ASSESSMENT OF THE MAGNITUDE OF AND FACTORS INFLUENCING MILK POST-HARVEST LOSSES ALONG THE DAIRY FORMAL MARKETING CHANNEL IN NYERI COUNTY, KENYA

MBAYA MERCY NKIROTE

A56/35930/2019

A THESIS SUBMITTED IN PARTIAL FULFILLMENT FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS

DEPARTMENT OF AGRICULTURAL ECONOMICS

FACULTY OF AGRICULTURE

UNIVERSITY OF NAIROBI

2023

DECLARATION

This thesis is my work and has not been presented for an award of any degree in any other university.

Signature… Date: 26/05/2023

Mbaya Mercy Nkirote

Reg. No: A56/35930/2019

This thesis has been submitted with our approval as university supervisors.

Signature…………………………………………… Date………26/05/2023

Prof. John Mburu

Department of Agricultural Economics, University of Nairobi

Signature……...………………………………… Date……26/05/2023

Prof. Charles Gachuiri

Department of Animal Production, University of Nairobi

DEDICATION

This thesis is dedicated to my supportive family members: My son Allen Johari, my husband John Dennis, my dad Jotham Mbaya and my late Mum Florence Mbaya.

ACKNOWLEDGEMENT

First and foremost, I would like to thank the Almighty God for the gift of life, His protection and guidance throughout my study period.

I would like to express my gratitude to my supervisors Prof John Mburu (Department of Agricultural and Applied Economics) and Prof. Charles Gachuiri (Department of Animal Production) for their patient guidance, support, encouragement, generous time, and very constructive critiques for this thesis.

My gratitude goes to my sponsors Kenya Climate Smart Agricultural Project (KCSAP) for funding this research and for continued support and encouragement by the Monitoring and Evaluation sections along the way for the successful completion. Africa Milk Project for giving me a platform to work with the cooperatives they support.

Finally, I would like to thank the enumerators; Charles Maina, Evans Muchai, Morris Wamae, Eunice Mwariri, Winstone Mbogo, Herman Kipkorir and Stanely Makumi for their support in the field, my fellow students; Afouleluo Aboulaye and Nancy Omeri who offered their support in the attainment of my master's degree.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

AI:	Artificial Insemination
FAO:	Food and Agricultural Organization
GDP:	Gross Domestic Products
GOK:	Government of Kenya
GPS:	Global Positioning System
IFAD:	International Fund for Agricultural Development
ILRI:	International Livestock Research Institute
KAVES:	Kenya Agricultural Value Chain Enterprises
KCC:	Kenya Cooperative Creameries
KCSAP:	Kenya Climate Smart Agricultural Project
KDB:	Kenya Dairy Board
KEBS:	Kenya Bureau of Standards
KES:	Kenya shillings
KNBS:	Kenya National Bureau of Statistics
MoALF:	Ministry of Agriculture, Livestock, and Fisheries
ODK:	Open Data Kit
PHL:	Post-harvest losses
SDP:	Smallholder Dairy (Research and Development) Project
TIMPS:	Technologies, Innovations, and Management Practices
UNEP:	United Nations Environmental Project

ABSTRACT

In Kenya, the dairy sub-sector is the highest contributor to the livestock sector at 8 percent of Gross Domestic Product. However, of all the milk produced, only 30 percent is traded along the formal chain. Nyeri County is ranked third among the leading counties in milk production, yet the sector has not been steady since it faces a wide range of challenges, such as post-harvest losses. Studies have not focused on the formal milk marketing channel yet it experiences both qualitative and quantitative post-harvest losses. This creates a gap in the magnitude of post-harvest losses (PHL) resulting in uncertain estimates of PHL accompanied by an imprecise understanding of the points where the losses occur. The objective of this study was to assess the magnitude of post-harvest losses and their influencing factors in the formal milk marketing channel in Nyeri County, Kenya. The study adopted both qualitative and quantitative research design. Primary data was collected from 432 households practicing dairy farming under cooperatives, 39 transporters/aggregators at milk collection points, and 7 farmers' cooperative representatives in Kieni East sub-county using questionnaires. Collection of data from each of the levels of the respondents using questionnaires was aided by ODK, a mobile data collection technology. The study utilized multistage sampling involving purposive and simple random sampling techniques to select respondents of the study. The results of the study revealed that most of the milk losses occurred due to spillage. At farm level spillage (38%), spoilage (24.7%), forced consumption (23.8%) and rejection due to adulteration (13.5%). At the cooperative level: spillage (86.8%) and spoilage (13.2%). At the transporters level spillage from loading, offloading and accidents (81.9%) and spoilage (18%). Lack of market access, price, quantity rejected, storage facilities, and handling positively and significantly affected the post-harvest loss ($p<0.05$). Moreover, regression results showed that road type positively and significantly influenced milk post-harvest loss at the transporter level ($p<0.05$). The study recommended that dairy farmers to be trained on best milk handling practices and milk quality requirements to reduce milk loss at the farm level and rejection by cooperatives. Improvement of road infrastructure to lower milk loss during poor weather conditions. In addition, the study recommends provision of credit to farmers to enable them acquire milk storage and cooling facilities to lower milk losses during post-harvesting.

Keywords: *Dairy, Post-harvest losses, Formal marketing, Milk, Nyeri*

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

With the global population expected to rise to 10 billion by the year 2050, the demand for food is expected to rise by approximately 50% (Food and Agriculture Organization of the United Nations [FAO], 2009). To satisfy this demand, food produced must be handled with minimum waste from production or harvesting, up to the consumer level. Annually, it has been recorded that large quantities of food get wasted between the stages of harvesting to consumption (Ridolfi et al., 2018). IFAD (2020) estimates that 14% of the world's food production goes to waste before it reaches the consumer. This is a direct threat to livelihoods of those people that are entirely dependent on agriculture as a source of income. One of the Sustainable Development Goals for 2030, is to ensure sustainable consumption and production patterns as well as reduction of food losses is a key attribute to sustainable food systems that eventually result in environmental protection (IFAD, 2020).

Globally the magnitude of post-harvest losses (PHL) in the food value chains is increasingly being deliberated among food system analysts and policymakers, along with the design of policies to try to reduce these losses (FAO, 2019). Food is lost or wasted throughout the supply chain, from initial production to final household consumption (Blakeney, 2019). Milk spoilage refers to any undesirable change or deterioration in the quality of milk while milk spillage refers to pouring. Among the sources of losses, milk spoilage is a major constraint in the industry especially in tropical countries (Azeze & Haji, 2016). Spoilage may be caused by many influencing factors including market availability, high prices, excessive milk production, poor handling, and slow market consumption (Ndungu et al., 2019; Ng'eno, 2016). In the dairy industry, postharvest losses are described as milk losses at the farm level and during transportation, processing, marketing, and consumption, which arise due to spillage, spoilage, or "forced consumption" (Ndungu et al., 2019). According to Muriuki (2003) "forced consumption" is usually at the farm level from drinking the evening surplus milk and is reported to be highest during the wet season.

In 2019, global milk production reached 906 million tonnes, with available estimates of losses varying from different sources of literature (March et al., 2019), even though these losses have been both qualitative and quantitative. In a study conducted by Edinburgh University as reported by the Guardian news website (https://www.theguardian.com), one in six pints of milk is lost, wasted, or thrown away each year. Sixteen percent of dairy products, about 116 million tonnes, are discarded globally each year (Gross, 2018). The study further estimated the annual milk losses to be 53 million tones globally.

Approximately 150 million households globally are involved in the production of milk (FAO, 2021a). In the developed world, milk production is mainly by large-scale farmers while in the developing world, production is through small-scale farmers who depend on milk for food security, nutrition, and as a source of income (FAO et al., 2018). India is the largest producer of milk with 22% of global production, followed by the USA, China, Pakistan, and Brazil (FAO, 2022). In Africa, past evidence demonstrates that significant milk losses occur at the farm level where, for instance, Kenya, Tanzania, Ethiopia, and Uganda lost 54.2, 46.4, 28.6, 8.4 million litres of milk per year respectively (March et al., 2019). In Africa, milk loss through low quality is a major challenge given the threat of food insecurity faced by over 374 million people (FAO, 2021c). However, in the last 10 years, milk production in Africa has been on the rise, and this is linked to the increase in the number of producing animals.

Kenya's dairy industry remains one of the most critical sectors of the economy (Kang'ethe et al., 2020). It contributes to 14% of agriculture's Gross Domestic Product (KDB, 2021). The dairy sector provides job creation, income generation, and food security to over 1 million households across the dairy value chain (Creemers & Aranguiz, 2019; Ndungu et al., 2019). This plays a role in the achievement of at least three of Kenya's Big Four strategic priorities namely: health, food and nutrition security, and manufacturing (Ndambi et al., 2019).

Small-scale farmers dominate the dairy sector and given that most of the population in developing countries is food insecure, any intervention in the reduction of food losses could have an immediate and significant impact on their livelihoods (Blakeney, 2019). To improve the livelihoods of the dairy smallholder farmers, efforts have to be made to improve the policy environment, and actions on constraints faced by those actors engaged in the dairy value chain (Devaux et al., 2018).

In 2019, Kenya produced 491.8 million liters of milk and cream, an increase from 468.4 million liters the previous year. In addition, 1000 metric tons of ghee and butter were produced within the same period (Faria, 2021). Despite the high production, the growth of this industry has been unsteady as characterized by low per-cow productivity over time, poor milk quality, and a lack of expertise in individuals along the formal value chain (Africa-Milk, 2019).

In Kenya, milk commercialization is through both the formal and informal market channels. The informal channels account for 70% of the traded milk while the remaining 30% is through formal channels (Nyokabi et al., 2021a). The formal channel is dominated by a few large processors and cooperatives, which aggregate and market milk on behalf of farmers while in the informal market, farmers sell unprocessed milk directly to consumers and end-users (Alonso et al., 2018). The sale of unprocessed milk however raises concerns, primarily due to low handling standards and poor hygiene as well as the selling of milk of poor quality (Ndambi et al., 2018).

Concerns over milk quality and safety have been used to criminalize and penalize the dairy sector in many countries in Africa (Zindove & Chimonyo, 2018). This has led to strategies to formalize the informal sector, an intervention that has a significant positive effect on farmers' welfare, even though a majority of dairy farmers are hesitant to get involved (Ng'eno, 2016). Despite having a well-defined legal framework for the formal marketing channel in Kenya, research has shown that milk traded along this channel is not always of high quality (Nyokabi et al., 2018). This can be attributed to the fact that Kenya's institutions are not adequately developed to provide effective support to the formal milk-marketing channel. In addition, regulatory institutions are too weak to regulate and enforce quality standards (USAID-KAVES, 2015). Low-quality milk consequently means that magnitude of post-harvest losses are higher.

Farmers, cooperatives, and processors play a key role in determining the quality of milk and dairy products (Nyokabi et al., 2018). The stages of the formal marketing channels include the farm, milk collection points, cooperatives, and processors. At the farm level, post-harvest losses mostly occur through milk handling techniques, spillages, forced consumption, and spoilage. At the transporters/aggregators level, the losses are through milk handling techniques, spillages and spoilage. While at the cooperatives and processors, losses are mainly through adulteration, spillage, and spoilage (USAID-KAVES, 2015). These losses are directly or indirectly influenced by milk management knowledge and skills, seasonality of milk supply, high cost of milk collection, poor infrastructure, low raw milk quality, competition from a large informal sector that erodes the capacity of the formal sector to grow (Alonso et al., 2018a; Ndungu et al., 2019; Ng'eno, 2016; USAID-KAVES, 2015). Additionally, large losses are recorded when the processors impose unilateral rationing or milk quotas of the amount delivered to their processing plants. Therefore, a quantitative aspect of value chain mapping is a major key to the accurate establishment of ultimate losses (Hengsdijk and de Boer, 2017).

In Kenya, the central region has over 600,000 smallholder farmers deriving their income from the dairy sector (Mbugua et al., 2012). It is estimated that farmers lose about 54.2 million liters of milk annually with losses approximated to be between 1.3% and 6.4% of the available milk (Lore et al., 2005b). Understanding how the dairy food system operates is essential in identifying mitigation measures for food insecurity's impact in Kenya (Kiambi et al., 2018). In Nyeri county, dairy farming has continually been a major enterprise with dairy cows about 178,000 and about 80% of the rural household keeping at least a dairy cow. In the last three years the county has installed 26 coolers through cooperative societies and self -help groups (Nyeri county-issue 53/2020)

1.2 Problem Statement

Milk being highly perishable by nature is highly prone to post-harvest losses through milk spoilage (deteriorations of quality), and spillage (Azeze & Haji, 2016). Despite having quality control measures in the Kenyan formal milk marketing channel, milk is not always of high quality (Nyokabi et al., 2018) leading to a potential risk of milk contamination resulting in spoilage (Amentie et al., 2016). From previous studies, postharvest losses are majorly associated with informal market channels (Nyokabi et al., 2018; Ndungu et al., 2019), even though losses are known to occur even in the formal market channel. Studies have not focused on the formal channel yet it experiences both qualitative and quantitative postharvest losses of milk. This creates a gap in the magnitude of post-harvest losses and there are uncertain estimates of PHL accompanied by an imprecise understanding of the points in the marketing channel where the losses occur (Affognon et al., 2015)

Post-harvest losses occur at the different stages of the marketing channel where the magnitude of losses is more often qualitative rather than quantitative (Affognon et al., 2015). These losses contribute to lower-quality and quantity of milk being availed to consumers and loss of income (FAO, 2018). However, it is apparent that the magnitude and causes of the postharvest losses in milk along the formal market channels in Kenya have not been adequately documented and available statistics have not been based on empirical research, but on assumptions (Ndungu et al., 2019).

According to Kiambi et al. (2018), understanding the magnitude of the problem can create opportunities to leverage food security and poverty outcomes from PHL reduction strategies. However, the number of existing PHL estimates lack consensus on loss data, both in physical mass and value (Sheahan & Barrett, 2017). In addition, there is scarce and lack of systematic evidence on the magnitude of post-harvest losses in sub-Saharan Africa hindering the identification of interventions to reduce losses (Hengsdijk & de Boer, 2017). Based on the determinants causing post-harvest losses in the milk market channel, detailed information about the nature and value of the losses along the chain is not widely reported (Ndungu et al., 2019).

1.3 Purpose

The purpose of this study was to assess the magnitude of milk post-harvest losses and their influencing factors along the formal marketing channel in Nyeri County, Kenya

1.4 Objectives

i. To assess magnitude of post-harvest losses of milk along the formal marketing channel.

ii. To evaluate factors influencing the magnitude of milk post-harvest losses along the formal marketing channel.

1.5 Hypotheses

i. The magnitude of post-harvest losses in milk along the formal marketing channel is zero.

ii. Handling practices, actor experience and expertise, and market constraints do not influence the magnitude of milk post-harvest losses along the formal marketing channel.

1.6 Significance

This study would help better understand the magnitude of losses at different levels of the formal milk value chain which would strengthen Kenya's institutions, especially farmers' and traders' associations and public institutions. Understanding the points where these losses occur offers potential information on areas to focus on when trying to mitigate these losses. Given that one of KCSAP's objectives is to offer support through management practices that enhance production, build institutional capacity, and support investments in smallholder farming systems, this study will be valuable source of information that will fill the knowledge gap on the nature and magnitude of post-harvest losses. Moreover, the results of the study will offer essential insights into the stages at which milk losses are likely to occur and possible reasons as to why the losses occurred, hence allowing focus on areas that require interventions.

Owing to the inadequate scientific evidence on post-harvest losses along the formal marketing channels, it is difficult to create interventions given the limited background information that is available in Kenya. Therefore, this study provides an important source of literature on magnitude of PHL and factors that causes postharvest losses along the formal marketing channel stages, thereby informing relevant agencies for easy formulation of policy and intervention.

Results obtained from this study on the magnitude of losses would inform the stakeholders of the importance of observing hygiene, as well as the use of recommended equipment in the milking and transportation of milk. Expertise would show the importance of education, experience, and extension services to farmers. If higher expertise resulted in less PHL, the study would be a good source of information on what areas to lay out interventions to improve the capacity of farmers. Market constraints on the other hand limit the productivity of farmers and result in PHL.

In this study, market constraints were assessed to identify what individual indicators affected the market, and how they could be resolved to lower losses. This study shall therefore be an information resource to governmental agencies that provide services to dairy farmers as well as enable a better policy intervention in the formalization of the informal sector in the milk industry. Eventually, the reduction of milk post-harvest losses has positive impacts on the environment and climate as it enhances farm-level productivity and reduces the utilization of production resources or expansion into fragile ecosystems to produce food that will be lost and not consumed.

1.7 Scope and Limitations

The study covers different stages of dairy formal marketing channels: At the farm level, the households; at transporter/aggregation centers, the representatives of routes at the cooperatives;

while at the cooperatives representative of top management were focused on. Biasness may have occurred during respondents' filling of questionnaires household level regarding the finite quantity of milk produced at their farm since the researcher was not able to control their attitudes. This limitation was addressed by informing the respondents about the nature and rationale of the study. Besides, the application or generalizability of the results of this research work to other regions might not be possible given the contextual factors, such as the environment, in which the study was conducted may be different in other regions.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 An Overview of the Food Losses along the Marketing Channel

Food loss is the decrease in the amount of food available for human consumption due to actions related to post-harvest handling, storage, packaging, and transportation (FAO, 2021b). According to UNEP (2021), food loss has hurt the social environment's aspects as it accounts for 8-10% of the total greenhouse gas emissions associated with unconsumed food. In addition to this, food loss and waste take place at all stages of the supply chain, especially on the farm and the home. Globally, 1.3 billion tonnes of all the food produced for purposes of human consumption is wasted or lost (FAO,2020). This accounts for a third of all global food production with 20% of all dairy products being lost or wasted globally.

In Sub-Sahara Africa, the cumulative food loss is estimated to be 100 million tonnes each year with the value of grains lost being higher than the value of imports and total food aid received in the region (FAO, 2021a). Despite efforts to reduce food losses in Africa, challenges such as the predominance of smallholder agriculture, limited access to processing and packaging as well as few agro-industries, have been major setbacks (FAO, 2021b). Food losses and wastage are highly dependent on the local situation of a country as well as other conditions specific to it (FAO, 2020). In low-income countries, for example, food losses result from managerial and technical setbacks in harvesting, transport, storage, processing, cooling facilities, infrastructure, packaging, and marketing systems. In Kenya, 6-8% liters of milk are lost annually, with the farmers experiencing the impact (FAO, 2014). Milk losses at the farm level occur after milking and are spread through the market chain to the consumption level mainly due to poor handling and a lack of cooling facilities (Ndungu, 2019).

2.2 Empirical Review

2.2.1 Handling of Milk and Post-harvest Losses

Milk provides an excellent environment for the growth and proliferation of microorganisms (Negash et al., 2012) resulting in souring due to the accumulation of lactobacilli, fermentation and gas production, proteolysis, and sliminess. Moreover, spoilage of milk results in a change in milk fat, the production of alkalis as well a change in flavor and color (Azad & Ahmed, 2016).

Healthy cows usually produce healthy and uncontaminated milk. However, contamination of milk usually happens during the milking process from the udder, soil, water, hands, and equipment used for milking (Fintrac, 2014). In addition to this, contamination may also increase further during transport through the transport equipment. Contamination of milk can be physical, biological, or chemical, and can happen intentionally or accidentally (Montgomery et al., 2020).

Milk quality may also be affected due to mishandling through adulteration by vendors, farmers, or farm workers (Salih et al., 2017b). Adulteration of milk is common practice throughout the world with possible reasons for adulteration being a gap in the supply and demand of milk, low purchasing power, perishability of milk, and unsuitable diagnostic tests (Kamthania et al., 2014). Typical non-harmful adulterants in milk include vegetable proteins, milk from other animals, and water (Singh & Gandhi, 2015). Harmful adulterants with adverse effects on humans include melamine, formalin, urea, boric acid, detergents, caustic soda, benzoic acid, sugars, and hydrogen peroxide (Azad & Ahmed, 2016) that could cause serious illnesses or fatalities. Other adulterants include extraneous water, sterilant, teat dips, neutralizers, skim milk, salts, fats, and preservatives (Harding, 1995).

Detergents in milk cause food poisoning and complications in the gastrointestinal tract (Tanzina and Shoeb, 2016). The study indicated that hydrogen peroxides cause GIT infections. Other adulterants such as urea, caustic soda, and formalin result in short-term effects such as gastroenteritis while long-term effects are reported to be even worse. Kidney failure is a common condition resulting from the ingestion of formalin (Kandapal et al., 2012; Kedija, 2018). Cane sugar reduces the nutritional value of milk; caustic soda harms the alimentary canal while detergents comprising sodium are gradual poisons to individuals with existing conditions (Rana et al., 2011).

Adulterants are added for various reasons; water is added to increase the volume of milk (Kandapal et al., 2012). Sugars are added to improve the starch content of milk thereby making it thicker (Kamthania et al., 2014). Starch, wheat flour, or rice flour increases milk solids (Arvind et al., 2012). Acids and formalin are used as preservatives (Arvind et al., 2012; Singh & Gandhi, 2015) to inhibit microbial growth. Soaps and detergents give milk the desirable frothy characteristics as they dissolve the oil in water. Urea increases the SNF (solids not fat) value in milk (Sharma et al., 2012) while neutralizers are added to conceal acidity developing in milk, a symptom of milk spoilage (Silva et al., 2015).

Adulteration of milk is usually done for the financial gain of the farmer, or due to improper handling of milk or its transportation equipment (Lateef et al., 2013). Water is added to milk to increase its volume, thereby increasing the profit margin. With milk comprising 87% water, it is not strange that water is the most common adulterant. When added, water reduces the nutritional value of the milk. In addition, as water is added, other adulterants such as starch and oils have to accompany it to balance the milk density and maintain its thickness (Abdallah & Yang, 2017). Milk with detected adulterants is rejected by the processors, thereby resulting in post-harvest losses. Adulteration of milk is mostly done by farmers supplying milk through informal channels (Shull et al., 2015).

Handling is a major contributor to post-harvest losses of milk. Handling practices of milk by farmers and transporters can determine the spoilage of milk. It has been pointed out that several milk handling practices along the milk chain are unhygienic both in the informal and formal marketing channel stages (Amentie et al., 2016). While assessing the post-handling practices of individuals and groups involved in handling milk across the supply chain, Amentie et al., (2016) assessed 54 milk collectors and transporters, 152 milk vendors, 160 consumers, and 160 milk producers using various methods such as one-on-one interviews, observations, and focus group discussions. They reported that illiteracy played a big role in the poor handling of milk. In addition, plastic containers were also used, a practice that has greatly been discouraged for the handling of milk (Debela, 2015). A lot of qualitative milk losses are a result of the storage of milk in unclean and unsuitable containers, which are susceptible to contamination by microbes (Debela, 2015). This is rampant in less developed countries such as Kenya where clean milk production practices are not strictly adhered to (Amentie et al., 2016).

Even in developed countries, milk quality has not attained the required standards due to poor handling. In a study conducted by Montgomery et al. (2020) using secondary data mined from the European Commission between 2015 and 2019, datasets were obtained from studies involving milk handling. They reported that out of 1094 samples analyzed, 255 samples had biological contaminants including 249 pathogenic and 16 non-pathogenic microorganisms. Twenty-nine samples had chemicals, while 43 had other physical contaminants.

Ndungu et al. (2019) assessed the causes of post-harvest milk losses in Kenya among milk producers within the county of Nyandarua. They interviewed 188 dairy farmers supplying milk through informal and formal channels. In addition to knowledge, experience, distance, total milk output, and record-keeping, it was concluded that poor handling was a potential source of post-harvest losses. Handling of milk comprised of containers and equipment for milking, keeping, and transporting milk. Poorly cleaned containers are a source of biological contamination where microbes can be transmitted. Containers cleaned with soap or detergent need to be thoroughly rinsed with water since detergents and soaps are major adulterants in milk (Silva et al., 2015) that could result in milk being rejected at the processors.

Milk collection is usually done for the farmers where it is aggregated together at a central point for ease of processing and transportation (Draarijer, 2004). The milk should be collected within four hours of milking to minimize losses. Tosun et al., (2009) suggested that the milk collection centers should be set up in such a way as to consider the number of milk producers, the total volume of milk, transport time, distance from farmers to the center, distance from the collection center to the processor, and several milk collections. Due to the perishable nature of milk, the collection centers should therefore be equipped with cooling facilities, adequate water, access roads, transport vehicles, electricity, etc. Milk collection can also be done at the processors where farmers supply directly to the processors.

The milk collection centers play a crucial role in the dairy industry by ensuring a supply of safe and high-quality milk. Handlers of milk at the collection centers, therefore, need to be individuals with an adequate level of education and experience (Demirbas et al., 2009). Skilled employees are more likely to have a good understanding of mitigating losses at the centers compared to unskilled personnel. In addition, the dairy equipment used for the collection of milk should be cleaned and rinsed after use to minimize the infection of milk (Durham, 2007). The centers should also be equipped with facilities such as refrigerators, surface coolers, cooling tanks, and lactose peroxidase systems (Draarijer, 2004). In a study by Kangethe et al. (2018), it was observed that a lot of milk goes to waste at the collection centers due to poor infrastructure, unhygienic equipment, lack of expertise, unsuitable transport equipment, and long distances from farmers to processors. Spoilage of milk has also been shown to occur at collection centers due to untrained personnel, hygiene issues, time management, and handling techniques (Masembe, 2003).

In Kenya, poor implementation of safety regulations in the dairy sector has resulted in poor milk quality finding its way through the formal value chains (Nyokabi, et al., 2021a). This is perhaps due to low stringent measures against processors, corruption, and nepotism by institutions governing the dairy sector such as the Kenya Dairy Board, Kenya Bureau of Standards, and Ministry of Health. An example of inadequate implementation of standards by these institutions was demonstrated when a milk processing company in Kenya was reported to have packaged water in milk packets instead of milk (Mukere, 2019).

Handling of milk has been shown to result in post-harvest losses of milk. This study, therefore, sought to understand the proportion of post-harvest losses that were caused by the handling of milk in Nyeri County along the formal marketing channel stages.

2.2.2 Human Capital Factors and Post-harvest Losses

Zargar (2015) observes that the largest cause of post-harvest losses in third-world countries is the lack of knowledge and expertise on mitigating the causes of losses. Individuals with higher education levels as well as training along key stages of milk marketing channel stages are perceived to result in lower PHL as compared to less educated persons (Shee et al., 2019). This is not limited to the dairy sector alone, but it is also found in all food sectors involving perishables. In a study by FAO et al. (2018) on determinants of post-harvest losses, it was shown that there was a negative correlation between the number of years of education and post-harvest losses, an indication that as people get educated, they tend to learn and find solutions to losses. Education is a significant contributor to perceived losses along key stages of the milk chain as supported by other recent studies (Mebratie et al., 2015) where regression analysis indicated that level of education was a major attribute to postharvest losses.

There is a significant gap in capacity management in the dairy sector with service providers along the milk market channel in the formal market greatly lacking skilled human resources (Masembe, 2003). This has not helped in the reduction of post-harvest losses. Dairy farmers have been facing challenges in accessing reliable information from trusted sources, and this has limited them from attaining their full potential (Marwa et al., 2020). They usually improve their capacity and knowledge through extension services provided by the government and other related agencies.

A study by Baluka (2019) indicated that dairy farmers with access to extension services were trained and received artificial insemination services had a higher productivity in milk production by up to 25% more than their counterparts who did not access extension services. Moreover, their monthly expenditure dropped. Training of dairy farmers has a positive impact on management practices, an element that has a positive impact on the management of post-harvest losses in milk (Michailidis & Papadaki-Klavdianou, 2008). Increasing management practices within a farm can help enhance the efficient use of resources while reducing post-harvest losses (Odhong' et al., 2018) as farmers have access to crucial information regarding markets and production practices.

In Kenya, dairy processors have begun to provide extension services to their milk suppliers; and by 2018, almost 60,000 farmers had access to these services (Odhong' et al., 2018). In addition, many cooperatives offer extension services through training and technical expertise to reduce inefficiencies by farmers, thereby cutting down on post-harvest losses. However, Fintrac (2014) indicated that the provision of dairy extension services in Kenya was still a very big problem with only 33% of respondents found to have access to extension services and a ratio of 1:4000 extension providers to farmers. This is a clear indication that despite the importance of these services, they may not have been provided as required in the past, thereby not able to mitigate PHL.

Farmers' age and experience are often associated with increase in attained hands-on knowledge. It is therefore expected that older farmers have better expertise in managing post-harvest losses than junior farmers. However, age can also be a negative attribute in that, junior farmers are more youthful and have better access to modern information. Therefore, while age is a positive attribute, it could also be a negative attribute. In a study by Shee et al. (2019) on determinants of post-harvest losses among small-scale farmers, it was established that the higher the age, the more likelihood of postharvest losses. This conclusion is supported by Tadesse et al. (2018), while doing an assessment of PHL along value chains in Ethiopia. In contrast, Kyei & Matsui (2019) reported that with age comes better management of post-harvest losses. According to them, older farmers pay more attention to small losses of milk even at the farm level as compared to youthful farmers who may overlook such details, thereby making age a positive attribute in managing PHL. Such contradiction is a clear indicator that the effect of age of the farmers on PHL is not conclusive and this study will help to provide additional information.

Record keeping is used to keep track of all the milk being traded along the market channel stages. In dairy farming, farmers keep records to keep track of inputs and outputs within the farm as well as the amount of milk produced, sold, consumed, etc. For processors, records are essential and help in monitoring incoming and outgoing milk (Ndungu et al., 2019) and have been significant in tracking post-harvest losses. Record-keeping helps farmers identify loopholes that result in PHL as well as becomes easy to seal such loopholes thereby minimizing PHL (Amentie et al., 2016).

2.2.3 Market Constraints and Post-harvest Losses

Post-harvest losses of milk and dairy products in sub–Saharan Africa has been related to poor marketing, low purchasing power, unreliable distribution network, and lack of an export market to offload surplus products (Masembe 2003). Studies conducted in Ethiopia (Azeze & Haji, 2016;) have shown that farm losses were mainly because of spillages while milking and transporting the milk, spoilage caused by mishandling and the use of unhygienic containers. Ultimately, this comes about because of market constraints, farmers without adequate hygiene knowledge, and a lack of infrastructure (cooling facilities and electricity supply).

Market constraints play a major role in post-harvest losses. These include the price of milk, the distance, absence/presence of processors, competition, transport, and distance. According to Lore et al. (2005b), poor access roads are a major contributor to post-harvest losses in Africa. This means that the milk produced does not reach the destination (processor, collection points, or markets) in time potentially resulting in spoilage. Within the milk marketing channel stages, the main challenge is poor infrastructure (bad roads, damaged bridges), and inappropriate transport machinery such as coolers or vehicles fitted with refrigeration capacity (Kiaya, 2014).

Given that the transport of milk requires specialized care, it has become increasingly difficult especially for small-scale farmers to get their produce to the collection centers or processors (Tadesse et al., 2018). Government legislation has equally made transportation more difficult with the introduction of harsh regulations which ban the use of public transport vehicles ('matatus', 'boda-boda', and taxis) for transporting milk (Imende, 2020). This requires that there be customized vehicles for milk transportation designed in such a way to be easy to clean and disinfect, and incapable of contaminating the milk. The act also requires all milk handlers within the marketing channel to undergo mandatory training from recognized institutions and as food handlers, they're also required to have regular medical checkups. The bill also requires that all individuals involved in the testing of milk and calibration of milk testing equipment have a calibration certificate. Non-adherence to such requirements may discourage farmers from supplying milk to a particular processor, a factor that could result in excess milk used for forced consumption.

A study in Uganda (Masembe, 2003) attributed the main causes of milk losses to overproduction, which could not find a market, thereby resulting in a surplus that easily goes to waste. Excess milk in the market results in a drop in prices, which discourages farmers from selling, consequently causing forced consumption.

Nyokabi et al. (2018) conducted a study to identify which stakeholders in the Kenyan dairy sector play a role in determining milk quality. The study pointed out that farmers, cooperatives, and processors play a key role in determining the quality of milk and dairy products, while cooperatives, processors, and government agencies exert influence over milk quality as the most powerful stakeholders in the network.

Kangethe et al. (2018) noted that the main causes of milk loss were poor roads, lack of transport equipment, and long distances to the market among others. Mathai (2019) also reported that a considerable amount of milk losses occur during transport as a result of bad roads, long distances, and inappropriate transporting equipment. In Nyandarua County, a mean volume of 104 liters per month was lost for each transporter with those using illegal modes of transport such as motorbikes and vehicles losing more milk per month. While assessing post-harvest losses in rural-urban value chains in Ethiopia, Minten et al. (2021) reported post-harvest losses of milk during transportation to be significant. Of the transporters, 6.7% had encountered losses estimated to be approximately 0.2% of their total load. Poor transport infrastructure could delay milk from reaching its collection point, resulting in milk spoilage which will ultimately be rejected by the processor, resulting in a farmer/transporter losing money and having to cope with the loss of milk rejected (FAO, 2021b).

It is estimated that milk losses in small-scale farms tend to be higher, perhaps due to better management practices in large-scale farms and more marketing constraints encountered by small-scale farmers (Masembe, 2003). Losses at the processing plants may be less when compared to losses at the farm level quantitatively. However, most of the losses incurred at processing occur in terms of qualitative losses with milk rejected due to quality issues. In such cases, farmers supplying to the processors incur further losses since they have to transport the milk back at their own expense (Kashongwe et al., 2017). This study shall attempt to explain how the market constraints cause post-harvest losses and by what magnitude.

2.2.4 Estimation of Magnitude of Post-harvest Losses

A meta-analysis study conducted by Affognon et al. (2015) on the magnitude of PHLs revealed that there were inadequacies of loss assessment methodologies that result in inaccurate PHL estimates. They further posited that losses are often economic rather than physical product losses. Muriuki (2003) estimated post-harvest milk losses (food losses) during the dry season along the milk value chain and found that losses were highest at the farm level. The findings from the study estimated milk losses within the cooperative milk chain to be on the range of 1-5 %, whose average can go up to over 10 % in the wet season when delivery rejections are common.

The rejection of milk at the market, which is higher in the wet season when production is high, is a result of poor handling and the time taken to reach markets (salih et al., 2017a). Similarly, Lore et al. (2005a) carried out a study to estimate milk post-harvest loss during the dry season and found that the total value loss ranged from approximately 10-24 million US dollars per year. From the estimates, the authors reported spillage and spoilage as the major causes of milk losses. Spillage is assumed to be minimal though detailed information about their nature and value at the farm level is not widely reported in the literature (Lore et al., 2005b).

A study conducted by Minten et al. (2021) on post-harvest losses in rural-urban value chains estimated PHL for raw milk at approximately 2.1% of the total produce along the entire chain using data collected from different agents along the milk channel including farmers, brokers, collection center agents, and processors. This however did not consider other important aspects such as the effect of distance covered during transportation of milk, milk equipment's used which are included in the current study. In the study, they also concluded that agents along the milk channel that incorporated modern tools or facilities experienced relatively lower post-harvest losses. The current study aims to fill the gap by estimating the magnitude of the milk post-harvest losses at different formal channel stages and add insight to future studies on milk post-harvest losses.

2.3 Theoretical Framework

The main theory underpinning the post-harvest losses effect along the milk marketing channels is the profit maximization theory. The profit maximization theory states that for a firm or business to maximize its profits, it has to produce at a level where the marginal cost (MC) is equal to marginal revenue (MR) (Hall and Hitch, 1939). That is to say that as the cost of producing one or more goods increases, the total revenue resulting from its sale increases. Therefore, maximum profit occurs when the difference between MR and MC is largest. Tripathi (2019) reiterates that any business increases profits under the following conditions: grows its revenue more than its costs, grows revenues while costs remain unchanged, minimizes loss more than it reduces its revenue, and reduces the cost while its revenue remains unchanged.

This theory is applicable in the study since for farmers or processors to obtain significant profits, they must reduce their production costs and increase their revenues by taking measures such as the reduction of post-harvest losses. Milk lost, is milk not sold, which will not bring income, even though the production costs remain the same whether lost or not. Therefore, all shareholders within the milk market channel must embrace this theory and deal with PHL at their respective stages.

2.4 Conceptual Framework

Figure 1 illustrates the Conceptual Framework of the study. The research work covered farm, transporter, and cooperative level factors within the context of milk post-harvest losses.

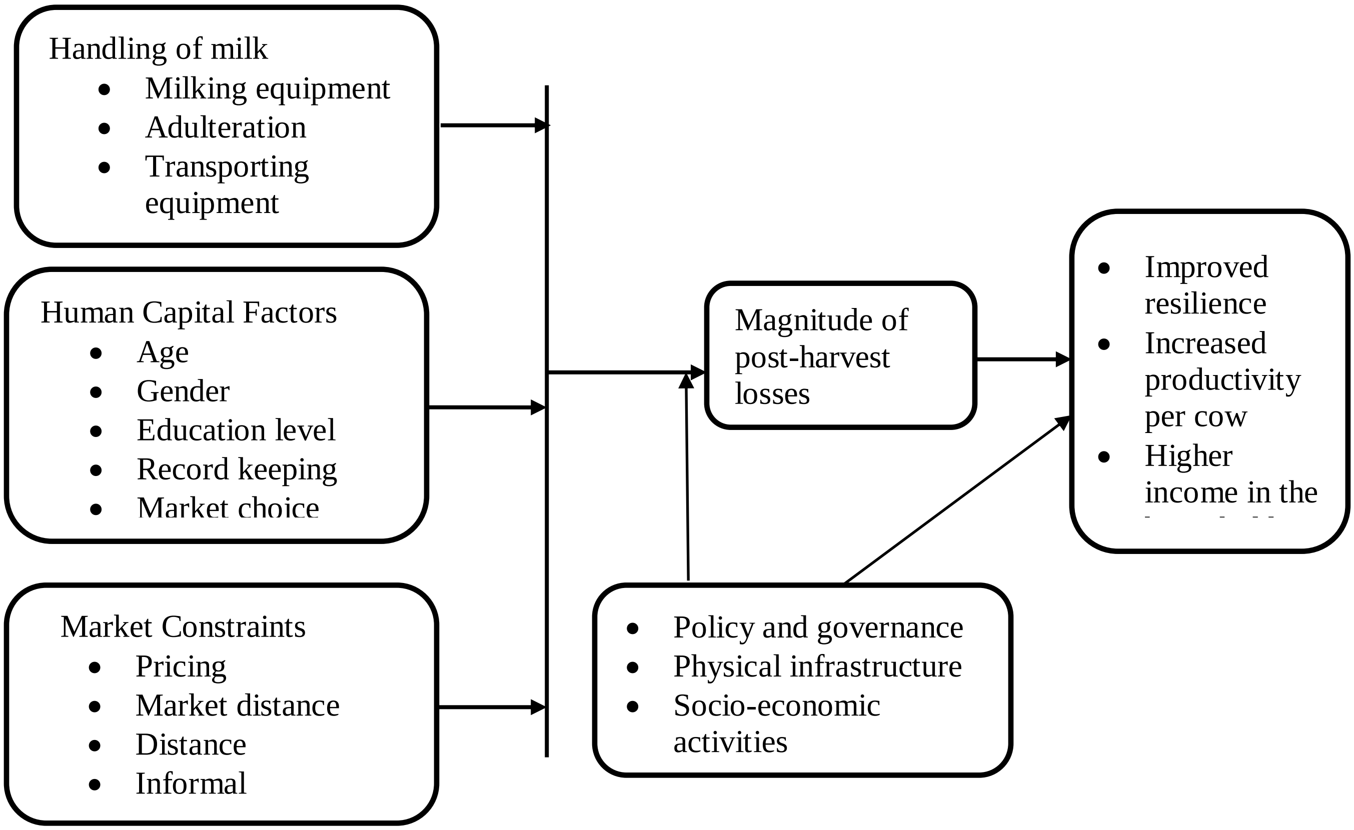

Figure 1: Conceptual framework of the study illustrating independent, dependent and intervening variables

Source: Author (2021)

The conceptual framework highlights the independent, intervening and dependent variables of the study. Under the institutional environment, it encompasses policy and governance, physical infrastructure, and social-economic activities. At the social economic level, the study is shaped by the social processes of dairy farming in the area. Majorly at the farm level where the households' representatives organize themselves into groups at the milk collection points or choose the cooperatives of their preference. Policy and governance are at the cooperative level where the farmers adhere to the set rules and guidelines of the market either through pricing, hygienic techniques, or practices. The physical infrastructural looked upon in the study was the location of the cooperatives, the availability of milk coolers and their capacity, and the number of farmers in the cooperatives among others.

The independent variables in the study were at the farm, cooperative, and transporter levels. The farm level is classified into three categories: Milk handling technique, human capital factors, and market constraints in the dairy post-harvest losses while the cooperative level is classified into milk handling, human capital factors, and operational aspects. The categories were indigenous variables and below them are the measurable variables. Milk handling techniques: Milking equipment, milk transportation equipment, adulteration, hygiene, and sanitation while for transporters level: Milk transportation equipment, hygiene, and sanitation, mode of transport, and testing on collection.

Human capital was common at all levels: age, gender, education level, record keeping, years of experience in dairy farming, and market choice. Market constraints along the formal marketing channel were determined by the market milk pricing, the distance from a cooperative or a market center, competition from the informal sector, the location of the farmer at the farm level, and the customer base for transporters. The transporters had an additional variable of the operational aspects that included: transport mode either by equipped vehicles, donkeys, or boda-bodas, number of routes covered, number of farmers covered, distance covered per route, mode of transport, and road types. The dependent variable is the magnitude of post-harvest losses which is determined at different stages of the marketing channel. At the farm level, the household heads or representatives who are members of dairy cooperatives were considered. The transporters or aggregators were considered for each route that cooperatives collect milk from the farmers. The points were referred to as nodes in the study where GPS has been taken for each point.

The outcome of the study was considered to be: resilience of the dairy farmers from the post-harvest losses during the surplus seasons and coping with the dry seasons, improvement of productivity per the milking cow if the magnitude of loss is reduced, and the increase in income of the farmers. However, the outcomes and intervening variables were not measured because they were beyond the scope of the study. Increased resilience and improved productivity are outcomes while the income is an output, after the magnitude of post-harvest loss is reduced then it improves them.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area

The study was carried out in Nyeri County, Kieni East sub-county as illustrated in the map shown in Figure 2. It has four wards namely: Gakawa, Narumoru/Kiamathaga, Thegu, and Kabaru. The sub-county was purposively selected because it has 32% (10) of the county cooperatives which is the highest number of milk cooperatives in the county. It also houses the KCSAP project which is focusing on marketing channels along the dairy value chain. Additionally, the wards selected have different ecological zones hence the variation provides an overview of the difference in dairy practices and milk marketing.

In the wards, different cooperatives were selected where those selected in Thegu ward included Gathuna, Lusoi, and Gaturiri dairy cooperatives while Gakawa cooperative was picked in Gakawa ward. Those picked from Naromoru/Kiamathaga were Nairutia, Ngukurani, and Mathaita cooperatives while Waraza, Island dairies, and Destiny Dairies were chosen in Kabaru ward. The cooperatives were selected because of the high number of participating farmers and the availability of functional coolers. The sub-county also has two major milk processors, the New KCC and Brookside which has a chilling plant. This boasts the functionality of the cooperative's milk marketing as a value-addition process.

Kieni East sub-county covers an area 1990.3 (KM2) square kilometer with a total population of 110,376 people from the recently carried out 2019 population census (Kenya National Bureau of Statistics [KNBS], 2019). It wards lies between Latitude: 0° 09' 60.00" and Longitude: 37° 00' 60.00" E. The sub-county is part of the larger Kieni constituency which is the largest representative area in Nyeri County, occupying 52% of the total land mass. Kieni East sub-county is located on the leeward side of Mt. Kenya, thus making some parts of it dry as it features semi-arid areas. However, despite being a semi-arid area, it is without a doubt one of the food baskets for Nyeri County as it has good soils and a favorable topography for sustainable dairy farming.

Additionally, the sub-county has the Chaka Market being upgraded into an industrial hub to serve not only the county but the entire Mt Kenya region. The market is expected to have an open-air market for food traders, clothes traders, matatu and boda-boda terminus, banking halls, a Sacco, cold rooms, an eaterie, and a wellness center among others. The project will give value and higher income to farmers which will in turn transform their lives. Road infrastructure in the sub-county is quite developed, with the county government upgrading most of the feeder roads. These will help in reducing spillages and milk spoilages along the transportation level reducing the post-harvest losses

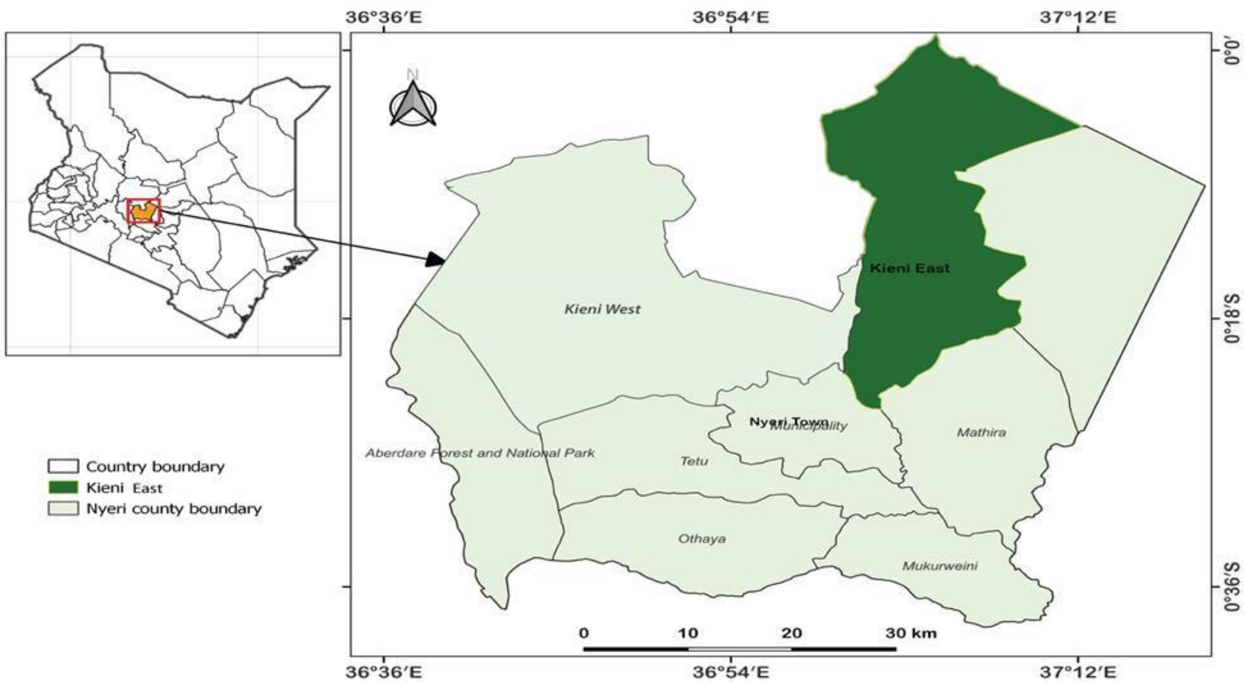

Figure 2: Map showing the study area (Kieni East Sub-County, Nyeri county)

Source: Republic of Kenya (2013)

3.2 Research Design

The study employed both qualitative and quantitative research design. Quantifying the magnitude of post-harvest losses as well as explores their effect in the estimated magnitude of milk loss in each step of the channel. Qualitative data is information that cannot be counted, measured, or easily expressed using numbers. It caters to the factors that influence the magnitude of post-harvest losses. Quantitative data is data in the form of counts or numbers where each data set has a unique numerical value. This data was used to generate the magnitude of losses in this study.

3.3 Sampling procedure

The target population of the study was the households practicing dairy farming under cooperatives, transporters or aggregators at milk collection points, and cooperatives in the Kieni East sub-county in Nyeri County. The study used a multistage sampling technique for the sample selection. The selection of the respondents of the study involved use of purposive and simple random sampling techniques. Purposive sampling method is a non-probability sampling technique that is used when there are a limited number of primary data that can contribute to the objectives of the study (Mugenda and Mugenda, 2003). Simple random sampling is a type of probability sampling used to randomly select a subset of participants from a population. The first stage of the sampling procedure involved selection of Kieni East sub-county, which was purposively selected. The second stage involved the purposive selection of cooperatives and the transporters from each route that the cooperative covered in the milk collection. The third stage of the sampling procedure involved simple random sampling of households practicing dairy farming under the cooperatives.

3.3.1 Sample Size Determination

The sample size for the study was determined using the Cochran (1963) formula. This formula was employed because the population size for the study was not known by the researcher. Where n is the sample size; $Z\alpha/2$ is the critical Z-value equal to 1.96; σ is the population standard; e is the expected margin of error, and α is the confidence level.

$$n = \frac{Z^2pq}{\sigma^2}$$

The desired confidence level for the study was 95% and a 5% level of precision. This was only employed for the farm level because the dairy farmers in the sub-county were not known, so the study assumed a variance of 0.5. This level of maximum variability would produce a more conservative sample size than the mean would calculate (Glen, 2019). The study assumed a 12.5% error term due to the Covid-19 pandemic that had occurred at the time when this study was conducted and data cleaning purposes.

Final n = (12.5/100) *384=19.2 = 48 respondents

384+48=432

Therefore, from the formula, the desired number of respondents for the study was 432 dairy farmer households. The sampled respondents were 329 still active members of the cooperative (cooperatives members) and 103 who were members, but dropped out to sell to other markets (non-cooperative members). The households were randomly selected from the cooperative member lists.

The purposively selected cooperatives for the study were 10; however, it was only possible to interview 8 because of the underlying management issues. The successful interviews were from the Thegu ward which included Gathuna, Lusoi, and Gaturiri dairy cooperatives. In the Gakawa ward, it was Gakawa cooperative while Naromoru/Kiamathaga ward had Mathaita and Ngukurani cooperatives. Finally, Kabaru ward covered Waraza and Island dairies. The transporters were representatives from routes covered by the cooperatives and they included Gathuna (2 routes), Lusoi (3 routes), Gaturiri (5 routes), Gakawa (1 route), Mathaita (4 routes), Gukurani (4 routes), Waraza (12 routes), and Island dairies (8 routes).

3.3.2 Data Sources and Collection

The study used primary data collected in August and September 2021 by use of a semi-structured questionnaire and an interview schedule. The questionnaires were designed for each channel step to suit the objective of the study. The questionnaires were coded using the ODK toolkit and data collection was done using smartphones. The data collected through questionnaires included: household and demographic data, milk handling and management practices, human capital factors, operational aspects of marketing and farm milk network, and the losses incurred. The data was collected by trained enumerators. Data collected from the farm level was from the household head or representative that takes care of the farm. At the transporters, the level was for the transport representative while at the cooperative it was the chairperson.

3.4 Empirical Data Analysis

3.4.1 Assessment of Magnitude of Post-harvest Losses

The first objective of the study on the assessment of magnitude of post-harvest along the dairy marketing channel was done using non-descriptive methods. Quantities of milk lost at the different post-harvest marketing channel stages were considered, the summation of those diverse quantities lost was calculated to give the total magnitude. The same method on estimation of magnitude of post-harvest losses was used by (Muriuki, 2003 and Lore et al., 2005b).

Different stages of the marketing channel considered were: Farm, transporters/aggregators, and cooperatives level. At each stage, absolute and relative losses were estimated in liters and percentages respectively as shown in Table 1. Absolute loss is the total loss of milk from all the respondents interviewed which is very much independent of the figures given by the respondent. Relative loss is the proportion of individual respondent loss to absolute loss. The relative loss is highly dependent on the absolute loss.

The equation explaining this method of calculation is given (Equation 1):

$Totalpostharvestloss = \sum PHLateachstageofthemilkformal$marketing $channel$

$$TotalPHL = \Sigma S_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation (1)}$$

*i – stands for critical stages from farm level to the process or transporter

S_i - stands for losses in each critical stage of the milk value chain

Table 1: Table on the calculation of magnitude of post-harvest losses

Stages	**Absolute loss**	**Relative loss**
Farm-level	L_F	$l^*_F = (L_F/T_F) *100)$
Collection points/Aggregators	L_R	$l^*_R = (L_R/TR) *100)$
Cooperatives	L_C	$l^*_C = (L_C/T_C) *100$

L_F= farm level Milk PHL; L_R= aggregator level Milk PHL; L_C= cooperative level Milk PHL

3.4.2 Evaluation of Factors Influencing Magnitude of Milk Post-harvest Losses

The second objective of the study was to evaluate factors influencing the magnitude of milk post-harvest losses. The analysis of this objective was undertaken using a linear regression equation utilizing Ordinary Least Square (OLS) model at farm and transporter steps. At the cooperative step the sample was small (<30) for the regression analysis. Linear regression analysis is used to predict the value of a variable based on the value of another variable. In this case, the value of the postharvest loss is based on other variables such as handling techniques, human capital factors, operational aspects, and market constraints. The OLS method was preferred for the study because the dependent variable was quantitative continuous, data was normally distributed, met the linearity assumption, and was not affected by heteroscedasticity issue.

Data collected from the field was cleaned, and thereafter statistical tests, like heteroscedasticity test, multicollinearity check, and data fitting test were carried out to ensure the quality and the correctness of the data to fit a linear regression model. The models were fitted to the data on both the predictor and outcome variables to evaluate factors influencing magnitude of milk post-harvest losses. Data analysis was conducted using STATA to compute statistical tests and descriptive statistics for the data because of its ease of manipulation. R software was used for modeling given its ability to provide details on whether variables are significant or not. The variables were derived from major independent variables that were hypothesized to influence the magnitude of the post-harvest milk losses along the stages of the marketing chain. As illustrated in Equations 2 and 3:

$$Postharvestloss \text{ at farm level} = \beta_0 + \beta_1 Handling + \beta_2 \text{ Human Capital Factor} + \beta_3 \; Market\text{Con}straints + \varepsilon \qquad \text{(Equation 2)}$$

$$Postharvestloss \text{ at transporter level} = \beta_0 + \beta_1 Handling + \beta_2 \text{ Human Capital Factor} + \beta_3 Market\text{Con}straints + \beta_3 \text{ Operational aspects} + \varepsilon \qquad \text{(Equation 3)}$$

Where:

At farm level

Handling - milking equipment, transport equipment, hygiene and sanitation, adulteration

Market Constraints - market pricing, farmer location, distance to cooperative, informal Competition

Human Capital Factors - age, gender, education level, record keeping, Marital status

At transporter level

Handling -Transporting equipment, Hygiene, and sanitation, Testing on collection

Operational Aspects - number of farmers, number of routes, distance covered per route, road types, distance from farmer to farmer

Human Capital Factors - age, gender, education level, record keeping, marital status

Market Constraints - Market Pricing, informal competition, customer base

$\beta_0 = constant term$

$\beta_{1 \ldots} \beta_4 = Coefficients$

$\varepsilon_i = Error\ term$

3.4.3 Explanatory variables and their expected signs

The description of the variables included in this model is indicated in Table 2. Here the variable codes, their meaning, and expected signs on both the farmer and transporters' levels are given.

Table 2: Summary of explanatory variables and their expected signs

Variable code	Description	Expected sign Farm level	Expected sign Transporters
Handling			
MILKING EQUIPMENT	Milking equipment used 1 when stainless equipment was used, 0 non-stainless was used	+	
HYGIENE AND SANITATION	1 for those who comply with hygienic measures, 0 for those who do not comply	+/-	+/-
ADULTERATION	1 for those not engaged in adulteration, 0 for those engaged in adulteration	+	

TRSPT EQP	Milk transport equipment used 1 when the right equipment was used, 0 when non-stainless was used	+/-	+/-
TEST	1 If milk test quality is done on the collection,0 if no test is done		+/-
Human Capital Factors			
AGE	Age of HH in years	+/-	+/-
EDU	Number of years in Education	+	+
EXP	Number of years in working in the value chain	+/-	+/-
RCD	1 for those who keep records, 0 for those who do not keep records	+/-	+/-
MARITAL	1 if married, 0 refer to otherwise	-	-
EXTN	1for those received extension services,0 for those not received any extension service		
Market constraints			
DISTANCE	Distance to the nearest cooperative in Km	+/-	+/-
MILK QTY	The volume of milk in liters	+	+
COMP	Competition from the informal marketing channel 1 if brokers are available, 0 if no brokers	+/-	+/-

PRICE	Market prices 1 if the market price is higher than for the cooperative, 0 if the prices are equal		+
LCTN	Location of the collection center in km		+
SRG FAC	1 for milk proper storage facility,0 for poor milk storage facility.	+	+
VOL.SOLD	Volume sold in Litres	+/-	+/-
QTY.REJ	Quantity of milk rejected in litres	+/-	+
Operational aspects			
NO. FARMERS	Number of farmers	+/-	
NO. ROUTES	Number of routes	+/-	
DST	distance covered per route	+/-	
ROAD	Type of road used 1=All weather road,0=other types of roads	+	
MODE	Type of transport mode used 1=equipped vehicle with coolers,0= not equipped	+	

Source: (Author: 2022)

The expected signs shown above on the relationship between the identified predictor variables and milk post-harvest losses are based on the underlying theory and empirical evidence from previous studies. For instance, the quality of milking equipment is an important factor that can affect post-harvest milk loss. Poor-quality equipment can lead to improper milking practices, which can increase milk loss. A lot of qualitative milk losses are a result of the storage of milk in unclean and unsuitable containers, which are susceptible to contamination by microbes (Debela, 2015). This is rampant in less developed countries such as Kenya where clean milk production practices are not strictly adhered to (Amentie et al., 2016).

Ndungu et al. (2019) concluded that poor handling was a potential source of post-harvest losses. Handling of milk comprised of containers and equipment for milking, keeping, and transporting milk. Poorly cleaned containers are a source of biological contamination where microbes can be transmitted. Containers cleaned with soap or detergent need to be thoroughly rinsed with water since detergents and soaps are major adulterants in milk (Silva et al., 2015) that could result in milk being rejected at the processors.

Adulteration of milk is usually done for the financial gain of the farmer, or due to improper handling of milk or its transportation equipment (Lateef et al., 2013). Milk with detected adulterants is rejected at processors, thereby resulting in post-harvest losses. Adulteration of milk is mostly done by farmers supplying milk through informal channels (Shull et al., 2015). In the formal channel, it is easily detected due to the tools used to check. The current study hypothesized that adulteration would increase the post-harvest loss at farm level.

The age of the dairy farmer can positively influence the magnitude of the post-harvest losses and majorly on the expertise of the exercise of milking. This is because age can represent experience and the availability of resources. Ndungu et al. (2019) postulated that the age of a farmer has a significant effect on the magnitude of losses in both the formal and informal channels Shee et al. (2019) however contrasts that the higher the age, the more likelihood of postharvest losses. The age of farmers can be an important factor in post-harvest milk loss, as younger or inexperienced farmers may be less knowledgeable about proper milking, storage, and transportation practices. Therefore, the expected sign for the coefficient of age would depend on the context. In some cases, younger farmers may have higher levels of education and training, which can lead to lower post-harvest milk loss. In other cases, older farmers may have more experience and knowledge, which can lead to lower post-harvest milk loss.

The experience of all personnel at the milk marketing channel is crucial and can positively influence the magnitude of loss incurred. Skilled employees are more likely to have a good understanding of mitigating losses at the centers compared to unskilled personnel. In addition, the dairy equipment used for the collection of milk should be cleaned and rinsed after use to minimize the disinfection of milk (Durham, 2007). Kyei & Matsui (2019) observed that with experience, farmers become better at the management of post-harvest losses. Therefore, experience can have a positive or a negative influence on the postharvest loss at either the farm or transporters marketing stage.

Record keeping is essential in keeping track of farm inputs and outputs such as the amount of milk produced, sold, consumed, etc. Processors keep records to monitor milk purchased, processed, and sold (Ndungu et al., 2019). Record keeping is therefore a key task in detecting post-harvest losses of milk. By keeping records, farmers can identify stages with milk losses and there seal such loopholes and minimize PHL (Amentie et al., 2016). According to Zargar (2015), lack of knowledge and expertise is the greatest cause of postharvest losses.

Persons without education may not know to mitigate the causes of milk losses. In a study by FAO et al. (2018) it was shown that as people tended to increase their level of education, the number of postharvest losses tended to reduce. Regression analysis by Mebratie et al. (2015) indicated that education was a major contributor to post-harvest losses. The current study hypothesized that the more the number of years of education the less the post-harvest loss which was tested to be true.

Extension services enhance the knowledge, skill, and capacity of farmers in dairy farming thereby reducing postharvest losses. This in turn enhances their productivity and food security (Syngenta Foundation, 2016).

These services can also provide farmers with information and access to credit services which could help a farmer increase their production (Baluka, 2019).

Azeze & Haji (2016) stated that milk price is a crucial market constraint that could impact PHL. Masembe (2003) attributed the main causes of milk losses to overproduction which could not find a market, thereby resulting in a surplus that easily goes to waste. Excess milk in the market results in a drop in prices, which discourages farmers from selling, consequently causing forced consumption.

The farther the distance from the farm to the milk collection point/cooperative, the more the likelihood of losing milk along the way through spillages and milk spoilage. Mathai (2019) adds that a considerable amount of milk losses occurs during transport as a result of bad roads, long distances, and inappropriate transporting equipment. Poor transport could delay milk from reaching its collection point, resulting in spoilage. Bad milk will ultimately be rejected by the processor, resulting in a farmer/transporter losing money and having to cope with the loss of milk rejected (FAO, 2018). Poor infrastructure (bad roads, damaged bridges) is a major challenge in the transportation of milk (Lore et al.,2005a). This when coupled with inappropriate transport machinery such as coolers or vehicles fitted with refrigeration capacity (Kiaya, 2014) results in an increased likelihood of post-harvest losses. As the distance of travel increases, post-harvest milk loss is expected to increase and vice versa. The reason for this expected relationship is that milk is a perishable product, and any delay in transportation or storage can result in spoilage and contamination, leading to significant post-harvest losses. In this regard, shorter travel distances and efficient transportation systems can help to reduce post-harvest milk loss by ensuring that milk is transported quickly and stored at the right temperature respectively.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Demographic Characteristics

The demographic data of the respondents collected in this study included age, level of education, gender, farming system, designation of the respondent and marital status. Based on the results indicated in Table 3 with regard to dairy farmers who were cooperatives and non-cooperatives members, the average age of dairy farmers belonging to these two categories was 54 years. This finding is a sharp pointer to the fact that there was no variation is the age of the dairy farmers of those holding memberships in cooperatives and those who were not members. Bayan (2020) reported no differences in age of farmers belonging to dairy cooperatives and non-members. Similarly, there was a difference of 6 years between the maximum average age of cooperative and non-members (Table 3). The minimum age of the 2 groups of farmers was similar. The result is in agreement with the findings of Nyokabi *et al*. (2021b) who found that the majority of dairy farmers are between the ages of 30 to 60 years. Maina et al. (2018) in a study on milk production among small holder farmers reported the mean age of dairy farmers to be 57 years.

Farmers who were members of the dairy cooperatives were more experienced (20 years) in dairy farming compared to their counterparts who had 19 years of experience. The average years of schooling for farmers in dairy cooperatives was 10 years and for non-cooperative was 9 years. The more years of experience and the relatively higher level of schooling exhibited by both farmers of dairy cooperatives and non-cooperatives suggests that they were knowledgeable about dairy farming and adopted requisite practices when undertaking various activities related to dairy farming (Maina et al., 2018)

Table 3: Demographic characteristics of the respondents at the (farm)household level

	Non-coop members (n=103)				Cooperative members (n=329)				Pooled (n=432)			
Continuous variable												
	Mean	Std.Dev	Min	Max	Mean	Std.Dev	Min	Max	Mean	Std.Dev	Min	Max
AGE	54	12.97	23	86	54	13.49	23	92	54	13.36	23	92
EXP	19	13.37	1	58	20	13.71	1	75	20	13.62	1	75
EDU	9	3.25	0	18	10	3.23	0	16	10	3.23	0	8
Categorical variables												
Gender	**Freq**	**%**			**Freq**	**%**			**Freq**	**%**		
Male	45	43.69			166	50.46			211	48.84		
Access extension services												
Yes	44	42.72			186	56.53			230	53.24		
Access to information												
Yes	52	50.49			230	69.1			282	65.28		

The result of the study shows limited participation of females in dairy farming and this is possibly because male-headed households may have greater access to resources such as land, credit, and education, which could increase their likelihood of joining and participating in cooperative societies. Moreover, female-headed households may face additional challenges and responsibilities, such as managing household duties, which may make it more difficult for them to engage in dairy farming activities or participate in cooperative societies. The result was in agreement with the findings of Bullock and Crane (2021) and Munyori (2019) that male-headed households are more in the dairy farming compared to the female headed households.

Most of the farmers in dairy cooperatives (56.53 %) have access to extension services compared to those who are not members of dairy cooperatives (42.72%). Greater access to extension services by farmers in dairy cooperatives is perhaps on account that cooperatives help them access a wide range of services, more especially the agricultural extension services among the smallholders in the form of building the capacities of the farmers for bargaining and marketing their produce, including offering them credit, physical inputs, and dissemination of crucial farming (Nicholas & Angubua, 2019). Lack of access to information by farmers is attributed to the inadequate influence of relevant governing bodies. This, therefore, means that farmers have limited information on better milk prices, and this could lead to exploitation by milk buyers (Makokha et al., 2020).

Results of the study further indicate that 69.1% of the farmers in dairy cooperatives had information on dairy production while a half (50.49 %) of the farmers of non-cooperatives had access to this information. This implies that dairy cooperatives provide important information and knowledge on dairy farming to their members. This finding of the study is consistent with past scientific studies, such as Bayan (2020), which have shown that dairy farmers who belong to dairy cooperatives have better access to extension services compared to those who were non-cooperative members. The reason behind the findings was that dairy cooperatives deliver extension services to their members for enhancing and improving milk quality delivered to them.

With regard to the farming distribution, the results of this research work indicated that majority (n=396, 91.7%) of the respondents were smallholder farmers. On the other hand, few (n=36, 8.3%) farmers participated in large scale farming (Figure 3). This result is in tandem with a previous report by FAO (2020) whose data showed that the majority of dairy farmers in Kenya were smallholder farmers. Banda et al. (2021) remark that even though smallholder farmers have fewer dairy cows, their contribution to livelihoods is more than just the income as they have more diversified income sources thus making them more resilient to food insecurity.

There is usually a difference between small scale farmers and large-scale farmers with respect to dairy farming centers on management practices, production efficiency, and market access. Moreover, small scale farmers may rely on traditional farming practices and have limited access to inputs such as veterinary services, feed, and breeding technologies. Large scale farmers, on the other hand, may have better access to these resources and are more likely to adopt modern technologies and management practices to improve their production efficiency (Montgomery et al., 2020). Small scale farmers may face more challenges in the dairy sector since they may not have access to proper milk storage facilities, and milk may be stored in containers that are not clean or hygienic, leading to spoilage and contamination.

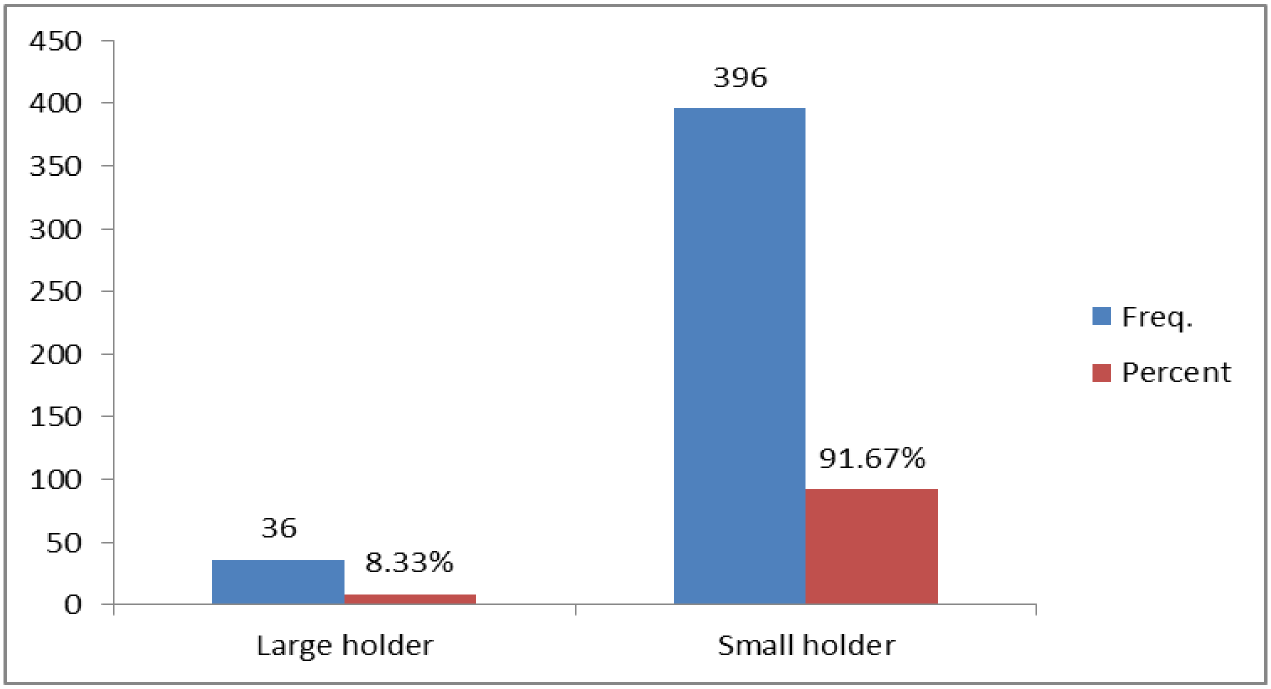

Figure 3: Farming patterns and distribution of the respondents in the study

Source: Survey (2022)

At transporters level

Transportation of milk plays an important role in the dairy sector in that it is at the center of linking producers or farmers to markets. Transporters often utilize many routes as they seek to collect milk and deliver it to relevant market outlets in a shorter time since it is a highly perishable produce. In effect, transporters who took part in this study were asked to provide information relating to the distance they covered in kilometers to collect milk from farmers and subsequently deliver it to the final delivery points. From the findings, transporters covered an average of 26.6 kilometers to reach dairy farmers milk collection points and deliver it to their respective market outlets. The average maximum distance covered by the milk transporters was 71 kilometers. A study by Ndungu et al. (2021) reported a lower average distance covered by milk transporters to be an average of 13 kilometers on daily basis. Within each route, the transporters served nodes ranging from none to a maximum of 58 nodes as shown in Table 4 and mapped in Figure 4.

According to the survey, milk transportation was majorly undertaken by males. The result of the study mirrors that of Galie et al. (2022) who found dairy transport business to be mainly conducted by men. The findings of the study further showed that the highest number of milk transporters was from Waraza (12) with the lowest being Gathuna with one milk transporter. The designation of these transporters covered drivers, intermediaries, riders (tuk-tuk, cart, motorbike), and milk traders. Raw milk from farmers is generally transported in bulk tankers and cans where drivers, intermediaries, and riders, among others, are the next link in the chain of milk supply (Munyori, 2019).

Table 4: Route distance covered by the transporters

	Mean	**Maximum**
Route distance in km	26.6	71
Number of nodes in the route	10.5	58

Source: survey (2021)

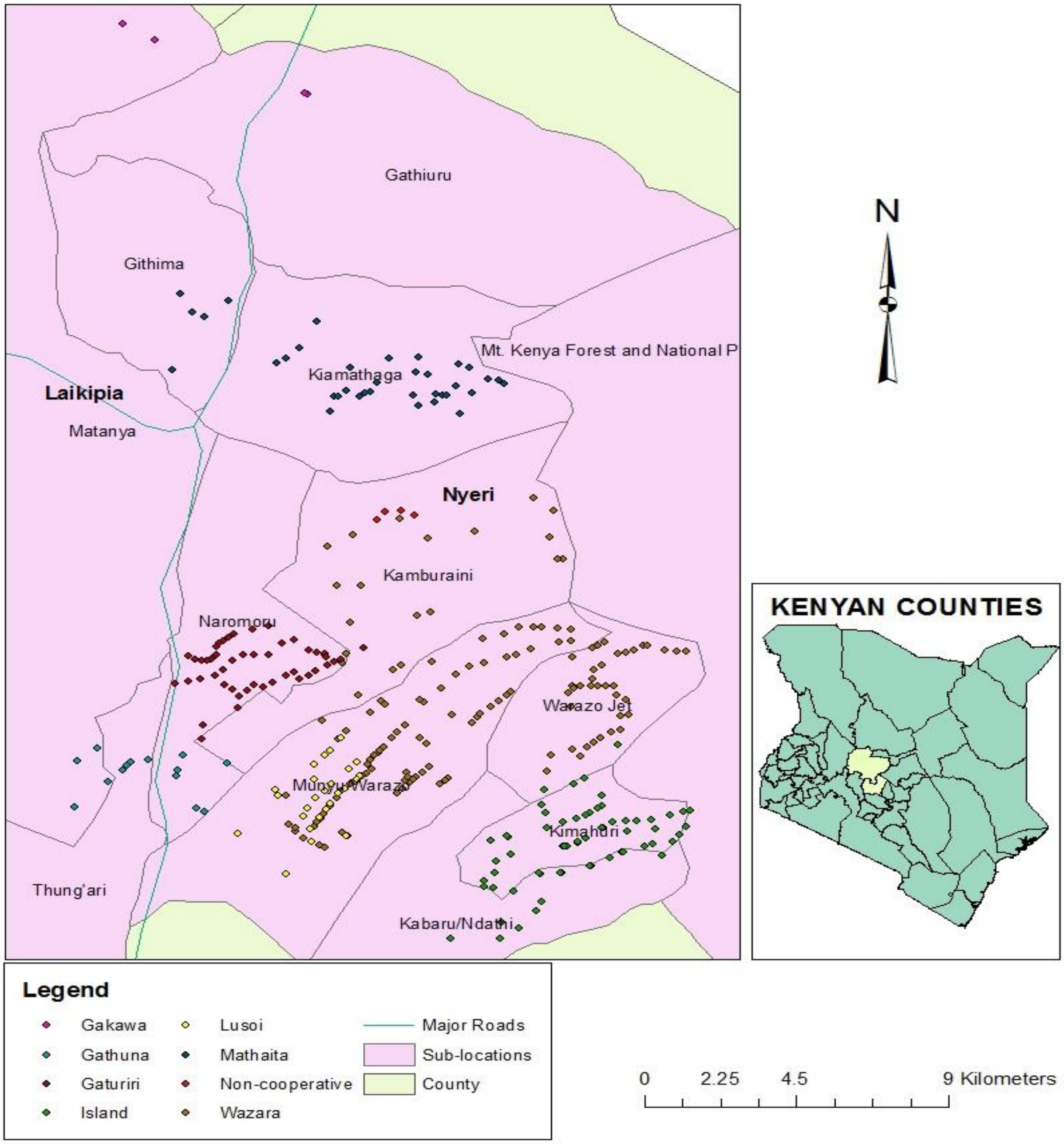

Figure 4: A map showing the nodes with the GPS coordinates covered by the transporters in each route per cooperative

Source: Author (2021) and Republic of Kenya (2013)

At cooperative level

To determine the actual number of farmers practicing dairy farming under cooperatives to participate in this study, proportional sampling was utilized where a predetermined number farmers was established based on the size of cooperatives in each of the wards. This, therefore, suggests that the ward with a highest number of cooperatives had a corresponding higher sample size. In effect, Thegu ward had the highest number of cooperative members sampled (n=198, 45.83%) based on its high number of dairy cooperatives compared to other wards (Table 5). The other wards were Kabaru (n=182, 42.13%), Narumoru/ Kiamathaga (n=22, 5.09%), Gakawa (, n=30, 6.94%). Table 5 summarizes the respondent distribution in the selected wards of the study.

Table 5: Respondents as distributed per ward

Ward	Freq.	Percent
Gakawa	30	6.94
Kabaru	182	42.13
Narumoru/Kiamatha	22	5.09
Thegu	198	45.83
Total	**432**	**100.00**

The results of the study in respect to milk collection showed that majority (55%) of the farmers delivered milk to milk collection points whereas 23% of them delivered their milk directly to dairy cooperatives. Few (1.4%) farmers delivered milk directly to milk processors and other market outlets. Brokers in the milk value chain were found to account for about 20% of the collection of milk from dairy farmers. The result revealed that majority of the farmers in Nyeri County relied on the milk collection points for delivering their milk to markets. The findings were in agreement with the findings of Rambim and Awuor

(2020) who found the majority of dairy farmers deliver their milk-to-milk collection centers. Figure 5 shows the milk collection distribution of the respondents.

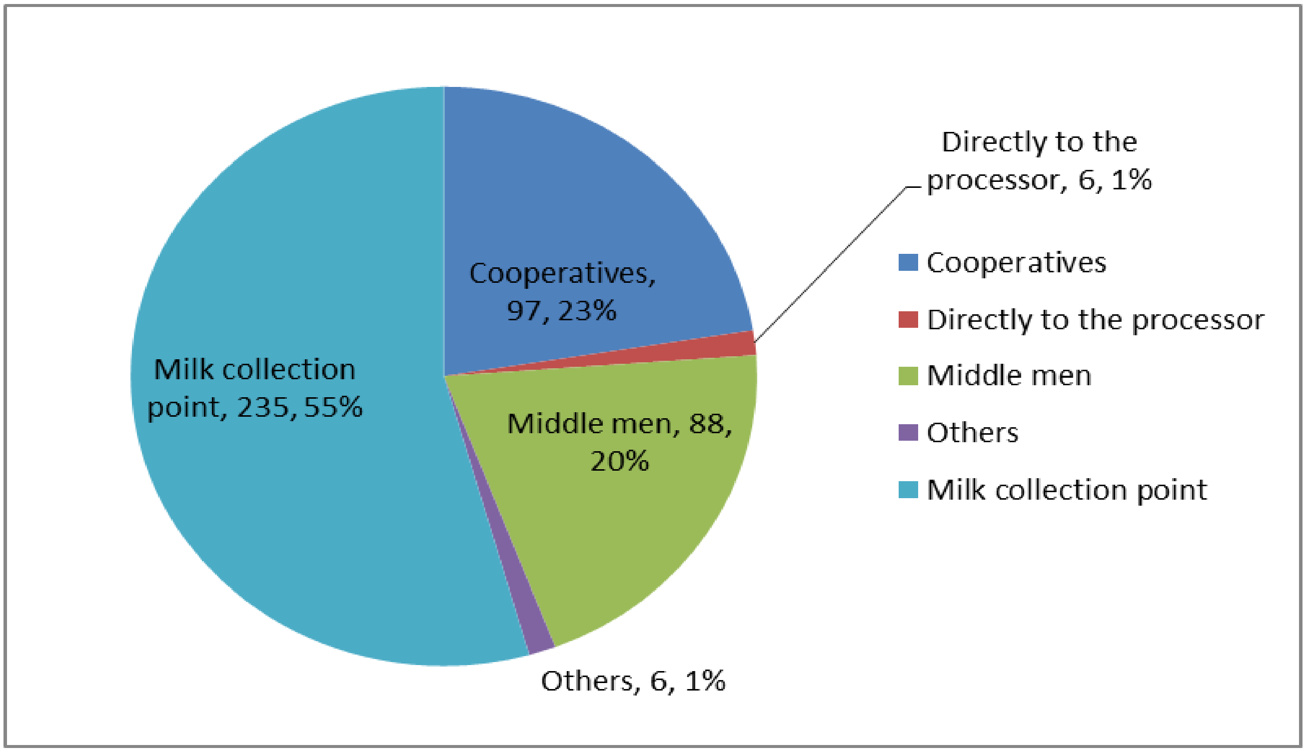

Figure 5: A pie chart showing milk collection distribution

Source: survey (2021)

4.2 Estimation of Magnitude of Post-harvest Losses

4.2.1 Farm level

The results on the magnitude of losses presented in Table 6 were pooled (accumulatively) from the active cooperative members and the non-cooperative members. Results showed that at the farm level, the average daily loss of milk produced by the farmers was 28 litres with a minimum of 3 litres and a maximum of 467 litres. The milk loss was distributed in terms of forced consumption, spoilage, rejection, and spillage. The average milk loss among farmers due to forced consumption was 7 litres per a day, an amount of loss similar to spoilage. The highest average amount of milk loss occurred through spillage (11 litres) while an average of 4 litres of milk loss was because of rejection by vendors. The average daily loss of milk through forced consumption, spoilage, rejection, and spillage was 467 litres. The maximum quantity of milk loss that resulted from forced consumption (101 litres), spoilage (152 litres), rejection (329 litres), and spillage (200 litres) is tabulated in Table 6 below. The finding of this study is in agreement with other studies (for example, Arage, 2021), which indicated that the highest magnitude of milk loss was attributed to forced consumption, spillage, and spoilage as the main causes at the farm level.

Table 6: Summary of estimated the absolute magnitude of losses at the farm level in liters per day

N=427	Forced consumption(liter)	Spoiled(liter)	Rejected(liter)	Spilt(liter)	Average daily losses(liter)
Mean	7	7	4	11	28
Minimum	0	0	0	1	3
Median	5	5	0	8	22
Maximum	101	152	329	200	467

Source: Survey (2021)

However, the analysis showed that farmers who were active cooperative members had less absolute milk loss compared to non-cooperative members (Table 7). The average daily milk loss by the dairy cooperative members was 2.25 litres, while that of non-cooperative members was 4.75 litres. The higher milk loss among the non-cooperative farmers can be attributed to the unpredictable market conditions unlike the dairy cooperative farmers who in most instances enjoy ready markets. The lower milk spillage among farmers who were members of dairy cooperatives was possibly because they were aware of milk quality requirements and other methods that can potentially reduce loss. Dairy farmers of cooperatives often have access to cooling facilities, thus reducing the milk loss in the value chain (Munyori, 2019).

Table 7: Absolute estimated magnitude of loss difference between active and non-active cooperative members

	Cooperative members	**Non-cooperative members**
Forced consumption(liter)	2	7
Spoiled(liter)	3	10
Rejected(liter)	2	0
Spilt(liter)	2	2
Average daily losses(liter)	2.25	4.75

Source: Survey (2021)

Losses from milk rejected due to hygienic practice, adulteration, and other quality issues was 2 litres for both the cooperative and non-cooperative members. The main reason for this was that most of the brokers or the market representative at the non-cooperative member's channel did not test the milk at the collection points (Munyori, 2019). Relative losses due to spillages accounted for 38% of the losses, spoilage was 24.7%, forced consumption was 23.8% and rejection due to adulteration was 13.5% (Figure 6).

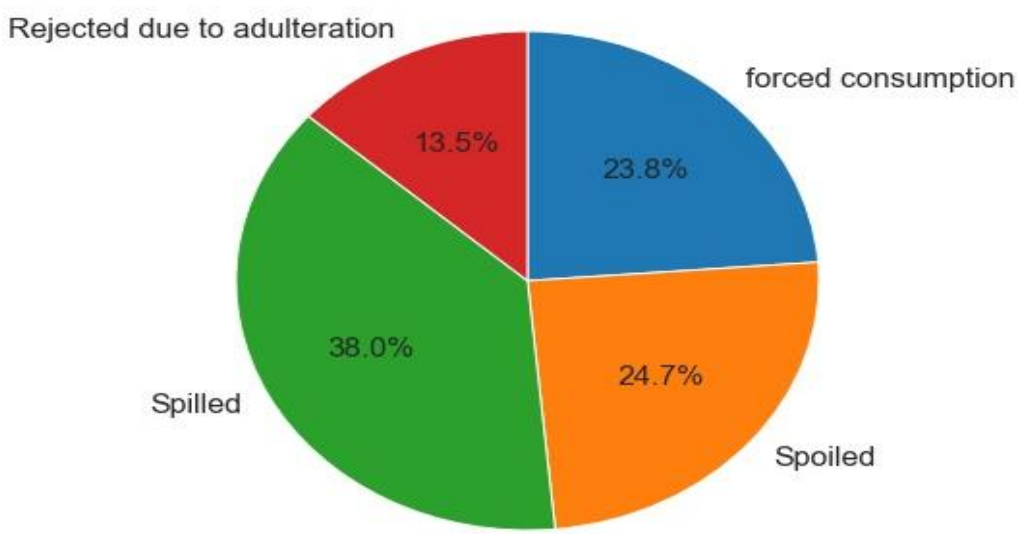

Figure 6: A pie chart to illustrate the relative magnitude of losses at the farm level

Source: Survey (2021)

4.2.2 Cooperative level

The dairy cooperatives included in this study were restricted to those that were both active and registered while the non-cooperatives comprised of other market sources, which households' representatives or the non-active cooperative members preferred. At the cooperatives level, milk loss majorly occurred through spillages (86.8%) rejection because of contamination (13.2%) as shown in Figure 7. There was no milk loss through spoilage at the cooperatives level. This implies that most of the milk losses experienced by farmers were due to spillages and rejection because of contamination. The result of the study established that no milk was estimated to have been spoiled. Overall, this finding of this study appears to mirror that of Zegeye and Teklehaymanot (2016) who found out that spillage accounted for the highest milk post-harvest losses contributed by poor hygiene practices of handling milk. Other reasons attached to milk post-harvest losses at the farm level were contamination, lack of proper technical knowledge, and milk cooling facilities at the farm level.

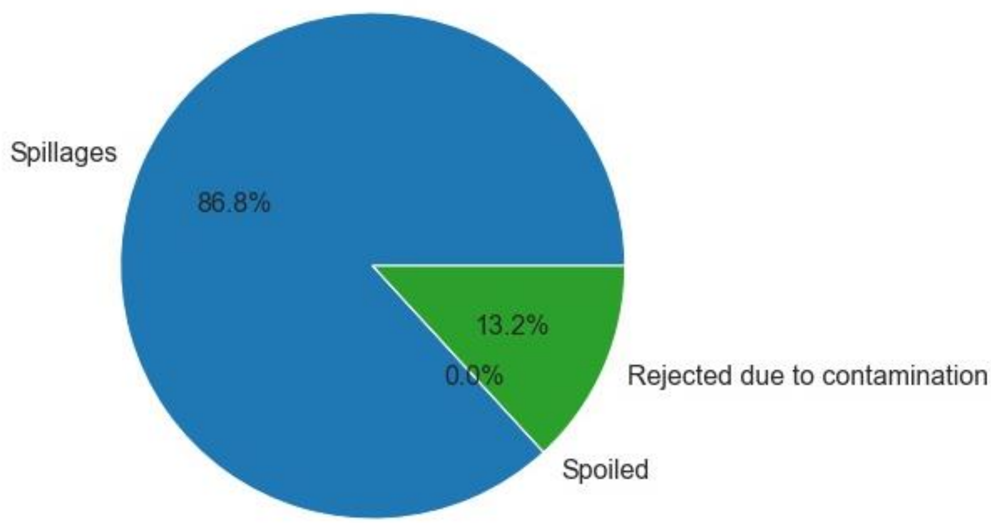

Figure 7: A pie chart on the relative estimated milk loss magnitude at the cooperatives level

Source: Survey (2021)

4.2.3 Transporter level

According to the results in Table 8, the total volume of milk rejected by transporters and buyers was 9 litres and 6 liters respectively. Milk lost on the road while loading, offloading, and picking totaled a volume of 21.7 liters, 21.6 liters, and 4.1 liters respectively. While a majority of transporters did not encounter losses while on transit, there were significant losses as shown with a maximum volume of milk lost during loading and offloading at 9 liters and 5 liters respectively. There were three cases of accidents occurring within the past year. On conversion to daily losses, the lowest average daily losses were at 0 liters while loading and offloading had the highest at 0.4 liters per day. While accidents rarely happened, their occurrence caused significant losses. In fact, the collected data demonstrated that a single incidence led to a loss of approximately 500 litres of milk. Faulty transport vehicles and bad roads were identified as the primary causes of accidents, which is consistent with Munyori's (2019) findings that milk losses are often attributable to transporters and the speed of their means of transportation. Besides, a study by Minten et al. (2021) stated that only 0.25% of milk loss was caused by transporters, a result that is in tandem the finding of this study that showed that the quantity of milk loss due to spillage was small on the highest average of 0.4 liters.

Table 8: Daily estimated absolute losses of milk at the transport level

N=429	Daily total	Daily average	Max
Milk rejected by transporters (liters)	9	0.2	2
Milk rejected by buyers (liters)	6	0.1	2
Milk lost during loading (liters)	21.7	0.4	9
Milk lost during offloading (liters)	21.6	0.4	5
Milk lost during picking (liters)	4.1	0.1	2
Milk lost during accidents (liters)	1.4	0	1.4

Source: Survey (2021)

As outlined in Figure 8, at the transporter level the spillage is from loading (33.9%) and offloading (33.9%) which accounted for the highest loss magnitude, accidents had 14.1% while picking, rejection by buyers, and rejection had 9.4%, 6.4%, and 2.2% respectively. The KDB directs that milk collection vehicles should be open on the sides for free air circulation, but covered on the top to prevent sunlight from heating the milk, which would lead to milk spoilage. On the other hand, if milk is transported in a closed vehicle, it could raise temperatures that could cause spoilage of the milk. For transporters using milk tankers, the tankers should be properly insulated and designed such that the milk only comes into contact with stainless steel (KDB, 2018).

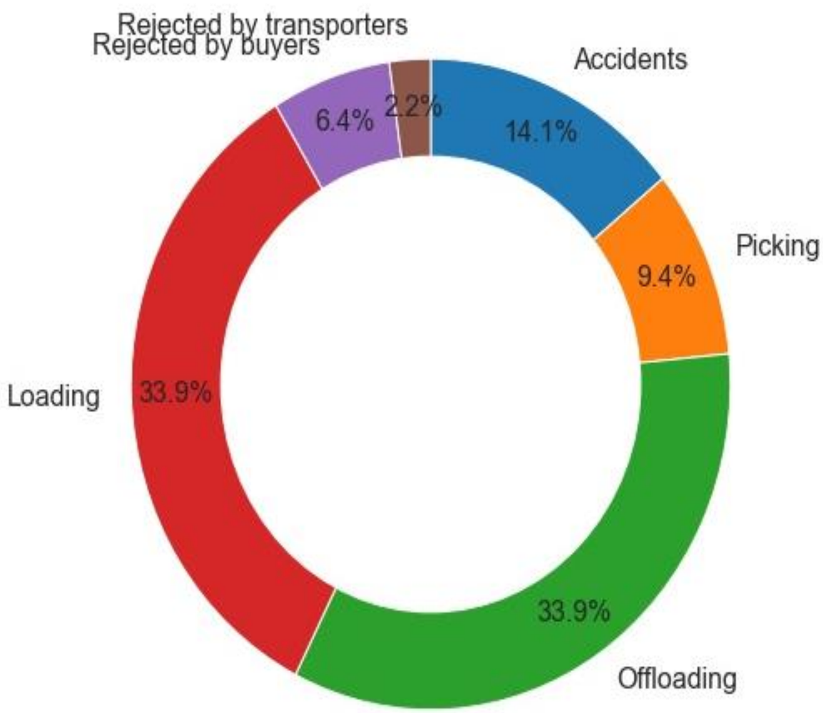

Figure 8: A pie chart on the relative estimated magnitude of milk loss at the transporters level

Source: Survey (2021)

4.3 Modelling of Factors that Influence Post-harvest Losses

4.3.1 Diagnostic Test of Regression Analysis

Multicollinearity was assessed by checking for correlation between the independent variables. The highest correlation between the two variables was 0.6, which was lower than the recommended threshold of 0.7, above which the variables would be rejected (Julie, 2013). There were no major outliers in the data since the data was standardized. Regression analysis at the cooperative level was not conducted since there was insufficient data from the sample size. Regression analysis was conducted by summing up the values of each independent variable and then proceeded to compute the mean. The data was then standardized to put all the values on the same scale. These values were then used to compute the regression analysis.

Prior to running OLS regression, the explanatory variables were tested for the presence of multicollinearity by use of Variance inflating factor (VIF) for continuous variables and Contingency Coefficient (CC) for categorical variables. Variables that correlated were dropped in the model and the model had a VIF of less than 10 showing no serious multicollinearity amongst continuous explanatory variables. The Breush – Pagan test was conducted to determine the presence of heteroscedasticity and the p-value was insignificant showing the absence of heteroscedasticity. Therefore, the explanatory variables were fit for running OLS and multiple regression. Table 9 illustrates the regression analysis results at the farmer level for the factors influencing milk post-harvest losses. Variables that were under investigation to determine if they have an influence on milk post-harvest loss were age, experience, price, the volume of milk sold, distance to the market, access to storage facilities, quantity rejected, and record keeping.

4.3.2 Analysis of Factors Influencing PHL at the Farmer level

Farmer level

The results of the study shown in Table 9 below indicate that volume sold, quantity rejected, and record keeping exhibited positive and statistically significant relationship with milk post-harvest losses by farmers. On other hand, price, distance, and storage facilities revealed a negative and statistically significant relationship with milk post-harvest loss. Despite age and experience depicting a negative relationship with milk post-harvest losses, the linkage was not statistically significant.

Table 9: OLS results of factors influencing milk post-harvest loss at the farmer level

PHL	Coefficients (n=432)	Std. Err.	P-value
AGE	-0.01	0.01	0.413
EDU	0.01	0.03	0.857
EXP	-0.01	0.02	0.667
PRICE	-0.61*	0.32	0.058
VOL.SOLD	0.13**	0.06	0.04
QTY.REJ	0.25***	0.02	0.000
DST	-0.01*	0.00	0.063
SRG FAC	-0.81**	0.37	0.03
RCD	0.25***	0.00	0.000
Cons	11.04	0.96	0.000

*Source: Survey (2021) *** p<0.01, ** p<0.05, * p<0.1*

Price per liter of milk, as one of the predictor variables, was found to negatively influence the quantity of milk loss during post-harvesting at farm level (p-value = 0.058). The positive sign was consistent with the hypothesized sign. The result implies that a unit increase in the price of milk leads to a decrease in milk post-harvest loss by 61 percent. The result of this study is consistent with of Kamilinski et al. (2020) whose findings showed that there was an inverse relationship between the price of milk and milk post-harvest loss. When the price of milk is high, farmers and other actors in the dairy value chain may have a greater incentive to take extra care in handling and preserving the milk, as they stand to gain more from selling it

Volume of milk sold was found to have a positive relationship with the milk post-harvest loss (p= 0.04). Thus, a unit increase in the liters of milk sold increases post-harvest by 13%. This is because as the volume of milk increases, the logistics involved in transporting, storing, and processing the milk become more complex, and there may be more opportunities for losses to occur. In this regard, the larger the volume of milk, the greater the need for efficient and effective logistical processes geared towards minimization of post-harvest losses, thus investment in transport infrastructure, storage facilities, and processing technologies becomes essential.

Quantity of the milk rejected had a positive significant influence on the milk post-harvest loss at the farm level. This shows that, 1 percent increase in the quantity rejected would contribute to 25% milk post-harvest loss at farmer level. The rejected milk is mostly due to milk adulteration. Farmers adding adulterants to milk voluntarily do so to take advantage of poor or lack of suitable detection tests at collection centers, and also for financial gains (Kamthania et al., 2014).

Distance has a negative significant relationship with milk post-harvest loss at the farmer level. This result implies that a unit increase in the distance to the delivery point reduce milk loss by 1 percent. Conversely, Ndgugu et al. (2019) obtained a positive relationship between distance and milk post-harvest loss attributing the influence of distance to weather, roads, and transport mode. In this study however, the improved transport mode for the distant farmers under cooperatives significantly reduces the milk losses.
The storage facilities were also found to negatively contribute to the milk post-harvest losses. The results signify that improving the storage facilities could reduce milk post-harvest losses by 81%. Proper milk storage reduces milk spoilage which may lead to post-harvest losses (Ndungu, 2019).

Record keeping has a positive significant relationship with milk post-harvest loss. The findings indicate that despite the fact that the dairy farmers under cooperatives keep records, they experience more losses than the dairy farmers in non-cooperatives. The reason is that the production records expose the losses that cannot be captured by the farmers in non-cooperative where the practice of record keeping is either non-existent or poor. Ndungu et al. (2019) reports a positive relationship between keeping of the production records and milk post-harvest loss. Some of the major constraints inhibiting farmers from keeping records are lack of incentive, limited time, low education level, lack of understanding of the importance of record-keeping (Yadeta & Fetene, 2020).

4.3.3 Analysis of Factors influencing PHL at Transporter level

Table 10 shows the OLS results for the factors influencing milk post-harvest losses at transporters level. The variables used to predict PLH included age, marital status, educational level, milk quantity rejected, the road type and the distance covered. The variables that exhibited significant relationship with milk post-harvest losses were: distance, road type, and the milk quantity rejected. The pairwise correlation test was strongly significant (P-value <0.001) for all the variables and they were highly affecting the outcome. To correct the problem of multicollinearity, those variables were removed from the model. The robust standard errors were used to run the model to current the problem of heteroscedasticity. Hence, the final model was left with variables, which constituted of age, education level, distance, road type, rejection and marital status.

Table 10: OLS results of factors influencing milk post-harvest loss at transporters level

PHL	Coefficients (n=432)	Std. Err.	P-value
AGE	0.00	0.01	0.576
EDU	0.01	0.02	0.684
DST	-0.28*	0.19	0.098
ROAD	0.43*	0.22	0.059
QTY.REJ	0.45*	0.26	0.088
MARITAL	0.08	0.18	0.66
Cons	0.25	0.69	0.722

*Source: survey (2021) *** p<0.01, ** p<0.05, * p<0.1*

Based on table 10, distance, road type, and rejection (quantity rejected) were significantly affecting post-harvest losses ($p<0.1$). The increasing of the distance to the market by 1 km reduced the post-harvest loss by 25 percent. The result could be explained by proper storage facilities and packaging to the distant markets leading to reduction of milk post-harvest loss through spillage and spoilage. For every liter of milk rejected on the basis of poor quality delivered resulted to an increase in the magnitude of post-harvest loss by 45 percent to the cooperatives. Further, the road types in which milk was transported through had a positive significant influence on the magnitude of milk post-harvest loss. An additional unit of travel distance on the non-weather road by the milk transporters increased the post-harvest losses by 43 percent. According to Muai et al. (2011), milk post-harvest loss in areas like Nyandarua is high during wet seasons due to poor road networks and long distance to the market. Further, Ndungu et al. (2019) reports that if the farmers are far from the milk collection points, the higher chances of losing milk during delivery due to bad weather, poor road networks, transport mode, and the cleanliness of the milk containers.

4.4 Other Important Factors Influencing Milk Post-harvest Losses

4.4.1 Milking Equipment used by Farmers

Figure 9 shows a summary of the milking equipment used by the respondents. These were categorized to be either standard stainless steel or other containers such as plastic containers, cans, and other specified during the interview. The stainless steel was the most preferred in the hygiene measures of the cooperatives. Stainless steel containers are the dominant milking equipment used by farmers. Two hundred and seventy-four (n=274) farmers use stainless steel containers for milking while 158 use plastic containers. The result of the study compares favorably with that of Gathura (2021) whose findings reported that farmers using stainless steel containers are likely to encounter less losses as compared to those who use plastic containers.

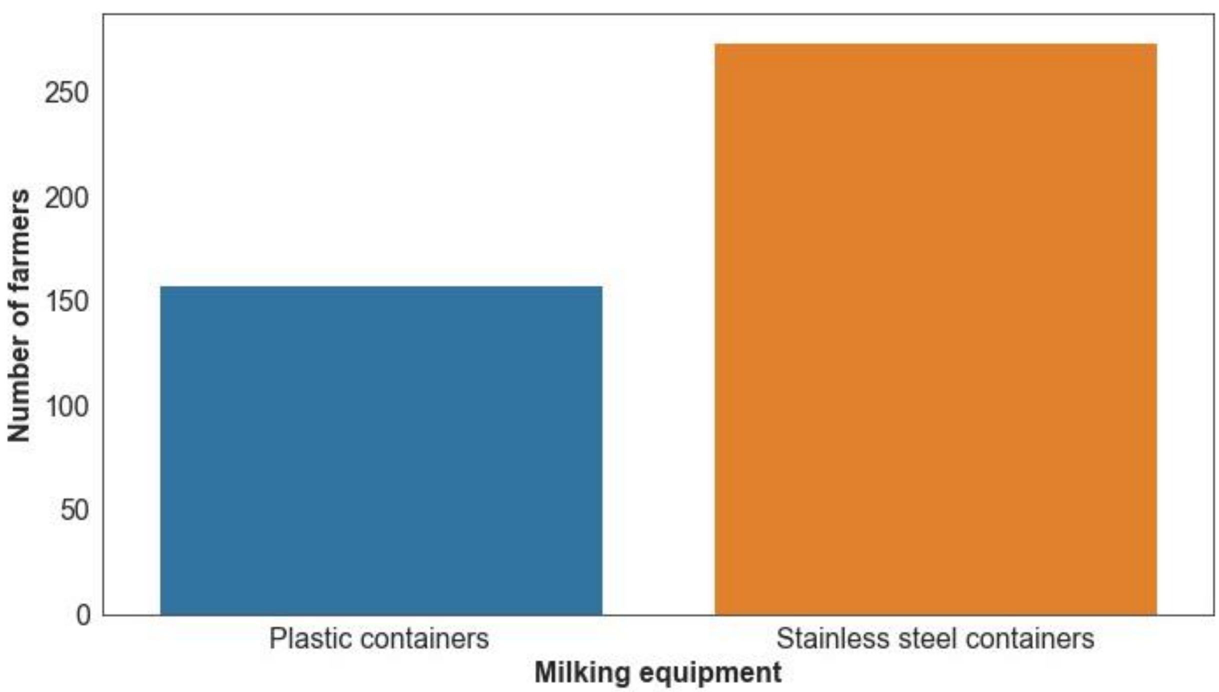

Figure 9: A count plot showing milking equipment used by farmers

Source: Survey (2021)

4.4.2 Cleaning of Udders and Cleaning Agent

Before milking, almost all farmers clean udders of their cattle with a majority using warm water and a cloth/towel. Others just use warm water, cold water, water and soap and even a wet towel as displayed in Figure 10. In the survey, it was noted that milk rejection was higher in cases where farmers used plastic containers and reusable towels to clean the cow's udder. This was explained by the higher absorbent capacity of towels that harbor infections if not well cleaned. The on-farm hygienic practices ensure quality and safety of the milk produced are thereby reduces post-harvest milk loss through rejection and spoilage due to contamination or poor quality. As Kashongwe et al. (2017) notes, the farmers who clean udders with warm water and dry with towel or clean cloths highly reduce the chances of milk contamination that could contribute to milk post-harvest loss.

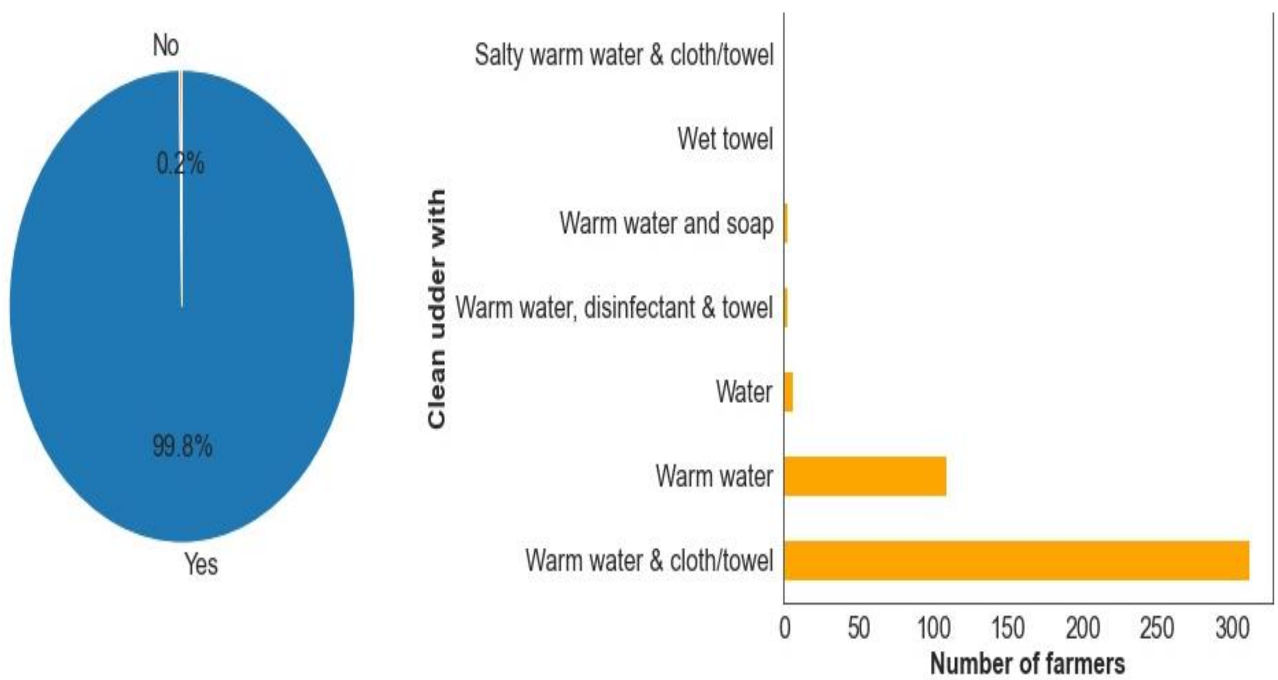

Figure 10: Cleaning of udders and cleaning agent

Source: Survey (2021)

4.4.3 Milk Testing at Collection Points

In some instances, milk was tested at collection points before being picked by transporters, and if it had any defects, it was rejected on the spot. On interviewing the transporters, 67% (n=35) stated that they were aware of milk being tested on the spot, with 33% (n=17) not aware of milk being tested at the collection points as outlined in Figure 11. Some of the tests conducted before ferrying the milk included lactometer tests for checking milk density, acidity tests, and physical dirt checks that informed on the properties of milk and hence, resulting in rejection of sub-standard milk. Some of the most common tests conducted to test milk include organoleptic tests for checking milk quality, clot on boiling tests for pH evaluation, alcohol test for the presence of proteins, alcohol-alizarin test for checking the acidity in milk, reassuring test for checking milk hygiene, the Gerber butterfat test for fat content in milk, lactometer test for excess water in milk, and inhibitor test for drugs/pesticide checks in milk (FAO, 2022).

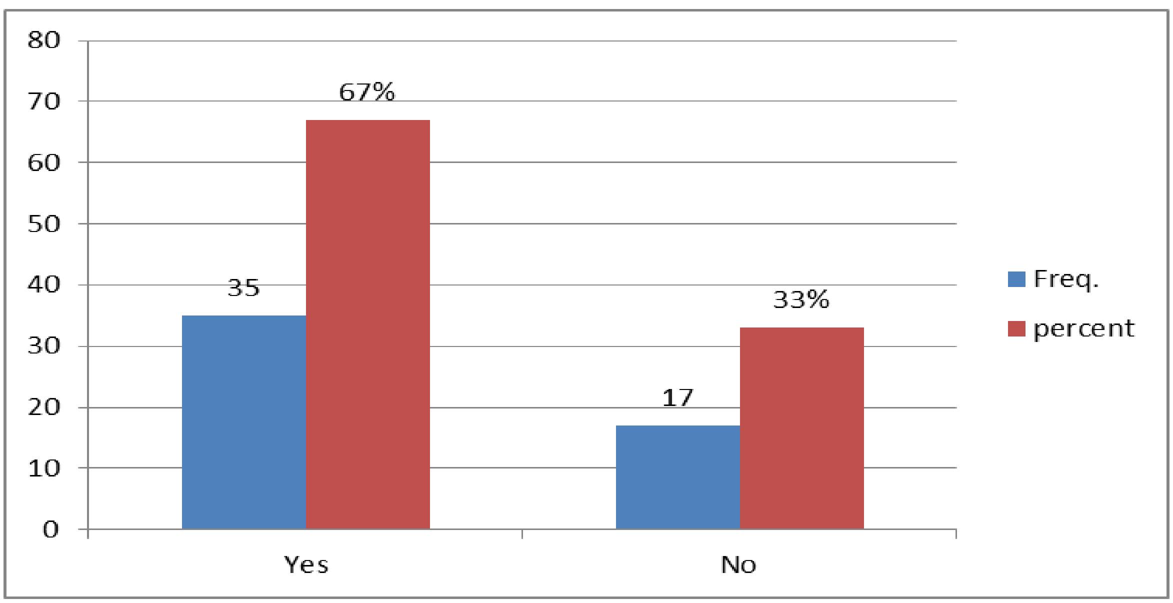

Figure 11: Milk testing being conducted at collection points

Source: Survey (2021)

As it has been demonstrated in this study, milk losses from rejection occur because of hygienic practice, adulteration, and other quality issues. Milk was rejected mainly because of excess water, physical dirt, sugars/salts, formalin, skim milk and milk from other animals. According to Gathura (2021), milk is rejected due to failure of routine tests, and these could include adulterations, poor hygiene and unsuitable containers. For whatever reason milk is rejected, it results in postharvest losses. Water density was the test that most farmers failed in that had their milk rejected. Other reasons for the rejection of milk were physical dirt, odor, mastitis, antibiotics and mixing of evening milk with morning milk.

4.4.4 Transport Containers Used

From the results, majority of the farmers used plastic containers for the transportation of their milk to the collection centers. Nonetheless, majority of the farmers used stainless steel containers as milking equipment as shown. A few farmers stated that they use stainless steel containers for transportation while some farmers use both plastic and stainless steels for transportation. However, almost all containers had plastic lids covering them during transportation. According to Gathura (2021), farmers have a higher preference for plastic containers since they are lighter, have varying sizes, and have a better closing mechanism than steel containers.

At the cooperative level, all respondents stated that they used stainless steel equipment containers for the transportation of milk. In addition, only three cooperatives indicated that they used specialized vehicles for the transportation of milk. The other three lacked special vehicles for the transportation of milk mainly due to lack of capital, low milk supply, or milk shortage.

Out of the 21 transporters who mentioned that they use milk equipment in the delivery of milk, 19 used stainless steel equipment with the other two using plastic equipment and a ‘Mazzi-can’. Transporters also indicated that they used various transport modes with 59% using specialized milk trucks, 22% using pick-up vehicles, and 14% using motorbikes. An additional 2% used tricycles and others (donkey carts) as shown in Figure 12. The KDB directs that milk collection vehicles should be open on the sides for free air circulation, but covered on the top to stop sunlight from heating the milk, which would lead to milk spoilage. On the other hand, if milk is transported in a closed vehicle, it could raise temperatures that could cause spoilage of the milk. For transporters using milk tankers, the tankers should be properly insulated and designed such that the milk only comes into contact with stainless steel (KDB, 2018).

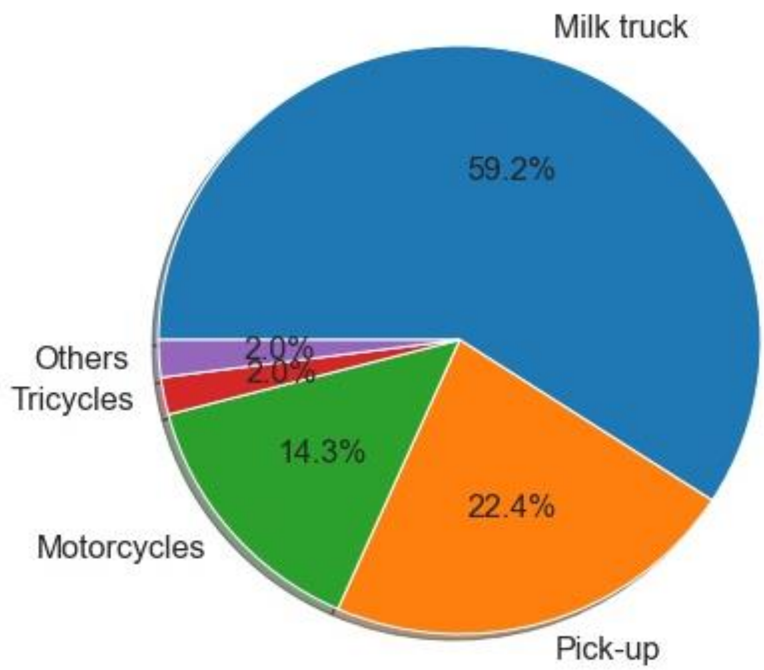

Figure 12: Modes of transport for delivering milk

Source: Survey (2021)

4.4.5 Cleaning of Containers

Four hundred and seventeen farmers (n=417) said that they cleaned their containers using soap while only 5 cleaned without soap. Only one respondent neither cleaned their container nor used soap at any point. The KDB (2018) report states that milk cans and containers should be cleaned with water and disinfectants only approved by relevant institutions. At the cooperative, they all cleaned their equipment before and after transporting their milk. With four cooperatives using water and detergent, another three using water, detergent and disinfectant while the remaining two cooperatives used only disinfectants. The KDB (2018) report reiterates that transport vehicles such as milk tankers should undergo cleaning using antibacterial agents, and all surfaces in contact with milk should be thoroughly cleaned.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The first objective of this study was to assess magnitude of post-harvest losses of milk along the formal marketing channel stages. Milk post-harvest loss magnitude was analyzed at farm level and the result revealed that daily milk loss was about 467 liters. Most milk loss at farm level was due to rejection (329 liters), spillage (200 liters), spoilage (152 liters), and forced consumption (101 liters). Farmers who were members of dairy cooperative were found to experience limited milk loss of about 3 liters compared to the non-cooperative members who experienced loss of about 3 liters daily. Further, spillage contributes a larger proportion of milk loss at cooperative level to about 86.8%, followed by rejection due to contamination (13.2%). During milk transportation, milk loading and offloading contribute to milk loss by 43.3% with a minimum loss from accident occurrence during transport.

The second objective was to evaluate the factors influencing the magnitude of milk post-harvest losses along the formal marketing channel stages. The determinant factors influencing milk loss at farm level were analyzed using OLS model. The result revealed that milk price, volume of milk sold, record keeping, quantity of milk rejected, access to storage facility and distance to the market influences the quantity of milk loss during post harvesting. Distance to the market and volume of milk sold were found to inversely influence the amount of milk loss during post-harvesting, while milk price, record keeping, access to storage facilities and quantity of milk rejected were found to directly influence the quantity of milk loss during post-harvesting at farm level. At transport level only distance to the market was found to negatively influence the amount of milk loss during post-harvest. Type of road used to access the market and rejection quantity was found to positively influences the quantity of milk loss during post-harvest due transportation.

Milk handling practices such as cleaning of udders, transportation means, use of stainless containers and use of cleaning detergents were found to reduce the amount of milk loss during post-harvesting.

The study found out that majority of the dairy farmers were smallholder farmers with their average age being 54 years. The farmers had dairy farming experience of over two decades with most of them having attained primary education level. The results also showed that the majority of the dairy farmers were females even though males dominated in the cooperatives. While majority of the farmers had access to dairy information, most did not have access to extension services. The main services from extension were training, farm inputs, artificial insemination and access to credit which were majorly provided by cooperatives, veterinary officers and experienced farmers. On average, the milk transporters in the region cover a distance of 26.6 Km and average of 11 nodes within the route per day with the milk transport sector in dairy being highly occupied by males. Most dairy cooperatives are located in Thegu region with few of them in Gakawa and Narumoru. Moreover, the study obtained that most of the dairy farmers (54%) deliver their milk to the milk collection points with few (1.4%) farmers delivering directly to the milk processors.

5.2 Recommendations for Policy

The findings reveal that there are fewer younger farmers in dairy production and there is gender gap between farmers in cooperatives and non-cooperatives. Youths to be encouraged to enter dairy production by developing policies that promote youths' engagement in the dairy sector at county level. Gender equality policies should also be promoted in the dairy sector to allow participation and decision making by women in the dairy sector. Such policies will increase number of female dairy farmers joining the dairy cooperatives.

It was also noted that many non-cooperatives members did not receive extension services while those who received the services did not obtain adequate attention. Accordingly, the number of extension officers need to be increased in various counties to ensure the smallholder farmers have access of extension services and information related to milk production, marketing and reduction of milk post-harvest losses. Distance being a significant factor contributing to milk loss, milk collection centers should be increased in the milk production zones to reduce distances covered by the milk transporter to get the milk form the farmers, this will tend to lower the post-harvest losses due to transportation. As well, the cooperatives can empower the dairy farmers to have milk coolants to pasteurize their milk and improve the milk stayover before delivery to the milk collection points. There is need for more dairy cooperatives in Nyeri county to provide market for dairy farmers in the area and to reduce the exploitation by middlemen.

Dairy farmers should be trained on the best milk handling practices to reduce milk loss at the farm level. Additionally, training on milk quality requirements in terms of livestock feeding programs should be introduced to reduce the amount of milk rejected by the cooperatives. Farmers selling their milk to informal sector should be encouraged to join cooperatives to acquire technical skills that lowers the rate of milk spoilage and spillage at farm level. Besides, training on milk handing milk reduce contamination of milk during milking and after milking, thus reducing spoilage at farm level. Farmers need to form groups to pool and mobilize resources for acquiring cooling facilities and transport vans to lower milk loss due to loading and offloading during transportation.

Furthermore, accessibility in terms of improving infrastructural facilities by the government such as maintenance of road will lower milk loss during bad weathers as the farmers will still manage to deliver milk produced to the market. Provision of credit to farmers to enable them acquire milk storage and cooling facilities will enhance low rate of milk loss during post-harvesting. Dairy farmers should be imparted with business management skills such as record keeping for observing the rate of milk loss, thus farmers will be careful in minimizing post-harvest loss. In addition, farmer should be imparted with milk handling skills such as cleaning of udder, cleaning milking equipment using detergents and use of stainless containers for holding milk for ensure minimum milk spoilage and spillage.

At the farm level, farmers can be potentially trained on how to enhance resilience by improving the health of their animals while tackling climate mitigation strategies through minimizing emissions by using innovation and technological advancements during transport and cooling of milk. Moreover, the productivity of farmers can be fostered through training by helping them make their production methods more efficient, changing their feeding techniques as well as proper management of animal waste and manure. If practised in Kenya through interventions of stakeholders, this would meet climatic smart agriculture on increased productivity, better resilience and a cutback in emissions.

At the cooperatives, capacity building should be conducted to farmers to discourage them from the adulteration of milk, which ultimately results in the rejection of milk. Kasirye (2003) further adds that there is a need to conduct needs assessment by stakeholders to identify the knowledge gap along the formal milk channel. This would inform the stakeholders on areas to concentrate on training milk handlers along the channel to equip them with the necessary knowledge and skill thus help reduce postharvest losses. A reduction in post-harvest losses would automatically lead to improved productivity, availability of more food that can be consumed.

At the level of the transporter capacity building is required has this will potentially reduce losses from spillages. To further reduce emissions, transporters need to be encouraged to use energy-efficient vehicles as well as clean energy. This will play an important role in achieving climate-smart approaches.

5.3 Recommendations for Further Studies

The current study estimates the absolute and relative losses in percentages across the value chain actors (farms, transporters/aggregators and cooperatives) and analyze the factors influencing post-harvest losses at these levels. However, a further study can be conducted to incorporate the economic impact of the milk PHL and its potential impacts on the sub-Saharan food security. Also, a similar study can be conducted but with a different econometric model other than OLS such as two-step Heckman model to ascertain the factor relationships obtained in this study.

REFERENCES

Affognon, H., Mutungi, C., Sanginga, P., & Borgemeister, C. (2015). Unpacking postharvest losses in sub-Saharan Africa: a meta-analysis. *World development*, *66*, 49-68.

Africa milk (2019). http://www.africa-milk.org.

Agarwal, S., & Bhardwaj, C. (2021). Goals of Competition Law in India. *Available at SSRN 3789536*.

Agrawal, R. K., Muchahary, F., & Tripathi, M. M. (2019). Ensemble of relevance vector machines and boosted trees for electricity price forecasting. *Applied Energy*, *250*, 540-548.

Alonso, S., Muunda, E., Ahlberg, S., Blackmore, E., & Grace, D. (2018). Beyond food safety: Socio-economic effects of training informal dairy vendors in Kenya. *Global food security*, *18*, 86-92.

Amentie, T., Eshetu, M., Mekasha, Y., & Kebede, A. (2016). Milk postharvest handling practices across the supply chain in Eastern Ethiopia. *Journal of advanced veterinary and animal research*, *3*(2), 112-126.

Arage, A. (2021). Review on Determinants of Milk and Milk Product Post-Harvest Loss in Ethiopia.

Azad, T., & Ahmed, S. (2016). Common milk adulteration and their detection techniques. *International Journal of Food Contamination*, *3*(1), 1-9.

Azeze, T., & Haji, B. (2016). Assessment of post-harvest loss of milk and milk products and traditional mitigation systems in Southern Ethiopia. *Assessment*, *48*.

Baluka, S. A., Musisi, L. N., Buyinza, L. S. Y., & Ejobi, F. (2021). Prevalence and Antimicrobial Resistance of Foodborne Pathogens in Sentinel Dairy Farms. *European Journal of Agriculture and Food Sciences*, *3*(5), 67-71.

Banda, L. J., Chiumia, D., Gondwe, T. N., & Gondwe, S. R. (2021). Smallholder dairy farming contributes to household resilience, food, and nutrition security besides income in rural households. *Animal Frontiers*, *11*(2), 41-46.

Bayan, B. (2020). Impact of Dairy Co-operative Society on Adoption of Improved Farm Practices: A Farm Level Experience in Assam. *Indian Journal of Agricultural Economics*, *75*(1), 62-7

Blakeney, M. (2019). *Food loss and food waste: Causes and solutions*. Edward Elgar Publishing.

Bourne, M. C. (2014). Food security: Postharvest losses.

Bullock, R., & Crane, T. (2021). Young Women's and Men's Opportunity Spaces in Dairy Intensification in Kenya. *Rural Sociology*, *86*(4), 777-808.

Creemers, J., & Aranguiz, A. A. (2019). Quick scan of Uganda's forage sub-sector.

Debela, G. T., Eshetu, M., & Regassa, A. (2015). Physico-chemical qualities of raw cow milk in Ethiopia. The case of Borana zone, Yabello District. *Global Journal of Dairy Farm Milk Production*, *3*, 86-91.

Deluca, A. (2017). The Effects of Governmental Programs on Dairy Production: An Analysis of the Modern Dairy Industry.

Devaux, A., Torero, M., Donovan, J., & Horton, D.(2018). Journal of Agribusiness in Developing and Emerging Economies.

Draaijer, J. (2002). Milk producer group. Resource book. A practical guide to assist milk producer groups.

Durham, J. A., Moore, U. J., Corbett, I. P., & Thomson, P. J. (2007). Assessing competency in dentoalveolar surgery: a 3-year study of cumulative experience in the undergraduate curriculum. *European Journal of Dental Education*, *11*(4), 200-207.

Fabi, C., Cachia, F., Conforti, P., English, A., & Moncayo, J. R. (2021). Improving data on food losses and waste: From theory to practice. *Food Policy*, *98*, 101934.

FAO, (2020). Food and Agriculture Organization of the UN [FAO] **FAOSTAT** (2020). http://www.fao.org/faostat/en/, Accessed 2nd Feb 2020.

FAO, (2009). *How to Feed the World in 2050*, FAO, Rome, Italy, 2009.

FAO, IFAD (2012) the State of Food Insecurity in the World 2012*: Economic Growth Is Necessary but Not Sufficient to Accelerate the Reduction of Hunger and Malnutrition*, FAO, Rome, Italy, 2014.

FAO (2014): Global Initiative on Food Loss and Waste Reduction: Food Loss Assessments; Causes and Solutions; Rome, Italy.

FAO, WHO, IFAD, UNICEF, & WFP. (2018). *The state of food security and nutrition in the world 2018* (Building Climate Resilience for Food Security and Nutrition).

FAO. (2021a). Dairy production and products: Production. Retrieved August 18, 2021, from http://www.fao.org/dairy-production-products/production/en/

FAO. (2021b). Hygienic milk handling and processing. Retrieved May 26, 2021, from http://www.fao.org/ag/againfo/resources/documents/MPGuide/mpguide1.htm

FAO. (2021c). Milk testing and Quality Control (Milk Processing Guide Series). Retrieved 19 May 2021, from http://www.fao.org/ag/againfo/resources/documents/MPGuide/mpguide2.htm

Faraz, A., Lateef, M., Mustafa, M. I., Akhtar, P., Yaqoob, M., & Rehman, S. (2013). Detection of adulteration, chemical composition and hygienic status of milk supplied to various canteens of educational institutes and public places in Faisalabad. *JAPS, Journal of Animal and Plant Sciences*, *23*(1 Supplement), 119-124.

Fikrineh, N., Estefanos, T., & Tatek, W. (2012). Microbial quality and chemical composition of raw milk in the Mid-Rift Valley of Ethiopia. *African Journal of Agricultural Research*, *7*(29), 4167-4170.

Fintrac. (2014). *USAID-KAVES Dairy value chain analysis*. 75.

Food and Agriculture Organization of the United Nations (2009). *How to feed the world: 2050. High expert forum, 12-13 Oct. 2009*. https://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf

Galiè, A., Njiru, N., Heckert, J., Myers, E., & Alonso, S. (2022). Gendered barriers and opportunities in Kenya's informal dairy sector: enhancing gender-equity in urban markets. *Gender, Technology and Development*, *26*(2), 214-237.

Gathura, F. M., Momanyi, M., & Mwalw'a, S. (2021). Effectiveness of Students' Council Leaders Involvement in Management Roles for Enhancing Students' Discipline among Different Categories of Public Secondary Schools in Machakos County, Kenya. *Journal of African Interdisciplinary Studies*, *5*(7), 89-116.

Glen, S. (2019). *Sample Size in Statistics (How to Find it): Excel, Cochran's Formula, General Tips*. Statistics How To. https://www.statisticshowto.com/probability-and-statistics/find-sample-size/

Gogo, E. O. (2017). *Pre-and postharvest treatments for the quality assurance of African indigenous leafy vegetables* (Vol. 41). Cuvillier Verlag.

Harding, F. (1995). Adulteration of milk. In *Milk quality* (pp. 60-74). Springer, Boston, MA.

Hengsdijk, H., & De Boer, W. J. (2017). Post-harvest management and post-harvest losses of cereals in Ethiopia. *Food Security*, *9*(5), 945-958.

IFAD. (2020). A decade of food loss reduction. Relief Web. https://reliefweb.int/report/world/decade-food-loss-reduction

Imende, B. (2020, March 4). Matatus, Boda bodas, taxis to be banned from carrying milk. *The Star*. https://www.the-star.co.ke/news/2020-03-04-matatus-boda-bodas-taxis-to-be-banned-from-carrying-milk/

Kaminski, A. M., Cole, S. M., Al Haddad, R. E., Kefi, A. S., Chilala, A. D., Chisule, G., ... & Ward, A. R. (2020). Fish losses for whom? A gendered assessment of post-harvest losses in the barotse floodplain fishery, Zambia. *Sustainability*, *12*(23), 10091

Kamthania, M., Saxena, J., Saxena, K., & Sharma, D. K. (2014). Milk Adulteration: Methods of Detection &Remedial Measures. *International Journal of Engineering and Technical Research*, *1*, 15-20.

Kandpal, S. D., Srivastava, A. K., & Negi, K. S. (2012). Estimation of quality of raw milk (open & branded) by milk adulteration testing kit. *Indian journal of community health*, *24*(3), 188-192.

Kang'ethe, E. K., Grace, D., Roesel, K., & Mutua, F. (2020). Food safety landscape analysis: The dairy value chain in Kenya.

Kang'ethe, E. K., Muriuki, S., Karugia, J. T., Guthiga, P. M., & Kirui, L. (2018). Scoping study report on: National food safety architecture of the dairy value chain in Kenya.

Kashongwe, O. B., Bebe, B. O., Matofari, J. W., & Huelsebusch, C. G. (2017). Associations between Milking Practices, Somatic Cell Counts and Milk.

Kasirye, N. F. M. (2003). Milk and Dairy Products, Post-harvest Losses and Food Safety in Sub Saharan Africa and the Near East. *A Review of the Small-Scale Dairy Sector Uganda. FAO*.

KDB. (2018). *Quality assurance guide for milk transporters*. Kenya Dairy Board.

Kenya National Bureau of Statistics (2019). 2019 Kenya population and housing census results. https://www.knbs.or.ke/2019-kenya-population-and-housing-census-results/

Khan, M. I., Younas, M., Bilal, M. Q., Rehman, M. S. U., Fiaz, M., Anjum, N., ... & Shakeel, M. (2018). Assessment of livestock extension services on dairy farm’s productivity. *Pakistan Journal of Science*, *70*(2), 131.

Kiambi, S., Alarcon, P., Rushton, J., Murungi, M. K., Muinde, P., Akoko, J., & Fèvre, E. M. (2018). Mapping Nairobi's dairy food system: An essential analysis for policy, industry and research. *Agricultural systems*, *167*, 47-60.

Kiaya, V. (2014). Post-harvest losses and strategies to reduce them. *Technical Paper on Postharvest Losses, Action Contre la Faim (ACF)*, *25*, 1-25.

Kyei, K., & Matsui, K. Assessing Fruit Farmers’ Perceptions of Post-Harvest Losses in the Ashanti Region of Ghana. *Age*, *49*(14.33), 25.

Lateef, M., Mustafa, M. I., Akhtar, P., Yaqoob, M., & Rehman, S. (2013). Detection of Adulteration, Chemical Composition and Hygienic Status of Milk Supplied to Various Canteens of Educational Institutes and Public Places in Faisalabad. *J Anim Plant Sci*, 6.

Leader, M. J. J. T., Scientist-Breeding, K. M. C. L., & Marketing, P. M. N. K. (2012). Strategic and Value Chain study of the smallholder Dairy sector in Central Kenya.

Lore, T. A., Mbugua, S. K., & Wangoh, J. (2005a). Enumeration and identification of microflora in suusac, a Kenyan traditional fermented camel milk product. *LWT-Food Science and Technology*, *38*(2), 125-130.

Lore, T. A., Omore, A. O., & Staal, S. J. (2005b). Types, levels and causes of post-harvest milk and dairy losses in sub-Saharan Africa and the Near East: Phase two synthesis report.

Maina, F., Mburu, J., Gitau, G., VanLeeuwen, J., & Negusse, Y. (2018). Economic efficiency of milk production among small scale dairy farmers in Mukurweini, Nyeri County, Kenya. *Journal of Development and Agricultural Economics*, *10*(5), 152-158.

Makokha, S. N., Metto, V., Yongo, D., Nyongesa, D., & Mwirigi, M. (2020). Access and Use of Information by Smallholder Dairy Farmers: A Case Study of Meru and Uasin Gishu Counties, Kenya. *Asian Journal of Agricultural Extension, Economics & Sociology*, 1–10. https://doi.org/10.9734/ajaees/2020/v38i1030422

March, M. D., Toma, L., Thompson, B., & Haskell, M. J. (2019). Food waste in primary production: Milk loss with mitigation potentials. *Frontiers in Nutrition*, *6*, 173.

Marwa, M. E., Mburu, J., Elizaphan, R., Oburu, J., Mwai, O., & Kahumbu, S. (2020). Impact of ICT based extension services on dairy production and household Welfare: the case of iCow service in Kenya. *Journal of Agricultural Science*, *12*(3), 1-12.

Masembe, F. N. (2003). *Milk and Dairy Products, Post-harvest Losses and Food Safety in Sub-Saharan Africa and the Near East* [A Review of The Small Scale Dairy Sector – Uganda]. Food Agriculture Organization. http://www.fao.org/fileadmin/templates/ags/docs/dairy/P1assessmentuganda.pdf

Mathai, M. N. (2019). *Determinants of post-harvest milk losses among milk producers and transporters in the dairy value chain in nyandarua north sub-county, kenya*. Egerton University.

Mebratie, M. A., Haji, J., Woldetsadik, K., Ayalew, A., & Ambo, E. (2015). Determinants of postharvest banana loss in the marketing chain of central Ethiopia. *Food Science and Quality Management*, *37*, 52-63.

Michailidis, A., & Papadaki-Klavdianou, A. (2008). The contribution of agricultural extension services to the productivity and socioeconomic profile of dairy cattle farmers. *Outlook on Agriculture*, *37*(2), 119-124.

Minten, B., Tamru, S., & Reardon, T. (2021). Post-harvest losses in rural-urban value chains: Evidence from Ethiopia. *Food Policy*, *98*, 101860.

Minten, B., Tamru, S., & Reardon, T. (2021). Post-harvest losses in rural-urban value chains: Evidence from Ethiopia. *Food Policy*, *98*, 101860.

Minten, B., Tamru, S., & Reardon, T. (2021). Post-harvest losses in rural-urban value chains: Evidence from Ethiopia. *Food Policy*, *98*, 101860.

Montgomery, H., Haughey, S. A., & Elliott, C. T. (2020). Recent food safety and fraud issues within the dairy supply chain (2015–2019). *Global Food Security*, *26*, 100447.

Munyori, M. N. (2019). *Determinants of post-harvest milk losses among milk producers and transporters in the dairy value chain in Nyandarua North Sub-County, Kenya* (Doctoral dissertation, Egerton University).

Muriuki, H. G. (2003). Milk and Dairy Products, Post-harvest Losses and Food Safety in Sub-Saharan Africa and the Near East: A Review of the Small-Scale Dairy Sector–Kenya. *Rome, Italy: Food and Agricultural Organization*.

Mwangi, R. W. (2013). *Factors influencing dairy cooperative societies performance in Mathira and Kieni constituencies, Nyeri county, Kenya* (Doctoral dissertation, University of Nairobi).

Naswem, A. A., & Ejembi, S. A. (2017). Reviving agricultural extension for effective transition from subsistence to commercial agriculture in Nigeria. *Journal of Rural Social Sciences*, *32*(1), 2.

Ndambi, A., Kilelu, C. W., van der Lee, J., Njiru, R., & Koge, J. (2019). *Making milk quality assurance work on an unlevel playing field: Lessons from the Happy Cow pilot* (No. 1165). Wageningen Livestock Research.

Ndambi, O. A., Bashuna, S. D., & Ozkan-Gulzari, S. (2020). *Milk quality assurance in smallholder-dominated dairy chains: Lessons from Uganda and Kenya| April 2020*. Wageningen University & Research.

Ndambi, O. A., Njiru, R., van Knippenberg, C., van der Lee, J., Kilelu, C. W., Ngigi, M., ... & Mwangi, W. (2018). *Enhancing milk quality and safety: Towards milk quality-based milk payments in Kenya*. Wageningen University & Research.

Ndungi, F., Muliro, P., Faraj, A., & Matofari, J. (2021). Milk handling practices and utilization at dairy farms and collection centers under rural and peri-urban milk value chain systems in Nakuru County, Kenya. *African Journal of Food, Agriculture, Nutrition and Development*, *21*(4), 17815-17833.

Ndungu, M. M., Lagat, J. K., & Langat, J. K. (2019). Determinants and causes of postharvest milk losses among milk producers in Nyandarua North subcounty, Kenya. *East African Agricultural and Forestry Journal*, *83*(4), 269-280.

Ng'eno, E. K. (2016). Impact of milk marketing channel choice decision on income, employment and breeding technologies among dairy farmer households in Kericho County, Kenya. *Asian Journal of Economics and Empirical Research*, *3*(2), 145-155.

Nicholas, A. B., & Angubua, B. S. (2019). Do extension services influence milk production among dairy farmers'cooperatives?*International Journal of Agricultural Extension and Rural Development Studies*,*6*(3), 1-10

Nyokabi, S. N., de Boer, I. J., Luning, P. A., Korir, L., Lindahl, J., Bett, B., & Oosting, S. J. (2021a). Milk quality along dairy farming systems and associated value chains in Kenya: An analysis of composition, contamination and adulteration. *Food Control*, *119*, 107482.

Nyokabi, S., Luning, P. A., de Boer, I. J., Korir, L., Muunda, E., Bebe, B. O., ... & Oosting, S. J. (2021b). Milk quality and hygiene: Knowledge, attitudes and practices of smallholder dairy farmers in central Kenya. *Food Control*, *130*, 108303.

Nyokabi, S., Oosting, S. J., Bebe, B. O., Phelan, L., Bett, B., Lindahl, J., & de Boer, I. J. M. (2018). The Kenyan dairy sector: stakeholder roles and relationships, and their impact on milk quality. In *Farming systems: facing uncertainties and enhancing opportunities*.

Odhong, C., Wilkes, A., & Dijk, S. V. (2018). Private-sector led extension in Kenya's dairy sector.

Paraffin, A. S., Zindove, T. J., & Chimonyo, M. (2018). Perceptions of factors affecting milk quality and safety among large-and small-scale dairy farmers in Zimbabwe. *Journal of Food Quality*, *2018*.

Raffaele, H. A., Petrovic, C., López, S. A. C., Yntema, L. D., & Faria, J. A. S. (2021). *Birds of Puerto Rico and the Virgin Islands: Fully Revised and Updated Third Edition*. Princeton University Press.

Rambim, M, D., & Awuor, F. M. (2020, May). Blockchain based milk delivery platform for stallholder dairy farmers in Kenya: enforcing transparency and fair payment. In *2020 IST-Africa Conference (IST-Africa)* (pp. 1-6). IEEE.

Rana, R., Singh, H., Singh, A., & Anuragi, S. (2014). Study of Composition, Adulteration and Hygienic Status of Milk Supplied in Mandi Town and Surrounding Villages.

Republic of Kenya (2013). Geospatial Information Section, Map of Kenya, January 2013.

Ridolfi, C., Hoffman, V., & Baral, S. (2018). *Post-harvest losses: Global scale, solutions, and relevance to Ghana*. Intl Food Policy Res Inst.

Roopnarain, A., Ndaba, B., Rama, H., Obi, L., Bello-Akinosho, M., & Akindolire, M. (2022). Liquid Gold: Harnessing the Potential of Digestate to Enhance Smallholder Farmer Food Security and Livelihood. In *Food Security for African Smallholder Farmers* (pp. 313-341). Springer, Singapore.

Rösel, K. (2018). *Assessment of the parasitic burden in the smallholder pig value chain and implications for public health in Uganda* (Doctoral dissertation).

Salih, M. A. M., & Yang, S. (2017a). Advances in Dairy Research.

Salih, M. A. M., & Yang, S. (2017b). Common milk adulteration in developing countries cases study in China and Sudan: a review. *J Adv Dairy Res*, *5*, 192.

Sharma, A., Jana, A. H., & Chavan, R. S. (2012). Functionality of milk powders and milk-based powders for end use applications—a review. *Comprehensive reviews in food science and food safety*, *11*(5), 518-528.

Sheahan, M., & Barrett, C. B. (2017). Food loss and waste in Sub-Saharan Africa. *Food policy*, *70*, 1-12.

Shee, A., Mayanja, S., Simba, E., Stathers, T., Bechoff, A., & Bennett, B. (2019). Determinants of postharvest losses along smallholder producers' maize and sweet potato value chains: an ordered Probit analysis. *Food Security*, *11*(5), 1101-1120.

Shull, P., Li, W., & Frederick, C. (2015). *China—Peoples Republic of Dairy and Products Annual 2015*. 7.

Silva, L. C. C. D., Tamanini, R., Pereira, J. R., Rios, E. A., Ribeiro Junior, J. C., & Beloti, V. (2015). Preservatives and neutralizing substances in milk: analytical sensitivity of official specific and nonspecific tests, microbial inhibition effect, and residue persistence in milk. *Ciência Rural*, *45*, 1613-1618.

Singh, P., & Gandhi, N. (2015). Milk preservatives and adulterants: processing, regulatory and safety issues. *Food Reviews International*, *31*(3), 236-261.

Syngenta Foundation. (2016, November 14). *Agricultural Extension*. Syngenta. https://www.syngentafoundation.org/agricultural-extension

Tadesse, B., Bakala, F., & Mariam, L. W. (2018). Assessment of postharvest loss along potato value chain: the case of Sheka Zone, southwest Ethiopia. *Agriculture & Food Security*, *7*(1), 1-14.

TOSUN, D., GÖLGE, E., Cukur, F., & DEMIRBA, N. (2009). Practices in milk collection centers for quality milk production: a case from the Aegean Region of Turkey. *New Medit : Mediterranean*

Journal of Economics, Agriculture and Environment= Revue Méditerranéenne d'Economie Agriculture et Environment, *8*(3), 21.

World Health Organization. (2018). *The state of food security and nutrition in the world 2018: building climate resilience for food security and nutrition*. Food & Agriculture Organization.

Yadeta, W., & Fetene, E. (2020). *Dairy Farm Record Keeping with Emphasis on its Importance, Methods, Types, and Status in Some Countries*. *8*, 16–25. https://doi.org/10.20431/2349-0365.0804003

Yeshiwas, Y., & Tadele, E. (2021). An investigation into major causes for postharvest losses of horticultural crops and their handling practice in debre markos, north-western Ethiopia. *Advances in Agriculture*, *2021*.

Zargar, M. A. (2015). Knowledge as a remedy to postharvest loss. *Preventing Postharvest Loss*. https://publish.illinois.edu/phlinstitute/2015/12/09/phl-zargar/

Zegeye, T., & Teklehaymanot, A. (2016). Assessment of post-harvest loss of milk and milk products and traditional mitigation systems in Mekelle milk shed, Northern Ethiopia. *Food Science and Quality Management*, *48*.

APPENDIXES

Appendix 1.1 Farmers Questionnaire

Dear Respondent,

My name is Mercy Mbaya, a student of Nairobi University studying Master of Science Degree in Agricultural and Applied Economics. I am conducting a study on post-harvest losses of milk in Nyeri County as part of an academic investigation for my studies. Any information collected from you will be used solely for academic research. Your personal details shall not be collected, confidentiality shall be strictly observed and any information collected shall not whatsoever be used against you. You are not forced to participate in the study; and you can pull out of the interview at any given time. You are allowed to not respond to any question should you feel uncomfortable.

SECTION A: DEMOGRAPHIC INFORMATION

1. Ward

   ◉ Narumoru/Kiamatha ○ Gakawa ○ Thegu ○ Kabaru

2. Age _______________
3. Gender

   ○ Male ○ Female

4. Farming system

   ○ Small holder ○ Large holder

5. Which cooperative are you from?

   ○ Mathaita ○ Gakawa ○ Lusoi ○ Gaturiri ○ Gathuna ○ Nairutia

   ○ Lamuria ○ Endarasha ○ Wazara ○ Island ○ Non-cooperative ◉ If others please specify ____________

6. Where do you supply your milk to

○ Directly to the processor ○ The milk collection point ○ Cooperatives ○ Middle men

○ Others

7. Enumerators name?

○ Winstone ○ Stanley ○ Herman ○ Wamae ○ Olive ○ Eunice ○ Charles ○ Mercy

SECTION B: HANDLING OF MILK AND POSTHARVEST LOSSES

8. What equipment do you use to milk cows?

○ Stainless steel containers ○ Plastic containers ○ Others

9. Do you clean a cow's udder before milking?

○ Yes ○ No

10. Has your milk been rejected at the cooperative/collection center for containing any unwanted substances?

○ Yes ○ No

11. What containers are used to transport milk

☐ Plastic ☐ Mazzi can ☐ Stainless steel

☐ Others please specify ____________________________

12. Are the containers covered with lids to avoid spillages and contamination?

○ Yes ○ No

13. Are the containers cleaned before and after use?

○ Yes ○ No

14. Do the milk collection centers have cooling facilities?

○ Yes ○ No

15. What type of cooling facilities do the milk collection centers have?

☐ Refrigerators ☐ Cooler ☐ Cold water ☐ Ice ☐ Shade ☐ Others, please specify ____________________

SECTION C: ACTOR EXPERIENCE & EXPERTISE

16. Experience in years in dairy farming ___________

17. Total number of years of education

18. Do you keep records of your dairy farming activities?

    ○ Yes ○ No

19. Do you receive extension services from agencies in the country?

    ○ Yes ○ No

20. Do you have easy access to information concerning dairy farming?

    ○ Yes ○ No

SECTION D: MARKET CONSTRAINTS AND POST HARVEST LOSSES

21. Distance from farm to milk collection point in km ____________

22. Distance from farm to processor

23. Is the road from farm to collection point/processor tarmacked?

    ○ No ○ Partly ○ Wholly

24. Does the road used to transport your milk result in losses of milk?

    ○ Yes ○ No

25. Does the price of milk affect whether you sell the milk to the processor or not?

○ Yes ○ No

26. Does the distance to the processor/collection point affect the quality or the quantity of your milk?

○ Yes ○ No

27. Does your processor use appropriate transport vehicles?

○ Yes ○ No

28. Does your processor use appropriate transport equipment?

○ Yes ○ No

29. Are there any other processors within the locality?

○ Yes ○ No

30. Would you consider selling your milk to other processors?

○ Yes ○ No

31. Are there government regulations that discourage you from selling milk to processors?

○ Yes ○ No

SECTION D: MAGNITUDE OF LOSSES

32. How much milk do you produce daily on average? ____________

33. How much milk do you consume every day on average? ___________

34. On average, how much milk do you set aside daily for selling to processors? ________

35. On average, how much milk do you sell to other channels? ____________

36. On average, how much milk do you force to consume just to avoid spoilage on monthly basis?

____

37. On average, how much milk do you lose monthly due to spoilage? __________

38. On average, how much milk do you lose monthly due to spillage? ___________

39. On average, how much milk is rejected by processors due to issues of contamination/ adulteration?

____

40. On average, how much milk is spilled while on transit? ___________

41. On average, how much milk is spoilt while on transit? _______________

42. Indicate the date _________________

43. GPS coordinates of the farmer ___________________

44. Farmers location/village ______________________

Appendixes 1.2: Transporters Questionnaire

Dear Respondent,

My name is Mercy Mbaya, a student of Nairobi University studying Master of Science Degree in Agricultural and Applied Economics. I am conducting a study on post-harvest losses of milk in Nyeri County as part of an academic investigation for my studies. Any information collected from you will be used solely for academic research. Your personal details shall not be collected, confidentiality shall be strictly observed and any information collected shall not whatsoever be used against you. You are not forced to participate in the study; and you can pull out of the interview at any given time. You are allowed to not respond to any question should you feel uncomfortable.

SECTION A: DEMOGRAPHIC INFORMATION

1. Ward

○ Gakawa ○ Narumoru/kiamathaga ○ Thegu ◉ Kabaru

2. Which cooperative are you from?

○ Mathaita ○ Gakawa ○ Lusoi ○ Gaturiri ○ Gathuna ○ Nairutia ○ Lamuria ○ Endarasha ○ Wazara ○ Island ○ Gukurani ◉ Non-cooperative

3. Designation of the respondent ___________________
4. Age of the respondent ___________
5. Gender

○ Male ○ Female

6. Education level of the respondent?

○ Primary ○ Secondary ○ College ○ University

7. Marital status of the respondent

   ○ Single ○ Married ○ Other, please specify _____________

SECTION B: OPERATIONAL ASPECTS

8. How many routes are covered by the Cooperative you work for?

   ○ One ○ Two ○ Three ○ Four

9. Which route are you in?

   ○ Route A ○ Route B ○ Route C ○ Route D ○ Route E

10. How many farmers do you take milk from in the route you cover? __________

11. How many km does your route cover? _____________

12. How many nodes are there in this route? ___________

13. In most nodes approximate how many farmers are represented? __________

14. How many hours does it take to cover the route you are assigned? ____________

15. At what time do you start the milk collection? ____________

16. At what time do you end the milk collection? __________

17. Approximately what distances are the nodes from each other? ___________

18. Does the distance from the farmers/collection points affect the quantity of milk received?

    ○ Yes ○ No

19. The total (quantity) litres of milk you pick in the route you cover? ______

20. Where do you deliver the milk to?

    ○ Directly to Processors ○ To cooperative

21. What mode of transport do you use in your route?

- [ ] Milk truck - [ ] Pick-up - [ ] Normal car - [ ] Tricycles - [x] Motorcycles - [ ] Bicycle

- [ ] Others, specify ______________

22. What type of containers do you use to transport the milk?

- [ ] Stainless steel - [ ] Plastic - [ ] Mazzi can - [ ] others

23. Does the road used to transport your milk result in losses of milk?

- [ ] Yes - [ ] No

24. What kind of roads are in the scope of the route you cover?

- [ ] Tarmac - [ ] All weather road - [ ] Non-motor able road

25. How many times do you collected milk from the nodes per week?

- [ ] Daily - [ ] After a day - [ ] After 2 days - [ ] After 3 days

26. How many times do you collected milk from the nodes per day?

- [ ] Morning - [ ] Evening - [ ] Both

27. Do you clean the vehicle during the transportation process?

- [ ] Yes - [ ] No

a. When do clean the vehicle?

- [ ] After transportation - [ ] Before transportation - [ ] Both

SECTION C: QUALITATIVE LOSSES

28. Do you do any test on milk during collection at the spot?

- [ ] Yes - [ ] No

29. Have you rejected milk from farmers for containing unwanted substances?

- [ ] Yes - [ ] No

30. How often do you reject milk from farmers for having unwanted substances?

○ Daily ○ Weekly ○ Fortnightly ○ Monthly

31. How much milk on daily basis is rejected by the transporters? (litres) __________

32. How much milk on daily basis is rejected by the buyers? (litres) _________

33. Does the distance from the farmers/collection points affect the quality and quantity of milk received?

○ Yes ○ No

34. .Do you lose milk through loading of milk to the means of transport?

○ Yes ◉ No

35. How often do you lose milk through loading of milk to the means of transport?

○ Daily ◉ After 2 days ○ After 4 days ○ Weekly ○ fortnightly

○ Monthly ○ Quarterly ○ Yearly

36. Do you lose milk through offloading of milk to the means of transport?

○ Yes ○ No

37. How often do you lose milk through offloading of milk to the means of transport?

○ Daily ○ After 2 days ○ After 4 days ○ Weekly

○ Fortnightly ○ Monthly ○ Quarterly ○ Yearly

38. Do you lose milk through picking in consideration to the road you use?

○ Yes ○ No

39. .How often do you lose milk through picking in consideration to the road you use?

○ Daily ○ After 2 days ○ After 4 days ○ Weekly ○ Fortnightly

○ Monthly ○ Quarterly ○ Yearly

40. Do you lose milk through accidents on the road?

○ Yes ○ No

41. How often do the accidents on the road occur?

○ Daily ◉ After 2 days ○ After 4 days ○ Weekly

○ Fortnightly ○ Monthly ○ Quarterly ○ Yearly

42. What majorly causes the accidents?

○ Bad roads ○ careless driving ○ Faulty transport vehicle/motorbikes ○ other road users ○ others

43. Node information:

Node	GPS coordinates	Number of farmers	Representative farmer/ carrier
Node 1			
Node 2			
Node 3			
Node 4			
Node 5			
Node 6			
Node 7			
Node 8			
Node 9			

Node 10			

Appendixes 1.3: Co-operative Questionnaire

Dear Respondent,

My name is Mercy Mbaya, a student of Nairobi University studying Master of Science Degree in Agricultural and Applied Economics. I am conducting a study on post-harvest losses of milk in Nyeri County as part of an academic investigation for my studies. Any information collected from you will be used solely for academic research. Your personal details shall not be collected, confidentiality shall be strictly observed and any information collected shall not whatsoever be used against you. You are not forced to participate in the study; and you can pull out of the interview at any given time. You are allowed to not respond to any question should you feel uncomfortable.

SECTION A: DEMOGRAPHIC INFORMATION

1. Ward

   ○ Gakawa ○ Narumoru/kiamathaga ○ Thegu ○ Kabaru

2. Number of farmers you buy milk from2a-which cooperative are you from?

   ○ Mathaita ○ Gakawa ○ Lusoi ○ Gaturiri ○ Gathuna ○ Nairutia

   ○ Lamuria ○ Endarasha ◉ Wazara ○ Island ○ non-cooperative

3. Gender

   ○ Male ○ Female

4. Enumerators

   ○ Herman ○ Evans ○ Charles

SECTION B: HANDLING OF MILK AND POSTHARVEST LOSSES

5. What equipment do you use to transport milk?

○ Stainless steel containers ○ Mazzi can ○ Plastic containers ◉ Others

6. Do you have a specialized vehicle for transporting milk?

○ Yes ○ No

7. Do you clean vehicle before and after transporting milk?

○ Yes ○ No

8. Do you clean other equipment used to handle milk?

○ Yes ○ No

9. Have you rejected milk from farmers for containing unwanted substances (adulterants)?

○ Yes ○ No

SECTION C: ACTOR EXPERIENCE &EXPERTISE

10. Do you hire employees with experience in dairy products management?

○ Yes ○ No

11. Are your employees trained in management of dairy products?

○ Yes ○ No

12. Are your employees aware of methods and techniques for reduction of postharvest losses?

○ Yes ○ No

SECTION D: MARKET CONSTRAINTS AND POST HARVEST LOSSES

13. Does your buying price affect volume of milk bought from farmers?

○ Yes ○ No

14. Does the road used to transport your milk result in losses of milk?

○ Yes ○ No

15. Does the distance from the farmers/collection points affect the quality and quantity of milk received?

○ Yes ○ No

16. What do you think would be the main reason that farmers supplying milk to your firm would consider selling milk to your competitors?

☐ Overproduction ☐ Better price ☐ Timely delivery ☐ Better skilled staff ☐ Less distance ☐ Better milks facilities/equipment ☐ Better handling of milk ☐ Better roads ☐ Prompt payment ☐ Credit facilities ☐ Less rules/requirements ☐ Others, please specify ___________

17. Are there government regulations that restrain you as a processor from buying milk from farmers?

○ Yes ○ No

SECTION E: MAGNITUDE OF LOSSES

18. On average how much milk do you buy from farmers every day? (litres) ________
19. On average, how much milk do you process every day? (litres) __________
20. On average how much milk do you sell every day? (litres) _____________
21. On average, how much milk is lost through spillages every day? (litres) _________
22. On average, how much milk is lost through spoilage every day? (litres) _________
23. On average, how much milk from farmers do you reject everyday due to contamination? (litres) _____________
24. Please click the GPS coordinates of the processors site. ____________