great amount of milk loss occurs at the production level, which accounts for 3.6% of losses due to spoilage caused by physical dirt, clinical mastitis, and antibiotic residue in milk. Also, the high electricity bills and power outages affect milk quality especially during cold storage as was reported by GDFCS staff during the interview. This was also revealed by other researchers who reported that across all the farms, 98.2% of produced milk farm was sold, 0.66% was purposely retained, 0.55% was rejected due to antibiotic residue in milk, 0.5% was lost from the parlour to the bulk tank, and 0.09 was rejected by the processor (March et al., 2019 and Nyokabi et al., 2021).

At the collection level, the loss was 0.11% due to mastitis, antibiotic residue, and mineral deficiency. Additionally, 0.01% was lost at the processing level due to spillage during packaging and spoilage resulting from contamination. In GDFCS milk shed, the production level contributed a higher share of milk loss in the value chain of about 94.39% of the loss, where 5.39% collection level and 0.22% at the processing level. The amount of PHL between the short and long routes was not significantly different (SD 0.11). This was revealed by analysing extra information on 37 routes including 17 short and 17 long routes (Table 10). Hence, the distance was not the factor influencing PHL between short and long routes. Also, the statistical test shows that the reason for milk loss between long and short routes was not a significant difference (SD 0.885). These results were revealed in 2005 by a study conducted in central Kenya, Tanzania, and Uganda (Lore et al., 2005).

It was reported that most of the milk loss in Kenya's milk value chain occurs at the farm level; about 4.5% of milk value available at the farm is lost due to spillage and spoilage resulting from poor handling practices that contaminate the milk. Along the value chain, the literature revealed that all the loss was due to spillage during transportation and, within the premise, adulteration, and spoilage due to disease and overstay. Mastitis has been identified as a problem at the farm level as it is a persistent disease. According to Nyokabi et al. (2021), the milk quality problem at collection centres or value chain nodes was contamination resulting from high Somatic Cell Count above 300,000 due to poor milk handling practices and added water as revealed in this study.

The current study on milk loss conducted in sub-Saharan Africa reported that milk loss at the production level is 24 %, and a large amount was observed at a collection centre (>34%) (Xue et al., 2017) which was different from this study conducted in Kenya. The different results could be due to the difficulty in defining the loss and waste at the production level. It was reported that limited studies consider primary production due to insufficient information from farmers. Also, it suggested that further knowledge of primary production loss and waste estimates is important (March et al., 2019).

Season with high contribution to milk loss

It was revealed that a higher amount of milk loss (PHL) occurs during the wet season due to high somatic cell count in milk, physical dirt, and poor feeding, as was reported by 92% of respondents. Also, the records from collection centres (GDFCS) identified the wet season to have a high PHL (1798Lt). The same results were revealed from previous research, it was reported that the wet season contributes to high PHL due to high SCC in the milk of about 492,180 SCC/ml (Cristiane et al., 2015).

5.1 The economic and CF impacts of PHL at the production, collection, and processing level of the value chain

PHL was identified to cause low-income generation at the farm level due to spoilage, spillage and rejection which was revealed by 82.5% of respondents. Also, PHL leads to stopping the farming activities since the farmers were not making a profit from it, this was revealed by 15% of respondents. In GDFCS milk shed about KES 113,489,172 is lost annually due to PHL where KES 107,122,500 was lost at the production level, KES 6,116,922 processing level and KES 249,750 was estimated at the processing level. The economic impact on the value chain was also revealed by a study conducted by FAO 2014, it was reported that Kenya loses about 95 million Litres of milk annually which was equivalent to KES 2.24 billion. Furthermore, it was identified the impacts were mainly felt at the farm level. Also, this was revealed by other researchers where it was reported that low profitability and forced consumption of evening and surplus milk are economic losses resulting from PHL (March et al., 2019).

The CF obtained per farm annually was 12,016.2 kg CO_2-eq FPCM. Whereas, at production level was 247,713,606 kg CO2-eq FPCM and 183,946,723 kg CO_2-eq FPCM at GDFCS milk shed annually. The CF in GDFCS milk shed was very low contributing to about 1.5% of national CF. This was revealed by the study conducted by FAO & NZAGRC (2019) and Vala (2019) In Kenya thus, the average carbon footprint was 12.3 million tonnes CO2-eq FPCM annually.

5.2 The disposal channels of rejected and spoiled milk at the production, collection and processing level

This study revealed that the rejected milk, due to low or high density and physical dirt, was fed to the calves. Although, other respondents reported feeding all rejected milk to animals (calf, pig and dog). Of the 40 surveyed respondents, 50% were using the rejects to feed animals, 24% were selling rejects to milk shops, hawkers, institutional consumers, and neighbours, and 15% were consuming rejects. Other literature revealed that rejected milk was fed to animals, consumed by humans, and sold to milk traders. Also was reported that feeding rejected milk to animals and home consumption resulted in multidrug-resistant, for example, methicillin-resistant S. aureus (MRSA) to livestock (Carfora et al., 2016). In addition, mineral deficiency such as Sodium was reported to result in low butter fat yield in lactating cows. Also, the use of

rejects for humans and feeding animals have health effects. For example, aflatoxin (AFM1) in milk was reported to cause human cancer (Gizachew et al., 2016).

5.3 Stakeholders' perspectives and Currents strategies on PHL reduction in the GDFCS value chain

The respondents were aware of the causes of milk loss based on season (wet and rainy seasons) PHL. It was identified that wet season is a season with high frequency of milk rejection at collection centres. However, they had insufficient knowledge of how much milk gets lost within the chain, this was revealed during the focus group discussion and interview with GDFCS staff. Different studies on post-harvest milk losses suggested the technical interventions and training of all players in the milk value chain as a solution to the reduction of milk losses in Kenya (Porter et al., 2016). The identified current strategies used to reduce milk loss at the farm level, collection centre and processing level in Githunguri were presented in (Table 20).

5.4 The Governance of GDFCS

The cooperative is well developed, collecting and processing large amounts of milk 230,000 Lt to 240,000Lt per day. However, the cooperative was still facing challenges with milk quality sourced from farmers. This study revealed that GDFCS had an excellent milk collection schedule from the farm, collection centre, and cooling point to processing, which helps reduce milk loss resulting from spillage and spoilage. In addition, the cooperative had an excellent dairy business hub that provides services such as livestock feed, extension services and consumable goods for easy accessibility by farmers. The cooperative has 86 collection centres and more than 50 mobile collection points to reduce the milk transportation time and 12 coolers located in 12 cooling points for chilling milk before transportation to the plant to prevent spoilage.

This study revealed that the average time taken from the farm to the collection centre was 10.53 minutes which was not significantly different from the short and long routes. Thus, the reason for milk rejection and spoilage between routes was due to other reasons and not the distance. This was also revealed by Kiiza (2018) and Teresiah et al. (2016) That increasing the number of collection centres and chilling milk before transportation reduces the chance of milk spoilage hence maintaining the milk quality. The literature also revealed that milk testing at all levels and creating awareness among farmers on quality standards were ways to reduce milk loss, as farmers must meet the standards to get to the milk market. Furthermore, Kiiza (2018) also revealed that GDFCS has a business hub providing a range of services to members and indicated that the core value of the cooperative includes continuous improvement and innovation, customer care, equity, equality, and integrity.

Table 20: Currents strategies that contribute to PHL reduction in the GDFCS value chain

Value chain level	Intervention	Focus area
Production level	Use of improved milk storage equipment such as aluminium cans and buckets.	Milking and storage
	Keeping improved breed of dairy cattle (Frisian, Ayrshire and Jersey) to improve the butter fat in the milk.	equipment Quality milk
	Engaging in a zero grazing system to improve the feeding system for a better quality of milk.	Production system and quality milk
	Availability and easy accessibility of dairy feed for increased quality and quantity of milk.	Dairy feed
	Reducing the time between milking and delivery to MCC to maintain the milk quality.	Milking, milk delivery time and quality milk
	Complete milking to prevent mastitis by establishing bucket feeding to calves.	Diseases (Mastitis) and quality milk.
Collection centre (GDFCS)	Monthly training of farmers on management practice (feeding, milk hygiene) and providing other extension services such as advice and disease treatment.	Improving farmers' awareness
	Reducing distance from farm to collection centre maximum 10 minutes' walk by establishing collection centres and collection points near the farm.	Distance from milk source and quality milk
	Milk Testing at collection centres (milk parameters) to ensure farmers produce quality milk	Quality milk
	Established cooling points within the milk collection route for chilling milk.	Quality milk
Processing plant	Reducing the time between milk storage and processing Use of trained staff in processing Use of improved processing equipment Milk testing at processing level (Aflatoxin, antibiotic residue and SCC)	Milk quality Trained staff Technology Milk quality

Source: Interview and FGD

5.5 Reflection on methodology

This study involved primary and secondary data. The secondary data was done by reviewing the literature. The primary data was collected from Githunguri dairy farmers registered under GDFCS, key informants in the Githunguri value chain. The approach used in data collection was an interview with key informants and a survey of Githunguri dairy farmers.

During data collection using a survey was challenging. Firstly, farmers wanted to be compensated for their time before participating in the survey. This was an extremely hard part with a limited budget that can pay 40 respondents. I was able to communicate with the management of Githunguri to help in solving this challenge with farmers. Finally, I gave the respondents a small amount of money as an incentive. The respondents were happy to participate in the survey and were able to provide me with the information I needed. This challenge was a lesson to me because this would not have happened if I had introduced myself well to them as a student. Most of the farmers thought that I work under GFDCS at the top management, so they were having more expectations.

Secondly, during data collection using the survey, the respondents were having a feeling that I work under GDFCS, so they were not ready to give information about the PHL, especially on the amount of milk rejected reasons for rejection, and the frequency of rejection at collection centres. The reason for this was, that GDFCS penalize and suspend farmers who have repeated cases of milk rejection. Farmers thought I was collecting information on behalf of the cooperative. This was influenced by the way the cooperative introduced me to them, I was introduced as an intern and working under the cooperative. To avoid this, I would have introduced myself as a student. After talking to the respondents before filling, out the questionnaire, I had to explain myself and the reason for conducting this survey to get their consent to participate.

Thirdly, when interviewing the key informants, especially at the cooperative level I met the same challenges such as the interviewees wanting to be given incentives before participating because they were told that I work under the FORQLAB project which made them think I have a budget for the fieldwork. So, it was challenging as I was introduced differently, the reason for this introduction was the person who was guiding me wanted to get the respondent's attention and give relevant information. But this was also helpful in getting more information because interviewees thought that this intervention is made to be implemented in Githunguri thus, wanted to give more information.

What I learnt from this study is that to get good, more, and relevant information it is important to introduce yourself well to the people involved in the study. Furthermore, it is important to find an effective way of providing incentives to farmers other than money for example buying a small gift, costing less than the amount you would have paid them. Also, I learned how to interview people and probe to get more information on the topic, this will also help me at my workplace as a researcher because I will be using the same methods in carrying out my research.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

This chapter provides the summary of findings from the study to answer the main research question thus addressing the research objective. Additionally, the recommendations towards interventions for PHL reduction were recommended for implementation.

6.1 Conclusion

6.1.1 The quantity and share of PHL at the production, collection, and processing level in the value chain

The cooperative PHL is quite low, but GDFCS is still not satisfied with the milk quality collected from the members (farmers). The milk loss, rejection, spillage and missing between short and long routes are not significantly different. Thus, the distance between the short and long routes is not a factor for milk loss in the chain. In GDFCS milk shed, the high amount of milk loss was at the production level where the estimated yearly loss is 2,380,500 Lt/year FPCM (3.6%) through spillage, spoilage, and rejection. The collection centre and processing plant contribute low amount of PHL 135,931.6Lt/year (0.11%) and 5,550Lt/year (0.01%), respectively. Thus, the production level is a leverage point thus needing more attention in milk loss reduction due to having a high amount of milk loss.

6.1.2 The economic and CF impact of PHL

The economic impact resulting from PHL at the farm level is the low-income generation where about KES 107,122,500 is lost annually which is extremely high. Thus, the low profitability of the farming business led to failure to run the business resulting in stopping farming activities. At the collection centres and processing level in all GDFCS milk sheds about KES 6,116,922 and KES 249,750 is lost yearly, respectively. The total loss in GDFCS milk sheds is estimated to be KES 113,489,172. The PHL economic impact is mainly felt at the farm level where high losses occur. The CF in GDFCS milk shed is low which accounts for 5,296,161.36 CO_2 -eq kg FPCM due to the high amount of milk produced thus contributing to 1.5% of the national CF.

6.1.3 The reasons for PHL

The causes of PHL at the production level were spoilage and spillage. The spoilage was due to physical dirt in milk resulting from contamination during milking and handling. Other reasons for spoilage at the production level was antibiotic residue during livestock treatment and clinical and subclinical mastitis thus resulting in blood spot in milk. The greatest reason for PHL was mastitis incidence, thus reducing or preventing mastitis issues at a further level would reduce the large amount of milk lost.

At the collection centre, the PHL was due to spillage, missing milk and rejection. There was no information on spoiled milk within the study period. The spillage was due to poor infrastructure such as rough and slippery roads during milk transportation. The missing milk was resulting from errors that occur during milk measurement at the collection centres.

At the processing level, the PHL was due to spillage that occur in the packaging area. This spillage is high since the packaging is done manually. Other spillage resulted from broken packaging material during packaging. The rejection at the processing plant was due to contamination and antibiotic residue in milk. There are also aflatoxin issues in milk, but the milk was not rejected as if they were to reject that milk, they would have rejected half of the collected milk.

6.1.4 The disposal channel of rejected milk

The poor-quality milk rejected or spoiled at the farm level was fed to calves especially the milk rejected due to low or high density and contaminated milk with physical dirt. This disposal channel is not recommended since it can deteriorate the calves' health such as diarrhoea. Other disposal channels include selling to institutional consumers, milk shops/bars, selling to neighbors and home consumption. Although, the milk was rejected due to clinical mastitis and antibiotic residues were poured on the ground. At collection centres, there are no disposal channels for rejected or spoiled milk. The poor-quality milk at the collection centre was transported to the cooperative for disposal. Whereas, at the cooperative, the rejected or spoiled milk was sold to farmers for feeding pigs, calves, and dogs.

6.1.5 Stakeholder perspectives on loss and the current strategies for milk loss reduction

The farmers were aware of the cause of milk rejection and the effect of the season on PHL. Farmers identified the wet season to have a great contribution to milk loss due to mastitis and contamination due to physical dirt. However, farmers were not aware of how much milk was lost in the chain at the production level and to determine the value of economic loss resulting from that loss.

The current strategies for milk loss reduction in GDFCS milk shed were training farmers on milk hygiene, delivering the milk on time and training on optimal hand milking techniques. Completing milking throughbucket feeding to reduce mastitis and use of aluminium cans in milking and milk storage, supplementing dairy cattle with concentrates and keeping improved dairy breed to improve milk quality. Other strategies include reducing travel distance from farm to collection centres (max 10 minutes), Standard operating procedure (SOP) were displayed and staff are trained on SOP, milk testing at collection centres and plans to ensure farmers meet the quality standards.

6.1.6 The governance of Githunguri

GDFCS is a well-developed cooperative although they are still experiencing quality problems with the collected milk. The cooperative has made efforts in reducing the losses by reducing the travel distance from the farm to collection centres and introducing the cooling point in the milk collection route to maintain the quality of milk. Also, they are still finding a way to reduce the travel distance from the farm to the collection centre to lower than the current average time (10 minutes) by introducing more collection and cooling points. This is going well due to having best practices. The cooperative has good information about farmers and staff. Although, there is a need to develop an information network between cooperatives and other stakeholders. However, GDFCS still has more PHL which occurs at the farm level due to mastitis as the farmers are registered under the cooperative. The incidence of persistent mastitis at the farm level gave the idea of coming up with the bucket milking machine. The production level is a leverage point to work on by the cooperative to reduce PHL.

6.2 General overview of PHL

The PHL is a challenge in the dairy sector as it has environmental (CF) and economic impacts on stakeholders in the milk value chain. Although, the cooperative is putting more effort into reducing PHL but still faces the PHL due to poor milk quality sourced from farmers and contamination during milk handling and storage. At GDFCS, the PHL was extremely low (2.9%) compared to milk intake which was 87,600,000 Lt/year. The cooperative contributes about 1.5% CF to the national annual CF (12.3 million tonnes CO2-eq FPCM). There was no significant difference in the amount and reasons of PHL between short and long routes due to reduced time intervals between milking and cooling and both routes have

the same causes of milk rejection, respectively. The reasons associated with the loss include mastitis incidences, antibiotic residue, low/high milk density and contamination due to poor milk hygiene thus leading to milk spoilage and rejection. Also, spillage due to transportation and packaging at the collection centres was counted as the reason for PHL in the milk value chain. As for GDFCS, the economic value of PHL was estimated to be KES 113,489,172. The PHL value may look small but the most impact is experienced by the farmers. The milk disposal channels identified especially feeding calve and consumption are not good disposal channel as it causes health problems. The most leverage point in the value chain is at the production level due to high PHL, thus the need for more efforts towards PHL reduction.

6.3 **Recommendations for interventions to reduce PHL**

The interventions for scaling up the post-harvest milk loss at different levels of the value chain such as production, collection and processing level were identified based on the finding at each level and from the SWOT analysis. The intervention area recommended includes training and motivating staff and farmers, making the evening shift the permanent shift, establishing solar power, feed testing before purchase, establishing a quality-based payment system, a simple and affordable milking machine and developing an information network. The easy and less costly interventions to implement include, training and motivating staff and farmers, developing an information network, and making evening shifts permanent. The most costly interventions that need more investment (money and time) include, establishing solar panels, milk test kits at the farm level, simple bucket milking machines and a quality-based payment system. Table 23 provides detailed information. Also, further research is needed at the national level to determine the extent of antibiotic residue and aflatoxin levels in the milk to make a better decision in reducing the cases of antibiotic residue and aflatoxin in milk. The intervention areas were further discussed in table 21.

Table 21: Intervention

These interventions were developed based on the statistical analysis done on milk loss and the SWOT tool

Leverage point	**Intervention**	**Focus area**	**Stakeholders involved**	**Stakeholders' roles**
Production level (Most important)	Training	Feeds and feeding: good preservation of animal feeds, especially maize meal, and maize bran, drying or reducing moisture contents in animal feed (grasses and forages) without losing its nutritive value. Disease treatment and observation of withdrawal period: Proper dosage and avoiding self-treatment at farm level without consulting extensionists or vets. Mastitis prevention measures	GDFCS extension officer, Training institutes, Quality Assurance Officer, and NGOs and FORQLAB project GDFCS extension officer and vets KALRO GDFCS and FORQLAB	4.16 Training and advisory services and Dissemination of technology Training farmers and disease treatment

				Development and dissemination of technology 4.17 Providing training material
		Establishing milk preservation or cooling method at the farm level: Putting more focus on spreading the technology of socking the milk bucket in clean and cold water for conservation and observing general milk hygiene. Also, training on milk quality assurance (HACCP) and good manufacturing practices (GMP)	GDFCS extension officer, Quality assurance officer and KDB. KALRO	4.18 Training farmers. 4.19 Dissemination of technology (local storage technology and small milking machines) and training
	Introducing simple and affordable milking machine	Fermentation of evening milk is one way of adding value and extending the milk's shelf life.	GDFCS	Training farmers on milk fermentation
		Improving milk hygiene by introducing the use of milk machines in milking to reduce contamination and mastitis incidences	GDFCS, KALRO and FORQLAB project.	Ensuring accessibility of milking machines. Researching simple milking machines economical for farmers.
Collection centre	Training staff	Increasing the training from once to twice per month to increase the awareness of the graders, inspectors and extensionists on current situations at the farm and,	KDB, KEBS, KALRO, training institute and Quality assurance officer.	Training and creating awareness of the extent of milk loss at all levels of the

		for example, training on milk handling during testing, measurement, and storage.		value chain. Displaying the SOPs around the processing plant
	Motivation	Motivating farmers based on the quality of milk produced quarterly (every after 3 months) either by providing certificates of appreciation/recognition or other incentives	GDFCS	Motivating farmers
	More attention on an evening or	The evening shift should be made a permanent shift as the morning and afternoon shifts motivate farmers to focus more on the evening shift to reduce spoilage and rejection resulting from mixing the evening and morning milk.	GDFCS	Establishing evening shift
	Establishing solar power	Using solar power at the cooling point to reduce the electricity bill Investing in solar power to reduce running costs and the effect on quality due to power outages.	KDB GDFCS	Negotiating with the county government on behalf of the cooperative to get a loan or equipment/solar panel at a lower interest rate. GDFCS investing in solar power.
Processing level	Training staff	Appropriate preservation, processing technologies and milk hygiene during testing, measurement, packaging, and storage to avoid milk contamination and spillages.	GDCFC PLANT	Training and disseminating technology
GDFCS	Testing feed quality and good storage at the GDFCS store	Sourcing and selling dairy feed free from aflatoxin by ensuring the feed is tested before purchasing and ensuring good storage at the store or shop	GDFCS, KALRO-Naivasha KEBS	Testing livestock feed Ensuring the livestock/dairy feeds sold meet KEBS standards.
	Promoting staff based on low incidences of mastitis in their working areas.	Extensionists and vets should be promoted or motivated by providing a certificate of recognition based on low or non-incidences of mastitis cases in their working area.	GDFCS	Promoting staff.
	Establishing a quality-based payment system	To improve the quality of milk sourced from the farm and reduce rejection, the cooperative should focus on buying and paying for milk delivered based on its quality	GDFCS	Establishing a quality-based payment system.

		rather than the volume.		
		Providing incentives at the end of every six months to the farmer who supplies the milk that meets the GDFCS milk standards	GDFCS	Motivating farmers to supply good quality milk
Development of Information network	Creating awareness among the dairy stakeholders on the general overview of PHL through the workshop, field visits/day and media campaigns (platforms, GDFCS and the national website) The players in the dairy sector and the public should be informed of the impacts of PHL for sound decision-making.	GDFCS, stakeholders involved in training and Media	Creating awareness on causes, the extent of losses and reduction strategies of losses.	Development of Information network

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ANNEX

ANNEX 1: Questionnaire

Questionnaire on Post-Harvest Loss Reduction in Milk Value Chain: A case study of Githunguri Dairy Farmers Cooperative Society in Kiambu County, Kenya

Dear respondent,
I am a Master's student in Agricultural Production Chain Management at Van Hall University of Applied sciences, the Netherlands. I am conducting a survey on Post-Harvest Milk Loss Reduction in the Milk Value Chain in the Githunguri sub-county. However, this report's findings will generalize Kiambu Counties and give an overview of post-harvest milk loss. Hence, providing the basis for milk loss reduction in the Kiambu milk value chain. Kindly, I will appreciate your participation in this survey by responding to the questions below.
The responses to these questions will be used for the sole purpose of research and treated confidentially.
Thank you for your willingness to participate.
TIME: 15-25 minutes

Section A: Respondent information

1 Name of respondent……..(OPTIONAL)
2 Ward……..
3 Age 18-35 years, 36-60 years, Over 60 years
4 Gender
- Female
- Male

5 Level of education
- Primary
- Secondary
- University
- None

6. The main source of income
- Livestock keeping
- Crop/vegetable production
- Business
- Employed

7. Are you a member of the Githunguri Dairy Farmer Cooperative Society?
Yes
No
If YES, Answer question 10

8. For how long you have been a member of the cooperative above?
    - 1 month - 1 year
    - 2 - 3 Years
    - 4 - 5 years
    - 0ver 5 years

Section B: Milk production

9. Breed of dairy cattle you have
    - Friesian
    - Jersey
    - Aryshire
    - Cross
    - Other, Mention……..

10. What is your herd composition?
    - Cows
    - Cows in milk
    - Dry cows
    - Pregnant heifers
11. What is the average body weight of your cow?
12. What is the time difference (Months) from the first calf to second calf (first calving to next calving)?.....

13. Under good management, what is the average milk production per day per cow?
    - 1 – 5 L
    - 6-10 L
    - 11-15 L
    - Over 15 L
14. What is the average milk yield/cow /day during dry season?.....
15. What is the average milk yield/cow /day during wet season?.....
16. What is the average milk yield at production peak during dry season?.....
17. What is the average milk yield at production peak during wet season?.....
18. What is the lactation length in dry season?.....
19. What is the lactation length in wet season?.....
20. What is the calving interval of your cows?.....

21. How do you use the milk produced per day?.....
    - Home consumption
    - Calf feeding
    - Selling to MCC
    - Other, Mention……
22. On average, how much milk do you use in
    - Feeding calves ……
    - Home consumption ……..
    - Selling to MCC ……
    - Other use……

23. What milk do you use to feed calves?
    - Rejected/spoilage milk
    - Fresh milk from cow

- All the above answer

Section C: Reasons for PHL and means of disposing the rejected and spoilage milk

24. At what time do you milk and bring the milk to the MCC……..
25. What is done with
    - Morning milk ……
    - Afternoon milk …….
    - Evening milk (thrice milk …….
26. How much milk can be delivered to the MCC per week?.....
27. What is the milk price per Litre?.....
28. How do you transport milk to market
    - Motorcycle
    - Car
    - Collected by MCC
    - Walking
    - Cycling
29. What is the milk storage equipment do you use?
    - Plastic can/buckets …….
    - Aluminium can/bucket……
    - Any other, mention ……..
30. How long does it take to reach the collection centre?.....
31. Have you ever experienced milk spoilage?
    - Yes
    - No
32. What was the reason for milk spoilage?.....
33. How much milk was spoiled?.....

How often……

34. How do you dispose the spoilage milk?.....
35. Has your milk ever been rejected by buyer?

    Yes
    No
36. How often does the milk get rejected?
    - Once per week
    - Twice per week
    - Once per month
    - Twice per month
    - More
    - None
37. How much was rejected?.....
38. What is the reason for milk rejection?.....
39. Which of the following reasons has a great contribution to Post-harvest milk loss? **(Rank 1 to 5)** where 1 is a least and 5 the most.
    - High somatic cell count

- Antibiotic residues
- Aflatoxin in milk
- Adulteration
- Distance to collection centre (cooling point)
- Physical dirty
- Other, Mention…….

40. Which production season the milk is highly rejected

- Dry season
- Wet season

Give reason…….

- High somatic cell count
- Antibacterial residual
- Aflatoxin in milk
- Adulteration
- Distance to collection centre (cooling point)

41. Which time of the day is the milk highly rejected?
    - Morning
    - Afternoon
    - Evening

42. How do you dispose of the rejected milk
    - Feeding animals
    - Selling to other buyers
    - Use for home consumption
    - Other, Mention……..

43. How much (Price) do you sell the rejected milk?.....
44. Do you sell your milk to other traders/buyers?

Yes
No
If any, Please mention……

Section D: Economic impacts of PHL and strategies for milk loss reduction in place.

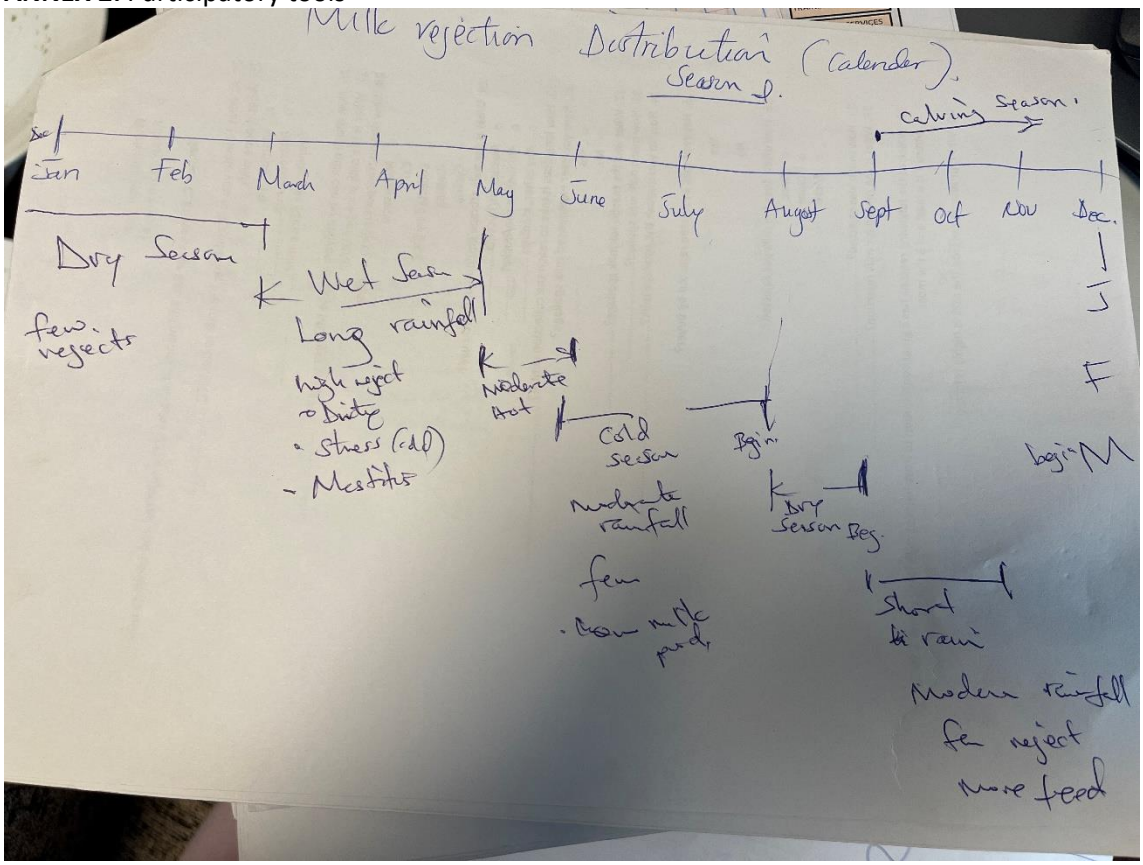
45. What are the economic impacts resulting from milk spoilage and rejection?

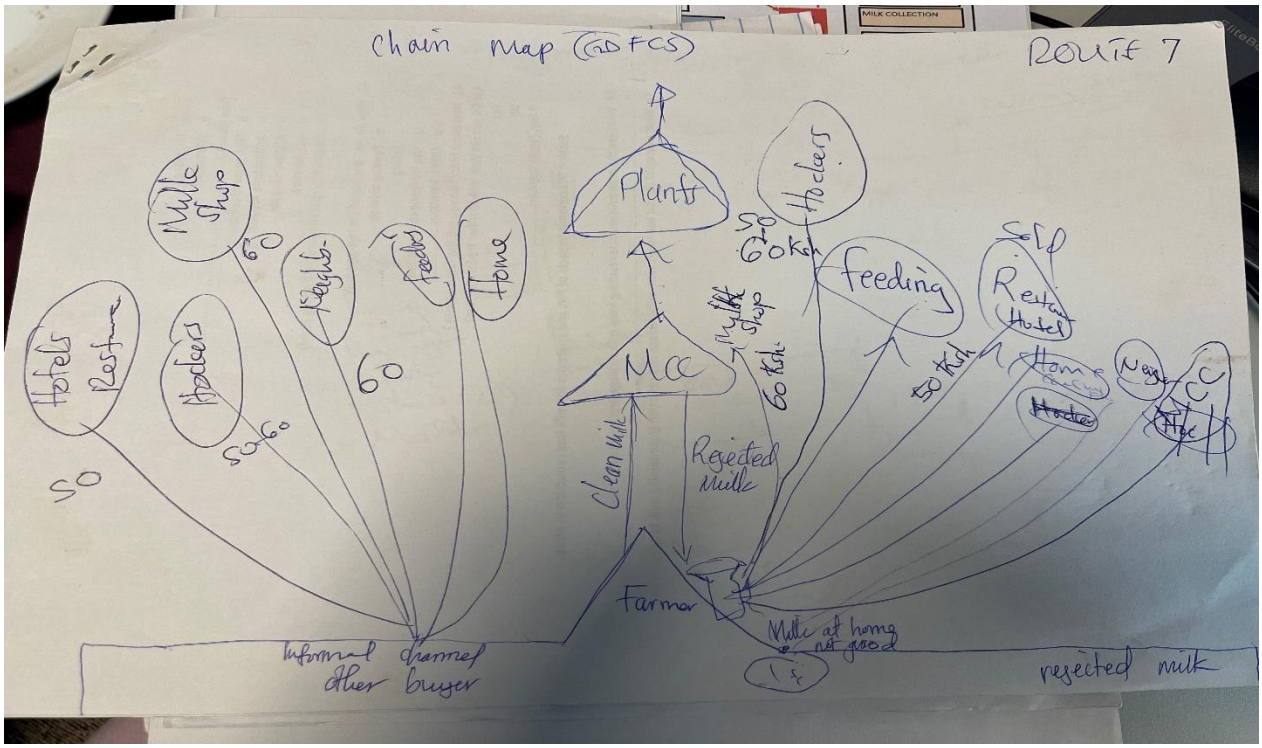
……

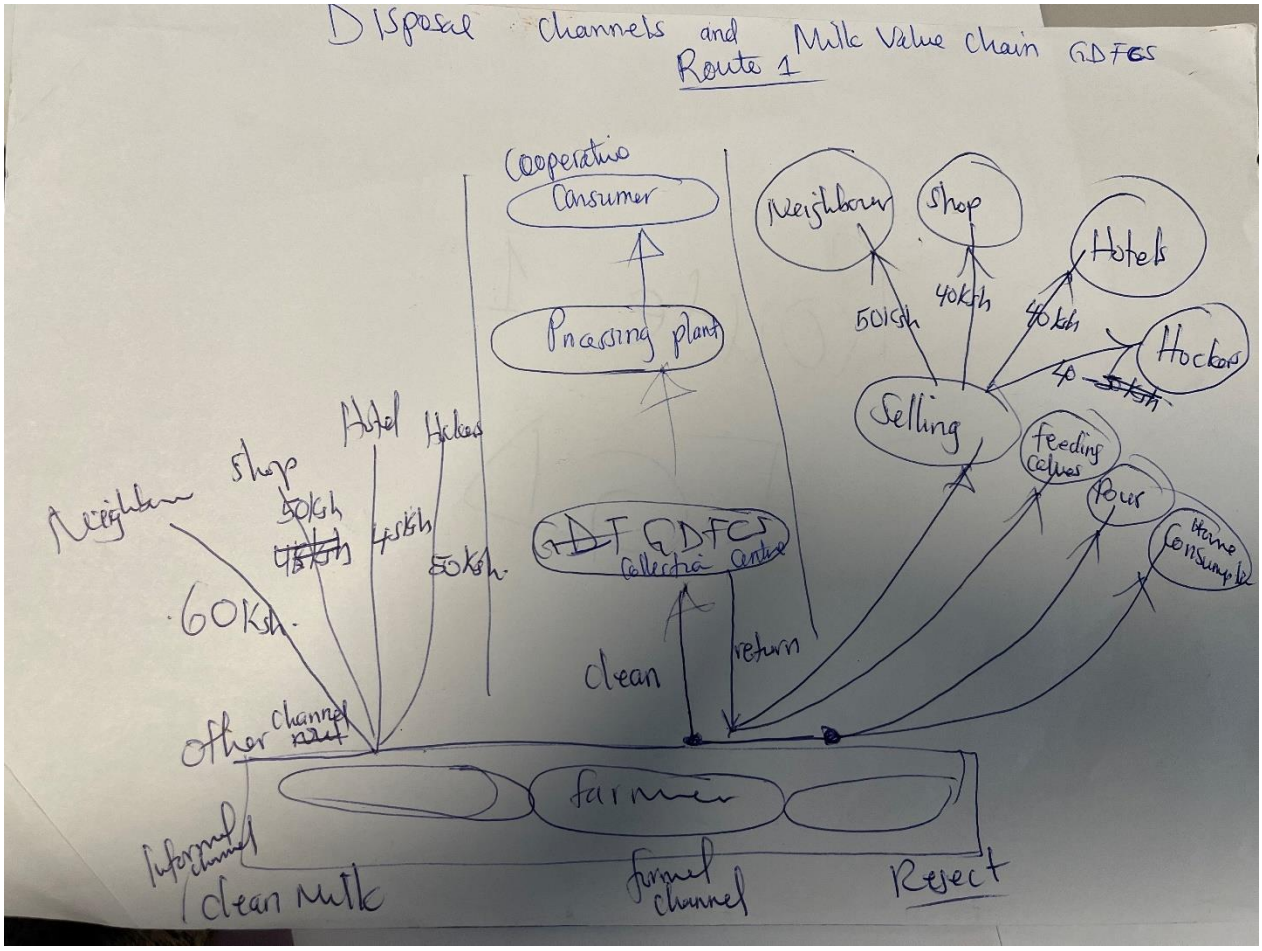
46. What strategies do you use to prevent milk spoilage and rejection (maintaining milk quality)?

N.B What is the size of land under livestock farming do you own?

ANNEX 2: Participatory tools







ANNEX 3: Interview analysis

Key informant 1	What does milk loss mean to you?	What is the average amount of milk lost annually in the county/farm/cooperative?	Reasons for milk loss	Current strategies for milk loss
K1	Milk unfit for use especially by people	Not sure	Not meeting the quality standard Antibiotic residue and diseases	Training on good feeding practices and withdrawal period observation
K2	Milk that get lost before being use	Not sure	Mastitis and spillage because of rough roads	Early treatment and proper dosage
K3	The loss of milk quality	Large amount but I'm not sure about exact amount lost	Low milk standard such as fat and SSC and protein	Training farmers on feeding
K4	Unsold milk due	<10% of the milk intake	Mastitis, SCC,	Regulatory bodies should ensure

	to spillage, spilled and spoilage		antibiotic residue, spoiled, spilled (Transport and packaging) adulteration	the milk marketed meet the standard GDFCS should invest in training and automated processing equipment Early disease treatment.
K5	Unsold milk	Not sure	Surplus milk, spillage, rejected in the market due to mastitis and adulteration	Treatment of mastitis and observing the withdrawal period. Not overfilling the cane.
K6	Spilled, spoiled and rejected milk	Not sure	Mastitis and adulteration. Rough roads in transporting milk	Penalizing farmers Disease treatment and sealing the milk can tightly when transporting the milk
K7	Milk pour on the ground not consumed	Not sure	Mastitis and antibiotic	Early disease treatment and complete milking
K8	Forced consumption, reject, spilled and spoiled milk	Not sure	Antibiotic, adulteration and late delivery	Observing the withdrawal period and timely milk delivery at MCC
K9	Milk that is unfit for consumption	Not sure of exact amount	Mastitis and antibiotic	Observing the withdrawal period after treatment
K10	Spilled and rejected milk	Not sure	Mastitis and antibiotic	Treating cow with right dosage and observing withdrawal period.
K11	Milk not marketed	Not sure	Mastitis, SCC and antibiotic residue	Treating cow and observing withdrawal period.
K12	Forced consumption	Not sure	Mastitis and antibiotic	Treating cow and observing withdrawal period.
K13	Loss in milk value	Not sure	Poor feeding (low fat and protein contents)	Training farmers on good livestock management especially on feeding practices
K14	Loss in milk value (low price than production cost),spilled, rejected and spoiled milk	1.8-6% of produce at farm level	Mastitis, low standard (Fat, protein, SSC) and aflatoxin	Training and observing milk hygiene at farm level, collection centres and processing plants
K15	Spilled, spoiled and rejected milk	Not sure	low fat and protein contents	Training farmers on feeding practices

K16	Milk not marketed	Not sure	Aflatoxin and mastitis	Treating cow with right dosage and observing withdrawal period
K17	Spilled, spoiled and rejected milk and force consumption	2-6% of produce at farm	Aflatoxin, mastitis, antibiotic, adulteration and spillages due to poor roads	Treating cow with right dosage and observing withdrawal period Training on milk preservation at farm level
K18	Milk not marketed	Not sure	Aflatoxin, mastitis and antibiotic	Good feed preservation and feeding. Observing withdrawal period.

ANNEX 4: PHL at Production (per farm)
Data used (refer table 13)
Milk yield/cow/year = peak production/1.7) * lactation length (days) * year (days)/calving interval (days)
17.48/1.7 × 324 × 365/394.2= **3060Lt/cow/year**

Milk yield/cow/year FPCM = milk/cow/year x FPCM formula (the formula: [kg FPCM = kg milk*(0.337 + 0.116*fat% + 0.06*protein%] as described by (FAO, 2010; Opio et al., 2013))
3060 × (0.337+0.116 × 3.5 + 0.06 × 3.2) = **2861.1 Lt/cow/year FPCM**

Milk/farm/year and in FCPM = milk/cow/year (or in FCPM) * average number of animals
2861.1 × 2 = **5,722 Lt/farm/year FPCM**

$PHL_{production}$ = Milk/farm/year and in FCPM – (total milk delivered per farm + home consumption(side selling included) + calf consumption / average number of animals).
Where: retained milk at farm = total milk delivered per farm + home consumption(side selling included) + calf consumption
Retained milk: 383.4 + 667.7 + 4464 = **5,515 Lt/farm/year**
$PHL_{production}$ = 5,722Lt/farm/year FPCM – 5515 Lt/farm/year
207Lt/farm/year

The percentage of milk loss per farm level: ($PHL_{production}$ /Milk/farm/year FPCM) × 100%
(207/5722) × 100 = **3.6%**

Economic value loss at production
Total Value of $PHL_{production}$ = PHL × (Average milk price per Litre)
207 Lt/farm/year × KES 45 = KES 9,315

ANNEX 5: PHL at collection centres for four route (1F,2E,6O and 7E)
Data used refer table 7 and 8
$PHL_{Collection\ centre}$ = X1 + X2 + X3 + X4 = 597 +1391.2 + 1173 =**3161.2 Lt (Jan to June)**
Where X1 = Rejects
X2 = Spillage
X3 = Spoilage (was reported to be zero within the six months)
X4 = Missing
Total PHL per year = 3161.2 × 2 = **6,322.4Lt/year**

Intake per year = 2,832,727.2 × 2 = **5,665,454.4 Lt/year**
%PHL for four routes = (6,322.4Lt/year /5,665,454.4 Lt/year) ×100 =**0.11%**

Economic value = 6,322.4 × 45 = **KES 284,508**

ANNEX 6: PHL at Processing plant

Post-harvest milk loss at processing level (PHL $_{\text{processing level}}$)

PHL $_{\text{processing level}}$ = Σ(Loss at packaging (Spillage) +Spoilage + Adulteration)
= Σ(1,380.8 + 81.7 + 582.5)

Based on the result (Table), the PHL at the processing plant was **2,775Lt (January to June)**

PHL per year = 2,775Lt (January to June) × 2 which was equal to **5,550 Lt/year**
The total loss was multiplied by 2 to get a total loss per year. The previous PHL loss was for six months.

Economic value loss at the processing plant (per year)

Total Value of PHL $_{\text{Processing plant}}$ = PHL $_{\text{Processing plant}}$ × (Average milk price per Litre)
= 5,550Lt × 45KES

Based on the survey and interview with key informants at GDFCS, the average milk price per litre was KES45.
Therefore, the total **value of PHL** at the processing plant was **KES 249,750.**

Per cent of PHL at processing = PHL $_{\text{processing level}}$ **/intake**

5550/83,950,000 = 0.01%

ANNEX 7: Total PHL all milkshed of GDFCS
Formular adapted from Omondi 2021 (during the interview)
Total PHL all milkshed of GDFCS = (Farm milk loss X number of farms) + (collection milk loss per collection centres × total number of collection centres) + PHL at processing plant
Total PHL at production level = 207Lt/farm/year × 11,500 which was equal to **2,380,500 Lt**
Total PHL at collection centre = (3161.2 × 21.5) × 2 which was equal to **135,931.6 Lt per year**
Total PHL at processing level = **2775 × 2 = 5,550 Lt/year**
Total PHL all milkshed of GDFCS = 2,380,500 Lt + 135,931.6 Lt + 5,550 Lt/year = **2,521,981.6 Lt/year**

ANNEX 8: Economic loss all milkshed of GDFCS
Economic loss at production level = 2,380,500 **×** 45 = **KES 107,122,500**
Economic loss at collection centre = 135,931.6 × 45 = **KES 6,116,922**
Economic loss at processing level = 5,550 × 45 = **KES 249,750**
Total economic loss = KES 107,122,500 + KES 6,116,922 + KES 249,750 = **KES 113,489,172**

ANNEX 9: The share of PHL in all milkshed of GDFCS
The share of PHL in all milkshed of GDFCS = PHL at each level of the value chain/ Total PHL of milkshed of GDFCS
Share of PHL at production level = (2,380,500/2,521,981.6) ×100 **= 94.39%**
Share of PHL at collection level = (**135,931.6 Lt/year** /2,521,981.6) ×100 **= 5.39%**
Share of PHL at processing level = (**5,550 Lt/year** /2,521,981.6) ×100 **= 0.22%**

ANNEX 10: CF impact all milkshed of GDFCS
CF at production level = milk yield at production level × 2.1= 117,958 × 2.1 = **247,713.606Lt CO2-eq FPCM**
CF at collection level = Intake at collection centre × 2.1 = 87,600,000 × 2.1 = **183,960,000 Lt CO2-eq**

CF at processing level = Intake at processing level × 2.1 = 87,588,127.6 × 2.1 = **183,935,067.96 Lt CO2-eq**
Total CF taken was the CF at processing plant because the milk intake in the chain considered is the milk accepted at the processing plant. Thus the CF in GDFC milkshed was **183,935,067.96 Lt CO2-eq**

ANNEX 11: Estimated milk production all milkshed of GDFCS
Milk yield = milk sold + home consumption + calf feeding + loss

(4,477.64 × 11,500) + (5,515 × 11,500) + (207 × 11,500) = 117,958, 860Lt/year

Estimated accepted milk to cooperative
Total intake per day =240,000 Lt × 365 days = 87,600,000 Lt/year
Total loss= 6,322.4
Milk accepted = 87,600,000 Lt/year – 6,322.4 Lt/year = **87,593,677.6 Lt/year**

Estimated milk processed/sale
Total intake per year = 87,593,677.6
Total loss= 5,550 Lt/year
Estimated milk sold (sale) = 87,593,677.6 Lt/year - 5,550 Lt/year = **87,588,127.6 Lt/year**

ANNEX 12: Extra milk collection routes used for comparison on quantities of milk loss

Short routes	Long routes
1A	1C
1B	2D
1D	2F
1F	2H
2A	3A
2B	4C
4B	5A
4G	5D
5B	6B
5C	6D1
6F	6K
6H	6L
6T	6M
6U	6O
2E	6P
9B	6R1
10A	8B

ANNEX 13: Transcript

Interview with KARLO

Interviewer: I'm Mariam Katarama a student from VHL conducting research on post-harvest milk loss in Kiambu, conducting research under the FORQLAB project which will be implemented in Kenya in few coming months. So, the data I'm going to collect now will be used as a baseline for implementation of the project. I welcome you to discuss about the milk loss and the current situation in Kenya, how can we able help farmers reduce the loss and through out the chain.
Interviewee: My name is Simon Omondi, I'm a former alumnae of VHL and I'm very happy to receive you in my office. You are carrying out the research on very important topic food losses. I'm aware of FORQLAB project and I was part of the group which took part in drafting the project. It's an important project seeking to address the issues of food losses. Because when we mitigateagainst food losses we can be able to have sufficient food without putting any resources on production. We are mainly focused to increase production by adding more resources but rarely we were not able to quantify and mitigate against milk losses. On that way will have more foodavailable both for household consumption and trade. Now as far as dairy is concerned, we have to look on the entire value chain from input suppliers like feed suppliers, production because we have losses occurring at production,. Also we have losses that occur during other stage to milk collection centre that occur at the cooperatives, traders on the milk marketed on informal chain. Then we have losses that occur at retails especially the supermarkets due to spillages, expired milk and losses that occur at consumption level. Maybe you by milk either in informal or formal market upon boiling you find the milk is already spoil so those are already losses.
To be able to get all overview is that, one has to look at each of the value chain segments with the view to; one what are factors that contribute to the losses for each of them. Secondly, how much is lost and thirdly, what are the potential mitigating measures. In other words, if you have to quantify milk loss in the dairy value chain, then I will use an equations.
Milk losses in the dairy chain = $\Sigma(X_1 + X_2 + X3 + X_n)$ where X represents the value chain segmens. So, that way you will be able to quantify the losses and therefore look at the factors and be able to recommend how stakeholders in the chain in each segment can be able to mitigate against the losses. The issues that are technical, and non-technical issues such as policy. So that way we can be able to come up with the measures to reduce the losses. So is quit a subject not by looking at one segment like production not unless your thesis you are only looking at production. You know you can focus your thesis to look on the production that is quit in order. But what I'm saying that you nee to have all chain wide approach to address all these issues.
Interviewer: On you introduction part you tried to explain what milk loss is, I was questioning myself, is the milk used to feed calves (the rejects) grouped under losses or no?
Interviewee: Post-harvest losses occur after you milk, is when you start to quantify the losses however we have diseases like mastitis clinical or sub-clinical that will cause lost depending on its sevearity. For instance mastitis that affect one quarter may reduce the milk then you may find mastitis affect the whole quarter. So this are some of the losses that can affect especially milk productivity especially when you stop milking because you will ask yourself, the cow as been producing 8 LT for now is 5Lts. But one is mastitis, so now you are accutually using five, so the loss is clear is 3Lt. So perps at his point you need to mention, when you talk about milk losses you need to be aware. When we talking losses, we talk about spoilage the category of loss. There is spoilage and spillage and adulteration of the milk. So, those three category you my find has different contribution of PHL in the value chain
Interviewer: The strategies we have at chain levels which are result of disease, little spillage at farm level. AT the cooperative the milk is rejected as a result of spoilage, spillage and adulteration. At the trader level especially the formal chain the milk is lost, only the customers can tell you about it. As it is adulteration. Then in the supermarket is mainly spillages because the milk over stays there, in adequate cooling or power failure. Those are some of the factors that may cause spoilage .Power failure, milk that have expired are losses.
Interviewee: Two times.
Interviewer: may you mention them?
Interviewee: Morning and afternoon. But now we started to collect the third shift now it already has 3 day from when we started collecting milk.
Interviewer: What was done with the thrice milk before you started the thrice shift?
Interviewee: They were preserving that milk and collect them during morning shift so they mix with morning milk. Other farmers were selling that evening milk to other milk buyers. The aim of opening third shift is to reduce the milk volume sold to other

buyers. Also, preserving milk is still a big risk at farm level its not 100% good way because other farmer when they mix the preserved milk with morning milk that milk get rejected at MCC after running a test. With third shift we also reduce losses. So what I'm saying Is that, in all categories we need to identify the factors that cause spoilageat different levels. If the level of spoilage is at farm levels what are factors. If its spillages, and the adulterations what are measures. What is needed to address this, simple milk cooling technologies, there are the farms without power. So you can not recommend power, simply is not there. The simple cooling technology is to put your water in the bucket and thereafter will not be spiled. When looking at cooperative level,the cooperative are very far or the road network is impasible, the the milk will take the minimum time of 2hours that way the growth of bacteria will even have doubled and cause further spoilages. There are spillage but not many especially during transportation of milk. From one can to another can. You will be able to see that.what is needed is extension knowledge building snd good transport trategies.
Interviewer: I saw that and they have many cans the 50kg can. Yesterday we tried to measure the remaining milk in the can and found out that seven kg of milk was lost on those cans.
Interviewee: But how to mitigate that, the cooperative like GDFCS have a very good extension programthat program should be adhered to training and building the capacity of farmers to be able to detect and control mastitis. The same programme could be geared towards training them on the use of simple cooling technologies and also, to have good transport practices. How do you transport milk, which way of transporting milk. At collection centre, how do you minimize spillages while you are having different Kg milking cans because that is already loss, economic loss.
Interviewer: Do you have any data about the PHL in Kenya? For example how much milk is loss in these three levels.
Interviewee: I will send you some literature done in this country. Generally, some quite bit of literature on the milk losses in this country. Milk loss occur at different levels. No difference in quality from all formal and or informal channels due to sourcing from the same farmer PHL is a big problem in the country
Interviewer: Thank you for your participation in this research.

Extensionist Long route (7E)

Interviewer: Please, may you introduces yourself?
Interviewee: My name is Suzan, the dairy extension officer, route 7 in Githunguri Dairy.
Interviewer: what do you know about the milk loss?
Interviewee: It is usually loss farmer get from their milk being rejected. They suffer so much with milk rejection considering their cost they incur also we train them to reduce losses.
Interviewer: How often do you train them?
Interviewee: We visit them every day, at least 20 farmers per day. So we meet the at the field and train them. I train them on clean milk production to reduce milk loss such as feeding, milk hygiene, cleaning and handling of milk storage equipment and delivering milk to MCC especially a person responsible for delivering milk on how to handle the milk. Also, I train them on feed preservation to avoid aflatoxin, disease control such as mastitis and fodder establishment.
Interviewer: You mentioned about training on how to reduce milk loss, may you clarify more about it?
Interviewee: we start with milk hygiene for a person, and for milk we train on proper milk handling techniques, milking techniques, milk handling utensils(equipment) and how often the animal shed is cleaned. When we talk about milk hygiene we look on everything concerning milk. How the milk is transported to the mcc., how the milk carried?eg much milk there are trolls used to carry milk, other use pick ups or Donkey.
Interviewer: Who own the pick up carrying the milk?
Interviewee: The farmers especially farmers with large number of cow and who produce large quantities of milk(5 to 15 milk cans).
Interviewer: How many large farmers do you have?
Interviewee: In route 7 there are about 10 high producers with more than 15 cows. We have 15-20 high producers who produce more than 1500kg of milk per month.
Interviewer: Since you said there are milk losses at mcc, what are the causes of milk loss?
Interviewee: losses is due to clotting which is brought out by mastitis, prolonged lactation, poor feeding especially

supplementation (minerals),physical dirty, spillage due to accident when delivering milk to collection centre, spillage resulting from vehicle caring milk to cooling station.
Interviewer: Do you have experience about somatic cell count leading to milk loss?
Interviewee: Yes, we go at farm level to identify the cause (clinical, subclinical mastitis or clonic mastitis). This is my daily routine. Because there are dairy farmers who don't care or assume their milk is ok. So when their milk is reject we follow them at their home to make test (CMT) and its where we find there is high somatic cell count in the milk.
Interviewer: how often do you test milk at farm level?
Interviewee: Its every time they go back with the milk. The graders give us the list of farmers whose their milk got rejected.so infacts we do it every day even though its not for the same farmers. For example at MCC they conduct organoleptic test and alcohol test so when the milk don't meet the standards it get rejected.
Interviewer: How farmers take it (feel) when the milk get reject may be like feeling that milk rejection is done purposely if you don't want their milk?
Interviewee: NO, they accept it and most of them they call us to help them identify the problem and to get solution from vet. Within those three days of treatment they don't bring milk to MCC so they pour the milk though they feel bad. Also there are cows who are resistance to mastitis. Many cows when they get treated their milk get clear and good for supply to MCC. We tell them to observe the withdrawal period.
Interviewer: Among those causes of milk loss, which one is the most causative?
Interviewee: Mastitis causing clotting and also prolonged lactation. Also cow have problem with hormonal imbalance caused by mineral deficiency, this can be solved by supplementing cows with minerals in the feed. Every 25th to 30th of every months farmers pick feed from dairy feed store so before that time farmers don't supplement their cow with mineral because they don't want to buy feeds they only feed on natural feed stuffs so during this time their milk has many problems.
Interviewer: where farmers take or dispose the rejected milk?
Interviewee: there are small upcoming milk companies, they add value to milk like making yoghurt and sell milk to others buyers. So when we reject the milk at MCC, farmers take the milk to them or sell to other milk shops, restaurants and hotels. Other farmers feed to their animals such as pigs.
Interviewer: What is the price for rejected milk farmer get by selling rejected milk to those small companies or shops?
Interviewee: The price ranges from 45-47Kshs/lt for small companies. In shop and hotels they sell to 50Ksh/lt.
Interviewer: What is the milk price at MCC?
Interviewee: 45Ksh/Litre
Interviewer: These small companies seem to be a big problem to MCC?
Interviewee: Yes, because they are always near the every MCC, when we reject milk they collect it from the farmers. They are mobile in the route, their pick up pack near centres collect milk and leave alghough they have other farmers who supply milk to them. These farmers are not dairy society members.
Interviewer: What is the payment system for dairy society cooperatives?
Interviewee: They are paid 5th of every month. The money is deposited in their account. Every farmer receive the message of what they delivered per month that's why knows what to be received at the end of the month. Also, they have the membership card (Member Produce Records) which is used to get services such as feed and AI on credit from the Dairy society store. So they transfer the records from app and store them in MPR.
Interviewer: How farmer pay for the feed they took on credit?
Interviewee: Its like a loan. Everything you take from the store it is reflected in the App where a farmer can see what he or she received and the produce they have, at the end of month they know what amount of money for milk delivered is remaining. Everything they take is deducted at the end of month from the milk delivered
Interviewer: Because you said you provide AI service to farmers, what breed of dairy cattle do you supply to farmers?
Interviewee: Mostly Friesian, Ayrshire and sometimes Jersey although not popular.
Interviewer: We know Friesian has low fat content, so what is standard fat do you require at MCC?
Interviewee: Dairy society is more into quantity than quality although the carry out different tests such as lactometer test for density (27 to 32g/mil), aflatoxin and antibiotic tests. Many cases at my route concerning milk quality is due to antibiotic residues because farmer can treat one cow in his/her herd and decide not to withdraw, when mixes that milk it is detected at the collection centre when tested. Also there are other private vets who treat cows and don't tell farmer what they used and when to withdraw

so farmer take that milk to collection centre which is wrong. What we do as extensionists when the residue in the milk is detected, we tell farmers to prolong the withdraw period.
Interviewer: You said, there other vets at the field, is there other extensionists in your routes?
Interviewee: They are there and it's a problem here because also we have cows who are already resistant to diseases such as mastitis due to wrong dose usage.
Interviewer: Since you many problems with milk quality which lead to milk loss, what are strategies use to reduce the losses?
Interviewee: Milk hygiene that's why we visit farmers to see what they use and we advise them to buy milk testing kits especially for farmers with large herd. For high producers we visit them at least twice a month.
Interviewer: Do you consider visiting these farmers more than twice a month?
Interviewee: We do, and sometimes they call us. We say we visit them at least twice but we visit them many times sometimes we don't count them.
Interviewer: What obstacles do you face in making farmers reduce losses
Interviewee: illiteracy, miscommunication because of presence of different vets in the field so farmers get different information from different people to harmonize this we train farmers at least twice a month by getting different people to train them either from county government, private sectors and NGO like now we have new training schedule for this month starting next week.
Interviewer: How do you consider the distance from farm to collection centres?
Interviewee: its <1km this for farmer living far from collection centre.
Interviewer: How farmers transport milk to MCC?
Interviewee: Farmers bring the milk to MCC and from MCC the milk is transported to cooling centres. Even other farmers take their milk to mobile centres where the mcc truck pass and collect the milk. Also when cow calves the farmer report to extension officer where we count the days they should bring the milk to collection centre which is at least 10 after calving for milk to be clean. Even if they don't report still we can discover new born calves from their records because their cows are zero grazed. So we train them several times. Also, we identify the calves on farms. Infacts the loss is small.
Interviewer: Do you mean every farmer in your route has zero grazing system?
Interviewee: Yes, that is the role or criteria to become a member of dairy society. My route is bordered with forest, there are other farmers who take their cows to graze in that forest but to have a zero grazing is a must and we inspect them.
Interviewer: I see you have good connection between farmer and extensionists, what about the connection between farmer and farmer?
Interviewee: They are good in disseminating the information, when they hear anything concerning milk or cow they tell to other farmer instantly. Also they communicate or exchange information when delivering milk to MCC and during training.
Interviewer: Do you have farmers who resist to adopt what you train them?
Interviewee: Yes. They are mostly farmers who always have problem with milk quality but they are not many. Milk clotting sometimes is repeated from the same farmers though its not every day. We call them persistent clotters. Infacts they will tell I will do what you advise me but they don't do it. Sometimes if they know they have problem with milk quality , they stop you from visiting insisting that they know the problem already. For extensionists we have WhatsApp group (platform) where we communicate so we know them.
Interviewer: What is your strategies to make these farmers adapt to changes?
Interviewee: We use other extensionists to talk to them or call private trainers to train them.
Additional information: our cooperative is well organized in the extent that we don't suffer much from the field. We have good communication with communication with other staff. We help each other when we find resisting farmers, so you an invite other extensionist to come and visit that farmer. Also, with have inspector who go around all the routes weekly to inspect on aflatoxin, antibiotic, density and mastitis at farm level and farmers are afraid of them. When they find problems they give penalty to farmers (2ksh/lt) when you get caught twice or thrice the farmer get suspended from selling milk to collection centres (maximum 2-3years). Farmers call inspectors as the people with vehicles.

Suggestion from interviewee: I'm looking forward to the interventions that will reduce loss at farm level and collection centres.

Extensionist Long route (1E)

Interviewer: May you introduces yourself?
Interviewee: My name is Joyce , dairy extension officer, route 6 in Githunguri Dairy. I'm presenting route one which is just around here the town (nearest route).
Interviewer: What do you consider the milk loss is?
Interviewee: Milk loss as the reject milk may be the milk that cannot be consumed.
Interviewer: Considering your role as extension officer to famers, how often do you train farmers on milk loss reduction or milk quality?
Interviewee: This is what I do on daily basis, we have to train farmers on how to handle the milk especially milk hygiene to avoid milk rejection and also we training on good animal management practices in order far to gaining something in their pockets.
Interviewer: Is there any milk loss occurring at farm level and collection centres?
Interviewee: Yes there is losses.
Interviewer: What are main causes for the losses?
Interviewee: it might be the cow is sick (mastitis) it is the main causes of milk loss.
Interviewer: Is there others causes apart from mastitis?
Interviewee: Yes, at collection centres there is milk loss due to rejection because of the milk that does not meet the required standards.
Interviewer: What are those standards you are talking about that lead to milk rejection at MCC?
Interviewee: We conduct alcohol test, lactometer test for density (27-32 lactometer leading), antibiotic and aflatoxin test.
Interviewer: How do you test for aflatoxin?
Interviewee: We have the kits for testing aflatoxin level in milk
Interviewer: Where the rejected or spoilage milk is disposed?
Interviewee: They sell to hotels or milk bars
Interviewer: What is the price for reject milk?
Interviewee: 50Ksh per litre
Interviewer: What is the raw milk price at MCC?
Interviewee: 45Ksh per litre
Interviewer: This different in milk price (5Ksh) between cooperative and other buyers can it make a farmer sell the milk them and not the cooperatives?
Interviewee: They cannot move to sell to those milk bars because at the cooperative there are more benefits. Because when you sell to milk bar they pay you and you decide to go to market and buy family needs by the end of the month the farmer has nothing (no money) so that's why farmers they decide to sell to cooperatives to get money in bulk at the end of the month.
Interviewer: What is the payment system at cooperative (cash or per month or any other way)?
Interviewee: They pay per month by depositing the money in their bank account.
Interviewer: What is the strategies you use at farm level in order to reduce milk loss?
Interviewee: Advising and Training farmers on milk handling (Milk hygiene)
Interviewer: what is the condition of milk hygiene at farm level?
Interviewee: Milk hygiene have to start on how the cow shed is cleaned, milking procedures, the milkers, handling equipment like milk cans and also milk delivering.
Interviewer: what do farmers practice concerning milk hygiene?
Interviewee: They wash hand, milking equipment, shed and animals before milking.
Interviewer: What are the obstacle do you face that makes it difficult in reducing milk losses?
Interviewee: Poor communication if the farmer got rejects but due to poor communication in telling of informing extension officer about it they get delayed in getting advise or solution to their problems. Other farmers takes 3 days to 4 days to get help from extensions.
Interviewer: Any other obstacle? What about the distance from farm to collection centres?
Interviewee: The distance is not a problem, but other problem is persistent mastitis. You find there are cows who are resistance to antibiotics.

Interviewer: What causes persistent mastitis to cows?
Interviewee: I think is due to frequent treatment of cow with wrong doses or uncomplete doses.
Interviewer: What do you consider about the trust between farmers and Cooperation considering the cases of milk rejection?
Interviewee: These training forums are of more help to farmers. Farmers know where to get help when the milk is rejected, they call me for any assistance and we respond immediately. So, immediate response creates trust to farmers.
Interviewer: What do you consider are the main solutions for milk loss reduction at collection centres?
Interviewee: I don't work at collection centres because my responsibilities end at farm level. So when the milk is rejected at MCC the grader will contact me and inform about that farmer with reject for follow up. So, I don't have ideas about any losses occurring mainly at MCC level.
Interviewer: May you talk about the relationship between farmers and farmers on they communicate?
Interviewee: When we conduct the training which is once a month so it's when we have forum for communication.
Interviewer: Is the training offered by dairy cooperatives society or there are other training from outside the cooperative?
Interviewee: There are other private trainers although I have a chance to talk to my farmers during that training.
Interviewer: Is there other extensionists in your routes other than from cooperatives?
Interviewee: Yes, we cooperate with county government extension officers
Interviewer: Do you have any challenges in information dissemination to farmers?
Interviewee: No, we collaborate very well.
Interviewer: You as extensionists, do you receive any training from the dairy society?
Interviewee: For this, I thank the cooperatives because they really provide training to us because they say we need to be ahead of farmers so that anything that come up we already aware of it before farmers eg technologies. For the training we are already ahead.
Interviewer: How often do you get trained?
Interviewee: At least once or twice. So, its every month.
Interviewer: We know milk rejection can be happening to different people, so what about in you routes?
Interviewee: At my route the losses is very low. I don't know its because the milk is collected directly to the factory or other reason. In other routes is high compared to my route may be because there are many milk channel ?(seem she is not sure, she is curious about it). From my route its takes less than 30 minutes for milk to be delivered to processing plant. The milk is collected directly to plant.
Interviewer: What do you see the challenge of distance to milk quality?
Interviewee: There is many problems with distance for example in other routes then encounter more less may be because the milk is collected from farm to mcc, then from mcc to cooling centre and from cooling centres the milk is transported to the processing plants. So it might be a problem (problem in milk handling)
Interviewer: What farmers feed the cows to ensure milk quality?
Interviewee: They supplement their cows but also the feed on Machicha, poultry wastes and pineapple wastes.
Interviewer: Is there any challenges on aflatoxins resulting from feeding?
Interviewee: Yes there is, especially when the poultry was treated and didn't observe the withdrawal period , when the feed that feed to cows the milk produced may be antibiotic positive when tested at the MCC.
Interviewer: Where do farmers buy feed supplement?
Interviewee: They buy locally or directly from breweries.
Interviewer: What about the feed from the dairy store?
Interviewee: The feed they buy from cooperative I have never heard about any issue concerning these feeds on feed quality.
Interviewer: How does farmers pay for these feed from the store?
Interviewee: They pay by credit or in cash if they want.
Interviewer: How do they pay this feed took by credit?
Interviewee: They have MPesa number they can use to pay.
Interviewer: I would like to know how they pay from the milk delivered?
Interviewee: it depend on the amount of milk you delivered to MCC. You cannot take more feed than the milk you have delivered. So if you don't have that amount you pay through the TIN number.
Interviewer: How does the MCC pay farmers?

Interviewee: They are paid through the bank.
Interviewer: How do farmers ensure that the amount they receive at the end of the months is correct?
Interviewee: They receive message everyday through their mobile phone about amount of milk delivered on every shift.so by the end of the month you have total kilograms of milk you supplied to Dairy , they also make calculations of what they got from the dairy store and hence get the amount remaining for that month that has to be paid.
Interviewer: have you ever received any complaints about payments?
Interviewee: It do occur, but through these training they are given hotline number to deal when they have any complaints. So it is taken care of immediately.
Interviewer: Thanking the interviewee for her time and cooperation received throughout the interview.
Interviewee: Was happy knowing the purpose for the interview.

Extensionist Long route (6O,6R)

Interviewer: May you introduces yourself?
Interviewee: My name is Dorcas Nyambura, dairy extension officer, route 6 in Githunguri Dairy. I'm covering the farthest route which is route 6L (has 10 mobile centres) , 6S (has 6 mobile centres), 6R (7mobile centres), 6T (has 1 mobile route).
Interviewer: why route 6T has 1 mobile centres?
Interviewee: There are many Dairy member confined in one area and in this centres members can collect 50 cans per shift. Routes with many mobile routes means they can collect 7-10 milk can per shift and this farmers are far apart. Reasons for this mobile centres is to reduce distance because they can't walk over 5km.
Interviewer: What do you consider the milk loss is?
Interviewee: Is a great challenge to us working in Dairy because as extension officer this is our main duty to check on the quality of milk at farm level. So you found majority of farmers their milk get rejected at MCC because graders conduct all the tests supposed to be done concerning the quality of milk. Also, its my duty to visit those farmers who their milk was rejected to identify the causes of rejection. Many farmers are trying to maintain the good quality and we try to help them although sometime we failed and farmers loose hope and decide to sell the milk to other traders.
Interviewer: Did you mean other farmers quit from supplying the milk to MCC?
Interviewee: Yes they stop for some times. Because we have a lot of test we conduct such as acidity test, aflatoxin test, antibiotic test and Lactometer test. We have hockers who buy milk in small quantities they are not more in quality so they buy the rejected milk from farmers and sell them to the city. The problem we have some farmers don't take what we advise them for milk quality. Other think we do it deliberately thus we don't need their milk so they decide to sell to hockers.
Interviewer: You said about hockers, do you know the price of rejected milk they offer to farmers?
Interviewee: They buy at lower cost than the price we offer for raw milk. Currently Dairy buy at 45Ksh /Lt while the hockers buy at 40Ksh/lt. But at the end of business (farmers and hockers) farmers ends up loosing the money because their mode of payment may be weekly or monthly , by the end of the day these farmers decides to sell again to dairy because they are assured to get paid and what is good with them, they tell you what happened when they sell to other buyers. And the main problem is mastitis and somatic sell count and this mastitis is due to high resistance of the cows to mastitis due to wrong dose usage (antibiotic), not completing doses, other farmers treat the cow themselves, and repeated treatments. So it's a repeated cases. At the end the farmers has to cull that cow.
Interviewer: You mentioned the causes of milk loss is somatic cell count, mastitis, antibiotic residues, aflatoxin level and adulteration. What is this adulteration, what are they adding in milk?
Interviewee: We test for neutralizers because farmers they are always ahead finding something will benefit them. So farmers add sodium bicarbonates in the milk or backing powder so even if you conduct alcohol test the milk will be negative.
Interviewer: So you mentioned the big challenge with milk rejection is high SCC?
Interviewee: Yes, because once the grader reject the milk I'm the one to make follow-up. When I go at farm level I conduct CMT test so most of cases after testing at farm level is somatic cell count.
Interviewer: Where do farmers find hockers?

Interviewee: Hockers are allover the areas. Actually in the routes there are farmers who are not members of Dairy society so they sell their milk to hockers that's how our members can get to sell to hockers. They are easily accessible. Because this route is a farthest route even dairy society is not throughout the routes so we still have few farmers in membership. Its difficult to find hockers in Githunguri town so when the milk get reject there, farmers sell to restaurants and hotels. Dairy society is well established in Gihunguri town than other areas around.

Interviewer: what do you consider the main strategies to reduced milk loss at farm level?

Interviewee: what we do is

- To advice farmers on how to feed cows, observe milk hygiene, complete milking to prevent mastitis. So more in clean milk production.
- Advice farmers to avoid prolonged lactation, observe withdrawal periods, feed preservation to avoid cases of aflatoxin (not to feed cow with moulds feeds).

There are many feed suppliers who sell range of feed quality from poor to good quality fees. So the poor quality feed are the ones with aflatoxins and always farmers find the cheaper feeds. Dairy society is currently in plan to buy a machine for detecting aflatoxins from feeds. So before a supplier bring the feed to dairy they will be testing the aflatoxin level.

Interviewer: So do you have any machines for testing aflatoxin?

Interviewee: No. currently we are taking sample to Naivasha (research institute) who test feed quality.

Interviewer: You said one of the strategies to reduce milk loss at farm level is by advising farmers on clean milk production, do you also train farmers on milk quality?

Interviewee: Yes we have training which is conducted monthly per routes where farmer gather according to routes and get trained. We also participate but for better changes we invite other trainers to train them on milk quality. For last month we just finished the training this week so next week we start a new round.

Interviewer: From your explanation it seems there are farmers with low adoption to technologies (training)?

Interviewee: Yes, and its also our big challenge. There are farmers who don't want to listen until you call someone to talk to them. They believe after listening the same training or story from other expert. They want always to hear that their milk is good once you say otherwise they will never believe you.

Interviewer: What are other challenges apart from farmer being resistance to change that hinder milk loss reduction?

Interviewee: Illiteracy and other believe on their cultural feeding, other farmers are negligent thus they neglet what you tell them and do what they believe because they know what you are telling is true but they don't want to take it. For example the case of prolonged lactation, farmers don't want to dry their cows or inseminate the cow for pregnancy because they want to continue milking to pay the loans they have or other economic aspects. But other farmers have no enough money to buy quality feed. Also, its challenging to advice farmer to stop buying low quality feed and bu high quality feeds because quality feed is more expensive and others can't afford it.

Interviewer: I heard dairy society has its feed store, how does it function to hep farmers especial members of society?

Interviewee: Yes we have store all around to sell feeds to how farmers under subsides but what's challenging us is that, farmers have freedom of choice where and what to buy we can't restrict them. They also lack honest, they may buy a certain mineral saying its for calf but they are purposely going to feed cows. Currently, our feed store is putting more attention on aflatoxin not quality of feeds because farmers are complaining they want to have all kind of feeds at their store so they have say because its their store so we need to satisfy them.

Interviewer: What is the payment system for feed and other services they receive?

Interviewee: they can pay by cash or on credit. But the larger part of it pay on credit. The active members pay by credit and non-active members pay by cash. For active members pay at the end of the month when are paid for their milk supply, so the amount took as credit is deducted from monthly payment . On 4th of every month the dairy deposit the money to SACCOS and SACCOS pay on 5th of every month

Non-active member- the member who bring milk to mcc to date.(not frequently).

Interviewer: How is the money being paid to farmer, by deposit or cash:

Interviewee: The money is deposited in their account. Every member must have account that is one of the membership joining criteria. So on every 5th of every month they line up at SACCOSS to withdraw their money.

Interviewer: You said that, their money is deposited in their account. Why are they coming to lined up at the bank?
Interviewee: They are waiting for their money for use. Every budget is shifted on that date so everything need to be accomplished on that date eg paying loan from their friends, buying food, and other things.
Interviewer: Because farmers are paid per month, don't you get complaints about the payment (amount delivered and being paid)?
Interviewee: The have application in their mobile phone where they get the message of the amount of milk they deliver per shift. And they receive this message after every delivery. The same applies to the services they receive on credit (AI, Feed) they get the same message. So at the end of the month they know what they delivered and what they used. So they can complain if they don't receive the message or if they receive the message with incorrect amount. They also ask as when we go to field so that we can make follow up. When you want to buy feed from feed store you have your membership card where everything about what you are served is also recorded.
Interviewer: who is responsible for receiving ad dealing with complaints from farmers?
Interviewee: We have customer care office where farmer bring their complaints after there the complaints is delt at complaints office at dairy society. We have different office dealing with complaints, they are divided according to the services such as AI, Feed and milk service.
Interviewer: How do you the trust between farmers and dairy society?
Interviewee: There is a good relationship (trust) because we take their complaints seriously and we try to solve them immediately. We believe and know that we are hired by farmers so by the time the complaints is repeated you can be fired from work. So we pay much attention on our relationship with farmers and most of staff loose their job because of bad relationship with farmers.
Interviewer: I see there is good relationship between farmers and staff, so what about farmer and farmer in sharing information?
Interviewee: Farmers do share information for example the quality of feed they get from the feed. Also if they have issue about graders at collection the talk about it and choose one farmers to report to dairy society. So they do share information.
Interviewer: Do you have any platform that can help to join farmers together for information sharing?
Interviewee: No, farmers share information when they bring milk to collection centres, physical communication and also they share information during training. In every route farmers have directors (farmers representative) who always attend training and also they are the one responsible for bringing farmers needs at the office. So farmer's directors facilitates the information flow among farmers and also farmers and staff. But only staff have WhatsApp group for information sharing.
Interviewer: May you give your suggestions toward milk loss reduction strategies?
Interviewee: Our store should bring the quality feed
Interviewer: Do the milk rejection occur to the same farmers or different farmers?
Interviewee: Yes, most is from the same farmers and we call them persistent farmers.
Interviewer: How do you help them to reduce losses
Interviewee: Talking to them and using other extensionists for advice.
Suggestion from interviewee: We have farmers who try to reduce loss although they still encounter a problem, so I will appreciate if we can come up with good strategies to reduce milk loss especially the somatic cell count.

Interview route 1F

Interviewer: May you introduce yourself?
Interviewee: My name is David, route 1F. I am a milk grader.
Interviewer: what is the different between quality officer ang grader?
Interviewee: No big different because the grader is the one going to the field to collect milk where he meet farmer and also test milk while, quality officer stay in lab test for milk standards eg protein, fat and other parameters.
Interviewer: How many time do you collect milk at MCC?
Interviewee: Two times.
Interviewer: may you mention them?
Interviewee: Morning and afternoon. But now we started to collect the third shift now it already has 3 day from when we started

collecting milk.
Interviewer: What was done with the thrice milk before you started the thrice shift?
Interviewee: They were preserving that milk and collect them during morning shift so they mix with morning milk. Other farmers were selling that evening milk to other milk buyers. The aim of opening third shift is to reduce the milk volume sold to other buyers. Also, preserving milk is still a big risk at farm level its not 100% good way because other farmer when they mix the preserved milk with morning milk that milk get rejected at MCC after running a test. With third shift we also reduce losses.
Interviewer: Is there many cases of milk rejection during morning shift?
Interviewee: Yes it happened sometimes not every day. Because they are preservation can make mistake and the milk is very sensitive to dirty.
Interviewer: What is that preservation method used by farmers?
Interviewee: They use cold water to preserve the milk, they put milk in bucket and then soated it in the bucket with cold water. The container with milk should be aluminium can.
Interviewer: So many farmers have aluminium cans?
Interviewee: Yes that is a must. All farmers have aluminium can.
Interviewer: May be during milking they use plastic bucket but just deliver milk at MCC with aluminium can?
Interviewee: No they only use aluminium bucket even in milking.
Interviewer: the cooperative is the one supplying aluminium cans to farmers or farmers buy that aluminium can themselves?
Interviewee: It is in dairy store/shop. So they buy from there or buy on credit and pay at the end of month from milk payment.
Interviewer: Since farmers are getting many service (AI, Feed and milk storage equipment) on credit, do they get money at the end of month?
Interviewee: They get credit based on the amount of milk they deliver, you can not take more than what you have (milk volume).
Interviewer: What are milk quality problem at MCC ?
Interviewee: Mastitis (clotting), physical dirty, adulteration, poor feeding resulting from mineral deficiency because farmers were not well educated on feeding.
Interviewer: Do you resistance or low technology adoption farmers?
Interviewee: Small cases. Few farmers.
Interviewer: What strategies do you use that make farmers adopt well new technologies?
Interviewee: use different extension officers to train them.
Interviewer: from the milk collected at MCC, is there any amount of milk sold to other buyers?
Interviewee: No. All milk go to plant.
Interviewer: Do you pay for milk based on quality or volume?
Interviewee: Volume
Interviewer: Do you have bonus for farmers will good quality milk throughout the year?
Interviewee: NO. The farmer is paid based on amount of milk delivered.
Interviewer: What motivation do you give to farmers for supplying good quality milk?
Interviewee: They are assured to be paid their money at the end of the month so it's a motivation to them. Also they are able to get service on credit when they supply milk to Cooperative. They get bonus after every year (end of the year) depend of milk volume supplied.
Interviewer: Between wet season and dry season, which season has great milk loss?
Interviewee: Wet season because of hygiene and mastitis due to dirty environment and few in dry season due to poor feeding.
Interviewer: Is possible to have the data of milk rejection from MCC (monthly/weekly?
Interviewee: Share the contact will send them.
Interviewer: May you mention strategies for milk loss reduction (new)?
Interviewee: The government should pay more attention on milk quality. Also, if possible the cooperative should formulate their own feed ratio.
Interviewer: Do you have any suggestion or question?
Interviewee: No.

Route 2

Interviewer: Please may introduce yourself
Interviewee: My name is Anthony, quality grader of Githunguri Dairy Society working in route 2 . The route has 6 sub-routes collecting milk in mobile.
Interviewer: How many times (shifts) do you collect milk from farmers?
Interviewee: twice a day, and we collect around 7,300 litres of milk per route per day (from all centres. Currently we started the third shift but we not yet started collecting milk.
Interviewer: Where do the milk from third shift go (if the farmer is milking thrice)?
Interviewee: They have been trained on how to preserve milk locally, they preserve the evening milk and collect it to MCC next day morning.
Interviewer: I would like to know how they preserve that milk it and still be fresh to be mixed with morning milk!
Interviewee: They are trained to put milk in milking can without covering the can then you soak that milking can in the contained with clean cold water until the time of collection. Also, farmer who want to preserve the evening milk is trained to milk the cow at least late for example they milk at 8 PM in order to reduce the interval between evening milk and morning milk because morning milk is milked at around 3 AM or 4 AM. Other farmer living near the cooling point they are allowed to bring the evening milk to the cooler.
Interviewer: At what time MCC starting collecting morning milk?
Interviewee: Around 3:30 AM but collection time differ between the route. The same to afternoon shift, in my route we start collecting at 2 PM.
Interviewer: What are the milk tests do you conduct at MCC?
Interviewee: We have lactometer for testing density, alcohol gun for alcohol test.
Interviewer: do you also test milk at farm level?
Interviewee: graders we are bridge so when I run these test at the centre and find any problem I refer that farmer to extension officer. The extension officer will be the one to visit farmer at test the milk. So going to the farm is not my responsibility.
Interviewer: What causes milk rejection at MCC?
Interviewee: Bad health of cow, poor milking hygiene and clotting due to mineral deficiency,
Interviewer: Do you face any problem with milk adulteration?
Interviewee: That's why we have lactometer because there are some cases. But not many cases and it happen once for a long period when they see the grader is not testing for density. It can happen for one farmer.
Interviewer: Does milk rejection happen to the same farmer or different farmers?
Interviewee: it happen to different farmers.
Interviewer: What are strategies for milk loss/rejection reduction?
Interviewee: Training farmers done by dairy cooperative, proper timing in collection so every route should have the sometime for milk collection and quality feed in the feed shops/store.
Interviewer: Why quality feed?
Interviewee: The way the market is, farmers get different feed quality.
Interviewer: We know the cooperative have a feed store so where farmers get that poor quality feed?
Interviewee: Even the company can use that opportunity to earn money (profit)
Interviewer: It means also the cooperative have poor quality feeds?
Interviewee: The cooperative do not produce their own feed, they source their feeds from other feed store. So these other feed store/companies may be they want to make more profits so they sell poor quality feed to cooperative.
Interviewer: What happen when the milk is rejected at collection centres?
Interviewee: We return the milk to farmers and when the milk get spoilage or rejected at cooling centre we transport that milk to processing plant where they sell that reject /spoilage milk to farmers with calves and pigs.
Interviewer: Is there any trader buying rejects?
Interviewee: I don't know about this because I return the milk to farmers I don't know where they take that milk to. Even the rejected at cooling point once It get rejected I transport it to the plant I don't know they do about it (reject).
Interviewer: What is the milk standards do you accept at the MCC?

Interviewee: This is not my duty but I know Fat is 3.5 to 4.5%, protein (not sure), lactometer reading 27g/mil to 32g/mil.
Interviewer: When the milk is rejected at MCC do you consult the farmer?
Interviewee: Other milk tests is done at MCC at cooling test when the test clot we tell the farmer about it. If the has many cows we tell him/her that the next shift the milk should delivered separate per cow in order to run separate test to find the source of problem. From there they continue to make follow up at farm level. After some days of making treatment or proper feeding the farmer will bring the milk and we run the test to confirm if the milk is good, if it still not good the farmer should return with milk and continue with treatment or wait for more time the milk to be clean. The extension officer will be the one visiting the farmer. If the farmer add water in milk more than once they get penalized and even suspension.
Interviewer: How much do you penalize the farmer?
Interviewee: They get fined 20,000Kshs directly if you have such amount on that month or half of their produce if the farmer produce is not more than 20,000 Ksh and also get suspended from bring the milk to the cooperative for a certain period of time.
Interviewer: Which season has more milk rejects?
Interviewee: Wet season due to diseases (mastitis).
Interviewer: Which shift has more milk rejects?
Interviewee: Morning shift because its collection takes more time but the afternoon shift is very short.
Interviewer: You mentioned training and milk collection time as strategies for milk loss reduction, is there any other strategies?
Interviewee: Milk hygiene. In my route the milk is not taken to cooler but directly from collection centres to processing plant.
Interviewer: the distance from farm to processing plant is it not having effect to milk quality?
Interviewee: No, because it is with four hours so no problem with the quality of milk.

Interviewer: Is there any livestock policies restricting milk loss reduction.
Interviewee: In Kenya feed supplier are importing low quality feed, so the policy should be more restricting on this. S the government may restrict importing low quality feed.
Interviewer: Do you have anything you wish to tell me or any question?
Interviewee: NO.
Interviewer: Requesting to have data on milk loss from grader.

Route 6

Interviewer: Please may introduce yourself
Interviewee: My name is Vicent Simba, quality grader of Githunguri Dairy Society working in route 6O . The route 6O has 18 sub-routes collecting milk in mobile.
Interviewer: How many times (shifts) do you collect milk from farmers?
Interviewee: thrice a day, and we collect around 7,300 litres of milk per route per day (from all centres. The night shift starts at 3 AM, its when farmers start milking about how late the finish milking depend on the technologies they use and the speed in milking.
Interviewer: Where do the milk from third shift go (if the farmer is milking thrice)?
Interviewee: Fresha has good programme for collecting milk so there is morning shift, afternoon shift and third shift. The farmer with third shift take the milk to the nearest cooler to avoid mixing of the milk.
Interviewer: what if the farmers mixes the evening milk with morning milk?
Interviewee: we usually test the milk for different parameters such as organoleptic test(like smell, taste), alcohol test and lactometer test at field level. If the farmers mix milk we reject the milk if it is of poor quality.
Interviewer: What happen when the milk is rejected at collection centres?
Interviewee: We return the milk to farmers and we report to the office. If the problem is cow, we have dairy extension officers so we inform them to visit the farmer to find out the problem if its due to cow or its resulting to milk handling (mixing milk). We advise the farmer on how to preserve the milk.

Interviewer: What is the milk standards do you accept at the MCC?
Interviewee: Fat is 3.5%, protein (not sure), acidity 0.17%, lactometer reading 1.027g/mil to 1.032g/mil alcohol should be alcohol negative on test.
Interviewer: What is the milk transportation system used by farmers to deliver milk to the MCC?
Interviewee: walking, Trolls, motorbikes, carts and personel vehicles,
Interviewer: Who are those farmers using vehicles?
Interviewee: Farmer with high milk produce 2-3 cans.
Interviewer: I know Githunguri has more small scale farmers, do you also have large scale farmers?
Interviewee: Not that large scale but medium
Interviewer: they have like how many cows?
Interviewee: It depends, other have 6 to 10 cows, these are small to medium scale farmers. You can have 5 cows but very produce a very low amount of milk but some one can have 3 cows producing high amount of milk it depends on feed formulation.
Interviewer: When you collect milk at MCC, all milk is used for processing or other amount of milk is sold to other traders/processors?
Interviewee: No local scales. But the only local scale we have is the learning institutions , its any learning institutions within the routes such as schools. So they are given contract to buy milk from cooperative via MCC.
Interviewer: What is the percentage of milk collected at MCC is sold to other institutions?
Interviewee: They take very small amount of milk like not even 1% like 0.001 % of milk collected.
Interviewer: what is the basis of milk price?
Interviewee: is quantity based payment.
Interviewer: What it price for 1 litre of milk?
Interviewee: for now is 45Ksh per litre
Interviewer: what about during the dry and wet season?
Interviewee: Here the milk price is all year through. Initially the milk price was 43Ksh now is 45Ksh.
Interviewer: Do you have any milk competitors around that buy milk from the same farmers?
Interviewee: Yes, the local traders they have motorbikes they sell to Ruiru and Nairobi.
Interviewer: how do they buy milk per litre?
Interviewer: I don't about their milk price they offer.
Interviewers: how milk producers are payed for milk delivered to MCC?
Interviewee: They are paid monthly, they count the amount delivered times the price of milk and then you get paid.
Interviewer: How sure farmer they are about the volume of milk supplied and the amount being paid monthly?
Interviewee: They have records and they receive daily delivery message from the mobile phone App. Also have the card for milk delivery record keeping so they get message.
Interviewer: Do you get any complaints about it?
Interviewee: No complaints but we usually give more attention in any matter arising immediately.
Interviewer: How many times do you test the milk per day?
Interviewee: each and every shift.
Interviewer: During milk testing, what is the main problem about milk quality arises?
Interviewee: Clots
Interviewer: what is the causes of milk clotting?
Interviewee: either the animal is suffering from mastitis and colostrum.
Interviewer: do you train farmers about it?
Interviewee: once the milk clots, we advise the farmer properly to ensure no more clotting for next delivery.
Interviewer: May be do you know anything about milk loss?
Interviewee: Yes. We normally keep records, so when the farmers milk get rejected frequently we know how much is being rejected and this is economic loss. So when reject increase we understand that there is a problem somewhere.
Interviewer: so is there high rate of milk loss?
Interviewee: Not so many milk losses.
Interviewer: Apart from clotting, is there any other causes of milk loss?

Interviewee: no any other.
Interviewer: is there milk adulteration in your route?
Interviewee: my route no other loss but at the plant may be other losses but I don't what are those losses.
Interviewer: what is the main causes of milk loss at MCC?
Interviewee: cases though is not big problem are density (lactometer test), alcohol test and neutralizers.
Interviewer: Does the milk reject happening to the same farmers or different farmers?
Interviewee: They are repeated farmers they are called persistent farmers. So for these farmers we use extension officer to talk to them and help them reduce the losses.
Interviewer: What to farmers who have repeated reject and after advising them resist to change?
Interviewee: it depend on the causes of the rejection. If the problem is the cow may be the cow is pregnant we dry that cow until get calves instead of forcing the cow to produce milk with problems.
Interviewer: what is the strategies do you use to reduce milk losses?
Interviewee: Milk loss is small compared to the amount of milk we collect. We ensure milk collection timing is the key, milk hygiene at high levels, educating farmers regularly, milk testing and ensuring proper records.
Interviewer: is it possible to get that milk record?
Interviewee: yes
Interviewer: Do you any interest in reducing milk loss?
Interviewee: Yes because if you have less loss you make more profits and its when you are doing good business.
Interviewer: May you suggest any new strategies of milk loss you wish should be employed and you are not using it yet?
Interviewee: reducing the milk routes (distance)
Interviewer: how many cooling points do you have in your routes?
Interviewee: one cooling point but is somehow far. So we planning to introduce another cooling point. It will help to reduce the distance.
Interviewer: How do you dispose the rejected milk?
Interviewee: we have HACCP at processing plants. So the rejected milk is kept at cooler and then is transported to the plant and they are responsible for disposing the that milk.
Interviewer: what about the reject milk returned to farmers, how do they dispose them?
Interviewee: other feed that milk to calves and pigs.
Interviewer: Are they not selling that reject milk?
Interviewee: I'm not sure.
Interviewer: can we share our contacts so that you send me those records (data) for milk loss in your routes? (collected milk and rejected milk)
Interviewee: Yes but this is monthly analysis. For what month?
Interviewer: For may
Interviewee: But you can get good records from supervisor
Interviewer: I will also ask for it, but you may also send it to me for comparison.
Interviewee: ok
Interviewer: what is the support that you give to farmers?
Interviewee: Training
Interviewer: how often?
Interviewee: monthly but it depends because Githunguri sub-county is very big and we have many routes, so its not simple to justify that for more month the training will be done for how many times.
Interviewer: How farmers adapt to changes?
Interviewee: Farmers are willingly to changes because they see changes in milk production. Because we see changes after trainings.
Interviewer: Is there any farmers owning milk test kit?
Interviewee: No, its not used at the MCC.
Interviewer: Do you have anything to tell me, or that require clarification or would like to ask?
Interviewer: I don't have any question.
Interviewer: giving word of confidentiality and thanks giving.

Interview with milk transporter

Interview with milk transporter at GDFCS (Contracted transporter).
Interviewer: May you introduce yourself? (Asked after the interviewer introduction)
Interviewee: I'm a milk transport working with GDFCS
Interviewer: In which milk collection route do you collect the milk from?
Interviewee: I don't have the permanent route, we work by rotating.
Interviewer: How many time do you collect milk at MCC?
Interviewee: Twice a day although in few route they collect the third shift.
Interviewer: May you mention some of those routes?
Interviewee: I can't memorize them but especially from short routes. Also, other farmers living near the cooling point they take their third milk to the cooling point. Other farmer keep and bring the next day with the morning milk.
Interviewer: What are challenges do you get during transportation of milk?
Interviewee: Spillage may occur when unsealing the milk can during offloading and measurement of milk during delivery at the processing plants. Other farmers they mix the evening milk with the morning milk, that milk may spoil when delayed at cooling point for chilling. Other challenge, is when offloading the milk at the processing plant, sometime we stay long time before loading if many trucks come the same time at the plant.
Interviewer: What is the required milk temperature?
Interviewee: It should be 4^{O} C to 10^{O}C.
Interviewer: What happens when the milk get spoiled or spilled during transportation?
Interviewee: The cost of loss is counted to the transporter. This is based on the contract between the transporter and GDFCS.
Interviewer: What is done to ensure the milk is not spoiled or spilled
Interviewee: Ealy collection of the milk, we normally start around 4pm to 6:30 pm depending on the route also we have rescue trucks if we get into emergency. And the milk can is covered well during transportation.
Interviewer: What are other challenges do you consider very important?
Interviewee: I hope the one I mentioned are the important ones.
Interviewer: Do you want to share anything with me about milk loss?
Interviewee: I don't have anything more.
Interviewer: Thank you for your time all I can say keep goog milk transportation practice to ensure the milk quality is maintain.
Interviewee: Thank you too

Interview with milk transporter at GDFCS (Contracted transporter).
Interviewer: After the interviewer introduction the interviewee was asked to introduce himself
Interviewee: I'm a transport working with GDFCS, where I collect milk from collection centre and collection point to cooling point and processing plant.
Interviewer: In which milk collection route do you collect the milk from?
Interviewee: Us trans[porters we don't have the permanent route for collecting milk, we get allocated in different routes all the time.
Interviewer: How many time do you collect milk at MCC?
Interviewee: Two times and sometimes we have the third shift but it is not permanent.
Interviewer: Why the third shift is not a permanent shift?
Interviewee: The evening shift has few farmers who milk their cows, that's why we have two permanent milk collection shift.
Interviewer: May be, does the distance or cost of collecting the third milk being the reason to not making it a permanent shift?
Interviewee: it is because farmers do not milk during the evening?
Interviewer: What is the distance from short route and long route to processing plant?
Interviewee: The long route is about 20km from processing plant while the long route is less than 3km.
Interviewer: Considering the distance from collection centre to processing plant, how do you ensure the milk is not spilled or spoiled?
Interviewee: We ensure the milk cans are well sealed during transportation.

Interviewer: What are challenges do you get during transportation of milk?
Interviewee: Rough loads especially during rainy season it leads to delay in delivering the milk to processing plants or cooler for chilling. Also, sometimes milk get spilled when the milk tank or milk cans are overfilled. Truck breakdown can lead to spoilage because the temperature my raise than what is enquired.
Interviewer: What is the required milk temperature?
Interviewee: About 4^{O} C to 10^{O}C.
Interviewer: What are strategies do you use to reduce the losses or maintain the milk quality during transportation?
Interviewee: We have more rescue trucks if other truck get breakdown. Increasing cooling temperature at the centre before transportation (4^{O} C to 10^{O}C). We also collect milk early to reduce the interval between milking and cooling, we use aluminium can when transporting the milk, ensuring proper sealing of the milking can.
Interviewer: What happens when the milk get soiled or rejected at collection centres?
Interviewee: The milk is returned to the farmers and if it happens at the collection centre, the milk is transported to the plant where they dispose that milk.
Interviewer: How does the milk get disposed at the plants ?
Interviewee: I'm not sure but I heard that the sell to farmers with pigs.
Interviewer: May how much per litre of rejected milk?
Interviewee: I don't know about it.
Interviewer: Thank you for your time, because I spend most of your presious time but we are doing this for the better performance of the cooperative, farmers and us as the stakeholders in the chain. You may ask any question or clarification you need.
Interviewee: Thank you too

Interview with quality Assurance officer

Interviewer: May you introduce yourself?
Interviewee: I'm …… the Quality Assurance and extension officer at GDFCS
(The interviewee was having an emergency and do to short time he had, we decided to skip the introduction and go to the main topic. The interviewee was aware of what I was doing during the introduction part)?
Interviewer: What are the strategies for milk loss reduction do you have in place?
Interviewee: There are many cases reading to milk loss so, the strategies depend on the causes of milk rejection at the collection centre. Depend on the cause is how we are going to address the issue. If it is due to adulteration, for example if the farmer has added water or preservatives like peroxides, Sodium carbonates there are different process. Because once your milk is rejected you will be subjected to the second test (a confirmatory test) during the next delivery if still does not comform maybe it is still adulterated we are going to reject the milk. Also, will be subjected to a third confirmatory test were by we have the quality inspectors visiting your farm where they supervise the milking and test the milk directly from the cow to be sure if is the cow with problem or is it someone else was adulterating. If it a cow producing that kind of milk with a very low density we now involve the dairy extension officer who will come and access the feeding, the minerals you have been feeding or is the breed of cows then will advise accordingly so that the farmer can improve the milk density. If during the second test at the centre the milk conforms that milk could be accepted but if that milk was firstly rejected and don't conform you will be sent here (GDFCS) to sign the adulteration form in brief on the causes of why your milk is rejected. It not always believed that the farmer will add water, its normally the labour doing that. So that's why qe require the farmer/ the registered member to come at the office and be briefed why the milk was rejected on first hand. He/she will show the results and sign the adulteration form. The will be told to come for an official hearing.
An official hearing come once in a month, we normally start at nine and end at 4 or three depending on the numbers of the farmers we have on that day. But I comes almost at the end of every month and the panel is comprised of the extension officer, Quality manager, accountant and audit person. We normally want to make the panel as diversity as possible so that we can deliver the fairly hearing. During the panel the farmer will be called upon and told to explain what happened and he will try to explain the

reason. If he doesn't give a conclusive answer the will be subjected to penalty where half of his/her produce is retained at the start and will get half of the produce. If is the second time the farmer will be suspended by the panel and will be referred to the full board hearing where it will be confirmed that he has been suspended or what. Thoses are the tools for adulteration.
If the milk was alcohol test for example the grader is supposed to to coordinate and make sure the DEO is informed so that he can visit the farmer. We have two ways of notifying the DEO, we have our WhatsApp platform where we post the member number and the cause. In that platform we haveall the graders and extension officers. So the extension officer will bring the farm for them or can be notified by calling directly. We also have cases of aflatoxin and antibiotics, normally due to nature of the test we not able to test each and every member for antibiotic and aflatoxin normally these tests are done at the cooler. The can with problem can be identified with a security deal on the can. When the milk is positive to the test, the grader will be notified by sending him/her the can number and the grader will test for that farmers with milk in that can. If may be five farmers used the same can and after testing found out the three farmer's milk are the ones with problems the extension officer will sent to them for advice. He should adhere to withdrawal time. If it was aflatoxin we should withdrawal/dispose of the feeds. The extension officer will help farmer to identify which fed has the aflatoxin and sensitize the farmer on how to store feeds so they don't develop aflatoxin. We normally have training during training forum, we train farmers on how to approach the issue of antibiotics and aflatoxin and the quality milk quality production. Normally farmers are aware and even before the milk is rejected. Also farmers get a routine visit by dairy extension officer even if your milk does not have the problem you can call the extension office, can do routine milk check at the farm even before the milk is delivered to the society or before the milk develop any problem. We also advice he farmers to also do self -routine milk check up by advising them to buy the CMT to monitor the mastitis.
Interviewer: So farmers have some milk tesing kits?
Interviewee: Yes they have, they are very available at the agrovets.
Interviewer: What happened when you don't find the farmers with milk problem on the suspected can?
Interviewee: Once the milk reaches the collection centre and after the test is done and found positive on a test the loss will not be under the farmer. So what we do at the cooler, we don't reject the milk with aflatoxin. We accept that milk then we start tracing back
Interviewer: So you process milk with aflatoxin?
Interviewee: yes we can't pour that milk because there is no way we can penalize that farmer as we are already collected that milk.
Interviewer: Since the milk is aflatoxin positive, why the milk can't be poured rather than processing it?
Interviewee: The challenge of aflatoxin is not something you can, we have that problem at the collection centre the reason why we can't test aflatoxin and other test a farm is due to expensive kits. At the collection centre time is a very sensitive issue and the testing takes more time so you can not be able to test each and every farmer. Now at the cooler they don't pour that milk. First of all is a very big percentage of farmers with the milk having aflatoxin. If I would say to pour that milk 70% of that milk will be poured. We can't pour that milk because was already accepted at the collection centre. We also don't have control on the aflatoxin, because farmers buy food all over from the society, agrovets or all feed formulation companies. So aflatoxin can be from a diversity of sources for that reason we have started to inform all farmers about aflatoxin, to sensitize them and at some point in future can start taking purity measures to farmers with aflatoxin cases in milk.
Interviewer: In Githunguri, is there any places we can test for aflatoxin in feed??
Interviewee: We don't have.
Interviewer: What do you do then?
Interviewee: In our stores, the feeds that we distribute to farmers we normall subject that feed to test in Nairobi. You can get that information from the stores.
Interviewer: Do you have any plan of buying a test kit for aflatoxin?
Interviewee: Oooh yes. Once this lab is finished we will be able to test the feed.
Interviewer: Do you have the lab here?
Interviewee: It is been constructed and we are doing final touches and will be finished soon. Once it is done we will start testing the milk.
Interviewer: Can you talk more about suspension and penalties? Like how much they are penalized, suspension period..
Interviewee: We normally deduct half the produce of that month so it depend on the amount of the milk you have delivered. For suspension they get suspended for three years and after three years he/she need to apply to be re admitted in the Dairy.
Interviewer: So farmers they still get chance to be accepted or not??

Interviewee: Yes, depending on how you have improve.
Interviewer: So, you test the milk before accepting the farmer?
Interviewee: Yes we send someone to access the farm before that farmers is reaccepted.
Interviewer: Do you have data for milk rejection at collection centre per routes?
Interviewee: Yes we have.
Interviewer: Is it possible for me to have that data?
Interviewee: Yes you can get.
Interviewer: Because one of my evidence/ prove to show there is low or high loss I really need to have that information
Interviewee: What we do, when the milk get rejected at the collection centre, the grader will send that amount Via WhatsAPP and someone in the office will process that data, the volume of loss is computed every month.
Interviewer: Do you have one person dealing with that records or there are different people?
Interviewee: New have one clerk dealing with that information, maybe I can show you this if you want. These are samples of data milk collected at collection centres, milk collected at the cooler and milk collected at the processing plant. So we have three levels. So loss can occur in any point. For example this is the milk each and every centre. Which month do you want see?
Interviewer: Maybe May.
Interviewee: So we have for every route, intake and accepted. So the data is fed every day. For individual route the farmers are identified.
Interviewer: Do you have farmers who loose trust on farming and stop farming?
Interviewee: Yes we have them and they even sold the cows and go out of dairy enterprise. It's a up to the farmers to make sure their farm Is well managed.

Interviewer: May be can I have the per cent of farmer who left the cooperative. What we have is the number of dominant farmers (Farmer who have cow in dry, died cow). For the reason a farmer to quit I can't tell you may be they are frustrated. You can get the number of farmers who have been penalized or suspended.
Interviewee: When do you want me to send you the data?
Interviewer: in this week.
Interviewee: I will send them tomorrow, just remind me.
Interviewer: Thanks for the information, because we are still together I will be asking you if I have a question.
Interviewee: Ok no problem (both laughing..)

KDB

Interviewer: Please may you introduce yourself?
Interviewee: I'm Timothy Kariuki, currently working at Kenya Dairy Board. Kenya Board is an regulatory body. Our mandate is to ensure that the milk and milk products does not cause harm to users. We have established a lab called the National Dairy Regulatory Laboratory what we do is what is called market surveillance, we go to all outlets we collect samples and from the plants or industry then we conduct analysis. We normally have three categories of analysis we do that is physical test, Chemical test and micro-biology test. All of this is in line of ensuring quality. Because you can ensure that something doesn't cause harm unless you have the analysis. The laboratory was launched last year so we have been in operation from the last year and we can see there is a lot of improvements in term of how the quality of the milk is before earlier we never had a lab.Before I joined KDB I was working here (GDFCS) about 17 years my major work was also in charge of chemical lab. So, basically what I'm doing now is what I have been doing long time ago in Githunguri Dairy Board. I have background of Chemistry and Mathematics (BSc)from Nairobi University where I was schooling when I was young.
I was also involved in other areas basically Science as I was attached at KEBS at testing departments where were doing analysis.KEBS have big scope because they deal with all products while KDB deal with milk and milk products. This is what I was been doing and I enjoy doing it.

Interviewer: Would you tell me the difference between KEBS and KDB?
Interviewee: There difference is in terms of their scope. KEBS is in charge of every product including milk they are also custodians of what we call standards. KDB basically we deal with milk and milk product so our scope is limited and was established in 1958 by the government that was present in those days. The concerned for establishing KDB is because the whole estate in Kenya consume milk and milk products so if the milk is not well controlled it can cause harm to our country. Almost 90% of home state in Kenya consume milk so is the product that needs to be controlled so much. KEBS and KDB most of the time work hand in hand because what KEBS do they constitute what we call the technical committee where the stakeholders are brought together such as Fresha, KCC, Brocksides all those people who are involved in production of particulars products they are constituted by KEBS by putting specifications to the products. KEBS ensures that everything brought into the market conform to those standards, that's why I said they are custodians of the standards.
When it comes into analysis our mandates there are some similarities but ours is limited because we deal with only milk and milk products.
Interviewer: I was able to catch up of everything you said were are in line, I wanted to know the difference between KEBS and KDB to understand your role in this chain. This research is for studying the post-harvest milk loss reduction at production, collection and processing level of milk value chain, in order to understand the general overview (challenges in the industry) I need to have interview with different stakeholders including KDB to understand the situation such problems, strategies for reducing losses those are some of things I'm going to measure on.
Interviewee: You know Loss is a general term look at this, I can produce on litre of milk may be at 30Ksh and then I sell it at 25Ksh there I have gone for only 5Ksh that is number one, number two I can produce that one liter of milk then before it reaches the market it go bad that is another loss. When you talk about loss be more particular. Maybe farmers didn't meet your expectations so what is the milk loss you are talking about?
Interviewer: Yes I need to be specific about what milk loss Is in this study, was going to ask you the same question like when I'm talking about milk loss what milk loss mean to you then I would have told you what milk loss means to this study. So in this study, the milk loss I'm talking about is the loss that occur at production, collection and processing may be due to spillage, spoilage and or due to not meet milk standards such as aflatoxin level, fat contents, antibiotic level etc.
Interviewee: Now I will explain from my previous experience in dairy because now at KDB we are not much concerned about the loss but we still have other mandates such as regulating and supporting. When it comes to support, we support by coming up with mechanism that prevent the losses because you can not say you are supporting the farm yet they are making losses so we put measures as the way of supporting the industry. Firstly, let me start by giving explanation from my former experience on how losses can occur. One of the major losses of the milk is perishability, as you know milk by nature is a perishable product. So if the distance from collection centres to plant is long probably we may have losses because the quality might be an issue. The mitigation factor is having coolers and as KDB we are collaborating with county government where by we negotiate on behalf of farmers or processors for donation of coolers. If you are able to cool milk on time the milk can not go bad so we came up with cooling milk at collection centres for example collecting milk from point A to processing plant when the milk is cooled with reaches the plant will still be good. So the milk collected from farmers are cooled immediately. Before dairy board introduced coolers we used to have many rejects because we used to transport milk from very far distance around 30km so you can try to imagine such distance. Then we used to have a lot of challenges with the roads as the condition of it, sometimes you find some vehicles stacked on the mud yet they are carrying milk and this milk is not chilled and may be the temperatures arise so sometimes we used to have many rejects you may find the whole truck the milk go bad not because it was bad when was collected from farmers its due logistics from collection centres to the plant because then cooling was done at the plant that's why I insists the ideas of having coolers at collection centres is the best because the milk is cooled at collection centres you can transport it at any time because it is already preserved by cooling.
For the places that do not have capacity to have coolers because of the volumes, because when you want to install cooler you need to consider the volume. The capacity for coolers, the smallest one has capacity of 1000Litres so assume a farmer has 500L then its nonsense to have cooler. So the condition of our weather to road contribute much to losses especially when its raining you find some places they are impassable even farmers are forced to walk a very long distance to deliver the milk that is the major factor can cause losses. All of these are tied to perishability.
Interviewer: Before you go to another factor, you mentioned about supporting farmers to get coolers, may you clarify it more?
Interviewee: As KDB we have two core mandates that is regulating and supporting. So one way of supporting, we negotiate with

county government. For instance you may have a plant like GDFCS we donated two cooler. So KDB come in by negotiating on behalf of processors you see is like we persuade the county government to facilitate or to donate those coolers to respective processors.
Another key factor that contribute to losses include post handling. If the farmers are not well educated about basic hygiene and good manufacturing practices they are likely going to contaminate the milk by themselves because may contaminate milk unknowingly. So eventually will introduce bacteria in the milk they are going to get quality deteriorating and the only way to mitigate this is by training the farmers and that is what KDB do. In fact one thing we have done in the last two months we offered training across the country. What we do, for cooperative who are able to bring farmers together we train them about good manufacturing practices. We believe by so doing we are able to reduce some of those issues. I also have another major point about feeding, when I'm talking about feeding because of climatic patterns due to global changes you find that most of farmers have shifted from natural supplements they offer to cattle today they are using other supplements which to some extent may affect the quality of milk. What is that, there are something called Machicha the product obtained when breweries (beer), if you are able to analyse the content of Machicha it has a very high levels of sucroseso what happen when you give it to cattle you end up with milk with high level of lactose. From the basic science,bacteria loves sugar that's why even people with diabetes when they get wound they take long time to heal because bacteria is like they attach them so much you know they are sweet. So for that milk even the bacteria in it will multiply because there is lot of food for them (lactose). The milk with high lactose is more perishable than the milk with low lactose.
Interviewer: I also heard they are feeding their cattle with poultry wastes…
Interviewee: This is another major way of milk loss, for instance you find people who vaccinated there poultry and now they are feeding from their wastes so you find even they high level of antibiotics is coming from the feeds. Another issue about feeding is about aflatoxin. As you are aware aflatoxin is caused by fungal which is available in our agricultural products like maize, if you do not dry them very well may get fungus (mould) which lead to aflatoxin B1 when it gets to liver it is converted to aflatoxin M1 as you are aware it is very toxic. So if carry a test and find out the farmer has brought milk with aflatoxin positive ofcourse I will reject that milk but you see I'm rejecting not because the farmer has done anything wrong its because of the feed now the rejection is the loss. Basically feeding can be a major cause of milk losses.
Feeding can also be source of loss in terms of its cost. If I'm aiming at making profit the cost of feeding is very high you may end up making losses because the cost is high than benefits. Today in Kenya to produce one litre of milk requires over 30Ksh and may be you are selling it at 40Ksh and and you can still earn low if feeding exceed the selling price. Personally I look feeding that way. The mitigation of feeding , about the cost all stakeholder including government should come in try to negotiate about the feed prices because now the animal feeds are becoming more expensive. About aflatoxin still the government can come in and regulate the animal feed which is the work of KEBS because they are the ones ensure that the animal feeds do not cause any harm to human because the feed with aflatoxin will eventually contaminate the milk by so doing we end up with rejects which is the loss.
Interviewer: Considering farmers normally buy cheap feed, for example I heard in Githunguri there are shop selling poor feed quality at lower price..
Interviewee: Yes, a control measure should be done by the government especially KEBS. Another major role is about import, if the government allows the importation of power milk this raw milk market will be affected. When the market is affected the farmers will lack the market for their produce. There is a time we used to have a system where farmers were around to not more than 100kg,if you produce much the only way is to pour down that surplus milk. But currently they have controlled the imports. Importation of milk and milk products is allowed if there is scarcity of produce or importing a certain amount with the reason of protecting the market of local farmer.
Interviewer: I heard farmer's are adding water in the milk, what do you say about that?
Interviewee: I can also look at loss in other way, looking at what farmer get from the produce and the costs incurred is a loss. So, loss can also be due to high cost of production because now for example the cost of electricity is very high than the last ten years and this is the same to animal production cost. Competence of the staff can compromise all the process leading to losses.
Interviewer: what the policies and regulations hindering milk loss reduction in Kenya?
Interviewee: The The problem is when the quality is compromised then we have to discard the products, if the quality is ok we support that process. The current regulations, there is some few duty fee pay for example 40 cents per litre regulation fee which is indirectly taken from the farmers, it also inform of loss. KDB we make sure all the stages in processing is done as required to ensure product quality. If doesn't qualify to the regulations, we have the mandate to stop them from selling. Penalties can also be termed

as a loss.
Interviewer: Regarding these challenges, what are the current strategies for reducing losses?
Interviewee: We advise the processors on best processing methods to maintain the quality of products. Also, they are supposed to meet NEMA (National Environmental Management Authority in Kenya) standards.
Interviewer: What are the obstacles that affects the implementation of the PHL reduction strategies?
Interviewee: Farmers lack honesty in their produces, for example when the milk has a problem they never talk about it and also they add water in milk purposely to increase the volume. The political instability affects delivery of milk for example the importation of processing machines.
Interviewer: What do you consider as the strategies to reduce the PHL other than what you have mentioned?
Interviewee: Organising milk price by considering the production costs. So, I hope we have covered a lot but to add on that we as KDB we organize the milk pricing to balance the cost of production and the output. For every processors including GDFCS they set a price base on their cost and farmers cost to ensure every player benefit from what they are doing.
Interviewer: Can I have the information the PHL in Kiambu County
Interviewee: I will find it and send them to you
Interviewer: Thanks so much for your cooperation, if you have any question you may ask
Interviewee: No thanks, I wish you good lucky.